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

September 29, 2016

Mr. Brian C. Hanson
President and Chief Nuclear Officer
Exelon Generation Company, LLC
4300 Winfield Rd
Warrenville, IL 60555

SUBJECT: CALVERT CLIFFS NUCLEAR POWER PLANT, 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. MF1142, MF1143, MF1140, AND MF1141)

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 10 CFRPart 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. ML13066A171), Exelon Generation, LLC (Exelon, the licensee), previously known as Constellation Energy Nuclear Group, LLC, submitted its OIP for Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (Calvert Cliffs) in response to Order EA-12-049. The licensee submitted a supplement on March 8, 2013 (ADAMS Accession No. ML13074A056). 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 December 17, 2013 (ADAMS Accession No. ML13225A566), and February 20, 2015 (ADAMS Accession No. ML14302A174), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letters dated July 2, 2015 (ADAMS Accession No. ML15183A235), and May 4, 2016 (ADAMS Accession No. ML16131A638), Exelon submitted compliance letters in response to Order EA-12-049. In addition, the May 4, 2016, letter, provided the Calvert Cliff's site Final Integrated Plan (FIP) in response to the order. The compliance letters stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 28, 2013 (ADAMS Accession No. ML13066A172), the licensee submitted its OIP for Calvert Cliffs in response to Order EA-12-051. The licensee submitted a supplement on March 8, 2013 (ADAMS Accession No. ML13073A155). At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the Order, and are listed in the attached safety evaluation. By letters dated September 25, 2013 (ADAMS Accession No. ML13267A285), and February 20, 2015 (ADAMS Accession No. ML14302A174), the NRC staff issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated April 30, 2015 (ADAMS Accession No. ML15120A277), 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.

The enclosed safety evaluation provides the results of the NRC staff's review of Exelon's strategies for Calvert Cliffs. 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 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

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

Sincerely,

Mandy K Halter

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

Docket Nos.: 50-317 and 50-318

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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5.0 CONCLUSION

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

EXELON GENERATION, LLC

CALVERT CLIFFS NUCLEAR POWER PLANT, UNITS 1 AND 2

DOCKET NOS. 50-317 AND 50-318

1.0 INTRODUCTION

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

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

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

2.0 REGULATORY EVALUATION

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

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

2.1 Order EA-12-049

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

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

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

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

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

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

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

2.2 Order EA-12-051

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 28, 2013 (ADAMS Accession No. ML13066A171), Exelon Generation, LLC (Exelon), previously known as Constellation Energy Nuclear Group, LLC (CENG), submitted its OIP for Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (Calvert Cliffs) in response to Order EA-12-049. The licensee submitted a supplement on March 8, 2013 (ADAMS Accession No. ML13074A056). By letters dated August 27, 2013 (ADAMS Accession No. ML13254A278), February 27, 2014 (ADAMS Accession No. ML14069A318), August 26, 2014 (ADAMS Accession No. ML14241A379), February 20, 2015 (ADAMS Accession No. ML15078A117), August 28, 2015 (ADAMS Accession No. ML15243A080), and February 26, 2016 (ADAMS Accession No. ML16057A005), the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated December 17, 2013 (ADAMS Accession No. ML13225A566), and February 20, 2015 (ADAMS Accession No. ML14302A174), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letters dated July 2, 2015 (ADAMS Accession No. ML15183A235), and May 4, 2016 (ADAMS Accession No. ML16131A638), Exelon submitted compliance letters in response to Order EA-12-049. In addition, the May 4, 2016, letter, provided the Calvert Cliff's site Final Integrated Plan (FIP) in response to the order. The compliance letters stated that the licensee had achieved full compliance with Order EA-12-049.

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.

Calvert Cliffs is a Combustion Engineering pressurized-water reactor (PWR); with a dry ambient pressure containment. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below.

At the onset of an ELAP both reactors are assumed to trip from full power. The reactor coolant pumps coast down and flow in the reactor coolant system (RCS) transitions to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by isolating potential RCS letdown paths. Decay heat is removed by steaming to atmosphere from the steam generators (SGs) through the atmospheric dump valves (ADVs) or SG safety valves, and makeup to the SGs is initially provided by the turbine-driven auxiliary feedwater (TDAFW) pump taking suction from the condensate storage tank (12-CST). Subsequently, the operators would begin a controlled cooldown and depressurization of the RCS by manually operating the SG ADVs. The SGs would be depressurized in a controlled manner to about 120 pounds per square inch absolute (psia) over a period of several hours and then maintained at this pressure while the operators borate the RCS. Depressurizing the SGs reduces RCS temperature and pressure. The licensee plans to complete this cooldown within 6 hours of the start of the event. The reduction in RCS temperature will result in inventory contraction in the RCS, with the result that the pressurizer would drain and a steam void would form in the reactor vessel upper head. The RCS leakage, particularly from the reactor coolant pump (RCP) seals, would also contribute to the decrease in RCS liquid volume. However, during the cooldown RCS pressure should drop below the safety injection accumulator pressure and the injection of some quantity of borated water into the RCS from the accumulators would then occur.

As discussed in its cooldown timeline, the licensee expects to further depressurize the SGs in order to further reduce RCS temperature and pressure. In addition, as noted in the FIP, by approximately 36 hours into the event, the licensee expects that FLEX equipment from offsite response centers will be connected and ready to support a further cooldown of the RCS until SG pressure reaches 75 psia. Prior to undertaking the additional cooling and depressurization of the RCS, operators would need to perform a number of supporting actions including injecting additional boric acid into the RCS to avoid the potential for recriticality and isolating the accumulators (using electrical power from FLEX generators) to avoid the potential for excessive accumulator injection to the point that the nitrogen cover gas could enter the RCS.

The operators will perform dc bus load stripping within the initial 2 hours following event initiation to ensure safety-related battery life is extended up to 12 hours. Following dc load stripping and prior to battery depletion, portable 500-kilowatt (kW) (one per unit) and 100 kW (one per unit) 480 Vac FLEX diesel generators (DGs) will be deployed from the FLEX Storage Robust building (FSRB). The 500 kW FLEX DGs (the primary strategy) would provide power to vital battery chargers, charging pumps, and vital reactor motor control centers (MCCs) to repower safety injection tank (SIT) outlet motor operated valves (MOVs), hydrogen purge exhaust MOVs, saltwater air compressors (SWACs), battery room supply and exhaust fans, and the inverter backup bus. The 100 kW FLEX DGs (alternate strategy) would directly repower vital 480 Vac reactor MCCs. These portable generators will be deployed within 7 hours of ELAP initiation.

The water supply for the TDAFW pump is initially from the units' shared 12-CST. The 12-CST will provide a minimum of 10 hours of RCS decay heat removal for both units, in addition to absorbing the latent heat associated with the planned RCS cooldown. Prior to emptying the 12-CST, the operators will establish makeup to the 12-CST, via the hose manifolds and a portable FLEX booster pump, preferably from any of five water storage tanks in the tank farm: 11- and 21-CSTs, the demineralized water storage tank (11-DWST), and the pretreated water storage tanks (11- and 12-PWST). These tanks are not protected from wind-borne missile hazards. Therefore, if the tanks do not survive the external event, operators will align makeup supply to 12-CST from 11-well water or, as a last resort, the ultimate heat sink (Chesapeake Bay).

The RCS makeup and boration will be initiated within 12 hours of the ELAP to ensure that natural circulation, reactivity control, and boron mixing is maintained in the RCS. Calvert Cliffs plans to repower one of its three installed positive displacement charging pumps at each unit, each with a capacity of 44 gallons per minute (gpm). As an alternate strategy, a portable FLEX RCS makeup pump with a capacity of 80 gpm can be deployed, which would discharge to a FLEX connection on the high pressure safety injection (HPSI) header. The charging pumps will take suction from either the refueling water tank (RWT) or the concentrated boric acid storage tanks (BASTs). However, the FLEX RCS makeup pump can only take suction from the RWT, or from the opposite unit's RWT (provided that the RWT is not being used by its own respective FLEX RCS pump).

In addition, a National Strategic Alliance of FLEX Emergency Response (SAFER) Response Center (NSRC) will provide high capacity pumps and large turbine-driven DGs which could be used to continue to supply power to the Phase 2 loads and service water system pump with sufficient spare margin for additional loads (for example, containment air cooling unit) if needed. There are two NSRCs in the United States.

Calvert Cliffs, Unit 1 and 2 have separate but connecting SFPs, essentially making one continuous volume. Upon initiation of the ELAP event, the SFP will heat up due to the unavailability of the normal cooling system. The licensee has calculated that boiling could start as soon as 10.1 hours after the start of the event. The licensee determined that it would take approximately 76 hours for SFP water level to drop to a level requiring the addition of makeup to preclude fuel damage. To maintain SFP cooling, makeup water would be provided using a portable FLEX SFP makeup pump with a suction from the UHS and discharging directly to the SFP via connection or via hoses on the refueling floor for surface makeup. Ventilation of the generated steam is accomplished by opening doors within specified times.

For Phases 1 and 2, the licensee's calculations demonstrate that no actions are required to maintain containment pressure below design limits for over 72 hours. However, during Phase 1, operators will isolate any non-essential air lines supplying loads inside containment. Leakage from these lines could add to the post-ELAP pressurization of containment reducing the length of time to reach containment design pressure and increasing the likelihood of releases from containment to the environment. In Phase 2, the licensee will continue monitoring the key containment parameters and relieve containment pressure using the hydrogen purge system, if necessary. During Phase 3, containment cooling and depressurization would be accomplished by restoring one containment air cooling fan, and associated support systems to service with an NSRC supplied 4160 Vac combustion turbine generators (CTGs) and NSRC supplied saltwater pumps.

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

3.2 Reactor Core Cooling Strategies

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

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

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

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

Following the trips of the reactor and RCPs resulting from the initiating external event, RCS temperature and pressure will stabilize at no-load conditions. Core cooling would be accomplished by natural circulation flow in the RCS using the SGs as the heat sink. SG inventory makeup would be promptly initiated using one of two TDAFW pumps installed at each unit, taking suction from the units' shared 12-CST, with steam vented via the ADVs. The 12-CST, which is fully protected from all applicable external hazards, has a minimum usable volume of 300,000 gallons and will supply sufficient water to the TDAFW pumps to cool both reactor cores for 10 hours using the SGs, which extends beyond the end of Phase 1.

Following event initiation, operators will verify feedwater flow is aligned to all SGs. Within 2 hours of event initiation, operators would further take local manual control of the ADVs to commence a symmetric RCS cooldown at 75°F/hr. As noted in the licensee's FIP, the cooldown would proceed to a target RCS cold leg temperature of approximately 340°F and SG pressure of 120 psia. The ADVs have been mechanically modified so that a single operator can manually adjust the valve's position during local manual operation. The licensee's FIP states that simulator exercises have demonstrated that the cooldown can be accomplished in approximately 3.75 hours, therefore the initial cooldown will be complete no later than 6 hours after the initial event. The cooldown will be terminated when SG pressure reaches 120 psia; RCS pressure will slightly exceed the nitrogen cover gas pressure (215-225 psig) in the SITs.

During the initial Phase 1 cooldown, operators will deploy two FLEX hose manifold trailers, a FLEX booster pump, and FLEX auxiliary feedwater (AFW) pumps to prepare for eventual makeup to 12-CST and the alternate SG makeup strategy, which would be employed in Phase 2.

3.2.1.1.2 Phase 2

The licensee's primary strategy in Phase 2 is to continue to control RCS temperature by feeding the SGs and releasing steam through the ADVs at a controlled rate to maintain stable RCS conditions. The licensee calculates that the TDAFW pumps can continue to operate as long as SG pressure remains above 65 psia, which can be maintained beyond the first 24 hours of the ELAP event. The licensee plans to maintain SG pressure at approximately 120 psia and RCS temperature at approximately 340°F throughout Phase 2.

As noted earlier, makeup to 12-CST will need to be established prior to 10 hours into the event. Makeup will be supplied, via the hose manifolds and a portable FLEX booster pump, preferably from any of five water storage tanks in the tank farm: 11- and 21-CSTs, the 11-DWST, and the 11- and 12-PWSTs. These tanks each have a capacity of 350,000 gallons, except the PWSTs, which each have a capacity of 500,000 gallons. A minimum of any two of these five tanks must be connected to the manifolds to supply sufficient suction head for 12-CST makeup. These tanks are all seismically qualified, but none of them are protected from wind-borne missile hazards. If the tanks do not survive the external event, FSG-6, "Alternate CST Makeup," directs operators to align makeup supply to 12-CST from 11-well water or, as a last resort, the ultimate heat sink (UHS) (Chesapeake Bay). FLEX access to 11-well water and the UHS is robust for all applicable external hazards. The trailer-mounted FLEX booster pump will take suction from one of the manifolds and discharge to 12-CST.

As a backup to the TDAFW pumps, FSG-3, "Alternate Low Pressure Feedwater," directs operators to align two diesel-driven FLEX AFW pumps with one taking suction from each of the trailer-mounted hose manifolds. The discharge of each FLEX AFW pump is connected via a pair of 2.5-inch hoses to a duplex FLEX hose connection on each unit's AFW system, specifically on the AFW train cross-connect header. An alternate hose route can be established which connects the FLEX AFW pump discharge to post-event installed temporary connections at the discharge of the unit's installed motor-driven AFW pump. As with the 12-CST makeup strategy, water supply to the hose manifold trailers would preferably be from two or more surviving water storage tanks, or (less preferably) from 11-well water or the UHS. The licensee notes in the FIP that use of water from the PWSTs, 11-well, or the UHS for SG makeup may have long-term adverse effects on SG heat transfer, but calculates that even the worst case of using UHS water from 10 to 72 hours following the event would only result in a 9.7 percent reduction in heat transfer capability.

3.2.1.1.3 Phase 3

Although the initial delivery of NSRC equipment is scheduled to reach plant sites within 24 hours of being requested, the licensee's FIP does not formally credit the use of NSRC equipment until 72 hours after the event begins. The NSRC will supply two 500-gpm, 500-psi SG makeup pumps to provide backup to the onsite FLEX AFW pumps. The NSRC will also provide four water treatment units, as well as connection hoses and water storage bladders, for long-term replenishment of 12-CST (or any other surviving water storage tank).

When RCS boration is complete and SITs have been isolated to prevent nitrogen injection into the RCS, Appendix 3 of emergency operating procedure (EOP)-7, "SG Depressurization to Support Long-Term Cooling," directs operators to perform a further cooldown of the RCS at 75°F/hr until SG pressure reaches 75 psia. If at any point SG pressure cannot support continuous use of the TDAFW pumps, FSG-9, "Low Decay Heat Temperature Control," provides actions to stop the cooldown and intermittently operate the TDAFW pump (if possible) to maintain SG level; FSG-3 provides actions to align a portable AFW pump for SG makeup if the TDAFW pumps can no longer be used (as in Phase 2).

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Cooldown and depressurization of the RCS significantly extends the expected coping time under ELAP conditions because it (1) reduces the potential for damage to RCP seals (as discussed in Section 3.2.3.3 of this safety evaluation (SE) and (2) allows coolant stored in the nitrogen-pressurized SITs to inject into the RCS to offset system leakage. Throughout Phase 1, the licensee's FIP states that RCS pressure would remain above the nitrogen cover gas pressure in the SITs; therefore, isolation of the SITs is not necessary in Phase 1 to ensure that nitrogen intrusion to the RCS would not occur.

Upon diagnosis of a loss of all ac power, operators will transition to EOP-7, "Station Blackout," which directs operators to isolate RCS letdown flow as an immediate action. This would greatly reduce RCS inventory loss, and delay or reduce the temperature rise at the RCP seals following the loss of seal cooling. With credit for passive injection of SIT inventory, the licensee's analyses demonstrate that natural circulation in the RCS will be maintained throughout Phase 1 without reliance upon FLEX RCS injection.

Additionally, the licensee's FIP states that the core will maintain sufficient Shutdown Margin (SDM) for at least 32 hours into the event without additional boration of the RCS, other than the borated water injected by the SITs. This extends well beyond the end of Phase 1. During Phase 1, FSG-5, "Initial Assessment and FLEX Equipment Staging," directs operators to deploy two 500 KW FLEX DGs and associated cable cart trailers for eventual repowering of vital load centers.

