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

August 30, 2017

Mr. Thomas D. Ray
Vice President, Oconee Nuclear Station
Duke Energy Carolinas, LLC
7800 Rochester Highway
Seneca, SC 29672-0752

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3 – 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. MF0782, MF0783, MF0784, MF0785, MF0786, AND MF0787)

Dear Mr. Ray:

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 28, 2013 (ADAMS Accession No. ML13063A065), Duke Energy Carolinas, LLC (Duke, the licensee) submitted its OIP for Oconee Nuclear Station, Units 1, 2, and 3 (Oconee) 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 attached 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 10, 2014 (ADAMS Accession No. ML13365A258), and October 6, 2015 (ADAMS Accession No. ML15259A387), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated January 26, 2017 (ADAMS Accession No. ML17031A431), Duke 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 28, 2013 (ADAMS Accession No. ML13086A095), Duke submitted its OIP for Oconee 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 attached safety evaluation. By letters dated November 1, 2013 (ADAMS Accession No. ML13298A696), and October 6, 2015 (ADAMS Accession No. ML15259A387), 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 February 29, 2016 (ADAMS Accession No. ML16064A092), Duke 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 Duke's strategies for Oconee. The intent of the safety evaluation is to inform Duke 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 2515-191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact John Boska, Orders Management Branch, Oconee Project Manager, at 301-415-2901 or at John.Boska@nrc.gov.

Sincerely,

Tony Brown, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-269, 50-270, and 50-287

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

DUKE ENERGY CAROLINAS, LLC

OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3

DOCKET NOS. 50-269, 50-270, AND 50-287

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" [Reference 4]. 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" [Reference 5]. This order directed licensees to install reliable SFP level instrumentation 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 [Reference 1]. 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," [Reference 2] 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 [Reference 3], the NRC staff issued Orders EA-12-049 and EA-12-051.

2.1 Order EA-12-049

Order EA-12-049, Attachment 2, [Reference 4] 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 August 21, 2012, following several submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0 [Reference 6] to the NRC to provide 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 and on August 29, 2012, issued its final version of Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" [Reference 7], endorsing NEI 12-06, Revision 0, with comments, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (77 FR 55230).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, [Reference 5] 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 [Reference 8] 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" [Reference 9], 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 <u>TECHNICAL EVALUATION OF ORDER EA-12-049</u>

By letter dated February 28, 2013 [Reference 10], Duke Energy Carolinas, LLC (Duke, the licensee) submitted an Overall Integrated Plan (OIP) for Oconee Nuclear Station, Units 1, 2, and 3 (Oconee) in response to Order EA-12-049. By letters dated August 29, 2013 [Reference 11], February 28, 2014 [Reference 12], August 27, 2014 [Reference 13], February 27, 2015 [Reference 14], August 26, 2015 [Reference 50], February 29, 2016 [Reference 51], and August 26, 2016 [Reference 52], the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], 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" [Reference 36]. By letters dated February 10, 2014 [Reference 16], and October 6, 2015 [Reference 17], the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated January 26, 2017 [Reference 18], 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 <u>Overall Mitigation Strategy</u>

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 alternating current (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 supplied by those batteries; however, over time the batteries may be depleted.
3. There is no core damage initially.
4. There is no assumption of any concurrent event.
5. 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.

Oconee Units 1, 2, and 3 are Babcock and Wilcox (B&W) pressurized-water reactors (PWRs); with a dry ambient pressure containment building. The containment building is also called the reactor building. There are three separate reactor buildings, one shared auxiliary building, and one shared turbine building. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below.

At the onset of an ELAP, all three reactors are 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 atmosphere from the steam generators (SGs) through the atmospheric dump valves (ADVs) or SG safety valves. Makeup to the SGs may be provided by the unit's turbine-driven emergency feedwater (TDEFW) pump taking suction from the unit's upper surge tanks, but this equipment is not robust considering the external events and therefore is not credited for the ELAP response. The credited response is for operators to go to the standby shutdown facility (SSF), which is seismically qualified, and start the SSF diesel generator (DG), and then start the SSF auxiliary service water (ASW) pump, which is capable of pumping water to all six SGs (two per unit). At the SSF, operators will also start the SSF reactor coolant makeup (RCMU) pumps (one per unit), which inject borated water from the SFPs into the shaft seals of the RCPs to protect the RCP seals from overheating (which may result in excessive leakage), and which also provides makeup water to the RCS. After an ELAP is confirmed, the operators would begin a controlled cooldown and depressurization of the RCS by locally operating the SG ADVs. The SGs would be depressurized in a controlled manner until the RCS cold legs reach about 350 degrees Fahrenheit (°F), which will also reduce the RCS pressure and SG pressure. The licensee plans to complete this cooldown within 18 hours of the start of the event. The reduction in RCS temperature will result in inventory contraction in the RCS, but the licensee will use the RCMU pumps to maintain pressurizer level. At about 14 hours from the start of the event, the licensee plans to begin a controlled depressurization of the RCS, reaching about 700 pounds per square inch gauge (psig) by 44 hours after the event. The core flood tanks (CFTs) are pressurized to about 600 psig, and will be isolated or vented prior to injecting into the RCS.

The SSF was designed to operate for 72 hours; however, the licensee has FLEX equipment at the site that can be ready for use in several hours. When the SSF can no longer be operated reliably, a diesel-driven low-pressure FLEX pump will be used to add water to the SGs from the intake canal, which is connected to Lake Keowee. The licensee plans to use a diesel-driven high-pressure FLEX pump to add borated water to the RCS, with suction from the unit's borated water storage tank (BWST). The BWST is seismically qualified and has protection against tornado-borne missiles.

As discussed in its cooldown timeline, the licensee expects to further depressurize the SGs in order to further reduce RCS temperature and pressure. This would reduce RCS temperature to about 250°F, and the RCS pressure to about 350 psig, although it may take several days.

One 500-kilowatt (kW), 600 volt alternating current (Vac) DG will be deployed from the FLEX support building (FSB) to each unit. These portable generators will be used to repower the vital battery chargers and recharge the vital batteries, which will then repower the vital 120 Vac panelboards via the vital inverters.

In addition, a National Strategic Alliance for FLEX Emergency Response (SAFER) Response Center (NSRC) will provide high capacity diesel-driven pumps and large combustion turbine generators (CTGs), which could be used to continue the Phase 2 strategy into Phase 3. There are two NSRCs in the United States.

There is one SFP for Units 1 and 2, and a second SFP for Unit 3. The two SFPs are in the shared auxiliary building. Upon initiation of the ELAP event, the SFPs will heat up due to the unavailability of the normal cooling system. The licensee has calculated that boiling could start as soon as 6.1 hours after the start of the event for a SFP with a full core offload (which is a conservative assumption). To maintain SFP cooling capabilities, the licensee determined that it would take more than 24 hours for either SFP water level to drop to a level requiring the addition of makeup to preclude fuel damage. Makeup water would be provided using the FLEX mitigating strategies pump (a diesel-driven FLEX pump) with a suction from the intake canal and discharging through a hose which will be connected to add water to the SFP.

For Phases 1 and 2, the licensee's calculations demonstrate that no actions are required to maintain reactor building (containment) pressure below design limits for more than 72 hours.

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 0, 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 coolant is necessary to transport heat from the reactor core to the heat sink via natural circulation. 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, all three units 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 coolant, 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 one or more units are 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

Immediately following the trip of the reactor and RCPs resulting from the initiating external event, RCS temperature and pressure will stabilize at no-load conditions. Core cooling would be accomplished by natural circulation flow in the RCS using the two SGs as the heat sink. The SG inventory makeup would be automatically initiated using the turbine-driven emergency feedwater (TDEFW) pump; however, this pump and its associated makeup water sources are not robust relative to all applicable hazards. Therefore, the TDEFW pump is not credited as part of the licensee's FLEX strategy. If the TDEFW pump is not available, the licensee's analysis shows that the pressurizer power-operated relief valves (PORVs) will lift until flow to the SGs is initiated.

Instead of the TDEFW pump, the licensee credits the use of the fully robust SSF, which provides a high-capacity pump for SG makeup, pumps for RCS makeup (see Section 3.2.1.2 of this safety evaluation (SE)), instrumentation for monitoring essential plant parameters, and a DG to power SSF loads. The SSF DG is disconnected from the normal and emergency electrical distribution systems. In its FIP, the licensee identifies crediting the SSF as an alternative to the assumed initial conditions in NEI 12-06, namely that "all installed sources of emergency on-site ac power and SBO Alternate ac power sources are assumed to be not available and not imminently recoverable." Given that the SSF is fully robust to all applicable external hazards, and that the SSF electrical distribution system can operate independent from the Oconee normal and emergency distribution systems, the staff considers this to be an acceptable alternative which meets the requirements of Order EA-12-049.

When the ELAP begins, operators will immediately start the SSF DG and align the SSF ASW pump, which will begin supplying makeup water to all units' SGs within 14 minutes of the initiating event. This is a centrifugal pump with a design flow rate of 1975 gallons per minute (gpm). The SSF ASW pump takes suction from the condenser circulating water (CCW) intake crossover line, and can discharge to all six SGs (two per unit) simultaneously. Operators would stabilize core conditions at an RCS pressure of 1950-2250 psig and core inlet temperatures of 550-555 °F.

Approximately 2 hours into the event, operators would commence a cooldown of the RCS using the SGs as a heat sink, with makeup flow from the SSF ASW pump and steam vented through the ADVs. The ADVs are manual valves which would be locally operated. During the cooldown, operators will limit the cooldown rate to no more than 50 °F/hour, maintain pressurizer level above 85 inches, and maintain RCS pressure between 1950 and 2250 psig. The target RCS temperature band for this cooldown would be 325-350 °F; the licensee's FLEX strategy is to cool the RCS below 350 °F by 18 hours into the event.

Use of the SG ADVs is identified by the licensee as another alternative to the guidance in NEI 12-06, as they are located in the turbine building, which is not robust relative to all applicable external hazards. In order to justify crediting the ADVs, the licensee performed a technical evaluation which confirmed that the ADVs themselves, and the associated piping downstream of the valves, are robust to the applicable hazards, and that worst-case seismic or tornado damage to the turbine building could not prevent operators from accessing the ADVs.

3.2.1.1.2 Phase 2

The licensee intends to use the SSF ASW pump to supply SG makeup water for as long as possible. The SSF is designed to operate for 72 hours. To provide backup to the SSF and meet the guidance of NEI 12-06, the licensee will also deploy a portable, diesel-driven, low-pressure, high capacity (3000 gpm) FLEX Mitigating Strategies pump to take suction from the intake canal. Two of these pumps are stored onsite in the FSB to meet "N+1" redundancy criteria; a single pump has sufficient capacity to support core cooling and SFP makeup for all three units at the site. However, SG pressure must be very low in order to achieve the required flow rates.

The primary connection for the discharge of the FLEX pump is a single SG fill line in the protected service water (PSW) system that aligns flow to both SGs at all three units. The alternate route for SG makeup flow uses a manifold with three discharge connections, which connects via fire hoses to three SSF ASW emergency connections, one for each unit. This alternate SG makeup method only supplies feedwater to the "B" SG at each unit, resulting in an asymmetric cooldown. The licensee's evaluation of a possible asymmetric cooldown is discussed further in Section 3.2.3.2 of this SE.

In Phase 2, operators would deploy a portable FLEX power distribution system at each affected unit, consisting of portable DGs, transformers, cable splitters, and associated cabling. In addition, a 6 kW DG would be used to repower the RCS cold leg temperature indications in the SSF control room. The licensee's repowering strategy supports continued indication of essential plant parameters and other equipment. Following isolation or venting of the CFTs to prevent injection of nitrogen into the RCS (as described in Section 3.2.1.2.2 of this SE) operators will continue the RCS cooldown to a temperature of 240-250 °F and a pressure of 300-350 psig. Until CFTs are isolated or vented, operators will maintain RCS pressure above 650 psig to prevent nitrogen gas injection into the RCS.

3.2.1.1.3 Phase 3

The licensee's FIP states that Phase 3 will be a continuation of the Phase 2 coping strategy, supplemented by backup pumps, DGs, and water treatment equipment provided by an NSRC. The NSRC water filtration and demineralization equipment will be deployed on the suction side of the high-capacity FLEX pump, when available, to improve the quality of makeup water that is being provided to the SGs.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following initiation of the ELAP event, operators would verify isolation of normal letdown and other isolable flowpaths to conserve RCS inventory. Oconee operators would start the SSF DG and the SSF RCMU pumps (one is located in each reactor building) and align them to provide RCP seal injection within 20 minutes of the initiating event, preserving the function of the RCP seals. The SSF RCMU pumps are positive displacement pumps with a design flow rate of 29 gpm, and are powered by the SSF DG. These pumps take suction from their unit's SFP and discharge to the RCP seal injection lines.

3.2.1.2.2 Phase 2

In Phase 2, the licensee will begin RCS makeup using a portable, high-pressure FLEX RCS makeup pump. The FLEX RCS makeup pumps are positive displacement pumps, each with a design capacity of 48 gpm at 2500 psig discharge pressure. Four of these pumps are stored in the FSB, representing "N+1" capability for the three Oconee units.

Once deployed, the FLEX RCS makeup pumps take suction from their respective unit's borated water storage tank (BWST), which are robust to all applicable external hazards. Each BWST contains a minimum useable volume of 198,000 gallons of borated water, which per the licensee's calculations represents sufficient capacity for RCS inventory control for 13.6 days following the initial event. The primary connection flowpath for FLEX RCS injection is a set of four vent and drain lines on the high pressure injection (HPI) header and seal injection lines in the auxiliary building east penetration room. The alternate RCS injection flowpath is via a different set of vent and drain lines on the HPI header and seal injection lines; these are located in the auxiliary building west penetration room. All primary and alternate connections are therefore located within a safety-related structure (the auxiliary building) and protected from all applicable external hazards.

In Phase 2, the licensee's electrical repowering strategy will allow operators to either isolate the CFTs by shutting their associated isolation valves (primary strategy), or vent the nitrogen cover gas by repowering and opening the CFT vent valves (alternate strategy). Either action will effectively prevent the injection of nitrogen gas from the CFTs to the RCS as operators continue cooldown and depressurization.

3.2.1.2.3 Phase 3

The licensee's FIP states that Phase 3 will be a continuation of the Phase 2 coping strategy, supplemented by NSRC backup high-pressure pumps, water treatment and mobile boration equipment, and diesel fuel. The NSRC mobile boration equipment, including a 1000-gallon mixing tank and a transfer pump, would establish an essentially indefinite supply of borated RCS makeup water, with raw water supplied from the intake canal.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

Oconee's current design basis does not include site flooding, as discussed in the NRC review of the Oconee reevaluated flood hazard, dated September 24, 2015 [Reference 22]. The reevaluated flood hazard for Oconee will be evaluated by the NRC staff as described in Section 3.5 below, and will not be evaluated in this SE.

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

In the FIP, Section 2.3.4.3 states that the FLEX strategy relies on the ADVs to discharge steam during cool down of the RCS. By letter dated August 26, 2015, the licensee acknowledged that reliance on the ADVs for its FLEX strategy is an alternative to NEI 12-06 since the ADVs are not located in a structure protected from all BDBEEs. The NRC staff noted that technical evaluations were performed to demonstrate that the ADVs can still be operated and that potential damage to the main steam piping would not impact the successful implementation of its FLEX strategy. There are no main steam isolation valves on the Oconee units. The first isolation valves on the main steam header are the turbine stop valves.

The licensee explained that all of the ADVs are manually operated valves and are located in the turbine building, which is a seismically qualified Category 2 structure. The licensee stated that each unit has two independent ADV 'sets', of which only one set is required for successful implementation of the FLEX strategy. One ADV set is connected to the steam line from SG-A and the other to the steam line from SG-B. The licensee explained that a single ADV set consists of four individual manually operated valves, which consist of a 12-inch isolation block valve with a parallel 1-inch pressure equalization bypass valve to assist in operating the block valve. The line then splits into two valves which both release steam to the atmosphere, a 10-inch control vent valve and a 12-inch block vent valve (10-inch valve on Unit 1). After the 12-inch isolation block valve is opened, the 10-inch vent valve is typically opened next, and if additional flow is needed at lower SG pressures, the 12-inch vent valve is opened. The FLEX strategy can be accomplished at a minimum with a 12-inch isolation block valve and one of the two downstream valves operable (either the 10-inch control vent valve or the 12-inch block vent valve). Based on the updated final safety analysis report (UFSAR) Sections 3 and 10, as well as licensee drawings provided during its audit, the NRC staff noted that the main steam lines up to and including the turbine stop valves, which includes the ADVs, are seismically qualified.

In the plant calculation OSC-11383, Attachment 9, "Atmospheric Dump Valve – Survivability and Accessibility (Seismic)," the licensee concluded that the ADV sets would remain functional and accessible, although some debris could be expected in the area from non-seismically qualified structures. In the plant calculation OSC-11383, Attachment 10, "Atmospheric Dump Valve – Survivability and Accessibility (Tornado, Wind, and Missile)," the licensee concluded that the turbine building was robust enough to survive a tornado, and due to the shelter provided from tornado missiles, at least one flow path for steam release to atmosphere through the SG ADVs should remain functional. If steam was released from only one SG instead of from both SGs, it would result in an asymmetric cooldown of the RCS. An asymmetric cooldown of the RCS is evaluated in section 3.2.3.2 below with acceptable results.

Feedwater is needed to the SG which is being steamed to atmosphere. The SSF ASW pump can feed all of the SGs, and is designed to operate for at least 72 hours. The FLEX Mitigating Strategies pump, through its primary connection, can feed all the SGs. However, if the primary connection is not available, the alternate connection for the FLEX Mitigating Strategies pump can only feed the B SGs. If the ADV set on one of the B SGs had been damaged, it would need to be repaired. The licensee stated in its evaluation that sufficient time would be available to perform repairs while using the SSF ASW pump to feed the SGs.

Based on the diversity of valve combinations available for successful ADV operation and FLEX implementation, as well as the seismic classification of the ADVs, the NRC staff finds it reasonable to assume that an ADV set will be available for the licensee to implement its FLEX strategy following a seismic event. Based on the diversity of valve combinations available for successful ADV operation and FLEX implementation, as well as shielding provided by the turbine building superstructure and ruggedness of the main steam pipe and valves, the NRC staff finds it reasonable to assume that an ADV set will be available for the licensee to implement its FLEX strategy following a high-wind event, including wind-generated missiles. Therefore, the NRC staff finds that reliance on the ADVs, which are not fully robust, is an acceptable alternative to NEI 12-06, as the licensee has demonstrated compliance with the order, and the staff concludes it is reasonable to assume that at least a single ADV set on each unit will be available to support the licensee's FLEX strategy.

