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

March 31, 2016

Mr. Richard M. Glover
Site Vice President
H.B. Robinson Steam Electric Plant
Duke Energy
3581 West Entrance Road
Hartsville, SC 29550

SUBJECT: H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2 SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0720 AND MF0793)

Dear Mr. Glover

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

By letter dated February 26, 2013 (ADAMS Accession No. ML13071A415), Duke Energy Progress, Inc. (Duke, the licensee) submitted its OIP for H. B. Robinson Steam Electric Plant, Unit No. 2 (Robinson) 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 19, 2014 (ADAMS Accession No. ML13365A291), and June 12, 2015 (ADAMS Accession No. ML15154B098), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated August 19, 2015 (ADAMS Accession No. ML15232A007), 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. ML13086A096), Duke submitted its OIP for Robinson 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 (ADAMS Accession No. ML13273A481), and June 12, 2015 (ADAMS Accession No. ML15154B098), the NRC issued an Interim Staff Evaluation (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 June 27, 2015 (ADAMS Accession No. ML15187A229), Duke submitted a compliance letter and FIP 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 Robinson. The intent of the safety evaluation is to inform Duke on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Jason Paige, Orders Management Branch, Robinson Project Manager, at 301-415-5888 or at Jason.Paige@nrc.gov.

Sincerely,

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

Docket No.: 50-261

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 PROGRESS, LLC

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

DOCKET NO. 50-261

1.0 INTRODUCTION

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

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

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

2.0 REGULATORY EVALUATION

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

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

2.1 Order EA-12-049

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

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

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

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

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

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

On 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 (ADAMS Accession No. ML12242A378) 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" (ADAMS Accession No. ML12229A174), 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 (ADAMS Accession No. ML12054A679) requires that operating power reactor licensees and construction permit holders install reliable SFP level instrumentation. Specific requirements of the order are listed below:

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

structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.

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

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

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

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

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

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

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

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

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

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

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

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 26, 2013 (ADAMS Accession No. ML13071A415), Duke Energy Progress, Inc. (Duke, the licensee) submitted an Overall Integrated Plan (OIP) for H. B Robinson Steam Electric Plant, Unit No. 2 (Robinson) in response to Order EA-12-049. By letters dated August 28, 2013 (ADAMS Accession Nos. ML13252A243), February 24, 2014 (ADAMS Accession No. ML14063A283), August 26, 2014 (ADAMS Accession No. ML14253A161), and February 23, 2015 (ADAMS Accession No. ML15065A041), the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 19, 2014 (ADAMS Accession No. ML13365A291), and June 12, 2015 (ADAMS Accession No. ML15154B098), the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated August 19, 2015 (ADAMS Accession No. ML15232A007), the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP).

3.1 Overall Mitigation Strategy

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

While the initiating event is undefined, it is assumed to result in an extended loss of ac power (ELAP) with loss of normal access to the ultimate heat sink (LUHS). Thus, the ELAP with LUHS 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 shutdown 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.

Robinson is a Westinghouse pressurized-water reactor (PWR) with a dry ambient pressure containment. The FIP describes the licensee's three-phase approach to mitigate a postulated ELAP event.

At the onset of an ELAP, the reactor is assumed to trip from full power. The reactor coolant pumps (RCPs) coast down and flow in the reactor coolant system (RCS) transitions to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by verifying the isolation of potential RCS letdown paths. The licensee stated in its FIP that the FLEX strategy for reactor core cooling and decay heat removal is to commence cooldown within 2 hours by releasing steam from the steam generators (SGs) using either manual control of the power operated relief valves (PORVs) or main steam isolation valve (MSIV) bypass lines and main steam header vents, and the addition of a corresponding amount of feedwater to the SGs via the steam driven auxiliary feedwater (SDAFW) pump. The auxiliary feedwater (AFW) system uses the condensate storage tank (CST) as the initial water supply to the SDAFW pump (seismic strategy) or the circulating water (CW) inlet bay via a pre-staged portable low pressure pump (high wind/missile strategy). Operator actions to verify, re-align, and throttle AFW flow are required following an ELAP/LUHS event to prevent SG dryout and/or overfill. The CST will provide approximately 7.5 hours of inventory before it is depleted.

The RCS will be cooled down and depressurized until SG pressure reaches 290 per square inch gage (psig). The RCS makeup to account for RCS leakage and RCS inventory contraction is initially provided from the safety injection system cold leg accumulators. The RCS cooldown is controlled to prevent nitrogen in the accumulators from entering the RCS. FLEX RCS makeup and boration will be initiated by 16 hours using Phase 2 portable equipment. Providing FLEX RCS makeup by this time is intended to maintain adequate shutdown margin. In addition, establishing FLEX RCS makeup by 16 hours ensures that natural circulation flow is maintained in the RCS for the analyzed ELAP event.

The dc bus load shedding will ensure battery life is extended to more than 3 hours. Pre-staged generators will repower instrumentation prior to battery depletion. Load shedding of all non-essential dc loads would begin within 44 minutes after the occurrence of an ELAP/LUHS and completed within the next 16 minutes. With deep load shedding, the useable station Class 1E battery life is calculated to be 3.75 hours for station battery 'A' and 3.25 hours for station battery 'B'. The licensee's Phase 2 electrical strategy includes aligning and placing into service one of two pre-staged 150 kilowatt (kW), 480 Volt (V) alternating current (ac), 3-phase 60 Hertz (Hz) FLEX diesel generators (DGs) located in the seismic Class 1 reactor auxiliary building (RAB) drumming room to repower battery chargers, safety injection valves, and vital instrumentation. The second permanently pre-staged FLEX DG provides backup capability.

The Phase 3 strategy for core cooling and decay heat removal is a continuation of the Phase 2 strategies. Additional pumps are available from the National SAFER [Strategic Alliance for FLEX Emergency Response] Response Centers (NSRCs) to provide backup to the Phase 2 FLEX pumps. Additionally, a reverse osmosis/ion exchanger system will be provided from the NSRCs to provide a method to remove impurities from alternate fresh water supplies to the SDAFW pump or the Phase 2 FLEX pumps.

Robinson has a dry, ambient pressure containment building. An engineering analysis by the licensee showed the containment design limits for temperature and pressure will not be challenged in the first 43 days following the event assuming no actions are taken to cool, spray, or vent containment. The Phase 1 coping strategy for containment involves verifying containment isolation, and monitoring containment temperature and pressure using installed instrumentation. The Phase 2 coping strategy is to continue monitoring containment temperature and pressure using installed instrumentation. Phase 2 activities to repower instruments are required to continue containment monitoring. The containment temperature will be procedurally monitored and, if necessary, the containment temperature will be reduced to ensure that key containment instruments will remain within analyzed limits for equipment qualification. For Phase 3, necessary actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will utilize existing plant systems restored by off-site equipment and resources. The Phase 3 coping strategy is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored.

The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide makeup water to the SFP sufficient to restore to the normal SFP level. The SFP boil-off to 10 feet above the fuel racks will occur at approximately 23 hours after the ELAP occurs (assumes full core offload and 150°F initial conditions). During non-outage conditions, the time to boiling in the pool is significantly longer, typically greater than 45 hours. The initial coping strategy for SFP cooling is to monitor spent fuel pool level using instrumentation installed as required by NRC Order EA-12-051. The Phase 2 strategy is to initiate makeup using a portable pump to draft from Lake Robinson or the discharge canal and makeup to the SFP through several possible locations. The primary draft location is the south end of the discharge canal. An alternate strategy is to deploy a hose directly into the pool from the SFP operating deck if the building is accessible. Additionally, in accordance with NEI 12-06, spray monitors and sufficient hose length required for the SFP spray option are located in the permanent FLEX storage building (PFSB). For Phase 3, additional high capacity pumps will be available from the NSRCs as a backup to the on-site portable pumps.

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

In accordance with Order EA-12-049, licensees are required to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with an LUHS. 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 Duke's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP/LUHS) that is robust in accordance with the guidance in NEI 12-06. In Phase 2, robust installed equipment is supplemented by onsite FLEX equipment, which is used to cool the core either directly (e.g., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

To adequately cool the reactor core under ELAP conditions, two fundamental physical requirements exist: (1) a heat sink is necessary to accept the heat transferred from the reactor core to coolant in the RCS and (2) sufficient RCS inventory is necessary to transport heat from the reactor core to the heat sink 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 subcritical as the RCS is cooled and depressurized.

As reviewed in this section, Duke's core cooling analysis for the ELAP/LUHS event presumes that, per endorsed guidance from NEI 12-06, the Robinson plant would have been operating at full power prior to the event. Therefore, the steam generators may be credited as the heat sink for core cooling during the ELAP/LUHS event. Maintenance of sufficient RCS inventory, despite ongoing system leakage expected under ELAP conditions, is accomplished through a combination of installed systems and FLEX equipment. The specific means used by Duke to accomplish adequate core cooling during the ELAP/LUHS event are discussed in further detail below. Because certain actions within the mitigating strategy and their timeline vary depending on whether the ELAP/LUHS results from (1) high winds and wind-borne missiles or (2) other natural hazards not associated with high winds, separate discussions are provided for each case, assuming the reactor is initially operating at full power. Duke's strategy for ensuring compliance with Order EA-12-049 for conditions where the reactor is shut down or being refueled is reviewed separately in Section 3.11 of this evaluation.

3.2.1 Core Cooling Strategy and RCS Makeup for Non-Flooding Event

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

As stated in Duke's August 19, 2015, FIP, the heat sink for core cooling in Phase 1 would be provided by the three SGs, which would be fed simultaneously by the unit's SDAFWP with inventory supplied from the CST, which is seismically qualified. Duke calculates that the CST water volume is sufficient to remove residual heat from the reactor for approximately 7.5 hours, including the sensible heat associated with the RCS cooldown starting at 2 hours.

Following closure of the main steam isolation valves, as would be expected in an ELAP event, steam release from the SGs to the atmosphere would be accomplished via the main steam safety valves or the SG Power PORVs. The SG PORVs would typically be operated by the instrument air system or backup nitrogen system, neither of which is robust; therefore, these supporting systems are not credited in the licensee's mitigating strategy. If these means of PORV operation are not available, Duke's FIP states that the RCS can be cooled by relieving steam from the SGs through the main steam isolation valve bypass lines to the main steam header, and then through the 4" main steam header vents to atmosphere. The licensee has confirmed that this flowpath is robust with respect to all external hazards, including earthquakes and windborne missiles. Alternately, the PORVs can be operated by aligning portable nitrogen tanks to the SG PORV header using B.5.b procedures if the valves and their pneumatic operators survive the event; the primary FLEX strategy is by steam release through the main steam header as described above which is robust with respect to the external hazards defined in NEI 12-06. .

Duke's Phase 1 strategy directs operators to commence a cooldown and depressurization of the RCS within 2 hours of the initiation of the ELAP/LUHS event. Over a period of approximately 3 hours, Duke would gradually cool down the RCS from post-trip conditions until a SG pressure of 290 psig is reached. A minimum SG pressure of 290 psig is set to avoid the injection of nitrogen gas from the safety injection accumulators into the RCS. Cooldown and depressurization of the RCS significantly extends the expected coping time under ELAP/LUHS conditions because it (1) reduces the potential for damage to RCP seals (as discussed in Section 3.2.3.3) and (2) allows coolant stored in the nitrogen-pressurized accumulators to inject into the RCS to offset system leakage.

3.2.1.1.2 Phase 2

Duke's FIP states that the primary strategy for core cooling in Phase 2 would be to continue using the SGs as a heat sink, with SG secondary inventory being supplied by the SDAFWP. Although functionality of the SDAFWP is expected throughout Phase 2 per the NEI 12-06 assumptions associated with the analyzed ELAP event, to satisfy provisions of the order, the licensee has two pre-staged intermediate pressure (IP) FLEX pumps that are capable of backing up this essential function.

According to Duke's calculations, the CST is capable of supplying SG makeup for approximately 7.5 hours. To provide an unlimited source of secondary makeup in Phase 2, Duke stated that a portable diesel-driven low-pressure (LP) FLEX pump would be deployed at the UHS (Lake Robinson). This pump would draw suction from the lake and refill the CST via hoses routed to the CST FLEX connection at the CST drain valve. Duke has evaluated lake water and deepwell chemistry and calculated a coping time of greater than 11 days using lake or discharge canal water; this coping time should allow ample margin for deployment of water treatment equipment from the NSRC in Phase 3.

The licensee's FIP states that its core cooling strategy for a seismic event is to rely initially on the SDAFWP taking suction from the CST. However, in the unanticipated event that AFW flow from the SDAFWP is interrupted early in the ELAP transient, the two LP pumps that are pre-staged in the protected area can provide SG makeup within approximately 23 minutes. The pumps are rated for 300 gallons per minute (gpm) at 1000 psig; therefore, they can begin feeding prior to depressurizing the SGs. Either pump can take suction from six pre-staged 20,000-gallon alternate cooling source (ACS) tanks (for a total volume of 120,000 gallons) and discharge to the SGs via either a primary or alternate FLEX connection to the AFW system. The licensee's FIP states that these ACS tanks can be replenished using two low-pressure FLEX pumps drawing suction on Lake Robinson.

3.2.1.1.3 Phase 3

According to its FIP, Robinson's core cooling strategy for Phase 3 is a continuation of the Phase 2 strategy with additional offsite equipment and resources. In particular, when core decay heat diminishes to the point that SG pressure cannot be maintained above 120 psig (the minimum pressure required to run the turbine-driven SDAFWP), operators will transition to the FLEX IP pumps or an NSRC pump for SG makeup.

The LP FLEX pump drawing water from Lake Robinson is capable of supplying the CST. As stated above, Duke has evaluated lake water and deepwell chemistry and calculated a coping time of greater than 11 days using lake or discharge canal water. In Phase 3, additional pumps from the NSRC are made available to provide backup to the on-site FLEX pumps. Additionally, a reverse osmosis/ion exchanger water processing system will be provided from the NSRC to remove impurities from alternate fresh water supplies. By removing impurities from the alternate fresh water supplies, the licensee will extend its ability to provide make-up water from more than 11 days to an indefinite period. As necessary to facilitate the use of higher quality water for core cooling, the NRC staff expects that the licensee would begin using purification equipment from the NSRC as soon as practical considering the overall event response prioritization.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following the reactor trip at the start of the ELAP/LUHS event, operators will isolate RCS letdown pathways and confirm the existence of natural circulation flow in the RCS. A small amount of RCS leakage will occur through the low-leakage RCP seals, but because the expected inventory loss would not be sufficient to drain the pressurizer prior to the RCS cooldown, its overall impact on the RCS behavior will be minor. Although the RCS cooldown planned for implementation between 2 and 5 hours into the event would be expected to drain the pressurizer and create a vapor void in the upper head of the reactor vessel, ample RCS volume should remain to support natural circulation flow throughout Phase 1. Likewise, there is no need to initiate boration during this period, since the reactor operating history assumed in the endorsed NEI 12-06 guidance implies that a substantial concentration of xenon-135 would be present in the reactor core. Nevertheless, as operators depressurize the RCS, some fraction of the borated inventory from the nitrogen-pressurized accumulators would be expected to passively inject. Following depressurization of the SGs to 290 psig, the licensee's procedures direct accumulator isolation once electrical power is restored to the corresponding isolation valves via FLEX equipment. During the audit, the licensee estimated that actions to effect accumulator isolation should be completed by approximately 6 to 8 hours into the event.

3.2.1.2.2 Phase 2

In Phase 2, RCS inventory control and boration are accomplished with portable equipment stored in the Permanent FLEX Storage Building (PFSB). In the course of cooling and depressurizing the SGs to a target pressure of 290 psig, a significant fraction of the accumulator liquid inventory may inject into the RCS, filling volume vacated by the thermally induced contraction of RCS coolant and system leakage. However, crediting boration from the accumulators is challenging because actual RCS leakage may be quite small, and furthermore, dependent upon the rate of heat loss from the RCS (i.e., particularly from the reactor vessel upper head), RCS pressure may remain several hundred psi above the SG target pressure for multiple hours into the event. Thus, in order to ensure long-term subcriticality as positive reactivity is added from the RCS cooldown and xenon decay, RCS boration will commence using a portable high-pressure FLEX pump no later than 16 hours into the ELAP/LUHS event. With low-leakage Westinghouse Generation 3 SHIELD RCP seals installed on all RCPs, Duke calculates that FLEX RCS makeup is not necessary to prevent the onset of reflux cooling for at least several days into the event. Therefore, the injection of borated RCS makeup water for reactivity control will be in progress long before entry into reflux cooling becomes a concern.

The primary method of boration and inventory control in Phase 2 is a portable high-pressure FLEX pump with a capacity of 60 gpm at 2000 psig. The pump will be aligned to take suction from either the refueling water storage tank (RWST), with a borated volume of at least 300,000 gallons, or two portable boric acid mixing tanks from the PFSB. The RWST is seismically qualified, but not hardened against windborne missiles. If the RWST is depleted or unavailable, the portable tanks will be transported to a location near the FLEX pump and configured for batching borated coolant. Water will be supplied from Lake Robinson via a portable pump, within which bags of boric acid will be mixed. The FLEX RCS pump can be aligned to discharge to either the charging header (primary strategy) or alternate connections in the safety injection system.

3.2.1.2.3 Phase 3

The Phase 3 strategy for indefinite RCS inventory control and subcriticality is simply a continuation of the Phase 2 strategy, with backup pumps and water treatment equipment supplied by the NSRC. To facilitate the use of higher quality water for RCS makeup, as necessary, the NRC staff expects that the licensee would begin using purification equipment from the NSRC as soon as practical considering the overall event response prioritization.

3.2.2 Variations to Core Cooling Strategy for High Wind Event

The CST at Robinson, Unit No. 2, is not protected against missiles that may be generated by a design-basis tornado or hurricane. Duke has deemed it inadvisable to attempt to harden the CST against high winds and missiles, due to structures in the vicinity of the tank, as well as obstructions and hazards above it. If the CST water volume is lost due to high winds or windborne missiles, there is no installed source of AFW supply to the SGs. However, in this case, two FLEX strategies can be employed.

First, the circulating water inlet bay at the main condenser has been modified to provide a point of access to the UHS from within the protected turbine building. Two portable LP diesel FLEX pumps are pre-staged in the turbine building; the timeline of events in the FIP states that one of these pumps can be aligned within 33 minutes to take suction from the CW inlet bay and discharge directly to the suction of the SDAFWP. The CW bay remains filled from the UHS as long as lake level is above 217 feet (normal level is 221 feet).

In addition, the FLEX IP pumps mentioned above (see Section 3.2.1.1.2) can take suction from the ACS tanks and discharge to the SGs via either a primary or alternate connection downstream of the SDAFWP. The CW inlet bay FLEX connection and LP pumps can also be aligned to refill the ACS tanks, thereby providing a source of inventory for indefinite coping. The licensee primarily intended this strategy for defense-in-depth against an extreme seismic event, but it is also available if the CST is lost to a windborne missile.