3.2.1.2.2 Phase 2

The licensee's analysis indicates that RCS makeup other than the SITs will be required prior to 24.7 hours into the event to maintain natural circulation, and that additional boration will be needed by 32 hours following the event. To satisfy these requirements, Calvert Cliffs plans to repower one of its three installed positive displacement charging pumps at each unit. A charging pump has a capacity of 44 gpm. As an alternate strategy, a portable FLEX RCS makeup pump with a capacity of 80 gpm can be deployed, which would discharge to a FLEX connection on the high pressure safety injection (HPSI) header. When pumped borated water injection becomes available (or before SIT level lowers to less than 10 inches) SITs will be isolated by shutting the repowered outlet MOVs.

The primary strategy for repowering charging pumps, SIT outlet MOVs, and other loads would be to deploy the two 500 KW FLEX DGs to repower one vital 480 VAC load center at each unit, which the FIP states can be accomplished within the first 7 hours of the event. This would energize one charging pump at each unit, as well as a vital reactor MCC, which powers the SIT outlet MOVs among other loads. The alternate repowering strategy is to energize the vital reactor MCCs directly from a 100 KW FLEX DG. Since this alternate strategy does not power a load center, a charging pump could not be used and the FLEX RCS makeup pump would be used to provide RCS boration and inventory control. The licensee estimates that the FLEX RCS makeup pump would be deployed to its setup location between 7 and 8 hours after the initiating event, and that the pump would be fully connected and started no later than 12 hours into the event.

Per the licensee's FIP, the charging pumps will take suction from either the RWT or the BASTs, with sufficient net positive suction head provided by gravity. The RWT contains at least 400,000 gallons of water, which is borated between 2300 and 2700 parts per million (ppm). The RWT is robust relative to all applicable external hazards, as discussed in Section 3.5 of this SE, with the exception of a wind-borne missile strike. Procedure FSG-1, "Long Term RCS Inventory Control," notes that even if the RWT is damaged, the tank may retain significant volume to support RCS inventory control. The licensee has stated that a 36" high vehicle barrier protects approximately 18,500 gallons in each RWT, which can be credited even assuming worst-case missile damage. The FLEX connection points at both units' RWTs are protected against all hazards, inside the Category I RWT rooms. Confirmatory calculations performed by the NRC staff indicate that this worst-case remaining volume in the RWTs, along with the maximum volume that could be injected by the SITs, would be sufficient to prevent the onset of reflux cooling at least until Phase 3 equipment is onsite and available to supply borated water for RCS makeup.

Each BAST (there are two BASTs at each unit) contains at least 5880 gallons of highly concentrated (greater than 10,000 ppm) boric acid solution. The BASTs are preferred for RCS makeup during an ELAP, because a smaller injection volume would be required to reach the target boron concentration of 2300 ppm in the RCS. However, the FLEX RCS makeup pump can only take suction from the RWT, or from the opposite unit's RWT (provided that the RWT is not being used by its own respective FLEX RCS pump).

Per the sequence of events in the licensee's FIP, requisite supporting actions are expected to be completed such that borated RCS injection can be commenced via the licensee's FLEX strategy no later than 12 hours into the ELAP event.

3.2.1.2.3 Phase 3

The Phase 3 RCS inventory control strategy is a continuation of the Phase 2 strategy, supplemented by additional equipment from the NSRC. The NSRC will provide two high-pressure injection pumps to serve as backups to the onsite FLEX RCS makeup pumps, as well as two 1000-gallon mobile boration units and bags of boric acid. The mobile boration units can be used to replenish the RWTs, or supply suction to the RCS makeup pump should an RWT be damaged. Both the NSRC injection pumps and the mobile boration units are assigned a priority of 24 hours in the plant's SAFER response plan, and the licensee states that the equipment would be connected and ready to supply RCS makeup by 36 hours into the event.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

In FIP Section 2.1.2, the licensee states that maximum flood levels are bounded by the existing structures, systems, and components. The local intense precipitation (LIP) assessment indicated that flood waters would stay below design basis, and recede prior to the time at which operators would begin to deploy FLEX equipment on the affected areas. For the probable maximum storm surge, the FIP again states that flooding would remain below design-basis, and that the affected FLEX strategies (drawing cooling water from Chesapeake Bay) are sufficiently flexible that flooding from the storm surge would not impact their implementation. Therefore, there are no variations to the core cooling strategy in the event of a flood.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Core Cooling and Inventory Control - MODES 1-4 with Steam Generators Available

In NEI 12-06, Section 3.2 states that installed equipment that is designed to be robust with respect to design basis external events is assumed to be fully available. In addition, 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 the applicable hazard(s) is available. The Calvert Cliffs updated final safety analysis report (UFSAR), Section 5A.1.2 c, states in part that all seismic Category I systems, equipment and components shall be designed to withstand the appropriate seismic load combined with other applicable loads without loss of function. Section 5A.3.1.9 of the UFSAR states that all Category I structures and critical components of Category I structures are designed to resist the effects of the site design-basis tornado including applicable tornado-generated missiles. Section 5A.4 of the UFSAR states that the design of all structures include a uniformly distributed live load to account for any anticipated snow and/or ice loading. Section 5A.5 of the UFSAR states that structures located at plant grade are above the maximum design-basis flood height and that no loads as a result of floods or inundation are considered for these structures. The intake structure, which is subject to flooding is protected against maximum probable flood loading including wave action.

Phase 1

The licensee's Phase 1 core cooling FLEX strategies for Calvert Cliffs rely on its existing SGs, TDAFW pump, AFW system piping, and ADVs to remove heat from the RCS using water from the safety-related 12-CST. In addition, the licensee relies on its class IE batteries, 125 volt dc (Vdc) distribution system, and 120 volt ac (Vac) vital distribution system, through inverters, for plant control and key reactor parameter monitoring. As discussed in Section 3.5 of the licensee's FIP, RCS inventory is conserved by initiating an early RCS cooldown. As a result, the licensee does not credit any existing plant SSCs for direct injection into the RCS during Phase 1.

The licensee's primary strategy uses one of two TDAFW pumps at each unit to supply water to the two SGs. The TDAFW pump auto starts following a reactor trip via the AFW actuation system, which is powered by the plant 120 Vac vital system. Operators can manually start the TDAFW pump if needed using existing station procedures. Operators can control flow to the SGs from the control room or locally using existing station procedures. A manually set governor controls steam flow to the TDAFW pump. Once set the governor provides a constant speed with a minimum of 50 pounds per square inch gage (psig) SG pressure. Operators can control the governor locally using existing station procedures if needed. The Calvert Cliffs UFSAR, Section 5A.2.1.1 lists the AFW pump rooms and the enclosures for the AFW valves and piping header as seismic Category I structures. Section 5A.2.1.2 of the UFSAR lists the AFW pumps and associated piping as seismic Category I components. Section 10.1.3 of the UFSAR describes the main steam system upstream of the main steam isolation valves (MSIVs), which includes the TDAFW pump steam supply piping, as a seismic Category I system. In addition, Section 7.10.1.3 of the UFSAR, states that the AFW actuation system is a seismic Category I system. Based on the location and design of the AFW system, the TDAFW pump, and the associated steam and water piping should be available to support Phase 1 core cooling during an ELAP as described in the licensee's FIP.

For Phase 1 core cooling, the TDAFW pump draws suction from 12-CST and discharges to the SGs. Calvert Cliffs UFSAR Section 5A.2.1.2 lists the SGs and associated AFW piping as seismic Category I components. The SGs are located in the seismic Category I containment building. As described in Section 10.3.2 of the UFSAR and the licensee's FIP, 12-CST is a seismic Category I structure and is protected from tornado winds and applicable tornado-generated missiles. In addition, Section 10.3.2 of the UFSAR states that the AFW pump suction piping, header, and associated valves connected to 12-CST are seismic Category I components located in tornado wind and tornado-generated missile protected seismic Category I structures. Based on the design and location of the SGs, 12-CST, and associated AFW piping and valves, these components should be available to support Phase 1 core cooling during an ELAP, as described in the licensee's FIP.

For Phase 1 core cooling, heat is transferred from the RCS through the SGs to the atmosphere via the ADVs, which are located on the main steam piping upstream of the MSIVs. Operators will manually control the ADVs using newly installed chain wheels. Section 5A.2.1.2 of the UFSAR lists the ADVs and associated piping as seismic Category I components. The steam piping is located in the seismic Category I containment building and seismic Category I portions of the auxiliary building, which provide protection from tornado winds and tornado-generated missiles. The ADVs are located within the seismic Category I portion of the auxiliary building and are protected from tornado winds and tornado-generated missiles. The newly installed chain wheels are located in the seismic Category I portion of the auxiliary building but are only designed to seismic Category II/I. As described in Section 5A.2.1.2 of the UFSAR, seismic Category II structures that are directly connected to seismic Category I (Seismic Category II/I) SSCs, are restrained in such a way that damage or excessive movement of the seismic Category II items will not adversely affect the seismic Category I SSCs. Even though the chain wheel is not safety related, and the chain wheel is directly connected to the ADV (a Category I component), the design must be such that, following an safe shutdown earthquake (SSE), the ADV can still function. As such, the chain wheels should be available following an SSE. Based on the location and design of the ADVs, the ADVs should be available to support Phase I core cooling during an ELAP, as described in the licensee's FIP.

Phase 2

The licensee's primary strategy for Phase 2 core cooling is the continued use of the TDAFW pump supplying water to the SGs and relieving heat to the atmosphere via the ADVs as described above. The licensee plans to provide makeup water to 12-CST via portable FLEX pumps from 11-CST, 21-CST, 11-DWST), 11-PWST, 12-PWST, 11-well, and, as a last resort, the Chesapeake Bay. As a backup to the TDAFW pumps, the licensee will use portable FLEX AFW pumps to provide water to the SGs via injection into the existing AFW system piping.

Prior to the depletion of 12-CST, the licensee will deploy a portable FLEX ring header which operators can connect to 11-CST, 21-CST, 11-DWST, 11-PWST, and 12-PWST to provide makeup water to 12-CST or directly to the FLEX AFW pumps. As described in the licensee's FIP, 11-CST, 21-CST, and 11-DWST are seismically qualified under the licensee's seismic verification program, while 11-PWST and 12-PWST are seismic Category II structures. However, none of the tanks used to provide makeup water to 12-CST in Phase 2 are protected against tornado-generated missiles. The licensee has made modifications to 11-well, which provides protection from tornado winds and tornado-generated missiles, but the well is not seismically qualified. The licensee plans to prioritize each water source based on quality and availability. If no other water sources are available, the licensee will draw water from the Chesapeake Bay, a natural body of water that is not subject to seismically induced dam failures. In addition, the licensee can use multiple locations to draw water from the bay depending on the level and environmental conditions. Based on the design and quantity of tanks on site and the availability of the Chesapeake Bay as an unlimited water source, the licensee should have a sufficient water source available to support Phase 2 core cooling during an ELAP.

If the TDAFW pumps become unavailable, the licensee will use portable FLEX AFW pumps to provide cooling water to the SGs by taking suction from the FLEX ring header or the Chesapeake Bay and discharging into the existing AFW system piping. As described above for Phase 1 core cooling, the AFW system is protected from the applicable hazards described in NEI 12-06 and should be available for use to support Phase 2 core cooling during an ELAP.

For Phase 2 RCS inventory control, the licensee relies on the existing SITs, charging pumps, chemical and volume control system (CVCS) piping, BASTs, RWTs, and the high-pressure safety injection (HPSI) systems on each unit to provide borated water makeup to each units respective RCS. In addition, the licensee relies on its 120 VAC vital distribution system and 480 Vac vital distribution system.

At the onset of Phase 2, the licensee relies on the existing SITs to provide passive injection into the RCS. Section 5A.2.1.2 of the UFSAR lists the SITs and associated piping as seismic Category I components. The SITs are located in the seismic Category I containment structure and are protected from all applicable external hazards as defined in NEI 12-06. Based on the design and location of the SITs, the SITs should be available to support Phase 2 RCS inventory control during an ELAP, as described in the licensee's FIP.

After the depletion of the SITs, the licensee uses one of two repowered charging pumps, part of the CVCS, on each unit to provide borated water to each units respective RCS through existing CVCS piping. Calvert Cliffs UFSAR Section 5A.2.1.2 lists the CVCS system as a seismic Category I system. The charging pumps are located in the seismic Category I portion of each units auxiliary building and are protected from all applicable external hazards as defined in NEI 12-06. The applicable CVCS piping is located in the seismic Category I portion of the auxiliary building and the seismic Category I containment structure. Based on the design and location of the charging pumps and the applicable CVCS piping, at least one pump per unit and the applicable piping should be available to support Phase 2 RCS inventory control during an ELAP.

The charging pumps can take suction from each unit's respective BASTs, which are part of the CVCS, or the RWT. Section 5A2.1.2 of the UFSAR lists the CVCS as a seismic Category I system and the RWT as a seismic Category I component. The BASTs are located in the seismic Category I portion of the auxiliary building and are protected from all applicable external hazards as defined in NEI 12-06. Even though the RWTs are seismic Category I components, the tanks are not protected from tornado-generated missiles. During the audit, the staff asked the licensee to provide information on the survivability of the RWT. The licensee stated that the seismic Category I RWT room and containment structure do provide some protection against tornado-generated missiles, and that the RWT has a 36-inch high vehicle barrier around the tank. In addition, the licensee stated that if the portion of the tank above the 36-inch barrier was damaged, the lower portion would still contain over 18,000 gallons of borated water, which would support RCS injection for greater than 72 hours.

If the charging pumps fail or are unavailable, the licensee will use a portable FLEX RCS makeup pump to take suction from the RWT and inject into each units' HPSI system piping. Section 5A2.1.2 of the UFSAR lists the HPSI as a seismic Category I system. The HPSI system is located in the seismic Category I portion of the auxiliary building and the seismic Category I containment building and is protected from all applicable external hazards as defined in NEI 12-06. Based on the design and location of the HPSI system, the system piping should be available to support Phase 2 RCS inventory control during an ELAP, as described in the licensee's FIP.

The licensee's Phase 2 inventory control strategy relies on various seismic Category I components which are powered by the station 120 Vac and 480 Vac vital distribution systems. Section 5A2.1.2 of the UFSAR states that all control boards, switchgears, load centers, batteries, and cable runs serving Category I equipment are designed and installed as Category I components. In addition, the applicable vital ac distribution systems are located within seismic Category I structures and are protected from all applicable external hazards as defined in NEI 12-06. Based on the design and location of the applicable vital ac distribution systems, the systems should be available to support Phase 2 RCS inventory control during an ELAP, as described in the licensee's FIP.

Phase 3

For Phase 3 core cooling and RCS inventory control, the licensee will use the NSRC equipment to supplement the onsite portable equipment, as necessary, using the same existing SSCs as discussed above for Phases 1 and 2.

3.2.3.1.2 Plant Instrumentation

Per the FIP, the following instrumentation credited for FLEX will be available in the control room following the stripping of non-essential loads:

- RCS Hot Leg Temperature
- RCS Cold Leg Temperature
- RCS Pressure (Wide Range)
- RCS Pressure (Narrow Range)
- Core Exit Thermocouples
- SIT Level (3 of 4 channels available after load shed)
- Pressurizer Level (Wide Range)
- Reactor Vessel Level
- Neutron Flux
- Auxiliary Feedwater Flow
- SG Pressure
- SG Water Level
- Containment Pressure
- Containment Temperature
- CST Level
- Battery Capacity/Voltage

The instrumentation available at Calvert Cliffs to support the licensee's strategies for core cooling and RCS inventory during an ELAP event appears to be consistent with and in some cases exceeds the recommendations specified in the endorsed guidance of NEI 12-06. Based upon the information provided by the licensee, the NRC staff understands that indication for the above instruments should be available and accessible continuously throughout the ELAP event. All of these instruments are located within seismic Category 1 structures and are fully protected against all external events as defined in NEI 12-06.

As recommended by Section 5.3.3 of NEI 12-06, FSG-7, "Loss of Vital Instrument or Control Power," provides instructions and information to obtain readings locally with the use of portable FLEX equipment.

3.2.3.2 Thermal-Hydraulic Analyses

The licensee relies on the analysis of the ELAP event performed by the Pressuirized-Water Rector Owners Group (PWROG) in WCAP-17601-P. The Combustion Engineering Nuclear Transient (CENTS) code was chosen for the evaluation of CE-designed plants such as Calvert Cliffs. The CENTS code, as described in Westinghouse topical report WCAP-15996-A (ADAMS Accession No. ML053320174), is a general-purpose thermal-hydraulic computer code that the NRC staff has previously reviewed and approved for calculating the behavior of the RCS and secondary systems of PWRs designed by CE and Westinghouse during non-loss-of-coolant accident (non-LOCA) transients. Although CENTS has been approved for performing certain design-basis non-LOCA transient analyses, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of an ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of CENTS and other thermal-hydraulic codes used for these analyses.

