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

October 24, 2018

Mr. Bryan Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: LIMERICK GENERATING STATION, UNITS 1 AND 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0847, MF0848, MF0854, AND MF0855; EPID NOS. L-2013-JLD-0013 AND L-2013-JLD-0014)

Dear Mr. Hanson:

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

By letter dated February 28, 2013 (ADAMS Accession No. ML13060A127), Exelon Generation Company, LLC (Exelon, the licensee) submitted its OIP for Limerick Generating Station, Units 1 and 2 (Limerick), 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 January 10, 2014 (ADAMS Accession No. ML13337A600), and March 17, 2015 (ADAMS Accession No. ML15054A366), the NRC issued an Interim Staff Evaluation (ISE) and an audit report, respectively, on the licensee's progress. By letter dated July 20, 2017 (ADAMS Accession No. ML17201A052), Exelon reported that Limerick, Unit 2, was in full compliance with Order EA-12-049. By letter dated June 7, 2018 (ADAMS Accession No. ML18159A138), Exelon reported that Limerick, Unit 1, was in full compliance with Order EA-12-049, and submitted a Final Integrated Plan for Limerick, Units 1 and 2.

By letter dated February 28, 2013 (ADAMS Accession No. ML13059A391), the licensee submitted its OIP for Limerick, Units 1 and 2, in response to Order EA-12-051. At six-month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the enclosed safety evaluation. By letters dated October 23, 2013 (ADAMS Accession No. ML13273A538), and March 17, 2015 (ADAMS Accession No. ML15054A366), the NRC staff issued an ISE and an 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 July 1, 2015 (ADAMS Accession No. ML15182A009), Exelon submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051 at Limerick, Units 1 and 2.

The enclosed safety evaluation provides the results of the NRC staff's review of Exelon's strategies for Limerick, Units 1 and 2. The intent of the safety evaluation is to inform Exelon on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 2515-191, "Inspection of the Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communication/Staffing/Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Peter Bamford, Beyond-Design-Basis Management Branch, Limerick Project Manager, at 301-415-2833, or by e-mail at Peter.Bamford@nrc.gov.

Sincerely,

Brett Titus

Brett A. Titus, Acting Chief
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket Nos.: 50-352 and 50-353

Enclosure:
Safety Evaluation

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

EXELON GENERATION COMPANY, LLC

LIMERICK GENERATING STATION, UNITS 1 AND 2

DOCKET NOS. 50-352 AND 50-353

1.0 INTRODUCTION

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

On March 12, 2012, the NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" [Reference 4]. This order directed licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities in the event of a BDBEE. Order EA-12-049 applies to all power reactor licensees and all holders of construction permits for power reactors.

On March 12, 2012, the NRC also issued Order EA-12-051, "Order Modifying Licenses With Regard to Reliable Spent Fuel Pool Instrumentation" [Reference 5]. This order directed licensees to install reliable SFP level instrumentation with a primary channel and a backup channel, and with independent power supplies that are independent of the plant alternating current (ac) and direct current (dc) power distribution systems. Order EA-12-051 applies to all power reactor licensees and all holders of construction permits for power reactors.

2.0 REGULATORY EVALUATION

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

(NTTF). The NTTF was tasked with conducting a systematic and methodical review of the NRC regulations and processes and determining if the agency should make additional improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a comprehensive set of recommendations, documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 [Reference 1]. Following interactions with stakeholders, these recommendations were enhanced by the NRC staff and presented to the Commission.

On February 17, 2012, the NRC staff provided SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," [Reference 2] to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by the Commission in Staff Requirements Memorandum (SRM)-SECY-12-0025 [Reference 3], the NRC staff issued Orders EA-12-049 and EA-12-051.

2.1 Order EA-12-049

Order EA-12-049, Attachment 2, [Reference 4] requires that operating power reactor licensees and construction permit holders use a three-phase approach for mitigating BDBEEs. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment and SFP cooling capabilities. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Specific requirements of the order are listed below:

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

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

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

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

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

On August 21, 2012, following several submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, "Diverse and Flexible

Coping Strategies (FLEX) Implementation Guide," Revision 0 [Reference 6] to the NRC to provide specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06 and on August 29, 2012, issued its final version of Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" [Reference 7], endorsing NEI 12-06, Revision 0, with comments, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (77 FR 55230).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2, [Reference 5] requires that operating power reactor licensees and construction permit holders install reliable SFP level instrumentation. Specific requirements of the order are listed below:

> All licensees identified in Attachment 1 to the order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement makeup water addition should no longer be deferred.
>
> 1. The spent fuel pool level instrumentation shall include the following design features:
>
> 1.1 Instruments: The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.
>
> 1.2 Arrangement: The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.
>
> 1.3 Mounting: Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and

following the maximum seismic ground motion considered in the design of the spent fuel pool structure.

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

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

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

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

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

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

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

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

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

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

On August 24, 2012, following several NEI submittals and discussions in public meetings with NRC staff, the NEI submitted document NEI 12-02, "Industry Guidance for Compliance With NRC Order EA-12-051, To Modify Licenses With Regard to Reliable Spent Fuel Pool Instrumentation," Revision 1 [Reference 8] to the NRC to provide specifications for an industry-developed methodology for compliance with Order EA-12-051. On August 29, 2012, the NRC staff issued its final version of JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" [Reference 9], endorsing NEI 12-02, Revision 1, as an acceptable means of meeting the requirements of Order EA-12-051 with certain clarifications and exceptions, and published a notice of its availability in the *Federal Register* (77 FR 55232).

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 28, 2013 [Reference 10], Exelon Generation Company, LLC (Exelon, the licensee) submitted an Overall Integrated Plan (OIP) for Limerick Generating Station, Units 1 and 2 (Limerick), in response to Order EA-12-049. By letters dated August 28, 2013 [Reference 11], February 28, 2014 [Reference 12], August 28, 2014 [Reference 13], February 27, 2015 [Reference 14], August 28, 2015 [Reference 15], February 26, 2016 [Reference 16], August 26, 2016 [Reference 17], February 28, 2017 [Reference 18], August 28, 2017 [Reference 19], and February 28, 2018 [Reference 20], the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 21], the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" [Reference 22]. By letters dated January 10, 2014 [Reference 23], and March 17, 2015 [Reference 24], the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated July 20, 2017 [Reference 25], Exelon reported that Limerick, Unit 2, was in full compliance with Order EA-12-049. By letter dated June 7, 2018 [Reference 26], Exelon reported that Limerick, Unit 1 was in full compliance with Order EA-12-049, and submitted a Final Integrated Plan (FIP) for Limerick, Units 1 and 2.

3.1 Overall Mitigation Strategy

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

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

1. The reactor is assumed to have safely shut down with all rods inserted (subcritical).
2. The dc power supplied by the plant batteries is initially available, as is the ac power from inverters 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.

Limerick, Units 1 and 2 are General Electric (GE) boiling-water reactors (BWRs), Model 4, with Mark II containments. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below.

At the onset of an ELAP both reactors are assumed to trip from full power. The main condenser is unavailable due to the loss of circulating water. Decay heat is removed when the safety relief valves (SRVs) open on high pressure and dump steam from the reactor pressure vessel (RPV) to the suppression pool located in the primary containment. Makeup to the RPV is provided by the reactor core isolation cooling (RCIC) turbine-driven pump. The licensee's mitigating strategy ensures that the RCIC pump suction is aligned to the suppression pool. Within approximately 20 minutes, the operators begin a controlled cooldown and depressurization of the RPV. The cooldown is stopped when RPV pressure reaches approximately 300 pounds per square inch gauge (psig) to ensure sufficient steam pressure to operate the RCIC pump. Approximately 6 hours into the event, the hardened containment vent to atmosphere is opened to mitigate the suppression pool pressure and temperature rise. The RCIC injection will be maintained for as long as possible, since it is a closed loop system using relatively clean suppression pool water.

When the RCIC system is no longer viable, the RPV is further depressurized and makeup supply comes from two diesel-driven FLEX pumps (one per unit) taking a suction from the spray pond. Together, these pumps are able to supply adequate makeup flow for both units.

Both reactors have Mark II containments. The licensee performed a containment evaluation and determined that opening the suppression chamber vent to atmosphere will support indefinite coping.

Each unit at Limerick has a SFP located on the refuel floor. According to the licensee's FIP, the refuel floor is a separate secondary containment zone located above the Reactor Buildings for each unit. The two pools are normally cross-connected and will initially heat up due to the unavailability of the normal cooling systems. The licensee has calculated that, for a normal heat load (one-third core offload), boiling could start at approximately 10 hours after the start of the ELAP. With this heat load, the water level would drop to 10 feet above the top of the fuel racks in approximately 76 hours if makeup is not provided. The licensee plans to have makeup available to the SFPs within 12 hours, and the necessary valve lineups, hose deployments, and building venting that must occur in the refuel floor area are planned to be established prior to the onset of SFP boiling.

To makeup to the SFPs, the licensee has multiple strategies that can be used. The primary strategy uses a combination of installed piping and a short flexible hose jumper to provide a makeup flow path that utilizes the same FLEX pump as is used in the RPV makeup strategy to supply the SFP. In addition, an alternate strategy using a combination of hoses and installed standpipes is included in the plan. This strategy has the capability to provide direct makeup or spray to either, or both, SFPs.

The operators will perform dc bus load shed to extend safety-related battery life sufficient to allow time for the deployment of a FLEX diesel generator (DG) for each unit. An initial load shed is completed approximately 2 hours into the event and a deeper load shed is completed approximately 3 hours into the event. Following the load shed and prior to battery depletion, two 500-kilowatt (kW), 480 volt alternating current (Vac) FLEX DGs (one per unit) will be deployed. These DGs will be used to repower essential battery chargers and are expected to be operational within approximately 7 hours of ELAP initiation.

In addition, a National SAFER [Strategic Alliance for FLEX Emergency Response] Response Center (NSRC) will provide high capacity pumps and large combustion turbine generators (CTGs) which could be used to provide spares or backups to the Phase 2 equipment and to restore selected plant systems.

Below are specific details on the licensee's strategies to restore or maintain core cooling, containment, and SFP cooling capabilities in the event of a BDBEE, and the results of the staff's review of these strategies. The NRC staff evaluated the licensee's strategies against the endorsed NEI 12-06, Revision 0, guidance.

3.2 Reactor Core Cooling Strategies

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

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

3.2.1 Core Cooling Strategy and RPV Makeup

3.2.1.1 Phase 1

According to the Limerick FIP, the initial injection of cooling water into the RPV will be accomplished through the use of the high pressure coolant injection (HPCI) and RCIC systems. Once water level is restored, HPCI will be secured and locked out, but would still be available for use, if necessary. The RCIC system will then be used to maintain water level. Because the turbine for the RCIC pump is driven by steam from the RPV, operation of the RCIC system further assists the SRVs with RPV pressure control. The RCIC system suction is initially lined up to the condensate storage tank (CST) and will pump water into the core from the CST, if it is available. However, the CSTs at Limerick are not a fully protected source of water for the ELAP event and therefore, the Limerick strategy assumes that the suppression pool is the RPV makeup source. The RCIC pump is protected from all applicable hazards.

According to the licensee's FIP, pressure control of the RPV is accomplished using the automatic depressurization system (ADS) SRVs, which are powered by the Class 1E dc buses. Within 20 minutes after the initiation of the event, operators will utilize the SRVs to depressurize at a rate of less than 100 degrees Fahrenheit (°F) per hour. After this point, the RPV pressure is lowered and maintained between 200 and 300 psig to allow for continued operation of the RCIC system. There is a backup nitrogen system in place that will be aligned to supply pneumatic motive force for at least 7 days of SRV operation. This system has the capability for bottle replacement that will allow for continued operation beyond 7 days.

According to the licensee's FIP, station batteries and the Class 1E dc distribution system provide power for operation of the RCIC system and instrumentation on each unit. Load shedding is performed to extend the battery capacity sufficient to allow time for the FLEX DGs to be deployed in Phase 2 of the event.

3.2.1.2 Phase 2

According to the Limerick FIP, RCIC will continue to be used until necessary to transfer to the FLEX pumps. The licensee's plan deploys two FLEX pumps (one per unit) near the UHS for the site (the spray pond). The spray pond will be the suction source for the pumps. The discharge of the FLEX pumps will be connected to the residual heat removal service water (RHRSW) system which can be aligned to each units' residual heat removal (RHR) system. This water could then be injected into the RPV. Each pump is rated at 1200 gallons per minute (gpm) with a 227 psig discharge head. The discharge of the pumps can be routed to various pathways for injection into both units' RPVs and SFPs. Nominally, RPV makeup requirements would be 300 gpm per unit and SFP makeup would be 200 gpm (250 gpm if using spray) per unit. The FLEX pumps can also provide suppression pool makeup, if necessary.

The alternate core cooling strategy involves injecting into the opposite loop of RHR for each unit. To accomplish this, the pump will be aligned to the RHRSW/RHR "A" loop on Unit 1 and the "B" loop of these systems for Unit 2. A 25 foot section of hose is necessary to cross connect the RHRSW and RHR systems to support the alternate strategy.

The licensee plans to open the hardened containment vent system (HCVS) on each unit to support the core cooling strategy and to maintain containment capability. According to the licensee's FIP, the vent would be opened approximately 4-6 hours after the event starts.