In the FIP, Sections 2.3.4.4 and 2.3.4.5 state that the FLEX strategy relies on the SSF ASW pump to provide feedwater for the SGs and on the SSF RCMU pumps to provide makeup water from the SFPs to the RCS during Phase 1. In the UFSAR, Sections 3.2.1.1.1 and 3.2.2 indicate that the SSF is a robust structure, which houses the SSF ASW pump. There is one SSF RCMU pump in each unit's reactor building. Therefore, these components are protected from all design-basis external hazards.

The staff finds that the SSF ASW pump and the SSF RCMU pumps are robust and these components are expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3. The licensee will rely on the installed plant SSCs with FLEX connection points and water sources as discussed in SE Sections 3.7 and 3.10, respectively.

3.2.3.1.2 Plant Instrumentation

According to the licensee's FIP, the following instrumentation required by NEI 12-06 would be initially powered by the SSF DG, and could be monitored from the SSF throughout the ELAP event:

- RCS pressure
- RCS hot leg and cold leg temperatures
- pressurizer level
- SG level
- core exit thermocouples (CETC)

Additional instrument indications are available in the main control room (MCR) and are powered by safety-related batteries. The battery-backed MCR instrumentation and indications will be available until manual isolation of the batteries at approximately 3 hours into the event. The batteries have a capacity of 4 hours, but will be isolated prior to full discharge as soon as the SSF is in service and instrument monitoring has been established. Later, during Phase 2, electrical re-powering strategies will restore these indications in the MCR. Instruments that can be monitored in the MCR include:

- RCS hot leg temperature
- RCS pressure (wide range)
- SG pressure
- SG level
- reactor vessel level
- pressurizer level
- CETC
- excore nuclear instruments (channels 1 and 2)

The licensee notes in the FIP that SG pressure, which NEI 12-06 lists as a typical key parameter, would not be available after isolation of the battery (at approximately 3 hours into the event) and before restoration of battery power in Phase 2. However, the licensee states that this parameter is not required to successfully execute the FLEX strategy; core cooling can be conducted by monitoring RCS parameters and using them to control the cooldown.

As recommended by Section 5.3.3 of NEI 12-06, the licensee has developed procedural guidance with instructions and information to obtain readings locally (e.g., at containment penetrations and instrument racks) for the following essential plant instrumentation:

- RCS pressure
- pressurizer level
- SG level
- CETC

3.2.3.2 Thermal-Hydraulic Analyses

In the analysis of the ELAP event performed by the PWR Owners Group (PWROG) 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," the RELAP5/MOD2-B&W code was chosen for the evaluation of B&W-designed plants such as Oconee. The RELAP5/MOD2-B&W code, as described in AREVA topical report BAW-10164-PA, "RELAP5/MOD2-B&W - An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analysis," Revision 6 (proprietary), is a general purpose thermal-hydraulic code that is capable of modeling accident scenarios including large- and small-break loss-of-coolant accidents (LOCAs), as well as a range of operational transients. The RELAP5/MOD2-B&W code is an adaption of the two-fluid, non-equilibrium RELAP5/MOD2 code developed at the Idaho National Engineering Laboratory. Although RELAP5/MOD2-B&W has been approved for performing certain design-basis transient and accident analyses, 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 the RELAP5/MOD2-B&W code and other thermal-hydraulic codes used for these analyses.

Based upon this review, the NRC staff questioned whether RELAP5/MOD2-B&W 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. In particular, for B&W PWRs with once-through SGs, the boiler-condenser cooling mode is said to exist when vapor boiled off from the reactor core flows up through the saturated, stratified hot legs, around the hot leg bends, and then down into the once-through SG tubes, where it is condensed by feedwater sprayed onto the SG tubes. Unlike PWRs with inverted U-tube SGs that undergo reflux cooling (i.e., wherein the majority of condensation occurs on the uphill side of the SG tubes, with the resulting condensate flowing back downhill into the reactor vessel via the hot legs), for B&W reactors in the boiler-condenser cooling mode, the condensate continues to drain downward through the once-through SGs and into the intermediate legs.

Due to the B&W RCS design configuration, at the time natural circulation ceases in the RCS (i.e., hot leg bends are sufficiently voided), the once-through SG tubes remain full of water. The presence of this stagnant liquid precludes effective heat transfer via boiler-condenser cooling, since it prevents vapor from penetrating down into the SG tubes being sprayed by feedwater flow. In this condition, degraded primary-to-secondary heat transfer conditions may occur, persisting until either: (1) sufficient RCS volume is restored to restart natural circulation, or (2) sufficient RCS volume is lost such that steam from the hot legs can enter the once-through SG tubes to permit adequate, continuous condensation heat transfer via boiler-condenser cooling. Owing to the relatively low RCS leakage rate considered during the analyzed ELAP event, if this situation occurs prior to the establishment of FLEX RCS makeup, a significant period of time may elapse, during which primary-to-secondary heat transfer may be significantly degraded, as illustrated in simulations conducted for B&W reactors in both WCAP-17601-P and WCAP-17792-P, "Emergency Procedure Development Strategies for the Extended Loss of AC Power Event for all Domestic Pressurized Water Reactor Designs" (proprietary). These simulations show the potential for RCS re-pressurization in excess of 2000 pounds per square inch absolute (psia) after RCS loop flow stagnates, with the RCS pressure in some cases remaining in this vicinity for many hours. Extensive re-pressurization of the RCS following a loss of natural circulation should be avoided for a number of reasons, including the potential to lift a safety or relief valve on the pressurizer and the potential for elevated RCS temperatures induced by the re-pressurization to result in RCP seal degradation and increased RCS leakage.

Furthermore, the NRC staff observed that the modeling capability of the RELAP5/MOD2-B&W code with respect to two-phase primary-to-secondary heat transfer for B&W reactors had not been sufficiently benchmarked to support best-estimate calculations for the ELAP event. As noted in BAW-10164-PA, limited benchmarking of the models for two-phase heat transfer across the SG was undertaken because the RCS pressure response during a LOCA tends to be dominated by the mass and energy loss from the break effluent, even down into the size range of the most limiting small break. However, considering the much lower RCS leakage rates associated with the analyzed ELAP event, heat transfer to the once-through SGs becomes the primary means of energy removal from the RCS. Furthermore, the analytical modeling techniques used in the calculations in WCAP-17601-P and WCAP-17792-P for B&W reactors were not adequately documented (e.g., modeling of SG tube wetting by auxiliary feedwater), and in some cases, the calculated results did not appear to match ostensible descriptions (e.g., the B&W simulations apparently did not use the 75°F per hour cooldown rate described in the Section 4.2.1 of WCAP-17601-P). As a result, the NRC staff could not credit the generic B&W coping time results from WCAP-17601-P and WCAP-17792-P beyond the point at which natural circulation ceases and RCS loop flow stagnates.

Likewise, the licensee did not credit boiler-condenser cooling to extend its credited coping time, but instead performed analysis intended to demonstrate that the Oconee strategy will be successful by taking actions to maintain natural circulation in all RCS loops and establish FLEX RCS makeup early in the event. In particular, for the B&W reactor design, prudent objectives for plant operators to prolong the duration of natural circulation flow in the RCS include:

- Maintaining adequate pressurizer level, which suppresses void formation in the RCS loop piping and the potential for an associated increase in flow resistance to interrupt natural circulation. Initiating RCS makeup early in the ELAP event using the SSF RCMU pump prevents RCS leakage from draining the pressurizer. Conducting a slow cooldown within the volumetric capacity of the FLEX RCS makeup source prevents thermally induced contraction of the RCS from draining the pressurizer.

- Maintaining adequate subcooling in the RCS loops, which similarly suppresses void formation in the RCS loops and the associated potential to interrupt natural circulation. Using the SGs to cool down the RCS with normal plant equipment unavailable would substantially degrade the RCS subcooling margin, potentially beneath minimum values considered desirable or necessary to support natural circulation. By delaying the RCS cooldown until critical steps within the FLEX strategy can be accomplished (e.g., restoration of pressurizer heaters, establishing FLEX RCS makeup), adequate subcooling margin to support natural circulation can be preserved during the RCS cooldown.

- Maximization of the elevation at which primary-to-secondary heat transfer occurs, since increasing the height of the heat sink relative to the heat source promotes natural circulation flow. In the B&W reactor design, upon demand, the EFW system sprays feedwater onto the once-through SG tubes at their upper elevation near the upper tubesheet. This elevation is significantly higher than the water level maintained by the main feedwater system during normal operation. Per the Oconee FLEX strategy, the SSF ASW pump and the FLEX pump used for SG makeup would discharge into the SG tube bundle via the upper nozzles and hence accrue a similar benefit.

Based upon the result of a plant-specific analysis performed using the RELAP5/MOD2-B&W code, the licensee concludes that its ELAP response strategy will effectively maintain RCS natural circulation and prevent boiler-condenser cooling. The base case (Case 1) of the Oconee FLEX analysis demonstrated the ability to establish stable plant conditions using the SSF ASW pump, SSF RCMU pumps, and supported pressurizer heaters. Cooling down using the ADVs to maintain a constant pressurizer level, while the RCMU pump provides makeup to the RCS via seal injection, results in a RCS cooldown from post-trip conditions to less than 350 °F core inlet temperature in approximately 14 hours.

This base case assumed the loss of SSF capability at 24 hours into the ELAP, after which time the FLEX Mitigating Strategies pump and the portable FLEX RCS makeup pump begin supporting SG makeup and RCS makeup. It was assumed that the alternate SG makeup flowpath (see Section 3.2.1.1.2) would be used, to investigate the impact of long-term asymmetric cooldown of the RCS using only the "B" loops and SGs. The case concluded that the licensee's mitigating strategy would ensure continuous natural circulation flow in the active loop(s) throughout the event, and that the core would remain covered. The case also concluded that operators should shut the ADVs and de-energize pressurizer heaters on an idle loop. The NRC staff notes that the Oconee procedures do not direct restoring flow to an idle loop at any point.

During the audit process, the NRC staff judged that a break in a main steam line, without actuation of the automatic feedwater isolation signal (AFIS), should be postulated and analyzed for, as the steam lines at Oconee are exposed to tornado missiles and no main steam isolation valves exist. Therefore, another case (Case 5f) of the licensee's analysis sought to determine the plant response to a double-ended guillotine main steam line break (MSLB) event concurrent with the ELAP, without credit for AFIS. This case demonstrated that in this scenario, the pressurizer would immediately empty due to uncontrolled RCS cooldown and depressurization. As subcooled liquid expands from the reactor vessel and surges into the pressurizer, the pressurizer goes water solid after approximately 3.8 hours. Eventually, the pressurizer heaters are able to recover a stable pressurizer bubble at approximately 13 hours into the event. The scenario concluded that for the first few hours of the event, natural circulation in the loop with the MSLB would be unstable, but would stabilize when SSF ASW flow initiated. Moreover, internal natural circulation in the reactor vessel would be sustained. Some voiding in the reactor vessel head was shown to occur, but did not affect the demonstrated ability to cool the core.

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 can be used to 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 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, potentially resulting in increased leakage and the 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.

Flowserve N-9000 3-stage seals are installed on the four RCPs at Unit 1. The N-9000 seal is a product in Flowserve's N-seal line of hydrodynamic seals that was developed by Flowserve in the 1980s. One of the design objectives for the N-9000 seal was to provide low-leakage performance under loss-of-seal-cooling conditions during events such as a station blackout. On August 5, 2015, in support of licensees using Flowserve RCP seals, the PWROG submitted to the NRC staff a white paper describing the response of the Flowserve N-Seal RCP Seal Package to a postulated ELAP (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15222A366). Units 2 and 3 have Bingham RCPs with Sulzer mechanical seals.

As discussed above, the licensee's FLEX strategy credits the use of SSF equipment, including the SSF RCMU pumps and the SSF DG which powers them. Within 20 minutes of the initiating event, the SSF RCMU pumps will restore seal injection to all RCPs at all Oconee units, thereby preventing the seals from overheating. Therefore, the licensee assumes a seal leakage rate of 2 gpm per RCP (9 gpm per unit, including 1 gpm of unidentified leakage) for its ELAP analyses, based on the guidance in Section 4.4.3 of WCAP-17601-P, which gives 2 gpm per RCP as a "reasonable assumption of realistic leakage" for B&W plants whose RCP seals do not experience overheating.

During the audit, the licensee addressed the status of its conformance with the Flowserve N-Seal white paper and the limitations and conditions in the NRC staff's endorsement letter. The licensee's FIP states that the plant design and planned mitigation strategy of Oconee are consistent with the calculation performed by Flowserve, as summarized in Table 1 of the white paper. The NRC staff audited the applicable information from the Flowserve white paper against the Oconee plant design and the mitigating strategy and determined that they were generally consistent. In particular, the peak cold-leg temperature prior to the RCS cooldown assumed in Flowserve's analysis (595 °F) was found to be higher than the saturation temperature (552 °F) corresponding to the lowest setpoint for a main steam safety valve lift pressure. The Flowserve analysis concurred with the licensee's position that re-establishing seal injection flow by 20 minutes would protect the seals from high temperature effects.

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 an 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 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 re criticality will not occur during a FLEX RCS cooldown.

During the audit, the NRC staff reviewed the licensee's shutdown margin calculations for Oconee. The licensee concluded that adequate shutdown margin could be achieved without crediting any boron injection from the core flood tanks. The assumptions in the licensee's analysis are appropriately conservative, including the most limiting initial core conditions, most limiting cooldown profile, and injected boron concentration from the SFP and BWST at the minimum allowed by technical specifications (2500 parts per million (ppm) minus 1 percent measurement uncertainty, as specified in the core operating limits report). The staff notes that, based on the sequence of events, RCS injection using the RCMU pumps is expected to be completed before the licensee adds unborated water to the SFP via the FLEX Mitigating Strategies pump. The staff also notes that if any RCMU pumps are running, the licensee's procedures direct operators to have the plant's technical support center (TSC) analyze the amount of unborated water that can be added to either SFP. Per NEI 12-06, there is no requirement to consider further random failures besides the initial ELAP/loss of normal access to the UHS; hence, all rods are assumed to insert into the core. The licensee concluded that if borated injection to the RCS is performed so as to maintain constant pressurizer level, and the boron concentration of the injected water is at least 2475 ppm, then the reactor will remain subcritical for the duration of the event. The licensee's calculations demonstrate that by the time the RCS has been cooled down to approximately 364 °F, the borated makeup injected up to that point will represent sufficient added boron to maintain long-term subcriticality for a xenon-free core at temperatures as low as 200 °F.

The calculation did not specifically address the potential for core flood tank injection. The boron concentration of the core flood tanks (2300 ppm) is slightly less than the concentration of the SFP and BWST (2500 ppm). As a result, substitution of some fraction of the volume assumed to be injected by the SSF RCMU pump (or FLEX RCS makeup pump) with coolant from the core flood tanks would likely extend the time required for RCS boration. However, the staff notes that the analyzed range of RCS leakage rates should result in the RCS pressure remaining sufficiently high to prevent core flood tank discharge prior to the injection of sufficient inventory from the BWST or SFP to provide the required shutdown margin. The NRC staff observed that the licensee's thermal-hydraulic calculations further support this conclusion.

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 in cases where minimal RCS leakage occurs. Understanding the need for RCS venting is necessary because completion of this action can extend the time required to complete RCS boration to the required concentration. The licensee's calculations adequately demonstrate that RCS venting would not be required. One assumption in the shutdown margin calculation is that pressurizer level is maintained at approximately 210 inches, and the high boron concentration of the injected water ensures that the makeup volume required to maintain 210 inches in the pressurizer is itself enough to keep the reactor subcritical.

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 proprietary position paper, dated August 15, 2013, which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability conditions 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, the NRC staff endorsed the above position paper with three conditions:

- The required timing and quantity of borated makeup should consider conditions with no RCS leakage and also with the highest applicable leakage rate.

- 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.

- 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 one hour is considered appropriate.

Because credit is taken for uniform boric acid mixing under natural circulation flow, the NRC staff determined that the boric acid mixing position paper, including the conditions in the endorsement letter, is applicable to Oconee. The licensee's FIP assumes perfect boron mixing in the RCS, which the licensee states is appropriate given that single-phase conditions are expected throughout the scenario. The NRC staff agrees that adequate boron mixing is assured for the duration of the event, and further notes that the licensee's timeline entails initiating RCS makeup early in the event, well before the time at which positive reactivity introduced by xenon decay or RCS cooldown would threaten shutdown margin.

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

The licensee relies on two different portable diesel-driven pumps during Phase 2. In the FIP, Section 2.3.10.1 states that if the SSF is no longer available, the FLEX response strategy relies on a portable, low-pressure pump (FLEX Mitigating Strategies pump), which is designed to supply a flow of 3,000 gpm, to provide cooling water from the intake canal to the SGs for core cooling and to the SFPs for makeup. In the FIP, Section 2.3.10.2 states that the FLEX response strategy also relies on a portable FLEX RCS makeup pump, which is designed to deliver a flow of 48 gpm at 2,500 psig discharge pressure, to provide boration and inventory makeup to the RCS from the BWST. The NRC staff reviewed the licensee's SAFER response plan and noted that the performance criteria for the FLEX Phase 3 NSRC pumps are capable of accomplishing the tasks of the onsite FLEX Phase 2 portable pumps. See Section 3.10 for detailed discussion of the availability and robustness of each water source.

The NRC staff reviewed the licensee's hydraulic calculation (OSC-11176, Rev. 1, "ELAP - Steam Generator Makeup Hydraulic Model Using FLEX Equipment") for core cooling and noted that the licensee assumed that the maximum required SG flow (i.e. 200 gpm per unit) from the portable pump is considered for the decay heat load at 2 hours after the reactor trip. The staff finds this assumption conservative because the FLEX strategy will initially rely on the SSF, which is designed to operate for at least 72 hours, to provide feedwater to the SGs before transitioning to the FLEX Mitigating Strategies pump. Based on the licensee's sequence of events, the FLEX strategy does not expect to begin using the FLEX Mitigating Strategies pump until at least 24 hours after the start of the ELAP event. The licensee's calculation assessed the flowrates delivered to each of the SGs at the site for various scenarios and pump discharge pressures. It was determined that the FLEX Mitigating Strategies pump will provide at least 200 gpm of flow to each unit's SGs if the pump discharges at a minimum of 180 psig. Furthermore, the hydraulic calculation determined that a maximum of 820 gpm of feedwater can be delivered to each unit's SGs at a pump discharge pressure of 250 psig. The FLEX strategy requires one

FLEX Mitigation Strategies pump for the entire site and there is a total of two FLEX Mitigation Strategies pumps, both of which are stored in the FSB, which the staff finds satisfies the N+1 requirement for equipment redundancy outlined in NEI 12-06.