To evaluate the effectiveness of these strategies for coping with a loss of the CST due to a windborne missile strike, the NRC staff performed an audit review of the licensee's existing calculation of 61 minutes as the time to steam generator dryout. The staff's effort included limited simulations using the TRACE thermal-hydraulic code to assess the sensitivity of the dryout time to (1) the use of the American Nuclear Society-5.1 standard decay heat model (without uncertainties) in place of a simplified analytical expression proposed by El-Wakil and (2) variation in steam generator pressure. Following discussions with the NRC staff, the licensee revised its calculation of SG dryout time, determining that approximately 55 minutes would be available prior to dryout for the ELAP event. The NRC staff audited the revised calculation and concluded that sufficient margin exists between the calculated dryout time and the time necessary for operators to initiate FLEX makeup to the SGs for a high-wind-induced ELAP event. The NRC staff further concluded that the core cooling strategy using the FLEX IP pumps involves a cleaner water source and could be implemented more rapidly than the core cooling strategy of supplying the SDAFWP with water from the CW inlet bay.

3.2.3 Staff Evaluations

3.2.3.1 Availability of Structures, Systems, and Components

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 Structures, Systems, and Components (SSCs) for core cooling during an ELAP caused by a BDBEE.

3.2.3.1.1 Plant SSCs

Core Cooling (SG) and Primary and Alternate Connections - MODES 1-4 only

For Phase 1, the licensee calculated that the AFW is required to be in operation within 55 minutes of event initiation to prevent SG dryout. The Robinson strategy with ac power lost is to manually operate at least one steam supply valve to the SDAFWP and AFW valves (AFW-V2-

14A, AFW-V2-14B, AFW-V2-14C) to the SGs. The SDAFWP and AFW valves are located in the turbine building Class 1 bay (seismically protected area) and are protected from high wind and/or tornado missile hazards. The FIP described the CST as providing an AFW water source at the onset of all extreme weather events except high wind and/or tornado missiles. The CST is the installed source of AFW to the SDAFWP, however, its inventory is only available up to 7.5 hours after the ELAP event. As described above in Section 3.2.1.1.1, the MSIV bypass lines will be used to assist cooldown of the RCS and the bypass lines will be protected in the turbine building Class 1 bay from the high winds and/or tornado missiles hazards.

For Phase 2, the FIP stated that the SG makeup will consist of the use of Lake Robinson, which is the assured water source for all weather events to provide an indefinite supply of water to the CST/SDAFW pump. The lake contains an average of 31,000 ac-ft. of water and is considered an indefinite supply of water. The LP portable pumps will be staged at the lake with hoses routed to the CST FLEX connection at valve C-66, CST Drain Valve as described in EC90622 to provide an indefinite water supply to the CST. As discussed in Section 3.2.1.1.2, the LP portable pumps can also be used to take suction from Lake Robinson to refill the six pre-staged AFW tanks. For Phase 3, the FIP indicated that the NSRC equipment will be used to help clean the water from Lake Robinson to continue feeding the SGs through the AFW system.

Based on the design of the CST, CW inlet, and Lake Robinson, as described in the FIP, these water sources should be available to support core cooling during an ELAP caused by a BDBEE, consistent with Condition 4 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and locations of the primary and alternate AFW connection points, as described in the FIP, at least one of the connection points should be available to support core cooling through a portable pump during an ELAP caused by a BDBEE, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

RCS Inventory Control and Primary and Alternate Connections - MODES 1-4 only

The FIP does not credit any installed plant equipment to support RCS inventory makeup until Phase 2/3 after ELAP, which is about 16 hours. The FIP indicates that the RWST will be utilized for ELAP events not involving high winds and/or tornado missile hazards by access of the new RWST Drain FLEX Connection installed at SI-837. Robinson is equipped with one RWST located at grade level just outside of the RAB. The RWST is designed with stainless steel, safety-related, seismically qualified, but not protected from missiles. The RWST borated volume is maintained greater than 300,000 gallons at a boron concentration between 1950 and 2400 parts per million (ppm). The RWST will provide a source of borated water for RCS makeup prior to using the HP FLEX portable pumps for makeup to the RCS. The FIP identified the primary RCS connections for boration and makeup as the charging header drain valves, CVC-121A and CVC-121B. High pressure couplings are stored with the high pressure hoses required with the portable boration equipment. The connections are made at the time of boration or makeup. The alternate RCS connections for boration and makeup are two safety injection (SI) header drain valves, SI-888P and SI-888S. High pressure couplings are stored with the high pressure hoses required with the portable boration equipment in the PFSB. The primary or alternate connections are made at the time of boration or makeup. The FIP also described an additional connection in the SFP cooling system (SFPC) at the suction of the B SFPC Pump. This connection is an alternate borated water source for RCS makeup if the RWST is not available.

Based on the design of the RWST, and the availability of portable boric acid mixing tanks, as described in the FIP, a borated water source should be available to support RCS inventory control via a portable pump during an ELAP caused by a BDBEE, consistent with Condition 3 of NEI 12-06, Section 3.2.1.3. Additionally, due to the design and location of the primary and alternate RCS injection connection points, as described in the FIP, at least one of the connection points should be available to support RCS injection through a portable pump during an ELAP caused by a BDBEE, consistent with NEI 12-06, Section 3.2.2 and Table D-1.

3.2.3.1.2 Plant Instrumentation

According to the FIP, the following instrumentation would be relied upon to support the licensee's core cooling and RCS inventory control strategy:

- RCS hot leg temperature (T_{hot})
- RCS cold leg temperature (T_{cold})
- RCS wide range pressure
- SG level (narrow range and wide range)
- core exit thermocouple temperature
- accumulator level
- pressurizer level
- Reactor Vessel Level Indicating System (RVLIS)
- AFW flow (SDAFWP flow indication for A and B SGs only; MDAFWP flow indication for A and C SGs only)
- SG pressure
- CST level
- battery capacity / dc bus voltage
- neutron flux

All of these instruments are powered by both safety-related batteries, with the exception of the indications for T_{cold}, accumulator level, and CST level. T_{cold} indication is not required if SG pressure is available, since it can be inferred from the saturation temperature corresponding to SG pressure, granted that Robinson's mitigating strategy would maintain natural circulation flow in the RCS.

Instrument channels powered by safety-related batteries could be lost if these batteries were allowed to deplete. Therefore, to prevent loss of vital instrumentation, during the first hour of the event, operators will extend battery life to 3.25-3.75 hours by shedding unnecessary loads. This leaves a margin of at least 1.25 hours between the expected battery run-time and the 2 hours needed to deploy and align one of two pre-staged FLEX DGs to power the vital battery chargers.

Guidance document FLEX Support Guideline (FSG)-007, "Loss of Instrumentation or Control Power," provides guidance for obtaining alternate readings for all of these parameters except accumulator level and battery capacity / dc bus voltage. Readings for T_{cold}, RCS pressure, SG level and pressure, and pressurizer level can all be taken using a digital multimeter at the Hagan rack in the relay room. Readings for T_{hot}, core exit thermocouple temperature, and RVLIS can be taken locally in the rod control room using a portable power pack from the FLEX storage building. The SDAFWP flow can be read locally in the turbine building, CST level can be read using a digital multimeter at Relay Rack DD, and neutron flux can be obtained using a portable power pack at the post-accident monitoring panel in the control room.

3.2.3.2 Thermal-Hydraulic Analyses

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

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

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

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

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

Duke provided the NRC staff with a comparison of the generic analysis values from WCAP-17601-P and PWROG-14064-P to the Robinson plant-specific values. Differences noted were the lower RCS average temperature (T_{avg}) value at Robinson, lower initial power level, and differences in the accumulator size, liquid volume, and pressure. Most importantly, Duke has installed low-leakage SHIELD shutdown seals; therefore, the seal leakage expected for Robinson is significantly less than assumed in the generic NOTRUMP analysis case, which provides ample margin to accommodate the other differences. Specifically, the NRC staff concluded that the licensee could maintain natural circulation flow in the RCS for multiple days during the ELAP event prior to requiring RCS makeup, whereas RCS makeup would be available per the licensee's mitigating strategy within 16 hours.

Therefore, based on the evaluation above, Duke's analytical approach should appropriately determine the sequence of events, including time-sensitive operator actions, and 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, resulting in the potential for increased seal 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.

Generation 3 SHIELD low-leakage RCP seals have been installed on all three RCPs at Robinson. The SHIELD seal incorporates a thermally driven actuator mechanism that is designed to initiate automatically upon a loss of seal cooling. Upon activation, the seals are designed to allow a leakage rate of less than 1 gpm per RCP.

The NRC staff's audit review considered whether the SHIELD low-leakage seals have been credited in Robinson's FLEX strategy in accordance with the four conditions identified in the NRC's endorsement letter of Westinghouse's white paper TR-FSE-14-1-P, "Use of Westinghouse SHIELD Passive Shutdown Seal for FLEX Strategies," dated May 28, 2014 (ADAMS Accession No. ML14132A128). The staff's audit review concluded that the licensee conforms to each condition from the NRC staff's endorsement letter as follows:

> Condition 1: Credit for the SHIELD seals is only endorsed for Westinghouse RCP Models 93, 93A, and 93A-1.

This condition is satisfied because the RCPs at Robinson are Westinghouse Model 93 RCPs.

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

The maximum steady-state RCP seal temperature during an ELAP event is expected to be the RCS cold leg temperature corresponding to the lowest SG safety relief valve setting. Per the Robinson technical specifications, the nominal lift setpoint is 1085 psig, with a ±3 percent tolerance. Therefore, this condition is satisfied, since the saturation temperature at this pressure (with +3 percent tolerance applied) implies an RCS cold leg temperature of approximately 560 °F.

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

Normal operating pressure at Robinson is 2235 psig. Allowing for the possibility of a brief pressure transient directly following the reactor trip, the NRC staff concludes that the licensee's mitigating strategy of cooling the reactor core via the main steam safety valves and SG PORVs will otherwise maintain reactor pressure below 2250 per square inch absolute (psia).

> Condition 4: Nuclear power plants that credit the SHIELD seal in an ELAP analysis shall assume the normal seal leakage rate before SHIELD seal actuation, and a constant seal leakage rate of 1.0 gallon per minute for the leakage after SHIELD seal actuation.

Duke's FIP and supporting calculations assume a constant Westinghouse SHIELD RCP seal package leakage rate of 1 gpm per RCP, plus 1 gpm of unidentified RCS leakage, for a total RCS leakage of 4 gpm. The actual seal leakage rate expected during an ELAP event would exceed this value for a brief period prior to actuation of the SHIELD seal (according to the actuation range specified in TR-FSE-14-1-P, actuation of the SHIELD seal would occur well within one hour of ELAP event initiation). As noted previously, Duke has calculated that reflux cooling would not be entered for multiple days into the event, even if FLEX RCS makeup flow were not provided as planned. In that Duke's mitigating strategy directs RCS makeup to begin approximately 16 hours after event initiation, ample margin exists to accommodate the small additional volume of leakage that is expected to occur prior to actuation of the SHIELD seal.

The seal leakoff analysis assumes no failure of the seal design, including the elastomeric o-rings. During the audit review, Duke confirmed that all installed RCP seal o-rings at Robinson are the high-temperature-qualified 7228-C type, and that only equivalent or better o-rings will be used in the future. Based on these factors, the staff's audit review concluded that o-ring failure for Robinson during a beyond-design-basis ELAP event would not be expected.

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 for analysis of the beyond-design-basis ELAP event.

3.2.3.4 Shutdown Margin Analyses

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

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

to the depressurization of the RCS, which adds negative reactivity

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

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

During the audit, the NRC staff reviewed the licensee's shutdown margin calculation. The licensee has a portable Phase 2 boration strategy employing two trailer-mounted boration skids that consist of an HP FLEX RCS injection pump (60 gpm at 2000 per square inch (psi)), a 1000-gallon tank, 28 55-pound bags of dry boric acid, one electric booster pump, a diesel-driven Hale fire pump to supply the tank, and sufficient hose to allow for various staging areas. Primary and alternate injection pathways to the RCS cold legs are available (i.e., FLEX connections to the Chemical Volume and Control System and SI systems). The licensee determined that this strategy will provide approximately 7000 gallons of 4000 ppm boric acid solution to the RCS; this is sufficient to maintain at least 1 percent shutdown margin in the RCS, even as the RCS cools down and xenon decays.

Toward the end of an operating cycle, when RCS boron concentration reaches its minimum value, some PWR licensees may need to vent the RCS to ensure that their FLEX strategies can inject a volume of borated coolant that is sufficient to satisfy shutdown margin requirements. The licensee's FIP concluded that, because the RCS volume shrinks as it cools down, the required volume of boric acid solution could be injected without having to vent the RCS. The licensee's calculations supporting this conclusion considered a limiting case where the RWST is not damaged. This case was considered limiting because it results in RCS makeup being provided at a reduced boron concentration, as compared to the batching method described above. Thus, the volume of borated coolant required to provide adequate shutdown margin is larger when taking suction upon the RWST, which, for an equivalent pumping capacity, extends the overall time required for boration. The larger required injection volume may further necessitate additional letdown from the RCS, which, depending upon the capacity of the letdown flowpath can significantly extend the overall time required to complete the boration evolution. During the audit, the NRC staff reviewed the basis for the licensee's conclusion and determined that (1) several assumptions made in the licensee's supporting calculations were not adequately justified and (2) RCS venting would likely be necessary for Robinson under limiting conditions. After revising its calculation to address the issues identified by the staff, the licensee agreed that venting the RCS would be necessary under limiting conditions. According to the licensee's procedures, RCS venting would be performed using dc-powered reactor vessel head vents and an associated flowpath that contains a 7/32" orifice to prevent excessive letdown flow rates. The licensee performed calculations to demonstrate that the sequence of events timeline specified in its FIP has sufficient margin to accommodate the additional time required to vent the RCS to support boration to a concentration that would ensure adequate reactor shutdown margin.

The NRC staff's audit review of the licensee's revised calculation identified several issues, including the determination of the volume of liquid injected into the RCS from the accumulators and the calculation of critical flow through the reactor vessel head vent line flow orifice. However, the staff's audit review, which included confirmatory calculations with the TRACE thermal-hydraulic code, found that these issues were overcome by a number of conservatisms in the licensee's calculation, chiefly including (1) the assumption that RCS letdown and makeup would be performed in series, whereas operators would be procedurally directed to carry out these actions simultaneously in an actual event, (2) calculating choked flow under the assumption that fluid in the reactor vessel head would remain saturated, whereas in reality it should experience significant subcooling as the head void is collapsed and the pressurizer refilled, and (3) the use of a conservative RCS temperature for determining the time at which injection of the boric acid solution should be completed. Therefore, the NRC staff concluded that the licensee's mitigating strategy provides sufficient capability for venting the RCS to support boration to ensure adequate reactor shutdown margin.

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

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

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

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

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

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

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

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

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

3.2.3.5 FLEX Equipment and Water Supplies

The FIP described the high pressure portable FLEX pumps for RCS injection. The FIP referenced the PWROG position paper PA-PSC-0965, "Core Team Interim Position on ELAP Core Cooling," Revision 0. This position paper recommends that the required delivery pressure for the RCS FLEX pump be established at 100 psi above the current design basis RCS pressure to allow for RCS injection. The position paper concluded that the required delivery pressure for the RCS injection pump at Robinson is approximately 1886 psia. Accordingly, the portable RCS injection pump is capable of delivering a minimum flow of 60 gpm at a discharge pressure of up to 2000 psig. The two high pressure FLEX portable pumps are available for the Robinson unit and are stored in the PFSB. The FIP also described 2 intermediate pressure portable FLEX pumps, each capable of 300 gpm at 1000 psig. As discussed in Section 3.2.1.1.2, the use of the intermediate portable FLEX pump combination eliminates the need to depressurize the SGs in the event the backup AFW feed capability is needed due to an AFW interruption early in the ELAP transient resulting from a seismic event. As described above in Section 3.2.2, the site has 2 LP portable FLEX pumps, each capable of 600 gpm at 70 psig. The pumps are stored in the turbine building protected from high winds and tornado missiles. The pumps are easily deployable at the CW inlet bay for the SG makeup strategy after high winds and/or tornado missile events.

The FIP described the two portable borated water mixing tanks, which will be stored in the PFSB, as being made available to provide a suction source for the high pressure portable FLEX pumps. The mixing tanks will be transported from the PFSB and positioned near the respective

FLEX pump. Dilution water will be added to the mixing tank by the low pressure FLEX pump from Lake Robinson. Bags of powdered boric acid, which are also stored in the PFSB, will be mixed with the dilution water to achieve concentration of approximately 4400 ppm for maintaining adequate shutdown margin while making up RCS inventory. The maximum boron concentration that will be mixed is below the level at which precipitation concerns occur, even at temperatures down to 32°F.

Section 11.2 of NEI 12-06 states that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. During the audit review, the licensee provided the following FLEX hydraulic calculations to indicate that the above portable FLEX pumps were capable of performing their functions after a BDBEE event:

1. For RCS Makeup, the licensee provided calculations RNP-M/MECH-1880, "Hydraulic Analysis to Support Fukushima FLEX 4.2 Strategy for SIS System," Revision 0 and RNP-M/MECH-1893, "Pressure Drop in EDMG-014, Alternate RCS Boration," Revision 0. These calculations provide analyses on the RCS makeup flow paths needed for Phase 2 and Phase 3 strategies. The calculations indicated flow rates and hose distances from the FLEX pumps needed to provide the necessary makeup to the RCS inventory. Hydraulic analysis of the portable RCS injection pump with the associated hoses and installed piping systems verified that the RCS Injection pump minimum flow rate and head capabilities exceed the FLEX strategy requirements for maintaining RCS inventory.

2. For SG Makeup, the licensee provided calculations RNP-M/MECH-1878, "Hydraulic Analysis to Support Fukushima FLEX 4.2 Strategy for AFW System," Revision 0 and RNP-M/MECH-1896, "Hydraulic Analysis to Support Fukushima FLEX 4.2 Strategy for Supplying Alternate Feed to AFW via the CW System," Revision 0. Both calculations provide analyses on the multiple flow paths for providing SG makeup either through refilling the CST using Lake Robinson and portable FLEX pump or using the FLEX pump taking suction from the CW Inlet Bay. The calculations determined the flow rates and hose distances from the FLEX pumps needed to establish appropriate flow for sustaining the cooling capability to the SGs through the SDAFW or directly in a pipe connection to the SGs. The hydraulic analysis of the portable FLEX pump with the associated hoses and installed piping systems for the CST makeup confirmed that the portable FLEX pump is capable of providing above the minimum required flow rate and head capabilities needed for the FLEX strategy when utilizing Lake Robinson or the CW Inlet Bay as the suction source.