3.2.1.3 Phase 3

According to the Limerick FIP, the Phase 3 strategy would be to continue the Phase 2 strategy, with the Phase 3 equipment being used to supplement and/or replace the Phase 2 equipment. The Phase 3 equipment begins to arrive from the NSRC within 24 hours of the NSRC notification and then can be connected to replace Phase 2 components. According to the licensee's FIP, the Phase 2 connection points can be used with the equipment that will be arriving from the NSRC.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

The licensee's FIP identifies no variations to the core cooling strategy for a flooding event.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Phase 1

Section 3.3.4.1 of the licensee's FIP describes the RCIC system as consisting of a steam driven turbine pump and associated valves that takes suction from the CST, or the suppression pool, and utilizes reactor steam to drive the turbine, which is exhausted into the suppression pool. The licensee's strategy will use the suppression pool as the RCIC suction source, either via an automatic swap from the CST, or manual alignment by the operators. The system operates independently of ac power, plant service air, and any external cooling water system, and relies on the 125 Volts-dc (Vdc) system for operation of valves and controls. The suppression pool absorbs the heat energy removed from the RPV via SRV discharge and is vented to atmosphere through the HCVS to remove heat from the containment and to limit its temperature rise. The suppression pool can supply the RCIC system for approximately 65 hours of the ELAP event before makeup water from the spray pond is needed. The licensee's FIP states that a strainer is located on the RCIC pump suction line to prevent any foreign objects in the suppression pool from entering the RPV. The RCIC system and suppression pool are located in the Reactor Building, which is protected from all applicable external hazards. The Limerick Updated Final Safety Analysis Report (UFSAR) [Reference 30], Table 3.2-1 lists the RCIC system as Seismic Category I. Based on the licensee's FIP description, the NRC staff finds that the RCIC system and the suppression pool are robust and should be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

Section 3.3.1.1 of the licensee's FIP describes the operation of 14 SRVs, 5 of which are part of the ADS logic, which are installed on the main steam lines inside the drywell. The ADS SRVs serve as the primary strategy for RPV pressure control and decay heat removal. The Primary Containment Instrument Gas (PCIG) system provides a safety-related long-term gas supply to the ADS SRVs, in the event that the non-safety related normal PCIG supply is unavailable. Two Seismic Category 1 gas supplies (nitrogen bottles) are provided to assure the availability of the ADS valves for long-term operation. One set of gas bottles serves three ADS SRVs; another set serves the other two ADS SRVs. Either set of bottles supplies the ADS SRVs with sufficient nitrogen for seven days of operation and are connected at all times during normal operation. The SRVs are actuated from one of two installed dc solenoid valves on each valve which open to supply pneumatic pressure to the valve operating piston. The SRVs and attendant support equipment are located in the Reactor Building, which is protected from all applicable external hazards. Additionally, according to the licensee's UFSAR, Table 3.2-1, the SRVs are Seismic Category I. Based on the FIP and UFSAR descriptions, the NRC staff concludes that the ADS SRVs and support systems are robust and should be available during the postulated ELAP event, consistent with NEI 12-06, Section 3.2.1.3.

Phase 2

The licensee's RPV and suppression pool makeup strategy for Phase 2 transitions from the RCIC system to the FLEX pumps. Operators are directed by FLEX support guidelines (FSGs) to align the suction of the FLEX pumps to the spray pond, which contains approximately 29 million gallons of water. The discharge of the FLEX pumps is aligned to the RHRSW system. The RHRSW system is safety-related and designed to normally supply cooling water to the RHR heat exchangers for both units. The system is common to both units and consists of two independent trains. The RHRSW system can be cross-connected to the RHR system through existing piping on one RHR loop of each unit. Each RHR loop is capable of providing water makeup to the RPV or to the suppression pool. In the Limerick UFSAR, Table 3.2-1, describes the RHRSW system, RHR system, and the spray pond as Seismic Category I. Table 3.3-2 in the UFSAR, lists the RHRSW and RHR systems as protected from tornado missiles and UFSAR Section 3.5.1.4 further describes the underground portions of the RHRSW system as protected from tornado missiles. Based on the FIP and UFSAR descriptions, the NRC staff concludes that the RHRSW system, RHR system, and the spray pond are robust and should be available during the postulated ELAP event, consistent with NEI 12-06, Section 3.2.1.3.

Phase 3

The licensee's Phase 3 RPV and suppression pool inventory strategy does not rely on any additional installed plant SSCs other than those discussed for Phases 1 and 2.

3.2.3.1.2 Plant Instrumentation

The licensee's plan is to monitor instrumentation in the Main Control Room (MCR), and also by alternate means, if necessary, in order to support FLEX cooling strategy. The instrumentation is powered by station batteries and will be maintained for indefinite coping via battery chargers powered by the FLEX DGs.

As described in the FIP, the following instrumentation will be relied upon to support FLEX core cooling and inventory control strategy:

- RPV level (wide range)
- Fuel zone RPV level
- RPV pressure
- Drywell pressure
- Drywell temperature
- Suppression pool level
- Suppression pool temperature

These instruments can be monitored from the MCR or locally at instrument racks.

The staff reviewed the licensee's instrumentation listing and concludes that it is consistent with the recommendations provided in the endorsed guidance of NEI 12-06.

According to the licensee's FIP, guidelines for obtaining critical parameters locally are provided in Limerick procedure T-370 "Primary and Alternate Instrumentation during ELAP". Based on the FIP, the staff finds that this capability provides alternate methods for obtaining critical parameters if key parameter instrumentation is unavailable, consistent with the provisions of NEI 12-06, Section 5.3.3.1.

3.2.3.2 Thermal-Hydraulic Analyses

The licensee concluded that its mitigating strategy for reactor core cooling would be adequate based, in part, on thermal-hydraulic analysis performed using Version 4 of the Modular Accident Analysis Program (MAAP). Because the thermal-hydraulic analysis for the reactor core and containment during an ELAP event are closely intertwined, as is typical of BWRs, Limerick has addressed both in a single, coupled calculation. This dependency notwithstanding, the NRC staff's discussion in this section of the safety evaluation focuses on the licensee's analysis of reactor core cooling. The NRC staff's review of the licensee's analysis of containment thermal-hydraulic behavior is provided in Section 3.4.4.2 of this safety evaluation.

The MAAP is an industry-developed, general-purpose thermal-hydraulic computer code that has been used to simulate the progression of a variety of light water reactor accident sequences, including severe accidents such as the Fukushima Dai-ichi event. Initial code development began in the early 1980s, with the objective of supporting an improved understanding of and predictive capability for severe accidents involving core overheating and degradation in the wake of the accident at Three Mile Island Nuclear Station, Unit 2. Currently, maintenance and development of the code is carried out under the direction of the Electric Power Research Institute (EPRI).

To provide analytical justification for their mitigating strategies in response to Order EA-12-049, a number of licensees for BWRs and pressurized-water reactors (PWRs) completed analysis of the ELAP event using Version 4 of the MAAP code (MAAP4). Although MAAP4 and predecessor code versions have been used by industry for a range of applications, such as the analysis of severe accident scenarios and probabilistic risk analysis (PRA) evaluations, the NRC staff had not previously examined the code's technical adequacy for performing best-estimate simulations of the ELAP event. In particular, due to the breadth and complexity of the physical phenomena within the code's calculation domain, as well as its intended capability for rapidly simulating a variety of accident scenarios to support PRA evaluations, the NRC staff observed that the MAAP code makes use of a number of simplified correlations and approximations that should be evaluated for their applicability to the ELAP event. Therefore, in support of the reviews of licensees' strategies for ELAP mitigation, the NRC staff audited the capability of the MAAP4 code for performing thermal-hydraulic analysis of the ELAP event for both BWRs and PWRs. The NRC staff's audit review involved a limited review of key code models, as well as confirmatory analysis with the TRACE[1] code to obtain an independent assessment of the predictions of the MAAP4 code.

In June 2013, EPRI issued a technical report entitled "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications" [Reference 48] to support the

1. TRACE stands for TRAC/RELAP [Transient Reactor Analysis Code/Reactor Excursion and Leak Analysis Program] Advanced Computational Engine. TRACE is the latest in a series of advanced, best-estimate reactor systems codes developed by the U.S. Nuclear Regulatory Commission for analyzing transient and steady-state neutronic-thermal-hydraulic behavior in light water reactors.

NRC staff's review of the use of MAAP4 for ELAP analyses. The document provided general information concerning the code and its development, as well as an overview of its physical models, modeling guidelines, validation, and quality assurance procedures.

Based on the NRC staff's review of EPRI's June 2013 technical report, as supplemented by further discussion with the code vendor, audit review of key sections of the MAAP code documentation, and confirmation of acceptable agreement with NRC staff simulations using the TRACE code, the NRC staff concluded that, under certain conditions, the MAAP4 code may be used for best-estimate prediction of the ELAP event sequence for BWRs. The NRC staff documented this conclusion via an endorsement letter dated October 3, 2013 [Reference 49], and identified specific limitations that BWR licensees should address to justify the applicability of simulations using the MAAP4 code for demonstrating that the requirements of Order EA-12-049 have been satisfied.

During the audit process, the NRC staff verified that the licensee's MAAP4 calculation, along with an associated addendum, addressed the limitations from the NRC staff's endorsement letter. The licensee utilized the generic roadmap and response template that had been developed by EPRI to support consistency in individual licensee's responses to the limitations from the endorsement letter. In particular, based upon review of the MAAP4 calculation documentation, the staff concluded that appropriate inputs and modeling options had been selected for the code parameters expected to have dominant influence for the ELAP event. The NRC staff further observed that the limitations imposed in the endorsement letter, particularly those concerning the RPV collapsed liquid level being maintained above the reactor core and the primary system cooldown rate being maintained within Technical Specification limits, were satisfied. Specifically, the licensee's analysis calculated that Limerick would maintain the collapsed liquid level in the reactor vessel above the top of the active fuel region throughout the analyzed ELAP event. By maintaining the reactor core fully covered with water, adequate core cooling is assured for this event. Additionally, the licensee's fulfillment of the endorsement letter condition regarding the primary system cooldown rate signifies that thermally induced volumetric contraction and other changes in primary system thermal-hydraulic conditions should proceed relatively slowly with time, which supports the NRC staff's confidence in the predictions of the MAAP4 code. Furthermore, the licensee's conclusion that the entire reactor core will be submerged throughout the ELAP event is consistent with the staff's expectation that the licensee's flow capacity for primary makeup (i.e., installed RCIC pump and, subsequently, FLEX pumps) should be sufficient to support adequate heat removal from the reactor core during the analyzed ELAP event, including potential losses due to expected primary leakage.

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

3.2.3.3 Recirculation Pump Seals

An ELAP event would result in the interruption of cooling to the recirculation pump seals, potentially resulting in increased leakage due to the distortion or failure of the seals, elastomeric O-rings, or other components. Sufficient primary makeup must be provided to offset recirculation pump seal leakage and other expected sources of primary leakage, in addition to removing decay heat from the reactor core.

During the audit, the NRC staff discussed recirculation pump seal leakage with the licensee and requested that the licensee justify the applicability of the assumed leakage rate to the ELAP event.

The licensee's calculations for Limerick assumed a seal leakage rate of 36 gpm at full reactor pressure. This leakage rate is meant to bound 18 gpm per recirculation pump seal in accordance with NRC Generic Letter 91-07, "GI-23, 'Reactor Coolant Pump Seal Failures' and its Possible Effect on Station Blackout" [Reference 50]. This leakage rate will decrease as RPV pressure decreases during the cooldown. The staff observes that the RCIC pump capability makes up for the leakage rate plus steam removal with margin. The FLEX pumps' capability of 1200 gpm at 227 psig allows for makeup to the RPV, SFP and the suppression pool with margin to account for any variances in the assumed seal leakage rate during the event.

In the MAAP analysis, the licensee discussed system response to the variation of seal leakage rate as a function of RPV pressure in the thermal hydraulic simulation. The initial seal leakage rate was assumed to be 36 gpm. As the RPV was depressurized, the seal leakage rate was reduced. The licensee concluded that the RPV water level continued to be above the top of the active fuel throughout the simulation period at Limerick.

Considering the above factors, the NRC staff concludes that the leakage rate assumed by Limerick is reasonable based on the stipulations presented in Generic Letter 91-07. The staff further notes that gross seal failures are not anticipated to occur during the postulated ELAP event. As is typical of the majority of U.S. BWRs, Limerick has an installed steam-driven pump (i.e., RCIC) capable of injecting into the primary system at a flow rate well in excess of the primary system leakage rate expected during an ELAP, and the other pumps used for core cooling in its FLEX strategy have a similar functional capability and margin well above the expected leakage rate.

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

3.2.3.4 Shutdown Margin Analyses

As described in Limerick Technical Specification 3.1.1, adequate shutdown margin must be maintained in all operating modes. Limerick Technical Specification 1.39 further clarifies that shutdown margin is to be calculated for a cold, xenon-free condition, with the assumption that the highest-worth control rod remains fully withdrawn, to ensure that the most reactive core conditions are bounded.

Based on the NRC staff's audit review, the licensee's ELAP mitigating strategy maintains the reactor within the envelope of conditions analyzed by the licensee's existing shutdown margin calculation. Furthermore, the existing calculation retains conservatism because the guidance in NEI 12-06 permits analyses of the beyond-design-basis ELAP event to assume that all control rods fully insert into the reactor core.

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

3.2.3.5 FLEX Pumps and Water Supplies

For Phase 2, the licensee utilizes two FLEX pumps, one for each unit, to supply RPV makeup, available approximately 6 hours after ELAP initiation. The FLEX pumps are diesel engine-driven, trailer-mounted pumps that each deliver a maximum flow of 1200 gpm at 227 psig. The FLEX pumps use a 6 inch rigid lightweight suction hose, which is lowered into the spray pond with a floating strainer attached. The FLEX pumps are stored in the FLEX Pump Storage Building, which is protected from all applicable external hazards. The licensee has a total of three FLEX pumps at Limerick, one for each unit, with the third pump providing the "N+1" component of the FLEX strategy. Section 3.10 of this safety evaluation provides a discussion of the availability and robustness of the spray pond, which is used as the suction source for the FLEX pumps.

When the RCIC system is no longer available, the FLEX pumps are used to inject water from the spray pond into the RPVs and suppression pools using primary or alternate connection points on the RHRSW system. Section 3.7.3.1 of this safety evaluation describes the primary and alternate connection points for RPV, suppression pool, and SFP makeup during this phase of the licensee's strategy. The licensee evaluated the FLEX pump capacities via calculation LM-0706, "Fukushima FLEX Hydraulic Analysis," Revision 0, to verify that the volumetric flow rate and head available would be sufficient to provide the necessary makeup flow following a BDBEE.

During the audit process, the NRC staff reviewed the licensee's hydraulic analysis and confirmed that the FLEX pumps could provide the required capacity for RPV, SFP, and suppression pool makeup. During the onsite audit, the NRC staff conducted a walk down of the location of the FLEX pumps, hose locations, and the primary and alternate connection points on the RHRSW system. This walk down confirmed that the licensee's strategy was consistent with the hydraulic analysis. Based on the licensee's FIP description, confirmed by the staff's review of the hydraulic analysis, the NRC staff concludes that the portable FLEX pumps should perform as intended to support core cooling and RPV inventory control during an ELAP event, consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to the equipment and instrumentation used to mitigate the ELAP and loss of normal access to the UHS. The electrical strategies described in the FIP are integrated in supporting the core cooling, containment, and SFP cooling key safety functions. Any additional specific electrical strategy features applicable to the SFP cooling and containment safety functions are noted in Sections 3.3.4.4 and 3.4.4.4 of this safety evaluation, respectively.