In the FIP, Section 2.3.10.2 states that the maximum flow demand from the FLEX high-head pump used for RCS makeup in its thermal hydraulic analyses is 40 gpm. The staff reviewed the licensee's hydraulic calculation (OSC-11179, Rev.1, "Portable RCS Makeup Pumps NPSH") for RCS makeup and noted that the diesel-driven portable RCS makeup pump is able at 100 percent pump speed (765 revolutions per minute) to produce 48 gpm at 2500 psi, which exceeds the required flowrate to the RCS. In addition, the licensee's hydraulic calculation also determined that there is adequate net positive suction head (NPSH) available for the portable FLEX RCS makeup pump at or above 20 feet water level in the BWST, with a suction stabilizer installed upstream of the pump. Furthermore, the Technical Specification minimum BWST level is 46 feet and with the useable BWST volume of 26 feet, the available minimum required BWST inventory supports 2.86 days of FLEX RCS makeup pump operation when the pump is providing full flow, and is operating continuously. Based on the available inventory in the BWST in addition to the available operating time of 72 hours of the SSF, the staff finds there is sufficient time for the off-site resources to arrive. The FLEX strategy requires one FLEX portable RCS makeup pump per unit and there is a total of four FLEX portable RCS makeup pumps, all of which are stored in the FSB, which the staff finds satisfies the N+1 requirement for equipment redundancy outlined in NEI 12-06.

The NRC staff confirmed that flow rates and pressures evaluated in the hydraulic analyses were reflected in the FIP for the respective SG and RCS makeup strategies based upon the above FLEX pumps being diesel-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 distance runs, and connection points as described in the above hydraulic analyses and FIP.

Based on the NRC staff's review of the FLEX pumping capabilities, as described in the above hydraulic analyses and the FIP, the staff concludes that the portable FLEX pumps should perform as intended to support core cooling and RCS inventory control during an ELAP event, consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to equipment and instrumentation used to mitigate an ELAP and loss of normal access to the UHS. The electrical strategies described in the licensee's 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, use of the SSF DG during Phase 1, and the summary of the licensee's calculation for sizing the FLEX DGs. 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 a loss of heating, ventilation, and air conditioning (HVAC) caused by the event.

During the first phase of an ELAP event the licensee would rely on the SSF DG, which is a permanently installed and independent source of emergency on-site ac power for SSF system loads. The licensee would use the SSF DG solely for operation of the SSF equipment and instruments. The SSF DG remains disconnected from the normal and emergency electrical distribution systems and the Oconee plant operators would manually start the SSF DG from the SSF control panel in the SSF building following a loss of all ac power. In its FIP, the licensee stated that use of the installed SSF is an alternative to NEI 12-06, Revision 0. The NRC staff's review of this alternative is discussed in Section 3.14 of this SE and in the NRC ISE Report [Reference 16]. In its FIP, the licensee stated that the plant operators would start implementing emergency operating procedure (EOP) EP/1,2,3/A/1800/00.1-0B, "Blackout," within 1 minute of the start of the event and would complete the necessary steps to energize the installed SSF equipment within 20 minutes of the start of the ELAP. The installed SSF DG would provide an independent source of electrical power to the Phase 1 SSF instruments and indications located in the SSF control room.

Additional instrument indications are available in the MCR from battery-backed vital panel boards. In its FIP, the licensee stated that during Phase 1 (up to approximately 3 hours into the event), operators will also be able to monitor plant parameters from the instrument indications in the MCR that are powered by the safety-related (Class 1E) batteries. However, this function (i.e. monitoring of plant parameters in the MCR) is not essential for Phase 1, as all required indications for the SSF powered plant instruments would be available in the SSF control room. The battery-backed MCR instrumentation and indications would be available until operators manually isolate the Class 1E batteries approximately 3 hours into the event. The licensee stated that the Class 1E batteries in each unit have sufficient capacity to supply dc loads for about 4 hours. As part of the licensee's FLEX strategy, plant operators would isolate all dc loads on the Class 1E batteries within 4 hours into the event to prevent the batteries from fully discharging. This will ensure the batteries will be available when battery chargers are reenergized later in the event. FLEX guidelines (FGs) FG/1, 2, 3/A/1900/004, "Unit 1, 2, 3 Extended Loss of AC Power DC Load Management" provide guidance to the plant operators to isolate dc loads. In OSC-11383, Attachment 3, "Performing Deep Load Shed Analysis," Revision 0, the licensee evaluated the need for deep load shedding the Class 1E batteries to extend the battery's life and capability to support dc loads and concluded that Oconee does not need to perform an additional dc battery load shed because the installed SSF DG will be used to energize the SSF battery charger to power required SSF dc loads and instruments needed for Phases 1 and 2 up to 72 hours.

The SSF DG is rated for 3500 kW, 4160 Vac at 0.8 power factor. The normal SSF system loads include an SSF battery charger, the SSF ASW pump for SG makeup water, one SSF RCMU pump for each unit, the SSF building HVAC system, and SSF instrumentation for monitoring key parameters required for the licensee's FLEX strategies. These SSF equipment and instruments are powered from an SSF 4160 Vac switchgear, an SSF 600 Vac load center, and an SSF 600 Vac motor control center (MCC), all powered by the SSF DG. The SSF battery charger would supply power to the SSF inverter and instruments. In its FIP, the licensee did not mention adding any new load on the SSF DG during Phase 1.

Based on its review of the licensee's procedures and licensee evaluation, the NRC staff finds that the licensee strategy to use the installed SSF DG to power required Phase 1 equipment and instruments until backup power (onsite portable FLEX DGs in Phase 2) is available is acceptable.

During Phase 2, the licensee's FLEX strategy includes transition from installed equipment to onsite FLEX equipment. Deployment of FLEX equipment will commence approximately 6 hours after the start of the event and will be completed within 24 hours into the event. In its FIP, the licensee discussed primary and alternate strategies for supplying power to the Phase 2 equipment using a combination of portable FLEX and permanently installed, seismically robust components. The licensee's FLEX strategy relies on portable DGs to repower equipment. Oconee has four portable FLEX 600 Vac, 500 kW DGs; four 120 Vac, 6 kW DGs; and four 120/240 Vac, 10 kW DGs, all stored in the FSB. There are four in order to have one for each unit plus one 'N+1' as a spare. If a FLEX DG becomes unavailable or is out of service for maintenance, the plant operators would deploy the other ('N+1') FLEX DG to continue to support the required loads. All four FLEX DGs in a set are identical, thus ensuring electrical compatibility and sufficient electrical capacity in an instance where substitution is required. Since the 'N+1' FLEX DG is identical and interchangeable with the other FLEX DGs, the NRC staff finds that the licensee has met the provisions of NEI 12-06, for spare equipment capability regarding the Phase 2 FLEX DGs.

In its FIP, the licensee stated that the primary strategy for each unit requires use of a 600 Vac, 500 kW FLEX DG and a 120 Vac, 6 kW FLEX DG. The alternate strategy for each Unit uses a 600 Vac, 500 kW FLEX DG and a 120/240 Vac, 10 kW FLEX DG. Guideline FSG/0/A/1900/005, "Initial Assessment and FLEX Equipment Strategy," provides guidance to the plant operators to implement the primary and alternate electrical power supply strategies for the Phase 2 equipment.

The NRC staff reviewed calculation OSC-11358, "U2, Flex Primary & Alternate Strategy-Electrical System Calculation (32-9231324-0021)," Revision 0, that showed that a 600 Vac, 500 kW FLEX DG that will be used in the primary repower strategy would be loaded to approximately 310 kW during Phase 2 operation. Calculation OSC-11358 showed that the 500 kW FLEX DG would supply power to the Class 1E Battery Chargers, reactor building pressure transmitters, CFT isolation valves (motor-operated) and other loads during Phase 2 of an ELAP event.

The 120/240 Vac, 6 kW FLEX DG will be used in the primary strategy to repower SSF panel board KSFC to energize the RCS cold leg temperature indications (available in the SSF control room). This DG would be loaded to approximately 1.8 kW.

The 120/240 Vac, 10 kW DG will be used in the alternate strategy to restore power to the instrument panels and provide 120 Vac feeds to the MCR and auxiliary building cable room equipment. The licensee estimated that the 120/240 Vac, 10 kW DG would be loaded to approximately 6.3 kW.

Calculation OSC-11358 showed that all analyzed electrical buses/equipment for primary and alternate electrical strategies are acceptable for worst-case voltage, loading, and short circuit requirements, with adequate margin for all three units.

Based on its review, the NRC staff concludes that the Phase 2 FLEX 500 kW, 6 kW and 10 kW DGs should have adequate capability and capacity to power the Phase 2 loads needed during an ELAP.

For Phase 3, the licensee plans to continue its Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by an NSRC include six (2 per unit) 1.0 megawatt (MW) 4160 Vac combustion turbine generators (CTGs), three (one per unit) 480 Vac 1000 kW CTGs, three (one per unit) 480/600 Vac step-up transformers, and distribution panels (including cables and connectors). The NSRC 480 Vac CTGs and associated 480/600 Vac step-up transformers would be used to replace the 600 Vac 500 kW FLEX DGs as needed. In its FIP, the licensee stated that the Phase 3 loading on the 480 Vac CTG will be same as the 500 kW FLEX DG as no additional loads are required for Phase 3 coping. Due to having higher rated capacity than the 500 kW FLEX DG, the NSRC-supplied 480 Vac CTG will have sufficient capacity to supply power to the equipment during Phase 3. The licensee did not discuss how they will use the NSRC supplied 4160 Vac CTGs but they will be available, if necessary.

Based on its review, the NRC staff finds that the plant batteries used in the strategy should have sufficient capacity to support the licensee's strategy, and that the FLEX DGs and turbine generators that the licensee plans to use should have sufficient capacity and capability to supply the necessary loads during an ELAP event.

3.2.4 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, 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 should 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 acceptable approach consisting of three 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; 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load; and 3) spray via portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gpm per unit (250 gpm if overspray occurs). 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 2.1, 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.

3.3.1 Phase 1

In the FIP, Section 2.4.1 states that the time to boil is estimated at 6.1 hours for the Unit 3 SFP and 6.9 hours for the Unit 1 and 2 SFP, which are based on a full core offload for each pool. Actions during Phase 1 include monitoring SFP water level using reliable SFP level instrumentation installed per Order EA-12-051 and ventilation of the SFP areas by opening doors.

3.3.2 Phase 2

In the FIP, Section 2.4.2 states that the Phase 2 SFP makeup strategy consists of using a portable high-capacity diesel-driven FLEX pump at the intake canal, which is the same pump that is deployed for the core cooling strategy (i.e., the FLEX Mitigating Strategies pump), and will already be in place when SFP makeup is required. Hose will be routed from the discharge of the pump to a gated wye that distributes flow to the two SFPs. The primary connection strategy uses hoses connected to the permanently installed SFP fill lines located in the Unit 1 Cask Decontamination Room and Unit 3 Fuel Receiving Bay stairwell. The alternate connection strategy uses flexible hose taken from the portable spray nozzle box (Boggs box) and will be deployed regardless of availability of the primary connection point, in case the SFP area becomes inaccessible.

3.3.3 Phase 3

In the FIP, Section 2.4.3 states that the site will receive water purification and boration equipment from an NSRC to provide the capability for an indefinite supply of borated makeup water. Furthermore, the NSRC will provide booster pumps to support water purification and boration packages.

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 NRC staff reviewed the licensee's calculation for SFP boiling. This calculation and the FIP indicate that boiling begins at approximately 6.1 hours for the Unit 3 SFP and 6.9 hours for the Unit 1 and 2 SFP, which is based on a full-core offload for each pool. The staff noted that this is conservative when compared to the time to boil for the SFP during a normal, non-outage situation. The staff noted that the licensee's sequence of events timeline in the FIP indicates that operators will deploy hoses and spray nozzles as a contingency for SFP makeup within 6 hours from event initiation to ensure the SFP area 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 establish ventilation of the SFP areas by opening doors from the SFP into the purge inlet rooms and then the doors from those rooms to the atmosphere, as well as opening the SFP truck receiving bay roll-up doors.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of the FLEX Mitigating Strategies pump or an NSRC-supplied pump for Phase 3, with suction from the intake canal, to supply water to the SFPs. 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. The staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

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 SFP level instrumentation, 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

In the FIP, Section 2.4.6 states that the time to boil is estimated at 6.1 hours for the Unit 3 SFP and 6.9 hours for the Unit 1 and 2 SFP, based on a full core offload for each pool. The staff noted that the time-to-boil during normal, non-outage conditions would be greater than these boil-off times due to the reduced heat load in the SFP.

The licensee explained that based on a decrease in volume in the SFP of 32 gpm per unit due to the SSF RCMU pump suction and 70 gpm from boil-off, the level in each SFP is reduced to approximately 10 feet above the fuel at approximately 24 hours. In its FIP, the licensee explained that its calculation includes the following conservative assumptions:

- SSF RCMU flow rate is for an operational unit (i.e., fuel is in the reactor vessel) and the boil-off rate is for a full core offload (i.e., fuel is in the SFP).
- SSF RCMU flow rate is not decreased through 25 hours in the ELAP event.
- The calculation uses boil-off rates starting immediately rather than at the time to boil.
- Time to fuel uncovery is in excess of 72 hours and it based on a full core offload and simultaneous SSF RCMU demand for the Unit 1&2 SFP.

The staff agrees that these assumptions are conservative because the high decay heat levels from a full-core offload would not be present during normal plant operation, the required SSF RCMU flow rate is expected to decrease as the ELAP event progresses and the plant cools down, and bulk boiling does not occur instantaneously at the start of the ELAP event as it will take time for the water in the SFPs to reach the boiling point.

The licensee explained that the SSF RCMU pump for each unit takes its suction from its associated SFP and provides flow at 32 gpm to the RCS; thus, the Unit 1 and 2 SFP is depleted at a rate of 64 gpm and the Unit 3 SFP is depleted at a rate of 32 gpm. In addition to these depletion rates for the SSF RCMU pumps is the boil-off volume losses which are 70 gpm per pool. The total depletion rate from the Unit 1 and 2 SFP could be 134 gpm and the total depletion rate from the Unit 3 SFP could be 102 gpm.

Therefore, the licensee conservatively determined that a SFP makeup flow rate of at least 134 gpm for the Unit 1 and 2 SFP and 102 gpm for the Unit 3 SFP will maintain adequate SFP level during an ELAP occurring during normal power operation. Consistent with the guidance in NEI 12-06, Section 3.2.1.6, the staff finds that the licensee has 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 relies on the FLEX Mitigating Strategies pump, which also supports core cooling, to provide SFP makeup during Phase 2. The NRC staff reviewed the licensee's SAFER response plan and noted that the performance criteria for the FLEX Phase 3 NSRC pumps are capable of accomplishing the tasks of the FLEX Phase 2 portable pumps. See Section 3.10 for a detailed discussion of the availability and robustness of each water source. In the FIP, Section 2.4.6 states that the overspray provision in NEI 12-06 is not applicable since the portable spray nozzle is located next to the SFP and will be deployed in time to permit any adjustments to prevent overspray. Based on the expected time to boil in the SFP during non-outage situations and licensee's expected response time to deploy operators to deploy the SFP FLEX strategies, the staff finds it reasonable that the licensee can adjust the spray pattern, as necessary, to minimize/prevent overspray to the SFP.

The staff reviewed the licensee's hydraulic calculation (OSC-11349, Rev. 0, "FLEX Spent Fuel Pool Makeup") for SFP cooling and noted that the licensee determined that the pump is capable of supporting the SFP makeup strategy to supply sufficient water to either SFP while the portable pump also maintains flow to the SGs for core cooling. The licensee assessed several scenarios involving feedwater being provided to the SGs and to either SFP makeup or to SFP spray. Furthermore, the licensee's calculation also determined that the greatest total flow rate required from the pump is 1,162 gpm for the scenario where unthrottled flow is being provided to both SFPs to support spray flow and to all units' SGs. The licensee determined that one pump is capable of providing this flow rate. The FLEX strategy requires one FLEX Mitigation Strategies pump for the entire site and there is a total of two FLEX Mitigation Strategies pumps, both of which are stored in the FSB, which the staff finds satisfies the N+1 requirement for equipment redundancy outlined in NEI 12-06. Based on the SSF's ability to support 72 hours of operation and the licensee's sequence of events, the staff finds it reasonable that it will not be necessary for the FLEX Mitigating Strategies pump to support both the FLEX core cooling and FLEX SFP cooling strategies at the maximum required flow rate simultaneously.

As stated above, the FLEX Mitigating Strategies pump can provide SFP makeup in excess of boil-off losses of 70 gpm and spray flow rate of 200 gpm to the Unit 1/2 SFP and 200 gpm to Unit 3 SFP, which both meets and exceeds the maximum SFP makeup requirements. Furthermore, the staff finds analysis above is consistent with NEI 12-06 Section 11.2 and the FLEX equipment is capable of supporting the SFP cooling strategy and is expected to be available during an ELAP event.

3.3.4.4 Electrical Analyses

The licensee's basic FLEX strategy for maintaining SFP cooling is to monitor the SFP level and provide makeup water to the SFPs.

In its FIP, the licensee did not credit any electrical equipment other than instruments required by NRC Order EA-12-051. The SFP level instrumentation system has separate and replaceable batteries with sufficient capacity to maintain the level indication function for at least 5 days. The staff finds that it is reasonable to expect that the licensee could replace the batteries prior to being fully discharged to ensure that the SFP level instrumentation remains available throughout the event.

Based on its review, the NRC staff finds that the licensee's electrical strategy is acceptable to restore or maintain SFP cooling indefinitely during an ELAP as a result of a BDBEE.

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 should 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 units each have a dry ambient pressure containment structure which contains the RCS. The containment structures at Oconee are called reactor buildings.