Based upon this review, the NRC staff questioned whether CENTS and other codes used to analyze ELAP scenarios for PWRs would provide reliable coping time predictions in the reflux or boiler-condenser cooling phase of the event because of challenges associated with modeling complex phenomena that could occur in this phase, including boric acid dilution in the intermediate leg loop seals, two-phase leakage through RCP seals, and primary-to-secondary heat transfer with two-phase flow in the RCS. In particular, for PWRs with inverted U-tube SGs, the reflux cooling mode is said to exist when vapor boiled off from the reactor core flows out the saturated, stratified hot leg and condenses on SG tubes, with the majority of the condensate subsequently draining back into the reactor vessel in countercurrent fashion. A specific concern arose with the use of CENTS for ELAP analysis because NRC staff reviews for previous non-LOCA applications had imposed a condition limiting the code's heat transfer modeling in natural circulation to the single-phase liquid flow regime. This condition was imposed due to the lack of benchmarking for the two-phase flow models that would become active in LOCA scenarios. Although the RCS leakage rates in an analyzed ELAP event are significantly lower than what is typically evaluated for limiting small-break LOCA scenarios, nevertheless, over the extended duration of an ELAP event, two-phase natural circulation flow may eventually be reached in the RCS, dependent upon the timing of reestablishing RCS makeup.

In the PWROG's Core Cooling Position Paper, which was provided in a letter dated January 30, 2013, the PWROG recommended that the reflux or boiler-condenser cooling phase be avoided under ELAP conditions because of uncertainties in operators' ability to control natural circulation following reflux cooling and the impact of dilute pockets of water on criticality. Due to the challenge of resolving the above issues within the compliance schedule specified in Order EA-12-049, the NRC staff agreed that PWR licensees should provide makeup to the RCS prior to entering the reflux or boiler-condenser cooling phase of an ELAP, such that reliance on thermal-hydraulic code predictions during this phase of the event would not be necessary. However, the PWROG's Core Cooling Position Paper did not fully address the staff's issues with CENTS, and in particular, lacked a quantitative definition for the threshold of entry into reflux cooling.

To address the NRC staff's remaining concerns associated with the use of CENTS to simulate the two-phase natural circulation flow that may occur during an ELAP for CE-designed PWRs, the PWROG submitted a white paper entitled "Westinghouse Response to NRC Generic Request for Additional Information (RAI) on CENTS Code in Support of the Pressurized Water Reactor Owners Group (PWROG) (PA-ASC-1187)" (ADAMS Accession No. ML14218A083). This white paper was originally submitted on September 24, 2013, and a revised version was resubmitted on November 20, 2013. The white paper focused on comparing several small-break LOCA simulations using the CENTS code to analogous calculations performed with the CEFLASH-4AS code, which was previously approved for analysis of design-basis small-break LOCAs under the conservative Appendix K paradigm for CE-designed reactors. The analyses in the CENTS white paper generally showed that CENTS' predictions were similar or conservative relative to CEFLASH-4AS for key figures of merit for conditions where natural circulation is occurring in the RCS, including predictions of RCS loop flow rates and the timing of the transition to reflux cooling. The NRC staff's review of the analyses in the white paper included performing confirmatory analyses with the TRACE code. In particular, the staff's TRACE simulations generally showed reasonable agreement with the predictions of CENTS regarding the fraction of the initial RCS mass remaining at the transition to reflux cooling. Therefore, as documented by letter dated October 7, 2013 (ADAMS Accession No. ML13276A555), the NRC staff endorsed the approach in the PWROG's white paper as an appropriate means for applying the CENTS code to beyond-design-basis ELAP analysis, with the limitation that reliance upon CENTS is limited to the phase of the event before reflux cooling begins.

Quantitatively, as proposed in the PWROG's white paper, the threshold for entry into reflux cooling is defined as the point at which the 1-hour centered time-average of the flow quality passing over the SG tubes' U-bend exceeds one-tenth (0.1) in any RCS loop. Considering this criterion relative to the RCS loop flow predictions of both the CENTS and TRACE codes, the NRC staff agreed that it provides a reasonable definition for the threshold of entering reflux cooling for the purpose of analyzing the beyond-design-basis ELAP event. Both the NRC staff and industry analysts acknowledged the adoption of this definition as a practical expedient for analyzing a slow-moving ELAP event. Inasmuch as the transition of flow in the RCS loops from natural circulation to reflux cooling in this event is a gradual process that typically occurs over multiple hours, lacking a quantitatively defined threshold, objective and consistent treatment would not be possible. As discussed further in Section 3.2.3.4 of this SE, a second metric for ensuring adequate coping time is associated with maintaining sufficient natural circulation flow in the RCS to support adequate mixing of boric acid.

Applying the one-tenth flow quality criterion to the analyses completed in WCAP-17601-P, the November 20, 2013, revision of the PWROG's white paper on CENTS determined ELAP coping times prior to entering the reflux cooling mode for each CE reactor included in WCAP-17601-P.

Unlike the generic calculations performed for reactors designed by other vendors, the analysis for CE plants in WCAP-17601-P was generally conducted at a plant-specific level. (One exception is that a single analysis was used to represent four plants of similar design, including Calvert Cliffs.) With respect to Calvert Cliffs, a coping time of 24.7 hours was identified, by which RCS makeup should be provided. This coping time is well in excess of the time at which the licensee intends to initiate RCS makeup according to its FIP (i.e., no later than 12 hours). The NRC staff performed confirmatory simulations with the TRACE code for Calvert Cliffs using an input deck generated from a mixture of plant-specific sources and generic information representative of CE-designed reactors. The results of the staff's calculations indicated that more than 19 hours should be available prior to entering the reflux cooling mode, thereby confirming the appropriateness of the licensee's mitigating strategy. As a result, the NRC staff considers the licensee's strategy for ensuring sufficient RCS makeup to avoid reflux cooling as having ample margin for mitigating the analyzed ELAP event.

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

3.2.3.3 Reactor Coolant Pump (RCP) Seals

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

The NRC staff observed that the licensee's analysis for determining the threshold for entry into reflux cooling was based on the assumption that RCP seal leakage would occur at an initial rate of 15 gpm at the RCS temperature and pressure conditions applicable when subcooling decreases below 50°F. Modeling RCP seal leakage in this manner was intended to envelop the potential for seal instability at low inlet subcooling conditions to result in "pop-open" failure, as described in WCAP-16175-P-A, "Model for Failure of RCP Seals Given Loss of Seal Cooling in CE NSSS Plants." Because leakage rates in excess of 15 gpm would be expected to trigger closure of the controlled bleedoff line excess flow check valves (i.e., which should isolate the majority of RCP seal leakage), the pop-open failure mode was assumed to occur upon loss of subcooling margin, resulting in leakage at the maximum rate that would not be expected to trigger closure of the excess flow check valves. Thermal-hydraulic analysis indicates that the RCS subcooling margin decreases below 50°F at approximately 3 hours into the event as the RCS cooldown is being conducted. Cooling down the RCS under ELAP conditions results in the RCS approaching saturation because the pressurizer heaters are not powered. As the RCS cooldown and depressurization continue, the analytical leakage rate decreases in accordance with the choked flow correlation[1] used in the CENTS code. Considering the leakage rates from the licensee's CENTS analysis, the NRC staff concluded that these analytically assumed leakage rates are sufficiently conservative relative to the leakage rate for Flowserve N-9000 seals that is expected during the analyzed ELAP event.

Sulzer Bingham model RCR875B-3V 3-stage plus vapor stage ("3+1") balanced stator design seals are installed on the RCPs at Calvert Cliffs. In response to the NRC's RAI on RCP seal leakage related to Order EA-12-049, on August 16, 2013, Westinghouse submitted a letter, LTR-FSE-13-45 (ADAMS Accession Number ML13235A149). The NRC RAI discussed CE RCP seal designs and their impact to RCP seal leak rate during an ELAP event, to include: failure modes considered in determining the leak rate, impact of single and two-phase flow on seal leak rate, impact of temperatures and subcooling on seal leak rate, and relationship to data contained in WCAP-16175-P. The Westinghouse letter promulgated recommendations for ELAP coping strategies for the CE fleet, namely:

- Rapid cooldown and depressurization of the RCS to limit seal degradation and reduce the differential pressure across the seal
- Maintaining RCS subcooling between 20°F and 50°F (based on core exit thermocouple temperature) to prevent RCP seal pop-open failure

In particular, these recommendations were intended to preclude the effects associated with pop-open failure. The licensee's FIP states that Calvert Cliffs' procedures satisfy these recommendations. As noted above, the licensee will initiate a cooldown of the RCS at a rate of 75 °F/hr no later than two hours into the event, stabilizing RCS temperature at 340°F and SG pressure at 120 psia. EOP-7 directs operators at Calvert Cliffs to maintain RCS subcooling between 30°F and 50°F by cooling the RCS using ADVs. The NRC staff notes, however, that maintaining subcooling in this range using ADVs, as the procedure directs, may not be possible in practice while continuing the RCS cooldown at 75 °F/hr.

Based upon the discussion above, the NRC staff concludes that the RCP seal leakage rates of 15 gpm per seal 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 <u>Shutdown Margin Analyses</u>

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

- the cooldown of the RCS and fuel rods adds positive reactivity
- the concentration of xenon-135
    - initially increases above its equilibrium value following reactor trip, thereby adding negative reactivity

[1] A choked flow correlation is used to estimate the maximum fluid velocity across a restrictive cross-sectional flow area.

  - o peaks at roughly 12 hours and subsequently decays away gradually, thereby adding positive reactivity
- the injection of borated makeup from passive accumulators due to the depressurization of the RCS, which adds negative reactivity

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

In support of its review of the mitigating strategy for Calvert Cliffs, the NRC staff audited the licensee's shutdown margin calculation. The shutdown margin calculation concluded that for a typical Calvert Cliffs core design, no additional boration would be necessary to ensure at least 1 percent shutdown margin under xenon-free conditions for RCS cold leg temperatures above 325°F for at least 32 hours after the initial ELAP event. In light of the post-cooldown target SG pressure of 120 psia, the staff expects the RCS cold leg temperature to remain above this value (i.e., approximately 340°F).

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

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

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

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

The NRC staff's audit review considered whether the licensee had followed recommendations from the PWROG's position paper and the associated conditions imposed in the NRC staff's endorsement letter. Regarding the first condition, the NRC staff's audit review found that the licensee's shutdown margin calculation had considered an appropriate range of RCS leakage rates in determining the limiting condition for the shutdown margin analysis. Furthermore, the NRC staff concluded that the licensee's plan to initiate RCS makeup no later than 12 hours satisfies the second two conditions. Therefore, the NRC staff concludes that the licensee's calculation appears to be consistent with the PWROG position paper, including the intent of the additional conditions imposed in the NRC staff's endorsement letter.

In NEI 12-06, Section 11.8.2, states that plant configuration control procedures will be modified to ensure that changes to the plant design will not adversely impact the approved FLEX strategies. Inasmuch as changes to the core design constitute changes to the plant design, the staff expects that any changes to the core design, such as those evaluated in a typical core reload analysis, will be evaluated to determine that they do not adversely impact the approved FLEX strategies, especially the analyses which demonstrate that no recriticality will occur during a FLEX RCS cooldown.

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

As described in the licensee's FIP, the licensee credits five portable pumps in its core cooling and inventory control FLEX strategies; two FLEX AFW pumps (one for each unit), two FLEX RCS makeup pumps, and a FLEX SFP makeup pump (used as a booster pump and shared between units). The FLEX AFW makeup pumps are trailer-mounted, diesel engine driven, centrifugal pumps. The FLEX AFW makeup pumps provide a backup SG injection method in the event that the TDAFW pump can no longer perform its function. The licensee has three FLEX AFW pumps on site, which satisfies the N+1 requirement. The FLEX RCS makeup pumps are trailer-mounted, diesel engine driven, positive displacement pumps. The RCS makeup pumps provide a backup RCS injection method in the event that the existing charging pumps are not available. The licensee has three FLEX RCS makeup pumps onsite, which satisfies the N+1 requirement. The SFP makeup pumps are trailer-mounted, diesel engine driven, centrifugal pumps. The licensee uses the FLEX SFP makeup pump as a booster pump to provide makeup to the 12-CST from the FLEX ring header or from the UHS, or to the FLEX AFW pumps from the UHS. The licensee has three FLEX SFP makeup pumps on site (one for use as a booster, one for SFP makeup, one extra), which satisfies the N+1 requirement.

In accordance with NEI 12-06, Section 11.2, the licensee performed calculations CA08575, "Hydraulic analysis of Steam Generator (SG) Makeup FLEX Portable Pump and Hose Connections," Revision 0, CA08576, "Hydraulic Analysis of Reactor Coolant System (RCS) Makeup FLEX Portable Pump and Hose Connections," Revision 1, and CA09973, "Hydraulic Analysis of Spent Fuel Pool Makeup from Portable FLEX Pumps," Revision 0 to determine the hydraulic demand of the FLEX pumps in order to provide the performance requirements for proper selection and procurement of pumps. The NRC staff performed a cursory review of the calculations to determine if the licensee used standard evaluation methods, and proper assumptions and inputs, and compared the results of the calculations to the actual design specifications of the procured pumps. The licensee's calculations used classical hydraulic analysis head loss and pressure gradient methods via hydraulic performance modeling software

AFT Fathom, Version 8.0, and included all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX strategy water supply using the most limiting set of conditions for SG and RCS injection. The calculation determined the minimum required flow rate, minimum discharge pressure, and minimum NPSHa for a pump to be able to perform its required function. Comparison of the actual pump performance data and the sizing criteria of the calculation showed that the FLEX AFW pumps, FLEX RCS makeup pumps, and FLEX SFP (booster) pumps should have the capacity needed to perform the required function for supporting core cooling and inventory control.

Therefore, based on the evaluation above, the NRC staff concludes that the portable FLEX pumps should perform as intended to support core cooling and RCS inventory control during an ELAP event, consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to the equipment and instrumentation used to mitigate the ELAP and LUHS. The licensee's strategy for RCS inventory control uses the same electrical strategy as for maintaining or restoring core cooling, containment, and SFP cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this SE. Furthermore, the electrical coping strategies are the same for all modes of operation.

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

According to the licensee's FIP, operators would initiate mitigating strategies following a loss of offsite power, loss of all emergency diesel generators, and the loss of any alternate ac power with a simultaneous loss of access to the UHS. The plants 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 EOPs. The FLEX strategies are implemented in support of EOPs using FLEX Support Guidelines (FSGs).

During the first phase of the ELAP event, Calvert Cliffs would rely on the station's Class 1E station batteries to provide power to key instrumentation for monitoring parameters and power to controls for SSCs used to maintain the key safety functions (reactor core cooling, RCS/PCS inventory control, and containment integrity). The Calvert Cliffs Class 1E station batteries and associated dc distribution systems are located within the auxiliary building, which is a seismic Category I structure. The Class 1E station batteries are therefore protected from the applicable extreme external hazards as defined in NEI 12-06. Licensee procedure FSG-4, "ELAP DC Bus Load Shed and Management," Revision 1, directs operators to conserve dc power during the event by stripping non-essential loads. The plant operators would commence stripping, or shedding dc loads within 1 hour after the occurrence of an ELAP event. The licensee expects load shedding to be completed within 2 hours of the ELAP event.

Calvert Cliffs has four Class 1E station batteries that were manufactured by Exide Technologies (GNB Flooded Classic model). Batteries 11 and 21 are model NCN-21 with a capacity of 1496 ampere-hours (A-H). Battery 12 is a model NCN-27 with a capacity of 1944 A-H. Battery 22 is a model NCX-27 with a capacity of 1944 A-H. The licensee noted and the staff confirmed that the useable Class 1E station battery capacity could be extended up to 7.07 and 7.33 hours, respectively for the limiting batteries (11 and 21) and 12 hours for the remaining batteries (12 and 22) by shedding non-essential loads.

In its FIP, the licensee noted that it had followed the guidance in NEI white paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern" (ADAMS Access No. ML13241A186), when calculating the duty cycle of the batteries. By letter dated September 16, 2013, the NRC endorsed the NEI white paper (ADAMS Accecssion No. ML13241A188). In addition to the white paper, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended battery Operation in Nuclear Power Plants," in May of 2015. The testing provided additional validation that the NEI white paper method was technically acceptable. The NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI white paper.

Based on the evaluation above, the NRC staff concludes that the Calvert Cliffs load shed strategy should ensure that the batteries have sufficient capacity to supply power to the required loads for at least 12 hours.