Based on its review of the FLEX pumping capabilities at Robinson, as described in RNP-M/MECH-1880, RNP-M/MECH-1893, RNP-M/MECH-1878, RNP-M/MECH-1896 and the FIP, the staff believes that the licensee has demonstrated that its FLEX portable pumps should perform as intended to support core cooling and RCS inventory control during ELAP caused by a BDBEE, consistent with NEI 12-06, Section 11.2.

Based on its review, the NRC staff concludes that the licensee, if implementation is performed as described, has demonstrated that its FLEX portable pumps are capable of supporting the water make-up to the SGs, RCS, and refilling the CSTs. The available water sources for Phase 2 and 3 FLEX portable pumps are discussed in Section 3.10 of this SE.

3.2.3.6 Electrical Analyses

Robinson electrical FLEX strategies are identical for maintaining or restoring core cooling, containment, and spent fuel pool cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this SE. Furthermore, the electrical coping strategies are the same for all modes of operation.

Once it has been determined that the emergency diesel generators (EDGs) cannot be restarted and off-site power cannot be restored, the Robinson operators would declare an ELAP. In the FIP, the licensee assumes that this determination can be made within 15 minutes after the onset of an ELAP/LUHS event.

According to the FIP, the Phase 1 electrical strategy involves completing a deep dc load shed of non-essential loads on the Class 1E station batteries to extend the dc coping time to 3.75 hours for station battery A and 3.25 hours for station battery B. Load shedding is expected to be completed within 60 minutes from the onset of an ELAP/LUHS event. During the first phase of the ELAP event, Robinson will be relying on the Class 1E station batteries to cope until additional power supplies (i.e., pre-staged FLEX DGs) can be aligned and connected to the Robinson electrical distribution system (Phase 2).

During the audit, NRC staff reviewed calculation RNP-E-6.021, "Load Profile and Battery Sizing Calculation for Battery A," Revision 9, RNP-E-6.020, "Load Profile and Battery Sizing Calculation for Battery B," Revision 9, RNP-E-6.032, "Fukushima FLEX 4.2 Phase 1 – Load Profile Calculation for Battery A and B, Revision 0, and RNP-E-6.023, "Minimum Inverter Voltage Verification," Revision 4, which verified the capability of the dc system to supply the required loads during the first phase of the Robinson FLEX mitigation strategy plan for an ELAP as a result of a BDBEE. The Robinson analysis identified the required loads and their associated ratings (amperage and minimum voltage) and loads that would be shed to ensure battery operation for at least 3.25 hours, which includes the 1-hour for load shedding.

The licensee's Phase 2 strategy includes aligning and placing into service one of two pre-staged 150 kW, 480 Volt (V) ac, 3-phase 60 Hz FLEX DGs located in the seismic Class 1 reactor auxiliary building drumming room to repower battery chargers, safety injection valves, and vital instrumentation. The second permanently pre-staged FLEX DG provides backup capability. The use of a pre-staged (versus portable) FLEX DG is considered an alternative to the conditions endorsed by the NRC in NEI 12-06 Revision 0.
The NRC staff reviewed calculation RNP-E/ELEC-1220, "Diesel Generator Loading Calculation in Support of Electrical FLEX Modification 90617," Revision 0, the FLEX DG manufacturer specification sheets, conceptual single line electrical diagrams, the separation and isolation of the FLEX DGs from the Class 1E emergency diesel generators (EDGs), and procedures that direct operators how to align, connect, and protect associated systems and components. The calculations confirmed that the FLEX DGs should have sufficient capacity and capability to supply the necessary loads following a BDBEE.

For Phase 3, Robinson plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite resources that will be provided by the

NSRC includes a 1-megawatt (MW) 480 VAC 3-phase turbine generator to supply power to either of the two Class 1E 480 VAC buses (emergency bus E1 or E2). Temporary power cables will be deployed from the PFSB to connect the 480 VAC turbine generator to the Class 1E 480 VAC bus through switchgear located in the emergency switchgear room. The switchgear will be connected using a DB50 bus feed adapter developed specifically for this purpose, or by using a pre-fabricated connection that replaces the EDG output current transformer disconnects. The capacity of this generator is of greater capacity than the capacity of the licensee's Phase 2 FLEX DG. Therefore, the Phase 3 turbine generator should have sufficient capacity and capability to supply the necessary loads to maintain or restore core cooling, spent fuel pool cooling, and containment indefinitely following a BDBEE.

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 following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-2 and Appendix D summarizes one acceptable approach for the SFP cooling strategies. This approach uses a portable injection source to provide 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 alternatively 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 to account for overspray). This approach will also provide a vent pathway for steam and condensate from the SFP. The spray capability is not required for SFPs that cannot be drained, due to a substantial portion of the pool being below ground level with no open structures beneath it.

As described in NEI 12-06, Section 3.2.1.7 and JLD-ISG-2012-01, Section 2.1, strategies that have a time constraint to be successful should be identified and a basis provided that the time can be reasonably met. 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 a BDBEE, 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 assume 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 sections below address the effects of a BDBEE on SFP cooling during operating, pre-fuel transfer or post-fuel transfer operations. The effects of a BDBEE with full core offload to the SFP will be addressed in Section 3.11.

3.3.1 Phase 1

The FIP referenced calculation RNP-M/MECH-1590, "Time-to-Boil Curves for the Fuel Pool and Refueling Cavity," Revision 5, which indicated SFP boil-off to 10 feet above the fuel racks will occur at approximately 23 hours after the ELAP occurs (assumes full core offload and 150°F initial conditions). During non-outage conditions, the time to boiling in the pool is significantly longer, typically greater than 45 hours. The initial coping strategy for SFP cooling is to monitor SFP level using instrumentation installed as required by NRC Order EA-12-051.

3.3.2 Phase 2

The FIP stated that the Phase 2 strategy will have the operators initiate SFP makeup at 20 hours after the declaration of ELAP, using the B.5.b pumps (Hale pumps), to draw from Lake Robinson or the discharge canal and makeup to the SFP through several possible locations. The primary draft location is the south end of the Discharge canal. Other back-up locations include any accessible location along the lakeside. Required hose lengths and fittings are pre-staged on hose trailers located in the PFSB. The pump and hose trailer will be towed to the draft point by tow vehicles also protected in the PFSB. The discharge of the pump would be connected to one of two hose connections outside of the spent fuel building in the SFP cooling room. The SFP cooling room is a seismic Class I structure adjacent to the spent fuel building. The FIP described an alternate SFP makeup strategy as the deployment of a hose directly into the pool from the SFP operating deck if the building is accessible. Additionally as required by NEI 12-06, spray monitors and sufficient hose length required for the SFP spray option are located in the PFSB.

3.3.3 Phase 3

The FIP stated that additional high capacity pumps will be available from the NSRC as a backup to the on-site portable pumps.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

Primary and Alternate Connections

The FIP described the primary hose connection for SFP makeup being located in the SFP cooling room. The primary emergency SFP make-up connection is directly inside the door to the SFP cooling room at valve SFPC-742 and designed to accept a 3" hose with a 2 ½" NHT connector. The licensee stated that the use of this makeup connection to the SFP will not require entry into the spent fuel building. The FIP described an alternate Phase 2 strategy for providing makeup water to the SFP, which would be to deploy a hose directly into the SFP from the operating deck. An additional alternate strategy utilizes a spray option to achieve SFP make-up. The 50.54(hh)(2) spray strategy (as required by NEI 12-06 Table D-3 for providing spray at 250 gpm) is to provide flow through portable spray monitors set up on the deck next to the SFP. A hose will be run from the discharge of the portable pump up to the SFP operating deck. From there, the hose may be run directly over the side of the pool or to a portable spray monitor. The spray monitor will spray water into the SFP to maintain water level. All equipment used for the 50.54(hh)(2) spray strategy is portable equipment that is deployed from its storage location in the PFSB.

Based on the location and design of the primary and alternate connections for SFP makeup as described in the FIP, the licensee appears to have demonstrated that at least one connection should be available to support SFP cooling during an ELAP caused by a BDBEE, consistent with Section 3.2.2 of NEI 12-06.

Ventilation

The FIP indicated that the SFP can be vented around the 20 minute mark after an ELAP is declared through the normal SFP personnel door directly to the outside atmosphere without interfering with plant equipment (RAB equipment would not be subjected to steam from the SFP). The SFP building is accessed from the outside through a door at the 275' elevation. There is also a large moveable hatch in the roof of the SFP (used for SFP casks). Either the door or the hatch can be used to vent the SFP. Steam and condensate cannot be vented into the RAB. Robinson ventilation requirements to prevent excessive steam accumulation in the spent fuel building are included in FSGs and direct operators to open the normal access door to the spent fuel building and the SFP roof hatch cover if necessary to establish a steam vent pathway. Airflow through the door and hatch cover provides adequate vent pathways through which the steam generated by SFP boiling can exit the Spent Fuel Building.

Based on the administrative controls to establish ventilation in the spent fuel building before bulk boiling occurs, the relatively long time before the SFP level would approach the top of the fuel racks, the higher prioritization of the strategies which do not require entry into the SFP area, and the availability of personal protective equipment if manual actions are needed, the staff concludes that the proposed ventilation strategy should be sufficient to facilitate the maintenance of SFP cooling following an ELAP-initiating event.

3.3.4.1.2 Plant Instrumentation

In its FIP, the licensee stated that the instrumentation for spent fuel pool level will align with the requirements of Order EA-12-051. Furthermore, the licensee stated that these instruments will have initial local battery power following a BDB event that are capable of powering the level instrumentation for approximately 130-230 hours (see Section 4.2.6 of the FIP). 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 safety evaluation (SE).

3.3.4.2 Thermal-Hydraulic Analyses

Section 11.2 of NEI 12-06 states, in part, that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. In addition, NEI 12-06, Section 3.2.1.6, Condition 4 states that SFP heat load assumes the maximum design-basis heat load for the site. In accordance with NEI 12-06, the licensee performed a thermal-hydraulic analysis of the SFP as a basis for the inputs and assumptions used in its FLEX equipment design requirements analysis. The licensee referenced calculation RNP-M/MECH-1590, "Time-to-Boil Curves for the Fuel Pool and Refueling Cavity," Revision 5, which indicated SFP boil-off to ten feet above the fuel racks will occur at approximately 23 hours after the ELAP occurs (assuming full core offload and 150°F initial conditions). The licensee provided additional evaluations in the calculation to estimate that without operator action following a loss of SFP cooling at the maximum design heat load (full core offload during refueling activities), the SFP will reach 200 degrees farenheit (°F) in approximately 5 hours and boil off to a level 10 feet above the top of fuel in approximately 24 hours from initiation of the event, with the assumption that a nominal initial SFP temperature of 120 °F is reached. During non-outage conditions, the time to boil off to a level 10 feet above the top of fuel is significantly longer, typically greater than 45 hours. Assuming an estimated boil-off rate of approximately 60 gpm, either Hale pump is sufficient to maintain normal SFP level in an ELAP event.

Based on the information contained in the FIP and calculation RNP-M/MECH-1590, the staff verified that the licensee performed an analysis using the maximum design-basis SFP heat load during operating, pre-fuel transfer or post-fuel transfer operations. Therefore, the NRC staff concludes that the licensee has developed guidance through analysis that, if implemented appropriately, should provide the basis for the assumptions and inputs used in determining the design requirements for FLEX equipment used in SFP cooling consistent with NEI 12-06 Section 3.2.1.6, Condition 4 and Section 11.2, and appears to adequately address the requirements of the order.

3.3.4.3 FLEX Pumps and Water Supplies

The FIP described two low pressure portable Hale pumps being used for the SFP makeup strategy. One Hale pump is a 3000 gpm, 100 psig pump, the other Hale pump is a 1500 gpm, 150 psig pump designated as the B.5.b (50.54(hh)(2)) pump. Both Hale pumps are stored in the PFSB. The FIP described the discharge canal as being accessible from the east or west deployment routes. The south end of the discharge canal has a convenient staging area for either Hale pump. It is separated from the lake by a berm and a concrete weir structure at the outlet of the canal. It is 4.2 miles long, 115' wide, and averages 13' deep. Lake Robinson, which is described in Section 3.2.3.1.1 above, is another source of water for deployment of the Phase 2 SFP strategy.

Section 11.2 of NEI 12-06 states that design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented analysis that the mitigation strategy and support equipment will perform as intended. During the audit review, the licensee provided calculation RNP-M/MECH-1886, "Hydraulic Analysis to Support Fukushima

FLEX 4.2 Strategy for Spent Fuel Pool Cooling," Revision 0. The calculation provided analysis of providing makeup to the SFP through the new FLEX connection and direct spray into the SFP. The calculation shows the flow rate and hose distances from the FLEX pumps, in which the suction is coming from the lake and discharge canal.

Based on this evaluation of the FLEX pumping capabilities, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore SFP cooling following a BDBEE consistent with NEI 12-06, Section 11.2, as endorsed, by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.3.4.4 Electrical Analyses

The licensee's OIP and FIP define strategies capable of mitigating a simultaneous loss of all alternating current (ac) power and LUHS resulting from a BDBEE by providing the capability to maintain or restore core cooling (the licensee's strategy for RCS Inventory Control uses the same electrical strategy as for maintaining or restoring core cooling, containment, and spent fuel pool cooling) at the Robinson site. Furthermore, the electrical coping strategies are the same for all modes of operation.

The NRC staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The NRC staff's review is discussed in detail in Section 3.2.3.6.

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 a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.4 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.

In accordance with NEI 12-06, the licensee performed a containment evaluation, RNP-M/MECH-1877, "RNP Extended Loss of AC (ELAP) Power Containment Response", Revision 0, based on the boundary conditions described in Section 2 of NEI 12-06. The calculation concludes that the containment parameters of pressure and temperature remain well below the respective Updated Final Safety Analysis Report (UFSAR) Section 3.1.2.53 design limits of 42 psig and 263 °F for more than 7 days (see Section 3.4.4.2 below for discussion of thermal-hydraulic analyses). 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.

3.4.1 Phase 1

The Phase 1 coping strategy for containment verifies containment isolation per ECA-0.0, "Loss of All AC Power", and monitors containment temperature and pressure using installed instrumentation. Control room indication for containment pressure and containment temperature is retained for the duration of the ELAP. The containment evaluation RNP-M/MECH-1877 indicates the containment pressure and temperature will remain below limits during this time.

3.4.2 Phase 2

The Phase 2 coping strategy is to continue monitoring containment temperature and pressure using installed instrumentation. Phase 2 activities to repower instruments are required to continue containment monitoring.

The containment evaluation RNP-M/MECH-1877 indicates the containment pressure and temperature will remain below limits. The containment temperature will be procedurally monitored. While not expected, if necessary, the containment temperature can be reduced to ensure that key containment instruments will remain within analyzed limits for equipment qualification. Methods for reducing containment temperature are discussed below.

3.4.3 Phase 3

The containment evaluation RPN-M/MECH-1877 indicates that the containment pressure and temperature will remain below limits. Phase 3 coping strategy is to continue monitoring containment pressure and temperature. If required, necessary actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will utilize existing plant systems restored by off-site equipment and resources during Phase 3. The most significant need is to provide 480 VAC power to station pumps and provide for a cooling water source.

Guidance document FSG-012, "Alternate Containment Cooling", Revision 0, provides actions to restore containment cooling to maintain containment pressure and temperature below limits. The Phase 3 coping strategy is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored. This capability will be provided by a 480 VAC portable DG provided from the NSRC to supply power to either of the two Class 1E 480 VAC buses. Additionally, by restoring the Class 1E 480 VAC bus, power can be restored to selected 480 VAC loads.

During the ELAP, it is assumed the service water (SW) pumps are not available. Therefore, Robinson has 4 available FLEX pumps that can be used to supply the SW headers from Lake Robinson through pre-fabricated FLEX connections on the SW strainers. The NSRC will also supply low pressure/high flow diesel driven pumps (up to 5,000 gpm) that can provide flow to existing site heat exchangers in order to remove heat from the containment atmosphere.

The licensee evaluated several options for Robinson to provide operators with the ability to reduce the containment temperature and pressure, which are discussed below.

Ventilation Option

The 480 VAC diesel generator from the NSRC will be aligned to power a Class 1E 480 VAC bus as described above, which will provide power to a reactor containment building cooling, heating and ventilation (HVH) unit. A portable DG can be used to power any one of the 4 site deepwells to supply service water cooling as directed in procedure SPP-038, "Installation, Operation, and Removal of Supplemental Cooling For HVH-1, 2, 3, & 4," Revision 20.

Spray Option

One spray option is to establish water spray within the containment using the containment spray (CS) system from the RWST. The 480 VAC DG from the NSRC will be aligned to power a Class 1E 480VAC bus as described above, which will provide power to the CS pump 480 VAC motor. This spray flow can provide heat removal from the containment atmosphere.

Alternate Spray Option

An alternate spray option is to establish water spray within the containment using the CS system from Lake Robinson in accordance with EDMG-005, Containment Vessel. This strategy assumes portions of the fire water system survives the BDBEE such that fire water can be supplied to the CS Pumps. The fire water system can be supplied using a portable pump from the lake.

The 480 VAC DG from the NSRC will be aligned to power a Class 1E 480 VAC bus as described above, which will provide power to the CS pump 480 VAC motor. This initial spray flow can provide heat removal from the containment atmosphere.

External Spray Option

Guidance document FSG-012, "Alternate Containment Cooling," describes a strategy whereby portable pumps or fire department pumpers are used to spray the exterior of the containment vessel using elevated platforms and fire monitors. This strategy has the potential to extend the time to a containment challenge to as much as 90 days.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

3.4.4.1.1 Plant SSCs

3.4.4.1.1.1 Ventilation Strategy

The ventilation strategy relies on the reactor containment building cooling system, and on the service water system.

Robinson's UFSAR, Section 6.2.2 identifies the reactor containment building cooling system as an engineered safety feature (ESF) system. Individual system components and their supports meet the requirement for Class I (Seismic) structures.

The reactor containment building cooling system cooling water is provided by the service water system.

Robinson's UFSAR, Section 9.2.1 states the service water system is designed to provide cooling water to those components necessary for plant safety. Robinson's UFSAR Section 3.2 identifies the service water system as seismic Class I structure.

3.4.4.1.1.2 Spray Strategies

Since the RWST is not protected against a high wind event, the containment spray option requires that the RWST is intact and has sufficient volume to supply CS pumps. Lake Robinson can be used to replenish the RWST using a portable pump delivering to the RWST Drain FLEX connection at SI-837.

If the licensee determines that the RWST is not intact, an alternate containment spray option utilizes both CS pumps and a portable pump to supply lake water to the CS pumps. Extreme Damage Mitigation Guideline (EDMG)-005, "Containment Vessel (CV)," Revision 8, provides guidance for control of the Containment Vessel (CV). This guidance provides for supplying water to the containment spray system.

The containment spray system is identified in UFSAR section 6.2.2 as an ESF system.