The licensee performed a containment evaluation, OSC-11295, "ONS ELAP Containment Response Analysis," which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the strategy for containment isolation and monitoring containment parameters and concluded that the containment parameters of pressure and temperature remain well below the respective UFSAR Section 3.1.49 design limits of 59 psig at 286 °F for more than 72 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

Oconee will establish containment closure by isolating all penetrations. Procedure FG/1[2,3]/A/1900/015, "Containment Isolation and Closure," provides guidance for verifying containment isolation. Oconee determined in calculation OSC-11295 that the containment response to an ELAP is slow enough that during Phase 1 no other actions are required.

3.4.2 Phase 2

The Phase 2 strategy is the deployment of the FLEX electrical repowering strategy to restore power to the reactor building wide range pressure indications to permit monitoring of containment pressure. As an alternative, the licensee may use a pressure gauge in the west penetration room to monitor this parameter (it has a piping tap into the reactor building). No other Phase 2 actions are required to ensure containment integrity.

3.4.3 Phase 3

The FIP states that the NSRC will provide backup CTGs to ensure continued functionality of the FLEX electrical repowering strategy. The licensee indicated that no other Phase 3 actions are required to ensure containment integrity. As part of the audit process, the NRC staff questioned the lack of a predetermined strategy for maintaining the containment function utilizing offsite equipment. The licensee responded that their position for not needing ELAP response provisions for containment cooling after 72 hours is captured in evaluation OSC-11295 Rev 1, which states:

> Moreover, none of the cases analyzed here are expected to challenge containment pressure and temperature design limits in the long-term (for periods beyond the duration of the analyses documented here). This is due to the stabilization of the pressure and temperature trends shown towards the end of the GOTHIC simulations, the decrease in decay heat levels (and continued conduction of heat out of the Reactor Building) after 72 hours, and the conservative input assumptions made for each case.

The licensee stated that the position above recognizes that while there is a slightly upward trend in containment pressure and temperature at the end of the period analyzed (72 hours), the rate of change is stable or decreasing over time (even with the conservatisms that were included in the analysis). The licensee stated that the low rate of change, combined with the margin from the containment limits, provides confidence that the limits will not be challenged in the long-term and thus Oconee does not need a defined strategy or prescribed equipment to address long-term containment cooling.

The licensee determined that the peak containment temperature and pressure is estimated to occur at 50 to 70 days, or longer, after event initiation and still remain below the containment design limits for pressure and temperature. The licensee reported that under these conditions it is within the capability of the plant's technical support center (TSC) to use FLEX onsite and offsite resources, if needed, to provide some containment heat removal capability without predetermined strategies. The NRC staff notes that per the Oconee Phase 2 Staffing Analysis [Reference 56], that following a large scale natural disaster on site, the emergency response organization personnel (which includes the TSC personnel) are trained to respond to their emergency response facility (or designated alternate site) as soon as safely possible. Therefore, the NRC staff finds it reasonable that the TSC (or its alternate site) will be operational prior to 72 hours after the ELAP.

The NRC staff reviewed the containment calculation and concluded there would be sufficient time for the TSC to determine how to utilize offsite and FLEX equipment to either restore existing equipment or establish other methods to remove heat from the containment so as not to exceed design limits.

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

Containment Structure (called Reactor Building at Oconee)

The Oconee UFSAR describes the containment structure as consisting of a post-tensioned reinforced concrete cylinder and dome connected to and supported by a massive reinforced concrete foundation slab. The entire interior surface of the structure is lined with a ¼ inch thick welded steel plate to assure a high degree of leak tightness. The containment inside diameter is 116 feet, the inside height (Including the dome) is 208½ feet, with a free volume of 1,773,000 cubic feet. The containment is a Class 1 structure. Class 1 structurers are designed for a maximum hypothetical earthquake ground acceleration of 0.10g. and 0.15g for Class 1 structures founded on bedrock and overburden respectively. Seismic Class I structures, components, and systems are designed to withstand the safe shutdown earthquake (SSE). The containment also provides protection from wind-borne missiles.

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. The licensee's FIP states that control room instrumentation would be available due to the coping capability of the station batteries and associated inverters in Phase 1, or the portable DGs deployed in Phase 2. If no ac or dc power was available, the FIP states that key credited plant parameters, including containment pressure, would be available using alternate methods as directed by guideline FG/1[2,3]/1900/007, "Alternate Monitoring of Essential Instrumentation."

3.4.4.2 Thermal-Hydraulic Analyses

Duke performed a containment evaluation, OSC-11295 Revision 1, "ONS ELAP Containment Response Analysis," to determine a best-estimate of the Oconee reactor building pressure and temperature response during an ELAP event. The evaluation was performed using a computer code, Generation of Thermal-Hydraulic Information in Containment (GOTHIC), version 8.0. The calculation assumes a release from the RCS through the pressurizer PORVs until adequate RCS cooling can be established using the SSF, a process which takes about 15 to 20 minutes. This release would normally be routed to the quench tank inside containment, but for the purposes of this analysis it is assumed that the PORV releases go directly into containment. The flow rates, enthalpies and pressures for the RCP seal leakage and PORV releases are taken from analysis OSC-10937, Revision 1, "Extended Loss of AC Power FLEX RELAP5 Analysis." Ambient heat from the RCS is modeled as a heat input to the reactor building. The ambient heat rate from the RCS to the reactor building is assumed to be proportional to the temperature difference between the RCS and the reactor building. RCP seal leakage of 2 gpm per RCP is assumed starting at t=20 minutes and continuing for the first 24 hours of the simulation, while the SSF RCMU pump is operating. For the remainder of the transient, the RCP seal leakoff flow model described in Section 7.5.1 of OSC-10937 provides the total RCP seal leakage for use in the GOTHIC analysis.

This GOTHIC analysis demonstrated that after 72 hours, containment pressure has increased to 18 psia (3.3 psig) and temperature has increased to 170 °F. The NRC staff notes that the analysis demonstrates that the mitigating strategies maintain containment temperature and pressure significantly below the design limits of 59 psig and 286 °F.

3.4.4.3 FLEX Pumps and Water Supplies

Based on the thermal-hydraulic analyses described in SE Section 3.4.4.2, the NRC staff finds it reasonable that no mitigation actions are necessary to maintain or restore containment cooling during Phases 1 or 2. In addition, the staff noted that the licensee's containment strategies do not rely on the use of FLEX pumps and water sources for maintaining containment pressure or temperature below the design limits for at least 72 hours. Off-site resources are expected to arrive prior to 72 hours and should be available to assist in restoring containment cooling if necessary.

3.4.4.4 Electrical Analyses

As noted above, Oconee GOTHIC Calculation OSC-11295, "ONS Containment Response Analyses,' Revision 1, showed that at 72 hours after the start of the ELAP, containment pressure and temperature would still be significantly below the containment design limits. Therefore, all containment instruments and equipment needed for the ELAP response should remain functional and immediate action to cool the containment is not required.

During Phase 1, Oconee will establish containment closure by isolating all penetrations. The SSF will be activated to provide SG feedwater and RCP seal injection. The SSF DG would continue to supply power to the containment instruments for monitoring. The NRC staff's evaluation of the capacity of the SSF DG is provided in Section 3.2.2.6 of this SE. Based on its review, the SSF DG should have adequate capacity and capability to supply the required loads.

During Phase 2, the licensee would use a 600 Vac, 500 kW FLEX DG and a 600 Vac to 208/120 Vac step-down transformer as a primary strategy and a 120/240 Vac 10 kW DG and associated splitter boxes as an alternate strategy to repower the reactor building wide range pressure instruments. The NRC staff's evaluation of the capacity and capability of the FLEX DGs is provided in Section 3.2.3.6 of this SE. Based on its review, the NRC staff finds that the 500 kW and 10 kW FLEX DGs should have adequate capacity and capability to supply power to the instruments monitoring containment pressure during Phase 2.

Guidelines FG/1,2,3/A/1900/007, "Alternate Monitoring of Essential Instrumentation," provide guidance to use a portable pressure gauge in the west penetration room to monitor reactor building pressure in lieu of taking readings at electrical penetrations since these transmitters are external to the reactor buildings and therefore a portable pressure gauge can be connected. This is an additional capability beyond the primary and alternate repower strategies described above. Guidelines FG/1,2,3/A/1900/007 also provide the capability to read temperatures in various reactor building locations if needed.

The licensee's Phase 3 strategy includes monitoring containment pressure and developing cooling strategies if needed, utilizing existing plant systems restored by off-site equipment and resources. In its FIP, the licensee stated that an NSRC will provide CTGs to ensure continued functionality of the FLEX electrical strategy. The licensee's strategy would use NSRC-supplied 480 Vac, 1000 kW CTGs to replace the Phase 2 500 kW FLEX DGs, if necessary.

Based on the above, the NRC staff concludes that the licensee's electrical strategy is acceptable to restore or maintain containment indefinitely during an ELAP.

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 should 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; severe storms with high winds; snow, ice and extreme cold; and extreme high temperatures.

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) [Reference 19] (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 [Reference 53]. 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" [Reference 47]. The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 20]. 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 impact 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 [Reference 37], 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 [Reference 54]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 55]. The licensee's MSAs will evaluate the mitigating strategies described in this SE using the revised seismic and flooding hazard information and, if necessary, make changes to the strategies or equipment.

The licensee developed its FIP 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 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 that the seismic criteria for Oconee includes a maximum hypothetical earthquake, which is also referred to as the SSE. The SSE is the current NRC terminology for the design-basis earthquake. The SSE for the site is one-tenth of the acceleration due to gravity (0.10g) peak ground acceleration (PGA) for Class 1 structures founded on rock and 0.15g PGA for Class 1 structures founded on overburden. 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 flood hazard reevaluation report [Reference 21], the licensee described that the current design basis for the limiting site flooding event is limited to flooding in streams and rivers that raises the level of Lake Keowee, but does not result in any flooding at the site. The licensee also described its reevaluated flood hazard for Oconee, which does result in some site flooding. The NRC staff review of the Oconee reevaluated flood hazard, dated September 24, 2015 [Reference 22], determined that the reevaluated flood hazard determined by the licensee was acceptable for use in an integrated assessment or a focused evaluation to address the reevaluated flood hazards. The licensee submitted a mitigation strategies assessment (MSA) report using the reevaluated flood hazard by letter dated January 31, 2017. The NRC staff reviewed the MSA report [Reference 57] and concluded that the licensee could implement the mitigation strategies described in this SE with the reevaluated flood hazards present.

For the purpose of order compliance, the licensee has appropriately evaluated this external hazard to the current design basis and determined that based on the current design basis, flooding is not a concern in responding to this order.

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 design basis for hurricanes.

In its FIP, regarding the determination of applicable extreme external hazards, the licensee indicated that the high wind hazard associated with hurricanes is applicable to Oconee. In the UFSAR, Section 3.3 describes the current design basis for hurricanes as a design wind velocity for Class 1 structures of 95 mph.

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 design basis for tornados or Regulatory Guide 1.76, Rev. 1.

In its FIP, regarding the determination of applicable extreme external hazards, the licensee indicated that the high wind hazard associated with tornados is applicable to Oconee. In the UFSAR, Section 3.3 describes the current design basis for tornados. External loadings for Class 1 structures include a differential pressure of 3 psi developed over 5 seconds, and external wind forces from a tornado having a velocity of 300 mph. For an analysis of missiles created by a tornado having maximum wind speeds of 300 mph, two missiles are considered. One is a missile equivalent to a 12 foot long piece of wood 8 inches in diameter traveling end on at a speed of 250 mph. The second is a 2000 pound automobile with a minimum impact area of 20 square feet traveling at a speed of 100 mph. The UFSAR states that the SSF has additional design requirements beyond these.

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.

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located above the 35th Parallel and therefore subject to snowfall accumulation and extremely low temperatures per NEI 12-06, Figure 8-1. The NRC staff reviewed UFSAR Table 2-18 and found that the historical minimum temperature was -7 °F. In addition, in its FIP the licensee stated that based on NEI 12-06, Figure 8-2, the Oconee site is also subject to catastrophic destruction of power lines and/or existence of extreme amounts of ice.

In summary, based on 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 the section of its FIP regarding the determination of applicable extreme external hazards, the licensee stated that, as per NEI 12-06 Section 9.2, all sites are required to consider the impact of extreme high temperatures. The NRC staff reviewed the UFSAR Table 2-18 and found the historical maximum temperature to be 105 °F.

In summary, based on the available local data and the guidance in Section 9 of NEI 12-06, the plant site does experience extreme high temperatures. The licensee has appropriately screened in 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 is consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and should 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

In its FIP, the licensee described that FLEX equipment is stored in a FLEX support building (FSB) designed to building code ASCE [American Society of Civil Engineers] 7-10 for structural design loading. The FSB is a single large reinforced concrete dome structure located in the northwest area of the plant. The building has two equipment doors and two personnel doors that can be manually operated in the event of a loss of power.

In addition, in its FIP, the licensee described that some selected FLEX equipment is stored in the auxiliary building and the SSF, which are protected against all the applicable external hazards.

Below are additional details on how FLEX equipment is protected from each of the applicable external hazards.

3.6.1.1 Seismic

In its FIP, the licensee described that the FSB was designed for seismic loading, and evaluated such that catastrophic collapse will not occur for an earthquake in excess of two times the SSE.

In its FIP, the licensee stated that equipment on trailers or beds are either seismically insensitive, secured rigidly to the trailer such that it moves with the trailer frames to prevent amplified movement, or positioned such that it will not move excessively or topple over on other equipment on the trailer nor topple out of the trailer. All wheeled equipment is chocked to prevent rolling. The licensee performed an evaluation on this equipment and concluded that the equipment has significant margin with respect to seismically-induced overturning, and that mobile equipment does not need to be seismically restrained. The licensee also concluded that there is sufficient space between equipment to alleviate concerns due to seismic interaction from sliding or rocking.

In its FIP, the licensee described that the auxiliary building and the SSF are seismically robust structures.

3.6.1.2 Flooding

As previously discussed in Section 3.5.2, the licensee has determined that based on the current design basis, flooding is not a concern in responding to this order.

3.6.1.3 High Winds

In its FIP, the licensee described that the FSB was designed for hurricane and tornado wind loads, and tornado missile loads.

In its FIP, the licensee described that the auxiliary building and the SSF are designed to provide protection from the design-basis hazards, which would include protection from high winds and tornado missiles.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee described that the FSB was designed for dead loads, operating and temporary loads to include ice and snow. In addition, the licensee stated that the FSB includes an HVAC system that will maintain the internal temperature between 40 °F and 110 °F and relative humidity of 70 percent or less.

In its FIP, the licensee described that the auxiliary building and the SSF are designed to provide protection from the design basis hazards, which would include protection from snow, ice, extreme cold and extreme heat.

In its FIP, the licensee stated that all FLEX equipment was procured/designed for routine outdoor commercial use in extreme ambient temperatures and harsh conditions. FLEX equipment engines are supplied with integral air cooled systems for use in high ambient temperatures and block heaters for use in freezing conditions.

In its FIP, the licensee stated that, if necessary, Oconee will take action to provide freeze protection for components utilized for the FLEX strategy. Specifically, Oconee will periodically start diesel-driven pumps, establish trickle flow while pumps are running or use gravity drains, as applicable.

3.6.1.5 Conclusions

Based on this evaluation, 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 guidance, as endorsed by JLD-ISG-2012-01, and should adequately address the requirements of the order.

3.6.2 Availability of FLEX Equipment

Section 3.2.2 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.

In its FIP, the licensee described that there are four FLEX portable RCS makeup pumps stored in the FSB (one per unit plus one spare) meeting the N+1 recommendation for equipment redundancy. The FLEX portable RCS makeup pumps deliver a design flow of 48 gpm at 2,500 psig discharge pressure, which is adequate to support the boration and RCS inventory control requirements for the FLEX response strategy. The maximum flow demand from the high-head pump used for RCS makeup in the Oconee thermal-hydraulic analyses was 40 gpm.

In its FIP, the licensee described that there are two FLEX mitigation strategies pumps stored in the FSB, each designed to supply a flow of 3,000 gpm, meeting the N+1 recommendation for equipment redundancy. The licensee performed an analysis to evaluate the capacity of the FLEX mitigating strategies pump and the hose configuration to simultaneously provide SG makeup and SFP makeup and determined that the greatest total flow rate required from the pump is 1,162 gpm for the scenario where unthrottled flow is provided to both SFPs and all units' SGs.

In its FIP, the licensee described that the primary and alternate repowering strategies require a set of DGs with a range of capacities. The primary strategy for each unit requires a 600 Vac, 500 kW DG and a 120 Vac, 6 kW DG. The alternate strategy for each unit uses the same 600 Vac, 500 kW DG and a 120/240 Vac, 10 kW DG. Oconee has four 600 Vac, 500 kW DGs; four 120 Vac, 6 kW DGs; and four 120/240 Vac, 10 kW DGs, all stored in the FSB, which satisfies the N+1 recommendation for equipment redundancy. The licensee performed an analysis to evaluate the primary and alternate electrical repower strategies, considering all loads to be repowered and the deployed cable configuration. This analysis concluded that all electrical buses and equipment are acceptable for the limiting voltage, loading, and short circuit requirements, with adequate margin. Additionally, the analysis concluded that all newly installed cables are acceptable for limiting loading and short circuit requirements. Adequate voltage was verified for associated buses.

For hoses and cables, the licensee performed an evaluation of the quantity of hoses and cables in document OSC-11383, Revision 0, Attachment 7, "Calculation of Minimum Spare Hoses and Cables," Revision 0. The NRC staff reviewed Attachment 7 and determined that the licensee was following NEI's proposed alternative [Reference 48] regarding the quantity of spare hoses and cables to be stored on site.

Based on the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP, the NRC staff finds 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 (with the exception of hoses and cables) consistent with the N+1 recommendation in Section 3.2.2 of NEI 12-06. Refer to Section 3.14.1 for a discussion of the hoses and cables alternative to NEI 12-06.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee stated that the FLEX response strategies include deployment of pumps, DGs, and other equipment from the FSB to locations in the power block to support the various FLEX capabilities.

3.7.1 Means of Deployment

In its FIP, the licensee stated that the site has a Caterpillar 924K loader for clearing debris on the deployment path and a large truck with 27,000 pound towing capacity for towing of FLEX equipment. The 924K loader and the truck are both stored in the FSB and will therefore be protected from the applicable extreme external hazards.

