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

December 23, 2015

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

SUBJECT: CLINTON POWER STATION, UNIT NO. 1 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (TAC NOS. MF0791 AND MF0901)

Dear Mr. Hanson:

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

By letter dated February 28, 2013 (ADAMS Accession No. ML13064A274), Exelon Generation Company. LLC (Exelon, the licensee) submitted its OIP for Clinton Power Station, Unit No. 1 (Clinton) in response to Order EA-12-049. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the attached safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated December 17, 2013 (ADAMS Accession No. ML13225A571), and April 27, 2015 (ADAMS Accession No. ML15100A051), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated July 15, 2015 (ADAMS Accession No. ML15198A115), Exelon submitted a compliance letter and Final Integrated Plan in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049. By letter dated December 14, 2015, Exelon submitted a revision to the Final Integrated Plan (ADAMS Accession No. ML15349A911).

By letter dated February 28, 2013 (ADAMS Accession No. ML13059A306), Exelon submitted its OIP for Clinton in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the attached safety evaluation. By letters dated November 15, 2013 (ADAMS Accession No. ML13280A326), and April 27, 2015 (ADAMS Accession No. ML15100A051), 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 July 15, 2015 (ADAMS Accession No. ML15198A113), Exelon submitted its 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 Clinton. The intent of the safety evaluation is to inform Exelon on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

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

Sincerely,

Mandy K Halter

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

Docket No.: 50-461

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

EXELON GENERATION COMPANY, LLC

CLINTON POWER STATION, UNIT NO. 1

DOCKET NO. 50-461

1.0 INTRODUCTION

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

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

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

2.0 REGULATORY EVALUATION

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

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

2.1 Order EA-12-049

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

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

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

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

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

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

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

2.2 Order EA-12-051

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

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

from missiles provided by existing recesses and corners in the spent fuel pool structure.

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

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

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

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

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

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

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

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

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

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

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

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 28, 2013 [Reference 10], Exelon Generation Company, LLC (Exelon, the licensee) submitted its Overall Integrated Plan (OIP) for Clinton Power Station, Unit No. 1 (Clinton) in response to Order EA-12-049. By letters dated August 28, 2013 [Reference 11], February 28, 2014 [Reference 12], August 28, 2014 [reference 13] and February 27, 2015 [Reference 14], the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML082900195). By letters dated December 17, 2013 [Reference 16], and April 27, 2015 [Reference 17], the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated July 15, 2015 [Reference 18], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP). By letter dated December 14, 2015 [Reference 64], Exelon submitted a revision to the Final Integrated Plan.

3.1 Overall Mitigation Strategy

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

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

1. The reactor is assumed to have safely 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.

Clinton is a General Electric boiling-water reactor (BWR) Model 6 with a Mark III containment. The FIP describes the licensee's three-phase approach to mitigate a postulated ELAP event. The approach is somewhat different if the plant receives warning of a pending flood, but the initial actions are similar.

At the onset of an ELAP, the reactor trips and the main condenser is unavailable due to the loss of circulating water. Decay heat is removed when the safety relief valves (SRVs) open on high pressure and dump steam from the reactor pressure vessel (RPV) to the suppression pool. Because Clinton's reactor core isolation cooling (RCIC) storage tank is not robust, the licensee's mitigating strategy assumes that makeup to the RPV is provided by the RCIC turbine-driven pump taking suction from the suppression pool. The operators will perform a gradual cooldown of the reactor vessel using the SRVs, and following the cooldown RPV pressure will be controlled between approximately 150 to 250 pounds per square inch gage (psig) to ensure sufficient steam pressure for continued RCIC operation. The RPV makeup will continue to be provided from RCIC until the gradual reduction in RPV pressure resulting from diminishing decay heat requires a transition to Phase 2 methods. The RCIC injection source will be maintained for as long as possible, since it is a closed loop system using relatively clean suppression pool water.

When the RCIC system is no longer available, the preferred RPV makeup supply in Phase 2 comes from the suppression pool cooling system using a suppression pool cleanup and transfer (SF) pump. This flowpath involves a hose-connection to residual heat removal (RHR) system piping, and injection to the RPV ultimately occurs via one of the low pressure coolant injection (LPCI) valves. Both SF pumps and the LPCI injection valve are repowered by the FLEX diesel generator (DG). The SF pump will take suction from the suppression pool. If RPV makeup from the ultimate heat sink (UHS) becomes necessary, external connections installed on the low pressure core spray (LPCS) and RHR-C injection headers enable a hose connected from the FLEX manifold located in the Diesel Generator Building to supply RPV makeup. The manifold is supplied from the diesel-driven FLEX pump staged in the FLEX storage building (FSB) taking suction from the UHS. The UHS is a submerged pond in Lake Clinton. A submerged dam in the lake will retain the UHS in the event of a failure of the lake's main dam. The bottom of the UHS is at 668.5 feet above mean sea level (MSL), and the water level in the UHS is at 675 feet above MSL. The other plant elevation measurements in this document are also relative to MSL.

During Phase 1, normal design features of the containment, including the containment isolation valves, maintain containment integrity. Containment heat removal and hydrogen igniter operation are not possible during Phase 1 since they both rely on the availability of 480 volt alternating current (Vac) power. This requirement is met in Phase 2, and the licensee does not plan to vent the containment to atmosphere.

The pre-staged FLEX DG located in the DG building would be used to reenergize installed battery chargers to keep the necessary dc buses energized, which will then keep the necessary RCIC controls, SRV controls, and vital instrumentation energized. This generator will also power the SF pump.

To accomplish suppression pool cooling, thereby removing heat from the containment, an existing 480 Vac SF pump would be aligned to circulate suppression pool water through the shell side of an RHR heat exchanger while UHS water supplied by a FLEX pump through the Diesel Generator Building FLEX manifold supplies the heat exchanger tube side that is normally supplied from the shutdown service water (SX) system. For diversity, either RHR heat exchanger can be used for the suppression pool cooling strategy. The one chosen will depend on the SX division supplied from the FLEX manifold located in the Diesel Generator Building and the electrical division aligned to the FLEX generator. This strategy will remove the core decay heat that is being dumped to the suppression pool via the SRVs, and provide an unlimited coping period for the containment.

Suppression pool makeup will initially be accomplished by draining the upper containment pool to the suppression pool when ac power is available to operate the valves. Also, water from the UHS will be available for suppression pool makeup by connecting hoses from the FLEX manifold in the diesel generator building to the LPCS or RHR-C injection headers.

In Phase 2 the pre-staged FLEX generator will also repower the Division 1 hydrogen igniter distribution panel to allow igniter operation inside the containment. This is a defense-in-depth measure, as no hydrogen generation is expected to occur. If the Division 1 panel is not available, the Division 2 panel can be used.

To maintain SFP cooling capabilities, the required action is to establish the water injection lineup before the environment on the SFP operating deck degrades due to boiling in the pool so that personnel can access the operating deck to accomplish the coping strategies. The pool will initially heat up due to the unavailability of the normal cooling system. The licensee has calculated that, depending on the spent fuel loading in the pool, boiling could start as soon as 3.2 hours after the start of the ELAP. The pool water level would drop to the top of the fuel racks in approximately 38 hours. The licensee determined that habitability on the pool operating deck area could become compromised as early as 11 hours after the ELAP, so valve lineups and hose deployments are planned prior to that time. The UHS water is used for makeup to the SFP using either the existing emergency SFP fill line from the SX system or hoses routed to the SFP with the discharge end positioned over the edge of the pool or connected to nozzles that spray the water over the spent fuel. The water is supplied from a diesel-driven FLEX pump located in the FSB with suction from the UHS and pumping through the FLEX manifold in the Diesel Generator Building.