The NRC staff reviewed the licensee's dc coping studies, CA08256, "Battery 11 Load Shed Coping Time for ELAP Event," Revision 0, CA08257, "Battery 12 Load Shed Coping Time for ELAP Event," Revision 8, CA08258, "Battery 21 Load Shed Coping Time for ELAP Event," Revision 0, and CA08259, "Battery 22 Load Shed Coping Time for ELAP Event," Revision 0, which verified the capability of the dc system to supply the required loads during the first phase of the Calvert Cliffs' FLEX mitigation strategy plan for an ELAP as a result of a BDBEE. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the non-essential loads that would be shed within 2 hours to ensure battery operation for least 7 hours.

Based on the staff's review of the licensee's analyses, the battery vendor's capacity and discharge rates for the Class 1E station batteries, and the licensee's procedures, the NRC staff concludes that the Calvert Cliffs dc systems appear to have adequate capacity and capability to power the loads required to mitigate the consequences during Phase 1 of an ELAP as a result of a BDBEE provided that necessary load shedding is completed within the times assumed in the licensee's analyses.

The licensee's Phase 2 strategy includes repowering 480 Vac buses within 7 hours after initiation of an ELAP using portable 500 kW (one per unit) and 100 kW (one per unit) 480 Vac FLEX DGs. The portable 480 Vac FLEX DGs would supply power to Calvert Cliffs' vital 480 Vac vital bus circuits providing continuity of key parameter monitoring and other required loads. The 500 kW FLEX DGs (the primary strategy) would provide power to vital battery chargers, charging pumps, and vital reactor MCCs to repower SIT outlet MOVs, hydrogen purge exhaust MOVs, SWACs, battery room supply and exhaust fans, and the inverter backup bus. The 100 kW FLEX DGs (alternate strategy) would directly repower vital 480 Vac reactor MCCs.

The NRC staff reviewed licensee calculations CA08800, "Fukushima 480VAC FLEX 500KW Diesel Generator Sizing," Revision 0 and CA08801, "Fukushima 480VAC FLEX 100KW Diesel

Generator Sizing," Revision 0 and procedures FSG-4, FSG-5, "Initial Assessment and FLEX Equipment Staging," Revision 1, conceptual single line diagrams, and the separation and isolation of the FLEX DGs from the Class 1E emergency DGs. Based on the NRC staff's review, the minimum required loads for the Phase 2 500kW and 100kW FLEX DGs are approximately 214 kW and 43 kW, respectively. Therefore, one 500 kW and one 100 kW FLEX DG per unit is adequate to support the electrical loads required for the licensee's Phase 2 primary and alternate strategies, respectively. Furthermore, the licensee's primary Phase 2 electrical strategy ensures that the safety-related battery chargers will be energized prior to the batteries depleting them below the minimum acceptable voltage. For the alternate strategy, the licensee will disconnect the vital batteries (vital instruments are powered via the ac system) to preserve the asset until additional power sources are available (e.g., Phase 3 generators).

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite. The offsite resources that will be provided by an NSRC includes four (2 per unit) 1-MW 4160 Vac CTGs, two (1 per unit) 1100 kW 480 Vac CTGs, and distribution panels (including cables and connectors). Each portable 4160 Vac CTGs is capable of supplying approximately 1 MW, but two CTGs will be operated in parallel to provide a total of approximately 2 MW. The licensee does not plan to utilize the NSRC CTGs until 72 hours following the initiation of the ELAP event. The licensee plans to have the technical support center (TSC) fully staffed at that time. During this time the TSC personnel will recommend the specific loads, priority, and time for staring the loads upon repowering the 4160 Vac busses with the CTGs. The licensee did not perform a loading calculation for the expected loads that will be powered by the NSRC supplied 4160 Vac and 480 Vac CTGs. However, the licensee determined that the two Phase 3 4160 Vac CTGs should have sufficient capacity (2 MW) to supply power to the Phase 2 loads (approximately 214 kW) and service water system pump (364 kW) with sufficient spare margin for additional loads (for example, containment air cooling Unit), if needed. Based on the margin available for the 4160 Vac CTGs and the 480 Vac CTGs providing backup to the Phase 2 portable FLEX DGs, the NRC staff concludes that the 4160 Vac and 480 Vac equipment being supplied from an NSRC should have sufficient capacity and capability to supply the required loads.

3.2.4 Conclusions

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

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-2 and Appendix D, summarize an approach consisting of two separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design-basis heat load; and 2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design basis heat load. However, in JLD-ISG-2012-01, Revision 1, the NRC staff did not fully accept this approach, and added another requirement to either have the capability to provide spray flow to the SFP, or complete an SFP integrity evaluation which demonstrates that a seismic event would have a very low probability of inducing a crack in the SFP or its piping systems so that spray would not be needed to cool the spent fuel. The evaluation must use the reevaluated seismic hazard described in Section 3.5.1 below if it is higher than the site's current SSE. During the event, the licensee selects the SFP makeup method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

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

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

The ELAP causes a loss of cooling in the SFP. As a result, the pool water will heat up and eventually boil off. The licensee's response is to provide makeup water. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP.

The licensee's FIP defines strategies capable of mitigating a simultaneous loss of all ac power and LUHS resulting from a BDBEE by providing the capability to maintain or restore SFP cooling at all units on the Calvert Cliffs site. The NRC staff reviewed the licensee's FIP to determine whether the strategies outlined in the FIP, if implemented appropriately, would maintain or restore SFP cooling following a BDBEE. As part of its review, the NRC staff reviewed simplified flow diagrams, engineering drawings, summaries of calculations for sizing the FLEX pumps, and summaries of calculations that addressed the heat up rates of the SFP as a result of losing normal cooling functions, during an ELAP as a result of a BDBEE.

While the licensee's FIP identifies specific strategies, due to the inability to anticipate all possible scenarios, the strategies are also diverse and flexible to encompass a wide range of possible conditions. According to the licensee, their FIP strategies have been incorporated into the site emergency operating procedures in accordance with established EOP change processes and their impact to the design basis capabilities of the unit evaluated under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.59.

The NRC staff discussed the SFP cooling portion of the Calvert Cliffs mitigation strategy for an ELAP event with the licensee's staff and performed a walk-down of the licensee's SFP cooling strategies during an onsite audit. The walk-down focused on the areas where SFP cooling FLEX equipment will be stored, deployed and operated, the connection points to the existing piping systems, and the hose runs from the staged and deployed FLEX pumps. The licensee's basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide makeup water to the SFP with the objective of maintaining at least 6 feet of water above the top of the fuel.

3.3.1 Phase 1

For Phase 1 SFP cooling, the licensee credits the large inventory and heat capacity of the water in the SFP. Following the loss of SFP cooling, the SFP will slowly heat up and eventually begin to boil. As described in the FIP, following a loss of SFP cooling the SFP would begin to boil in approximately 10.1 hours. As the water in the SFP boils, the water level will lower to 6 feet above the fuel in 58.8 hours with fuel uncovering in 76 hours. The licensee's initial coping strategy for SFP cooling is to allow evaporative cooling of the SFP while monitoring SFP level using instrumentation installed as required by NRC Order EA-12-051. Although SFP makeup is commenced during Phase 2, the licensee plans to deploy makeup hoses in the SFP area prior to commencement of boiling to minimize personnel entering the area during a high heat and humidity conditions which may occur in later phases.

3.3.2 Phase 2

The licensee has developed two baseline SFP cooling strategies. The strategies use a portable injection source to provide makeup via connection to spent fuel pool cooling piping without having to access the refueling floor and via hoses on the refueling floor for surface makeup. The licensee performed a seismic SFP integrity evaluation for their mitigating strategies seismic hazard determined under the March 12, 2012, requests for information under 10 CFR 50.54(f). The evaluation was performed in accordance with the NRC approved method in Electric Power Research Intitute (EPRI) 3002007148, "Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation." The evaluation compared the Calvert Cliffs site-specific seismic hazard and SFP design to the acceptance criteria set forth in EPRI 3002007148. The evaluation showed that the Calvert Cliffs SFP meets or exceeds the criteria in EPRI 3002007148, and therefore, is seismically adequate and should retain adequate water inventory for at least 72 hours. As a result, the licensee does not need to provide spray cooling to the SFP.

The FLEX SFP makeup pump takes suction from the Chesapeake Bay through a six-inch rigid hose with a barrel strainer attached to minimize debris entering the pump suction. Pump discharge is through a five inch hose which is routed from the pump to a FLEX hose manifold located just outside of the auxiliary building. The hose manifold for SFP makeup consists of a five inch Storz inlet connection with three outlets.

The licensee's first method provides water at a rate that matches boil-off to the SFP from the UHS via the FLEX SFP makeup pump discharging through a fire hose connected to the FLEX hose manifold. From the manifold, a fire hose connects to existing SFP cooling piping. This method provides the capability to supply makeup water to the SFP without accessing the refueling floor.

The licensee's second method provides water at a rate that matches boil-off to the SFP using FLEX SFP makeup pump taking suction from the UHS and discharging through fire hoses connected to the FLEX hose manifold. From the manifold, a fire hose is run directly into the SFP. Prior to the onset of bulk boiling, the licensee will connect and deploy hoses from the hose manifold to the SFP area. Once the FLEX SFP makeup pump is deployed, the licensee will deploy a hose from the pump discharge and connect it to the hose manifold.

3.3.3 Phase 3

For Phase 3 SFP cooling, the licensee plans to continue using Phase 2 strategies and equipment. Personnel will continue monitoring SFP level and adding inventory as necessary using the FLEX SFP makeup pump. In addition, the licensee can employ the NSRC supplied 4160 Vac diesel powered generators to repower the Number 11 or Number 12 SFPC pumps. Once NSRC supplied equipment is installed, plant personnel can begin the process of restoring cooling to the SFP, and augment as necessary with the additional equipment received from the NSRC.

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 Phase 1 SFP cooling strategy does not require connections to any existing plant equipment. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. Calculation CA08253, Section 8 lists several doors, and hatches that must be opened within 2, 4, and 8-hour action times to support the ventilation strategy. Procedure FSG-15 directs operators to open the necessary doors.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of the FLEX SFP makeup pump and augmenting when necessary with NSRC supplied equipment, to supply water to the SFP via the existing SFP cooling system piping. The staff's evaluation of the robustness and availability of FLEX connections points for the FLEX pump is discussed in Section 3.7.3.1 below. In addition, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

3.3.4.1.2 Plant Instrumentation

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

3.3.4.2 Thermal-Hydraulic Analyses

Calvert Cliffs has separate but connecting SFPs, essential making one continuous volume. As described in the FIP, the SFP normal operating level and temperature is the 67.25 ft. elevation, or 23.09 ft. above the top of the fuel, and 85°F respectively. However, for conservatism, the licensee uses the SFP low-level alarm set point of 66.5 ft. elevation, or 22.34 ft. above the top of the fuel, and the SFP high-temperature alarm of 125°F as inputs to its SFP heat-up evaluation. The licensee uses its design-basis maximum heat load of 45.96×10^6 British thermal units per hour (Btu/hr), the SFP low-level set point, and the SFP high-temperature set point to determine the SFP heat-up time and makeup rate for FLEX equipment sizing and ventilation strategies. The licensee uses the methodology in calculation CA07900, "CCNPP Spent Fuel Pool Decay Heat Load During the 2013 RFO," Revision 1, to calculate the elapsed time from loss of SFP cooling to boiling in the SFP, boiling down to 6 ft. above the top of the fuel, and boiling down to the top of the fuel. Following the loss of SFP cooling, the SFP will begin to boil in 10.1 hours, with the water level reaching 6 ft. above the top of the fuel in 58.8 hours and the top of the fuel in 76 hours. With the SFP boiling, water must be added at a rate of 99 gpm in order to maintain level in the pool.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy relies on a FLEX pump to provide SFP makeup during Phase 2 and 3. The licensee performed calculation CA09973, "Hydraulic Analysis of Spent Fuel Pool Makeup from Portable FLEX Pumps," Revision 0, to determine the hydraulic demand of the FLEX pumps in order to provide the performance requirements for proper selection and procurement of pumps. The NRC staff reviewed the summary of the calculation to determine if the licensee used standard evaluation methods, and proper assumptions and inputs, and compared the results of the calculation to the actual design specifications of the procured pumps. The licensee's calculation uses classical hydraulic analysis head loss and pressure gradient methods, and includes all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX strategy water supply using the most limiting set of conditions for SFP makeup. The calculation determined the minimum required flow rate, minimum discharge pressure, and minimum NPSHa for a pump to be able to perform its required function. Comparison of the actual pump performance data and the sizing criteria of the calculation shows that the FLEX SFP makeup pumps should have the capacity needed to perform the required function for supporting SFP cooling. In the FIP, Section 7.5.1 describes the hydraulic performance criteria for the FLEX pump. The staff noted that the performance criteria of a FLEX pump supplied from an NSRC for Phase 3 would allow the NSRC pump to fulfill the mission of the onsite FLEX pump if the onsite FLEX pump were to fail. As stated above, the SFP makeup rate of 99 gpm meets or exceeds the maximum SFP makeup requirements as outlined in the previous section of this SE.

3.3.4.4 Electrical Analyses

The staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The licensee's Phase 1 and Phase 2 strategies are to monitor SFP level using installed instrumentation to ensure adequate water remains over the fuel (the capability of this instrumentation is described in other areas of this SE). For Phase 3, the licensee plans to employ the same strategies utilized during Phase 1 and 2, and use NSRC supplied equipment as necessary. If necessary, an NSRC 4160 Vac CTGs could provide power to the SFP cooling system pumps to provide long term SFP cooling via normal means. The staff reviewed the licensee's analysis and determined that the CTGs have sufficient capacity and capability to supply these loads, if necessary.

3.3.5 Conclusions

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

3.4 Containment Function Strategies

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

The licensee performed a containment evaluation CA07961, "Analysis of Containment Response to Extended Loss of AC Power," which is based on the boundary conditions described in Section 2 of NEI 12-06. The Case D1, the credited limiting case in the calculation, analyzed containment heat up and pressurization, assuming an operator initiated RCS cooldown concurrent with high RCS leakage, no containment air cooler, and no containment spray. Under Case D1, at 72 hours after loss of power, peak pressure reaches approximately 10 psig and temperature reaches approximately 200°F. Case D1 containment parameters (pressure and temperature) remain well below the respective UFSAR Section 5.1.1 design limits of 50 psig and 276 °F for more than 72 hours. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

3.4.1 Phase 1

During Phase 1, the licensee maintains containment integrity through normal design features of the containment (i.e., containment isolation valves). Following a loss of power, EOP-7, "Station Blackout," directs operators to ensure containment integrity by verifying that the applicable containment isolation valves are shut. In addition, FSG-12, "Alternate Containment Cooling," directs operators to isolate any non-essential air lines supplying loads inside containment. Any air leakage from these lines would add to the post-ELAP pressurization of containment reducing the length of time to reach containment design pressure and increasing the likelihood of releases from containment to the environment. Operators will continue to monitor key containment parameters (containment wide-range pressure, containment dome temperature, and reactor cavity temperature) located in the control room.

3.4.2 Phase 2

The RCS cooldown to a temperature of 340°F, performed in Phase 1 for core cooling, should have a positive effect on containment temperature and pressure. The licensee's Phase 2 strategy for containment integrity is to continue monitoring the key containment parameters.

The key parameter indications are powered from the 120 Vac vital distribution system, which is powered by the station batteries through inverters during an ELAP. Actions taken in Phase 1 to strip loads off of the 125 Vdc batteries, as detailed in FSG-4, "ELAP DC Bus Load Shed and Management," should extend battery life up to 12 hours to provide time for connection of the FLEX DG to the 480 Vac buses that power the battery chargers. As a last resort, if containment pressure rises to 10 psig, the licensee can relieve the pressure using the hydrogen purge system.

3.4.3 Phase 3

The licensee's Phase 3 strategy for containment integrity is to continue monitoring the key containment parameters, and maintain containment integrity either by the use of fire suppression equipment spraying the outside of the containment, or use of the NSRC supplied equipment (4160 Vac generators and saltwater pumps) to provide containment cooling.

The licensee plans to restore at least one containment air cooling (CAC) unit, and associated support systems (salt water system, service water system) to service with an NSRC supplied 4160 Vac DG and NSRC supplied saltwater pumps. When the NSRC equipment arrives, the licensee will restore a 4160 Vac safety bus using the supplied generators. The licensee will use the saltwater pumps to provide water to the salt water (SW) system a cooling medium for the service water system, which is the cooling medium for the CACs.