3.7.2 Deployment Strategies

In its FIP, the licensee stated that they performed an evaluation of the primary and alternate deployment paths, which considered the likely potential debris. This evaluation confirmed that pathway diversity and debris cleaning/towing capabilities are expected to be adequate to support timely deployment of FLEX strategies following a BDBEE.

In its FIP, the licensee stated that it evaluated deployment paths for seismic stability and confirmed that they are acceptable. The evaluation considered beyond-design-basis seismic loading with a PGA equal to 2.23 times the SSE.

In its FIP, the licensee stated that water temperature in the intake canal will not decrease to the point where access will be challenged due to ice formation.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

In the FIP, Section 2.3.4.2 states that the FLEX strategy relies on installed piping from various plant systems to deliver water for core cooling and RCS inventory makeup. Specifically, the licensee relies on piping and components from the RCS and other plant systems including SFP Cooling (SF), HPI, Low Pressure Injection (LP), Feedwater (FDW), Core Flood (CF), Main Steam (MS), CCW, and PSW. The licensee confirmed that the credited portions of these systems were either designed for safety-related service or evaluated to survive the applicable hazards. Furthermore, location of these connection points, including the associated flow paths, are within the Class 1 portions of the auxiliary building and the reactor building, which are designed to withstand an SSE and tornado wind loads and missile (See UFSAR Sections 3.2.1.1.1 and 3.3).

SG Feedwater Primary and Alternate Connection

In the FIP, Section 2.3.5.1 states that the primary Phase 2 SG feedwater strategy uses a connection in the PSW piping that can distribute water to both SGs in all three units. The piping supplies feedwater to both SGs in each unit, thereby allowing symmetric cooldown. The connection is at a valve in the PSW system, which is located inside the auxiliary building. In the FIP, Section 2.3.5.2 states that the alternate SG feedwater strategy uses three individual unit connections in the CCW system that will provide feedwater to the B steam generator in each unit. The connections are located in the cask decontamination rooms for each unit, which are part of the auxiliary building.

RCS Inventory Primary and Alternate Connection

In the FIP, Section 2.3.5.3 states that the primary connection points for RCS makeup include a set of four connection points associated with vent and drain lines on the HPI header and seal injection lines located in the auxiliary building east penetration room. In the FIP, Section 2.3.5.4 states that the alternate connection points for RCS makeup include a set of four connection points associated with vent and drain lines on the HPI header and seal injection lines located in the auxiliary building west penetration room. During its audit, the staff noted that the primary connection points are on safety train A while the alternate connection points are on safety train B; thus providing flexibility and diversity.

SFP Make-up Primary and Alternate Connection

In the FIP, Section 2.4.4.3 states that the primary connection strategy for SFP makeup uses permanently installed SFP fill lines located in the Unit 1 cask decontamination room and Unit 3 fuel receiving bay stairwell, which are located in the auxiliary building. In the FIP, Section 2.4.4.4 states that the alternate connection strategy for SFP makeup uses flexible hose taken from the Boggs box, which is stored in the SFP change rooms in the auxiliary building and deployed at the pool deck. The portable spray nozzle will be attached to the rail on the side of the SFP with a tie-down strap, and provides SFP spray capability.

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

3.7.3.2 Electrical Connection Points

The electrical connection points are only applicable to Phase 2 and Phase 3 of an ELAP.

Oconee FLEX guidelines FG/0/A/1900/005 and FG/1, 2, 3/A/1900/020, "FLEX Electrical Distribution," provide guidance to the plant operators to deploy and stage FLEX DG and establish primary and alternate strategy electrical connections.

Primary Strategy

For the primary repower strategy, the licensee would stage a 600 Vac, 500 kW FLEX DG near the auxiliary building roll-up door at each unit. The licensee would route color-coded cables from the color coded cable connectors on a 500 kW FLEX DG to the FLEX splitter boxes located in the unit's auxiliary building equipment room (near MCCs XO and XP) and FLEX cables with connectors from the FLEX splitter boxes to the connection points at a selected cubicle of the installed MCCs XO and XP to reenergize these MCCs.

The licensee would route a second set of color coded cables from the FLEX DG color coded cable connectors to the primary side of a 600/208-120 Vac FLEX transformer located at the auxiliary building ground floor and FLEX cables with connectors from the secondary side of the FLEX transformer to the FLEX transfer switches at the installed safety-related Panel Boards SKJ and SKK. These Panel Boards would be reenergized to supply power to the containment instruments.

The licensee would route a third set of color coded cables from the FLEX DG color coded cable connectors to a connection station located on the auxiliary building second floor. This connection station supplies power to 600 Vac motor control center XPSW which supplies power to the vital battery chargers.

The licensee would stage a 6 kW FLEX DG outside near the entrance to the SSF building and route FLEX cables to connect the 6 kW FLEX DG to a connection point at the safety-related Panel Board KSFC in the SSF building.

Since the auxiliary building and the SSF building are designed as safety-related Seismic Category I structures, all primary electrical connections are protected from the site applicable extreme external hazards.

Alternate Strategy

The licensee would stage a 600 Vac, 500 kW FLEX DG near the auxiliary building roll-up door at each unit and route color coded FLEX cables from FLEX DG cable connectors to the connection points at the primary side of a 600/208-120 Vac FLEX transformer and from the secondary side of the FLEX transformer to a connection point at selected cubicles of the installed MCCs XO and XP on the 208 Vac side.

A 120/240 Vac, 10 kW FLEX DG and three cable splitter boxes would be staged to the turbine building ground floor for each affected unit. The licensee will route the FLEX cables from the 10 kW FLEX DG to the FLEX splitter boxes and from FLEX splitter boxes to the transfer switches at the installed safety-related Panel Boards SKJ, SKK, SKL, KVIA, KVIB, and KVIC located in several locations in the auxiliary building. Additionally, the licensee will route a third set of FLEX cables from the 10 kW FLEX DG to the RCS cold leg temperature signal conditioner power supply in the MCR.

In its FIP, the licensee stated that the proper phase rotation was verified based on post-modification testing of permanently installed connections, factory acceptance testing of the FLEX DGs, and the use of color-coded connections and cables.

The Phase 3 strategy consists of sustaining Phase 2 capabilities with redundant and replacement equipment from an NSRC. For Phase 3, the licensee will use an NSRC-supplied 480 Vac, 1000 kW CTG and an NSRC 480/600 Vac step up transformer to replace a FLEX 500 kW DG, if necessary. The licensee would stage the NSRC 480 Vac, 1000 kW CTG and an NSRC 480/600 Vac step-up transformer near the Phase 2 500 kW FLEX DG it would replace and connect them to the connection points used for the Phase 2 primary or alternate strategy. The licensee reported that the NSRC CTGs will have the same phase rotation as the site's FLEX generators when the phases are connected using the same color code used at the site, and therefore the licensee does not plan to test the NSRC generators for phase rotation. The licensee will use the instructions in the NSRC operating aid (PIM EP-1-12) that comes with the NSRC CTGs and will connect cables according to the color code (phase 1 is brown, phase 2 is orange, and phase 3 is yellow).

Based on its review of single line electrical diagrams and station procedures, the NRC staff finds that the licensee's approach is acceptable given the protection and diversity of the power supply pathways, the separation and isolation of the FLEX DGs from the onsite emergency power supply (the Keowee hydro generators), 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 Oconee performed an evaluation to determine lighting requirements for the FLEX strategies that included all activities associated with the FLEX strategies, the type and amount of lighting equipment required, the duration of the lighting need, and the lighting staging location. Types of lighting used in the FLEX strategy include hard hat lights, portable tripod flood lights, portable lanterns, and equipment mounted lights. The licensee further stated that portable lighting is stored in the FSB.

In its FIP, the licensee stated that National Fire Protection Association (NFPA) 805 lighting is available in many areas where manual actions (e.g., connecting hoses, power cables, or operating pumps) are necessary. The NFPA 805 lights have self-contained batteries with an 8-hour life.

The licensee further stated in its FIP that hard hat LED lights will be used to ensure operators can safely move through the plant during an ELAP. Additional portable lighting will be used to provide lighting in the yard and to replace some of the emergency lighting once the batteries are depleted, and to enhance lighting in other areas of the plant as deemed necessary.

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 its FIP, the licensee described that portable FLEX pumps and DGs are stored in the FSB with full fuel tanks that are sized to support up to 12 hours of operation at the equipment's rated capacity. Additionally, a portable 1,240-gallon trailer-mounted refueling tank is maintained near full with ultra-low sulfur fuel oil and stored in the FSB and will be used to service the deployed portable pumps, generators, and other diesel-operated FLEX equipment as needed. In its FIP, the licensee described that diesel fuel oil (DFO) for SSF equipment and FLEX equipment will be obtained from the 50,000 gallon (25,000 gallons minimum) safety-related, underground SSF DG fuel oil storage tank, which is sufficient for full load SSF DG operation in excess of 72 hours. The licensee further described in its FIP that DFO may be pumped out of the underground tank and transferred to a FLEX portable refueling trailer using a diesel-driven portable transfer pump. The portable refueling trailer can then be towed by the FLEX pickup truck to the various site locations for refueling FLEX diesel engines. The SSF DG fuel oil storage tank currently has a sulfur concentration in the range of 170 ppm and is replenished with ultra-low-sulfur fuel oil, which has a sulfur concentration of less than 15 ppm. The licensee further stated in its FIP that all diesel-powered FLEX equipment is compatible with fuel containing sulfur levels of 170 ppm or less. Based on the design and location of this DFO storage tank and its safety-related classification, the staff finds the tank is robust and the fuel oil contents should be available to support the licensee's FLEX strategies during an ELAP event. Furthermore, the staff finds the fuel oil on-board in the FLEX refueling equipment, which is stored in the FSB, should be available to support the licensee's FLEX strategies during an ELAP event.

In its FIP, the licensee stated that Oconee performed a fuel consumption evaluation and determined that there is sufficient fuel on-site for operation in excess of 72 hours without an external source of fuel. If the SSF DG stops operating, the Phase 2 FLEX strategies are placed in operation for all three units. With all Phase 2 equipment operating continuously and at capacity, fuel consumption would be approximately 4,300 gallons per day. Since the Phase 1 SSF DG consumption rate of 6,600 gallons per day bounds the potential Phase 2 consumption rate, the DFO in the SSF DG fuel tank is sufficient for Phase 1 and 2 through at least 72 hours. Thereafter, maximum fuel consumption would be approximately 3,500 gallons per day, provided that the FLEX DGs are in use, and approximately 5,500 gallons per day if the NSRC DGs are in use. Based on the fuel oil consumption rates of the SSF and the portable FLEX equipment and the protected fuel oil volume, the staff finds the fuel oil quantity available on-site is sufficient until offsite resources can provide fuel oil replenishment to the site.

In Phase 3, contact with fuel oil suppliers will be made to arrange delivery of additional fuel oil by trucks. In the event that roadways to the site are impassable, fuel can be provided by helicopter using NSRC airlift fuel shipping containers.

In its FIP, the licensee also described some non-credited sources of DFO that are not robust to the applicable hazards that could be used if available, including a 10,000 gallon underground DFO tank at the Duke Energy fleet services garage, and two 75,000 gallon total capacity auxiliary steam boiler DFO tanks.

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 should adequately address the requirements of the order.

3.8 Considerations in Using Offsite Resources

3.8.1 Oconee Nuclear Station SAFER Plan

The industry has collectively established the needed off-site capabilities to support FLEX Phase 3 equipment needs via the Strategic Alliance for FLEX Emergency Response (SAFER) Team. The SAFER team consists of the Pooled Equipment Inventory Company (PEICo) 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 National SAFER Response Centers (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 [Reference 23], 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 Oconee, Staging Area D (alternate) is the Oconee County Regional Airport. Staging Area C is the Anderson Regional Airport. Staging Area B is at the softball field at Oconee. Staging Area A is the final location in the plant.

Use of helicopters to transport equipment from Staging Area C to Staging Area B is recognized as a potential need within the Oconee SAFER Plan and is provided for.

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 should 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 Oconee, 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 in areas that continue to have heat loads. The licensee performed an analysis to quantify the maximum steady-state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable. The key areas identified for all phases of FLEX are the SSF, MCRs, auxiliary building (including battery rooms and equipment rooms), and reactor buildings (containment).

SSF Building

Calculation OSC-11383, Revision 0, Attachment 15, "FLEX Mitigating Actions for Environmental Cooling," Revision 0, states that equipment powered by the SSF DG is located in the SSF, auxiliary building, and reactor buildings. While the SSF DG is running, the SSF HVAC system powered by the SSF DG will limit the temperature in the SSF building to less than or equal to 100 °F. FLEX Phases 2 and 3 do not credit any SSF equipment in the SSF building except for Panel Board KSFC and the RCS cold leg temperature instrumentation for the primary strategy. With very little heat load in the SSF after the FLEX equipment is placed in service and the SSF DG is stopped, temperatures in the SSF will be limited to outdoor ambient temperatures and should remain below 120 °F.

Attachment 15 of calculation OSC-11383 states that the only SSF equipment in the auxiliary building is the ASW flow transmitters. Section 2.3.6. of the FIP states that the ASW flow rate is not essential for executing the FLEX strategy. The SG level indication will provide the operators with the necessary information.

The licensee stated in attachment 2 of the FIP cover letter that the SSF equipment in the reactor building (RCMU pumps) is qualified to operate in ambient conditions of 267 °F, 41.8 psig (52.5 psia), and 100 percent humidity. These bound the calculated reactor building ELAP temperature and pressure of 185 °F and 21 psia. The licensee's Phase 1 strategy uses SSF equipment in the reactor building for Phase 1 only and could make a transition to Phase 2, using portable FLEX equipment deployed from the FSB, at approximately 6 hours into the event.

Based on above, the NRC staff finds that the credited SSF equipment should remain available during the time it is required to operate.

MCRs

In calculation OSC-11383 the licensee determined that MCR temperature would not exceed 110 °F at least 5 days for the Unit 1 and 2 MCR and 7 days for the Unit 3 MCR with selected doors opened for natural ventilation through the MCR. The licensee stated that electrical equipment and components in the MCRs are qualified for 120 °F or higher. Guideline FG/0/A/1900/005, "Initial Assessment and FLEX Equipment Staging," Revision 3, provides guidance to the plant operators to block open selected doors for natural ventilation through the MCR within 12 hours into the event. In addition to opening selected doors, the licensee also has the non-credited options to use temporary fans, spot coolers, and exhaust fans. When electrical power is available, the licensee could also use the auxiliary chilled water (ACW) system as defense-in-depth to supply cooling water to the MCR air handling units if necessary to ensure MCR temperature remains below 120 °F. The licensee stated that the ACW system is not robust but could be used if available to cool the MCR.

Based on the expected temperature remaining below 120 °F for at least 5 days with selected doors open (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 electrical and electronic equipment to be able to survive indefinitely), the NRC staff finds that the electrical and electronic equipment in the MCRs that has power available and is needed for FLEX response should remain functional during the first 5 days of an ELAP event. Additional actions to ensure MCR temperature remains below 120 °F in the long-term can be taken by the licensee.

Auxiliary Building

The licensee performed analysis OSC-11253, "Auxiliary Building GOTHIC Heat Up Analysis-ELAP Event Cases", Revision 1, to determine the environmental response of various plant areas during an ELAP. The analysis is an auxiliary building heat-up analysis specific to BDBEEs or "FLEX" events, and predicts expected temperatures in the auxiliary building for various scenarios. There is one auxiliary building, shared by the three reactors. The two SFPs are in the auxiliary building, therefore the calculation modeled the SFPs to reflect the SFP heatup profile and boil off rate. The licensee stated in FIP Section 2.4.1 that time to boil is estimated at 6.1 hours for the Unit 3 SFP and 6.9 hours for the Unit 1 and 2 SFP. These values are based on a full core offload for each pool, which is conservative for a scenario starting from 100 percent power. The analysis also evaluated hydrogen buildup during ELAP Phase 2 battery charging. Manipulation of doorways and the use of portable coolers and portable fans to maintain an acceptable environment in critical areas were evaluated for various areas. Guideline FG/0/A/1900/005, "Initial Assessment and FLEX Equipment Staging," provides guidance for opening selected doors to establish natural ventilation for various areas.

Installed mechanical equipment credited for coping for FLEX mitigating actions in Phase 2 and 3 (primarily manual valves and piping) were not considered sensitive to high ambient temperature. The NRC staff concurs with this assumption.

As part of the mitigating actions, Oconee plans to provide spot coolers. The licensee stated in the FIP that the use of spot coolers should not be required until at least 4 days into the event. These 120 Vac spot coolers typically require about 1.25 kW of power each. Each spot cooler can provide about 10,700 British thermal units (BTU) of cooling per hour. The hot air exhaust from the use of these air-cooled spot coolers could be ducted to the turbine building when cooling the MCRs and equipment rooms. When cooling the penetration rooms, the hot air could be ducted to the auxiliary building stairwell. The FLEX primary and alternate portable DGs are designed with significant margin and could be used to provide power to the 120 Vac spot coolers.

In addition to spot coolers, self-contained portable HVAC systems are readily available. Within the Duke fleet, Brunswick, Robinson, and Harris plants each have a trailer mounted 49 kW generator with two 5-ton air-conditioning units (120,000 BTU/hour) in their FLEX equipment inventory that could be deployed to Oconee prior to temperatures exceeding the limits. Catawba, McGuire, and Robinson plants have portable exhaust fans in their FLEX equipment inventory that could be used if needed.

Auxiliary Building SFPs

In FIP Section 2.11.1 the licensee stated that personnel would open the SFP truck bay doors and the purge inlet equipment room doors before the time to boil in the SFPs to prevent pressurization of the fuel handling areas or steam exhausting into undesired areas of the auxiliary building. The SFP level instrumentation, which is evaluated in Section 4 of this SE, is designed to function with 100 percent humidity above the SFPs.

Auxiliary Building Battery Rooms

Oconee Calculation OSC-11383 showed that expected room temperatures would remain less than 115 °F for 24 hours with selected doors opened for natural ventilation of the auxiliary building and the battery rooms. The calculated battery room temperatures appear to remain flat beyond a 24 hour time frame. Oconee Calculation OSC-11230 showed that the auxiliary building safety-related batteries CA and CB were manufactured by C&D Technologies (model LCU27). According to the manufacturer, these batteries have a maximum design temperature of 120 °F. The licensee determined that no heat removal actions are required for the auxiliary building battery rooms. Licensee calculation OSC-11230 recommends that the battery operating temperature should be monitored to prevent mechanical and/or procedural degradations. If continued battery charging is desired, cell temperature should be monitored to prevent cell temperature from exceeding the 120 °F design temperature. Although the licensee plans to block open selected doors to restore ventilation, periodic monitoring and refilling of electrolyte level may be necessary to protect the battery since the battery may gas more at higher temperatures.