During a flood event, the mitigating strategies are similar with the exception that the FLEX equipment stored in the FSB is moved to higher ground. Since the rise in Lake Clinton water level is a slow-moving event (a storm duration of about 48 to 72 hours), there is adequate time to relocate and connect the FLEX pumps to implement the necessary mitigation strategies which are similar to those for the non-flood BDBEE.

The Phase 3 strategy is to use the Phase 2 connections, both mechanical and electrical, but supply water using Phase 3 portable pumps and ac power using Phase 3 portable generators if necessary. The Phase 3 equipment will act as backup or redundant equipment to the Phase 2 portable equipment and is deployed from an off-site facility and delivered to Clinton.

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

3.2 Reactor Core Cooling Strategies

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

As reviewed in this section, the licensee's core cooling analysis for the ELAP/LUHS event presumes that, per endorsed guidance from NEI 12-06, the reactor would have been operating at full power prior to the event and that no additional random failures occur. Therefore, primary containment integrity is being credited by the licensee, and the nominal suppression pool liquid volume during power operation is assumed to be available as a heat sink for core cooling during the ELAP/LUHS event. Maintenance of sufficient RPV inventory, despite blowdown from SRVs and the ongoing system leakage expected under ELAP conditions, is accomplished through a combination of installed systems and FLEX equipment. The specific means used by the licensee to accomplish adequate core cooling during the ELAP/LUHS event are discussed in further detail below. Because certain actions within the mitigating strategy and their timeline vary depending on whether the ELAP/LUHS results from (1) flooding or (2) other natural hazards not associated with flooding, separate discussions are provided for each case, assuming the reactor is initially operating at full power. 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 for Non-Flooding Event

3.2.1.1 Phase 1

Per the Clinton FIP, SRVs will operate automatically to maintain reactor vessel pressure within design limits (i.e., safety mode). The SRV operation may also be controlled manually from the control room (i.e., relief mode). Sixteen SRVs are installed on the main steam lines inside the drywell. Each SRV can be manually actuated from one of two installed dc solenoid valves which open to supply pneumatic pressure to the valve operating piston. Each SRV is provided with an air accumulator capable of providing for a total of 37 lifts in relief mode. Nine of the SRVs are capable of being supplied with actuating air from Division 1 and 2 backup air bottles. These bottles, located in the Auxiliary Building, are sized to provide an additional 100 lifts per division. The backup air supply can be lined up manually or remotely during Phase 2 after the FLEX generator has been placed in service.

The RCIC system will be used for RPV makeup with its suction assumed to be from the suppression pool. Because the turbine for the RCIC pump is driven by steam from the RPV, operation of the RCIC system further assists the SRVs with RPV pressure control. Although the preferred suction source for RCIC is the RCIC storage tank, this tank is not protected from all ELAP initiating events. By design, at the minimum storage tank level, an automatic, safety grade switchover to a seismic Category 1 supply (i.e., the suppression pool) will occur to maximize the utilization of the RCIC storage tank inventory for events where it is available. The instrumentation required to transfer RCIC pump suction from the RCIC storage tank to the suppression pool is redundant and safety grade. The RCIC storage tank level instrumentation is seismically qualified and is not routed through nonseismic areas. In addition, the level transmitters, sensing lines, and process taps are physically located in the fuel building to protect against instrument line freezing. The RCIC storage tank level instrumentation and logic are powered from the Division 1 Nuclear System Protection System (NSPS) power supply system. The NSPS is designed to provide adequate uninterrupted power to all the NSPS loading during all modes of operation, including abnormal and accident conditions. The valves involved in the switchover are supplied from the Division 1 Class 1E dc power system, which supplies 125 Vdc power to Class 1E loads. The system includes batteries, battery chargers, motor control centers, and DC distribution panels. Therefore, even in the case that the RCIC storage tank is damaged by the ELAP initiating event, an automatic switchover to the suppression pool can be credited in the ELAP analysis.

The RCIC system will initiate automatically upon reaching the Reactor Vessel Level-Low Low setpoint, or can be manually operated in the control room and at the Remote Shutdown Panel. At about one hour into the event, a gradual cooldown will be performed with the SRVs and reactor vessel pressure will be controlled between approximately 150 and 250 psig. The RCIC system piping and components are protected from externally generated missiles by Seismic Category 1 structures including pump room walls. The RCIC capabilities are discussed further in Section 3.2.3.1.1.

3.2.1.2 Phase 2

The licensee states that RCIC will continue to be used for Phase 2 RPV makeup and to assist the SRVs with RPV pressure control for as long as RCIC operation is viable. Division 1 or

Division 2 backup air bottles can be aligned manually or remotely to provide for continued SRV use. The licensee developed a strategy to provide an indefinite supply of air to support SRV functionality. A prestaged hose and hose adapter connect the installed Division 1 or Division 2 Diesel Generator Starting Air compressors to the backup air bottle charging line for the SRVs which are part of the automatic depressurization system (ADS). This strategy is implemented by removing a spoolpiece downstream of the DG air receiver and installing in its place the hose fitting. A modification on the ADS charging line provides a connection point for the air hoses. The air compressors are powered from DG Motor Control Center (MCC) 1A (Division 1) or DG MCC 1B (Division 2) which are repowered by the FLEX generator.

A pre-installed 480 VAC FLEX generator will be lined up to the Division 1 ac distribution system to repower the Division 1 battery charger and enable the continued use of RCIC, SRVs, and vital instrumentation. Alternatively, the pre-installed FLEX generator can be aligned to a safety-related swing battery charger to energize the Division 1 dc bus for the same purpose.

Per the FIP, instructions for RPV level control in procedure Emergency Operating Procedure (EOP)-1 specify a RPV level band between the top of the active fuel (TAF), which is -162", and 101" prior to lowering RPV pressure for transition to low pressure RPV makeup. The licensee stated that this expanded level band encompasses a wide variety of accident responses, including ELAP. Through discussion with the licensee, NRC staff understand that RPV water level is expected to be maintained between Level 3 (8.9") and Level 8 (52") while the licensee conducts a controlled transition to the Phase 2 core cooling strategy. Additionally, the primary Phase 2 strategy is capable of providing makeup to the RPV before steam pressure for RCIC is lost, allowing for a controlled transition of RPV level control.

When RCIC is no longer available due to diminishing decay heat, the RPV makeup strategy transitions to low pressure RPV makeup. The preferred strategy involves pumping water from the suppression pool using a suppression pool cleanup and transfer (SF) pump. The flow is then routed to the RHR system piping through a temporary hose connection and subsequently injected into the RPV via a LPCI injection valve.

Alternatively, a FLEX pump can be used to provide water from the UHS for RPV makeup. The flowpath from the FLEX pump at the UHS uses a previously abandoned underground shutdown service water supply line, and continues up to the FLEX manifold located in the DG building. A hose would be used to connect one of the FLEX manifold discharge valves to a connection point on the LPCS or RHR-C injection headers. Water can then be injected into the RPV through LPCS injection valve 1E21-F005 or LPCI injection valve 1E12-F042C. Both of these valves are outside containment and can be operated manually.