3.4.4.1.2 Plant Instrumentation

Instrumentation providing the following key parameters is credited for all phases of the containment integrity strategy. The licensee states the instrumentation is maintained as described in Section 2.2.6 of the FIP.

- Containment Pressure: Containment pressure indication is available in the main control room (MCR) throughout the event.
- Containment Temperature: Containment temperature indication is available in the Control Room throughout the event.

3.4.4.2 Thermal-Hydraulic Analyses

The calculation used the GOTHIC computer code (Generation of Thermal-Hydraulic Information for Containments), version 8.0. Initial containment pressure is assumed to be 1 psig (15.7 psia). Maximum initial containment temperature is assumed to be 120 °F. The RCS cooldown is assumed to be 75 °F per hour to 42 5°F. After cooldown, RCS is maintained at 425°F.

The model assumed an RCP seal leakage of 1 gpm/pump with an additional gallon-per-minute for unidentified RCS leakage. The RCS makeup is assumed available after 16-hours. For the first 16-hours, all RCS leakage is assumed to be saturated steam. After 16-hours, all RCS leakage is assumed to be saturated liquid. However, RCS makeup is assumed to be available.

The containment pressure spikes to 26.6 psig early in the event. This is a result of RCS water and steam released from the pressurizer PORVs. This release is terminated by RCS cooldown and depressurization. Following the depressurization, the steam is condensed by heat transfer to existing heat sinks reducing the containment pressure.

The results indicate the containment pressure will be 15.7 psig (30.4 psia) at 10 days after the ELAP. Containment design pressure of 42 psig will not be reached until 43 days following the ELAP.

The containment temperature reaches 203°F after 10 days after the ELAP. The containment design temperature is 263°F after 44 days following the ELAP.

3.4.4.3 FLEX Pumps and Water Supplies

The NSRC is providing a high capacity low pressure pump which will be used, if necessary, to provide cooling loads. Available water supplies are the "D" Deepwell, Lake Robinson, or the discharge canal.

3.4.4.4 Electrical Analyses

According to its FIP, Robinson performed an analysis to determine the temperature and pressure increase resulting from an ELAP during a BDBEE. Based on the results of this analysis, required actions to ensure maintenance of containment integrity and required instrumentation function have been developed. The Phase 1 coping strategy for containment involves verifying containment isolation per ECA-0.0, "Loss of All AC Power," and monitoring containment temperature and pressure using installed instrumentation. The licensee confirmed that the FLEX DGs have the necessary capacity to support the necessary equipment during Phase 2 and 3. For Phase 2, the FLEX DGs are required for containment instrumentation. For Phase 3, the 480 VAC NSRC turbine generator can be used to power station pumps, CV HVH Unit 480 VAC motor, and CS pump 480 VAC motor. The NRC staff's review of the licensee's containment electrical analyses did not identify any discrepancies.

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 a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06, Revision 0, 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 site-specific BDBEEs leading to an ELAP and LUHS.

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

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; severe storms with high winds; 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 interim staff guidance in JLD-ISG-2012-01, Revision 0. Coincident with the issuance of the order, on March 12, 2012, the NRC staff issued a Request for information Pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) (ADAMS Accession No. ML12053A340) (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in responses to the requests for information and the requirements for Order EA-2-049 and related rulemaking to address beyond-design-basis external events (see COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated November 21, 2014). The Commission provided guidance in a SRM to COMSECY-14-0037 (ADAMS Accession No. ML15089A236). The Commission approved the staff's recommendations that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly damage the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition.

By letter dated March 12, 2014 (ADAMS Accession No. ML14086A384), supplemented by letters dated May 26, 2015 (ADAMS Accession No. ML15146A390), August 29, 2015 (two letters) (ADAMS Accession Nos. ML15243A077 and ML15244A002), and December 15 2015 (ADAMS Accession No.ML15349A796), the licensee submitted its flood hazard reevaluation report (FHRR). The licensee developed its OIP for mitigation strategies in February 2013 by considering the guidance in NEI 12-06 and its then-current design-basis hazards. Therefore, this safety evaluation makes a determination based on the OIP and FIP, and only notes the possibility of future actions by the licensee when the licensee's flooding reevaluation activities are completed.

Per the 50.54(f) letter, licensees were also asked to provide a seismic hazard screening and evaluation report to reevaluate the seismic hazard at their site. By letter dated March 31, 2014 (ADAMS Accession No. ML14099A204), the licensee completed a seismic hazard screening report (SHSR). By letters dated November 12, 2014 (ADAMS Accession No. ML14325A645) and July 17, 2015 (ADAMS Accession No. ML15201A006), Duke also submitted revisions to its SHSR to include new ground motion response spectra (GMRS) using new geotechnical data and shear-wave testing for Robinson but the NRC staff has not completed a review of these reports. Therefore, this SE makes a determination based on the OIP and FIP, and only notes the possibility of future actions by the licensee when the licensee's seismic reevaluation hazards are completed.

The characterization of the specific external hazards for the plant site is discussed below. In addition, Sections 3.5.1 and 3.5.2 summarizes the licensee's activities to address the 50.54(f) seismic and flooding reevaluations.

3.5.1 Seismic

The licensee stated in its OIP that NEI 12-06 Table 4-2 states that all sites will consider seismic events. Per the Robinson UFSAR, ". . . this site is located in Zone 1 of the Uniform Building Codes' Map and Equal Seismic Probability (UFSAR Section 2.5.2.1.2). Zone 1 is characterized as a zone of light earthquake activity which would result in minor damage. Therefore, on an historical basis, it would appear that the site will not experience damaging earthquake motion during the life of the planned facilities." The dynamic analyses of all seismic Category I structures include the operating basis earthquake (OBE) and safe shutdown earthquake (SSE) with design values of maximum horizontal ground acceleration of 0.1g (UFSAR Section 2.5.2.7) and 0.2g (UFSAR Section 2.5.2.6), respectively.

As previously discussed, the NRC issued a 50.54(f) letter that required facilities to reevaluate the site's seismic hazard (i.e., NTTF Recommendation 2.1). In addition, the 50.54(f) letter requested that licensees submit, along with the hazard evaluation, an interim evaluation and actions planned or taken to address the reevaluated hazard where it exceeds the current design-basis.

In Electric Power Research Institute (EPRI) Report 3002000704 (ADAMS Accession No. ML13102A142), referred to as the Augmented Approach, was developed as the process for evaluating selected critical plant equipment prior to completing plant seismic risk evaluations. The NRC endorsed this report by letter dated May 7, 2013 (ADAMS Accession No. ML13114A949). The Augmented Approach outlines a process for responding to the seismic evaluation requested in the 50.54(f) letter under Recommendation 2.1, "Seismic." The process includes a near-term expedited seismic evaluation process followed by plant risk evaluations in accordance with EPRI Report 1025287 screening, prioritization and implementation details (SPID) (ADAMS Accession No. ML12333A170). This Augmented Approach ensures that FLEX credited equipment (both currently installed and new) would retain function during and after a beyond design basis seismic event using seismic margins assessment criteria, by calculating a High Confidence of Low Probability of Failure (HCLPF) seismic capacity and comparing that to the seismic demand of a Review Level Ground Motion (RLGM), capped to two times the SSE from 1 to 10 Hz. By letter dated October 6, 2015 (ADAMS Accession No. ML15201A602), the NRC staff acknowledged its review of the Robinson Expedited Seismic Evaluation Process (ESEP) interim action was implemented consistent with the endorsed ESEP guidance.

By Letter dated July 17, 2015 (ADAMS Accession No. Ml15201A006), the licensee submitted a revision to the SHSR entitled "Include New Ground Motion Response Spectra (GMRS) Using New Geotechnical Data and Shear-Wave Testing." In that report, the licensee stated that Robinson screens in for risk evaluation, a spent fuel pool evaluation, and a high frequency confirmation. The revision to the SHSR also stated that due to limited availability of data on dynamic material properties at the Robinson site, site investigations were performed in 2014 to obtain dynamic material properties including shear wave velocity profiles. New shear wave velocities were obtained using the P-S suspension seismic velocity logging and Spectral Analysis of Surface Waves (SASW). Site-specific shear modulus degradation and damping curves were developed. Using the results of the new site investigations, a new GMRS was developed for the Robinson site. The new GMRS revealed that seismic hazard at the Robinson site is not as high as previously determined in the March 2014 submittal. The NRC staff documented its review of the licensee's hazard information in letter dated October 19, 2015 (ADAMS Accession No. ML15280A199) and concluded that the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF Recommendation 2.1: "Seismic".

By letter dated October 27, 2015 (ADAMS Accession No. ML 15194A015), the NRC staff provided seismic probabilistic risk assessment (SPRA) submittal dates for sites that will submit an SPRA, including Robinson. Robinson's SPRA submittal date is March 31, 2019. As clarified in Footnote 2 of Table 1a, SPRAs will assess the effects of high frequency exceedance on plant equipment. Therefore, as indicated in Table 1a, Robinson will not perform an independent high frequency limited scope evaluation. Robinson will perform a limited scope evaluation of the SFP. The submittal date for the SFP evaluation is December 31, 2016.

As the license's seismic reevaluation activities are completed, the licensee will enter appropriate issues into the corrective action program. The licensee has appropriately screened in this external hazard and identified the hazard levels for reasonable protection of the FLEX equipment.

3.5.2 Flooding

The licensee stated in its FIP, that the flood hazard is not applicable to Robinson since the plant is built above the design basis flood level. As stated in the Robinson UFSAR Chapter 2, Sections 2.4.2 and 2.4.4, the maximum flood elevation is 222 ft. while the grade level is 225 ft. Per NEI 12-06 (Section 6.2.1), Robinson is classified as a dry site and the external flood hazard is, therefore, not applicable. Additionally, the licensee stated that since the site is not located on an estuary or open coast, surge flooding is not a concern. Tsunami flooding is not a concern for the site because of its inland location.

However, the licensee submitted its FHRR, as noted above in Section 3.5. The licensee stated that the FHRR shows that some flood levels exceed the current licensing basis (CLB) levels. The increased levels are the results of methodologies and guidance which are applicable to new reactor reviews and typically exceed the methodology and guidance used to establish the CLB for existing plants.

By letter dated December 23, 2015 (ADAMS Accession No. ML15357A064), the NRC staff issued an interim hazard letter summarizing the results of the hazards review. In the letter, the staff described the beyond-design-basis reevaluated flood hazards that exceed the current design-basis for Robinson as: local intense precipitation; streams and rivers; failure of dams; storm surge and seiche. The NRC staff concluded that Robinson's reevaluated flood hazard information is a suitable input for other assessments associated with Near-Term Task Force Recommendation 2.1 "Flooding." The NRC staff plans to issue a staff assessment documenting the basis for these conclusions at a later time

The Licensee is expected to closeout NTTF 2.1 activities via a Focused Evaluation by June 2017 or an Integrated Assessment by December 2018.

The licensee stated that the flood walkdowns verified that the flood protection systems for Robinson are available, functional and implementable and if necessary, any degraded nonconforming flood protection features were entered in Robinson's corrective action program.

Section 5 of the FHRR, provides a discussion of the interim evaluation and actions taken or planned to address the higher flooding levels, resulting from a Local Intense Precipitation (LIP) and a Probable Maximum Flood (PMF), relative to the CLB flood levels. The FHRR interim actions do not adversely affect any existing site structures, systems or components. Procedures have been prepared and training performed for the flooding interim actions as follows:

- Severe Weather Procedure has been revised to include guidance, based on tainter gate operating limits being met and an ensuing major storm to safely shut down the plant. If a known major storm is heading toward the plant, the conservative decision making process of the Unit Threat Team will ensure a safe plant shutdown prior to the main flooding event for adequate core decay heat removal. Temporary equipment could then be utilized as needed. Additionally, Severe Weather Procedure has been revised to plug the drain lines at the "D" Deepwell pump enclosure to ensure its availability as a long term source.
- Revised tainter gate operating procedure to activate the Unit Threat Team when preset limits are reached.
- Developed and implemented procedures to pre-stage equipment capable of filling the steam generator and the SFP after the plant is shutdown.
- For SFP cooling, existing procedures will be utilized to fill the SFP. The necessary equipment will be available above the flood elevation to ensure that sufficient water is supplied to the SFP from the refueling water storage tank (RWST) or alternate source.
- For RCS inventory and boration, a safe shutdown within 24 hours prior to the main flooding event will ensure that RCS boration will be accomplished. Thereafter, for RCS inventory control, the new high pressure, portable diesel-driven pump will be available for use after the flood recedes per new procedures.
- Implemented new procedures that inject borated water into the RCS, using portable temporary equipment, as needed. Training on the use of the Portable RCS Boration equipment has been completed.
- Procedures have been revised and addresses pre-staging a new pump above the expected flood elevation to provide AFW to the steam generators from the CST.

These actions will enhance the current capability to maintain the plant in a safe condition during the beyond-design-basis extremal flooding events that exceed the CLB flood levels and as a result, continued plant operation does not impose an imminent risk to the public health and safety while completing the Integrated Assessment.

As the licensee's flooding reevaluation activities are completed, the licensee will enter appropriate issues into the corrective action program. The licensee has appropriately screened in this external hazard and identified the hazard levels for reasonable protection of the FLEX equipment.

3.5.3 High Winds

The licensee stated in its FIP that current plant design bases address the storm hazards of hurricanes, high winds and tornados. The high wind hazard is applicable for Robinson. Robinson is located in Darlington County, SC with coordinates Latitude 34° 24' 02" N, Longitude 80° 09' 05" W (UFSAR Section 2.1.1.1). Peak-gust wind speed, per NEI 12-06 Figure 7-1, is 170 mph. Tornado design wind speed per NEI 12-06 Figure 7-2, Block #172 (Region 1) is 200 mph. These values indicate that Robinson has the potential to experience severe winds from hurricanes and tornadoes with the capacity to do significant damage, which are generally considered to be winds above 130 mph as defined in NEI 12-06 Section 7.2.1.

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

The licensee stated in its FIP, that Robinson is located in Darlington County, SC with coordinates Latitude 34° 24' 02" N, Longitude 80° 09' 05" W (UFSAR Section 2.1.1.1). Robinson is located below the 35th parallel. Per NEI 12-06, Figure 8-1, Robinson is in an area corresponding to "low to significant snow accumulations" and "low temperatures." The area represents a record snowfall that is approximately 18-25 inches accumulation over three days. Such snowfalls are considered unlikely to present a significant problem for deployment of FLEX equipment. Robinson is not required to address extreme snowfall. Per NEI 12-06, Figure 8-2, Robinson is located in a Level 5 area, which is characterized as "Catastrophic destruction to power lines and/or existence of extreme amount of ice." Robinson is required to consider the adverse effects of ice on the deployment of FLEX equipment.

In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the plant site does experience significant amounts of 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

The licensee stated in its FIP, that extreme high temperature hazard is applicable for all sites in the United States based on NEI 12-06 Section 9.2. Virtually every state in the lower 48 contiguous United States has experienced temperatures in excess of 110°F and many in excess of 120 °F. Robinson will consider the impacts of extreme high temperature conditions of 130 °F on the procurement, storage, and deployment of FLEX equipment.

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 appears to adequately address the requirements of the order.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

The licensee stated in its FIP that the PFSB is a single robust/hardened structure, which is sized to facilitate the storage, maintenance, and deployment of portable FLEX equipment and equipment/vehicles necessary for use of the N+1 FLEX equipment as Phase 2 flexible coping strategies. The PFSB is classified as an uninhabited structure and is intended to function as a storage facility for equipment which will be deployed following a BDBEE. The building is designed to withstand the Robinson hazards as described below. The licensee also stated that some equipment (e.g., DGs, and some pumps) will be stored (pre-staged) in the RAB, or the turbine building (TB) and protected from seismic, high winds (TB only) and extreme temperatures.

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

3.6.1.1 Seismic

The licensee stated in the FIP that the PFSB is designed to withstand the Robinson hazards described above in Section 3.5.1. The PFSB is located at the northern most location within the owner controlled area (OCA). The licensee also stated that the PFSB was designed and constructed under Engineering Change (EC) 290625. During the on-site audit, the staff reviewed the EC and verified that regarding seismic interactions, equipment will be secured with tie downs with a capacity of 10,000 lbs. to prevent sliding and overturning, and the max load from FLEX equipment is 9,000 lbs. The floor anchors are rated at 17,000 lbs. Two FLEX DGs will be stored in their deployed positions in the seismic Category I RAB near the battery chargers. The DGs will be seismically mounted to restrict movement during seismic events.

3.6.1.2 Flooding

As noted in Section 3.5.2 above, the Robinson site is not subject to flooding and as such, no flood protection is currently required for FLEX equipment. The PFSB is protected from flood events. However the licensee stated that the FHRR shows that some flood levels could exceed the CLB levels, as noted above in Section 3.5.2. Additionally, Section 5 of the FHRR provides a discussion of the interim evaluation and actions taken or planned to address the higher flooding levels relative to the CLB flood levels.

3.6.1.3 High Winds

The licensee stated in its FIP, that the PFSB is designed to withstand the Robinson hazards described above in Section 3.5.3. During the on-site audit, the staff reviewed the EC and verified that the PFSB will be is designed in accordance with American Society of Civil Engineers 7-10 for high winds.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

The licensee stated in its FIP that the PFSB is designed to withstand the Robinson hazards described above in Sections 3.5.4 and 3.5.5, including snow, ice and extreme cold and heat conditions. During the on-site audit, the staff reviewed the EC and verified that the PFSB building heating, ventilation, or air conditioning (HVAC) system is designed to maintain a minimum temperature of 40 °F and a max temp of 110 °F.

3.6.2 Reliability of FLEX Equipment

In the FIP, the licensee provided a table listing all of the equipment required for each strategy requiring portable equipment, (RCS cooling pumps, RCS boration portable tanks and inventory control pumps, instrumentation repowering DGs, SFP cooling pumps, and Phase 3 electrical power generators). For the reactor core cooling strategy this includes; 2 diesel driven low pressure pumps (600 gpm at 20-75 psig), 2 diesel driven intermediate pressure Hale pumps (300 gpm at 1000 psi). For the RCS boration and inventory control strategy, this includes two trailer mounted high pressure boration units that consist of; one diesel driven high pressure positive displacement pump (60 gpm at 2000 psi), one mixing tank (1000 gal), one electric booster pump to support the high pressure pump net positive suction head (NPSH) with associated 6 Kw DG, and one diesel driven Hale fire pump to supply the water to the 1000 gallon tank. For the electrical instrumentation power strategy this includes two pre-staged diesel driven generators (150 KW), two sets of cables stored on K-Karts, installed receptacles/breakers on each battery charger pre-staged in the reactor auxiliary building. For the SFP cooling strategy this includes two diesel driven Hale fire pumps (1500 gpm and 3000 gpm at 250 psig), which are dual purpose for the boration strategy. The table also includes appropriate length of hoses for each strategy, Fluke multi-meters, Yeti inverter power packs, instrument probes, and cables. Each of the above FLEX equipment for the respective SG, RCS, and SFP makeup strategies were ordered in sets of two to satisfy the N+1 requirement of NEI 12-06. All of the N+1 equipment as described above is stored in the FLEX Building, with the exception of two low pressure FLEX pumps which are pre-staged in a protected area in the turbine building for the SG makeup strategy after a high wind/missile event.