Based on temperatures remaining below 120 °F (the design temperature limit as identified by the battery manufacturer), the NRC staff finds that the equipment in the auxiliary building safety-related battery rooms will remain functional during a loss of ventilation as a result of an ELAP event.

Auxiliary Building Equipment Rooms

The auxiliary building equipment rooms contain electrical connections, installed electrical equipment (battery chargers, vital inverters, dc distribution centers, motor control centers, etc.). In calculation OSC-11383 the licensee determined that the expected temperatures in the auxiliary building equipment rooms would remain below 120 °F until up to approximately 4 days after the ELAP with selected doors opened for natural ventilation through the auxiliary building and the auxiliary building equipment rooms. Calculation OSC-11230, "Non PSW Installed Auxiliary Building Electrical Equipment That Supports PSW - Temperature Rating Evaluations," Revision 1, showed that the vital battery chargers and inverters in the auxiliary building can operate at 140 °F temperature for 72 hours. Calculation OSC-11230 also stated that the electrical equipment and components in the rooms are design qualified for 130 °F or higher, with the exception of breakers in MCCs XO and XP which have an operating limit of 122 °F. The analysis indicates the only FLEX loads fed from the MCCs are core flood tank isolation valves and vent valves. These valves will be manipulated prior to the room temperature exceeding 120 °F. Once positioned, the valves are not affected by nuisance breaker tripping. Guideline FG/0/A/1900/005 provides guidance to the plant operators to block open selected doors within 24 hours for natural ventilation into the auxiliary building and the auxiliary building equipment rooms which should maintain room temperatures below 130 °F. In addition to opening doors, the licensee also has options to use non-credited spot coolers, room exhaust fans and an ACW system as defense-in-depth to supply cooling water to the air handling units, if necessary.

Based on expected temperature in the auxiliary building equipment rooms remaining below 130 °F indefinitely, or equipment being used before the room temperature exceeds its qualified temperature, the NRC staff concludes that electrical equipment required for the FLEX strategy in the auxiliary building equipment rooms should remain functional during an ELAP event.

Auxiliary Building Penetration Rooms

Auxiliary building penetration room equipment credited for FLEX is limited to the electrical penetrations, containment pressure transmitters, and portable maintenance and test equipment (M&TE) used to monitor various process parameters. The analysis indicates the containment pressure transmitters are qualified to maximum temperatures in excess of 145 °F. The portable Fluke M&TE has a maximum operating temperature of 131 °F. With no mitigating actions the penetration rooms exceed 130 °F by approximately 5 days.

Based on the mitigating actions available including the portable spot coolers, the NRC staff concludes that the licensee can limit the rise in penetration room temperatures in order to permit credited equipment to remain functional during an ELAP event.

Reactor Building (Containment)

Oconee performed a GOTHIC evaluation in calculation OSC-11295 in support of developing its mitigating strategies. The licensee's evaluation determined that containment pressure increases to a maximum of 6.3 psig and temperature increases to a maximum of 185 °F after 72 hours. Over an extended period, further reduction in decay heat levels and continued passive heat conduction through the reactor building walls to the outside environment should keep pressure and temperature well below containment design limits of 59 psig and 286 °F.

In Attachment 15 of calculation OSC 11383, the licensee determined that the FLEX credited instrumentation located in the reactor building are environmentally qualified (EQ) for the loss of coolant accident or steam line break accident or utilize manufacturer/model numbers that are EQ rated. All the EQ manufacturer/model numbers for the electrical instruments are qualified to peak temperatures and pressures that bound the maximum expected temperatures and pressures indefinitely for an ELAP event.

The NRC staff finds that the licensee's evaluations in calculations OSC-11295 and OSC-11383 provide reasonable assurance that the maximum expected temperature in the reactor building would remain below the EQ instrument rated temperature indefinitely and the credited electrical powered instruments within the reactor building would remain functional for an ELAP event.

TDEFW Pump Room

In its FIP, the licensee stated that the TDEFW pumps are not credited as part of the FLEX strategy because they are not located in a hardened structure and their suction sources are not missile protected.

FLEX Equipment Outdoors

In the FIP, Section 2.8.2 indicates that all FLEX equipment which is operated outdoors was procured and designed for routine outdoor commercial use in extreme high ambient temperatures and harsh conditions. Specifically, FLEX equipment engines are supplied with integral air cooled systems for use in high ambient temperatures. During its audit, the NRC staff reviewed the procurement/purchase specifications for the FLEX pumps and FLEX diesel generators and confirmed they are capable of operating in the highest ambient temperatures which are predicted for the site.

3.9.1.2 Loss of Heating

The FIP indicates that ventilation for the SSF is available when the SSF is in operation; thus, the staff finds that the ELAP would not cause loss of heating effects for those parts of the FLEX strategy that rely on the SSF DG and SSF auxiliary service water system. The SSF RCMU pumps are located in the reactor buildings, which do not experience any significant temperature drop since there is an internal heat source (decay heat from the fuel assemblies).

In the FIP, Section 2.8.2 indicates that all FLEX equipment which is operated outdoors was procured and designed for routine outdoor commercial use in extreme low ambient temperatures and harsh conditions. Specifically, FLEX equipment engines are supplied with block heaters for use in freezing conditions. FIP Section 2.11.2 states that operators will take protective measures as necessary in freezing temperatures, such as establishing trickle flow in pumps and hoses to prevent freezing. During its audit, the staff reviewed the procurement/purchase specifications for the FLEX pumps and FLEX DGs and confirmed they are capable of operating in the lowest predicted ambient temperatures for the site.

For the BWSTs, it is expected that freezing or boron precipitation at low temperatures will not occur prior to remedial actions. The BWSTs are insulated and maintained greater than 45 °F per Technical Specifications, and should maintain temperature above freezing for a significant period of time even with the ELAP. At the boron concentration in the BWSTs (2500 ppm), freezing will occur prior to boron precipitation.

For the vital battery rooms in the auxiliary building, licensee calculation OSC-11230 shows that the minimum acceptable temperature limit for the safety-related batteries is 32 °F. At the onset of the event, the vital battery rooms would be at their normal operating temperature of about 75 °F and the temperature of the electrolyte in the cells would build up due to the heat generated by the batteries discharging and during recharging. Temperatures in the battery rooms are not expected to be sensitive to extreme cold conditions due to their location within the auxiliary building, the concrete walls isolating the rooms from the outdoors, and lack of forced outdoor air ventilation during early phases of the ELAP event. Therefore, the temperature of the vital battery rooms should not drop below the minimum acceptable temperature limit.

Based on the above, the NRC staff finds that Oconee FLEX strategies should be effective even with a loss of heating during an ELAP event with the lowest predicted ambient temperatures for the site.

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 vital battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging.

In its FIP, the licensee stated that by approximately 18 hours into the ELAP, the vital batteries will be placed on float charge when the battery chargers are repowered by a FLEX DG. As a result, hydrogen gas will be generated in each unit's battery rooms. The minimum concentration limit of hydrogen gas which may result in an explosive mixture is 4 percent. Attachment E of licensee's calculation OSC-11253, "Oconee Nuclear Station Units 1, 2 & 3 Auxiliary Building GOTHIC Heat Up Analysis – ELAP Event Cases," Revision 1, showed that the hydrogen concentration will be maintained in the battery rooms at or below 0.37 percent with battery room doors and auxiliary building doors opened for natural ventilation within 12 hours into the event.

Based on its review of the licensee's calculation and battery room ventilation strategy (opening selected doors and establishing natural ventilation), the NRC staff finds that hydrogen accumulation in the Oconee vital 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

See the discussion in Section 3.9.1.1 above. In calculation OSC-11383 the licensee determined that MCR temperature would not exceed 110 °F at least 5 days for the Unit 1 and 2 MCR and 7 days for the Unit 3 MCR with selected doors opened for natural ventilation through the MCR. The temperature recommendation for personnel access for limited periods of time, as identified in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, is 110 °F. The licensee has a heat stroke prevention program which addresses time limits for high temperature areas. The NRC staff finds that personnel will be able to access the MCR, and that there will be sufficient time available to establish additional cooling such as spot coolers.

3.9.2.2 Spent Fuel Pool Area

In the FIP, Sections 2.4.4.5 and 2.11 indicate that a ventilation path is established in the SFP areas by opening doors from the SFP into the purge inlet rooms, and then doors from those rooms to the atmosphere, as well as opening the SFP truck receiving bay roll-up doors prior to the SFP boiling to prevent pressurization of the fuel handling areas or steaming/exhausting into undesired areas of the auxiliary building. During its audit, the NRC staff noted the licensee's FLEX guidelines provide a warning to operators that the SFP could boil as soon as 6 hours after the start of the event with a recent full-core offload and provides guidance on the necessary doors to open in the auxiliary building to establish a vent path. During non-outage situations, the heat load in the SFP would be less than a full-core offload; thus, the staff finds it appropriate that the licensee's sequence of events indicate that actions associated with providing ventilation to the auxiliary building begins at about 6 hours after the initiating event.

The NRC staff finds the above strategies are consistent with NEI 12-06, Section 3.2.2.11, such that station personnel can safely enter the SFP area and perform the necessary actions to support the FLEX mitigation strategy, during an ELAP event.

3.9.2.3 Other Plant Areas

See the discussion in Section 3.9.1.1 above. The NRC staff has not identified any areas that must be entered to execute the FLEX strategy that would not support personnel habitability.

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 should adequately address the requirements of the order.

3.10 Water Sources

3.10.1 Steam Generator Makeup

In its FIP, the licensee stated that for SG makeup, Oconee will provide water from one of the following sources:

- Condenser circulating water (CCW) intake crossover line (using the ASW pump in the SSF)
- Intake canal (using a FLEX portable pump)

The licensee further stated in its FIP, that the CCW intake crossover line (which is the suction source for the SSF ASW pump) and the intake canal are protected from all design-basis hazards and will therefore be available following any of the applicable hazards. The CCW intake canal dike as a Class 2 structure that has been qualified to the same seismic loading as nuclear safety-related structures and provides a large amount of lake water in the intake canal that is trapped behind the dike.

3.10.2 Reactor Coolant System Make-Up

In its FIP, the licensee described that during Phase 1, borated water from an SFP will be supplied to the RCS using the SSF RCMU pumps. The two SFPs are robust structures protected against all design-basis hazards; thus, the borated water in the SFPs will be available to support Phase 1 RCS make-up during an ELAP event.

In its FIP, the licensee described RCS makeup/boration during Phase 2 from each unit's BWST, which is protected against all design-basis hazards. The licensee further described that each BWST has a usable volume of 198,000 gallons which would support RCS inventory control for 13.6 days. Based on the robust design of the BWST, the staff find that it will be available to support Phase 2 RCS make-up during an ELAP event and will be sufficient until off-site resources arrive.

In its FIP, the licensee stated that during Phase 3, an NSRC will provide additional water purification and boration equipment that can be used to provide high quality, borated water. The staff finds that the licensee will have the capability to purify and produce borated water for RCS make-up indefinitely.

3.10.3 Spent Fuel Pool Make-Up

In its FIP, the licensee described inventory control of the SFPs by use of water from the intake canal to provide any necessary makeup. The preferred supply of water to the SFP will be demineralized borated water using equipment from the NSRC, if possible. As discussed in SE Section 3.10.1, the intake canal is robust with respect to all design-basis hazards and should be available to support the licensee's FLEX strategy. In addition, as discussed in SE Section 3.10.2, the NSRC will provide the necessary off-site equipment to purify and produce borated water for SFP make-up indefinitely.

3.10.4 Containment Cooling

In its FIP, the licensee stated that cooling water to the reactor building is not required to support the Oconee FLEX strategy.

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 should 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 SSF ASW pump to provide the water to the SGs that is 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. In FIP Section 2.4.6, the licensee stated that assuming there was a full-core offload to a SFP, that SSF RCMU pumps were taking a suction on the SFPs, and that there was no cooling to the SFPs, about 24 hours was available before reaching 10 feet of water above the fuel. This will provide sufficient shielding to allow operators to access the SFP areas. The NRC staff finds that this is sufficient time for the licensee to implement a method to add water to the SFPs.

When a plant is in a shutdown mode in which fuel assemblies are still in the reactor vessel and core cooling cannot be performed by releasing steam from the SGs (which for Oconee typically occurs when the RCS has been partially drained or the vessel head removed), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes" [Reference 38], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 39], 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. By letter dated February 27, 2015 [Reference 14], the licensee informed the NRC staff of its plans to follow the guidance in this position paper. During the audit process, the NRC staff observed that the licensee had made progress in implementing this guidance.

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 should adequately address the requirements of the order.

3.12 Procedures and Training

3.12.1 Procedures

The licensee has developed a comprehensive set of FLEX Guidelines (FGs). In its FIP, the licensee stated that the inability to predict actual plant conditions that require the use of BDBEE equipment makes it impossible to provide specific procedural guidance. As such, the FGs provide guidance that can be employed for a variety of conditions. The FGs, to the extent possible, provide pre-planned FLEX response strategies for accomplishing specific tasks in support of EOPs and abnormal operating procedures. The FGs are used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

3.12.2 Training

In its FIP, the licensee provided the following information in regards to training:

> Programs and controls were established to assure that personnel proficiency for the mitigation of a BDBEE is developed and maintained. The Systematic Approach to Training (SAT) process was utilized to evaluate, develop and implement training for applicable personnel. Initial training was provided for Auxiliary Operators, Licensed Operators and shift maintenance technicians in August and September 2015, prior to implementation of FLEX on ONS [Oconee Nuclear Station] Unit 2 (i.e., the first Unit to implement FLEX). Recurring training is on the Non-Licensed Operator Requalification and Licensed Operator Requalification schedule and maintenance continuing training schedule.
>
> A basic ERO [emergency response organization] Computer Based Training (CBT) module and an ONS Site Specific CBT module were developed and delivered to all ERO members. An Advanced CBT for ERO Decision makers was developed and delivered to all ERO Decision makers. Periodic training will be provided to emergency response leaders and personnel assigned to direct the execution of the FLEX strategies. FLEX drills will be planned and conducted to demonstrate site readiness, consistent with industry guidance.

3.12.3 Conclusions

Based on the descriptions above, the NRC staff finds that the licensee has adequately addressed the procedures and training associated with FLEX. The guidelines have been issued in accordance with NEI 12-06, Section 11.4, and a training program has been established in accordance with NEI 12-06, Section 11.6.

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter to the NRC dated October 3, 2013 [Reference 40], which included Electric Power Research Institute (EPRI) Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX

Equipment." By letter dated October 7, 2013 [Reference 41], 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.

In its FIP, the licensee stated that they would conduct maintenance and testing of the FLEX equipment in accordance NEI 12-06, Revision 0, Section 11.5. In addition, the licensee stated that they have adopted EPRI Report 3002000623, to the extent possible.

The NRC staff finds that the licensee has adequately addressed equipment maintenance and testing activities associated with FLEX equipment because a maintenance and testing program has been established in accordance with NEI 12-06, Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 0

3.14.1 Use of Equipment (ADVs) Which Is Not Fully Protected

The licensee relies on using the SG ADVs as part of the FLEX strategy to perform a cooldown of the RCS. The ADVs are located in the turbine building, which is not designed to protect the ADVs from all applicable hazards. In Section 2.1 of its FIP, the licensee noted that the use of the ADVs is an alternative to NEI 12-06. The licensee performed a technical evaluation that verified the robustness of the ADVs and downstream piping for the applicable hazards. The NRC staff finds that due to the robustness of the ADVs, and the protection provided by the turbine building, the use of the ADVs is an acceptable alternative. Refer to SE Section 3.2.3.1.1 for additional discussion.

3.14.2 Use of the SSF DG

The use of the SSF DG is an alternative to the NEI 12-06 guidance. In NEI 12-06, Section 3.2.1.3, "Initial Conditions," conditions (2) and (6) state that:

> (2) All installed sources of emergency on-site ac power and SBO [station blackout] alternate ac power sources are assumed to be not available and not imminently recoverable.
>
> (6) Permanent plant equipment that is contained in structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles, are available.

The licensee has proposed the use of the SSF as noted above. The SSF DG is also the SBO alternate ac power source at Oconee, and under condition (2) above would be assumed not to be available. However, the SSF DG is robust as described in condition (6) above. The NRC staff considered the design features of the SSF, especially its independence from other plant systems and structures, and finds that crediting the SSF DG is an acceptable alternative to the NEI 12-06 guidance.

3.14.3 Reduced Set of Hoses and Cables As Backup Equipment

The licensee took an alternative approach to the NEI 12-06 guidance for hoses and cables. In NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, 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. Thus, a single-unit site would nominally have at least two portable pumps, two sets of portable ac/dc power supplies, two sets of hoses & cables, etc. NEI, on behalf of the industry, submitted a letter to the NRC [Reference 48] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that that either a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the N capability plus at least one spare of the longest single section/length of hose and cable be provided or b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. By letter dated May 18, 2015 [Reference 49], the NRC agreed that the alternative approach is reasonable, but that the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. The licensee performed an evaluation of the quantity of hoses and cables in document OSC-11383, Revision 0, Attachment 7, "Calculation of Minimum Spare Hoses and Cables," Revision 0. The NRC staff reviewed Attachment 7 and determined that the licensee was following NEI's proposed alternative [Reference 48] regarding the quantity of spare hoses and cables to be stored on site. The NRC staff approves this alternative as being an acceptable method of compliance with the order.

3.14.4 Conclusion

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

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 28, 2013 [Reference 24], the licensee submitted its OIP for Oconee Nuclear Station (Oconee) in response to Order EA-12-051. By letter dated June 21, 2013 [Reference 25], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided its response by letter dated July 19, 2013 [Reference 26]. By letter dated November 1, 2013 [Reference 27], the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 26, 2013 [Reference 29], February 28, 2014 [Reference 30], August 27, 2014 [Reference 31], February 27, 2015 [Reference 32], and August 26, 2015 [Reference 33], the licensee submitted status reports for the Integrated Plan and the RAI in the ISE. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation (SFPLI), which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letters dated January 20, 2016 [Reference 34, Units 1 and 2], and February 29, 2016 [Reference 35, Unit 3], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed SFPLI systems designed by AREVA. The NRC staff reviewed the vendor's SFPLI system design specifications, calculations, analyses, test plans, and test reports, and issued an audit report of AREVA on September 15, 2014 [Reference 28].