Makeup from the UHS to the suppression pool would be provided via a FLEX pump using the same flowpath to the FLEX manifold in the DG building to the LPCS or RHR-C injection headers as described above. Water from the UHS can then be added to the suppression pool using 1E21-F012 LPCS Test Return to Suppression Pool Valve or 1E12-F021 RHR-C Test Valve to Suppression Pool. These two valves are outside containment and can be operated manually. The quality of suppression pool water and other water sources are discussed in Section 3.10.

The use of the DG Building FLEX manifold is considered an alternative to NEI 12-06 and is further discussed in Section 3.14.

3.2.1.3 Phase 3

Per the FIP, Phase 3 strategies are the same as those for Phase 2. Phase 3 NSRC equipment will act as a backup or redundant equipment for Phase 2 strategies.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

The flooding event of concern is the probable maximum flood (PMF) due to precipitation in the basin area that drains into Lake Clinton. The licensee will have advance warning of heavy precipitation. There will be limited flooding at the site, in the area of the intake structures, but since the FSB is at the intake area it will be flooded by this event. The licensee's flood strategy is to move the FLEX equipment out of the FSB and above the flood level. The FLEX pumps are moved up the hillside as the lake level rises, but still maintain the capability to deploy submersible suction pumps into the lake which will supply water to the trailer-mounted FLEX pump. Temporary hoses are used to connect the FLEX pump discharge to the FLEX manifold located in the DG building. Preparations for and effects of on-site flooding are discussed in section 3.5.2. Core cooling and RCS makeup strategy implementation remain the same for a flooding event, as the water supply is maintained to the FLEX manifold.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Core Cooling – Phase 1

Clinton's Phase 1 core cooling FLEX strategies rely on the existing RCIC system to maintain water level in the RPV. As described in the Clinton Updated Final Safety Analysis Report (UFSAR), Rev 15, Table 3.2-1, the RCIC pump and piping are seismic Category I, and RCIC components are located in the Auxiliary (Aux) Building, Containment, and Fuel Building. The RCIC control power is provided by the safety-related, 125V dc Class 1E Batteries, and the RCIC system can be controlled from the main control room (MCR). Procedure CPS 4306.01P005, "FLEX RCIC Operation," Rev 0, directs the operators to use procedure 4303.01P013, "RCIC Manual Operation without DC Power," to operate RCIC if control power is not available. As described in Clinton's FIP, RCIC will take suction directly from the suppression pool, but can also take suction from the RCIC storage tank if available. The RCIC storage tank has not been credited as it does not meet the criteria for robust equipment. Further explanation and the staff's evaluation of the robustness and availability of water sources for an ELAP event is discussed in Section 3.10 below.

Core decay heat will produce steam in the RPV, which will cause the SRVs to open on high steam pressure and relieve the steam to the suppression pool. Additionally, the licensee plans to eventually depressurize the RPV using the SRVs. As described in the Clinton UFSAR, Rev. 15, Table 3.2-1, the SRVs are seismic Category I, and are located in the Containment. As described in the licensee's FIP, the SRVs can be controlled from the MCR with power provided by the Class 1E safety-related batteries during Phase 1, or they can actuate mechanically without power due to high pressure in the RPV. As discussed in Sections 3.2.1.1 and 3.2.1.2 above, the licensee has plans to provide control power and operating air to the SRVs indefinitely. As described in UFSAR Table 3.2-1, both the primary air accumulators for the SRVs and the backup air bottles and supply lines are seismic Category 1 systems located in the Containment and the Auxiliary Building.

As described in the Clinton UFSAR, Rev. 15, Table 3.2-1, the Containment, Fuel Building and Auxiliary Building are seismic Category I structures that are designed to withstand design wind/tornado loadings, missile impacts and floods. The staff noted that RCIC and the SRVs and associated systems are located in temperature-controlled areas of the Auxiliary Building, Containment, and Fuel Building and that equipment operation during an ELAP event will be addressed in section 3.9 below. Based on the location of the RCIC and the SRVs, both systems should be available during an ELAP event.

Core Cooling – Phase 2

Clinton's Phase 2 core cooling strategy will use RCIC and the SRVs as long as operation is possible and then will transition to one of two methods discussed below once RCIC is no longer available. To extend the RCIC service period, when the suppression pool approaches temperatures higher than those RCIC was designed for RCIC suction can be swapped to the outlet of the RHR heat exchanger. This alignment requires that an SF pump is placed into service and aligned to provide flow through the RHR heat exchanger and to the RCIC suction.

The preferred method of maintaining RPV level once RCIC is no longer available is to use an installed SF pump and the LPCI injection line. The SF (A and B) pumps, which can be powered by the 480 Vac FLEX DG, take suction from the suppression pool via a suction line common to both pumps. The discharge of the two pumps goes to a common discharge header and then can be routed via a temporary hose connection to the RHR steam condensing piping where it can then be aligned to either the A or B RHR heat exchanger. After passing through the shell side of the selected heat exchanger, the SF pump discharge can either be routed to the suppression pool (discussed in Section 3.4) or to the RPV via the RHR LPCI line. The SF system is located in the Auxiliary Building so it is protected from wind/tornado loadings, missile impacts and floods. However, the SF system was not originally seismically designed. During the audit review process, the licensee provided calculation IP-S-0295, "FLEX Seismic Analysis of SF Components," Rev 0. The calculation determined the portion of the SF system relied on during a BDBEE is seismically robust. The calculation identified three new supports that needed to be installed to reduce the seismic loads on existing supports.

The alternate RPV injection method is to use UHS water supplied to the FLEX manifold in the DG building via a FLEX pump. Temporary hoses run from the FLEX manifold can be connected to the LPCS or RHR-C injection lines to the RPV. Water can then be injected into the RPV through LPCS injection valve 1E21-F005 or LPCI injection valve 1E12-F042C. Both valves can be operated manually and are located outside containment. The staff's evaluation of the robustness and availability of FLEX RPV injection connection points and the FLEX manifold are discussed in Section 3.7. The staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.

As discussed earlier, 9 of the 16 SRVs have backup air supply bottles that provide additional lifts. In order to ensure continued remote operation of the SRVs, the licensee's Phase 2 strategy includes providing a long term supply of SRV actuating air. The licensee uses a pre-staged hose and hose adapter to connect to the installed Division 1 or Division 2 DG starting air compressors and provide actuating air to the SRV backup air supply bottles. The compressors are powered by the FLEX DG. As described in the Clinton UFSAR, Rev 15, Table 3.2-1, the DG air compressors are non-safety compressors that are seismically supported and are located in the DG Building which is a seismic Category 1 structure that is protected from all applicable hazards.

Core Cooling – Phase 3

The Clinton Phase 3 core cooling strategy continues to maintain level in the RPV using RCIC, or the SF pumps, or the FLEX pump with suction from the UHS, and discharge the decay heat to the suppression pool through the SRVs. The suppression pool is cooled using the SF pumps with flow through the shell side of the RHR heat exchanger. The tube side of the RHR heat exchanger is cooled by the FLEX pump with suction from the UHS and discharge back to the UHS. The licensee does not plan to vent the containment. The licensee plans to continue using the onsite Phase 2 equipment supplemented as necessary by equipment delivered from an NSRC.

3.2.3.1.2 Plant Instrumentation

Per the FIP, the following main control room (MCR) indication is credited for all phases of reactor core cooling and decay heat removal strategy:

- Wide Range RPV Level: Division 1 ATMs 1B21-N691A and 1B21-N691E
- RPV Pressure: Division 1 ATMs 1B21-N697A, 1B21-N697E, 1B21-N678A (wide range)

This instrumentation is available prior to and after station blackout (SBO)/ELAP load shedding. Availability after 6 hours can be provided by successfully implementing the primary or alternate battery charging FLEX strategy.