3.6.3 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 appears to adequately address the requirements of the order.

3.7 Planned Deployment of FLEX Equipment

The licensee stated in its FIP that pre-determined, preferred haul paths have been identified and documented in the FSGs. Figure 1 of the FIP shows the haul paths from the PFSB to the various deployment locations. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

3.7.1 Means of Deployment

The deployment of onsite FLEX equipment to implement coping strategies beyond the initial plant capabilities (Phase 1) requires that pathways between the PFSB and various deployment locations be clear of debris resulting from seismic, high wind (tornado) events. The stored FLEX equipment includes a CAT 924K front end loader to move or remove debris from the needed travel paths. Pumps, DGs, boration units and hose trailers will be deployed by tow vehicles also protected in the PFSB.

Robinson procedure AP-053, "Severe Weather Response," includes the following activities that are performed prior to the arrival of severe winter weather regarding mitigating an ice event:

- Keep at least two volunteers, who are certified to operate heavy equipment, onsite during and after the storm.
- Prepare salt and sand supplies for road and sidewalk application both inside and outside the protected area.
- Coordinate staff for snow and ice removal both inside and outside the protected area.
- Coordinate staff for tree removal along plant access road.
- Ensure maintenance vehicles are gassed up (i.e., trucks, groves, forklifts).
- Contact the Darlington County Department of Roads and Bridges to coordinate clearing the roads and highways to the plant.

The above listed actions will prepare the site for mitigating the impact of snow and ice on deployment of FLEX strategies.

Security doors and gates that rely on electric power to operate opening and/or locking mechanisms can be overridden by manual key locks; all operators and security personnel carry the required key to open all doors and gates.

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

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities, such as fuel and supplies. Transportation of these deliveries can be through airlift or via ground transportation. Debris removal for the pathway between the site and the NSRC receiving location (Staging Area 'B') and from the various plant access routes may be required. The same debris removal equipment used for on-site pathways will be used to support debris removal to facilitate road access to the site.

3.7.2 Deployment Strategies

For the AFW makeup strategy, Lake Robinson provides an indefinite supply of water, as make-up to the CST for supply to the SDAFW pump or directly to the suction of the portable diesel driven FLEX pump. Lake Robinson will remain available for any of the applicable external hazards. Additionally, the discharge canal will also remain available for any of the external hazards listed in Section 2.5. Figures 2 and 3 of the FIP provide a diagram of the flowpath and equipment utilized to facilitate use of these water supplies.

A portable, diesel driven Hale pump will be transported from the PFSB to a location near the selected water source. A flexible hose will be routed from the pump suction to the water source where water will be drawn through a strainer sized to limit solid debris size to prevent damage to the SDAFW or the Hale pump. A flexible hose will be routed from the Hale pump discharge to the CST FLEX connection or to the suction of the SDAFWP. Water from the selected water source can also be pumped to the SFP. Water from the selected water source (Lake Robinson or the discharge canal) can also be pumped to the SFP. The alternate Hale pump discharge connection is located within the seismic Category I RAB motor-driven auxiliary feedwater pump (MDAFWP) room. The connection is protected from the external hazards as defined in NEI 12-06.

The primary method of boration and inventory control is to use a portable high pressure, low volume pump connected directly to the charging lines or safety injection headers from the RWST or a portable tanker containing borated water. One of the two portable high pressure boration units, stored in the PFSB will be deployed to the yard location outside the RAB. Water supply hoses will be routed to the boration units from the discharge canal or Lake Robinson, or a closed drain valve at the base of the RWST if available. Supply hoses will be routed into the RAB to the noted connection points to support this function.

For the electrical strategy, two FLEX DGs will be stored in their deployed positions in the seismic Class I RAB drumming room.

During the audit process, the licensee provided information which noted that, based on the conclusions of the native soil in the AMEC subsurface Investigation report in Attachment Z07 as well as the haul route evaluation in attachment Z08, the haul route and the underground utilities are acceptable and can withstand vehicle loadings. In addition, according to Z07, the existing soil is adequate to support live loads of 300 pounds per square feet (psf) which envelopes the live wheel loading of a HS 20-44 vehicle. The AMEC subsurface investigation report concludes the Robinson site soil as a whole is not liquefiable during a seismic event. The licensee stated in its FIP, that deployment pathways and haul routes were evaluated for liquefaction and remediation was not required. In addition, the licensee determined that the deployment pathways and haul routes are stable following a seismic event. The NRC staff reviewed the licensee's evaluation and verified that following a seismic event the haul routes should remain stable to deploy FLEX equipment.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

For AFW makeup connections, a portable, diesel driven Hale pump will be transported from the PFSB to a location near the selected water source. A flexible hose will be routed from the pump suction to the water source (Lake Robinson or the discharge canal) where water will be drawn through a strainer sized to limit solid debris size to prevent damage to the SDAFW or the Hale pump. A flexible hose will be routed from the Hale pump discharge to the CST FLEX connection or to the suction of the SDAFWP, located in the turbine building (TB) Class 1 bay (seismically protected area) and are protected from high wind and tornado missile hazards.

The primary AFW FLEX tee connection is at the SDAFWP discharge piping. Access to this primary connection is through the seismically qualified TB Class 1 bay. This pre-staged seismic strategy can provide SG feed within approximately 23 minutes, well within the 61 minute dry-out time, and is a portable backup to the SDAFWP. The alternate AFW pump discharge connection (EC 90623) adds an alternate mechanical FLEX connection inside the MDAFWP room on line 4-AFW-23, upstream of AFW-54. The MDAFWP room is in the RAB and is protected against applicable Robinson hazards. The MDAFWP room can be accessed from the outside through the seismically protected RAB hallways.

For the high wind hazard, a portable low pressure diesel pumper will be staged in the TB protected by the turbine pedestal structure and easily deployable at the CW inlet bay. The Phase 2 wind/missile strategy for AFW supply will connect the pre-staged pumper to the CW inlet bay FLEX connection and discharge directly to the suction of the SDAFWP downstream of isolation valve, or to the CST Drain FLEX connection.

For RCS makeup, the primary RCS injection pump discharge connections are located inside the RAB in the charging pump room and provide a path to the RCS through the charging system. Accordingly, these connections are protected against the beyond-design-basis (BDB) hazards as defined in NEI12-06. The alternate RCS injection pump discharge connections are located inside the RAB in the SI pump room and provide a path to the RCS through the SI system. Accordingly, these connections are protected against BDB hazards as defined in NEI12-06.

For SFP makeup, the primary and alternate Hale pump discharge connections are located within the seismic Category I SFP cooling room. The connection is protected from the external hazards described in NEI 12-06.

3.7.3.2 Electrical Connection Points

According to its FIP, the licensee has made modifications to facilitate the electrical connections required to repower the vital battery chargers from the FLEX DGs. For Phase 2, this will be accomplished by routing power from one of the two pre-staged FLEX DGs located in the RAB drumming room, which is a seismic Class I structure that is protected from all applicable extreme external hazards. Power from the FLEX DGs can be routed through an attached output breaker to one of two distribution panels located in the drumming room. Similar electric cables stored in the drumming room will be routed from either distribution panel, out the propped open door and down the hall to the boric acid batching tank room. Cables stored in the batching tank room will be connected to the cables from the distribution panels and routed through another door into the vital battery room, where they will be connected to either battery charger for each battery (A or A1, and B or B1 battery charger).

For Phase 3, temporary power cables will be deployed from the PFSB to connect the 480 VAC turbine generator to the Class 1E 480 VAC bus through switchgear located in the emergency switchgear room. The switchgear will be connected using a DB50 bus feed adapter developed specifically for this purpose, or by using a pre-fabricated connections that replace the EDG output current transformer disconnects

3.7.4 Accessibility and Lighting

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

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

Regarding lighting, the licensee stated in its FIP that upon loss of ac power, plant lighting is provided by 8 hour battery packs and by vital batteries A and B. The vital lighting in the control room will be restored by providing power back to the battery chargers, as described above. When Appendix R light batteries are depleted, portable lighting will be used in areas of the plant necessary for event mitigation. That lighting will be stored in the PFSB. All battery powered portable equipment will be supported by battery tenders during storage. Additional portable lighting and generators have been procured to facilitate implementation of FLEX strategies. The additional portable lighting units will reduce human error and increase safety during a BDBEE event. The additional portable lighting will augment battery powered head and hand lamps, and will need to be coordinated with each FLEX strategy's needs using a toolbox approach for deployment. The following areas at a minimum will require portable area lighting:

- Drumming room
- RAB 2nd floor hallway
- Charging pump room
- Battery room
- E1/E2 room
- SFP/RWST area

- Emergency diesel generator (EDG) rollup door area
- Radwaste Building area to access fuel oil supplies
- Radwaste Building area to stage Phase 3 generators
- Intake Structure (Phase 3)
- AFW and CST areas
- Permanent FLEX Storage Building

The licensee stated that the strategy for getting power restored to other critical lighting areas in Phase 3 is by modifying the current 480 VAC switchgear E1 and E2. The NSRC will supply 3 additional diesel lighting towers after approximately 24 hours.

3.7.5 Access to Protected and Vital Areas

The licensee stated in its FIP that security doors and gates that rely on electric power to operate opening and/or locking mechanisms can be overridden by manual key locks, and that all operators and security personnel carry the required key to open all doors and gates. The security force will initiate an access contingency upon loss of the security diesel and all ac/dc power as part of the security plan. Access to the OCA, site protected area, and areas within the plant structures will be controlled under this access contingency as implemented by security personnel.

3.7.6 Fueling of FLEX Equipment

The licensee stated in its FIP that the FLEX strategies for maintenance and/or support of safety functions involve several elements including the supply of fuel to necessary diesel powered generators, pumps, hauling vehicles, and compressors. The general coping strategy for supplying fuel oil to diesel driven portable equipment, i.e., pumps and generators, deployed to cope with an ELAP / LUHS, is to draw fuel oil out of any available existing diesel fuel oil tanks on the Robinson site. While Robinson has several onsite fuel oil storage tanks, including the diesel fuel oil storage tanks (DFOST), alternate fuel oil storage tanks (AFOST), Unit No. 1 fuel oil storage tanks, and dedicated shutdown DFOST, not all are protected from all external hazards.

Additionally, the licensee stated in its FIP that Robinson has two 500 gallon fuel pumping trailers that can be used to retrieve fuel oil from all tanks on site and deliver to the FLEX equipment staged in various plant locations. The portable tankers will be stored with approximately 800 gallons of diesel fuel in the PFSB. FLEX connections are provided to allow connectivity to the onsite fuel pumping trailers from the DFOST, the alternate fuel tank "A" and alternate fuel tank "B". The alternate fuel oil tanks can also be accessed from each EDG room emergency day tank fill connections. Hoses enable compatibility between the onsite fuel vehicles and the fuel oil storage tanks' access points. Assuming a seismic event, there is an available volume of 19,800 gallons in the DFOST and portable FLEX fuel oil tankers #1 and #2 (both stored in the PFSB, which is protected from all hazards). This is sufficient to supply operating diesel driven FLEX equipment for approximately 11 days. Assuming a high wind/missile event, there is an available volume of 5,264 gallons in the AFOST A and AFOST B (protected in the robust radwaste building) and portable FLEX fuel oil tankers #1 and #2 (both stored in the PFSB, protected from all Robinson hazards). This is sufficient to supply operating diesel driven FLEX equipment for approximately 3 days. An analysis to determine the fuel consumption rate of all portable generators/equipment is presented in the FIP. The staff reviewed the licensee's fuel consumption analysis to verify that the proposed portable FLEX equipment deployed for FLEX strategies will remain fueled throughout the duration of the ELAP event.

3.7.7 Conclusions

The staff verified the planned deployment of FLEX equipment by reviewing procedures and walking down haul routes during the onsite audit. Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow deploying the FLEX equipment following a BDBEE consistent with NEI 12-06 guidance as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.8 Considerations in Using Offsite Resources

3.8.1 Robinson SAFER Plan

The industry established two regional (Memphis and Phoenix areas) response centers designated the NSRCs to support utilities during BDBEE. Duke has established contracts with the Pooled Equipment Inventory Company (PEICo) to participate in the process for support of the NSRCs, as required. Each NSRC will hold five sets of equipment, four of which will be able to be fully deployed when requested, the fifth set will have equipment in a maintenance cycle. In addition, on-site BDBEE equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

By letter dated September 26, 2014 (ADAMS Accession No. ML14265A107), the staff issued its staff 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.

3.8.2 Staging Areas

The licensee stated in its FIP that, in the event of a BDBEE and subsequent ELAP/LUHS condition, equipment will be moved from an NSRC to a local assembly area established by the SAFER team. For Robinson, the local assembly area is the Florence Regional Airport (Staging Area "C"). From there, equipment can be taken to the Robinson site and staged at Staging Area 'B' (outage parking lot on SC highway 23) or the PFSB by helicopter, if ground transportation is unavailable. Communications will be established between the Robinson plant site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. The order at which equipment is delivered is identified in the SAFER Response Plan for Robinson.

3.8.3 Conclusions

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

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Upon loss of ac power, no HVAC systems are available. The licensee developed calculation NAI-1809-001, "RNP-2 Reactor Auxiliary Building Extended Loss of AC Power FLEX Response," Revision 0, to analyze the Robinson RAB heatup and cooldown responses in summer and winter months in an ELAP condition. The calculation uses the GOTHIC version 8.0 computer program. The calculation was owner reviewed in EC 99569. The majority of room/area temperatures remain below a value of 110 °F during the 7-day transient. A dry bulb temperature of 110 °F is notable in that it is part of the control room habitability guidelines used for station blackout and adopted for ELAP.

Heat loads for the analyzed rooms accounted for FLEX portable lighting, heat loads from equipment energized from FLEX portable generators, and six full-time operators in the control room. As part of FLEX strategies, two diesel generators will be installed, with a dedicated HVAC cooling system, in the drumming room of the RAB.

Several rooms/areas exceed the uppermost habitability temperature limit, 110 °F, during the 7-day transient. Guideline FSG-005, "Initial Assessment and FLEX Equipment Staging," directs an evaluation of rooms requiring access and list the available ventilation and heating equipment stored in the PFSB. Therefore, when personnel access to these rooms/areas is required, a toolbox approach to temperature control and access will be employed using door openings, fans, portable blowers, portable HVAC units, and limited stay-times as necessary. Upon room/area temperatures exceeding 110°F, the toolbox approach will be utilized to provide personnel access as necessary.

In its FIP, Robinson states that the GOTHIC model showed the maximum temperature in the MCR at the end of 7 days is 110 °F. Procedure ECA-0.0, "Loss of All AC Power – ELAP," Rev. 1 directs the opening of all Control Room and Hagan Room cabinets within 30 minutes after the beginning of an event, as well as opening all control room and hagan room doors to the outside based on habitability judgment by the operators. Based on temperatures remaining below 120°F (the temperature limit, as identified in NUMARC-87-00, for electronic equipment to be able to survive indefinitely), the staff finds that the equipment in the MCR will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

In its FIP, Robinson states that the GOTHIC model showed the battery room temperature remains at or below 110 °F for the first 26 hours, then remains below 120 °F for the remainder of the 7-day transient. The battery room doors will be opened early in the transient (2-3 hours) to route cables to power the battery chargers and remain open until the recovery phase. The licensee plans to restore normal battery room ventilation during Phase 3. The fans would draw air as designed through the battery room and the room temperatures would trend toward the ambient air temperature of the auxiliary building interior. As a result of its review, the NRC staff did not identify any issues with ventilation of the battery rooms.

3.9.1.2 Loss of Heating

Calculation NAI-1809-001, Revision 0, also analyzed the effect of cold weather during an ELAP. The calculation assumes the rooms analyzed are at minimum normal room temperature (60°F) at the start of the event.

The Control Room/Relay Room starts at 60 °F and drops to 40°F in 24-hours. The motor driven auxiliary feedwater pump room remains above 32°F for at least 100-hours. The safety injection and containment spray pump room remains above 32 °F for the first 36-hours. The A and B diesel generator rooms will drop below freezing in less than 12-hours.

During the audit review, the licensee identified the main steam line pressure transmitters and diesel fuel oil lines as being vulnerable to cold weather in FLEX strategies. The licensee referenced OP-925, "Cold Weather Operation", which includes strategies to be employed when temperatures are expected to be below 42°F. FLEX strategies include the purchase and storage of at least two portable electric heaters and commodities to restore freeze protection as described in Attachment 10.13 of OP-925. The licensee also plans to utilize at least 8 portable FLEX 6 KW generators and two portable FLEX 92 KW generators capable of re-powering electric heaters that will be deployed throughout the site. The staff walked down the location of the main steam line pressure transmitters and diesel fuel oil lines and the FLEX equipment to be used for those locations. The current FLEX strategy allows for the licensee to deploy the associated FLEX equipment after 6 hours to provide heating to these locations for long term functionality during cold weather.

The battery rooms are in the interior of the auxiliary building and the battery rooms are normally maintained at approximately 77°F. In the event of an ELAP, the battery room temperatures are expected to rise with loss of ventilation, which is verified in calculation NAI-1809-001, "RNP-2 Reactor Auxiliary Building Extended Loss of AC Power FLEX Response," Revision 0. Therefore, reaching the minimum pilot cell temperature limit of 65°F is not expected. Based on its review of the licensee's battery room assessment, the NRC staff concludes that Robinson's safety-related batteries should perform their required functions at the expected temperatures as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

The staff reviewed Robinson calculation, NAI-1809-001, "RNP-2 Reactor Auxiliary Building Extended Loss of AC Power FLEX Response," Revision 0, to verify that hydrogen gas accumulation in the 125 VDC Vital Battery rooms will not reach combustible levels while HVAC is lost during an ELAP as a result of a BDBEE. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. As stated in the FIP, the licensee's ventilation strategy is to open battery room doors early during the ELAP event (2-3 hours) to route cables to power the battery chargers. After this time, the doors will remain open eliminating any hydrogen buildup in the room. During Phase 3, battery room exhaust fans are repowered when portable FLEX NSRC diesel generators are deployed to power E1 or E2. Robinson calculated that hydrogen concentration remains below 1 percent 7 days into the event.

Based on its review of the licensee's calculation and battery room ventilation strategy, the NRC staff concluded that hydrogen accumulation in the Robinson safety-related battery room should not reach the combustibility limit for hydrogen (4 percent) during an ELAP as a result of a BDBEE since the licensee plans to open battery room doors early into the event and repower the battery room exhaust fans during Phase 3.