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 6, 2015 [Reference 17], the NRC issued an audit report on the licensee's progress. The following evaluation is common for Oconee Units 1, 2, and 3, unless otherwise noted. Refer to Section 2.2 above for the regulatory background for this section. Note that there is one SFP for Units 1 and 2, and a second SFP for Unit 3. The two SFPs are in the shared auxiliary building.

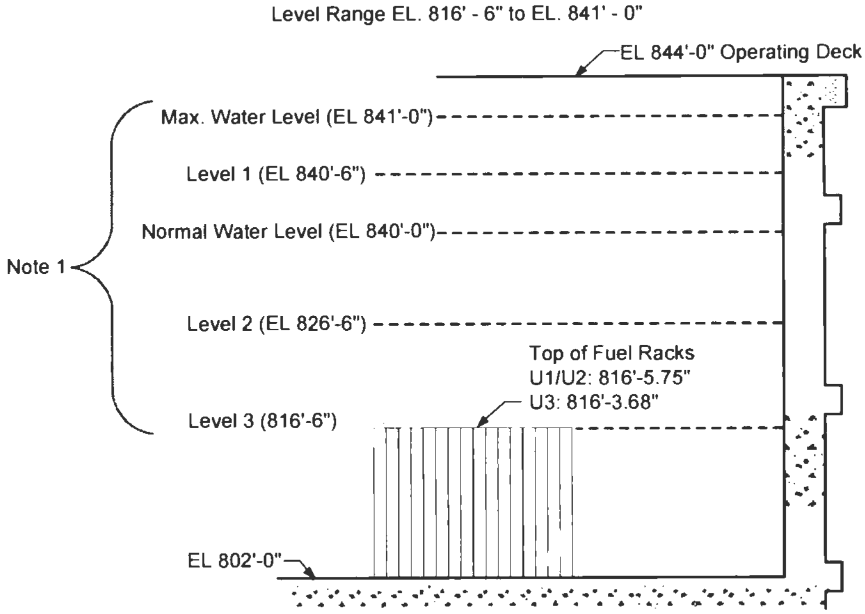
4.1 Levels of Required Monitoring

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

- Level 1 corresponds to plant elevation (EL.) 837'-6"
- Level 2 corresponds to EL. 826'-6" for Units 1&2; and El. 826'-4" for Unit 3
- Level 3 corresponds to EL. 816'-6" for Units 1&2; and El. 816'-4" for Unit 3

In its letter dated July 19, 2013 [Reference 26], the licensee revised Level 1 from EL. 837'-6" to EL. 840'-6" and stated that the normal SFP water level is EL. 840'-0". The SFP cooling pump suction piping submergence is lost when water level decreases below EL. 836'-0" (Point A). During normal operation, SFP cooling pumps are automatically tripped at EL. 837'-6" to protect against NPSH and vortex concerns. However, as the SFP temperatures increase above normal, including temperatures that approach saturation conditions, the SFP cooling pump flow rates are procedurally controlled to prevent operation with potentially inadequate NPSH or vortex conditions based on engineering analysis. Under these high temperature and reduced flow conditions, the limiting level which provides protection against inadequate NPSH or vortex conditions is EL. 840'-6", which is 6 inches above the normal SFP water level. Due to the design of the SFP suction piping, pump operation cannot be supported at all during saturation conditions in the pool. Thus, Point B for Oconee can only be approximated by the point at which NPSH protection is provided, which varies dependent on SFP conditions. Under normal conditions, Point B relates to EL. 837'-6". But as SFP temperatures approach saturation, Point B relates to EL. 840'-6". Therefore, Oconee will consider EL. 840'-6" as its "Level 1" datum due to it being higher that Point A and higher than EL. 837'-6".

In its letter dated February 29, 2016 [Reference 35], the licensee provided a sketch depicting the SFP levels of monitoring as illustrated below in Figure 1, "Oconee SFP Levels of Monitoring".



Note 1: Level 1, Level 2 and Level 3 are applicable to both the Unit 1&2 SFP and the Unit 3 SFP. The range of the level indication will meet or exceed elevations defined by the maximum pool level (841'-0") and Level 3 (816'-6").

Figure 1 – Oconee SFP Levels of Monitoring

The NRC staff's assessment of the licensee's selection of the SFP levels of monitoring is as follows.

- Level 1: Level 1 at EL. 840'-0" is adequate for normal SFP cooling system operation and it is also adequate to ensure the required fuel pool cooling pump NPSH. This level represents the higher of the two points described in NEI 12-02 for Level 1.

- Level 2: Level 2 was identified by the licensee as EL. 826'-6". This level is consistent with the first of the two NEI 12-02 options for Level 2, which is 10 feet above the highest point of any fuel rack seated in the SFP.

- Level 3: Level 3 was identified by the licensee as EL. 816'-6", which is the highest point of any fuel rack seated in the SFP where fuel remains covered; and therefore, consistent with NEI 12-02.

Based on the evaluation above, the NRC staff finds 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 should adequately address the requirements of the order.

4.2 Evaluation of Design Features

Order EA-12-051 requires 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 NRC staff's assessment of the design features of the SFPLI.

4.2.1 Design Features: Instruments

In its OIP, the licensee stated, in part, that the instrumentation will consist of two diverse, permanent, fixed instrument channels to monitor SFP water level continuously, from one foot above normal level down to approximately the top of the fuel storage racks. The level instrumentation will allow remote monitoring capability, whereby level monitoring can be performed under conditions that could restrict personnel access to the pool, such as structural damage, high radiation levels, or heat and humidity from a boiling pool.

In its letter dated February 29, 2016 [Reference 35], the licensee provided a sketch (Figure 1, "Oconee SFP Levels of Monitoring") depicting the SFP sensor's measurement range from EL. 816'-6" to EL. 841'-0". The NRC staff noted that this measurement range covers Levels 1, 2, and 3 as described in Section 4.1 above.

The staff finds that the licensee's design, with respect to the number of SFP instrument channels and measurement range, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately addresses the requirements of the order.

4.2.2 Design Features: Arrangement

In its letter dated February 29, 2016 [Reference 35], the licensee stated that the radar horn antenna for each level instrument will be installed on opposite ends of the SFP near the southwest and northeast corners of each pool. The waveguide piping will be routed toward the extreme southeast and northeast corners of the SFP rooms near the reactor building walls, which provides maximum separation of the two channels in the SFP area and reasonable protection against any missiles that may result from damage to the structure over the SFP. The electronics for each channel including a level sensor or transmitter, a power control panel that includes battery back-up capability, and a local display; will be located on the 838' elevation of the auxiliary building in separate rooms remote from the SFP area. For each channel, one field-routed cable connects the sensor/transmitter to the power control panel and a second field-routed cable connects the local display to the power control panel. For each channel, a level signal cable is routed from the power control panel through a cable shaft to the cable spreading rooms and then to separate independent displays on control room auxiliary bench board 2AB3 (Unit 1 and 2 SFP level channels) and control room auxiliary bench board 3AB3A (Unit 3 SFP level channels). The level signal cables for the primary and back-up channels will be separated consistent with plant standards for routing redundant safety-related cabling. All electronics and cabling are located in the Seismic Category 1 auxiliary building and/or control rooms remote from the SFP area.

The NRC staff noted, and verified by walkdown during the onsite audit, that there is sufficient channel separation between the primary and back-up level instrument channels, sensor electronics, and routing cables to provide reasonable protection against loss of indication of SFP level due to missiles that may result from damage to the structure over the SFP.

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

4.2.3 Design Features: Mounting

Regarding mounting design for the SFPLI, in its letter dated February 29, 2016 [Reference 35], the licensee stated that each SFPLI channel, which consists of the electronic sensor/transmitter, radar horn, and waveguide piping, is mounted seismically. The mounting designs for the electronic sensor support, radar horn support, and intermediate supports were qualified considering the total weight of the waveguide piping and its components and the seismic accelerations for the building structure. To meet the design criteria for a beyond-design-basis (BDB) event, the loading for the mounting supports were generated using a minimum of four times the SSE accelerations. The mounting designs for these supports are qualified by calculations using the Manual for Steel Construction AISC 9th Edition, Hilti Product Technical Guides, and site specific specifications. The electronic sensor mounting support is qualified by a generic calculation using a simple C-channel steel section that is welded centrally on a ½" thick steel base plate on the auxiliary building concrete wall. This auxiliary building wall is Seismic Category 1. The base plate is anchored to the wall with four concrete anchor bolts. The generic sensor mounting support was designed for generic enveloping SSE zero period acceleration (ZPA) seismic accelerations of 2g (horizontal) and 1g (vertical). The calculation further assumed an enveloping sensor cantilevered length.

The licensee also stated that both radar horn support designs are qualified to withstand deadweight, seismic and sloshing loads, as well as the loads acting on them from the horn end assembly. Both radar horn mounting supports are designed for generic enveloping SSE ZPA seismic accelerations of 2g (horizontal) and 1g (vertical). A hydrodynamic loading analysis has been completed which indicates hydrodynamic interaction of SFP inventory with the radar horn assembly does not occur during a seismic event characterized by the Oconee ground motion response spectrum (GMRS). The installation design for the instruments provides more than enough clearance to preclude any hydrodynamic interaction during the event. The intermediate mounting supports are qualified by a site specific calculation. Standard Oconee conduit supports are used to support the waveguide system. These supports are qualified up to a current maximum loading, however they have been re-qualified as needed to show they can be used to support the loading from the waveguide pipe using four times the SSE accelerations. All intermediate supports used are intended to be two-way supports and allow free movement in the axial direction (along the pipe). The waveguide pipe has been qualified using increased seismic requirements with a maximum allowable span between pipe supports of 9'-0". All of the mounting supports for the waveguide piping will be attached to either the concrete wall or concrete floor. These are Seismic Category 1 concrete structures with a minimum concrete strength of 3000 psi.

The mounting design for the power control panels (PCPs) and the local digital displays are qualified considering the total weight of the enclosures and their associated components and the seismic accelerations for the building structure. The PCPs and the local digital displays are to be installed on the concrete wall or floor of the purge exhaust equipment rooms in the auxiliary building, above floor elevation 838'-0". A floor response spectrum for a higher floor elevation of 848' is used, which bounds lower elevation accelerations. The elevated (four times the SSE) accelerations are also applied. In the original seismic test for the PCP and digital display assembly, Grade 5 and Grade 8 fasteners were used to connect the PCP and digital display to a back plate, which in turn was connected to the shake table via unistruts. The assembly was tested to a minimum required response spectrum (RRS) of 14g for the SSE. However, for the Oconee installations, the back plates are not used. The PCP and digital display are mounted to the wall or steel stanchion directly via unistruts. In this mounting configuration with the back plate removed and the PCP mounted directly to the unistrut, the mounting configuration (and load path) continues to be rigid and the PCP configuration unchanged. Therefore, the test results remain valid without the back plate. Additionally, the equipment was tested to accelerations that bound seismic demand in the United States; the test curves are significantly higher than Oconee response spectra where the equipment is being mounted (at least 7 times peak SSE), demonstrating additional margin in the design. For PCPs or digital displays that are to be installed on a concrete wall, the electrical components are bolted to two horizontal unistruts which are then anchored to the wall by two concrete anchor bolts. For PCPs or digital displays that are installed on the floor a supporting steel stanchion is used. The stanchion consists of a hollow structure section (HSS) 7" x 7" x 3/8" welded to a 1" base plate of dimensions 16" x 16". The base plate is anchored to the floor by four concrete anchor bolts. Two horizontal unistruts are welded to the HSS and the electrical components are bolted to the unistruts. Installation and mounting of all field-run electray/cable tray is done per procedure OSS-0218.00-00-0025 which is applicable to QA-1 safety-related installations. The remote indicators will be seismically mounted in the QA-1 safety-related auxiliary bench boards located in the Unit 2 and Unit 3 main control rooms.

During the onsite audit, the NRC staff verified the mounting design of the SFPLI by performing a walkdown and by reviewing the following:

- PCP and electronics component mountings: OM-201-3517.001, "ONS FLEX SFPLI – Power Control Panel and Digital Display Mounting and Anchorage Design for Units 1, 2 &3"," Rev. 1
- Type "B" Waveguide support and horn end assembly mounting (Units 1 &2): OM-201-3514.001, "Qualifications for a Waveguide Type "B" Support and Horn End Assembly for AREVA Spent Fuel Pool Level Monitoring Instrumentation," Rev. 0
- Type "A" Waveguide support and horn end assembly mounting (Unit 3): OM-201-3515.001, "Qualifications for a Waveguide Type "A" Support and Horn End Assembly for AREVA Spent Fuel Pool Level Monitoring Instrumentation," Rev. 2
- Sensor support mounting: OM-201-3516.001, "Qualification for a Standard Orthogonal Sensor Support for the AREVA Spent Fuel Pool Level Monitoring Instrumentation," Rev. 2
- Waveguide piping support: OM-201-3518.001, "ONS SFPLI – Vega Waveguide Span Criteria, Standard Pipe Support Design and Anchorage Verification for Vega Waveguide Supports," Rev. 1
- Unit 1 & 2 control room Weschler indicator mounting: Interim Calculation Change ONS MCB OSC-2509-ICC-0011, "Seismic Qualification for EC105805 R000" (Calculation OSC-2509 revision to add weight to Panel 2AB3 IQF)

- Unit 3 control room Weschler indicator mounting: Interim Calculation Change ONS MCB OSC-2509-ICC-0012, "Seismic Qualification for EC105806 R000" (Calculation OSC-2509 revision to add weight to Panel 3AB3A IQF)

The NRC staff noted that the licensee adequately addressed SFP level instrument mounting requirements. The methodology, design criteria, assumptions, and analytical model used to estimate and test the total loading on the mounting devices, including the design-basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing, are adequate. The site-specific seismic analyses demonstrated that the SFP level instrumentation's mounting design is satisfactory to allow the instrument to function per design following the maximum seismic ground motion.

The NRC staff finds that the licensee's proposed mounting design for the SFPLI appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should 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 is not already covered by existing quality assurance requirements. Per JLD-ISG-2012-03, the NRC staff found 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 instrument reliability would be established through vendor qualification documents procured under an augmented quality assurance process defined by Duke.

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

4.2.4.2 Equipment 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 components used for all instrument components,
>
> - effects of shock and vibration on instrument channel components used during any applicable event for only 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 tests envelope the plant-specific requirements.

During the vendor audit [Reference 28], the NRC staff reviewed the Areva SFPLI's qualifications and testing for temperature, humidity, radiation, shock and vibration, seismic, and electromagnetic compatibility. The staff further reviewed Oconee's anticipated seismic, radiation, and environmental conditions to verify the Oconee bounding conditions. Below is the staff's assessment of the equipment reliability of the Oconee SFPLI.

4.2.4.2.1 Temperature, humidity, and radiation

With regard to temperature conditions related to the SFPLI qualifications, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the postulated temperature in the SFP area that results from a boiling pool is 212 °F. No temperature sensitive components will be located in the SFP area. The radar sensor electronics (sensor, PCP and local digital display) will be located outside of the SFP area and in an area where the temperature will not exceed the rated design temperature. The most limiting maximum ambient temperature for the electronics is 149 °F for the PCP components which includes a 9 °F heat rise allowance within the panel. The maximum expected temperature for a BDBEE resulting in an ELAP and loss of ventilation at the location of the system electronics does not exceed 149 °F with no cooling mitigating actions employed. Draft FLEX guide FG/0/A/1900/005, "Initial Assessment and FLEX Equipment Staging," contains actions to open various doors within the auxiliary building for natural circulation before T=12 hours which reduces the maximum temperature at the location of the system electronics to 134 °F. The maximum ambient temperature limit for the remote displays located in the control rooms exceeds the maximum expected temperature for a BDBEE resulting in an ELAP and loss of ventilation based on planned cooling mitigating actions for FLEX.

For the humidity conditions related to the SFPLI qualifications, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the maximum humidity postulated for the SFP area is 100 percent relative humidity, saturated steam. The radar horn assembly over the SFP will have a sealed glass cover to prevent steam or high humidity air from entering the waveguide piping. The radar sensor electronics will be located outside of the SFP area and in an area away from the steam atmosphere. The sensor has been tested in accordance with International Electrotechnical Commission standard IEC 60068-2-30, which varies the room temperature from normal room temperature to elevated temperature at high humidity conditions, to verify that the test item withstands condensation that can occur due to the changing conditions. The sensor is rated IP66/IP68, which signifies totally dust tight housing, protection against string water jets and waves, and protection against the prolonged effects of immersion under 0.2 bar pressure. The sensor has also been tested to EN 60529:2000. The PCP enclosure is rated NEMA 4X and provides protection to the internal components from the effects of high humidity. The ambient humidity in the auxiliary building at the location of the sensor electronics would be expected to be below 100 percent relative humidity during a postulated ELAP.

In regards to the environmental qualification of the Weschler Model VX-252 analog indicators installed in the main control rooms, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the environmental qualification of the remote displays to be installed in the main control rooms is documented in DPM-1393.01-0009-001. The remote displays were tested to 122 °F, which bounds the expected maximum temperature for the main control rooms considering planned cooling mitigating actions for FLEX.

In describing the radiological conditions related to the SFPLI qualifications, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the area above and around the SFP will be subject to large amounts of radiation in the event water level decreases near the top of the fuel racks. The only parts of the measurement channel in the pool radiation environment are the metallic waveguide and horn and the glass horn cover. The metallic waveguide and radar horn are not susceptible to the expected levels of radiation. The horn cover is made of fused silica glass, which is inorganic and not sensitive to radiation. Test data for the Dow Corning Sylgard 170 silicone elastomer which attaches the glass horn cover to the metallic horn shows test data for exposures up to 7.13×10^8 rads. At 1.64×10^8 rads the elastomer still showed some flexibility, but continued to become more brittle with higher exposure. Change in brittleness is not considered to be a significant factor as this level of exposure is not anticipated. The licensee intends to maintain SFP water level greater than 11.5 feet above the top of the fuel racks, as indicated on the wide range SFP level indicator in the main control rooms, which should prevent excessive radiation dose in the SFP area. A specific radiation dose calculation was performed for the auxiliary building locations where the sensor electronics will be located. The calculated dose is applicable for a normal refueling quantity of freshly discharged (100 hour decayed) fuel with the SFP water level at the top of the fuel racks for 7 days as specified by NEI 12-02 and is bounding for both the Unit 1 and 2 SFP, and the Unit 3 SFP. The calculated total integrated dose does not exceed the 1×10^3 rad design limit for the required operating time.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFPLI with respect to temperature, humidity and radiation. The equipment qualifications envelop the expected Oconee temperature, humidity and radiological conditions during a postulated BDBEE. The equipment environmental testing demonstrated that the SFPLI should maintain its functionality under expected BDB conditions.