The CPS Support Guide 4303.01P015, "Alternate Methods for Obtaining Essential Parameter Values," provides alternate methods for obtaining critical parameters if key parameter instrumentation is unavailable. Some critical parameters in CPS 4303.01P015 include suppression pool level, suppression pool temperature, and containment pressure. The SFP level instruments are discussed in Section 4 below.

3.2.3.2 Thermal-Hydraulic Analyses

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

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

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

To support the NRC staff's review of the use of MAAP4 for ELAP analyses, in June 2013, EPRI issued a technical report entitled "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications." The document provided general information concerning the code and its development, as well as an overview of its physical models, modeling guidelines, validation, and quality assurance procedures.

Based on the staff's review of EPRI's June 2013 technical report, as supplemented by further discussion with the code vendor, audit review of key sections of the MAAP code documentation, and confirmation of acceptable agreement with NRC staff simulations using the TRACE code, the NRC staff concluded that, under certain conditions, the MAAP4 code may be used for best-estimate prediction of the ELAP event sequence for BWRs. However, in part due to the reliance of the MAAP4 code on a simplified correlation for predicting natural circulation flows, as well as observations of inadequate agreement with the staff's confirmatory calculations, the staff was unable to conclude that the MAAP4 code could be used for predicting RCS thermal-hydraulic behavior for PWRs during an ELAP. The NRC staff issued an endorsement letter dated October 3, 2013, which documented these conclusions and identified specific limitations that BWR licensees should address to justify the applicability of simulations using the MAAP4 code for demonstrating that the requirements of Order EA-12-049 have been satisfied.

The licensee addressed the limitations from the NRC staff's endorsement letter in an attachment to its third six month status report [Reference 13]. The licensee's response utilized the generic roadmap and response template that had been developed by EPRI to support consistency in individual licensee's responses to the limitations from the endorsement letter. The staff's review of this information, as well as the staff's audit of Clinton's plant-specific MAAP analysis, confirmed that the licensee had acceptably addressed all limitations from the endorsement letter. In particular, the staff concluded that appropriate inputs and modeling options had been selected for the code parameters expected to have dominant influence for the ELAP event, and further observed that limitations concerning RPV collapsed liquid level and depressurization were satisfied.

The NRC staff reviewed calculation IP-M-0812, "Clinton Power Station (CPS) FLEX Suppression Pool (SP) Piping Modifications Fluid Flow Evaluation", Rev. 0. The calculation evaluated the net positive suction head (NPSH) available for the three configurations in which the suppression pool clean-up (SF) pumps would be put into service following an ELAP event:

(1) SF pump taking suction from the SP and discharging the full flow of 1500 gpm back to the SP through the RHR heat exchanger,

(2) SF pump taking suction from the SP and discharging through the RHR heat exchanger with a flow of 300 gpm injected to the RPV via the LPCI injection line and the remainder being directed back to the SP, and

(3) SF pump taking suction from the SP and discharging through the RHR heat exchanger with a flow of 300 gpm directed to the RCIC pump and the remainder being directed back to the SP.

The calculation shows that, once the upper containment pool is dumped into the suppression pool (about 5.5 hours after ELAP), there is sufficient NPSH to provide 1500 gpm from the SF pump through the RHR heat exchanger and back to the suppression pool (Case 1) and from the SF pump through the RHR heat exchanger and back to the suppression pool with RCIC injection (Case 3). For the alignment with SF to the suppression pool through the RHR heat exchanger and RPV injection via the LPCI line, the available NPSH is not sufficient to supply 300 gpm to the RPV through LPCI and 1200 gpm back to the suppression pool. In this configuration, the operators will have to control the system in a "batch mode" and alternate feed to each of the destinations separately. Additionally, at the time when this configuration is needed (RPV pressure insufficient to support continuous RCIC operation), the loss of water from the RPV due to boil-off from decay heat will require much less than 300 gpm.

Therefore, based on the evaluation above, as well as the conclusions regarding the adequacy of the containment thermal-hydraulic modeling in Section 3.4.4.2 of this evaluation, the NRC staff concludes that the licensee's analytical approach appropriately determined the sequence of events for reactor core cooling, including time-sensitive operator actions, and the required equipment to mitigate the analyzed ELAP event, including pump sizing and cooling water capacity.

3.2.3.3 Recirculation Pump Seals

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

The FIP states that a reactor coolant system leakage rate of 100 gpm is assumed in the analysis for the ELAP event. This leakage rate is intended to encompass expected leakage from the recirculation pump seals and all other sources of primary leakage. The NRC staff observed that, during power operation, Clinton's technical specifications require that primary system leakage be maintained below 30 gpm. Thus, conservatively assuming a primary system leakage rate at its technical specification limit would leave margin for a recirculation pump seal leakage rate of 35 gpm per pump under ELAP conditions.

During the audit, the NRC staff discussed recirculation pump seal leakage with the licensee and requested that the licensee justify the applicability of the assumed leakage rate to the ELAP event. The licensee stated that Clinton has Model CAN8C recirculation pump seals that were manufactured by Atomic Energy of Canada Limited (AECL). According to AECL, the CAN8 seal line is essentially an improved version of the CAN2A seal that has been scaled up in size to accommodate a larger shaft diameter. The first CAN2A seal was installed at a U.S. BWR in 1986 to provide improved overall seal performance, with consideration given to postulated SBO conditions wherein seal cooling is lost. Inasmuch as the lead U.S. BWR installing CAN2A seals relies on isolation condensers in lieu of a turbine-driven pump for cooling an isolated reactor core, SBO testing was performed in the early 1990s with relatively strict acceptance criteria. The results of the CAN2A station blackout testing showed that, provided that conditions are maintained within a qualification envelope, the seal faces did not "pop-open," nor did the seals otherwise experience excessive leakage when seal cooling was lost. Beyond this, the NRC staff understands that some dynamic testing of CAN8 seals has been performed at increased seal cavity temperatures to simulate a loss of cooling during pump operation for a Canadian CANDU reactor, but is not aware of SBO testing performed specifically for this design.

Considering the above factors, the NRC staff concludes that the leakage rate assumed by Clinton is reasonable in light of the similarity of the CAN2A and CAN8 seal designs. The staff further notes that the recirculation pump design for Clinton includes a breakdown bushing that is intended to prevent excessive leakage even in the case of gross seal failures that are not anticipated to occur during the postulated ELAP event. As is typical of the majority of U.S. BWRs, Clinton has an installed steam-driven pump (i.e., RCIC) capable of injecting into the primary system at a flow rate well in excess of the primary system leakage rate expected during an ELAP, and the other pumps used for core cooling in its FLEX strategy have a similar functional capability.

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

3.2.3.4 <u>Shutdown Margin Analyses</u>

As described in its UFSAR, Clinton's design is such that the control rods provide adequate shutdown margin under all anticipated plant conditions, with the conservative assumption that the highest-worth control rod remains fully withdrawn. Clinton's Technical Specification 1.1 further clarifies that shutdown margin is to be calculated for a cold, xenon-free condition to ensure that the most reactive core conditions are bounded.

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

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

3.2.3.5 <u>FLEX Equipment and Water Supplies</u>

Clinton's FLEX strategy relies on a trailer-mounted, diesel-driven, centrifugal FLEX pump that can provide core cooling, containment cooling, and SFP cooling. This FLEX pump takes suction from the UHS. Further discussion of the UHS robustness is in Section 3.10. The NRC staff noted that Clinton identified the performance criteria (e.g., flow rate, discharge pressure, total dynamic head) for its FLEX pump in Section 3.2.1 of its FIP [Reference 44]. 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.