3.9.2 Personnel Habitability

Heat up calculations indicate that actions are not required before the Emergency Response Organization (ERO) is manned. Once the ERO is manned, temperature control and access will be employed by using open doors, spot coolers and stay times as needed. In addition, the licensee will utilize FLEX portable ventilation fans and portable generators to ventilate areas that require access. Robinson also has a heat stress program described in procedure AD-HS-ALL-0106, "Heat and Cold Stress."

As discussed above, a similar approach will also be used during cold weather. In addition to opening doors and using portable fans, portable heaters will also be available. Portable HVAC equipment will be stored in the permanent FLEX storage building.

3.9.2.1 Main Control Room

The licensee's calculation indicates that the Control Room will remain below 100 °F for the first 72 hours. It remains below 110 °F for the 7 days evaluated. Guidance document EPP-1, "Loss of All AC Power", revision 51, provides guidance to monitor the control room temperature. Mitigating actions are provided in case the control room temperature becomes uncomfortable.

3.9.2.2 Spent Fuel Pool Area

Licensee performed calculation NAI-1809-003, "H B Robinson Spent Pool Pit and Panel Enclosed Area GOTHIC Heat Up Model and ELAP Analysis", Revision 0. The calculation assumes a constant maximum heat load as indicated in UFSAR, Revision 23, Table 9.1.3-1. Initial room temperature is assumed to be 104°F, 50 percent relative humidity (rh). The calculation assumes no operator actions to establish ventilation pathways.

Spent fuel pool (SFP) operating floor exceeds 120 °F at approximately 1-hour into the ELAP. It remains at approximately 120 °F until 6-hours. From 6 to 8-hours into the event, the temperature ramps to 125 °F. The SFP operating floor temperature reaches 198 °F at approximately 9-hours into the ELAP. The SFP room humidity approaches 100 percent rh at roughly 5-hours into the event. The timeline for SFP heat up is such that all FLEX activities can be performed before the pool starts to boil and access to the SFP is not required after FLEX deployment. However, to mitigate a harsh environment, the SFP has one access door to the outside and a rolling roof hatch that can be opened to allow ventilation.

3.9.2.3 Other Plant Areas

The licensee stated that the SDAFW pump is located in an open environment in the TB and is not susceptible for extreme high temperatures that would impede its operation during an ELAP. The licensee also indicated that portable air blowers could be made available to the location if needed for air movement in extreme external high temperature days. The staff walked down the location of the SDAFW pump with plant personnel and confirmed that the SDAFW pump is in an open environment in the TB.

Calculation NAI-1809-002, "H B Robinson New Fuel Storage Building GOTHIC Room Heat Up Model and ELAP Analysis," Revision 0, shows the platform areas remaining below 110 °F for roughly 5 days following the ELAP.

To support ventilation needs, the licensee has six fan ventilators, eight portable diesel generators, one HVAC trailer with two, five-ton cooling capacity HVAC units, and an electric generator, and an assortment of portable duct work and connectors. These will be used as a toolbox approach to support FLEX strategies. The equipment will be stored in the permanent FLEX storage building.

3.9.3 Conclusions

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

3.10 Water Sources

3.10.1 Steam Generator Makeup

The licensee provided the following table in its FIP, which lists potential water sources that may be used to provide makeup water to the SGs for core cooling or the SFP, their capacities, and an assessment of availability following the applicable hazards identified in Section 3.5 above. Descriptions of the preferred water usage sources identified in the table below are in the sequence in which they would be utilized, based on their availability after an ELAP/LUHS event.

Water Sources						
Water Sources	Usable Volume (Gallons	Satisfies Seismic	Satisfies High Winds	Satisfies Low Temp	Satisfies High Temp	Time Based on Decay Heat
CST (Phase 1)	170,000	Y	N	Y	Y	7.5 hours
AFW Tanks	120,000	Y	N	Y	Y	13.5 hours [1]
'D' Deepwell	Indefinite	N	Y	Y	Y	Indefinite
Lake Robinson	Indefinite	Y	Y	Y	Y	Indefinite
Discharge Canal	Indefinite	Y	Y	Y	Y	Indefinite
[1] Assumes use of portable intermediate pressure pumps						

In its FIP, the licensee stated that the on-site water sources have a wide range of associated chemical compositions. Therefore, extended periods of operation with the addition of these various on-site water sources to the SGs were evaluated for impact on long-term SG performance and SG material (e.g., tube) degradation and potential impact on the heat transfer capabilities of the SGs. Use of the available clean water sources, tanks and condenser, are limited only by their quantities. The water supply from Lake Robinson and the discharge canal is essentially unlimited by quantity, but is limited by quality, specifically the concentration of total suspended solids (TSS). The licensee stated in its FIP that the evaluation shows that the water from Lake Robinson or the discharge canal could be used for approximately 283 hours after CST and AFW tank depletion before the SG design blockage limit would be expected to be reached, assuming a conservative TSS level of 500 ppm. Water from the deepwells could be used for about 700 hours after CST and AFW depletion before the SG design blockage limit would be expected to be reached. The results of the water quality evaluation show that the credited, fully protected, on-site water sources provide an adequate AFW supply source for a much longer time than would be required for the delivery and deployment of the Phase 3 NSRC reverse osmosis (RO) / ion exchange equipment to remove impurities from the on-site natural water sources. The RO units have a capacity up to 250 gpm. Once the reverse osmosis / ion exchange equipment is in operation, the on-site water sources provide an indefinite supply of purified water.

During the on-site audit, the NRC staff questioned the Robinson strategy for providing water from the CW system after a high wind event. The NRC question centered on debris that might be deposited near the water source after a high wind event, and that this debris may limit accessibility to the new valve CW-125 and the associated hose assembly located in the condenser waterbox pit area. Limited accessibility may challenge the ability to respond to the event within the 61 minute time allotted for response. The Robinson Fukushima response organization table-top exercises for the strategy to supply CW to the SDAFW pump have been timed at approximately 30 minutes. This leaves approximately 30 minutes for debris removal in the condenser waterbox pit area to access the hose connection point.

An engineering evaluation (EC 99828, "Debris Removal At New Circ Water Valve For FLEX Pump") was performed to characterize debris type and weight that may be located in the condenser waterbox pit area following a high wind event. Light weight, loose debris may be deposited over valve CW-125 and the associated hose assembly. The debris may block access to the valve and hose. The evaluation also determined the equipment needed to remove debris to access valve CW-125 and hose assembly. The recommended tool storage location is the same location as the pre-deployed portable low press FLEX pumps. This location is inside the TB ground floor.

The licensee stated that debris removal equipment will be pre-staged near the two LP pumps in the turbine building, in a location protected from high winds and/or tornado missile hazards. The licensee stated in EC99828, "Debris Removal At New Circulating Water Valve For FLEX Pump," Revision 0, that removal of the heaviest piece of debris will require movement of only a few feet from the FLEX connection and the debris removal equipment will not require any power. The licensee also validated the time to complete the alignment of the portable FLEX pump to the CW inlet bay, in which the operators can perform in 18 minutes and leaving about 33 minutes for prior debris removal activity near the CW inlet bay. The licensee concluded that by pre-staging the debris removal equipment and two LP pumps, this strategy can be accomplished within the timeframe needed to implement core cooling after an ELAP is declared. Based on the licensee's description of the availability and protection of the pre-staged debris removal equipment, and the staff's observation of the designated area during the onsite audit walk down, the staff did not identify any discrepancies with the licensee's alternate strategy for addressing SG makeup for high winds and/or tornado missile events.

3.10.2 Reactor Coolant System Make-Up

The licensee stated in its FIP that there are no installed means to provide borated makeup following an ELAP. The primary method of boration and inventory control is to use a portable high-pressure, low-volume pump connected directly to the charging lines or safety injection headers from the RWST or portable tanker (1,000 gallon capacity) containing borated water. The makeup capacity of the portable pump is 60 gpm at 2,000 psig, which is adequate for the bounding analysis discussed in WCAP-17601-P for Phase 2 boration. Phase 3 inventory control will be accomplished using the same portable diesel pumper.

The licensee also stated in its FIP that Robinson has an existing portable boration strategy with a capacity of 60 gpm at 2,000 psig through the charging header drain valves. Alternate RCS connections are available in the safety injection (SI) system through SI system valves. Currently, the RWST is seismically qualified, but is not protected from wind or missiles. When the RWST is not available, portable high pressure pumping and portable tanker capability is available in the PFSB to support this function. Calculation EC 90622 added a FLEX connection to the exposed end downstream of normally locked closed drain valve located at the base of the RWST to water sources for the RCS makeup and boration strategies are provided by portable mixing tanks and pump skids. The staff reviewed the licensee's boration strategy and verified that the portable tanker and pumps being stored in protected locations are capable of being deployed, as needed, in the event that the RWST is unavailable after an ELAP event.

3.10.3 Spent Fuel Pool Make-Up

See Section 3.1 above for a list and discussion for SFP makeup water sources. The SFP makeup is not required in Phase 1, and there is ample warning time to align an appropriate water source for Phase 2 and 3.

3.10.4 Containment Cooling

In its FIP, the licensee stated that no containment cooling is required for Phase 1 and 2. The licensee stated that the results of calculation RNP-MECH-1877 indicate that the containment design limits for temperature and pressure will not be challenged in the first 43 days following the event assuming no actions are taken to cool, spray, or vent the containment. This calculation also assumes that low leakage RCP seals are installed. For Phase 3, the licensee stated that the strategy will be to spray the containment dome with any available water source (lake, discharge canal, deepwell) using a Hale pump and monitor nozzles. The licensee stated that given the extended coping times available, any of the 4 site deepwells can be accessed and procedure SPP-038, "Installation, Operation, and Removal of Supplemental Cooling For HVH-1, 2, 3, & 4" can be used with portable power to any of the HVH units in containment.

3.10.5 Conclusions

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

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on a BDBEE occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the BDBEE occurs with the plant at power, the mitigation strategy initially focuses on the use of a pump coupled to a steam-powered turbine to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP

The licensee stated in its FIP that Robinson will abide by the September 18, 2013 (ADAMS Accession No. ML13273A514), Nuclear Energy Institute (NEI) position paper, "Shutdown/Refueling Modes," addressing mitigating strategies in shutdown and refueling modes which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 (ADAMS Accession No. ML13267A382), the NRC staff endorsed this position paper as a means of meeting the requirements of the order. The position paper provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. The NRC staff concludes that the position paper provides an acceptable approach for demonstrating that the licensees are capable of implementing mitigating strategies in shutdown and refueling modes of operation.

The licensee stated in its FIP that the reactor core cooling and heat removal strategies discussed above are effective as long as the RCS is intact and the SGs are available for use. The window between elimination of natural circulation availability, and when the refueling cavity is flooded, is considered in the Modes 5 and 6 core cooling strategy development. During this window, the RCS is partially drained and vented. When the RCS is depressurized and drained to reduced inventory, the SGs are no longer coupled to the core and core cooling is accomplished through evaporative cooling. Injection flow to remove decay heat is less than 150 gpm. In Modes 5 and 6, RCS makeup for core cooling and inventory control in an ELAP event will be accomplished with a portable diesel pumper rated at 300 gpm at 1000 psig.

The licensee also stated in the FIP that a portable pumper can take suction from the RWST via a FLEX connection RWST Drain, or SFP via an emergency cooling connection (ECC) in the SFP cooling system, and deliver through pre-staged connections in the safety injection lines. The SFP can also be accessed by using portable hoses and a pumper directly from the SFP operating floor. If the SFP is used as a source of borated water, the SFP can be replenished using existing SFP makeup strategies and manual addition of boric acid to the SFP. Calculations in EC 95216 can be extrapolated to show that the addition of approximately 100 lbs. of boric acid per 1000 gallons of SFP makeup is sufficient to maintain shutdown margin in the SFP and the RCS. Installation of the FLEX connections will be controlled using the shutdown risk management process as described in the Shutdown Modes Position Paper endorsed by the NRC. Procedure GP-008, "Draining the Reactor Coolant System," was revised to include the following preparations:

- Prior to venting the RCS (pressure below 200 psig), and until the cavity is flooded with the vessel cover removed, the following pre-emptive actions shall be taken to ensure FLEX mitigation strategies are maintained for RCS cooling in the condition:
    - The replacement check valve covers for SI-879A and SI-879B, along with the necessary tools to remove the existing covers, and install the replacement covers are staged in the SI pump room.
    - The FLEX connection spool piece for SFPC-796, along with the necessary tools to remove the existing spool piece flange and install the FLEX connection spool piece, are staged in the SFP pump room.
    - Individuals are designated to accomplish the action for installing the check valve cover on either SI-879A or SI-879B. The individuals must be designated in writing, understand and acknowledge the assignment, and maintain the ability to accomplish the task within two hours of the loss of RHR [residual heat removal] Core cooling.
    - Individuals are designated to accomplish the action for installing the FLEX connection spool piece for SFPC-796. The individuals must be designated in writing, understand and acknowledge the assignment, and maintain the ability to accomplish the task within two hours of the loss of RHR core cooling.

The licensee stated in its FIP that the RWST is not protected from all hazards (i.e. tornado missiles). In the unlikely event that a tornado missile will damage the RWST, procedures will direct the operators to use the SFP as an alternative supply of borated water. The lake or discharge canal would be available following a tornado event, providing a method for restoring core cooling for all hazards during Modes 5 and 6.

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

3.12 Procedures and Training

Procedures

Regarding procedures, the licensee stated in its FIP that the inability to predict actual plant conditions that require the use of BDB equipment makes it impossible to provide specific procedural guidance. As such, the FSGs will provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs will ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When BDB equipment is needed to supplement emergency operating procedures (EOPs) or abnormal operating procedures (AOPs), the EOP or AOP, severe accident management guidelines (SAMGs), or EDGMs will direct the entry into and exit from the appropriate FSG procedure.

FSGs have been developed in accordance with PWROG guidelines. The FSGs will provide available, preplanned FLEX strategies for accomplishing specific tasks in the EOPs or AOPs. The FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Procedural interfaces have been incorporated into ECA-0.0, "Loss of All AC Power" to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, procedural interfaces have been incorporated into the following AOPs to include appropriate reference to FSGs:

- AOP-20, "Loss of RHR (ELAP)"
- AOP-36, "Spent Fuel Pit Events"

The licensee also stated in its FIP that FSG maintenance will be performed by the Station Procedures group via the Procedure Action Request in AD-AC-ALL-0201, "Development and Maintenance of Controlled Procedure Manual Procedures." In accordance with site administrative procedures, NEI 96-07, Revision 1, and NEI 97-04, Revision 1 are to be used to evaluate changes to current procedures, including the FSG, to determine the need for prior NRC approval. However, per the guidance and examples provided in NEI 96-07, Revision 1, changes to procedures (EOPs, AOPs, EDMGs, SAMGs, or FSGs) that perform actions in response to events that exceed a site's design-basis should screen out. Therefore, procedure steps which recognize the BDB ELAP/LUHS has occurred and which direct actions to ensure core cooling, SFP cooling, or containment integrity should not require prior NRC approval. The FSGs will be reviewed and validated by the involved groups to the extent necessary to ensure the strategy is feasible. Validation may be accomplished via walk-throughs or drills of the guidelines.

Training

The licensee also stated in its FIP that Duke's Nuclear Training Program for Robinson has been revised to assure personnel proficiency in the mitigation of BDBEEs is adequate and maintained. These programs and controls were developed and have been implemented in accordance with the Systematic Approach to Training (SAT) Process. Initial training has been provided and periodic training will be provided to site emergency response leaders on BDB emergency response strategies and implementing guidelines. Personnel assigned to direct the execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints. Care has been taken to not give undue weight (in comparison with other training requirements) for operator training for BDBEE accident mitigation. The testing/evaluation of operator knowledge and skills in this area has been similarly weighted. American National Standards Institute/American Nuclear Society "ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training" certification of simulator fidelity is considered to be sufficient for the initial stages of the BDBEE scenario until the current capability of the simulator model is exceeded. Full scope simulator models will not be upgraded to accommodate FLEX training or drills. The Robinson simulator and model were updated to account for new strategies implemented in the early stages (< 6 hours) of a BDBEE ELAP/LUHS. Where appropriate, integrated FLEX drills will be organized on a team or crew basis and conducted periodically; with all time-sensitive actions to be evaluated over a period of not more than eight years. It is not required to connect/operate permanently installed equipment during these drills.

Therefore, the NRC staff concludes that the licensee appears to have adequately addressed the procedures and training associated with FLEX because the procedures have been issued and a training program has been established and will be maintained 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 dated October 3, 2013 (ADAMS Accession No. ML13276A573), which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 (ADAMS Accession No. ML13276A224), the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs. Preventative maintenance templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued.

In its FIP, the licensee stated that periodic testing and preventative maintenance of the BDB equipment conforms to the guidance provided in Institute of Nuclear Power Operations AP-913. A fleet procedure has been developed to address preventative maintenance (PM) using EPRI templates or manufacturer provided information/recommendations, equipment testing, and the unavailability of equipment. The PM templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued. The PM templates include activities such as:

- Periodic Static Inspections – Monthly walkdown
- Fluid analysis (Yearly)
- Periodic operational verifications – Quarterly starts
- Periodic functional verifications with performance tests – Annual 1 hour run with pump flow and head verifications

The EPRI PM templates for FLEX equipment conform to the guidance of NEI 12-06, which assures that stored or pre-staged FLEX equipment are being properly maintained and tested. EPRI templates are used for most equipment. However, in those cases where EPRI templates were not available, PM actions were developed based on manufacturer provided information/ recommendations.

The unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core, containment, and SFP will be managed such that risk to mitigating strategy capability is minimized. Maintenance/risk guidance conforms to the guidance of NEI 12-06 as follows:

- Portable BDB equipment may be unavailable for 90 days provided that the site FLEX capability (N) is available.
- If portable equipment becomes unavailable such that the site FLEX capability (N) is not maintained, initiate actions within 24 hours to restore the site FLEX capability (N) and implement compensatory measures (e.g., use of alternate suitable equipment or supplemental personnel) within 72 hours.

3.14 Alternatives to NEI 12-06, Revision 0

During the on-site audit, the NRC staff determined that the FLEX strategy to use permanently pre-staged DGs should be considered an alternative to the guidance in NEI 12-06. The licensee evaluated the strategy regarding the approach for permanently pre-staging two 480 VAC, 150 KW FLEX DGs in the RAB's solid radioactive waste drumming room that is robust with respect to seismic events, flood, high winds, and associated missiles. The licensee provided a justification for the proposed alternative in a position paper. The licensee stated in its position paper that the FLEX DG connection points are also contained within this structure and that AC power from either FLEX DG can be routed through an attached output breaker to a power panel using portable quick disconnect cables. Power from the power panel is routed for two station battery chargers (one in each train), a supply and exhaust fan, and power to close reactor coolant system accumulator isolation valves. Therefore, the FLEX DGs, associated output devices, and cabling are protected from the external hazards defined in NEI 12-06 from the FLEX DG to the station battery chargers, while remaining physically disconnected from the plant's installed electrical distribution system.