According to the licensee's FIP, operators would declare an ELAP following a loss of offsite power and the emergency diesel generators (EDGs). The plant's indefinite coping capability is attained through the implementation of pre-determined FLEX strategies that are focused on maintaining or restoring key plant safety functions. A safety function-based approach provides consistency with, and allows coordination with, existing plant emergency operating procedures (EOPs). The FLEX strategies are implemented in support of EOPs using FSGs.

During the first phase of an ELAP event, the licensee relies on the safety-related Class 1E batteries to provide power to key instrumentation and applicable dc components. The Limerick

Class 1E station batteries and associated dc distribution systems are located within safety-related structures designed to meet applicable design basis external hazards. Licensee procedure E-1, "Loss of All AC Power (Station Blackout)," directs operators to conserve dc power during the event by stripping non-essential loads. Operators will strip or shed unnecessary loads to extend battery life such that it will be available until backup power is deployed (Phase 2). During the postulated event, the plant operators commence load shedding of the station batteries within 45 minutes of event initiation and will complete deep load shedding within 2 hours.

As part of the mitigating strategies, the licensee is crediting the Class 1E 125/250 Vdc Division 1 and 2 batteries (1A1D101, 1A2D101, 1B1D101, 1B2D101). C&D Technologies manufactured each battery. The 125/250 Vdc station batteries are C&D model LCR-21 with a nominal capacity of 1500 ampere-hours. The licensee's FIP states that the Division 1 and Division 2 coping times are 7.4 and 14.5 hours, respectively.

The NEI white paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," [Reference 55] provides guidance for calculating extended duty cycles of batteries (i.e., beyond 8 hours). This paper was endorsed by the NRC [Reference 56]. In addition to the white paper, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended Battery Operation in Nuclear Power Plants," in May of 2015 [Reference 57]. The testing provided additional validation that the NEI white paper method was technically acceptable. During the audit process, the NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI white paper.

During the audit process, the NRC staff reviewed the licensee's dc coping calculation LE-0125, "Class 1E Battery Load Duty Cycle Determination ELAP Scenario," Revision 3, which evaluated the capability of the dc system to supply power to the required loads during the first phase of the Limerick FLEX mitigation strategy. The staff confirmed that the licensee's calculation identified the required loads and their associated ratings (ampere and minimum required voltage), as well as the non-essential loads that would be shed within 2 hours to ensure battery operation for at least 7.4 (Division 1) and 14.5 (Division 2) hours.

Based on the FIP description, confirmed by its review of the licensee's analyses and procedures, and the battery vendor's capacity and discharge rates for the Class 1E station batteries, the NRC staff concludes that the Limerick dc systems have adequate capacity and capability to power the loads required to mitigate the ELAP event during Phase 1. This conclusion is contingent upon the licensee performing the necessary load shedding within the times assumed in the analyses.

The licensee's Phase 2 strategy includes repowering the Class 1E battery chargers within 7 hours after initiation of an ELAP to maintain the safety-related dc buses and other essential loads. The licensee's Phase 2 strategy relies on the deployment of one portable 500 kilowatt (kW) 480 Vac FLEX DG per unit. The 480 Vac FLEX DG would provide power to the Class 1E battery chargers and other selected loads. The licensee has a total of three 480 Vac 500 kW FLEX DGs, with the third FLEX DG providing the "N+1" capability.

During the audit process, the NRC staff reviewed licensee engineering change ECR 14-00019 (EC 422939), "Fukushima FLEX – Electrical Engineering Modification," Revision 1, conceptual single line diagrams, and the separation and isolation of the FLEX DGs from the EDGs. Based on the NRC staff's review of ECR 14-00019, the minimum required load for the licensee's Phase 2 500 kW FLEX DG is 163 kW. The staff noted that the licensee took the FLEX cable lengths into consideration when sizing the FLEX DGs (i.e., by ensuring that the voltage drop did not exceed the minimum voltage required at the limiting component). Based on its review of the licensee's calculation, the NRC staff finds that a single 500 kW FLEX DG per unit is adequate to support the electrical loads required for the licensee's Phase 2 strategies. The staff also confirmed that licensee procedures T-333, "FLEX Generator Connection for Repowering Div 1 Battery Charger (Unit 1)," Revision 1, T-333, "FLEX Generator Connection for Repowering Div 1 Battery Charger (Unit 2)," Revision 1, T-334, "FLEX Generator Connection for Repowering Div 2 Battery Charger (Unit 1)," Revision 2, and T-334, "FLEX Generator Connection for Repowering Div 2 Battery Charger (Unit 2), Revision 3, provide direction for staging and connecting a FLEX DG to energize the electrical buses to supply required loads within the required timeframes.

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources. The offsite electrical equipment that will be provided by an NSRC includes four (two per unit) 1-megawatt (MW) 4160 Vac combustion turbine generators (CTGs), two (one per unit) 1100 kW 480 Vac CTGs, and distribution panels (including cables and connectors). The licensee plans to only connect the 480 Vac CTGs and not the 4160 Vac CTGs, should the Phase 3 CTGs be deployed. Based on the additional margin available due to the higher capacity (1100 kW) of the 480 Vac CTGs as compared to the Phase 2 FLEX DGs (500 kW), the NRC staff finds that the 480 Vac CTGs being supplied from an NSRC have sufficient capacity and capability to supply the required loads.

Based on its review, the NRC staff finds that the Class 1E station batteries should have sufficient capacity to support the licensee's strategy, and that the FLEX DGs and NSRC supplied CTGs should have sufficient capacity and capability to supply the necessary loads during an ELAP event.

3.2.4 Conclusions

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

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-1 and Appendix C summarize an acceptable approach consisting of three separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for: (1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design basis heat load; (2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load; and (3) spray via portable monitor nozzles from the refueling floor using a portable pump capable of providing a minimum of 200 gpm per unit (250 gpm if overspray occurs). During the event, the licensee selects the method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting of the Reactor Building.

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 beyond-design-basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters, and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. 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 additional initial conditions; and Section 3.2.1.6 describes SFP initial conditions.

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

The ELAP causes a loss of cooling in the SFP. As a result, the pool water will heat up and eventually boil off. The licensee's response is to provide makeup water. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP. The occurrence of an ELAP during a plant shutdown with a full core offload to the SFP is addressed in Section 3.11 of this safety evaluation.

3.3.1 Phase 1

The licensee stated in its FIP that no actions are required during ELAP Phase 1 for SFP makeup because the time to boil is sufficient to enable deployment of Phase 2 equipment. According to the licensee's FIP, setup activities will commence within 6 hours of the ELAP, in advance of high dose rates or temperatures, to prepare for the deployment of the FLEX pump in Phase 2. These activities involve running hoses in the vicinity of the refuel floor and providing a ventilation path in anticipation of SFP boiling. During this time, the licensee will also monitor SFP water level using the reliable SFP level instrumentation installed per Order EA-12-051.

3.3.2 Phase 2

During Phase 2, the licensee's FIP indicates that the portable FLEX pump will be aligned to take suction from the spray pond to provide SFP makeup. The licensee has a primary and alternate strategy. Both strategies can provide either direct SFP makeup or spray capability via connections to monitor nozzles staged on the refuel floor. The mechanical connections for SFP makeup are described in Section 3.7.3.1 of this safety evaluation.

3.3.3 Phase 3

The licensee's FIP states that SFP cooling can be maintained indefinitely using the makeup strategies described in Phase 2 above and also notes that high capacity pumps from an NSRC will be available during Phase 3 as a backup to the onsite pumps.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

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

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any operator actions. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. The operators are directed to open the airlock doors to the south stack in the Reactor Building at the onset of ELAP initiation to establish ventilation of the refuel floor. In addition, the licensee's FIP states that within the first 6 hours after the event initiates, setup activities will commence to support preparation for SFP makeup when it is needed in Phase 2.

The licensee's FIP describes two cases of analyzed SFP heat load. The first case involves a one-third core offload of one unit 5 days after shutdown. The second case describes a full core offload of one unit 5 days after shutdown. The NRC staff notes that both SFP heat load cases are conservative with respect to a scenario with both units operating. For the first case (one-third core offload), the licensee calculates that the combined SFPs will boil approximately 10 hours after event initiation and the water inventory will reach 10 feet above fuel assemblies in approximately 86 hours, assuming no makeup is provided. Therefore, the licensee's strategy to initiate refuel floor actions at approximately 6 hours into the event should occur before the building environment starts to degrade due to boiling. Further, the licensee's strategy to initiate water makeup around 12 hours, as described in the FIP, will provide water well in advance of SFP level reaching 10 feet above the fuel assemblies. For a full core offload, the time to boil shortens to approximately 4.5 hours and the time for the SFP level to drop to 10 feet above the fuel shortens to approximately 39 hours. However, in this scenario the licensee staff on the affected unit would only have to focus on the SFP (not the reactor core), and thus should be able to initiate makeup more quickly than for the partial offload case.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of the FLEX pumps (or NSRC-supplied pumps for Phase 3), with suction from the spray pond, to supply water to the SFP. The primary strategy uses permanently installed RHRSW to RHR system cross-ties (Unit 1 "B" /Unit 2 "A" loop) as part of the injection lineup for SFP makeup, in a similar manner to that used for RPV makeup. This strategy also utilizes a hose jumper from the RHR system to the spent fuel pool cooling return line and into the SFP. The alternate strategy (Unit 1 "A" /Unit 2 "B" loop) uses a hose jumper to connect from the RHRSW system to the RHR system. This strategy then uses a combination of hoses and standpipes to complete the flow path to the SFP. As described in Section 3.2.3.1.1 of this safety evaluation, the staff considers the RHRSW and RHR systems are considered to be robust. The SFP cooling system and standpipes are located in Seismic Category I and tornado missile-protected structures and are likewise considered to be robust. The NRC staff's evaluation of the robustness and availability of the connection points for the FLEX pump is discussed in Section 3.7.3.1 of this safety evaluation, and the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.

During the audit process, the staff reviewed the licensee's calculations relating to habitability on the SFP refuel floor. These included LM-0708, "Spent Fuel Pool Heat-up – FLEX," Revision 0, and LM-0710, "Refueling Floor Air Space Transient Temperature Profile following ELAP," Revision 0. The staff's review confirmed the analytical basis for the provisions described in the licensee's FIP regarding SFP decay heat loads and deployment timing.

3.3.4.1.2 Plant Instrumentation

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

3.3.4.2 Thermal-Hydraulic Analyses

As described in FIP Section 3.5.6, the combined SFPs will boil in approximately 4.56 hours and boil off to a level of 10 feet above the spent fuel racks in 39.4 hours from initiation of the ELAP event, at the maximum design heat load (full core offload from one unit), assuming that no makeup is provided. The licensee's FIP and the supporting hydraulic analysis describe a projected SFP makeup flow of 200 gpm per pool (250 gpm per pool if using spray). These SFP makeup values are based on the provisions of NEI 12-06, Table C-1. The 200 gpm SFP makeup flow per pool is generally considered to be a bounding value with respect to the expected boil-off rate for a typical SFP. During the audit process, the NRC staff performed an evaluation to confirm that the licensee's projected maximum decay heat load would result in a SFP boil-off rate below the makeup parameters assumed in the FLEX pump hydraulic analysis. Therefore, based on the licensee's FIP description and confirmed by the audit review, the staff concludes that the licensee has conservatively determined a SFP makeup flow that should maintain adequate SFP level for an ELAP event. Consistent with the guidance in NEI 12-06, Section 3.2.1.6, the NRC staff also finds the licensee has considered the maximum design-basis SFP heat load.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on the FLEX pumps to provide SFP makeup during Phase 2 Section 3.2.1 of the FIP references calculation LM-0706, "Fukushima FLEX Hydraulic Analysis," Revision 0, which provides the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the FLEX pumps. The FLEX pumps are also used for RPV and suppression pool makeup as described previously in Section 3.2.3.5 of this safety evaluation. During the audit process the staff confirmed that the licensee's calculations reflected simultaneous makeup to the RPV, suppression pool, and SFP. The NRC staff also notes that the performance criteria of a FLEX pump supplied from an NSRC in Phase 3 would have a similar capability and thus should fulfill the SFP makeup function, if it was needed.

3.3.4.4 Electrical Analyses

The licensee's mitigating strategies for SFP cooling do not rely on electrical power except for what is needed for operation of the SFP level instrumentation. According to the FIP, the Limerick SFP level instrumentation has sufficient battery capacity for 72 hours. Prior to the battery fully depleting, the licensee could replace the batteries or use portable generators to supply power to instrumentation and display panels, and recharge the installed battery.

Based on its review, the NRC staff finds that the licensee's electrical strategy should be able to support the ability to restore or maintain SFP cooling indefinitely during an ELAP.

3.3.5 Conclusions

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

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06, Table 3-1, provides some examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to effectively maintain containment functions during all phases of an ELAP event. One such approach is for a licensee to perform an analysis demonstrating that containment pressure control is not challenged.

The licensee's FIP describes the results of the containment evaluation that was performed. During the audit process that staff reviewed the licensee's calculation, LG-MISC-012, "MAAP Analysis to Support FLEX Initial Strategy," Revision 3, Case FLEX22, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the strategy of venting the suppression pool starting at approximately 3 hours and concluded that the containment parameters of pressure and temperature remain well below the respective UFSAR Section 6.2, Table 6.2-1 design limits of 55 psig and 340°F for the drywell and 55 psig for the suppression chamber. The calculation was run for a period of 72 hours and shows that after 72 hours conditions in the drywell have stabilized or are in a downward trend. The suppression pool reaches a peak temperature of 225°F at approximately 10 hours into the event. This temperature exceeds the design temperature of 220°F and a discussion of exceeding the suppression chamber temperature design parameter is covered in Section 3.4.4.2 of this safety evaluation. From its review of the FIP description, supplemented by the audit review, the NRC staff concludes that actions to maintain containment capability and the required instrumentation functions have been developed, and are summarized below.

3.4.1 Phase 1

During Phase 1, containment integrity is maintained by normal design features of the containment, such as the containment isolation valves. Containment isolation actions to be taken by operators are included in existing station blackout (SBO) procedures.