The FLEX pump takes suction from the UHS and discharges to the previously abandoned Unit 2 Emergency SX 30" supply line. The SX supply line is routed underground up to the Diesel Building where a permanent 12" branch pipe was connected and routed to the permanently installed FLEX manifold located on the 762' elevation of the Diesel Building. From this FLEX manifold hoses can be routed to either service water header (Division 1 or Division 2), to the SFP for SFP makeup/spray, or to the LPCS or RHR-C injection lines, which permit injection to the RPV. Two FLEX pumps are stored in the FSB. One of these pumps is a backup (N+1) pump. The UHS can be accessed in the FLEX building using either of two unused Unit 2 SX pump bays, which are shafts through the floor of the FSB into the UHS. The pump discharge is routed via hose to the Unit 2 SX 30" supply line via a connection point in the FSB. Each FLEX pump uses twin hydraulically-driven submersible booster pumps, which are lowered into the Unit 2 SX pump bay using a chain fall. The FLEX pump can provide 3000 gpm at 330 feet of head. A single pump provides full capability to perform all the FLEX functions, so the second FLEX pump satisfies the N+1 requirement outlined in NEI 12-06. During the audit review, the licensee provided the hydraulic calculation IP-M-0809, "Hydraulic Evaluation for FLEX Diesel Pump Sizing," Rev 1, which determined the necessary pump performance criteria for the portable FLEX pump to support the licensee's core, containment and SFP cooling strategies. The minimum flow requirements specified in the calculation are as follows: 2000 gpm for suppression pool cooling, 300 gpm for RPV makeup, 100 gpm for suppression pool makeup, 100 gpm for SFP makeup, and 250 gpm for SFP spray. The staff noted that Clinton's calculation relied upon the hydraulic modeling program PIPE-FLO to create a hydraulic model using FLEX strategies. The staff noted this calculation assessed different possible lineups based on different suction sources, and the different connection points that are available. The staff walked down the FLEX pump deployment paths. The FLEX pumps are stored in the FSB (elevation 701') and one pump will be connected to the Unit 2 SX header through a connection manifold located in the FSB and the pump discharge is routed to the FLEX manifold in the Diesel Building via the Unit 2 SX 30" supply header. From that FLEX manifold multiple cooling connections can be. The staff walked down the hose deployment routes and found them to be consistent with the hydraulic analyses discussed above

Based on its review, the NRC staff concludes that the licensee has demonstrated that its FLEX portable pumps are capable of supporting the licensee's FLEX strategies if implementation is performed as described by the licensee.

3.2.3.6 <u>Electrical Analyses</u>

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

After determining that the emergency diesel generators cannot be restarted and off-site power is unlikely to be restored for a period greater than the SBO coping time (4 hours), the Clinton operators would declare ELAP. In the FIP, the licensee assumes that this determination can be made less than one 1 hour after the onset of an ELAP/LUHS event.

During Phase 1 reactor vessel makeup is provided from the RCIC system with suction from the suppression pool and reactor vessel pressure control is provided by the SRVs. The Clinton safety-related batteries will be used to initially power required key instrumentation and applicable direct current (dc) components required for monitoring RPV level and RCIC system operation. The RCIC system valves required for automatic and manual operation, one set of SRV solenoids, and an NSPS inverter are all supplied from the Division 1 Class 1E dc power system. Since required loads are supplied by the Division 1 battery, the licensee plans to shed non-essential loads on the battery to extend the dc coping time to 6 hours. Load shedding is expected to be completed within 60 minutes from the onset of an ELAP/LUHS event.

Clinton has four Class 1E station batteries in Divisions 1 through 4. Both the primary and alternate electrical strategies ensure the Division 1 battery charger is energized before the Division 1 battery coping time is exceeded. The Division 1 battery charger is the focus of both strategies because the RCIC system controls and dc valves are powered from the Division 1 dc MCC, as well as the Division 1 SRV solenoids and Division 1 NSPS Inverter. The alternate strategy energizes the safety-related swing battery charger to supply the Division 1 dc bus, and also energizes the Division 2 battery charger providing redundant indication of key parameters from the Division 2 NSPS Inverter and power to the Division 2 SRV solenoids. Division 3 and 4 batteries provide some redundant indication of key parameters, but otherwise are not required.

The licensee performed a dc coping study EC 391824, "FLEX Battery Coping Study," Rev. 0, for the Clinton Division 1 and 2 batteries under SBO conditions. The coping times established for Division 1 with the 60 minute SBO load shedding per Procedure CPS 4200.01C002, "DC Load Shedding During a SBO," Rev. 5a, are 360 minutes with a 1.25 age factor, and 510 minutes with the age factor reduced to 1.00. The coping times for Division 2 with the 60 minute SBO load shedding per Procedure 4200.01C002 are 696 minutes with a 1.25 age factor, and 990 minutes with the age factor reduced to 1.00.

During Phase 2, the licensee has developed a primary and alternate strategy for supplying power to equipment required to provide core, containment, and SFP cooling using a combination of permanently installed, seismically robust components and cable reels stored in seismically robust cabinets (except Control Building 825' elevation, which has reels but not cabinets). The licensee noted that all of the cable reels are seismically mounted and that the purpose of the cabinets, which contain the cable reels, is to address fire loading in the associated areas and not for seismic protection. The licensee also noted that a seismic engineer walked down the area surrounding the cable reels confirming that there are no hazards that would adversely impact the cable reels that are not stored in cabinets in the event of a seismic event.

The licensee's Phase 2 strategy relies on a pre-staged 500 kilowatt (kW) 480 Vac FLEX DG that is located in the seismic Category 1 Diesel Generator Building and will be lined up to the Division 1 ac distribution system to repower the Division 1 battery charger and enable the continued use of RCIC, SRVs, and vital instrumentation. Alternatively, the pre-staged generator can be lined up to a safety-related swing battery charger to energize the Division 1 dc bus for the same purpose. The use of a pre-staged (versus portable) FLEX diesel generator is considered an alternative to the conditions endorsed by the NRC in NEI 12-06, Rev. 0.

If the pre-staged FLEX DG is not available, the licensee has a backup (N+1) 500 kW, 480 Vac, FLEX generator that is mounted on a trailer and is stored in the seismically robust FSB. In the event the N+1 generator is used, it will be transported from the FSB at the screen house to the A2 staging area outside the Diesel Generator Building and connected to the in-plant electrical distribution system using cables deployed from within the Diesel Generator Building. With respect to flooding, the storage building housing the portable N+1 FLEX generator will not be protected up to the PMF elevation. Sufficient time will be available to relocate the N+1 FLEX generator to a higher elevation in advance of the rising lake level. The haul path for relocating the FLEX generator will not be affected by the flood.

Per the licensee's FLEX DG sizing calculation, EAD-FLEXGEN-1, "Electrical Loading and Rating in KW for the FLEX Generator," Rev. 000 - CC-AA-309-1-1, Rev. 8, one Phase 2 FLEX DG is capable of supplying the loads required for either the primary (Division 1 loads) or the alternate (Division 2 loads plus the swing charger) strategy. The licensee's Phase 2 electrical strategy ensures that the Division 1 or safety-related swing battery charger is able to be energized prior to the batteries becoming exhausted.