The licensee's evaluation considered the potential causes of a failure of both FLEX DGs and determined that such a failure is highly unlikely given the design and layout of the FLEX DG installation and the quality of the installed components. The evaluations included (a) catastrophic mechanical failure of one FLEX DG potentially impacting the other, (b) inadvertent fire suppression system discharge in the RAB solid radioactive waste drumming room, and (c) fire in the RAB solid radioactive waste drumming room affecting both FLEX DGs. The licensee evaluated FLEX DG installation against the applicable requirements and concluded that the installation constitutes an acceptable alternative to the NRC endorsed guidance provided in NEI 12-06. The NRC staff found the proposed alternative to be acceptable.

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

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 (ADAMS Accession No. ML13086A096), the licensee submitted its Overall Integrated Plan (OIP) for Robinson, in response to Order EA-12-051. By letter dated July 11, 2013 (ADAMS Accession No. ML13189A056), the NRC staff sent a Request for Additional Information (RAI) to the licensee. The licensee provided its RAI response by letter dated August 8, 2013 (ADAMS Accession No. ML13233A313). By letter dated November 19, 2013 (ADAMS Accession No. ML13273A481), the NRC staff issued an Interim Staff Evaluation (ISE) and RAI to the licensee.

By letters dated August 26, 2013 (ADAMS Accession No. ML13242A010), February 24, 2014 (ADAMS Accession No. ML14063A604), August 26, 2014 (ADAMS Accession No. ML14251A013), and February 23, 2015 (ADAMS Accession No. ML15082A016), the licensee submitted status reports for the integrated plan. The integrated plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable Spent Fuel Pool Level Instrumentation (SFPLI), which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated June 27, 2015 (ADAMS Accession No. ML15187A229), the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

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

The NRC staff performed an onsite audit at Robinson to review the implementation of SFPLI related to Order EA-12-051. The scope of the audit includes 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 June 12, 2015 (ADAMS Accession No. ML15154B098), the NRC issued an audit report on the licensee's progress.

4.1 Levels of Required Monitoring

Attachment 2 of Order EA-12-051 states in part:

> All licensees identified in Attachment 1 to this 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 [Level 1], (2) level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck [Level 2], and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred [Level 3].

In its OIP, the licensee stated that the bottom of the SFP is at 236 feet 9 inches plant elevation. The highest point of any fuel racks with fuel seated in the SFP is approximately 252 feet plant elevation.

In accordance with the guidance in NEI 12-02, the SFP water level instrumentation system will be capable of continuously monitoring three distinct water levels:

- Level 1 - The water level adequate to support operation of the normal fuel pool cooling system is approximately 273 feet plant elevation.
- Level 2 - The water level adequate to provide substantial radiation shielding for a person standing on the SFP operating deck (i.e., greater than 10 feet above the highest point of any fuel racks) is approximately 262 feet plant elevation.
- Level 3 - The water level where fuel remains covered but actions to implement make-up water addition should no longer be deferred will be established based on the accuracy of the chosen instrumentation and the highest point of any fuel racks at approximately 252 feet plant elevation.

The approximate range of the instrumentation system will be from 252 feet to 273 feet plant elevation.

In RAI-1 (NRC letter dated July 11, 2013), the NRC staff requested the following information:

- For Level 1, specify how the identified elevation represents the HIGHER of the two points described in the NEI 12-02 guidance for this level.
- A clearly labeled sketch depicting the elevation view of the proposed typical mounting arrangement for the portions of instrument channel consisting of permanent measurement channel equipment (e.g., fixed level sensors and/or stilling wells, and mounting brackets). Indicate on this sketch the datum values representing Level 1, Level 2, and Level 3, as well as the top of the fuel racks. Indicate on this sketch the portion of the level sensor measurement range that is sensitive to measurement of the fuel pool level, with respect to the Level 1, Level 2, and Level 3 datum points.

The licensee provided a response by letter dated August 8, 2013, in which it stated, in part, that:

> In accordance with NEI 12-02, SFP Level 1 is set at 272.6 feet elevation to assure that the pool suction line inlets are covered. This is based on the following:
>
> - The SFP cooling pump suction centerline elevation is 269.75 feet and there is a common suction that branches to two parallel paths supplying each pump (SFPC pumps A and B).
> - Adequate NPSH will be assured at normal system flowrates as long as water is 2.6 feet above the suction pipe inlet, or elevation 272.6.
>
> The February 28, 2013 submittal identified SFP Level 1 as 273 feet elevation. Based on the above information, SFP Level 1 is revised to 272.6 feet elevation.

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

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

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

> The instrumentation will consist of two separate permanent fixed instrument channels to monitor SFP water level continuously, from normal water level (approximately 273 feet plant elevation) down to a level at the highest point of any fuel racks, at approximately 252 feet plant elevation. 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. Because both channels will be permanent, they are considered redundant and neither is designated as "primary" or "backup."

The NRC staff noted that the range specified for the licensee's instrumentation will cover Levels 1, 2, and 3 as described in Section 4.1 above.

Based on the discussion above, the NRC staff concludes that the licensee's design, with respect to the number of channels for its SFP, is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.2 Design Features: Arrangement

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

> In accordance with the guidance in NEI 12-02, the level instrument channels will be installed in diverse locations and physically 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 SFP.
>
> *Sensing Component*
>
> The sensing component of each level instrument channel will be installed separately within the SFP in order to reduce common susceptibility to missiles and other external events. The final location and mounting will be determined by the detailed design.
>
> *Electronics*
>
> Electronics associated with the level instrumentation will be located outside the SFP operating area due to sensitivity to radiation. The final location will be determined by the detailed design.
>
> *Cable Routing*
>
> Cable routings will be installed that will provide reasonable protection from missiles that may result from damage to the structure over the SFP and refuel floor. The conduit and cable routing will be determined by the detailed design.

In ISE RAI-1 (previously RAI-2 in NRC letter dated July 11, 2013), the NRC staff requested the following information:

- A clearly labeled sketch or marked-up plant drawing of the plan view of the SFP area, depicting the SFP inside dimensions, the planned locations/placement of the primary and backup SFP level sensor, and the proposed routing of the cables that will extend from these sensors toward the location of the read-out/display devices.

In its compliance letter dated June 27, 2015, the licensee provided the following:

- NRC Response Sketch 1
- Sketch SK-89580-E-3020 of EC 89580, "Spent Fuel Pool Level Indication Channel 1 Conduit Diagram"
- Sketch SK-89580-E-3030 of EC 89580, "Spent Fuel Pool Level Indication Channel 2 Conduit Diagram"

These sketches depict the SFP inside dimensions, the planned locations of the primary and backup SFP level sensors, and the routing of the cables.

The NRC staff concludes, and verified by walkdown during the onsite audit, that there is sufficient channel separation within the SFP area between the primary and back-up level instruments, 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 discussion above, the NRC staff concludes that the licensee's arrangement for the SFP level instrumentation, if implemented appropriately, is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.3 Design Features: Mounting

In its OIP, the licensee stated that:

> Each permanently installed instrument channel will be mounted to retain its design configuration during and following the maximum seismic ground motion considered in the design of the SFP structure in accordance with the guidance in NRC JLD-ISG-2012-03 and NEI 12-02.

In ISE RAI-2 (previously RAI-3 in NRC letter dated July 11, 2013), the NRC staff requested the following information:

- The design criteria that will be used to estimate the total loading on the mounting device(s), including static weight loads and dynamic loads. Describe the methodology that will be used to estimate the total loading, inclusive of design basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing or other effects that could accompany such seismic forces.
- A description of the manner in which the level sensor (and stilling well, if appropriate) will be attached to the refueling floor and/or other support structures for each planned point of attachment of the probe assembly. Indicate in a schematic the portions of the level sensor that will serve as points of attachment for mechanical/mounting or electrical connections.
- A description of the manner by which the mechanical connections will attach the level instrument to permanent SFP structures so as to support the level sensor assembly.

In its compliance letter dated June 27, 2015, the licensee stated, in part, that:

> AREVA developed a calculation (32-9221237-002) to qualify a standard support configuration for the horn assembly for its SFPL monitoring system that is applicable to RNP Unit 2. This calculation documents the design criteria used to estimate the total loading on the mounting device, called Type 'A' support. These criteria include static and dynamic loads imposed by deadweight, seismic and sloshing. Since the instrument is located inside the building, it is not subject to wind loads. AREVA document provides the qualification of the VEGAPULS 62

> ER through air radar in accordance with the requirements of USNRC EA-12-051, JLD-ISG-12-03, and NEI 12-02.
>
> The Type 'A' support is qualified while also identifying a maximum sloshing load that can be withstood by the horn end assembly and waveguide support configuration. The waveguide system and supports are considered augmented quality, seismically qualified.
>
> The NAI site specific sloshing analysis prepared a three dimensional GOTHIC sub-divided model of the SFP and induce the characteristics of a seismic event on the model. A modified version of the GOTHIC 8.0 (QA) code containing adjustable body force terms in the x, y, and z direction momentum conservation equations is used to perform analysis. The seismic accelerations bound forces applied to the horn, waveguide and electronics supports to above the 2 X SSE Criteria for the BDBEE.
>
> There are two level sensing lines (waveguides) for the RNP Unit 2 modification. One waveguide is installed at the southeast side of the spent fuel pool identified as waveguide sensing line Channel 2 and the second waveguide is installed at the northwest side of the spent fuel pool identified as waveguide sensing line Channel 1.
>
> Each sensing line consists of stainless piping, 1.059" OD, 0.102" thick which is equivalent to 3/4", schedule 40 pipe, attached to the antenna horn and an instrument box mounted on the spent fuel pool wall. For sensing line Channel 2 the instrument box is located on the east wall and for sensing line Channel 1 the instrument box is located on the west wall. Installation of waveguide up to the instrument box mounted on the spent fuel pool wall is included in AREVA's scope. Waveguide installed at the southeast side of the pool has its instrument box mounted on the east wall of the pool and the waveguide installed at the northwest side has its instrument box mounted on the west wall of the pool. AREVA's scope consists of installation of waveguide from the spent fuel pool to the instrument box along with the two supports for each waveguide. AREVA has qualified the supports and piping up to the first support. Installation of additional supports as required between the first support and the instrument box is included in RNP's scope.

In ISE RAI-3, the NRC staff requested for the analyses used to verify the design criteria and methodology for seismic testing of the SFP instrumentation and the electronics units, including design basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing or other effects that could accompany such seismic forces.

In its compliance letter dated June 27, 2015, the licensee stated, in part, that:

> The VEGAPULS 62 ER seismic qualification requirements are specified in detail in the Seismic Qualification Specification. A seismic shake test was performed to the requirements of IEEE 344-2004 for elements of the VEGAPULS 62 ER

> through air radar to levels anticipated to envelop most if not all plants in the US. The equipment qualified included the VEGAPULS 62 ER sensor, PLICSCOM indicating and adjustment module, VEGADIS 62 display, Power Control Panel, horn waveguide assembly, waveguide piping including standard and repair flanges, and pool end and sensor end mounting brackets. The brackets are considered to be the standard design. Brackets can be provided in shorter cantilever lengths than the tested lengths. The shorter cantilever lengths are inherently more rigid that the tested lengths. Therefore, the seismic test results are considered to be also applicable to brackets with shorter cantilever lengths. Other modifications to the standard design brackets beyond just a shortened cantilever length for specific applications, including longer lengths, will be qualified by analysis. The horn waveguide assembly can be provided in shorter cantilever lengths than the tested assembly. The shorter cantilever lengths are inherently more rigid than the tested lengths. Therefore, the seismic test results are considered to be also applicable to horn waveguide assemblies with shorter cantilever lengths. The tested horn waveguide assembly included a standard flange just above the horn. The supplied horn waveguide assemblies do not include the flange, but are considered to be enveloped by the seismic testing. The supplied horn waveguide assemblies also include a horn cover that was not included in the seismic test. The seismic qualification of the horn cover and seismic effect that the cover impacts to the horn waveguide assembly are covered in AREVA Doc. No. 32-9221237-002, "Qualification for a Waveguide Type "A" Support and Horn End Assembly for AREVA Spent Fuel Pool Level Monitoring Instrumentation" and AREVA Doc. No. 51-9221032-000, "Qualification Analysis for Waveguide Horn Cover".

In ISE RAI-4, the NRC staff requested for each of the mounting attachments required to attach SFP Level equipment to plant structures, a description of the design inputs and the methodology that was used to qualify the structural integrity of the affected structures/equipment.

In its compliance letter dated June 27, 2015, the licensee stated, in part, that:

> AREVA developed a calculation (32-9221237-002) to qualify a standard support configuration for the horn assembly for its SFPL monitoring system that is applicable to RNP Unit 2. This calculation documents the design criteria used to estimate the total loading on the mounting device, called Type 'A' support. These criteria include static and dynamic loads imposed by deadweight, seismic and sloshing. A seismic shake test was performed to the requirements of IEEE 344-2004 for elements of the VEGAPULS 62 ER through air radar to levels anticipated to envelop most if not all plants in the US. The equipment qualified included the VEGAPULS 62 ER sensor, PLICSCOM indicating and adjustment module, VEGADIS 62 display, Power Control Panel, horn waveguide assembly, waveguide piping including standard and repair flanges, and pool end and sensor end mounting brackets.
>
> There are two level sensing lines (waveguides). One waveguide is installed at the southeast side (Channel 2) and the second waveguide is installed at the

> northwest side (Channel 1) of the spent fuel pool. Each sensing line consists of stainless piping, 1.059" OD, .102" thick which is equivalent to 3/4", schedule 40 pipe, attached to the antenna horn and an instrument box mounted on the spent fuel pool wall. For sensing line Channel 2 the instrument box is located on the east wall and for sensing line Channel 1 the instrument box is located on the west wall. Installation of waveguide up to the instrument box mounted on the spent fuel pool wall is included in AREVA's scope. Waveguide installed at the southeast side of the pool has its instrument box mounted on the east wall of the pool and the waveguide installed at the northwest side has its instrument box mounted on the west wall of the pool. AREVA's scope consists of installation of waveguide from the spent fuel pool to the instrument box along with the two supports for each waveguide. AREVA has qualified the supports and piping up to the first support. Installation of additional supports as required between the first support and the instrument box is included in RNP's scope.

The NRC staff concludes that the response adequately addressed design inputs and the methodology that was used to qualify the structural integrity of the affected structures for each mounting attachment.

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

4.2.4 <u>Design Features: Qualification</u>

In its OIP, the licensee stated that:

> The channels will be capable of performing their function and maintaining the required accuracy, except during the period when a potential seismic event is occurring, including harsh conditions where the equipment is installed.
>
> Sensing components and cables for the channels will be reliable at temperature, humidity, and radiation levels consistent with the SFP water at saturation conditions over an extended period of time. Sensing components and cables will be qualified for expected conditions at the installed location assuming the SFP has been at saturation for an extended period. Sensing components and cables located at the SFP will be qualified to withstand peak and total integrated dose radiation levels for their installed location based on post-event SFP water level equal to Level 3 for an extended period of time.
>
> Additionally, the instrument channels will be tested, where possible, and analytically evaluated to remain functional after a potential seismic event with the exception of the battery charger and replacement batteries.
>
> Augmented Quality provisions will be applied to ensure that rigor of the qualification documentation reviews and in-plant modification installation oversight is sufficient to ensure compliance with the qualification requirements

described above. This approach to quality assurance is consistent with the guidance in NRC JLD-ISG-2012-03 and NEI 12-02.

In ISE RAI-5 (previously RAI-4 in NRC letter dated July 11, 2013), the NRC staff requested the following:

- A description of the specific method or combination of methods you intend to apply to demonstrate the reliability of the permanently installed equipment under BDB ambient temperature, humidity, shock, vibration, and radiation conditions.
- A description of the testing and/or analyses that will be conducted to provide assurance that the equipment will perform reliably under the worst-case credible design basis loading at the location where the equipment will be mounted. Include a discussion of this seismic reliability demonstration as it applies to (a) the level sensor mounted in the SFP area, and (b) any control boxes, electronics, or read-out and re-transmitting devices that will be employed to convey the level information from the level sensor to the plant operators or emergency responders.
- A description of the specific method or combination of methods that will be used to confirm the reliability of the permanently installed equipment during and following seismic conditions to maintain its required accuracy.

In its compliance letter dated June 27, 2015, the licensee stated, in part, that:

> The SFP level instrumentation intended for installation has been qualified for ambient temperatures, humidity, shock, vibration and radiation conditions utilizing the following methods described below:
>
> 1. Shock and Vibration: The VEGAPULS 62 ER through air radar sensor is similar in form, fit and function to the VEGAPULS 66 including PLICSCOM indicator that was shock tested in accordance with MIL-S-901D, and vibration tested in accordance with MIL STD 167-1. The test report is contained in AREVA Doc. 38-9193058-000, "Report of Shock and Vibration Tests on Two (2) 3" Navy Flange Mount Level Indicators and One (1) 3" Triclamp, 1-1/2" Navy Flange Mount Level Indicator for Ohmart/VEGA Corporation Cincinnati, Ohio." The primary difference in construction is the smaller size of the VEGAPULS 62 ER.
>
>   The shape of the housing, its material construction (precision cast stainless steel), the mass and form factor for the electronics modules, the materials and method for mounting the electronics into the sensor housing are the same between the VEGAPULS 66 and the VEGAPULS 62 ER. The end coupling and antennas for VEGAPULS 62 ER are smaller and lighter than for VEGAPULS 66 and therefore less susceptible to shock and vibration. Therefore, the shock and vibration testing is considered to be applicable to the VEGAPULS 62 ER sensor and the PLICSCOM indicator.
>
>   The MIL-S-901D test consisted of a total of nine (9) shock blows, three (3) through each of the three (3) 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 one (1) foot, three (3) feet and five (5) feet.

The MIL STD 167-1 vibration test procedure applies to equipment found on Navy ships with conventional shafted propeller propulsion. The test frequencies ranged from 4 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 spent fuel pool and surrounding building structure might contain higher frequencies than were achieved in the testing discussed above. However, in addition to the MIL Standard testing above, the VEGAPULS 62 ER sensor has been shock tested in accordance with EN 60068-2-27 "Basic environmental testing procedures – Part 2: Tests – Test Ea and guidance: Shock", (100g, 6 ms), and vibration tested in accordance with EN 60068-2-6 "Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal)," Method 204 (except 4g, 200 Hz).