The licensee's strategy includes venting the suppression chamber via the HCVS. This action will provide a mechanism to remove decay heat from containment and limit the rise of the suppression pool temperature. Venting will maintain containment pressure well below the UFSAR design value of 55 psig. During Phase 1, RPV makeup is provided by the RCIC pump using water drawn from the suppression pool.

Drywell pressure along with suppression pool temperature and level will be available and will be monitored.

3.4.2 Phase 2

The Phase 2 strategy will continue the Phase 1 activities of monitoring key containment parameters and operation of the HCVS. A FLEX DG will be lined up to repower the battery chargers and sustain key instrumentation.

Makeup water can be provided to the suppression pool as needed via a portable FLEX pump.

3.4.3 Phase 3

The Phase 3 strategy is to maintain the Phase 2 strategy with offsite equipment being available to replace or supplement FLEX equipment as required.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

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

3.4.4.1.1 Plant SSCs

Primary Containment

The primary containment structure for each unit is a Seismic Category I structure designed to withstand the effects of a safe shutdown earthquake (SSE) and remain functional to prevent or mitigate the consequences of accidents which could result in potential offsite exposures in excess of the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 100. According to the Limerick UFSAR, Section 3.5.1.4, the safety-related structures, systems, and components are designed either to resist tornado missiles or are protected by tornado-resistant enclosures. The containment consists of the drywell, the pressure suppression chamber, and the drywell floor which separates the drywell and suppression chamber. The drywell is a steel-lined reinforced concrete vessel in the shape of a frustum of a cone, as described in Table 1.3-4 of the Limerick UFSAR. The pressure suppression chamber is a cylindrical stainless steel clad steel-lined reinforced concrete vessel located below the drywell. The pressure suppression chamber stores a large volume of water (a minimum of approximately 122,120 cubic feet). The primary containment structure houses the RPV, the reactor recirculation system, and other branch connections of the reactor coolant pressure boundary.

In the UFSAR, Section 6.2.1 identifies the containment drywell design parameters as 55 psig internal design pressure, 340°F design temperature. For the suppression chamber the design pressure is 55 psig internal design pressure, 220°F design temperature.

Secondary Containment

The Reactor Building encloses the RPV and its primary containment. The structure provides secondary containment when the primary containment is in service, and will provide primary containment function when the primary containment is open, as during refueling or maintenance. The Reactor Building houses the refueling and reactor servicing equipment and the new and spent fuel storage facilities. The principal purpose of the secondary containment is to confine the leakage of airborne radioactive materials from the primary containment and provide a means for a controlled, elevated release to the atmosphere. The Reactor Building is a Seismic Category I structure. The secondary containment, up to and including the roof slab, is of reinforced concrete construction and is designed to withstand postulated tornado-generated missiles as listed in the UFSAR, Section 3.5.1.4.

Hardened Containment Vent System

The HCVS is designed and installed to meet the operational requirements of NRC Order EA-13-109. The HCVS provides a means to vent the suppression chamber to the atmosphere. The HCVS system can be operated from either the MCR or from the remote operating station (ROS). Pneumatic supply to valves and dc power for instrumentation and controls are provided by nitrogen bottles and a HCVS battery. Both can support system operation for at least 24 hours.

Residual Heat Removal (RHR) System

The RHR system includes pumps and heat exchangers that can be used to cool the nuclear system under a variety of situations. The RHR system allows removal of decay and sensible heat during and after plant shutdown. It consists of two independent loops ("A" and "B"). Each RHR loop can provide FLEX water makeup to the RPV or to the suppression pool. The RHR valves in the flow path to the RPV or the suppression pool can be opened manually or electrically if power is available from the portable FLEX DG. The RHR system is Seismic Category I and is located in the Reactor Building where it is protected from wind-generated missiles.

RCIC Suction and Discharge Piping

The licensee's FIP notes that the RCIC suction and discharge piping design temperature is 170°F. Since the ELAP event leads to higher suppression pool temperatures than was originally considered in the system design, the licensee evaluated the impact on this piping for higher water temperatures. This evaluation concluded that the RCIC suction and discharge piping and supports can withstand the additional thermal loading due to 250°F suppression pool temperature.

Based on the description provided in the licensee's FIP and the Limerick UFSAR, the NRC staff concludes that the plant SSCs integral to the strategy for maintaining containment capability are robust in accordance with the provisions of NEI 12-06.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-1 specifies that containment pressure, suppression pool level, and suppression pool temperature are key containment parameters that should be monitored by repowering the appropriate instruments. The licensee's FIP states that the following instrumentation will be available:

- Drywell temperature
- Suppression pool level
- Suppression pool temperature
- Drywell pressure

According to the licensee's FIP, in the unlikely event that battery chargers are non-functional rendering key parameter instrumentation unavailable, alternate methods for obtaining the critical parameters locally is provided in plant procedures.

The staff concludes that the availability of key containment parameters specified in the licensee's FIP meets the provisions of NEI 12-06, and should adequately support the licensee's mitigating strategy.

3.4.4.2 Thermal-Hydraulic Analyses

The licensee's FIP describes the thermal-hydraulic analysis that was used to simulate the ELAP event for Limerick and forms the basis for the containment evaluation. According to the licensee's FIP, calculation LG-MISC-012, "MAAP Analysis to Support FLEX Initial Strategy," Revision 3, contains the evaluation. As part of this evaluation, several cases were run to analyze methods of containment heat removal using anticipatory containment venting. According to the licensee, the MAAP cases indicate that anticipatory venting will maintain margin to the primary containment design pressure limit.

According to the licensee, Case FLEX22 from LG-MISC-012 provides a representative simulation consistent with the overall Limerick strategy. For this case, the suppression chamber vent is opened at 3 hours.

The results are summarized as follows:

- Peak suppression pool temperature 225°F (approximately hour 10)
- Suppression pool level: Minimum 9 feet (hour 70), Maximum 23 feet (time zero)
- Peak drywell airspace temperature 240°F (approximately hour 60)
- Peak drywell airspace pressure 21 psia [pounds per square inch absolute] (when venting commenced) and drops to approximately 15 psig by hour 72

In the UFSAR, Table 6.2-1 notes that the suppression chamber design pressure is 55 psig (internal), and the design temperature is 220°F. The licensee noted that the calculation predicts that the suppression chamber design temperature is exceeded after the 6 hour period that the Limerick FLEX strategy relies on RCIC for makeup to the RPV. The BWR Owners Group (BWROG) had GE Hitachi evaluate RCIC turbine and pump mechanical components assuming pump suction from the suppression pool at elevated temperatures. The evaluation concluded that except for the turbine journal bearings and the pump seal, the mechanical components would remain functional with a pool temperature up to 300°F and a 7 day mission time. The licensee also reviewed the impact of the higher temperature on the RCIC piping. Based on the RCIC evaluation, the licensee concluded that the predicted suppression pool temperature was acceptable. The FIP did not provide a discussion of the structural impact of exceeding the design temperature on the suppression chamber.

The NRC staff reviewed the impact of the water in the suppression pool exceeding of the suppression chamber design temperature by 5°F. The staff compared the design of the containment drywell (340°F design temperature) and the suppression pool (220°F design temperature) and evaluated the magnitude of the exceedance in terms of projected stresses and strains.

Based on that review, the NRC staff concluded that given the minimal impact to overall stress levels caused by the temperature excursion above the design criteria, the similarity in construction between the drywell and suppression chamber, the safety factors used in the design code, the simultaneous venting operation maintaining containment pressure well below the pressure limit, the fact that the higher temperature does not approach the physical limits of the construction materials, the overall capability of the containment will not be challenged.

3.4.4.3 FLEX Pumps and Water Supplies

Suppression pool water will be used as the primary source of water for the RPV. Starting in Phase 2, portable FLEX pumps will take water from the spray pond for RPV and suppression pool makeup. Phase 3 will continue the Phase 2 strategy with additional equipment available from an NSRC. Section 3.2.3.5 of this safety evaluation provides a detailed description of the FLEX pumps and water supplies.

3.4.4.4 Electrical Analyses

The licensee's Phase 1 coping strategy is to monitor containment pressure and temperature using installed instrumentation, and maintain containment integrity using normal design features of the containment, such as the containment isolation valves and the HCVS. The licensee's strategy to repower instrumentation using the Class 1E station batteries is identical to what was described in Section 3.2.3.6 of this safety evaluation and is adequate to ensure continued containment monitoring. Each unit's HCVS has a dedicated 125 Vdc battery and battery charger.

The licensee's Phase 2 coping strategy is to continue monitoring containment pressure and temperature using installed instrumentation and maintaining containment integrity. The licensee's strategy to repower instrumentation using a 500 kW FLEX DG is identical to what was described in Section 3.2.3.6 of this safety evaluation and is adequate to ensure continued containment monitoring. The licensee also plans to repower the HCVS battery charger utilizing the 500 kW FLEX DG. In order to confirm the FIP strategy, the staff reviewed licensee engineering change ECR 14-00019, "Fukushima FLEX – Electrical Engineering Modification," Revision 1, during the audit process. The staff confirmed that the addition of the HCVS battery chargers is within the limits of the FLEX DG and that licensee procedures (T-334 series for Unit 1 and Unit 2) provide guidance to place the HCVS battery chargers in service and power them from the FLEX DG.

The licensee's Phase 3 strategy is to continue its Phase 2 strategy throughout the event. Limerick will receive offsite resources and equipment from an NSRC within 72 hours after the onset of an ELAP event. Given the capacity of the CTGs, the NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to supply power to the HCVS components to maintain containment indefinitely.

Based on its review, the NRC staff determined that the electrical equipment available onsite (e.g., Class 1E batteries, HCVS batteries, and 500 kW FLEX DGs) as supplemented with the equipment that will be supplied from an NSRC, has sufficient capacity and capability to supply the required loads to maintain containment.

3.4.5 Conclusions

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

3.5 Characterization of External Hazards

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

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

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; 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 safety evaluation are consistent with the guidance in NEI 12-06 and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information under 10 CFR Part 50, Section 50.54(f) [Reference 27] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a draft final rule, titled "Mitigation of Beyond-Design-Basis Events," hereafter called the MBDBE rule, which was provided to the Commission for approval on December 15, 2016 [Reference 54]. The MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 51]. The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 28]. The Commission approved the staff's recommendations that licensees would need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly impact the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 41], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC safety evaluations and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, and the related industry guidance in NEI 12-06. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049.

As discussed above, licensees are reevaluating, or have reevaluated, the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H [Reference 52]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 53]. The licensee's MSAs evaluate the mitigating strategies described in this safety evaluation using the revised seismic and flooding hazard information and, if necessary, make changes to the strategies or equipment. For Limerick, the licensee has submitted MSAs for the reevaluated seismic and flooding hazards [References 58 and 60 for seismic and flooding, respectively]. The licensee's MSAs concluded that the FLEX strategies do not require changes to accommodate the reevaluated hazards. The NRC assessments of the Limerick MSAs [References 59 and 61] have confirmed this conclusion.

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

3.5.1 Seismic

In its FIP, the licensee described the current design-basis seismic hazard, including descriptions of the operating basis earthquake (OBE) and the SSE. As described in UFSAR, the SSE seismic criteria for the site is fifteen-hundredths of the acceleration due to gravity (0.15g) peak horizontal ground acceleration, with the peak horizontal ground acceleration for the OBE specified as 0.075g. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the numbers above, is often used as a shortened way to describe the hazard.

In order to assess the reevaluated seismic hazard, the licensee submitted an MSA to the NRC [Reference 58]. The purpose of the MSA was to review the FLEX strategies against the reevaluated seismic hazard. For Limerick the reevaluated hazard was bounded by the design-basis SSE, except for frequencies greater than 10 Hertz. The licensee's MSA evaluated the applicable plant components that could be impacted by this high-frequency exceedance and concluded that the FLEX strategy would be capable of being implemented and deployed as designed, and would not have to be modified to account for the reevaluated hazard. By letter dated May 25, 2017 [Reference 59], the NRC staff concluded that the FLEX strategies at Limerick, including deployment, were not affected by the impacts of the reevaluated seismic hazard, as will potentially be required by the proposed MDBDE rulemaking.

Based on the FIP description and the MSA review, the NRC staff concludes that the licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

In its FIP, the licensee described that the design basis flood elevation for the adjacent Schuylkill River, including wave activity, as 207 feet mean sea level. This compares to a site grade elevation that is no lower than 215 feet mean sea level at any of the safety-related structures. According to the licensee's FIP, the site is considered to be a "dry site" as stipulated in NEI 12-06. This is consistent with the description of the site in the Limerick UFSAR, Section 2.4.2. The licensee's FIP also describes a flooding review that was conducted for the spray pond. The spray pond is located at a higher elevation on the site from the main power block structures. The maximum flood level applicable to the spray pond area is 254.9 feet mean sea level and the lowest elevation for the spray pond pump house is 268 feet mean sea level. In addition, the licensee's FIP states that a local intense precipitation (LIP) event was evaluated for Limerick and the review for that event concluded that the LIP event would not impact storage and deployment of the FLEX equipment. The licensee's FIP does not contain provisions for any groundwater in-leakage mitigation within the FLEX strategy.

In order to assess the reevaluated flooding hazard the licensee submitted an MSA to the NRC [Reference 60]. The purpose of the MSA was to review the FLEX strategies against flooding mechanisms that were not bounded by the design basis. For Limerick this was the LIP event. The licensee's MSA concluded that for the reevaluated hazard level, the FLEX strategy would be capable of being implemented and deployed as designed, and would not have to be modified to account for the reevaluated hazard. By letter dated May 25, 2017 [Reference 61], the NRC staff concluded that the FLEX strategies at Limerick, including deployment, were not affected by the impacts of the reevaluated flooding hazard, as will potentially be required by the proposed MDBDE rulemaking. Based on the FIP description and the MSA review, the staff concludes that the licensee has appropriately reviewed this external hazard and identified the hazard levels to be evaluated.