The licensee's FSG-12, "Alternate Containment Cooling," provides instructions for initiating flow to a CAC if operators determine that containment cooling is required. The NSRC pump takes a suction from the Chesapeake Bay with the discharge connected to the SW system, which provides cooling for the critical service water system heat exchangers. Once the NRCS pump is in service, operators apply the service water to the CAC slowly to avoid possible water hammer, which could damage the system. Operators would start the CAC once the service water inlet isolation valve to the CAC is fully open. With containment cooling in service, operators will continue to monitor containment key parameters and make adjustments as necessary.

As an alternate strategy, the licensee would use fire suppression equipment to spray the external containment surfaces to cool containment and maintain temperature less than 276°F.

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

As described in the licensee's FIP, after 72 hours containment temperature and pressure peak at approximately 200°F and 10 psig, respectively. For Phases 1 and 2, the licensee maintains containment integrity via the containment structure itself and containment isolation valves. As described in the Calvert Cliffs UFSAR, Sections 5A.2.1.1 and 5A.2.1.2, the containment building is a seismic Category I structure with all containment penetrations, up to and including the first isolation valves outside the containment, classified as seismic Category I systems or components. As such, the containment building and all penetrations are protected from all applicable external hazards as defined in Section 3.5 of this SE and should be available during an ELAP.

The licensee's Phase 3 strategy for maintaining containment integrity involves using NSRC equipment to provide water to and repower portions of the SW system, service water system and the CAC. Section 5A.2.1.2 of the UFSAR lists the critical SW, critical service water, and CAC systems as seismic Category I systems. The air coolers are located inside the seismic Category I containment structure and are protected from all applicable external hazards as defined in Section 3.5 of this SE. The applicable portion of the service water system are located in the seismic Category I containment structure and the seismic Category I portion of the auxiliary building and is protected from all applicable external hazards as defined in Section 3.5 of this SE. Applicable portions of the SW systems are located in the seismic Category I portion of the auxiliary building and the seismic Category I portions of the intake structure and are protected from all applicable external hazards as defined in Section 3.5 of this SE.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2, specifies that containment pressure is a key containment parameter which should be monitored by repowering the appropriate instruments. The licensee's FIP states that control room instrumentation would be available due to the coping capability of the station batteries and associated inverters in Phase 1, or the portable DGs deployed in Phase 2. If no ac or dc power is available, the FIP states that key credited plant parameters, including containment pressure, would be available using alternate methods as directed in FSG-7-1, "Loss of Vital Instrument and Control Power (Unit 1)," and FSG-7-2, "Loss of Vital Instrument and Control Power (Unit 2)."

As discussed in its FIP, the licensee made modifications to its power supplies for key parameters that support containment strategies. Originally, the Unit 1 and 2 containment dome and reactor cavity temperatures indications were powered from a non-vital 120 Vac power supply. In support of FLEX strategies, the licensee moved the power supply for containment dome and reactor cavity temperatures to vital 120 Vac power supplies. With these containment parameters powered by vital 120 Vac, containment temperature and pressure can be monitored during an ELAP.

3.4.4.2 Thermal-Hydraulic Analyses

The licensee's analysis, CA07961, "Analysis of Containment Response to Extended Loss of AC Power," Revision 0, uses Generation of Thermal Hydraulic Information for Containment (GOTHIC) Version 8.0. In the analysis, RCP seal leakage is assumed to be 15 gpm per pump. An additional leakage of 3 gpm total is assumed to account for unidentified leakage sources. Results of the credited case show the peak pressure is approximately 10 psig at 72 hours and the peak containment shell temperature is approximately 200°F at 120 hours. This is below the containment design limits of 50 psig and 276 °F.

3.4.4.3 FLEX Pumps and Water Supplies

The licensee performed calculation CA09991, "Hydraulic Analysis of the FLEX Pump Connection at the Salt Water System," Revision 0, to determine if the NSRC supplied pump could supply water to the SW system at the pressure and flow rate required for adequate containment cooing via the CAC (5,000 gpm and 25 psig in the SW pump discharge header) while not exceeding the SW piping pressure rating. The NRC staff performed a cursory review of the calculation to determine if the licensee used standard evaluation methods, and proper assumptions and inputs. The licensee's calculation uses classical hydraulic analysis head loss and pressure gradient methods via hydraulic performance modeling software AFT Fathom, Version 8.0, and includes all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX containment cooling strategy using the most limiting set of conditions for SW injection. The calculation determined the minimum required flow rate, minimum discharge pressure, and minimum NPSHa for a pump to be able to perform its required function. Comparison of the required performance data and the sizing criteria of the calculation shows that NSRC supplied low-pressure/high-flow pump should have the capacity needed to perform the required function for supporting long-term containment cooling.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation based on the boundary conditions described in Section 2 of NEI 12-06 to determine the temperature and pressure increase in the containment vessels resulting from an ELAP as a result of a BDBEE. Based on the results of the evaluation, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation function. With an ELAP initiated, while either Calvert Cliffs' units are in Modes 1-4, containment cooling for that unit is also lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. Structural integrity of the reactor containment building due to increasing containment pressure will not be challenged during the first few days of an ELAP event. However, with no cooling in the containment, temperatures in the containment are expected to rise and could reach a point where continued reliable operation of key instrumentation might be challenged. The licensee's evaluations have concluded that containment temperature and pressure will remain below containment design limits and that key parameter instruments subject to the containment environment will remain functional for a minimum of 3 days. Therefore, actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will not be required immediately.

The licensee's Phase 1 coping strategy for containment involves initiating and verifying containment isolation per EOP-7, "Station Blackout," Revision 20. These actions ensure containment isolation following an ELAP. Phase 1 also includes monitoring wide range containment pressure, containment dome temperature, and containment reactor cavity temperature using installed equipment. Control room indication for containment pressure and temperature is available for the duration of the ELAP event.

The licensee's Phase 2 coping strategy is to continue monitoring containment temperature and pressure using installed instrumentation. In its FIP, the licensee stated that the RCS cooldown to a temperature of 340°F performed during Phase 1 for core cooling has a positive effect on containment temperature and pressure.

The licensee's Phase 3 coping strategy is to continue monitoring containment temperature and pressure, and maintain containment integrity. The primary strategy is to restore at least one CAC unit to service and support systems (SW and service water) to operation with an NSRC supplied 4160 Vac CTG and saltwater pump. The alternate strategy is to use the fire suppression equipment spraying the outside of the containment to provide containment cooling. Procedure FSG-12, "Alternate Containment Cooling," Revision 1 provides actions to restore containment cooling to maintain containment temperature and pressure within limits.

Based on its review, the NRC staff determined that the electrical equipment available onsite (i.e., 480 Vac FLEX DGs) and the supplemental equipment that will be supplied from an NSRC (e.g., 480 Vac and 4160 Vac CTGs), there is sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure.

3.4.5 Conclusions

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

3.5 Characterization of External Hazards

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

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

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

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

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

As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H (ADAMS Accession No. ML16005A625). The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163). The licensee's MSAs will evaluate the mitigating strategies described in this SE using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

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

3.5.1 Seismic

In its FIP, the licensee described the current design-basis seismic hazard, the SSE. As described in UFSAR Section 2.6, the SSE seismic criteria for the site is 0.15g peak horizontal ground acceleration and 0.10g peak ground acceleration acting vertically. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the numbers above, is often used as a shortened way to describe the hazard.

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

3.5.2 Flooding

Calvert Cliffs is located on the western shore of the Chesapeake Bay, approximately 110 miles north from the Chesapeake Bay entrance. In its FIP, the licensee provided a table of eight separate flood mechanisms that were analyzed in the Calvert Cliffs UFSAR, in which the limiting site flooding events are the LIP and the storm surge including wave run up. As described in the UFSAR, Calvert Cliffs safety-related and important-to-safety SSCs were constructed across three nearly level terraces to ensure that the structures are not susceptible to external flooding, including LIP and the storm surge including wave run up.

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

3.5.3 High Winds

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

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

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06, Figure 7-2, from U.S. NRC, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, 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.

In its OIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at 38° 25' 55" North latitude and 76° 26' 32" West longitude. In NEI 12-06, Figure 7-2, "Recommended Tornado Design Wind Speeds for the 1E-6/year Probability Level," indicates the site is in Region 1, where the tornado design wind speed

exceeds 130 mph. Therefore, the plant screens in for an assessment for high winds, hurricanes, and tornados, including missiles produced by these events.
Therefore, high-wind hazards are applicable to the plant site. The licensee has appropriately screened in the high wind hazard and characterized the hazard in terms of wind velocities and wind-borne missiles.

3.5.4 Snow, Ice, and Extreme Cold

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

In its OIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at 38° 25' 55" North latitude and 76° 26' 32" West longitude. In addition, the site is located within the region characterized by EPRI as ice severity level 4 (NEI 12-06, Figure 8-2, "Maximum Ice Storm Severity Maps"). Consequently, the site is subject to severe icing conditions that could cause severe damage to electrical transmission lines.

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

3.5.5 Extreme Heat

In the section of its FIP regarding the determination of applicable extreme external hazards, the licensee stated that, as per NEI 12-06 Section 9.2, all sites are required to consider the impact of extreme high temperatures. The local maximum temperature observed was 103°F in Lusby; Maryland, approximately 3 miles south of Calvert Cliffs in July 1980. The plant site screens in for an assessment for extreme high temperature hazard.

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

3.5.6 Conclusions

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

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

In its FIP, the licensee stated that Calvert Cliffs has a single hardened FLEX storage structure (i.e., FLEX Storage Robust building (FSRB)) of approximately 8,400 square feet that is protected from the hazards described above in Section 3.5. Equipment credited for implementation of the FLEX strategies (N) at Calvert Cliffs is stored in the FSRB. In addition to the FSRB, the licensee has constructed a FLEX Storage Commercial building (FSCB), which is a commercial grade building. The FSCB is not a seismic Class I building, but it is high wind resistant and provides weather protection for equipment stored inside. N+ 1 equipment is stored in the FSCB as well as additional equipment such as two dewatering pumps which are not essential to the FLEX Strategies. Below are additional details on how FLEX equipment is protected from each of the applicable external hazards as defined in Section 3.5.

3.6.1.1 Seismic

In its FIP, the licensee described that the FLEX N equipment will be stored in the FSRB and the N+ 1 equipment will be stored in the FSCB. The FSRB is a Class I structure but the FSCB is not a Class I structure. Large FLEX portable equipment stored in the FSRB, such as pumps, generators, trailers, and trucks are secured with tie-down straps to floor anchors inside the FSRB to protect them during a seismic event. The FSRB anchors are integrated into the floor slab. Similarily, equipment in the FSCB is strapped down to prevent movement in a seismic event. During the audit process, the NRC staff verified that FLEX equipment will be secured as appropriate for a potential SSE and will be protected from seismic interactions from other components.

3.6.1.2 Flooding

As indicated above, Calvert Cliffs safety-related and important-to-safety SSCs were constructed across three nearly level terraces to ensure that the structures are not susceptible to external flooding. Specifically, the FIP states that the three level terraces are: (1) the safety-related intake structure is located at a deck elevation of 10 ft., (2) safety-related and important-to-safety SSCs in the main plant area are located at a grade elevation of about 45 ft., and (3) plant substation (switchyard) and administrative buildings are located at a grade elevation of about 70 ft. There are two limiting flooding mechanisms at Calvert Cliffs, which are LIP and storm surge including wave runup. The design-basis flood levels for the LIP and storm surge events are 44.8 ft and 27.5 ft, respectively. The FSRB is located on elevated ground of 127.1 ft and the FSCB is located in the plant parking lot at elevation 67.1 ft, which are both above the maximum probable flood elevation at the site.

3.6.1.3 High Winds

As described in Section 3.6.1 of this SE, the N FLEX equipment is stored in the FSRB building, which is capable of withstanding the site design-basis high wind conditions (including tornado missiles). The N+1 equipment is stored in the FSCB building, which is high wind protected but not protected against tornado missiles. Therefore, the licensee constructed the FSCB building over 2100 ft from the FSRB to add protection of the N+1 by separation. According to the licensee, this meets the protection guidance for external events identified in NEI 12-06, such as storms with high winds, and tornadoes.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

FLEX equipment (i.e., pumps, DGs, etc.) has been evaluated to be capable of operating in hot weather at an extreme maximum temperature of 110°F. Regarding extreme cold, the licensee stated that an evaluation was conducted to qualify the FLEX portable equipment above -9°F. In addition, the licensee has identified compensatory actions and incorporated into FSGs when the tempaerature is below 10°F. Thus, it is not expected that FLEX equipment and deployment would be affected by high or cold temperatures. The FSRB and FSCB have their own heating and ventilation systems to maintain the temperature within the buidlings between 40°F and 100°F.

3.6.2 Reliability of FLEX Equipment

Section 3.2.2 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an N+1 capability, where "N" is the number of units on site). It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the N+1 could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare.

Based on the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP and during the audit review, the NRC staff concludes that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment for RCS make-up and boration, SFP make-up, and maintaining containment consistent with the N+1 recommendation in Section 3.2.2 of NEI 12-06.

3.6.3 Conclusions

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

3.7 Planned Deployment of FLEX Equipment

The licensee stated in the FIP that pre-determined, preferred haul paths have been identified and documented in the FLEX Support Guidelines (FSGs). Figure 14-1 of the FIP shows the haul paths from the FSRB and FSCB to the various deployment locations. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

3.7.1 Means of Deployment

The deployment of onsite FLEX equipment to implement coping strategies beyond the initial plant capabilities (Phase 1) requires that pathways between the FSRB and FSCB and various deployment locations be clear of debris resulting from seismic, high wind (tornado), or flooding events. The stored FLEX equipment includes tow vehicles, fork lift and Bobcat equipped with front end bucket and rear tow connections to provide a means to move or remove debris from the needed travel paths. In addition, the tow vehicles will be used to deploy the pumps, DGs, boration units and hose trailers.

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

In its FIP, the licensee identified four predetermined, preferred haul paths for Calvert Cliffs, and these haul paths have been reviewed for possible obstructions. However, high winds can cause debris from distant sources to interfere with planned haul paths. Therefore, debris removal equipment is stored inside the FRSB, which protects the equipment from severe storm and high wind hazards such that the equipment remains functional and deployable to clear obstructions from the pathway between the FRSB and its deployment location(s).

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

3.7.2 Deployment Strategies

In its FIP, the licensee stated that the haul paths were reviewed for potential soil liquefaction. The licensee evaluated the primary and alternate routes using original site borings, the extensive borings conducted for the installation of the Independent Spent Fuel Storage Installation (ISFSI) and the associate heavy haul path, and the recent soil borings for the design of the new FSRB. The licensee concluded that the soil liquefaction potential for the primary and alternate deployment paths is considered minimal. The NRC staff reviewed document CA0996, Liquefaction Evaluation for FLEX Travel Paths," to verify the licensee's conclusions and the NRC staff believes that liquefaction should not inhibit the necessary equipment deployment after an earthquake.

For the RCS cooling strategy, the licensee will deploy two FLEX hose manifold trailers and a FLEX booster pump to provide makeup water to the 12-CST. This equipment is deployed to the FLEX setup areas adjacent to the tank farm at the north end of the plant protected area such that suction can be taken from any combination of two tanks in the tank farm, or if needed from well water, or from the Chesapeake Bay.

For RCS makeup, if an installed charging pump is not available, then the FLEX RCS makeup pump is used for RCS makeup and boration. The suction source for the FLEX RCS makeup pump is either unit's RWT. The pumps for each unit are deployed into the protected area to the west road outside of 11 RWT and 21 RWT pump rooms, respectively

For SFP make-up, a FLEX SFP makeup pump will be staged near and take suction from the Chesapeake Bay (either intake or discharge structure).

For the electrical strategy, two 480 Vac DG cable cart trailers and two FLEX 480 Vac DGs are deployed into the protected area with one cable cart trailer and one DG positioned adjacent to the 45 ft. elevation roll-up door at the north end of the common turbine building and the other set adjacent to the 45 ft. elevation roll-up door at the south end.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Section 3.2.2.17 of NEI 12-06 states that the portable pumps for core and SFP functions are expected to have a primary and an alternate connection or delivery point. At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site equipment but the secondary connection point can require reconfiguration if the licensee can show that adequate time and resources are available to support the reconfiguration. In addition, NEI 12-06, Table D-1 states that primary and alternate injection points should establish capability to inject through separate divisions/trains (i.e., should not have both connections in one division/train). The licensee's FIP described the use of 5 portable pumps that connect to existing plant system piping via FLEX connections to support core cooling and inventory control, SFP cooling, and long-term containment cooling.