The NRC staff reviewed calculation EAD-FLEXGEN-1, CPS 4306.01P001, "FLEX Electrical Connections," Rev. 0, CPS 4306.01C001, "FLEX Electrical Connection Hard Cards," Rev. 0, conceptual single line electrical diagrams, the separation and isolation of the FLEX DGs from the Class 1E emergency DGs, and procedures that direct operators how to align, connect, and protect associated systems and components. Based on the NRC staff's review, the calculations confirmed that one FLEX DG should have sufficient capacity and capability to supply the necessary loads following an ELAP.

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment/resources as needed. The offsite resources that will be provided by an NSRC includes a 1-megawatt (MW) 480 Vac 3-phase turbine generator. The NSRC generators come with the same style and size connectors as the on-site Phase 2 FLEX generators. Therefore, the licensee's Phase 3 strategy will utilize the Phase 2 electrical connections. The capacity of the NSRC-supplied generator is of greater capacity than the capacity of the licensee's Phase 2 FLEX DG. Therefore, the NRC staff finds that the Phase 3 turbine generator will provide adequate capacity to supply the minimum required loads (same as Phase 2) to maintain or restore core cooling, SFP cooling, and containment indefinitely following an ELAP.

The NRC staff's review of the licensee's electrical analyses did not identify any discrepancies.

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 during an ELAP event and adequately addresses the requirements of the order.

3.3 Spent Fuel Pool Cooling Strategies

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

As described in NEI 12-06, Section 3.2.1.7 and JLD-ISG-2012-01, Section 2.1, strategies that have a time constraint to be successful should be identified and a basis provided that the time can be reasonably met. In NEI 12-06, Section 3 provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is beyond design basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters, and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. 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 in the SFP. The sections below address the response during operating, pre-fuel transfer or post-fuel transfer operations. The effects of an ELAP with full core offload to the SFP is addressed in Section 3.11. Clinton has one SFP, located in the Fuel Building with the refueling floor at the 755 foot elevation.

3.3.1 Phase 1

The FIP states no action is required for Phase 1 makeup because the time to uncover the fuel is sufficient to deploy Phase 2 equipment. However, the FIP states that boiling may start as soon as 11 hours after the ELAP, and may affect personnel habitability on the refueling floor. For this reason, the licensee's strategy is to complete the hose deployment on the refueling floor prior to 11 hours. The FIP also states that the time for boil-off to lower the water level to the top of the fuel racks is 38.65 hours with the conservative assumption of a full-core offload scenario.

3.3.2 Phase 2

Clinton's Phase 2 SFP cooling strategy consists of pressurizing a service water (SX) header with the FLEX pump via the FLEX manifold. As described in the FIP, the seismically qualified emergency SFP makeup supply from the SX header can be used to supply makeup to the SFP without accessing the SFP floor. The SX header is supplied via hose from the FLEX manifold. Additionally, a hose can be connected to the FLEX manifold and routed directly to the SFP to provide makeup and spray capability if necessary. As described in Section 3.2.3.5, the FLEX manifold is pressurized using the portable FLEX pump staged at the FSB.

3.3.3 Phase 3

Clinton will continue to use its Phase 2 strategy into Phase 3 with the NSRC pump available to replace the onsite FLEX pump if necessary.

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.

During the audit review, the licensee provided VF-54, "SFP Area Conditions Following a BDBEE," Rev 8. The purpose of this calculation is to determine the time after a BDBEE when the SFP exceeds the dry bulb temperature limit for habitability. This calculation and FIP indicate that boiling begins at approximately 11 hours during a normal, non-outage situation. This analysis assumes a heat load of 18.3 million British Thermal Unit (Btu)/hr and a starting SFP temperature of 118.74 °F. The staff noted that Clinton's sequence of events timeline in the FIP indicates that operators will deploy hoses and spray nozzles as a contingency for SFP makeup within 11 hours from event initiation. The Clinton documents CPS 4306.01, "Extended Loss of AC Power/Loss of Ultimate Heat Sink," Rev. 0, and CPS 4306.01P007, "FLEX Spent Fuel Pool Makeup," Rev. 0, both contain precautions that SFP hoses should be deployed prior to 11 hours to ensure the SFP area remains habitable for personnel entry.

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any anticipated actions. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. Clinton document CPS 4306.01, "Extended Loss of AC Power/Loss of Ultimate Heat Sink," Rev. 0, directs the operators to establish a Fuel Handling vent pathway per CPS 4306.01P010, "FLEX Ventilation," Rev. 0. This procedure contains instruction to establish a SFP vent path following the ELAP. The operators are directed to open the rail bay door and personnel doors in the Fuel Building to establish the ventilation path. The licensee's FLEX support guidelines also instruct personnel to take actions to prevent the hot humid air and steam from entering the Auxiliary Building.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves use of the FLEX pump (or NSRC supplied pump for Phase 3), with suction from the UHS, to pressurize the FLEX manifold. The FLEX manifold can then be connected to either division of the SX system. Each division of the SX system has an emergency SFP makeup line. As described in the Clinton UFSAR Section 9.1 and Table 3.2.-1, the SX divisions that provide emergency makeup to the SFP are seismic Category I, located in the seismic Category I Aux Building and the seismic Category I Fuel Handling Building so they are protected from all applicable hazards. The staff's evaluation of the robustness and availability of FLEX connections points for the FLEX Pump is discussed in Section 3.7.3.1 below. Furthermore, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3.

3.3.4.1.2 Plant Instrumentation

In its FIP, the licensee stated that the instrumentation for spent fuel pool 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 480 V FLEX DGs. The NRC staff's review of the SFP level instrumentation, including the primary and back-up channels, the display to monitor the SFP water level and environmental qualifications to operate reliably for an extended period are discussed in Section 4 of this SE.

3.3.4.2 Thermal-Hydraulic Analyses

In its FIP, Clinton analyzed two different SFP cooling heat load cases when determining SFP makeup rate. These two cases are a maximum normal heat load during an outage following a normal batch discharge (Case 1), and a maximum abnormal heat load during an outage following a full core discharge (Case 2). The maximum heat load, boil-off time to top of the fuel and makeup rate can be found in the table below.

	Heat Load	Time to boil to top of fuel	Makeup rate
Case 1	27.7 million Btu/hr	55.81 hrs	60 gpm
Case 2	40.0 million Btu/hr	38.65 hrs	86 gpm

As stated in Section 3.2.3.5 of this SE, the licensee's FLEX Pump is capable of supplying 100 gpm of SFP makeup and 250 gpm of SFP spray flow which are more than either worst case SFP makeup requirements.

The staff noted that NEI 12-06, Section 3.2.1.6, states that one of the initial SFP conditions is that the SFP heat load assumes the maximum design-basis heat load for the site. Consistent with NEI 12-06, Section 3.2.1.6, the staff finds that Clinton has considered the maximum design-basis SFP heat load. Considering that the ELAP event is postulated to start from 100 percent power, it is not possible to have a full core offload in the SFP, and the required makeup rate would be 60 gpm. The licensee has the capability to provide this makeup rate.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the Clinton FIP, the SFP cooling strategy relies on one of two FLEX Pumps to provide SFP makeup during Phase 2. Clinton's FIP Section 3.2.1 describes the hydraulic performance criteria (e.g., flow rate, discharge pressure) for its 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 100 gpm and SFP spray rate of 250 gpm both exceed the maximum SFP makeup requirements as outlined in the previous section of this SE.

3.3.4.4 Electrical Analyses

The basic FLEX strategy for maintaining SFP cooling is to monitor the SFP level and provide makeup water to the SFP sufficient to maintain substantial radiation shielding for a person standing on the SFP refueling floor and provide for cooling for the spent fuel due to boil-off of the water.