3.5.3 High Winds

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

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

According to the Limerick FIP, the site location is at 40° 13' 26" north latitude and 75° 35' 16" west longitude. Based on that location, NEI 12-06, Figure 7-1 shows that Limerick is susceptible to hurricanes. In addition, NEI 12-06 Figure 7-2, indicates the site is in a region where the tornado design wind speed exceeds 130 mph. Therefore, the plant screens in for an assessment for high winds due to hurricanes and tornados, including missiles produced by these events. In the Limerick UFSAR, Table 2.3.1-7 lists the following tornado design parameters: (1) maximum wind speed - 360 mph; (2) maximum rotational wind speed – 300 mph; (3) translational wind speed - 60 mph; (4) external pressure drop - 3 psi; and (5) rate of pressure drop - 1 psi per second. In the Limerick UFSAR, Section 2.3.1.2.1.1 discusses the hurricane susceptibility of the site. Between 1963 and 1980, the maximum wind speed resulting from a tropical storm in the region was 38 mph recorded at Philadelphia. In general, for inland sites such as Limerick, the primary impact from hurricanes is rain, which is evaluated in the flooding section of this safety evaluation.

In terms of tornado missiles, the Limerick UFSAR, Table 3.5-4, lists the applicable missile parameters, summarized as follows:

Missile	Physical Properties	Horizontal Impact Velocity (mph)
Wood Plank	4 inch x 12 inch x 12 feet	300
Steel pipe	3 inch diameter, 10 feet long, schedule 40	144
Automobile	4000 pounds	72
Steel Rod	1 inch outside diameter, 3 feet long, 8 pounds	216
Utility Pole	13-½ inch outside diameter, 35 feet long, 1490 pounds	144

Therefore, hurricane and tornado-based high wind hazards are applicable to the plant site. The staff concludes that the licensee's use of the design-basis tornado wind and missile criteria for the high wind evaluation is appropriate for Limerick. 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 <u>Snow, Ice, and Extreme Cold</u>

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

According to the Limerick FIP, the site location is at 40° 13' 26" north latitude and 75° 35' 16" west longitude. In addition, the licensee's FIP states that the site is located within the region characterized by NEI 12-06, Figure 8-2, as ice severity level 4. Consequently, the site is subject to large amounts of ice that could cause severe damage to electrical transmission lines. In its FIP, referencing the plant UFSAR, the licensee stated that temperatures at the site rarely drop below 0°F. The licensee concludes that the plant screens in for an assessment for snow, ice, and extreme cold hazard.

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

3.5.5 Extreme Heat

The licensee's FIP notes that, as per NEI 12-06 Section 9.2, all sites are required to consider the impact of extreme high temperatures. The licensee's FIP notes that according to the Limerick UFSAR, temperatures rarely exceed 100°F and the maximum temperature measured in the local area between 1874 and 1976 was 106°F.

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

3.5.6 Conclusions

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

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

According to the licensee's FIP, two hardened FLEX storage structures were constructed to protect the FLEX equipment at Limerick. One is a 40-foot x 60-foot robust structure located in the protected area south of the Reactor Enclosure and the second is a 60-foot x 90-foot robust structure located near the west end of the spray pond. According to the licensee's FIP, these structures have been designed to meet the requirements to protect the stored equipment from all of the external events identified in NEI 12-06. The design of the two buildings includes protection of the roll-up doors from tornado missiles.

According to the licensee's FIP, all FLEX portable equipment is stored in the two buildings. The storage building inside the protected area south of the Reactor Enclosure houses the two "N" DGs (as described in NEI 12-06, "N" refers to the number of units on site). The FLEX pumps are stored in the larger building located near the spray pond, along with the "N+1" FLEX DG. Debris removal equipment is stored in both buildings. This keeps the major pieces of FLEX equipment stored near their deployment locations, with the exception of the "N+1" FLEX DG, should it be needed. The licensee's FIP states that all actions required to access and deploy the FLEX equipment can be accomplished manually (without the need for ac power).

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

3.6.1.1 Seismic

According to NEI 12-06, Revision 2, a robust structure means that the design either meets the current plant design basis for the applicable external hazard(s) or the current NRC design guidance for the applicable hazard; or has been shown by analysis or test to meet or exceed the current design basis. Therefore, the licensee's two FLEX Buildings must protect the equipment stored within from an earthquake at the design basis (SSE) level such that the equipment survives the event and is subsequently deployable. In order to confirm the licensee's FIP statements regarding the robustness of the two storage facilities, the NRC staff reviewed the licensee's design specification for the two buildings during the audit process. The building specification, 15871-DC-C-00001-0, "Civil/Structural Design Criteria for Exelon FLEX Storage and Commercial Buildings," Revision 0, states that the enveloping SSE for the applicable Exelon sites will be used for the seismic design component of the buildings. The staff further confirmed that the licensee's specification included the Limerick specific ground response spectra in the assessment of the enveloping building design load.

According to the licensee's FIP, for both of the robust storage buildings, the large pumps and generators, as well as cabinets and shelving units, are secured with tie-down straps to protect them and prevent overturning during a seismic event.

Based on the licensee's FIP description, confirmed by the audit review, the NRC staff concludes that the licensee's storage plan for the FLEX equipment provides reasonable protection against postulated seismic events.

3.6.1.2 Flooding

As previously discussed in this safety evaluation, Limerick is considered to be a "dry site" and therefore there are no specific provisions regarding protection and deployment of FLEX equipment necessary to respond to postulated flooding conditions. The NRC staff's evaluation of the licensee's flooding MSA [Reference 61] noted that the FLEX storage locations and deployment routes are located at higher elevations than the flood level for both the design-basis and reevaluated flooding hazards, except for the re-evaluated LIP event. For LIP considerations, the MSA notes that based on deployment timing and water diversion, the short-term LIP event would not impact deployment of the FLEX strategies. Based on the FIP description and the MSA review the staff concludes that the licensee's storage plan for the FLEX equipment provides reasonable protection against postulated flooding events

3.6.1.3 High Winds

According to NEI 12-06, a robust structure means that the design either meets the current plant design basis for the applicable external hazard(s) or the current NRC design guidance for the applicable hazard; or has been shown by analysis or test to meet or exceed the current design basis. Therefore, the licensee's two FLEX Buildings must protect the equipment stored within from tornado wind and missile loads at the design basis level such that the equipment survives the event and is subsequently deployable. In order to confirm the licensee's FIP statements regarding the robustness of the two storage facilities, the NRC staff reviewed the licensee's design specification for the two buildings during the audit process. The building specification, 15871-DC-C-00001-0, "Civil/Structural Design Criteria for Exelon FLEX Storage and Commercial Buildings," Revision 0, states that the enveloping tornado wind and missile conditions for the applicable Exelon sites will be used for the high wind design component of the buildings. The staff confirmed that the parameters for the design missiles chosen for the robust FLEX buildings' design bounds the applicable design-basis site parameters for Limerick.

Based on the licensee's FIP description, confirmed by the audit review, the NRC staff concludes that the licensee's storage plan for the FLEX equipment provides reasonable protection against postulated high wind events.

3.6.1.4 Snow, Ice, Extreme Cold, and Extreme Heat

According to NEI 12-06, a robust structure means that the design either meets the current plant design basis for the applicable external hazard(s) or the current NRC design guidance for the applicable hazard; or has been shown by analysis or test to meet or exceed the current design basis. Therefore, the licensee's two "N" FLEX Buildings must provide protection from snow, ice, cold, and heat consistent with the design basis. According to the licensee's FIP the FLEX storage structures have been designed to protect the stored equipment from extreme snow, ice, extreme heat and cold temperature conditions. The staff's audit review of specification 15871-DC-C-00001-0 confirms that the storage buildings' design accounts for snow, ice, extreme cold, and extreme heat consistent with the site design basis. Based on the licensee's FIP description, confirmed by the audit review the staff concludes that that the licensee's storage plan for the FLEX equipment provides reasonable protection against snow, ice, extreme cold, and extreme heat.

3.6.1.5 Conclusions

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

3.6.2 Availability of FLEX Equipment

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

The major components of the licensee's FLEX strategy subject to the "N+1" provision of NEI 12-06 are the FLEX DGs, the FLEX pumps, and the associated hoses and cables. For the FLEX DGs, the licensee's strategy uses one DG per unit with a third DG available as a spare to meet the "N+1" criteria. The two "N" DGs are stored in the smaller robust storage building and the "N+1" DG is stored in the larger robust building. Since all three DGs are stored in robust structures, this meets the provisions of NEI 12-06, Revision 0. Regarding the FLEX pumps, the two "N" pumps and "N+1" pump are stored in the larger robust FLEX building and thus the licensee's storage plan for these pumps meets the "N+1" provisions of NEI 12-06. For hoses and cables, the licensee has chosen an alternate approach to the provisions of NEI 12-06, Revision 0. This is discussed further in Section 3.14.1 of this safety evaluation.

Based on the number of portable FLEX pumps and DGs, identified in the FIP, the NRC staff finds that, if implemented appropriately, the licensee's FLEX strategies include sufficient portable equipment provisions for RPV makeup and core cooling, SFP makeup, and maintaining containment consistent with the "N+1" recommendation in Section 3.2.2.16 of NEI 12-06.

3.7 Planned Deployment of FLEX Equipment

The major pieces of FLEX equipment that must be deployed to support the licensee's strategy are the two FLEX DGs (one per unit) and the FLEX pumps (one per unit). According to the licensee's FIP, the large portable FLEX equipment will be moved from the FLEX storage locations using the two trucks that function as tow vehicles.

3.7.1 Means of Deployment

According to the licensee's FIP, there are two tow vehicles available to support large FLEX equipment deployment. One is stored in each robust FLEX storage building. These vehicles are also designated for debris removal and are outfitted with plows. The FIP also states that debris removal equipment is stored inside each of the FLEX storage buildings in order to be reasonably protected from the applicable external events such that the equipment is likely to remain functional and deployable to clear obstructions from the pathway between the equipment's storage location and its deployment location. Table 3 in the licensee's FIP indicates that miscellaneous pieces of debris removal equipment (large bolt cutters, chain saws, sawzalls, and proximity voltage detectors) are also available to support deployment. Also, according to the license's FIP, deployment of the FLEX debris removal equipment from the storage locations is not dependent on electrical power. Based on the FIP description, the staff concludes that the licensee's means of deployment meets the provisions of NEI 12-06 regarding protection, debris removal capability, and accessibility, and is therefore acceptable.

3.7.2 Deployment Strategies

The licensee has pre-determined staging locations and deployment routes for the major pieces of FLEX equipment. In addition, clearing of deployment paths has been incorporated into the Limerick snow removal plan.

According to the license's FIP, soil liquefaction was reviewed for the site. The FIP notes that as described in the UFSAR, the soil at the Seismic Category I spray pond was analyzed for liquefaction potential and the soils at other Seismic Category I facilities were not analyzed since these soils are not saturated and the potential for becoming saturated is negligible. Based on the UFSAR, the licensee concludes that the spray pond does not have a soil liquefaction concern. The FIP further states that the site area, including haul paths from the FLEX buildings to the point of use, was evaluated for liquefaction and has been determined to be stable following a seismic event.

According to the licensee's FIP, the spray pond (UHS) was reviewed for icing conditions. In the Limerick UFSAR, Section 9.2.6.3.2 indicates that an ice layer can develop on the surface during the winter months. The licensee's FIP states that the FLEX truck includes tools for breaking ice on the spray pond, if required, to submerge the suction hoses.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

RPV and Suppression Pool Makeup

Sections 3.2, 3.3.2.1, 3.3.2.2, 7.2, and 7.3 of the licensee's FIP describe the primary and alternate RPV and suppression pool makeup connection points involving the FLEX pump. The FLEX pumps are deployed near the spray pond and the discharge hoses are routed to the inside of the spray pond pump house. There, the hoses are connected to the RHRSW system, preferably aligned with one pump supplying each train ("A" and "B") separately. This allows full pressurization of the RHRSW system, which is a common system with two independent trains that supplies cooling water to both Limerick units. For the licensee's primary strategy, Unit 1 utilizes the "B" loop of RHRSW which is designed with an existing piping cross-connect to the "B" RHR system. Unit 2 similarly utilizes the "A" loop of RHRSW which is cross-connected the "A" RHR system. The licensee uses this as the primary strategy to minimize the operator actions that must be made. If this strategy is available, once the FLEX pumps are aligned to the RHRSW system in the spray pond pump house, a flow path can be established to the RPV and suppression pool on each unit via system alignments. The spray pond pump house is a safety-related structure and thus the connections on both RHRSW trains are protected from all events.

The alternate configuration for RPV and suppression pool makeup uses each units opposite RHR train (Loop "A" for Unit 1; Loop "B" for Unit 2). The licensee's FIP describes a modification that was installed in each unit's RHR room to add valves and connections that allow a jumper to be installed to cross-connect the RHR and RHRSW systems. For this strategy, a toolbox is pre-staged in each unit's RHR room with the hose, gasket, and tools required to install the 25 foot hose jumper. These connections are located in the Reactor Buildings, which are protected from all applicable external hazards. The connections in the spray pond pump house that were described for the primary strategy would be used in the alternate strategy. In order to provide further flexibility, the licensee's plan has provisions for both FLEX pumps to connect to one RHRSW loop, should one of the loops be unavailable.

SFP Cooling

Sections 3.5.2 and 7.5 of the licensee's FIP describe the configurations for SFP makeup using the FLEX pumps. The FLEX pumps obtain suction from the spray pond and discharge into the

RHRSW system as described above for RPV makeup. For the primary strategy, the licensee's FIP describes new 3 inch valves that have been installed in the fuel pool heat exchanger rooms on each unit. These valves allow a short hose jumper to be installed between the RHR system ("B" RHR-Unit 1, "A" RHR-Unit 2) and a return line to the unit's SFP for makeup. This strategy provides direct SFP makeup. Alternatively, water from the opposite RHR loop ("A" RHR-Unit 1, "B" RHR-Unit 2) can be provided to the SFP via combinations of hoses and a standpipe to supply either spray or direct hose makeup to the SFP.

Based on the licensee's FIP description and the Limerick UFSAR, the staff concludes that the mechanical connection points for the FLEX strategy are robust and have sufficient redundancy such that the necessary flow paths should be able to be established following a BDBEE.

3.7.3.2 Electrical Connection Points

The licensee's FLEX strategy to re-power the station's battery chargers requires the use of a single 500 kW, 480 Vac DG per unit. For the primary and alternate strategy, the deployed FLEX DG location is on the south side of the EDG Enclosure. For the primary electrical strategy, the FLEX DGs would be connected to portable distribution panels and then connected to Division 1 and 2 motor control center (MCC) connections in the EDG rooms. For the alternate electrical strategy, the FLEX DGs would be connected to portable distribution panels and then connected to Division 1 and 2 MCC connections in the Reactor Enclosure on elevation 217 feet. Based on the licensee's FIP description, the staff concludes that the electrical connection points for the FLEX DGs are robust and have sufficient redundancy such that the necessary electrical power should be able to be provided following a BDBEE.