4.2.4.2.2 Shock and Vibration

With regard to the shock qualification of the SFPLI, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the sensor and the indicating and adjustment module mounted to the sensor were shock tested in accordance with MIL-STD-901 D. The MIL-STD-901 D test consisted of a total of nine shock blows, three through each of the three principal axes of the sensor, delivered to the anvil plate of the shock machine. The heights of hammer drop for the shock blows in each axis were 1 foot, 3 feet and 5 feet. The sensor has also been shock tested in accordance with EN60068-2-27 (100g, 6ms), 10 shock blows applied along a radial line through the support flange. The foregoing testing demonstrates the sensor is reliable under severe shock conditions.

Related to the vibration qualification of the SFPLI, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the sensor and the indicating and adjustment module mounted to the sensor were successfully vibration tested in accordance with MIL-STD-167-1. The test frequencies ranged from 4 Hertz (Hz) to 50 Hz with amplitudes ranging from 0.048" at the low frequencies to 0.006" at the higher frequencies. The potential vibration environment around the SFP and surrounding building structure might contain higher frequencies than were achieved in the testing discussed above. Additional testing of the sensor was performed in accordance with EN 60068-2-6 Method 204 (except 4g, 200 Hz). This additional testing is considered to provide a stand-alone demonstration of the resistance to vibration of the sensor and further substantiates the results of the MIL-STD-167-1 testing.

The licensee also stated that the shock and vibration testing performed for the SFPLI adequately demonstrates that the sensor and PCP will be reliable in the installed design location. The instrumentation is rigidly mounted to the Seismic Category I auxiliary building wall and would not be subjected to any significant shock or vibration during a postulated BDB event, or during normal operation. The instrumentation is located within the Seismic Category I auxiliary building and is protected from external wind borne missile threats. The instrumentation installed design location is not susceptible to vibration from surrounding rotating equipment. The radar sensor and PCP design location provides spatial separation from surrounding SSCs, such that potential seismic interaction with surrounding SSCs is also not a concern. The testing bounds the expected component shock environment and accelerations for the PCP design mounting location (i.e., concrete walls or rigid metal building structures).

The NRC staff noted that the licensee adequately addressed the equipment reliability of the SFPLI system with respect to shock and vibration. If implemented appropriately, the SFPLI system should provide its design functions.

4.2.4.2.3 Seismic

With regard to the seismic qualification of the SFPLI, in its letter dated February 29, 2016 [Reference 35], the licensee stated, in part, that the RRS used for seismic testing of the SFPLI envelop the Oconee design-basis seismic spectra for the locations where the equipment would be installed. The seismic testing and analysis performed is in accordance with the Institute of Electrical and Electronics Engineers (IEEE) 344-2004 methodology per site procedures. A hydrodynamic loading analysis has been completed which indicates hydrodynamic interaction of SFP inventory with the radar horn assembly does not occur during a seismic event characterized by the Oconee GMRS. The installation design for the instruments provides more than enough clearance to preclude any hydrodynamic interaction during the event. The waveguide and horn end assembly are evaluated for deadweight and seismic loads. The level sensor, PCP, local display, horn end of the waveguide, standard pool end, sensor end mounting brackets, and waveguide piping were successfully seismically tested in accordance with the requirements of IEEE Standard 344-2004. The system was monitored for operability before and after the resonance search and seismic tests. The required response spectra used for the five Operating Basis Earthquakes (OBEs) and one SSE in the test were taken from EPRI TR-107330. This test level exceeds the building response spectra where the equipment will be located. Seismic qualification of the remote display to be installed in the main control room was performed in accordance with IEEE 344-1987 and is documented in DPM-1393.01-0009-001. The display (Weschler VX-252) is qualified to envelope the RRS with 20g peak and 6.6 g ZPA at 5 percent damping which envelopes the Oconee main control board in-cabinet spectra.

The NRC staff noted that the licensee adequately addressed the equipment reliability of SFPLI with respect to seismic. The SFPLI was tested to the seismic conditions that envelop Oconee's design basis maximum ground motion. Further seismic qualifications of the SFPLI mounting is addressed in Subsection 4.2.3, "Design Features: Mounting," of this evaluation.

In conclusion of the NRC staff's assessment of Oconee equipment qualification, the staff finds that the licensee's instrument qualification process appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.5 Design Features: Independence

In its letter dated February 29, 2016 [Reference 35], the licensee described the SFPLI channel's physical independence as follows. The radar horn antenna for each level instrument channel will be installed on opposite ends of the SFP near the southwest and northeast corners of each pool. The waveguide piping will be routed toward the extreme southeast and northeast corners of the SFP rooms near the reactor building walls which provides maximum separation of the two channels in the SFP area.

Related to the SFPLI's electrical independence, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the primary SFP level channel is provided non-safety-related ac power from a 120 Vac panel board located within the room containing the primary channel electronics. Similarly, the back-up SFP level channel is provided non-safety-related ac power from a 120 Vac panel board located within the room containing the back-up channel electronics. The primary and back-up channel 120 Vac panel boards are fed from different transformers. For each channel, located in separate rooms, one field-routed cable connects the sensor/transmitter to the power control panel and a second field-routed cable connects the local display to the power control panel. For each channel, a level signal cable is routed from the power control panel through a cable shaft to the cable spreading rooms and then to separate independent displays on control room auxiliary bench board 2AB3 (Unit 1 and 2 SFP level channels) and control room auxiliary bench board 3AB3A (Unit 3 SFP level channels). The level signal cables for the primary and back-up channels will be separated consistent with plant standards for routing redundant safety-related cabling. All electronics and cabling (power and signal) are located in the Seismic Category 1 auxiliary building and control rooms.

The NRC staff noted, and verified during the walkdown, that the licensee adequately addressed the instrument channel independence. The primary instrument channel is physically and electrically independent of the backup instrument channel. The instrument channels' physical separation is discussed in Subsection 4.2.2, "Design Features: Arrangement". 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 BDBEE conditions.

Based on the evaluation above, the NRC staff finds 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 should adequately addresses the requirements of the order.

4.2.6 Design Features: Power Supplies

With regard to the SFPLI power supply, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the PCP for each instrument channel normally operates on 120 Vac which is provided from a non-safety-related 120 Vac power panel board located in same room with the channel electronics. The power path and sources for each channel are listed below:

Unit 1&2 SFP Channel A - Lighting Panel board 2L11 fed from 208 Vac MCC 2XR

Unit 1&2 SFP Channel B - Lighting Panel board 1L11 fed from 208 Vac MCC 1XR

Unit 3 SFP Channel A - Lighting Panel board 3L11 fed from 208 Vac MCC 3XT

Unit 3 SFP Channel B - Lighting Panel board 3L15 fed from 208 Vac MCC 3XR

Each PCP contains a 120 Vac to 24 Vdc power supply that provides normal dc power to the sensor. Each PCP contains eight lithium batteries that provide the required dc voltage automatically upon loss of the normal 120 Vac source. An indicating light is provided on the PCP which illuminates with 120 Vac normal power provided to the unit. Loss of normal 120 Vac power is alarmed on the Operator Aid Computer via a digital input from a relay in the PCP to indicate a loss of normal power to the unit. Analysis of the battery life in relation to operating temperature is documented in OM-201-3520. The batteries can support operation at full voltage at 20 milliamps dc for approximately 130 hours at -22 °F and approximately 230 hours at 32 °F. Battery life expectancy increases with increasing temperature. This demonstrates the batteries have sufficient capacity to support reliable instrument channel operation until offsite resource availability is reasonably assured. Per OM-201-3520, battery life expectancy is 330 hours (13.75 days) at 77 °F and 349 hours (14.5 days) at 131 °F. Therefore, actions will be added to FG/1-2,3/A/1900/011 "Alternate SFP Cooling" to replace the batteries on each channel as needed to ensure long-term availability of the wide range SFP level indication during an ELAP.

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

4.2.7 Design Features: Accuracy

With regard to the SFPLI design accuracy, in its letter dated February 29, 2016 [Reference 35], the licensee stated, in part, that the manufacturer reference accuracy for each radar level channel is no greater than ±1 inch based on tests performed by Areva. This is the design accuracy value that will be specified for each level instrument channel, but is subject to change depending on the actual performance with the installed waveguide and potential uncertainties associated with the calibration method. The ±1 inch accuracy is applicable to the radar measurement system and does not include other components in the overall instrument loop. The uncertainty of the radar level channels are minimally affected by postulated BDB conditions (i.e., radiation, temperature, humidity, post-seismic and post shock conditions). The stainless steel horn antenna and waveguide pipe that is exposed to BDB conditions is unaffected by radiation, temperature and humidity. The horn cover prevents formation of condensation inside the waveguide. A minor effect on the measurement uncertainty is the length of the overall measurement path which can change due to temperature related expansion of the waveguide pipe. The waveguide pipe permits the sensor electronics to be located in a mild environment so that the effect of elevated temperature on accuracy is also limited. Based on VEGA operating instructions for the VEGAPULS 62ER, a small correction factor is applied to account for the impact of saturated steam at atmospheric pressure on the radar beam velocity. Testing performed by AREVA using saturated steam and saturated steam combined with smoke indicate that the overall effect on the instrument uncertainty is minimal.

The overall uncertainty due to BDB conditions described above is estimated to not exceed ±3 inches for the radar measurement system. The uncertainty of the SFP level channels is documented in 0SC-11203. The bounding uncertainty at the control room indicator is ±9 inches for normal plant operating conditions and +12/-11 inches for BDBEE conditions. These bounding uncertainty values include the uncertainty of the analog indicators. Calibration tolerances will be established for the radar system local indication in accordance with vendor specifications (i.e., ±1 inch or as limited by the actual performance with the installed waveguide and potential uncertainties associated with the calibration method). Calibration tolerances for the loop to the remote indicator will be established using a SRSS (square root sum of the squares) methodology considering resolution of the analog indicator.

The NRC staff noted that the licensee adequately addressed the SFPLI accuracy design including the expected instrument channel accuracy performance under both normal and BDB conditions. The methodology used to determine the total instrument loop uncertainties for a combined Areva and Weschler instrument loop is adequate. If implemented properly, the instrument channels should maintain the designed accuracy following a change or interruption of power source without the need of recalibration.

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

4.2.8 Design Features: Testing

With regard to the SFPLI's testing design feature, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the functional check verifies that the system is functioning correctly. The functional check includes calibration testing of the analog indicators located in the main control rooms. Initial system calibration, and subsequent calibration (if required), will be performed per vendor recommendations which requires the calibration check to be performed using at least two distance measurements at least 2 inches apart. The preferred method is to lower SFP water level or place a metal target between the horn and water level in the measurement range to achieve a minimum level change of at least 2 inches. If neither one of the above approaches are practical, the radar horn can be rotated by slightly loosening the three bolts on the lap joint flange holding the horn antenna and waveguide elbow to the seismic mount. Calibration can then be performed using a test target placed perpendicularly to the radar beam path.

Related to the instrument channel check in its letter dated February 29, 2016 [Reference 35], the licensee stated that channel checks will be performed as specified in the Selected Licensee Commitment. Channel checks will compare the new wide range level indications to each other and to existing independent narrow range level indications available in the main control room.

The NRC staff noted that the SFP level instrumentation is adequately designed to provide the capability for routine testing and calibration including in-situ testing/calibration. By comparing the levels in the instrument channels and the maximum level allowed deviation for the instrument channel design accuracy, the operators could determine if recalibration or troubleshooting is needed. The staff finds the licensee's proposed SFP instrumentation design allows for testing and appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.9 Design Features: Display

With regard to the SFPLI display location, in its letter dated February 29, 2016 [Reference 35], the licensee stated that the primary and backup channel displays for the Unit 1 and 2 SFPLI channels will be located on auxiliary bench board 2AB3 in the Unit 2 main control room. The primary and backup channel displays for the Unit 3 SFPLI channels will be located on auxiliary bench board 3AB3A in the Unit 3 main control room.

The NRC staff noted that the NEI 12-02 guidance for "Display" specifically mentions the control room as an acceptable location for SFP level instrumentation displays as it is occupied by trained personnel and promptly accessible, outside the area surrounding the SFP, inside a structure providing protection against adverse weather, and outside of any very high radiation areas or locked high rad area during normal operation. Further evaluation of these displays' qualification is discussed in Subsection 4.2.4, "Design Features: Qualification".

The staff finds that the licensee's proposed location and design of the SFP instrumentation displays appear to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3 Evaluation of Programmatic Controls

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that personnel shall be trained in the use and the provision of alternate power to each instrument channel. Station personnel performing functions associated with the SFP level instrumentation will be trained to perform the job specific functions necessary for their assigned tasks. The Systematic Approach to Training (SAT) will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training.

The NRC staff finds that the use of SAT to identify the training population and to determine both the elements of the required training is acceptable. The licensee's proposed plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFPI and the provision of alternate power to the primary and backup instrument channels, including the approach to identify the population to be trained, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its letter dated February 29, 2016 [Reference 35], the licensee listed procedures related to the SFPLI that address operation, calibration, test, maintenance, and inspection as follows:

- EP/1,2,3/A/1800/001B: Loss of All AC Power (Station Blackout)
- EP/1,2,3/A/1800/001N: Enclosure 5.44, Parallel Actions for SBO
- AP/1-2,3/A/1700/035: Loss of SFP Cooling and/or Level
- FG/1-2,3/A/1900/011: Alternative SFP Cooling
- FG/0/A/1900/005: Initial Assessment and FLEX Equipment Staging
- PT/1,2,3/A/0600/001: Periodic Instrument Surveillance Procedure
- IP/1-2/B/0220/001G3: Unit 1&2 Wide Range SFP Level Instrument Calibration Procedure
- IP/3/B/0220/001G3: Unit 3 Wide Range SFP Level Instrument Calibration Procedure

The licensee also stated that existing steps within the emergency and abnormal procedures identified above will be modified as needed to allow monitoring of SFP level via the primary and/or backup SFP level channels. The operations periodic instrument surveillance procedure will be modified to require the performance of channel checks on the new wide range SFP level primary and backup channels. A maintenance calibration procedure will be created to perform periodic functional checks and calibration (if required) of the primary and back-up SFP level instrumentation including a functional check of the battery backup capability for each channel. The procedure will verify proper operation of the level instrumentation and provide instruction for equipment calibration adjustment within design accuracy requirements.

The NRC staff noted that the licensee adequately addressed the procedure requirements. The procedures being established provide for the testing, surveillance, calibration, and operation of the primary and backup SFP level instrument channels. The staff finds that the licensee's procedure development appears to be consistent with NEI 12 02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.3 Programmatic Controls: Testing and Calibration

In its letter dated February 29, 2016 [Reference 35], the licensee described the Oconee testing and calibration program as follows. Programmatic controls will be established to ensure the performance of periodic channel checks, functional tests, calibration, and maintenance for the instrument channels. The programmatic controls will be established, in part, by a new Selected Licensee Commitment (SLC). The new SLC will be established for the primary and backup SFP level channels. The new SLC will specify the required frequency of performance for periodic channel checks and functional tests, as appropriate. The SLC will outline allowed out of service time frames consistent with NEI 12-02 requirements. The SLC will specify required remedial actions, in the event one or more channels cannot be restored within the allowed out of service time-frame. The remedial actions will be consistent with NEI 12-02 requirements. The SLC will further require the functional testing be performed to verify proper channel operation within 60 days of a planned refueling outage, as required by NEI 12-02. The channel out of service durations required remedial actions and required action timeframes will be formally controlled similar to that for Technical Specifications. The calibration frequency will be controlled by the plant preventive maintenance program and will be based on manufacturer recommendations and/or operating experience.

As for the compensatory measures for the SFPLI channel(s) out-of-service, in its letter dated February 29, 2016 [Reference 35], the licensee stated that compensatory actions for a single primary or back-up level channel out of service beyond 90 days could include one or more of the following:

- Increased surveillance (channel check) to verify functionality of the remaining level channel
- Implementation of equipment protection measures
- Increased operator visual surveillance of the SFP level and area
- Maintain elevated SFP level
- Reduce SFP temperature
- Supplemental operations staffing

Compensatory actions for both the primary and back-up level channels out of service could include one or more of the following:

- Increased operator visual surveillance of the SFP level and area
- Maintain elevated SFP level
- Reduce SFP temperature
- Supplemental operations staffing
- Pre-stage FLEX support equipment (nozzles, hoses, etc.) which are relied upon for SFP make-up. Pre-staged equipment would be located within Seismic Category I structures.

The licensee further stated that, as required by NEI 12-02, compensatory actions must be implemented if one channel is not expected to be restored to functional within 90 days. The corrective action program will evaluate and establish appropriate compensatory actions for a channel that cannot be restored to functional within 90 days.

The NRC staff noted that the licensee adequately addressed necessary testing and calibration of the primary and backup SFP level instrument channels to maintain the instrument channels at the design accuracy. The testing and calibration appear to be consistent with the vendor recommendations. Additionally, compensatory actions for instrument channel(s) out-of-service appear to be consistent with guidance in NEI 12-02.

The NRC staff finds that the licensee's proposed testing and calibration plan appears to be consistent with NEI 12-02, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.4 Conclusions for Order EA-12-051

In its letters dated January 20, 2016 [Reference 34] and February 29, 2016 [Reference 35], the licensee stated that it met 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 finds that, if implemented appropriately, the licensee's plans conform to the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. Based on the evaluations above, the NRC staff concludes that if the SFP level instrumentation is installed at Oconee Units 1, 2, and 3 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 [Reference 17]. The licensee reached its final compliance date on November 26, 2016, and has declared that all three of the reactors are in compliance with the orders. The purpose of this SE 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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OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 DATED AUGUST 30, 2017

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