Core Cooling (SG) Primary and Alternate Connections

Calvert Cliffs has two TDAFW pumps per unit. The licensee's strategy is to use one TDAFW as long as possible and hold the additional TDAFW pump in reserve as a back-up. If both pumps should fail, a portable FLEX AFW pump can provide injection to the SGs. The primary injection connection is on each units' SG cross-connect header which allows injection into both SGs, or separately into each SG. The primary connection point is located in the seismic Category I auxiliary building and connects to existing seismic Category I piping. The connection is protected from all applicable external hazards as defined in Section 3.5 of this SE. The alternate connection is a post-event-installed temporary connection attached at the discharge piping of each unit's motor-driven AFW pump. This connection is in each units' seismic Category I service water pump rooms and connected to existing seismic Category I piping. The connection is protected from applicable hazards as defined in Section 3.5 of this SE, but access to it is through the non-seismic Category I turbine building. The pump can take suction from the FLEX manifold which is connected to the 12-CST, 11-CST, 21-CST, 11-DWST, 11-PWST, 12-PWST, and 11-well. According to the FIP, 11-CST, 21-CST, and 11-DWST have been seismically qualified under the Calvert Cliffs seismic verification program, while 11-PWST, 12-PWST are seismic Category II tanks. However, none of the tanks or connections are tornado missile protected. The connection to the well pumps are protected from tornado-generated missiles but the well system is not seismic Category I. As a last resort, the FLEX AFW pump can take a suction from the discharge of a booster pump drawing from the Chesapeake Bay.

The credited water source for the TDAFW pumps is the 12-CST. In order to run the pumps longer than 10 hours, the licensee has added connections to the tank to allow makeup from the FLEX header or from the booster pump taking suction from the Chesapeake Bay. The licensee can also use a portable pump to take suction from the 12-CST through the FLEX header. The 12-CST connection is stored inside of the 12-CST tornado missile structure and will be installed on existing seismic Category I piping during Phase 2.

RCS Inventory Control Primary and Alternate Connections

The licensee's primary Phase 2 RCS injection strategy is to repower an existing charging pump in lieu of a portable pump. The charging pump uses existing system flow paths and does not require any mechanical connections. The licensee's alternate method is to use a portable pump that takes suction from the RWT and injects into each units' HPSI system. The injection connections are located on existing seismic Category I piping within the seismic Category I portions of the auxiliary build and are protected from all applicable externa hazards as defined in Section 3.5 of this SE. The suction connections to the RWT are located on existing seismic Category I piping within the seismic Category I RWT room and are protected from all applicable external hazards as defined in Section 3.5 of this SE.

Containment Connections

For long-term containment cooling, the licensee plans to inject water into the SW system using an NSRC pump taking suction from the Chesapeake Bay. The Connection to the SW system is located on existing seismic Category I piping within the seismic Category I portion of the intake structure and is protected from all applicable external hazards as defined in Section 3.5 of this SE.

SFP Make-up Primary and Alternate Connections

For SFP cooling, the licensee plans to provide makeup to the SFP via hoses from a portable pump directly into the pool or by connecting the hoses to SFP cooling piping. The connection is located on existing seismic Category I piping within the seismic Category I portions of the auxiliary building and is protected from all applicable external hazards as defined in Section 3.5 of this SE. The pump takes suction directly from the Chesapeake Bay and does not require a mechanical connection to any existing plant equipment.

3.7.3.2 Electrical Connection Points

The Calvert Cliffs primary FLEX strategy for re-powering 480 Vac vital bus circuits during Phase 2 is through the use of pre-installed connections and the deployment of one 480 Vac FLEX DG per unit connected to the Class 1E 480 Vac bus. This strategy utilizes the 500 kW FLEX DG to repower one vital 480 Vac load center on each unit (11B or 21B (A-Train) and 14A or 24A (B-Train)). Bus connection devices (BCDs) are install into the specified FLEX BCD compartment on the selected 480 Vac load centers. Each vital 480 Vac load center has a designated BCD located in a seismic storage box within the same switchgear room as the vital 480 Vac load center. The vital 480 Vac load center designated BCD installation locations are 11B (52-1124), 14A (52-1408), 21B (52-2124) and 24A (52-2403). These load centers provide power to vital 480 Vac reactor MCCs-104R and 114R (Unit 1), and MCCs-204R and 214R (Unit 2). Operators would deploy the portable 500 kW 480 Vac FLEX DGs and their associated cables from the

FSRB to roll-up doors at the north and south end of the common turbine building on the 45 ft. elevation level. The licensee performed phase rotation checks on the portable 500 kW DGs and phase rotation verification with its associated 480 Vac load center.

The Calvert Cliffs alternate FLEX strategy for re-powering 480 Vac vital bus circuits during Phase 2 utilizes the 100 kW FLEX DG to repower vital 480 Vac reactor MCCs 104R on Unit 1 and/or MCC-204R on Unit 2. The A-Train and B-Train reactor MCCs can be connected together via tie breakers (one located on each vital reactor MCC). The vital reactor 480 Vac MCCs 104R and 204R also have a designated BCD located in a seismic storage box mounted on the west wall within the same electrical penetration room as the vital reactor MCC. The vital 480 Vac reactor MCC designated BCD installation locations are 104R (52-10462) and 204R (52-20460). Operators would deploy the 100 kW 480 Vac FLEX DGs and their associated cables from the FSRB to the north and south end of the auxiliary building truck bay roll-up doors on the 45 ft. elevation level. The licensee performed phase rotation checks on the portable 100 kW DGs and phase rotation verification with its associated reactor MCC.

For Phase 3, the licensee will receive four (two per unit) 1-MW 4160 Vac and two (one per unit) 1100 kW 480 Vac CTGs from the NSRC. The two 1-MW 4160 Vac CTGs would be connected to 4160 Vac vital buses 14 (Unit 1) and 21 (Unit 2). The tie-in to the class 1E 4160 Vac buses 14 and 21 are made at manual disconnects located on the output of the 1B and 2A emergency DGs, respectively. The NSRC supplied 4160 Vac CTGs for both units will be staged outside the auxiliary building across the west road near the DG building. The NSRC supplied 480 Vac CTGs will be staged in the vicinity of the portable FLEX 480 Vac DGs, if necessary. Procedure FSG-4, provides direction for ensuring proper phase rotation before attempting to power equipment from the 4160 Vac and 480 Vac CTGs.

3.7.4 Accessibility and Lighting

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

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

In its FIP, the licensee described that the control room has a sufficient level of battery backed lighting to perform all essential tasks for over four hours. In addition, the control room and adjacent plant computer data acquisition rooms have a separate emergency lighting system powered from vital 125 Vdc station battery 22. As stated above, battery 22 has a coping time of 12 hours following load stripping. During an ELAP, when either 480 Vac load center 11B or 21B is energized from a FLEX 500 KW DG, then the associated battery charger for dc bus 22 (battery 22) is placed in service to maintain battery 22 and associated loads.

The licensee performed a station blackout (SBO) analysis, in which includes a list of rooms that might be entered by personnel during an SBO, emergency lighting wattage per room, and drawing references for each lighting circuit. During an ELAP, it assumed that the majority of exterior plant lighting is lost. Therefore, lighting can be provided by miners lights that are available to operators as part of the FLEX strategy with 24 lights stored in the FLEX storage cabinet in the control room annex, and additional lights stored in the FSRB. In addition, portable DG powered light towers provide lighting in the exterior areas where FLEX equipment will be deployed and for safety purposes.

3.7.5 Access to Protected and Vital Areas

During the onsite audit, the licensee stated that contingencies are available to open security doors and gates that rely on electric power to operate opening and/or locking mechanisms. The security force will initiate an access contingency upon loss of power as part of the Security Plan. Access to the owner controlled area, site protected area, and areas within the plant structures will be controlled under this access contingency as implemented by security personnel.

3.7.6 Fueling of FLEX Equipment

For refueling of Phase 2 equipment, the licensee plans to use the diesel fuel oil stored on site in the number 21 fuel oil storage tank (21-FOST). As described in the FIP, 21-FOST is protected from all applicable external events as deifned in Section 3.5 of this SE and contains a usable volume of 107,000 gallons of diesel fuel oil with a technical specification (TS) required minimum volume of 85,000 gallons. The licensee has two 2,800 gallon fuel oil tanker trucks for transporting diesel fuel oil to the FLEX portable equipment. One tanker truck containing ultra-low sulfur diesel fuel oil is stored in the FSRB while the other is stored in the FSCB. During an ELAP, after FLEX equipment is staged, the licensee dispatches one truck into the protected area to provide refueling services, with the other truck in standby. The licensee has installed an air-powered fuel oil transfer pump inside the protected 21-FOST structure to transfer fuel oil from 21-FOST to the fuel oil tanker trucks. The air-powered fuel oil pump receives air from a FLEX diesel-driven air compressor set up outside of the 21-FOST structure.

The fuel stored in 21-FOST is low sulfur diesel fuel oil (as opposed to ultra-low sulfur), which should not be used to fuel Tier 4 (ultra-low sulfur using) equipment, as engine damage may occur. Initially, the licensee will refuel FLEX equipment from a fuel truck filled with ultra-low sulfur fuel oil. When that tanker truck is empty, the licensee will fill the truck with low sulfur fuel from 21-FOST. Once the fuel oil tanker truck is filled with the higher sulfur fuel from 21-FOST, it cannot be used to service the Tier 4 FLEX equipment. At this point, the licensee plans to use the other tanker truck, with ultra-low sulfur fuel still loaded, for servicing Tier 4 equipment. The licensee has an F-350 pickup truck, stored in the FSRB, which has a 100 gallon fuel tank for dispensing ultra-low sulfur diesel oil to small Tier 4 engines as well. In addition, the licensee has a 4,000 gallon fuel oil storage tank located outside of the FSRB, which is used to refuel

FLEX equipment after maintenance. If available, the licensee would use this tank as well to resupply Tier 4 FLEX equipment.

Procedure FSG-5, "Initial Assessment and FLEX Equipment Staging," provides a FLEX equipment fuel cycle, which is derived from the licensee's calculation CA09986, "FLEX Fuel Oil Consumption Rate Analysis," Revision 0, with estimated times to 50% level and empty. The licensee's calculation shows an initial 72-hour fuel consumption of low sulfur fuel of approximately 7,630 gallons, and an ultra-low fuel consumption of approximately 5,234 gallons, which is bounded by the onsite protected fuel supplies of both low and ultra-low fuel.

3.7.7 Conclusions

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

3.8 Considerations in Using Offsite Resources

3.8.1 Calvert Cliffs SAFER Plan

In its FIP, the licensee described that the industry has established two NSRCs to support utilities during BDBEE. Each NSRC holds five sets of equipment, four of which can be fully deployed when requested, the fifth set may have equipment in a maintenance cycle. Equipment is moved from an NSRC to the near site staging area, established by the SAFER team and the utility. Communications are established between the affected nuclear site and the SAFER team and required equipment moved to the site as needed. First arriving equipment, as established during development of the SAFER Response plan, is to be delivered to the site within 24 hours from the initial request. The licensee has signed a contract with SAFER to meet the requirements of NEI 12-06.

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

3.8.2 Staging Areas

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a Primary (Area C) and an Alternate (Area D), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas C and/or D, the SAFER team will transport the Phase 3 equipment to the on-site Staging Area B for interim staging prior to it being transported to the final location in the plant (Staging Area A) for use in Phase 3. For Calvert Cliffs, Staging Area D is the Baltimore-Washington International Airport. Staging Area C is Northern High School in Owings, Maryland. Staging Area B is the site parking lots 1-8, where the FSCB is located on lot 5. Staging Area A is north, west, and south on the 45 ft. elevation terrace surrounding the power block.

Use of helicopters to transport equipment from Staging Area C to Staging Area B is recognized as a potential need within the Calvert Cliffs SAFER Plan and is provided for moving equipment if ground transportation is unavailable or inhibited.

3.8.3 Conclusions

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

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at Calvert Cliffs, ventilation providing cooling to occupied areas and areas containing FLEX strategy 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 BDBEE resulting in an ELAP. The primary concern with regard to ventilation is the heat buildup that occurs with the loss of forced ventilation in areas that continue to have heat loads. The key areas identified for all phases of execution of the FLEX strategy activities are the control room, TDAFW pump room, ADV enclosure area, vital battery rooms, electrical switchgear rooms, cable spreading rooms (CSRs), east/west electrical penetration rooms, and containment. The licensee evaluated these areas to determine the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability and within equipment qualification limits.

The NRC staff reviewed calculation CA08253, "Room Heat Up for FLEX Evaluation (Loss of HVAC): Auxiliary Building, Charging Pump, and TDAFW Rooms," Revision 1, to verify that equipment will not be adversely affected by increases in temperature as a result of loss of HVAC. Procedure FSG-15, "Alignment for Area Cooling," Revision 1, provides guidance for alignment of doors and ventilation access openings to minimize area temperature increases after a loss of ventilation and cooling due to an ELAP event.

TDAFW Pump Rooms

According to CA08253, the temperature limit for the TDAFW pump room is 150°F for the first hour and 140°F for every hour thereafter. The licensee's SBO analysis determines that the TDAFW pump room will reach 137°F at four hours into an SBO. However, this analysis assumed that the double watertight doors to the room would be open and operators could enter the room for short periods of time to control and monitor TDAFW pump performance. During an ELAP, these doors might be closed to prevent flooding. Calculation CA08253 determined that, with the doors closed, the TDAFW room temperature would peak at 148°F in the first hour and then return to under 140°F just after 2 hours and remain under 140°F until 52 hours, at which time the FLEX AFW pump would be available for use, if needed. An action derived from this calculation, to minimize heat load in the room, is for the licensee to make sure that only one TDAFW pump is in operation in the first hour of the ELAP. Procedure FSG-15 directs operators to ensure only one TDAFW pump is in operation for each unit. In addition, personnel are directed to open hatches for the ventilation return paths for the Unit 1 and 2 TDAFW pump rooms by 7.5 hours into the ELAP. When at least one of the reactor MCC buses is powered on a unit, one of the TDAFW pump room exhaust fans can be energized to aid in cooling the TDAFW pump room. If a room exhaust fan is not available, then personnel can open the TDAFW pump room double doors and use a portable blower, powered from a 5500W Pramac portable generator, to exhaust air from the TDAFW pump room into the turbine building.

Auxiliary Building 45 ft. Elevation ADV Enclosure

According to CA08253, the ADV enclosure does not have an equipment acceptance temperature limit. The licensee's calculation determined that the ADV enclosure will peak at 132°F if specific doors are opened within 4 hours of the ELAP initiation. Procedure FSG-15 directs personnel to open these doors consistent with the calculation assumptions.

Unit 1 and 2 Turbine Building 45 ft. Elevation Switchgear Room

According to CA08253, the equipment acceptance temperature limit for the 45 ft. elevation switchgear rooms is 131°F. The licensee's calculation determined that the switchgear room will remain below 96°F if specific doors are opened within 3 hours. Procedure FSG-15 directs personnel to open these doors when the turbine building temperature is less than the 45 ft. elevation switchgear room temperature, or when at least 3 hours have elapsed since initiation of the ELAP.

Unit 1 and 2 Turbine Building 27 ft. Elevation Switchgear Room

According to CA08253, the equipment acceptance temperature limit for the 27 ft. elevation switchgear rooms is 131°F. The licensee's calculation determined that the switchgear room will remain below 100°F if specific doors are opened within 3 hours of ELAP initiation. Procedure FSG-15 directs personnel to open the doors consistent with the analysis assumptions.

Charging Pump Rooms

According to CA08253, the equipment acceptance temperature limit for the charging pump room is 130°F. The licensee's calculation determined that the maximum charging pump room temperature will peak at 103°F if specific doors are opened within 12 hours of the ELAP initiation. If a charging pump is started, FSG-15 directs personnel to open the associated doors within 12 hours of the ELAP initiation, consistent with the analysis.

East/West Electrical Penetration Rooms 45 ft. and 69 ft. Elevations

According to CA08253, the equipment acceptance temperature limit for the electrical penetration rooms is 120°F. For the east and west electrical penetration rooms on the 45 ft. elevation, the calculation determined that the temperature will remain below 102°F and 101°F, respectively, without any mitigating actions being taken. For the west electrical penetration room on the 69 ft. elevation, the calculation determined that the temperature will remain below 113°F if doors are opened and portable fans are supplying outside air within 24 hours of ELAP initiation. Procedure FSG-15 directs personnel to set up two 2000 cubic feet per minute (cfm) blowers on the auxiliary building 69 ft. elevation roof to blow outside air through exhaust trunks into the Unit 1 and Unit 2 west electrical penetration rooms.