According to the licensee's FIP, procedures provide direction for staging and connecting the FLEX DGs to energize Limerick's electrical buses. During the audit process the NRC staff confirmed that the licensee performed phase rotation checks during post modification testing to ensure proper phase rotation exists between the FLEX DGs and Limerick electrical buses. In addition, the connections and cables are color coded to ensure that proper phase rotation is maintained.

For Phase 3, the licensee plans to only connect the 480 Vac CTGs and not the 4160 Vac CTGs. The 480 Vac CTGs would be deployed in the vicinity of the 480 Vac FLEX DGs. During the audit process, the staff confirmed that licensee procedure TSG-4.6, "Transition to National SAFER Response Center Equipment," Revision 0, provides direction to perform phase rotation checks to verify proper phase rotation and for connecting the 480 Vac CTGs to the Limerick buses.

3.7.4 Accessibility and Lighting

According to the licensee's FIP, there is sufficient lighting available to make required hose and electrical connections, perform instrumentation monitoring, and illuminate the associated travel paths to/from the various areas. Battery powered (Appendix "R") emergency lights, backed up by light emitting diode (LED) hard hat lamps, as well as battery operated LED flashlights and LED lanterns, provide adequate lighting for all primary connection points and implementation of the FLEX strategies. There are spare batteries staged for use in each of the FLEX buildings for use in the headlamps and flashlights. The Appendix "R" emergency lights located in many plant areas are designed and periodically tested to ensure the battery pack will provide a minimum of 8 hours of lighting with no external ac power sources. The FLEX trucks each have a roof mounted spot light in addition to the normal headlights. The debris removal skid steer loaders include headlights for night operations. The FLEX buildings are equipped with LED emergency lighting units that will provide illumination within the building for obtaining equipment in the buildings. Once the FLEX DG has repowered portions of the 480 Vac system, some Reactor Building lighting that is powered from Division 2 can be restored. The LED tripod lights and lighting stringers are staged in the FLEX Generator Storage Building to provide additional lighting. These would be powered from portable generators. The portable pumps have been retrofitted with 12 volt LED "Scene lights" powered from the engine-driven alternator to provide general area lighting at the pump suction location to support the UHS water strategy. The licensee's FIP also describes miscellaneous support equipment stored on-site that includes flashlights, batteries, lanterns and extension cords that could support the lighting strategy.

3.7.5 Access to Protected and Vital Areas

According to the licensee's FIP, the ability to open doors for ingress and egress, ventilation, or temporary cables/hoses routing is necessary to implement the FLEX coping strategies. Operators responding to the BDBEE will obtain security keys to open security doors normally controlled by electronic key card reads. The FLEX storage building doors and spray pond gates can be manually opened.

During the audit process, the staff confirmed that the licensee has the ability to provide vehicular access to the protected area without ac power being available and that the licensee has contingencies in place to provide access to areas required for the ELAP response if the normal access control systems are without power.

3.7.6 Fueling of FLEX Equipment

Section 4.1 of the licensee's FIP states that there are eight underground seismically designed and flood-protected EDG fuel oil storage tanks at Limerick that each have about 33,500 gallons of usable fuel. The eight Limerick EDGs also have day tanks with an additional 250 gallons each. A stationary 1,000 gallon fuel tank with a 120 Vac fuel transfer pump (and backup manual hand pump) is installed inside the FLEX Pump Storage Building. With the fuel tank stored on the pump trailer (250 gallons each) and the tank in the FLEX pump storage building the licensee estimates that the FLEX pumps each have about 37 hours of full load run time before supplemental fuel oil would be necessary. The FLEX Pump Storage Building fuel tank can refilled either from offsite supplies later in the ELAP event or fuel can be transported from the protected area underground EDG storage tanks by using the tanks installed on the F-750 truck. The licensee's FIP also describes how diesel fuel oil will be delivered to the FLEX DGs. The FLEX DGs are stored with a fuel supply of at least 80 percent. The installed normal 480 Vac EDG fuel transfer pump is powered by the FLEX DG and delivers fuel through a hose reel to the FLEX DG. As a backup, a 120 Vac fuel transfer pump can take suction from any one of the eight EDG day tanks by removing a drain cap and connecting a hose. This portable fuel transfer pump is powered from a 120 VAC portable diesel generator used for lighting and radio charging. The licensee analyzed that the on-site available fuel oil will be able to support operation of FLEX equipment for well over 30 days before off-site fuel oil will be needed. The licensee indicated in the FIP that the fuel oil stored with the diesel engine-driven FLEX equipment will be maintained as part of the Preventative Maintenance (PM) program in accordance with the EPRI maintenance templates.

During the audit process, the NRC staff conducted an onsite walk down of the FLEX Pump Storage Building and the eight underground EDG storage tank and day tank locations. Based on the FIP description, as confirmed by the audit walk down, the NRC staff finds that the overall FLEX refueling strategy is acceptable for the Limerick site.

3.7.7 Conclusions

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

3.8 Considerations in Using Offsite Resources

3.8.1 Limerick SAFER Plan

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

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

By letter dated September 26, 2014 [Reference 29], the NRC staff issued its assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER response plans to meet the Phase 3 requirements of Order EA-12-049.

During the audit process, the NRC staff reviewed the Limerick SAFER plan and noted that it contains: (1) SAFER control center procedures; (2) NSRC procedures; (3) logistics and transportation procedures; (4) staging area procedures, which include travel routes between staging areas to the site; (5) guidance for site interface procedure development; and (6) a listing of site-specific equipment (generic and non-generic) to be deployed for FLEX Phase 3.

3.8.2 Staging Areas

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER plans for each reactor site. These are a Primary (Area "C") and an Alternate (Area "D"), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas "C" and/or "D", the SAFER team will transport the Phase 3 equipment to the on-site Staging Area "B" for interim staging prior to it being transported to the final location in the plant (Staging Area "A") for use in Phase 3. The Limerick SAFER plan does not have provisions for Alternate Staging Area "D". Staging Area "C" is the Exelon Power labs facility in Coatesville, PA, approximately 19 miles southwest of the site (travel distance approximately 31 miles). Staging Area "B" is the Limerick site upper parking lot. Staging Area "A" corresponds to the various deployment locations for the FLEX equipment in the vicinity of the applicable plant buildings.

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

3.8.3 Conclusions

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

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at Limerick, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. Per the guidance given in NEI 12-06, FLEX strategies must be capable of execution under the adverse conditions (unavailability of installed plant lighting, ventilation, etc.) expected following a BDB external event resulting in an ELAP.

The primary concern with regard to ventilation is the heat buildup which occurs with the loss of forced ventilation in areas that continue to have heat loads. The licensee performed a loss of ventilation analysis to quantify the maximum steady-state temperatures expected in specific areas related to FLEX implementation to ensure that the environmental conditions remain acceptable and within equipment qualification and design limits.

The key areas identified by the licensee for all phases of execution of the FLEX strategy activities are the MCR, Class 1E battery rooms, RCIC pump rooms, and containment. The licensee evaluated these areas to determine the temperature profiles following the postulated event. The results of the licensee's room heat-up evaluations have concluded that temperatures remain within acceptable limits based on conservative input heat load assumptions for all rooms/areas using passive and active means of ventilation.

Main Control Room

According to the licensee's FIP, a technical evaluation was performed to supplement a previous analysis performed for SBO. The technical evaluation concluded that temperatures would remain below 110°F for at least 24 hours. The licensee's FIP also states that Limerick has developed procedural guidance to install portable fans in MCR doorways to improve ventilation.

During the audit process the NRC staff reviewed the licensee's calculations to confirm the FIP statements. Calculation LM-0158 "Control Heatup Analysis in an Event of Station Blackout," Revision 1, determined the MCR temperature transient when all MCR cooling is lost due to an SBO. Case 2B indicates Control Room temperature after 1 hour is approximately 101°F. Case 2B credits the concrete ceiling above the MCR drop ceiling as a heat sink. The calculation did not specifically address the transfer of heat past the drop ceiling, although it did note that there are a few grill and duct openings between the MCR and the stagnant ceiling volume. The NRC staff noted that the calculation conservatively does not credit the energy required to increase the temperature of the air in the ceiling volume and does not include the volume of adjacent rooms along with the associated heat sinks. The licensee's technical evaluation 1550669-04, "ELAP MCR Temperatures," dated October 2, 2014, was also reviewed by the staff. This evaluation builds on the SBO model and evaluates the MCR temperatures for the longer duration ELAP event. The staff noted that the licensee's calculation uses a very conservative heat load for the MCR since it assumes the normally operating heat input from the MCR equipment versus the much lower heat input that would be present during an ELAP event. This evaluation determined that temperatures would remain below 110°F until mitigating actions of opening selected doors and installing portable ventilation (which are not credited in the evaluation) can be implemented. Overall, the NRC's audit review of the licensee's calculation and ELAP evaluation concludes that it is a reasonable projection of the MCR temperatures. The staff also confirmed that licensee procedure T-362, "Main Control Room Portable Ventilation and Lighting," Revision 1, provides guidance to establish portable ventilation and open doors during the early stages of an ELAP event.

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

Class 1E Battery Rooms

The licensee's FIP describes an evaluation that the licensee performed for the battery rooms. According to the FIP, the initial temperature rise in the battery rooms is slow while the batteries are discharging. The rooms heat up more quickly once the battery chargers are energized. The licensee's FIP states that temperatures remain acceptable for at least 24 hours, at which point temporary forced air ventilation is required. These actions involve opening selected doors and deploying a portable fan, powered by a portable generator. In order to confirm the licensee's FIP description, the NRC staff reviewed licensee technical evaluation 1550669-05, "Battery Room Heat-up and Hydrogen Generation," dated January 30, 2015, to verify that electrical equipment relied upon as part of the Limerick mitigation strategy for ELAP as a result of a BDBEE will not be adversely affected by increased temperatures as a result of loss of ventilation. This calculation showed that the temperature in the Class 1E battery rooms is expected to remain less than 121°F over 72 hours when portable ventilation is established and doors are opened within 24 hours. The staff confirmed that licensee procedures T-361, "Division 1 & 2 Safeguard Battery Room Emergency Ventilation (Unit 1)," Revision 1, and T-361, "Division 1 & 2 Safeguard Battery Room Emergency Ventilation (Unit 2)," Revision 1, provide guidance to establish portable ventilation and open doors within 24 hours of the onset of an ELAP event.

Based on the above, the NRC staff finds that the licensee's ventilation strategy (establishing portable ventilation and opening doors) should maintain battery room temperature below the maximum temperature limit (122°F) of the batteries, as specified by the battery manufacturer (C&D Technologies). Therefore, the NRC staff finds that the electrical equipment located in the battery rooms should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Licensee technical evaluation 1550669-05 showed that peak temperatures in the switchgear rooms are expected to remain less than 96°F for at least 72 hours. For time greater than 72 hours, emergency switchgear room doors can be opened and portable fans deployed to provide cooling of the equipment.

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

RCIC Pump Rooms

According to the licensee's FIP an analysis of the RCIC pump rooms was performed and it recommended that room temperature be maintained below the equipment qualification limit of 158°F. The licensee's FIP also states that the actions of opening a blowout panel and room doors are incorporated into a site procedure. During the audit process the staff reviewed calculation LM-0689, "RCIC Pump R[oo]m Temps for Extended Loss AC Power-Post Fukushima Scenario," Revision 0, which modeled the transient temperature response for the first 72 hours and determined the survivability of the RCIC equipment during an ELAP. The calculation assumes failure of the barometric condenser. The calculation showed that the temperature in the RCIC pump room at 72 hours is expected to reach 134.4°F if blowout panels and doors are opened within 90 minutes of an ELAP event. The staff confirmed that licensee procedure E-1 provides guidance to open a blowout panel and selected doors if ELAP conditions are present.

Based on the above, the NRC staff finds that the licensee ventilation strategy (opening blowout panels and doors) should maintain RCIC pump rooms temperatures below 158°F (equipment environmental limits). Therefore, the NRC staff finds that the equipment in the RCIC pump room function will not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Containment

According to the licensee's FIP, the MAAP analysis shows that the peak drywell air temperature for a FLEX event reaches approximately 240°F. The specific equipment items inside containment relating to the FLEX strategy include the SRVs located in the drywell and the associated solenoid valves, also located in the drywell.

During the audit process the staff reviewed analysis LG-MISC-012, "MAAP Analysis to Support FLEX Implementation FLEX Strategy," Revision 3, which modeled the transient temperature response in the containment for the first 72 hours. The results of the licensee's analysis show that the peak drywell pressure is expected to reach 21 psia (when venting commences), the peak drywell airspace temperature is expected to reach 240°F (in approximately 60 hours). The above parameters are expected to either stabilize or trend downward 72 hours into an ELAP event. The containment drywell temperature remains well below the respective UFSAR Section 6.2.1.1.3.1, design limit of 340°F for more than 72 hours. Continued operation of the HCVS and lowering decay heat in the reactor will prevent further rises in drywell pressures and temperatures.

To assess electrical equipment located in the drywell, such as the SRVs, the staff reviewed the Limerick UFSAR, Section 7.3.1.1.1.2.10 and Table 3.8-3. According to the UFSAR, the SRVs are qualified for environmental conditions that include a drywell temperature of greater than or equal to 220°F (as high as 340°F) for the first 24 hours after a postulated loss of coolant accident, which bounds the MAAP analysis for the initial hours of the ELAP event. Thus, the NRC staff concludes that the SRVs should perform as intended in the licensee's plan.

Based on projected temperature profile, the ability to vent the containment via the HCVS system, and the eventual availability of offsite resources, the NRC staff finds that the electrical equipment in the containment should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

The NRC staff also notes that the licensee will receive offsite resources and equipment from an NSRC between 24 and 72 hours after the onset of an ELAP event. The NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to reduce or maintain temperatures in the appropriate equipment areas supporting the FLEX strategy to ensure that required electrical equipment survives indefinitely beyond the 72 hour timeframe evaluated, if necessary.

Based on its review of the essential station equipment required to support the FLEX mitigation strategy, which are primarily located in the MCR, Class 1E Battery Rooms, RCIC Pump Rooms, and Containment, the NRC staff finds that the electrical equipment should perform their required functions at the expected temperatures as a result of a loss of ventilation during an postulated ELAP event.