The VEGADIS 61 and VEGADIS 62 displays feature housings that are similar in size, materials, and form factor to the VEGAPULS 62 ER sensor. They contain a terminal base attached with two screws similar to the electronics module in the VEGAPULS 62 ER, and contain a LCD display module that installs into the housing similar to the PLICSCOM in the VEGAPULS 62 ER. Therefore, these devices are considered to have the same resistance to shock and vibration as the VEGAPULS 62 ER and PLICSCOM.

The power control panel was shock tested per EN 60068-2-27 (10g, 6 ms), and vibration tested per EN 60068-2-6 (2g, 200 Hz).

2. <u>Temperature and Humidity</u>: The postulated temperature and humidity in the spent fuel pool room that results from a boiling pool is 100^{0}C (212^{0}F) with saturated steam. The electronics in the sensor are rated for a maximum continuous duty temperature of 80^{0}C (176^{0}F) on the condition that the process temperature (that which the flange connection is in contact with) is no greater than 130^{0}C (266^{0}F). If a PLICSCOM indicating and adjustment module is mounted on the sensor, the maximum ambient temperature rating is reduced to 70^{0}C (158^{0}F). In either case, the sensor is located away from the spent fuel pool in an area where the temperature is at or below the rated temperature.

The sensor has been tested in accordance with IEC 60068-2-30, "Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12h + 12h cycle)," which varies the temperature from 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 has been tested to EN 60529:2000, "Degrees of Protection Provided by Enclosure (IP Code)," to achieve the rating IP66/IP68, which signifies totally dust tight housing, protection against string water jets and waves, and protection against prolonged effects of immersion under 0.2 bar pressure. The VEGADIS 61 indicating and adjustment module and VEGADIS 62 display have housings which are similar to the

VEGAPULS 62 ER sensor and are therefore considered to be equally covered by the tests referenced above.

The power control panel internal components are rated for a maximum temperature of at least 70°C (158°F). Allowing for 5°C (9°F) heat rise in the panel, the overall panel maximum ambient temperature for operation is 65°C (149°F). The power control panel enclosure is rated NEMA 4X and provides protection to the internal components from the effects of high humidity environments.

Condensation formation on the inner waveguide pipe walls would require very moist air to enter the pipe at the sensor and travel to a colder area where the air temperature in the pipe would be lowered to the dew point. This is a highly unlikely occurrence given the limited length of waveguide. The horn cover, which blocks airflow through the waveguide pipe, reduces the potential for transfer of warm moist air to a colder area and therefore reduces the potential for condensation forming in the pipe.

3. Radiation: The area above and around the pool will be subject to large amounts of radiation in the event that the fuel becomes uncovered. The only parts of the measurement channel in the pool radiation environment are the metallic waveguide, horn, and fused silica glass horn cover which are not susceptible to the expected levels of radiation, and silicone elastomer moisture seal for the horn cover, which has associated radiation test data from the manufacturer. The silicon elastomer seal has been tested for up to 7×10^8 rad, although above 1.6×10^8 rad the elastic modulus began to increase substantially. The silicon elastomer test data demonstrates that the silicon is acceptable for the expected radiation dose for this application.

The electronics are located in an area that is shielded from the direct shine from the fuel, and bounce and scatter effects above the pool. For the purpose of this analysis, the radiation levels in the area do not exceed 1×10^3 rad.

Table C-1 of USNRC Bulletin 79-01B, "Thermal and Radiation Aging Degradation of Selected Materials," contains a listing of radiation thresholds for various materials. The most susceptible material, and therefore having the lowest threshold, was NMOS electronics with a threshold of 1×10^3 rad. For current generation operating reactors, the staff's definition of a mild radiation environment for electronic components, such as semiconductors, or any electronic component containing organic materials as a total integrated dose of less than 1×10^3 rad. This is further confirmed in Regulatory Guide 1.209, "Guidelines for Environmental Qualification of Safety-Related Computer – Based Instrumentation and Control Systems in Nuclear Power Plants", which states "ionizing dose radiation hardness levels for MOS IC families range from about 10 gray (Gy) or 1 kilorad (krad) for commercial off-the-shelf (COTS) circuits to about 105 Gy (104 krad) for radiation hardened circuits". Based on the information in the above references, the electronics in the VEGAPULS 62 ER sensor, displays and power control panel are considered to be qualified for 1×10^3 rad.

4. Seismic: AREVA NP is qualifying the VEGAPULS 62 ER Through Air Radar system as a proposed method for operating stations to meet the Order requirements. This report documents the test results of qualification test procedure 172-9211123-001 to seismically qualify the VEGAPULS 62 ER system.

   The test program seismically tested the specimens to levels that enveloped the Required Response Spectra (RRS). The seismic testing and associated qualification documentation were performed in accordance with IEEE 344-2004. The seismic test input that produced the test response spectra (TRS) enveloped the RRS with exceptions as allowed and noted. The required curves operating basis earthquake (OBE) and safe shutdown earthquake (SSE) tests are shown in the table's displacement limitations.

   The test specimen failed the Post-Seismic visual inspection test following the first and second OBE test sequences prior to passing the third. Subsequently, the test specimen failed the Post-Seismic visual inspection test following the SSE test with a broken bolt head. The bolt did not impair equipment function that was tested in the post seismic functional test.

   While the equipment did not pass the post-resonance search and post-seismic testing distance reading acceptance criteria, the equipment performance was within ±3.0 inches. As the acceptance criterion was arbitrarily chosen, the equipment is considered operable for accident conditions; including seismic events.

The NRC staff concludes that the response adequately addressed the reliability and environmental requirements for the SFPLI equipment provided by AREVA. The staff also performed a vendor audit and found the AREVA's SFPI design and qualification process acceptable.

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

4.2.5 Design Features: Independence

In its OIP, the licensee stated that:

> Independence will be established in accordance with the guidance in NRC JLD-ISG-2012-03 and NEI 12-02. Both instrument channels will be of the same technology, permanently installed, separated by distance, and electrically independent of one another.
>
> Both channels will have their own sensing components reasonably separated in accordance with NEI 12-02, separate cable routes, and separate electronics.

In ISE RAI-7 (previously RAI-5 in NRC letter dated July 11, 2013), the NRC staff requested the following:

- A description of how the two channels of the proposed level measurement system meet this requirement so that the potential for a common cause event to adversely affect both channels is precluded.
- Further information on how each level measurement system, consisting of level sensor electronics, cabling, and readout devices will be designed and installed to address independence through the application and selection of independent power sources, the use of physical and spatial separation, independence of signals sent to the location(s) of the readout devices, and the independence of the displays.

In its compliance letter dated June 27, 2015, the licensee stated, in part, that:

> Both channels of level indication will be permanently installed. Normal power to each channel will be from different lighting panels, supplied from different buses. Additionally, each of these channels are designed with separate battery backup power therefore, independence of electrical power is met.
>
> All conduit and cable of each channel have been arranged to maximize separation to the extent practical and consistent with the separation criteria of safety-related equipment. The power control panels, sensors and local indicators are separated by adequate distance to ensure damage to both channels by a common hazard is minimal. The equipment installed at the Spent Fuel Pool has been designed to be the maximum practical distance apart based on the construction of the pool.

The NRC staff concludes that the response is acceptable and verified it during the onsite audit walkdown. Based on the discussion above, the NRC staff concludes that the licensee's proposed design, with respect to instrument channel independence, is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.6 <u>Design Features: Power Supplies</u>

In its OIP, the licensee stated that:

> Instrument channels will each be powered normally by a separate station power source and will have rechargeable or replaceable batteries with sufficient capacity to maintain the level indication function until the normal power is restored, consistent with the guidance in NEI 12-02.

In ISE RAI-8 (previously RAI-6 in NRC letter dated July 11, 2013), the NRC staff requested the following:

- Provide the results of the calculation depicting battery backup duty cycle requirements demonstrating that its capacity is sufficient to maintain level indication function until offsite resources availability is reasonably assured.

In its compliance letter dated June 27, 2015, the licensee stated in part, that:

> Vendor analyses supports the battery capacity (at 20 milliamp (mA) continuous discharge) can support ~130 hours and ~230 hours at -22°F and 32°F, respectively. The calculated battery backup times demonstrate that the backup battery has sufficient capacity to support reliable instrument channel operation until off-site resources can be deployed by the mitigating strategies in response to Order EA-12-049.

The NRC staff also reviewed the back-up battery qualification during the vendor audit and found it acceptable.

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

4.2.7 Design Features: Accuracy

In its OIP, the licensee stated that:

> Instrument channels will be designed such that they will maintain their design accuracy without recalibration following a power interruption or change in power source.
>
> Accuracy will consider SFP post-event conditions, e.g., saturated water, steam environment, or concentrated borated water. Additionally, instrument accuracy will be sufficient to allow trained personnel to determine when the actual level exceeds the specified level of each indicating range (Levels 1, 2, and 3) without conflicting or ambiguous indication. The accuracy will be within the resolution requirements of Figure 1 of NEI 12-02.

In ISE RAI-9 (previously RAI-7 in NRC letter dated July 11, 2013), the NRC staff requested the following information:

- An estimate of the expected instrument channel accuracy performance under both (a) normal SFP level conditions (approximately Level 1 or higher) and (b) at the BDB conditions (i.e., radiation, temperature, humidity, post-seismic and post-shock conditions) that would be present if the SFP level were at the Level 2 and Level 3 datum points.

- A description of the methodology that will be used for determining the maximum allowed deviation from the instrument channel design accuracy that will be employed under normal operating conditions as an acceptance criterion for a calibration procedure to flag to operators and to technicians that the channel requires adjustment to within the normal condition design accuracy.

In its compliance letter dated June 27, 2015, the licensee stated in part, that:

> A Factory Acceptance Test was performed by AREVA and the accuracy of the system considering overall error due to all effects is ± 3 inches. AREVA document 51-9228351-000 (EC 89580 Attachment AU pages 18-76) contains the completed test report. This test verified the system is capable of performance within the specified accuracy listed in the AREVA Instruction Manual 01-9228622-000 (EC 89580 Attachment AA page 30) under normal operating conditions.
>
> AREVA Seismic Test Report 174-9213558-006 (EC 89580 Attachment AY) was performed to ensure the system is capable of performance within the specified accuracy following a BDB seismic event. The conclusion of that report was the system performance was within the accuracy listed in the AREVA Instruction Manual 01-9228622-000 (EC 89580 Attachment AA page 30).

The NRC staff reviewed the AREVA SFP instrument test report for accuracy during the vendor audit and found it acceptable.

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

4.2.8 <u>Design Features: Testing</u>

In its OIP, the licensee stated that:

> Testing and calibration will be consistent with the guidelines of NRC JLD-ISG-2012-03, NEI 12-02 guidance and vendor recommendations.
>
> Channel degradation due to age or corrosion is not expected but can be identified by monitoring trends.
>
> Station procedures and preventive maintenance tasks will be developed to perform required surveillance testing, calibration, backup battery maintenance, functional checks, and visual inspections of the sensing components.

In ISE RAI-10 (previously RAI-8 in NRC letter dated July 11, 2013), the NRC staff requested the following information:

- A description of the capability and provisions the proposed level sensing equipment will have to enable periodic testing and calibration, including how this capability enables the equipment to be tested in-situ.

- A description of how such testing and calibration will enable the conduct of regular channel checks of each independent channel against the other, and against any other permanently-installed SFP level instrumentation.

- A description of how functional checks will be performed, and the frequency at which they will be conducted. Describe how calibration test will be performed, and the frequency at which they will be conducted. Provide a discussion as to how these surveillances will be incorporated into the plant surveillance program.

- A description of what preventive maintenance tasks are required to be performed during normal operation, and the planned maximum surveillance interval that is necessary to ensure that the channels are fully conditioned to accurately and reliably perform their functions when needed.

In its compliance letter dated June 27, 2015, the licensee stated in part, that:

> The sensing equipment is not in contact with the SFP water. It does not interface with other SSC which would prevent in-situ channel checks. Each channel can be read in the control room or locally. The local instrument provides calibration/setup connections. Each channel will be functionally checked on a periodic bases aligned with the Guidance of NEI 12-02.
>
> Operations procedures will direct periodic verification of each level channel with each other and compared to the local level indicator at the pool.
>
> Functional checks will be performed on a periodic bases per Operation procedures to verify each channel is reading normal water level correctly. Also, maintenance functional checks will be conducted, which will align with the suggested frequency of NEI 12-02. These procedures are being developed for incorporation into the maintenance procedures program.
>
> Battery replacement will occur during functional checks which will be conducted on a frequency aligned with NEI 12-02. Also, Operations will periodically verify correct level readings for each channel.

The licensee also made available for staff to review Technical Procedures (Maintenance), PM-548-1, "Spent Fuel Pool Level Indication Channel I," Rev. 0 and PM-548-2, "Spent Fuel Pool Level Indication Channel II," Revision 0. The staff reviewed these procedures and concluded that they adequately address channel function checks, testing and calibration, and battery replacement.

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

4.2.9 Design Features: Display

In its OIP, the licensee stated that:

> The instrument displays for both channels will be located in a mild environment under normal and expected beyond design basis conditions that are accessible

> to plant personnel properly trained in the use of the equipment. The display will be consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02.

In ISE RAI-11 (previously RAI-9 in NRC letter dated July 11, 2013), the NRC staff requested the following information:

- The specific location for the primary and backup instrument channel display.
- For any SFP instrumentation display located outside the main control room, please describe the evaluation used to validate that the display location can be accessed without unreasonable delay following a BDB event. Include the time available for personnel to access the display as credited in the evaluation as well as the actual time (e.g., based on walk-throughs) that it will take for personnel to access the display. Additionally, please include a description of the radiological and environmental conditions on the paths personnel might take. Describe whether the display location remains habitable for radiological, heat and humidity, and other environmental conditions following a BDB event. Describe whether personnel are continuously stationed at the display or monitor the display periodically.

In its compliance letter dated June 27, 2015, the licensee stated in part, that:

> Both channels of Spent Fuel Pool Level will be indicated in the Control Room. Also, both channels will provide indication at the Power Control Panels. Both the Control Room and remote indicators fully meet the requirements of the NEI 12-02 guidance; therefore, neither is considered a backup or alternate. Section 3.9 of NEI 12-02 states if multiple displays are desired they shall not affect the "primary" display. In the case of the installation at RNP, both displays are considered the "primary" display and can fully meet the requirements; therefore, this statement does not apply to RNP.

Based on the discussion above, the NRC staff concludes that the licensee's proposed location and design of the SFP instrumentation displays is consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to 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:

> 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. Training will be completed prior to placing the instrumentation in service.

Based on the discussion above, the NRC staff concludes that the licensee's proposed plan to train personnel, including the approach to identify the population to be trained is consistent with

NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its OIP, the licensee stated that:

> Procedures will be developed using guidelines and vendor instructions to address the maintenance, operation and abnormal response issues associated with the SFP level instrumentation.
>
> Procedures will also address strategy to ensure SFP water addition is initiated at an appropriate time consistent with implementation of NEI 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide.

In ISE RAI-12 (previously RAI-10 in NRC letter dated July 11, 2013), the NRC staff requested a list of the procedures addressing operation (both normal and abnormal response), calibration, test, maintenance, and inspection procedures that will be developed for use of the spent SFP instrumentation. The NRC staff also requested a brief description of the specific technical objectives to be achieved within each procedure.

In its compliance letter dated June 27, 2015, the licensee stated in part, that:

> FLEX Support Guideline (FSG) procedures will provide operators with directions on the monitoring of level following a BDBEE.
>
> Operations surveillance procedure will periodically verify proper operation of both channels of SFP level instrumentation. The procedure will perform periodic channel checks or comparisons between available SFP level instrumentation to verify proper operation of the primary and backup SFP level instrumentation. The procedure is intended to provide a means of detection of channel drift and/or malfunction.
>
> Maintenance procedures will provide periodic checks of both channels of SFP level instrumentation and functional check battery back-up capability. The procedure(s) will verify proper operation of the level instrumentation, and provide instruction for equipment channel check within design accuracy requirements. This procedure will also serve to verify proper channel functionality within 60 days of a planned refueling outage, as required by NEI 12-02. These procedures are being developed for incorporation into the maintenance procedures program.

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

4.3.3 Programmatic Controls: Testing and Calibration

In its OIP, the licensee stated that:

> Testing and calibration of the instrumentation will be consistent with vendor recommendations or other documented basis. Calibration will be specific to the mounted instruments and the displays. A maintenance procedure will be written to direct calibration and repair of the instruments.

In ISE RAI-13 (previously RAI-11 in NRC letter dated July 11, 2013), the NRC staff requested the following information:

- Further information describing the maintenance and testing program the licensee will establish and implement to ensure that regular testing and calibration is performed and verified by inspection and audit to demonstrate conformance with design and system readiness requirements. Include a description of your plans for ensuring that necessary channel checks, functional tests, periodic calibration, and maintenance will be conducted for the level measurement system and its supporting equipment.
- A description of how the guidance in NEI12-02 section 4.3 regarding compensatory actions for one or both non-functioning channels will be addressed.
- A description of what compensatory actions are planned in the event that the non-functioning instrument channel cannot be restored to functional status within 90 days.

In its compliance letter dated June 27, 2015, the licensee stated in part, that:

> Channel Checks will be performed by Operations Procedure OST-023 on a periodic basis. A maintenance procedure is being created for the new instrumentation. This procedure will most likely include replacement of batteries and a functional check of the sensors.
>
> Spent Fuel Pool Level Indication will be included in the Technical Requirements Manual. That procedure will control compensatory actions in regards to non-functional channels of level indication.

The licensee also made available for staff to review Technical Requirements Manual Section (TRMS) 3.26, "Spent Fuel Pool – Wide Range Level Instrumentation," which address compensatory actions in regards to non-functional channels of level indication. The TRMS states in part, that:

> Compensatory measures for a single primary or back-up level channel out of service beyond 90 days could include one or more of the following actions:
>
> a. Increased surveillance (channel check) to verify functionality of the remaining level channel.
>
> b. Implementation of equipment protection measures.

c. Increased operator visual surveillance of the SFP level and area.

d. Maintain elevated SFP level and reduce SFP temperature

e. Supplemental Operations staffing.

Compensatory measures for both the primary and back-up level channel out of service beyond 90 days could include one or more of the following actions:

a. Increased operator visual surveillance of the SFP level and area.

b. Maintain elevated SFP level and reduce SFP temperature

c. Supplemental Operations staffing.

d. Pre-stage FLEX support equipment which are relied upon for SFP make-up (nozzles, hoses, etc.).

The staff reviewed this information and cocnludes that it adequately addresses implementing compensatory actions when there are non-functioning channels of level indication.

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

4.4 Conclusions for Order EA-12-051

In its letter dated June 27, 2015 (ADAMS Accession No. ML15187A229), the licensee stated that it would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff concludes that, if implemented appropriately, the licensee's plans should conform to the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at Robinson according to the licensee's proposed design, it appears to adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that, if implemented appropriately, appears to adequately address the requirements of Orders EA-12-049 and EA-12-051.

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Sincerely,

/RA/

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