Battery Rooms

According to CA08253, the battery rooms do not have an equipment acceptance temperature. However, hydrogen gas is released from the batteries during charging and needs to be removed from the rooms to prevent hydrogen explosions. The licensee's calculation determined that the penetration room will peak at 102°F when specific doors are opened within 4 hours of ELAP initiation. Procedure FSG-15 directs personnel to open these doors accordingly. In addition, FSG-4, "ELAP DC Bus Load Shed and Management," contains instructions to restore battery room ventilation when either reactor MCCs 114R or 204R are energized. The MCC-114R supplies the battery rooms exhaust fan and MCC-204R supplies the battery rooms supply fan. Restoring either of these fans provides both cooling and hydrogen gas removal.

Main Control Room

According to NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, the equipment temperature acceptance limit for the control room is 120°F. The licensee's calculation determined that the expected room temperature will remain below 97°F if the control room access doors are opened and portable fans and/or air conditioning units are provided within 12 hours. Procedure FSG-15 directs the operators to open doors accordingly.

Cable Spreading Room

According to NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, and calculation CA08253, the equipment acceptance temperature limit for the CSR is 120°F. The lciensee's calculation determined that the temperature will remain below 103°F if specific doors are opened within 4 hours. Procedure FSG-15 directs operators to open the CSR and stairwell doors within 4 hours of ELAP initiation.

Containment

See Section 3.4.4.4 of this SE for the NRC staff's evaluation of the licensee's mitigating strategy for maintaining containment temperature to ensure the functionality of required instrumentation and equipment.

3.9.1.2 Loss of Heating

In its FIP, the licensee stated that the FLEX equipment is qualified to temperatures down to -9°F. In addition, the FIP states that any required compensatory actions when below 10°F were identified and incorporated into the FSGs.

Loss of heating to onsite water sources can potentially cause freezing and pipe blockage. During the audit, the staff asked the licensee to provide information about the loss of heating on water sources. The licensee provided a discussion on the effects of the loss of heating on each credited water source.

Ultimate Heat Sink (Chesapeake Bay)

The licensee stated that the Chesapeake Bay last experienced area-wide freezing during the winter of 1976-1977 when, for a 3-week period, large portions of the Chesapeake Bay were frozen over. As discussed in the FIP, the initial location to draw water is the manway access to the discharge outfall, where plant discharge water would be at elevated temperatures due to the heat loads generated by the plant. The second location is the intake structure. If site conditions drop below 35°F, plant operators backflow circulating water system flow per abnormal operating procedure (AOP)-7L, "Circulating Water I Intake Malfunctions." Backflow of the circulating water system results in twice heated water flowing into the intake structure, significantly reducing the buildup of ice in the intake structure. Although the backflow would not continue in ELAP conditions, the initially warmer water would limit the formation of ice.

12-CST

The 12-CST does not have heating. However, short sections of exposed AFW suction line inside the enclosure building are insulated and heat traced. During TDAFW pump operation, part of the pump discharge is recirculated back to 12-CST. This return flow to the tank will provide some amount of mixing action to prevent the stored water from freezing and the formation of significant surface ice. The TDAFW suction line is heat traced and insulated. The licensee stated that the heat loss rate at the lowest ambient air temperature with the insulation fully intact is insufficient to result in freezing the suction line located above ground. High winds could have some effect on heat loss through the 12-CST concrete structure entrance ways but the concrete structure limits air exchange and cooling of the AFW lines that are no longer warmed by heat tracing.

11-PWST and 12-PWST

The 11-PWST and 12-PTWST are each provided heating by a closed loop heating circuit consisting of a small recirculation pump and a small heat exchanger that uses plant heating system steam as the heating source. This heating loop is in service during cold weather months to maintain PWST water temperature greater than 40°F. The licensee maintains the PWST water temperature at approximately 70°F when the heating system is in service. At the onset of an ELAP, the PWST recirculation pump will lose power, and the source of plant heating steam from the reheat steam system will be lost. Each PWST contains approximately 500,000 gallons of water. The licensee stated that it would take greater than 72 hours for this volume to cool to less than 40°F, and that significant surface icing is not expected.

Other Water Storage Tanks

The 11-CST, 21-CST, 11-DWST, and 11-well are considered available if they survive the external event, but are not required. If these sources are unavailable, cooling water will be drawn from the UHS (Chesapeake Bay).

Boric Acid Storage Tanks (BAST)

The BASTs are located on the 5 ft. elevation of the auxiliary building. The licensee stated that the auxiliary building ambient air temperature is room dependent but ranges from 75°F to 85°F during cold weather months and that with ventilation secured, the thermal mass from the BASTs and CVCS maintain room temperatures above freezing beyond 72 hours.

In addition to the loss of ventilation, there will be a loss of power to the heat trace circuits. Calvert Cliffs' mitigation strategy for core inventory restoration is planned to begin between 10-12 hours into the ELAP. Once a vital 480 Vac Load center is recovered by a FLEX portable DG, personnel will start a charging pump, taking direct suction from the BAST, to begin restoring RCS inventory. The charging pump to BAST direct suction pipe has jacketed insulation. The licensee stated that the conservative initial condition will be the heat trace temperature controller has turned off and temperature is drifting down to the controller ON set point of 150°F at the time of ELAP. The licensee stated that based on a 7% solution of boric acid, it will take approximately 5 hours for the boric acid solution in the suction line to reach 115°F and begin to precipitate out of solution, but that there is insufficient boric acid in solution to cause suction line blockage.

RWTs 11 and 21

The RWTs are provided with heating by a closed loop heating circuit consisting of a small recirculation pump and a small heat exchanger that uses plant heating system steam as the heating source. This heating loop is in service during cold weather months to maintain RWT water temperature between 40°F (TS minimum temperature) and 100°F (TS maximum temperature). Under normal conditions, the licensee maintains the RWT water temperature 70°F to 80 °F when the heating system is in service. At the onset of an ELAP, the RWT recirculation pump will lose power and the source of heating steam. The licensee stated that at TS minimum level each RWT contains 400,000 gallons of water containing a TS boron concentration of 2,300-2,700 ppm boron. The licensee determined that it would take greater than 72 hours for this volume to cool to less than 40°F and that significant surface icing is not expected.

Auxiliary Building

The ambient air temperature in the auxiliary building is room dependent, but ranges from 75°F-85°F during cold weather months with ventilation running. The licensee stated that with the loss of ventilation during an ELAP the heat loads within vital rooms would keep ambient temperatures above freezing for greater than 72 hours.

3.9.1.3 <u>Hydrogen Gas Control in Vital Battery Rooms</u>

As discussed above in Section 3.9.1.1, an additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. The NRC staff reviewed calculation, CA08253, to verify that hydrogen gas accumulation in the 125 Vdc vital battery rooms will not reach combustible levels while HVAC is lost during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. In order to prevent a buildup of hydrogen in the battery rooms, the licensee's procedure FSG-15 provides directions to open specific doors within four hours of the initiation of the ELAP event. Procedure FSG-4, provides direction to restore battery room ventilation when either reactor MCCs 114R or 204R are energized from the portable 480 Vac FLEX DGs. The MCC-114R supplies the battery rooms exhaust fan and MCC-204R supplies the battery rooms supply fan. Restoring either of these fans provides both cooling and hydrogen gas removal.

Based on its review of the licensee's calculation and battery room ventilation strategy, the NRC staff concludes that hydrogen accumulation in the vital battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP as a result of a BDBEE.

3.9.2 Personnel Habitability

During an ELAP event at Calvert Cliffs, ventilation providing cooling to occupied areas will be lost. Calculation CA08253, "Room Heat Up for FLEX Evaluation (Loss of HVAC), Auxiliary Building, Charging Pump, and TDAFWP Rooms," Revision 1, evaluates the temperature response of auxiliary and turbine building areas during an ELAP. The licensee evaluated key areas identified for all phases of execution of the FLEX strategy activities to determine the temperature profiles during an ELAP event. The conclusions of calculation CA08253 resulted in actions that the licensee included in FSG-15, "Alignment for Area Cooling," to minimize temperature increases due to the loss of ventilation and maintain areas acceptable for personnel entry and continued equipment operation.

Calculation CA08253 provides a table with recommended stay times at different wet bulb globe temperatures (WBGT) for moderate work. Temperatures below 82°F WBGT are considered appropriate for continuous stay times and are coded as the color green. Temperatures greater than 82°F WBGT but less than 120°F WBGT are considered limited stay times, may have recommended personal protective equipment (PPSE) requirements, and are coded as the color yellow. Temperatures over 120°F WBGT are considered extremely limited stay times, require PPE to be worn, and are coded as the color red.

3.9.2.1 Main Control Room

Calculation CA08253 determined that the main control room will reach a maximum of 97 °F WBGT at 53 hours following an ELAP initiation. Procedure FSG- 5 directs personnel to open specific doors at 12 hours and initiate cooling with a portable fan and/or air conditioning unit. Calculation CA08253 estimates the WBGT at 12 hours to be 88°F.

3.9.2.2 Spent Fuel Pool Area

The staff reviewed the licensee's calculation of SFP area heat loads. This calculation indicates that boiling begins at approximately 10.1 hours following the loss of power. The licensee's FIP states that hose alignments on the auxiliary building 69 ft. elevation (SFP area) are performed early in the event to minimize personnel entering the area during a high heat and humidity conditions which occur in later phases. However, the staff noted that the licensee's sequence of events timeline in its FIP does not indicate that operators will deploy hoses and spray nozzles as a contingency for SFP makeup. The licensee stated that personnel arriving onsite after the first six hours would be utilized for SFP hose deployments in the SFP area. Calculation CA08253 determined that the SFP area will reach a maximum WBGT of 184°F at 54 hours following an ELAP initiation if specific doors are opened. Procedure FSG-15 directs personnel to open each applicable door within its required time. The highest WBGT during a required action is 139°F at 24 hours. However, several required actions take place in temperatures over 120°F and PPE should be worn.

3.9.2.3 Other Plant Areas

Truck Bay 45 ft. Elevation

Calculation CA08253 determined that the truck bay maximum WBGT peaks at 102°F 4 hours after ELAP initiation with specific doors opened. FSG-15 directs personnel to open each applicable door within its required time.

Unit 1 and 2 Turbine Building Switchgear Room 45 ft. Elevation

Calculation CA08253 determined that the switchgear room maximum WBGT peaks at 96°F 3 hours after ELAP initiation with specific doors opened. Procedure FSG-15 directs personnel to open each applicable door within its required time.

Unit 1 and 2 Turbine Building Switchgear Room 27 ft. Elevation

Calculation CA08253 determined that the switchgear room maximum WBGT peaks at 100 F 1 hour after ELAP initiation with specific doors opened. Procedure FSG- 15 directs personnel to open each applicable door within its required time.

ADV Enclosure

Calculation CA08253 determined that the ADV enclosure maximum WBGT peaks at 113°F 4 hours after ELAP initiation with specific doors opened. Procedure FSG-15 directs personnel to open each applicable door within its required time.

Charging Pump Rooms

Calculation CA08253 determined that the charging pump room maximum WBGT peaks at 103°F 71 hours after ELAP initiation with specific doors opened. Procedure FSG-15 directs personnel to open the applicable door within its required time, if a charging pump is started.

Mechanical Equipment Room Auxiliary Building 5 ft. Elevation

Calculation CA08253 determined that the equipment room maximum WBGT peaks at 124°F 72 hours after ELAP initiation when fan rooms are activated and return paths from TDAW pump rooms are opened in support of TDAFW pump room cooling at 7.5 hours. Procedure FSG-15 directs personnel to start fans and open applicable hatches within the required time. Calculation CA08523 estimates the WBGT at the time of required action to be 98°F.

Battery Rooms

Calculation CA08253 determined that the battery room maximum WBGT peaks at 102°F 30 hours after ELAP initiation with specific doors opened. Procedure FSG-15 directs personnel to open the applicable doors within its required time. Calculation CA08523 estimates the WBGT at the time of required action to be 72°F.

Cable Spreading Rooms

Calculation CA08253 determined that the cable spreading room maximum WBGT peaks at 103°F 54 hours after ELAP initiation with specific doors opened. Procedure FSG-15 directs personnel to open the applicable doors within its required time. Calculation CA08523 estimates the WBGT at the time of required action to be 88°F.

Unit 1 and Unit 2 West Electrical Penetration Rooms 69 ft. Elevation

Calculation CA08253 determined that the penetration room maximum WBGT peaks at 113°F 24 hours after ELAP initiation with specific doors opened. Procedure FSG-15 directs personnel to open the applicable doors and establish forced cooling within the required time.

3.9.3 Conclusions

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

3.10 Water Sources

Condition 3 of NEI 12-06, Section 3.2.1.3, states that cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles are available. The staff reviewed the licensee's planned water sources to verify that each water source is robust as defined in NEI 12-06.

3.10.1 Steam Generator Make-Up

Phase 1

For Phase 1 core cooling, the TDAFW pump draws suction from the 12-CST and discharges to the SGs. As described in Section 10.3.2 of the UFSAR and the licensee's FIP, the 12-CST is a seismic Category I structure and is protected from tornado winds and applicable tornado-generated missiles. In addition, Section 10.3.2 of the UFSAR states that the AFW pump suction piping, header, and associated valves connected to the 12-CST are seismic Category I components located in tornado wind and tornado-generated missile protected seismic Category I structures. Based on the design and location of the 12-CST, and associated AFW piping and valves, this water source should be available to support Phase 1 core cooling during an ELAP, as described in the licensee's FIP.

Phase 2

The licensee plans to provide makeup water to the 12-CST via portable FLEX pumps from any combination of two tanks 11-CST, 21-CST, 11-DWST, 11-PWST, 12-PWST, or the 11-well, or the Chesapeake Bay. As a backup to the TDAFW pumps, the licensee will use portable FLEX AFW pumps to provide water to the SGs using the same water sources.

As described in the licensee's FIP, the 11-CST, 21-CST, and 11-DWST were seismically qualified under the licensee's seismic verification program structures, while the 11-PWST and 12-PWST are only seismic Category II structures. None of the tanks used to provide makeup water to the 12-CST in Phase 2 are protected against tornado-generated missiles. The licensee has made modifications to protect the 11-well from tornado winds and tornado-generated missiles, but the well is not seismically qualified. The licensee plans to prioritize each water source based on quality and availability. As a last resort, if no other water sources are available, the licensee will draw water from the Chesapeake Bay. The Chesapeake Bay is a natural body of water that is not subject to seismically induced dam failures. In addition, the licensee can use multiple locations to draw water from the bay depending on the level and environmental conditions. Based on the design and quantity of the tanks on site and the availability of the Chesapeake Bay as an unlimited water source, the licensee should have a sufficient water source available to support Phase 2 core cooling during an ELAP, as described in the licensee's FIP.

Phase 3

For Phase 3 core cooling and RCS inventory control, the licensee will use the NSRC equipment to supplement the onsite portable equipment, as necessary, using the same water sources discussed above for Phases I and 2.

3.10.2 Reactor Coolant System Make-Up

Phase 1

As discussed in the licensee's FIP, RCS inventory is conserved by initiating an early RCS cooldown. As a result, the licensee does not credit any existing plant water sources for direct injection into the RCS during Phase 1.

Phase 2

For Phase 2 RCS inventory control, the licensee relies on the existing SITs, BASTs, and RWTs to provide borated water makeup to each units respective RCS.

At the onset of Phase 2, the licensee relies on the existing SITs to provide passive injection into the RCS. Section 5A.2.1.2 of the UFSAR lists the SITs and associated piping as seismic Category I components. The SITs are located in the seismic Category I containment structure and are protected from all applicable external hazards as defined in Section 3.5 of this SE.

After the depletion of the SITs, the licensee uses one of two repowered charging pumps, part of the CVCS, on each unit, to provide borated water to each units respective RCS through existing CVCS piping. The charging pumps can take a suction from each units respective BASTs, which are part of the CVCS, or the RWT. Section 5A2.1.2 of the UFSAR lists the CVCS as a seismic Category I system and the RWT as a seismic Category I component. The BASTs are located in the seismic Category I portion of the auxiliary building and are protected from all applicable external hazards as defined in Section 3.5 of this SE. Even though the RWTs are seismic

Category I components, the tanks are not fully protected from tornado-generated missiles. During the audit, the staff asked the licensee to provide information on the survivability of the RWT. The licensee stated that the seismic Category I RWT room and containment structure do provide some protection against tornado-generated missiles and the RWT has a 36-in high vehicle barrier around the tank. In addition, the licensee stated that if the portion of the tank above 36-inches was damaged, the lower portion would still contain over 18,000 gallons of borated water, which would support RCS injection for greater than 72 hours.