3.9.1.2 Loss of Heating

The Limerick Class 1E station battery rooms are located inside safety-related structures and will not be directly exposed to extreme low temperatures. At the onset of the event, the Class 1E battery rooms would be at their normal operating temperature and the temperature of the electrolyte in the cells would build up due to the heat generated by the batteries discharging and during recharging. Temperatures in the battery rooms are not expected to be sensitive to extreme cold conditions due to their location, the concrete walls isolating the rooms from the outdoors, and lack of forced outdoor air ventilation during the early phases of an ELAP event. Based on the above, the NRC staff finds that Limerick Class 1E station batteries should perform their required functions as a result of loss of normal heating during a postulated ELAP event.

The licensee's FIP states that heat tracing is not required for FLEX strategies due to the equipment being stored either inside the plant or the FLEX storage buildings, which are protected from snow, ice, and extreme cold in accordance with NEI 12-06, and are temperature controlled. The FIP also states that all of the FLEX connections are located inside structures which are temperature controlled. Additional tools used to support FLEX connections are stored inside in the vicinity of the connection points or in the FLEX storage buildings. The licensee also described that the spray pond, which is used as the UHS for Limerick, is designed to operate during icing conditions. The return flow to the spray pond is initially directed to the winter bypasses, which inject the warm return water directly to the spray pond volume. The winter bypasses are directed toward the ends of the spray pond to allow the return water to circulate and mix with the pond volume. The warmer pond water eventually melts any layers of ice on the surface and a return path for spray water is available for makeup strategies. Thus, the spray pond should be available at the beginning of the event and the licensee's FLEX truck includes tools for breaking ice on the Spray Pond if required to submerge the suction hoses. Based on the above, the NRC staff finds that the equipment used for FLEX strategies should perform their required functions as a result of loss of normal heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3 is the potential buildup of hydrogen in the Class 1E battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. According to the licensee's FIP the temporary ventilation that is established at approximately 24 hours includes considerations for hydrogen generation in the battery rooms. During the audit process, the staff reviewed the licensee's technical evaluation 1550669-05. In that evaluation, the licensee concluded that with the batteries charging, and without ventilation and recirculation for the battery rooms, the earliest time to accumulate 2 percent hydrogen is 47.5 hours. The licensee plans to establish portable ventilation and open doors to the battery rooms once the FLEX DGs are placed in service which should reduce the hydrogen concentration in the Class 1E battery rooms. The staff confirmed that licensee procedures provide guidance to establish portable ventilation and open doors.

Based on its review of the licensee's battery room ventilation strategy, the NRC staff finds that hydrogen accumulation in the Limerick Class 1E battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP event.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

The licensee's FIP states that the evaluation of MCR temperatures during ELAP conditions shows that temperatures would remain less than 110°F until the mitigating actions of opening doors and installing portable ventilation can be performed. As described in Section 3.9.1.1 of this safety evaluation, the NRC staff reviewed the licensee's calculation and evaluation of the projected MCR temperature for ELAP conditions and determined that it presented a reasonable projection of the postulated MCR temperature profile under ELAP conditions. The licensee's evaluation bases the acceptance criteria on the guidance in NUMARC 87-00, "Guidance and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors". NUMARC 87-00 indicates that 110°F for light work conditions is acceptable for a 4 hour coping time. This is consistent with the provisions of NEI 12-06 and is therefore acceptable to the NRC staff.

The licensee's FIP also describes the development of procedural guidance to open selected doors and to install portable fans in the MCR doorways to improved ventilation. According to the licensee, this information is included in T-362, "Main Control Room Potable Ventilation and

Lighting." Additionally, a toolbox approach (e.g., rotation of personnel) will be employed if further mitigating actions are required. These actions would help to alleviate concerns over operator performance under high MCR temperature conditions that could persist over a longer coping period than was envisioned in NUMARC 87-00. Based on the review of the licensee's projected temperatures, combined with the mitigating actions that would be available as described in the licensee's FIP, the staff finds that the MCR temperature during an ELAP should not impede the operators from performing their required actions to address the event.

3.9.2.2 Spent Fuel Pool Area

According to the licensee's FIP, calculation LM-0710 developed a GOTHIC model to determine the bulk SFP area conditions following a BDBEE in order to analyze the habitability conditions on the refuel floor and identify the timeline for completing required FLEX strategy actions in the affected area for spent fuel pool cooling. During the audit process the NRC staff reviewed the licensee's calculation. The calculation models the opening of select doors and opening an airlock into the South Stack structure. Spent Fuel Pool boiling occurs at approximately 6-10 hours, depending on the decay heat load and the status of the hydraulic coupling of the interconnected SFPs. Once SFP boiling starts, the temperature and humidity increase rapidly. The licensee's FIP notes that FSG T-346, "Refuel Floor Alignment for SFP Makeup and Ventilation," provides guidance for the required mitigating actions necessary to set up the required hoses on the refuel floor and open the airlock doors to the south stack on the refuel floor while conditions allow, prior to the onset of SFP boiling.

Based on the FIP description, confirmed by the audit review of the licensee's calculation, the NRC staff concludes that the licensee should be able to perform the required actions necessary to deploy the required FLEX equipment on in the SFP area prior the SFP reaching boiling conditions.

3.9.2.3 Reactor Core Isolation Cooling (RCIC) Pump Room

Section 3.9.1.1 of this safety evaluation describes the staff's review of the licensee's projections for temperatures in the RCIC pump rooms. Specifically the licensee takes certain actions to ensure that the temperature in the rooms stays below the equipment qualification limit of 158°F. According to the licensee's FIP, the actions to accomplish this have been incorporated into procedure E-1, Station Blackout and would be required to be performed for an ELAP condition. Specifically, actions to open a blowout panel and room doors are necessary to ensure RCIC will remain operational for as long as required. Any required entries into the RCIC pump room should be of short duration and manageable within the licensee's industrial safety program. Based on the licensee's FIP description, the NRC staff concludes that the required actions necessary for the operation of the RCIC for the duration of its ELAP mission time should be completed.

3.9.2.4 Other Plant Areas

During the audit process the NRC staff noted that the licensee has a special event procedure that provides guidance for establishing temporary ventilation in the remote shutdown panel room, MCR, auxiliary equipment room, inverter rooms, 4 kilovolt switchgear rooms, and the spray pond pump room. In addition, the staff notes that existing plant procedures for hot area work should provide the necessary coping capabilities such that the environmental conditions should not prevent plant personnel from performing their required actions for addressing the event.

3.9.3 Conclusions

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

3.10 Water Sources

Condition 3 of NEI 12-06, Section 3.2.2.5, states that cooling and makeup water inventories are considered available if they are contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles. The NRC staff reviewed the licensee's planned water sources to verify that each water source was robust as defined in NEI 12-06.

3.10.1 RPV Makeup

Phase 1

The FIP indicates that for Phase 1, the suppression pool provides the initial source of makeup water to the RPV through the RCIC pump. The suppression pool is safety-related and provides a minimum of approximately 122,120 cubic feet (913,521 gallons) of water, according to the Limerick UFSAR, Table 1.3-4. The FIP describes suppression pool water quality as near reactor grade at the beginning of the event. As the event progresses, the FLEX pumps will be aligned to provide makeup from the spray pond to the RPV for each unit.

Phase 2

During Phase 2, the FLEX pumps are aligned to take suction from the spray pond. The spray pond is described in the FIP as containing a minimum of 29 million gallons of water. It is the safety-related UHS for the site, and is protected from all applicable external hazards.

Phase 3

For Phase 3, RPV makeup strategy is the same as the Phase 2 strategy.

3.10.2 Suppression Pool Makeup

Figure 8 of the licensee's FIP depicts a steady decrease in suppression pool level, primarily occurring after the suppression chamber is vented via the HCVS approximately 6 hours into the event. The FIP also describes provisions in the licensee's strategy to provide suppression pool makeup. The spray pond is the suction source for the FLEX pumps that will provide this makeup water. The licensee's FIP timeline indicates that this makeup supply will be available around 20 hours into the ELAP event.

3.10.3 Spent Fuel Pool Makeup

No SFP makeup is required in Phase 1. During Phases 2 and 3, makeup to the SFP is from the spray pond, as described in Section 3.7.3.1 of this safety evaluation. The licensee's FIP timeline indicates that water from the spray pond would be available to supply makeup to the SFP within 12 hours after ELAP initiation.

3.10.4 Containment Cooling

The licensee's FIP indicates that operation of the HCVS will maintain containment temperature and pressure parameters with acceptable limits for implementation of the FLEX strategy. The licensee's FIP also notes that in Phase 3, equipment from an NSRC would be available to act as a backup or as redundant equipment to the Phase 2 equipment, such that containment cooling can be provided indefinitely.

3.10.5 Conclusions

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

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, since plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven RCIC pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 39 hours are available to implement makeup before boil-off results in the water level in the SFP dropping to a level approximately 10 feet above fuel assemblies. While this time is shorter than the partial core offload scenario evaluated in Section 3.3 of this safety evaluation, the licensee's FIP states that during outage conditions the added around-the-clock staffing will allow the shorter timelines to be met.

When a plant is in a shutdown mode in which steam is not available to operate a steam-powered pump such as RCIC (which typically occurs when the RPV has been cooled below about 300°F), another strategy must be used for decay heat removal. In its FIP, the licensee stated that it would follow an NEI position paper regarding shutdown/refueling modes [Reference 44] that has been endorsed by the NRC [Reference 45]. This 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 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 has concluded 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's FIP states that Limerick personnel will follow the guidance in this position paper and also describes how the station has incorporated the guidance from the position paper into the shutdown safety management program that is used to help manage risk and maintain safety during outages.

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

3.12 Procedures and Training

3.12.1 Procedures

In its FIP, the licensee indicated 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 Limerick FSGs 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 FLEX equipment is needed to accomplish FLEX strategies or supplement EOPs, procedural guidance will direct the entry into and exit from the appropriate FSG procedure. The licensee also stated that FLEX strategy guidelines have been developed in accordance with BWROG guidelines. The FSGs provide available, pre-planned FLEX strategies for accomplishing specific tasks. The FSGs are used to supplement (not replace) the existing procedure structure that establishes command and control for the event. In addition, the licensee indicated in its FIP that procedural interfaces have been incorporated into an existing station blackout procedure to include appropriate reference to FSGs and provide command and control for the ELAP.

3.12.2 Training

In its FIP, the licensee stated that Limerick's Nuclear Training Program has been revised to assure personnel proficiency in the mitigation of BDBEEs is adequate and maintained. According to the licensee, these programs and controls were developed and have been implemented in accordance with the Systematic [NRC term - Systems] Approach to Training (SAT) process. Training for both operations personnel and site emergency response leaders has been developed and initial training provided.

In its FIP, the licensee stated that 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. Upon SAFER equipment deployment and connection in an event, turnover and familiarization training on each piece of SAFER equipment will be provided to station operators by the SAFER deployment/operating staff.

3.12.3 Conclusions

Based on the description above, the NRC staff finds that the licensee has adequately addressed the procedures and training associated with FLEX. The procedures have been issued in accordance with NEI 12-06, Section 11.4, 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 to the NRC dated October 3, 2013 [Reference 42], which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 43], the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs.

In its FIP, the licensee stated that periodic testing and preventative maintenance of the BDB/FLEX equipment conforms to the guidance provided in INPO [Institute of Nuclear Power Operations] AP-913. A fleet procedure has been developed to address preventative maintenance (PM) activities using EPRI templates or manufacturer provided information/recommendations, equipment testing, and the unavailability of equipment. The EPRI has completed and has issued "Preventive Maintenance Basis for FLEX Equipment - Project Overview Report." The PM templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued.

According to the licensee, the EPRI PM templates for FLEX equipment conform to the guidance of NEI 12-06, providing assurance that stored or pre-staged FLEX equipment are being properly maintained and tested. The EPRI templates are used for equipment where applicable. However, in those cases where EPRI templates were not available, PM actions were developed based on manufacturer provided information/recommendations and an Exelon fleet procedure.

The licensee's FIP states that the unavailability of FLEX equipment and applicable connections that perform a FLEX mitigation strategy for core, containment, and SFP is controlled and managed per a site procedure such that risk to mitigating strategy capability is minimized. According to the licensee, the guidance in this procedure conforms to the guidance of NEI 12-06 for FLEX equipment as follows:

- Portable FLEX 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.

The NRC staff reviewed the unavailability provisions listed in the licensee's FIP and noted that unavailability provisions of NEI 12-06, Revision 0, were not fully described. Specifically, out-of-service provisions for FLEX equipment connections, out-of-service provisions for equipment greater than 90 days, and provisions for forecast site-specific external events were not listed. The staff consulted Exelon procedure CC-AA-118, "Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program Document," Revision 2, and confirmed that these additional provisions are included as described in NEI 12-06, Revision 0. Thus the staff concludes that the licensee's plan meets the applicable unavailability provisions of NEI 12-06, Revision 0, and are therefore acceptable. Further, the NRC staff finds that the licensee has adequately addressed equipment maintenance and testing activities associated with FLEX equipment because a maintenance and testing program has been established in accordance with NEI 12-06, Section 11.5.

3.14 Alternatives to NEI 12-06, Revision 0

3.14.1 Reduced Set of Hoses and Cables as Backup Equipment

In its FIP, the licensee described an alternative approach to the NEI 12-06 guidance for hoses and cables. In NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an "N+1" capability, where "N" is the number of units on-site. Thus, a dual-unit site would nominally have at least three portable pumps, three sets of portable ac/dc power supplies, three sets of hoses and cables, etc. On behalf of the industry, NEI submitted a letter to the NRC [Reference 46] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that that either: (a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the "N" capability plus at least one spare of the longest single section/length of hose and cable be provided; or (b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. By letter dated May 18, 2015 [Reference 47], the NRC agreed that the proposed alternative approach was reasonable, but that the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. The NRC's endorsement of the hoses and cables alternative was subsequently incorporated into NEI 12-06, Revision 2 [Reference 52]. The licensee's FIP references the hoses and cables alternative as being incorporated into NEI 12-06, Revision 2. Based on the licensee implementing the alternative in accordance with the provisions of NEI 12-06, Revision 2, as endorsed, the NRC staff approves this alternative to NEI 12-06, Revision 0, as being an acceptable method of compliance with the order.

In conclusion, the NRC staff finds that although the guidance of NEI 12-06, Revision 0, has not been met, if these alternatives are implemented as described by the licensee, they 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, should adequately address the requirements of Order EA-12-049.