Clinton does not require any actions during Phase 1. The licensee's FLEX strategy during Phase 1 of an ELAP/LUHS event for SFP cooling is to utilize the SFP water level instrumentation installed in response to NRC Order EA-12-051 to monitor the SFP water level. The licensee will stage a FLEX portable diesel-driven pump for the addition of makeup water to the SFP as it is needed in order to restore and maintain an appropriate water level in the SFP in Phase 2.

After the SFP reaches the boiling point, a source of makeup water will be needed to ensure the water level does not fall below the level of the fuel in the SFP and that radiological conditions on the refueling floor do not prohibit personnel access. The licensee plans to utilize the seismically qualified emergency SFP makeup supply from the SX system to supply >60 gpm to the SFP. Motor operated valves 1SX016A (Division 1) and 1SX016B (Division 2) are the makeup valves to the SFP which must be opened. They can be operated manually with the handwheel, or with ac power supplied from a FLEX DG. The valve used will depend on which SX division the Diesel Generator Building FLEX manifold is supplying.

The licensee's Phase 3 strategy is to continue with the Phase 2 methodologies using a FLEX pump. Additional high capacity pumps will be available from an NSRC as a backup to the on-site FLEX Pumps.

3.3.5 Conclusions

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

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06, Table 3-1, provides some examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to effectively maintain containment functions during all phases of an ELAP event. Clinton is a BWR with a Mark III containment. The Mark III containment is not equipped with a hardened containment vent capable of performing the necessary pressure control and heat removal functions associated with an ELAP event; therefore, consistent with Table 3-1, Clinton has proposed an alternative containment heat removal mechanism to satisfy the requirements of Order EA-12-049. Specifically, Clinton will utilize FLEX equipment to repower a suppression pool cleanup and transfer (SF) pump to circulate suppression pool water through the shell side of an RHR heat exchanger. The tube side of the heat exchanger will be supplied with cooling water from the Diesel Generator Building FLEX manifold.

The licensee performed a containment evaluation, CL-MISC-009, "MAAP Analysis to Support FLEX Initial Strategy," Rev. 5, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the alternative heat removal strategy and concludes that the containment parameters of pressure and temperature in the drywell remain below the respective UFSAR Section 6.2.1.1.3.1, Rev. 15, design limits of 30 psig and 330 degrees Fahrenheit (°F) for at least 72 hours following an ELAP-inducing event. Furthermore, the calculation concludes that the pressure in the wetwell (designated as "Containment" in the UFSAR) also remains below the design limit of 15 psig for at least 72 hours. The 185 °F design limit for the wetwell (liquid) temperature is calculated to be exceeded by a peak value of approximately 25 °F. A justification for exceeding this temperature limit is discussed in Section 3.4.4.1.1.

Additionally, although core damage and subsequent hydrogen generation is not expected, NEI 12-06, Table 3-1, guides licensees with Mark III containments to repower the unit's hydrogen igniters by using a portable power supply as a defense-in-depth measure to maintain containment integrity. The Clinton FIP states that a train of hydrogen igniters will be repowered within 5.5 hours following an ELAP-inducing event.

3.4.1 Phase 1

During Phase 1, containment integrity is maintained by normal design features of the containment. Decay heat will be transmitted from the RPV to the suppression pool via RCIC steam exhaust and SRV operations. Suppression pool temperature readings can be manually obtained using a procedure. Suppression pool level and containment pressure instruments remain available during Phase 1 since they are powered from Division 1 NSPS. This instrumentation is available prior to and after dc load shedding of the dc buses during an ELAP event for up to 6 hours. Availability after 6 hours is dependent on actions to restore ac power to the Division 1 battery charger (primary) or the safety-related swing battery charger (alternate).

In the unlikely event that the battery chargers or alternate methods of repowering NSPS are not available, alternate methods for obtaining the critical parameters locally is provided in FLEX Support Guide CPS 4303.01P015, "Alternate Methods For Obtaining Essential Parameter Values."

3.4.2 Phase 2

The Clinton FIP states that during Phase 2, the installed 480 VAC FLEX generator will be lined up to repower the suppression pool makeup (SPMU) dump valves, which are located inside the containment. These valves are 1SM001A and 1SM002A (Division 1), or alternatively Division 2 SPMU dump valves 1SM001B and 1SM002B. The subsequent opening of these valves will allow the water in the SPMU pool to be gravity-drained into the suppression pool. The added inventory from the SPMU pool (also referred to as the upper containment pool) will extend the time before suppression pool cooling is required and further prevents significant containment pressurization. As indicated in the Sequence of Events Timeline Table of the FIP, this action is planned to occur no later than 5.5 hours after the ELAP-initiating event.

To employ the alternative heat removal strategy, the FIP states that a 480 Vac SF pump (powered by a FLEX generator) will be aligned to circulate suppression pool water through the shell side of an RHR heat exchanger using modified RHR steam condensing mode piping. Cooling water from the Diesel Generator Building FLEX manifold will supply the heat exchanger tube side that is normally supplied from the SX system. For diversity, either RHR heat exchanger can be used for the suppression pool cooling strategy. The one chosen will depend on the SX division supplied from the Diesel Generator Building FLEX manifold and the electrical division aligned to the FLEX diesel generator. The Clinton FIP states that the alternative heat removal strategy will be employed no later than 8 hours following an ELAP-inducing event and will provide an unlimited coping period for the containment.

The NRC staff notes that most of the recirculation pump seal leakage and other postulated leakage from the RCS is expected to drain to the drywell basement area, which is normally dry. With RCIC taking a suction from the suppression pool and providing makeup to the RPV, the overall effect is that the leaking water is lost from the suppression pool and results in a slowly decreasing water level in the suppression pool until the water level in the drywell basement reaches the top of the weir wall and spills back into the suppression pool. The licensee has provided the capability to makeup to the suppression pool to compensate for this.

During an ELAP, the FIP states that suppression pool water addition is also required to maintain RCIC pump NPSH and to provide additional pressure suppression volume to the suppression pool. The Diesel Generator Building FLEX manifold can supply water to the LPCS injection header or alternatively to the RHR-C injection header, and water can be added, as necessary, to the suppression pool using valves in either of these headers. These valves are 1E21-F012, LPCS Test Return To Suppression Pool Valve and 1E12-F021 RHR C Test Valve To Suppression Pool. The subject valves are located outside the primary containment and can be operated manually with handwheels or electrically via the FLEX generator. The suppression pool level band specified in procedure EOP-6, "Primary Containment Control," allows operators to maintain level in the range established when upper containment pool water was added to the suppression pool.

The FIP further states that, approximately 5.5 hours following an ELAP-inducing event, the installed FLEX generator can repower the Division 1 or Division 2 hydrogen igniter distribution panels to allow igniter operation as prescribed by EOP-6, "Primary Containment Control."