Phase 3

For Phase 3 RCS makeup, if needed, the licensee would use a boric acid mixing tank supplied from the NSRC. The licensee would use any available water source discussed in Phase 2 to provide water to the batching tank. If the licensee needs to use the Chesapeake Bay, water would be treated with an NSRC supplied water treatment system.

3.10.3 Spent Fuel Pool Make-Up

For SFP cooling, the licensee plans to provide makeup water from the Chesapeake Bay.

3.10.4 Containment Cooling

For containment cooling, the licensee plans to repower the service water system and CAC. The licensee will provide water from the Chesapeake Bay to the SW system to provide cooling water to the service water heat exchangers which provide the cooling medium for the CAC.

3.10.5 Conclusions

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

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven TDAFW 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 76 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the TDAFW pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300°F), another strategy must be used for decay heat removal. The NRC-endorsed strategy is described in NEI 12-06. Section 3.2.3 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. In its FIP, the licensee provided a summary of procedures that incorporates this guidance. During the audit process, the NRC staff observed that the licensee had made progress in implementing this guidance.

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

3.12 Procedures and Training

3.12.1 Procedures

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

FLEX strategy support guidelines have been developed in accordance with PWROG guidelines. FSGs will provide available, preplanned FLEX strategies for accomplishing specific tasks in the EOPs or AOPs. The FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. Procedural interfaces have been incorporated into EOP-7, "Station Blackout," to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, procedural interfaces have been incorporated into AOP-3B, "Abnormal Shutdown Cooling Conditions," to include appropriate reference to FSGs.

The licensee also stated in the FIP that changes to FSGs are controlled by Exelon fleet procedure AD-AA-101, "Processing of Procedures and T&RMs." The FSG changes will be reviewed and validated by the involved groups to the extent necessary to ensure the strategy remains feasible. Validation for existing FSGs has been accomplished in accordance with the guidelines provided in NEI APC14-17, "FLEX Validation Process," issued July 18, 2014.

3.12.2 Training

In its FIP, the licensee stated that Calvert Cliffs nuclear training program has been revised to assure response leaders proficiency on beyond-design-basis emergency response strategies and implementing guidelines. In addition, personnel assigned to the direct execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, instructions, and mitigating strategy time constraints. The training plan development was done in accordance with Calvert Cliffs' procedures using the Systematic Approach to Training (SAT) process.

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

3.13 Maintenance and Testing of FLEX Equipment

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

In its FIP, the licensee stated that Calvert Cliffs followed the EPRI generic industry guidance program for maintenance and testing of FLEX equipment or manufacturer provided information/recommendations, equipment testing, and the unavailability of equipment. The licensee states in its FIP, that preventive maintenance procedures and intervals have been established to ensure FLEX equipment is reliably maintained per manufacturer recommendations. The EPRI Templates are used for equipment where applicable. However, in those cases where EPRI templates were not available, preventative maintenance actions were developed based on manufacturer provided information/recommendations and Exelon fleet procedure ER-AA-200, "Preventive Maintenance Program."

The NRC staff concludes that the licensee appears to have 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 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 (ADAMS Accession No. ML13066A172), supplemented by letter dated March 8, 2013 (ADAMS Accession No. ML13073A155), the licensee submitted its OIP for Calvert Cliffs in response to Order EA-12-051. By letter dated June 19, 2013 (ADAMS Accession No. ML13164A393), the NRC staff sent an RAI to the licensee. The licensee provided a response by letter dated July 3, 2013 (ADAMS Accession No. ML13190A017). By letter dated November 15, 2013 (ADAMS Accession No. ML13281A205), the NRC staff issued an ISE and RAI to the licensee. By letter dated February 20, 2015 (ADAMS Accession No. ML14302A174), the NRC issued an audit report on the licensee's progress.

By letters dated August 27, 2013 (ADAMS Accession No. ML13254A279), February 24, 2014 (ADAMS Accession No. ML14069A180), August 26, 2014 (ADAMS Accession No. ML14241A017), and February 20, 2015 (ADAMS Accession No. ML15057A045), the licensee submitted status reports for the Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable 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 April 30, 2015 (ADAMS Accession No. ML15120A277), the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFP level instrumentation system designed by Areva. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on October 9, 2014 (ADAMS Accession No. ML14241A454).

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051. The scope of the audit included verification of (a) site's seismic and environmental conditions enveloped by the equipment qualifications, (b) equipment installation met the requirements and vendor's recommendations, and (c) program features met the requirements. By letter dated February 20, 2015 (ADAMS Accession No. ML14302A174), the NRC issued an audit report on the licensee's progress. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

The licensee identified the levels in its OIP; Level 1 is 65'-8.5", Level 2 is 50'-2" and Level 3 is 45'-2". The staff verified the NPSH calculation dated May 30, 2014 confirming the bottom of the weir at 65'-8.5" is the higher of the two points for Level 1. The staff determined that Level 2 provided adequate shielding during the ISE review, noting that a dose of 100mrem/hr is acceptable and the licensee performed calculations in accordance with EPA-400. Level 3 was confirmed via the supplied sketch (July 3, 2013, letter) to be above the fuel racks.

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

4.2 Evaluation of Design Features

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

4.2.1 Design Features: Instruments

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

> Primary and backup instrument channels will consist of fixed components. The primary and backup instrument channel level sensing components will be located and permanently mounted in the SFP. Measured range will be continuous from the high SFP alarm elevation 67'-2.75" plus the accuracy of the SFP water level instrument channel to the top of the spent fuel racks at elevation 45'-2" minus the accuracy of the SFP water level instrument channel.
>
> Primary instrument channel level sensing components will be located in the northeast corner of Unit 1 SFP (No. 11). Backup instrument channel level sensing components will be located in the southwest corner of Unit 2 SFP (No. 21).

The staff noted in its ISE that the configuration meets the guidance when the gate is not installed. In its letter dated August 26, 2014, the licensee stated, in part, that the divider is not installed under normal operating conditions including refueling operations and would only be installed under severe accident conditions, such as a leak in the pool. A sketch included in the August 26, 2014, letter confirms the instrument span covers the full range from normal operating level to the top of the fuel racks including Levels 1-3.

During the onsite audit, the staff reviewed CENG drawing 61-706-E/C-206, Revision 18, and confirmed the bottom of the gate opening is at elevation 42'-8". Level three is at elevation 45'-2" and above the bottom of the gate. The gate will not interfere with level indication over the full indicated range, consistent with the guidance.

Based on the evaluation above, the NRC staff concludes 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 appears to adequately address the requirements of the order.

4.2.2 Design Features: Arrangement

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

> Primary instrument channel level sensing components will be located in the northeast corner of Unit 1 SFP (No. 11). Backup instrument channel level sensing components will be located in the southwest corner of Unit 2 SFP (No. 21).

In its letter dated August 26, 2014, the licensee provided a sketch depicting the sensor and display locations. During the onsite audit, the NRC staff observed the installed configuration, confirming the supplied sketch. The NRC staff noted during the audit that channel separation was maximized in the SFP area and met the channel separation criteria in NEI 12-02.

The NRC staff noted that there appears to be sufficient channel separation within the SFP area between the primary and back-up level instruments, sensor electronics, and routing cables to provide reasonable protection against loss of indication of SFP level due to missiles that may result from damage to the structure over the SFP.

Based on the discussion above, the NRC staff concludes that, 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 appears to adequately address the requirements of the order.

4.2.3 Design Features: Mounting

The Areva design is a through air radar using a horn above the pool surface and a waveguide from the horn to the sensor device mounted outside the SFP area. A separate display unit is mounted in an alternate location and electrically connected to the sensor device. The horn mounting is a cantilever design mounted at the pool edge. Qualification testing was reviewed during the Areva vendor audit documented in letter dated October 9, 2014.

In its letter August 26, 2014, the licensee provided detailed responses in RAI 4 and 5 detailing seismic qualification including hydrodynamic (sloshing) analysis. All components except the Areva designed horn mounting bracket are seismic Category I mounting.

During the onsite audit, the NRC staff reviewed the following documents to confirm the structural integrity and confirm compliance with seismic requirements:

- Areva Document 32-9218253-001, "Horn Support Qualification for CCNP"
- CENG calculation CA08171, "Sloshing Analysis"
- CENG calculation 11865-5502, Attachment H, "Response Spectra Plots Aux Building, 45' & 69' Elevation Aux Bldg Accelerations"

The staff concluded that the Areva design, as installed by the licensee, met the criteria of NEI 12-02.

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

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

Appendix A-1 of the guidance in NEI 12 02 describes a quality assurance process for non-safety systems and equipment that are not already covered by existing quality assurance requirements. In JLD-ISG-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.

By letter dated February 28, 2013, the licensee stated that instrument channel reliability shall be established by use of an augmented quality assurance process similar to that described in NEI 12-02.

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

4.2.4.2 Instrument Channel Reliability

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

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

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

The NRC staff reviewed vendor qualification testing and results during the vendor audit which is documented in letter dated October 9, 2014. The Calvert Cliffs configuration has just the horns and waveguides in the SFP area. These components contain no electronics devices. The sensor electronics are seismic Category I mounted to concrete walls outside the SFP area on a lower elevation than the pool deck. The display electronics are seismic Category I mounted to concrete walls near each of the control rooms.

During the onsite audit, the staff reviewed CENG calculation CA07918, Revision 0, and confirmed the anticipated radiological conditions for each installed location of the elctronics units is less than 1E3 Rad. The staff notes that the passive horn and waveguide devices in the SFP area contain no active components and their performance are not susceptible to the anticipated radiological conditions. Sheilding provided by the concrete walls for the electronic components outside the SFP area limited exposure to less than 1 E3 RAD. By letter dated August 26, 2014, the licensee provided a summary of the analysis in the RAI 6 response.

Temperature and humidity conditions in the pool area, per NEI 12-02, are assumed to be 212°F condensing. Areva testing confirms temperature does not impact the performance of the passive horn and waveguide. The condensing steam conditions, however, may have minor impact on the instrument accuracy, but as determined in the vendor audit, the impact is less than the accuracy criteria in NEI 12-02.

During the audit, the NRC staff reviewed CENG calculation CA08114, Revision 0, and confirmed the anticipated temperature and humidity conditions for each installed location of the elctronic units are 135°F and 40 percent RH and within the operating characteristics determined by Areva testing. The licensee also provided a response to RAI 7 by letter dated August 26, 2014, that stated maximum conditions for beyond-design-basis conditions are as high as 120°F. The RAI also clarified the continuous duty rating is 176°F for the sensor, 158°F for the indicator and 149°F for the power control panel.

Seismic qualification was discussed in Section 4.2.3 above.

Based on walkdown of the installed instruments during the onsite audit, the NRC concluded that the as-installed configuration appears to be consistent with the guidance for shock and vibration.

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

4.2.5 Design Features: Independence

The NRC staff confirmed during the onsite audit that the primary and backup channels are physically and electrically isolated. To verify electrical isolation, the staff confimed the channels were powered by two different independent busses.

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

4.2.6 Design Features: Power Supplies

The NRC staff confirmed the independent power sources during the onsite audit. Further, in its letter dated August 26, 2014, the licensee provided detailed information on the power sources in its response to RAI 14.

Battery backup capabilities were confirmed during the vendor audit. Further, in its letter dated August 26, 2014, the licensee provided detailed information on the battery backup capability in its response to RAI 15.

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

4.2.7 Design Features: Accuracy

The NRC staff reviewed the instrument accuracy during the vendor audit and confirmed that it met the criteria in NEI 12-02.

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

4.2.8 Design Features: Testing

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

> Instrument channel design will provide for routine testing and calibration that can be performed in-situ consistent with Order EA-12-051 and the guidance in NEI 12-02. Details will be determined during the engineering and design phase. Additional testing and calibration information is provided in Section XV of this plan.

In its letter dated July 3, 2013, the licensee stated, in part, that:

> Calibration of the SFP level system is performed in-situ. Channel check and calibration tolerances will be developed as part of the detailed design and incorporated into station maintenance procedures. The final calibration methodology will be available upon completion of the final design. It will be forwarded to the NRC on February 28, 2014 with the second CCNPP Overall Integrated Plan status update.

Further, in its letter dated July 3, 2013, the licensee stated, in part, that:

> Multi-point testing is enabled by means of a radar horn antenna capable of being rotated away from the SFP water surface and aimed at a movable metal target that is positioned at known distances from the horn. This allows checking for correct readings of all indicators along a measurement range and validates the functionality of the installed system.

In its letter dated July 3, 2013, the licensee also explained that the instrument channels will have indicators to allow operators to compare the level indicated against other SFP level instrumentation currently installed. According to the licensee, with this information and the maximum level allowed deviation for the instrument channel design accuracy, the operators could determine if recalibration or troubleshooting is needed.

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

4.2.9 Design Features: Display

In its OIP, the licensee stated that the credited SFP water level indication will be provided in the common control room. The licensee also explained how the control room met the characteristics identified in NEI 12-02 for an accessible location.

Based on the evaluation above, 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 appears to adequately address the requirements of the order.

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the SFP 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 SFP instrumentation.

4.3.1 Programmatic Controls: Training

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

> The Systematic Approach to Training (SAT) will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service.

Based on the evaluation above, the NRC staff concludes 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 appears to adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its letter dated August 26, 2014, the licensee stated, in part, in response to RAI 17:

> The following procedures are either in development or will be developed in support of the RSFPI system:
>
> - 01-24D, "Spent Fuel Pool Cooling - Infrequent Operations Normal startup and shutdown procedure for the system"
> - 01-27D, "Station Power 480 Volt System – Notes added for the power panels"
> - AOP-6F, "Spent Fuel Pool Cooling System Malfunctions - Sustained Loss of SFP Cooling"

- AOP-71, "Loss of 4KV, 480 Volt or 208/120 Volt Instrument Bus Power - Loss of instrument power for the existing narrow range level indicators will point to the use of the new wide range level"

- ERPIP-612, "Candidate High Level Actions SFP Fuel Uncovered (our existing SFP SAMG) -Use of the new level indicators for wide range level monitoring will be added"

- FSG-11, "Alternate SFP Makeup and Cooling," use of the new level indicators for wide range level monitoring will be included in this FSG.

- SFP Wide Range Level Monitoring Instrumentation Maintenance Procedure

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

4.3.3 Programmatic Controls: Testing and Calibration

The NRC staff reviewed the licensee's OIP information and July 3, 2013, RAI response associated with testing and concluded that the response appeared to be acceptable except for compensatory actions, RAI 18 and in-situ testing, RAI 19.

In its letter dated August 26, 2014, the licensee provided in its response to RAI 18 detailed information on the compensatory actions. The NRC staff reviewed the compensatory actions and concluded that they appear to meet the criteria in NEI 12-02.

In addition, insitu testing was reviewed as part of the vendor audit and determined to be acceptable. The vendor uses an articulating horn that can be moved to point at a fixed target of known distance to verify accuracy. In its letter dated August 26, 2014, in its response to RAI 19, the licensee provided a similar description for in-situ testing at Calvert Cliffs.

Based on the evaluation above, the NRC staff concludes 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 appears to adequately address the requirements of the order.

4.4 Conclusions for Order EA-12-051

In its letter dated April 30, 2015, the licensee stated that they would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed, by JLD-ISG-2012-03. In the evaluation above, the NRC staff concludes that, if implemented appropriately, the licensee has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at Calvert Cliffs according to the licensee's proposed design, it appears to adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013, the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit in September 2014 (ADAMS Accession No. ML14302A174). By letter dated May 4, 2016 (ADAMS Accession No. ML16131A638), the licensee notified the NRC that Calvert Cliffs reached its final compliance date, and has declared that both of the reactors are in compliance with the orders. The purpose of this SE is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that if implemented appropriately should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

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Date: September 29, 2016

By letter dated February 28, 2013 (ADAMS Accession No. ML13066A172), the licensee submitted its OIP for Calvert Cliffs in response to Order EA-12-051. The licensee submitted a supplement on March 8, 2013 (ADAMS Accession No. ML13073A155). At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the Order, and are listed in the attached safety evaluation. By letters dated September 25, 2013 (ADAMS Accession No. ML13267A285), and February 20, 2015 (ADAMS Accession No. ML14302A174), the NRC staff issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated April 30, 2015 (ADAMS Accession No. ML15120A277), 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.

The enclosed safety evaluation provides the results of the NRC staff's review of Exelon's strategies for Calvert Cliffs. 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 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML15257A188). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

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

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

Docket Nos.: 50-317 and 50-318
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ADAMS Accession No. ML16258A446 **via email**

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