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 [Reference 31], the licensee submitted its OIP for Limerick in response to Order EA-12-051. By letter dated June 24, 2013 [Reference 32], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided a response by letter dated July 18, 2013 [Reference 33]. By letter dated October 23, 2013 [Reference 34], the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 28, 2013 [Reference 35], February 28, 2014 [Reference 36], August 28, 2014 [Reference 37], and February 27, 2015 [Reference 38], the licensee submitted status reports for the OIP and the RAI in the ISE. The OIP describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated July 1, 2015 [Reference 39], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved at both units.

The licensee has installed a SFP level instrumentation system designed by Westinghouse, LLC. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports during a vendor audit. The staff issued an audit report regarding the Westinghouse system on August 18, 2014 [Reference 40].

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051 at Limerick. The scope of the audit included verification of: (a) whether the site's seismic and environmental conditions are enveloped by the equipment qualifications; (b) whether the equipment installation met the requirements and vendor's recommendations; and (c) whether program features met the order requirements. By letter dated March 17, 2015 [Reference 24], the NRC issued an audit report on the licensee's progress.

4.1 Levels of Required Monitoring

In its OIP [Reference 31] and RAI response letter [Reference 33], the licensee identified Level 1 as elevation 351'-0", Level 2 as elevation 337'-6", and Level 3 as elevation 327'-6". The NRC staff previously reviewed these levels in the Limerick SFP ISE and found Levels 1 and 2 to be consistent with the endorsed guidance, and therefore acceptable. Specifically, the staff concluded that Level 1 supports normal SFP cooling and provides adequate net positive suction head for the SFP cooling pump, while Level 2 is more than 10 feet above active fuel and provides adequate shielding. According to NEI 12-02, Level 3 should be within ±1 foot of the top of the fuel racks. However, in the ISE the staff noted that the ability to monitor Level 3 on both channels would be dependent on the elevation of the interconnected transfer pit/canal, and asked the licensee to provide additional information to support the proposed Level 3 designation. The licensee responded to this concern in the third six-month update letter, modifying the Level 3 designation to 327'-11.32", which is slightly above the bottom of the transfer pit. The NRC staff finds that the licensee's response resolves the staff's concern and maintains conformance to NEI 12-02, and thus the licensee's revised Level 3 designation is acceptable.

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

4.2 Evaluation of Design Features

Order EA-12-051 requires that the SFP level instrumentation include specific design features, including specifications on the instruments, arrangement, mounting, qualification, independence, power supplies, accuracy, testing, and display. Below is the staff's assessment of the design features of the SFP level instrumentation.

4.2.1 Design Features: Instruments

In its OIP, the licensee stated it will provide fixed instruments, one in each SFP. The Unit 1 and Unit 2 SFPs are interconnected, and have administratively-controlled gates that are normally open, but could allow the pools to be separated if they are closed. This configuration does not provide the required redundancy (two instruments per SFP) when the pools are not hydraulically connected, such as when the gates are installed.

In its third six-month update [Reference 37], the licensee stated that the gates are not normally installed during operation. The licensee also indicated that in the event the gates are installed (nullifying SFP level instrument redundancy), the 90 day out-of-service condition specified in NEI 12-02 would be invoked. As described in Section 4.3.3 of this safety evaluation, the staff has concluded that the licensee's compensatory actions, as described, are consistent with the endorsed guidance of NEI 12-02. The licensee's third six-month update letter also stated that Limerick procedure M-097-009, "Cask Pit Gate removal, Installation, Maintenance and Movement for Fuel Gates Between Storage/Repair Locations," would be updated to include the NEI 12-02 out-of-service criterion.

In its third six-month update the licensee clarified that the bottom of the transfer pit is at elevation 327'-8.75", which is below the Level 3 designation of 327'-11.32", and therefore a single instrument can accurately indicate down to Level 3 for both Unit 1 and Unit 2 SFPs.

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

4.2.2 Design Features: Arrangement

In its third six-month update letter, the licensee provided a sketch of the SFP level instrument configuration for Limerick. The Unit 1 level sensing instrument is installed near the northeast corner of the pool. The Unit 2 level sensing instrument is installed near the northwest corner of the pool. The sketch shows that the level sensing instruments are separated by approximately 37 feet. The signal cables extend toward the north wall, maintaining separation in the open area of the refueling floor. The signal cables are routed through the Reactor Building and the transmitters and displays are located in the auxiliary equipment room (AER). During the onsite audit, the NRC staff observed the installed configuration of the SFP level instruments and questioned the adequacy of the separation/protection arrangement for the primary and backup coaxial signal cables. As described in its Order EA-12-051 compliance letter, dated

July 1, 2015 [Reference 39], the licensee addressed this concern by relocating junction boxes for the coaxial cables such that there would be approximately 13 feet of separation.

The NRC staff concludes that, following the cable relocation, 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 evaluation above, the NRC staff finds that, if implemented appropriately, the licensee's proposed arrangement for the SFP level instrumentation appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.3 Design Features: Mounting

In its third six-month update, the licensee provided a sketch of the pool-side mounting bracket used to support the sensor cable and signal cable. The bracket is a cantilever design bolted to the deck of the refueling floor. The mounting bracket supports a launch plate which provides mounting points for the cable conduit and the probe. The licensee also provided a sketch and description of the mounting arrangement design in its third six-month update. During an on-site audit walk down of Limerick SFPs, the NRC staff was able to confirm that the design and mounting of the (then) partially installed SFP level instrument components were consistent with the licensee's description in the third six-month update letter.

In its third six-month update, the licensee stated that the analysis of the bracket included seismic and hydrodynamic loading considerations. Hydrodynamic loading is caused by pool sloshing during a seismic event. To confirm the licensee's analysis description, the NRC staff reviewed Westinghouse document CN-PEUS-14-10, "Seismic Analysis of the SFP Mounting Bracket for Limerick Generating Station Units 1 & 2" Revision 0, during the onsite audit. The staff also reviewed Westinghouse documents LTR-SEE-II-13-47, "Determination if the Proposed Spent Fuel Pool Instrumentation Could be Sloshed Out of the Spent Fuel Pool During a Seismic Event," Revision 0, and WNA-T-03149-GEN, "SFPIS Standard Product Final Summary Design Verification Report," Revision 1, to confirm the sloshing analysis for Limerick. The staff's review concluded that the analyses appropriately evaluated the mounting arrangement.

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

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

Appendix A-1 of NEI 12-02 describes a quality assurance process for non-safety systems and equipment that are not already covered by existing quality assurance requirements. In JLD-ISG-2012-03, the NRC staff found the use of this quality assurance process to be an acceptable means of meeting the augmented quality requirements of Order EA-12-051. In its OIP, the licensee stated that instrument channel reliability will be established by use of an augmented quality assurance process similar to that described in NEI 12-02.

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

4.2.4.2 Instrument Channel Reliability

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

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

For the Westinghouse system equipment reliability performance testing was performed to: (1) demonstrate that the SFP instrumentation will not experience failures during postulated BDB conditions of temperature, humidity, emissions, surge, and radiation; and (2) to verify those tests envelope the plant-specific requirements. The NRC staff reviewed the Westinghouse system qualification testing and results during the vendor audit and documented the staff review in letter dated August 18, 2014 [Reference 40]. The staff notes that the Limerick SFP level instrument configuration has only passive components with no electronic devices in the SFP area.

The electronics and displays for each unit are seismically mounted outside the SFP area in the AER. In its third six-month update, the licensee stated the AER is considered a mild environment. The NRC staff confirmed during the on-site audit that the AER is located a sufficient distance from the SFPs and that sufficient shielding exists to conclude the equipment will not exceed the qualified rating of 1000 Rad total integrated dose. During the on-site audit, the staff confirmed that the AER temperature would not exceed the Westinghouse qualification temperature of 140°F.

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

4.2.5 Design Features: Independence

As noted in Section 4.2.2 of this safety evaluation, the licensee provided a sketch in the third month update, showing adequate separation of the installed primary and secondary instruments. The staff also observed the separation of the (then) partially installed system during the on-site audit. Based on the licensee's description, confirmed during the audit, the staff concludes that the installed configuration at Limerick meets the guidance for physical separation.

In its third six-month update, the licensee stated that the primary instrument is normally powered from distribution panel 10Y161 and the secondary instrument is normally powered from distribution panel 2L29. The licensee's letter also states that these panels are powered from different electrical busses. The NRC staff confirmed that the panels are on different electrical busses during the on-site audit.

Based on the licensee's description, confirmed during her onsite audit, the NRC staff concludes that the licensee's proposed design, with respect to instrument channel independence, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.2.6 Design Features: Power Supplies

As described in Section 4.2.5 of this safety evaluation, the Limerick SFP instruments are powered from panels that are supplied from different electrical busses. In its third six-month update, the licensee also stated that following loss of power, the SFP level instruments are powered by dedicated SFP level instrumentation batteries installed in each channel's electronics enclosure. These batteries are capable of powering the instruments for 72 hours. After 72 hours, a receptacle and selector switch are available so that 120 Vac power may be supplied from a FLEX generator to provide a long term power supply. During the on-site audit, the NRC staff confirmed the ability of the batteries to supply power for 72 hours by reviewing report WNA-CN-00300-GEN, "Spent Fuel Pool Instrumentation System Power Consumption Calculation," Revision 1.

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

4.2.7 Design Features: Accuracy

The licensee's third six-month update states that the installed system will be accurate to within ± 3 inches during both normal and BDB conditions. This meets the provisions of NEI 12-02 which specifies an accuracy of ± 12 inches. The NRC staff reviewed the accuracy of the Westinghouse SFP level instrumentation system during the vendor audit and found that it met the endorsed guidance. Details of this review are described in the Westinghouse vendor audit report dated August 18, 2014 [Reference 40].

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

4.2.8 Design Features: Testing

The NRC staff's review of the vendor testing performed for the Westinghouse system is documented in the vendor audit report [Reference 40]. The Westinghouse design uses a "two point" test where a technician raises the flexible probe cable a measured distance out of the water and confirms the corresponding change on the display. The design also offers a calibration test that removes the probe from the launch plate above the pool and installs it in a test fixture that includes a movable level simulator. Calibration can be verified over the entire length of the probe. In its fourth six-month update letter, the licensee stated that it will follow Westinghouse established procedures for testing the SFP level instruments.

Based on the testing evaluated in the vendor audit report and the licensee's continued use of the vendor recommended testing protocol, the NRC staff finds 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 should adequately address the requirements of the order.

4.2.9 Design Features: Display

The NRC staff's review of the technical aspects of the Westinghouse display is documented the vendor audit report [Reference 40]. According to the licensee's third six-month update, the displays at Limerick are located in the AER, which was chosen due to its proximity to the MCR. The NRC staff confirmed the accessibility of the displays from the MCR during the on-site audit. The staff observed that the travel time from the MCR to the display location was less than 6 minutes.

Based on the licensee's submittal, confirmed by the onsite audit review, the NRC staff concludes that the licensee's proposed location and design of the SFP instrumentation displays appear to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specifies that the SFP level instrumentation shall be maintained available and reliable through appropriate development and implementation programmatic controls, including training, procedures, and testing and calibration. Below is the NRC staff's assessment of the programmatic controls for the spent fuel pool instrumentation.

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that personnel performing functions associated with these SFP level instrumentation channels will be trained to perform the job specific functions necessary for their assigned tasks (maintenance, calibration, surveillance, etc.). The licensee also stated that training will be consistent with equipment vendor guidelines, instructions, and recommendations and the SAT process will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. In its full compliance letter, the licensee stated that training at Limerick has been completed.

Based on the licensee's description, the NRC staff finds that the licensee's plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFP level instrumentation, including the approach to identify the population to be trained, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

The licensee stated in its third six-month update that procedures will be developed for system inspection, calibration and test, maintenance, repair, operation, and normal and abnormal responses. The licensee also described the technical objectives of each of the procedures. The licensee's compliance letter dated July 1, 2015, states that the SFP level instrumentation operating and maintenance procedures have been developed and integrated with existing procedures and are available for use in accordance with the site procedure control program.

Based on the licensee's description, the NRC staff finds that the licensee's procedure development appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.3 Programmatic Controls: Testing and Calibration

In its third six-month update letter, the licensee stated it will follow the vendor recommendations for functional checks, testing, calibration, and maintenance. Regarding out-of-service controls, the licensee's letter states that with one channel out-of-service it will be restored within 90 days. If the required restoration is not completed within the specified time, additional action will be taken. If two channels are out-of-service, action will be initiated within 24 hours to restore one channel to service, with a restoration time for one channel of 72 hours. If the restoration action is not completed within the specified time, additional action will be taken. In the licensee's fourth six-month update the additional actions for both the one channel out-of-service and two channels out-of-service conditions were specified. Specifically, the additional actions are: (1) enter the issue into the Corrective Action Program; (2) develop an alternate method of monitoring; (3) determine the cause of the non-functionality; and (4) determine the plans to restore the channel(s) to functional status.

The staff reviewed the licensee's restoration actions for both one channel and two channels out-of-service and compared them to the provisions of NEI 12-02. This review included the licensee's plan for SFP-related cask pit gate installation as described in Section 4.2.1 of this safety evaluation. The staff concluded the licensee's plan is consistent with the provisions of NEI 12-02, and is therefore acceptable.

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

4.4 Conclusions for Order EA-12-051

In its compliance letter dated April 27, 2015 [Reference 39], the licensee stated that they would meet the requirements of Order EA-12-051 for each unit by following the guidelines of NEI 12-02, which has been endorsed, with clarifications and exceptions, by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at Limerick according to the licensee's design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013, the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit at Limerick in January 2015 [Reference 24]. The licensee reached its final compliance date on April 15, 2018, for Order EA-12-049, and April 25, 2015 for Order EA-12-051, and has declared that both of the reactors are in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and designs that, if implemented appropriately, should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

6.0 REFERENCES

1. SECY-11-0093, "Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," July 12, 2011 (ADAMS Accession No. ML11186A950)

2. 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," February 17, 2012 (ADAMS Accession No. ML12039A103)

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Date: October 24, 2018

SUBJECT: LIMERICK GENERATING STATION, UNITS 1 AND 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0847, MF0848, MF0854, AND MF0855; EPID NOS. L-2013-JLD-0013 AND L-2013-JLD-0014) DATED October 24, 2018

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