3.4.3 Phase 3

The Clinton FIP states that the Phase 3 strategy is to use the Phase 2 connections, both mechanical and electrical, but supply water using NSRC portable pumps and AC power using NSRC portable generators if necessary. Furthermore, it states that the NSRC equipment will act as backup or redundant equipment to the onsite Phase 2 portable equipment.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

3.4.4.1.1 Plant SSCs

As stated in Section 1.1.6 of the Clinton UFSAR, Rev. 15, the containment system employs the drywell/pressure suppression features of the BWR-Mark III containment concept. The containment is a right cylindrical, reinforced concrete, steel-lined pressure vessel with a hemispherical dome. Table 3.2-1 of the UFSAR lists the containment as a seismic Category I structure, and further defines the design criteria for seismic Category I structures by stating that all civil structures classified as seismic Category I are designed for the effects of Clinton natural phenomena such as tornado, wind loads, external missiles, and floods, except for the containment gas control boundary, which is not designed for tornado and external missiles. The containment gas control boundary surrounds the containment structure and is made up of siding supported by structural steel framing attached to the containment. The containment structure itself is a fully qualified seismic Category I structure, which provides protection from natural hazards for all components inside. Section 3.8.1.1 of the UFSAR further confirms that the containment has the capability to maintain its functional integrity during any postulated design event, including protection against missiles from internal or external sources.

The Suppression Pool Makeup System (which supplies a large volume of cooling water to the suppression pool from the upper containment pool in Phase 2) is listed in Table 3.2-1 and Section 6.2.7.1 of the UFSAR as a Safety Class 2, Seismic Category I system.

Section 6.2.2 of the Clinton UFSAR, Rev. 15, states that the containment heat removal system is designed to seismic Category I requirements. System components, as appropriate, are designed to meet American Society of Mechanical Engineers (ASME) Code Section III, Class 2 requirements. Specifically, the RHR heat exchangers, which are essential to the containment heat removal strategy, are shown in Table 3.2-1 of the UFSAR, Rev. 15, as being seismic Category I components.

In the Clinton UFSAR, Table 3.2-1 shows that the Suppression Pool Cleanup System (SF) is only seismic Category I for the piping and valves that form part of the containment boundary. As stated in the FIP, the SF pumps and piping needed to be bolstered to be qualified as "robust" as defined by NEI 12-06, and the installation of a manual valve was needed to isolate the non-seismic downstream piping leading to the Turbine Building. During the audit process, the licensee provided calculation IP-S-0295, "FLEX Seismic Analysis of SF Components," Rev. 0, which concluded that the portion of the non-safety related SF System which will be relied upon to perform the containment heat removal strategy is now seismically robust in accordance with the definition of NEI 12-06. The calculation identified 3 new supports which needed to be installed in the system to reduce the seismic loads on the existing supports in the system. The staff noted that the installation of the new supports was captured in Engineering Change EC 392540, "Fukushima FLEX SF Pump Disch Hdr to RHR Stm Condense Mode Piping Required to Support NEI 12-06 FLEX Response."

The seismic evaluation of the RHR System steam condensing mode piping to which the SF System would be connected by a high-temperature, 6" diameter hose, was evaluated in analysis EMD-025440, "Subsystem 1 RH-07A Piping Analysis", Rev. 3. This calculation concluded that the piping system was qualified to operate in its required configuration following an ELAP event, and no support modifications or additions were required for qualification.

The FIP also states that the previously abandoned steam condensing mode piping will be utilized to fulfill the containment heat removal strategy during an ELAP event. During the audit process, the staff noted that the RHR steam condensing mode piping was installed during initial construction as safety-related piping. It was tested and certified in accordance with ASME code requirements. Clinton subsequently elected not to use this function of the RHR system and abandoned the piping in place. However, several valves that are part of the steam condensing mode piping will be used in the flow path for cooling the suppression pool water. The licensee stated that these valves will be manually stroked to verify that they are functional and can be reliably used to implement the containment heat removal FLEX strategy. Furthermore, the staff noted that the steam condensing mode piping design pressures and temperatures exceed the expected temperature and pressure of the suppression pool water that will be circulated through the RHR heat exchanger during an ELAP event.

Section 6.2.5.2.3 of the UFSAR states that the Clinton hydrogen igniter assemblies are dynamically qualified to ensure the operability and structural integrity of the assemblies under seismic events and hydrodynamic loads resulting from suppression pool transients.

As stated in Section 3.4 above, the 185 °F design limit for the suppression pool temperature is calculated to be exceeded by a peak value of approximately 25 °F and remain over the limit for at least 60 hours during an ELAP event. The licensee performed an evaluation in EC 401925, "Suppression Pool Liner Evaluation for Elevated Suppression Pool Temperatures during an Extended Loss of AC Power," to confirm that the elevated suppression pool temperature does not compromise primary containment integrity. The evaluation focused on four specific, potential impact areas: the suppression pool liner, the SRV quenchers, the emergency core cooling system (ECCS) suction strainer, and the ECCS suction piping from the strainer.

To address the potential impact on the suppression pool liner, the licensee referenced a finite element analysis calculation, which was performed to support a temperature increase in the SFP. The licensee's evaluation stated that the SFP liner and the suppression pool liner are the same material type and thickness and have been joined together using the same mechanical process (i.e. welding). The SFP water temperature which was used in the evaluation was 252 °F (as compared to the 210 °F peak temperature expected in the suppression pool). Furthermore, the licensee's evaluation of the SFP assumed a hydrostatic pressure based on a depth of 21 ft. The suppression pool calculation under ELAP conditions is expected to be approximately 23 ft. which the licensee concluded was comparable. Under the stated conditions, the SFP liner was shown not to buckle due to differential thermal expansion and the maximum stress and strain values remained within allowable limits. The EC 401925 evaluation concluded that this justification could reasonably be applied to demonstrate that the suppression pool liner would also maintain integrity under the expected ELAP conditions.

With respect to the SRV quenchers, the SRVs and piping are designed for discharging high pressure/high temperature steam and the licensee concluded they are suitable to carry out their intended function at a suppression pool temperature of 210 °F. The potential adverse effect would be local elevated temperature considerations on the suppression pool liner itself. To address this issue, the licensee referenced the conclusions of the NRC SE on Topical Reports NEDO-30832, "Elimination of Limit on BWR Suppression Pool Temperature for SRV Discharge with Quenchers," and NEDO-31 695, "BWR Suppression Pool Temperature Technical Specification Limits." The SE concluded that local suppression pool temperature limits could be eliminated for plants with SRVs that discharge through a T- or X-quencher device and whose emergency safety features pump inlets are located below the elevation of the SRV quenchers. The licensee stated that these two conditions are met at Clinton; thus, the local suppression pool temperature effects need not be evaluated.

The licensee's evaluation of the potential effects of the elevated suppression pool temperature on the ECCS strainer stated that the strainer is designed for a temperature of 200 °F. Additionally, the strainer is connected together with flexible connections to accommodate thermal growth. The licensee stated that a review of the strainer structural analysis indicated that the resulting loads from an increase to 210 °F would have no adverse impact on the strainer.

Finally, to address the potential effects of the elevated suppression pool temperature on the RCIC suction piping, the licensee performed evaluation EC 401924, "RCIC Piping Evaluation for Extended Loss of AC Power." This evaluation considered the effects of the 210 °F suppression pool temperature on the piping and supports. The evaluation concluded that the RCIC suction piping and supports can withstand the additional thermal loading.

Regarding each of the above aspects of the potential consequences of the elevated suppression pool temperature that the licensee has addressed, the NRC staff finds that each of the topics has been adequately justified to demonstrate that there will not be significant adverse effects. Thus, it is reasonable that the structural integrity of the suppression pool will be maintained under the expected ELAP conditions. The staff further notes that the Grand Gulf Nuclear Station, which is also a BWR with a Mark III containment, was granted a license amendment to permanently increase the design temperature of the suppression pool to 210 °F (ADAMS Accession No. ML121210003, non-public, proprietary information).

Based on the above UFSAR qualifications, licensee calculations, and the implementation of the described plant modifications, the equipment essential to the containment heat removal and containment integrity protection strategies is robust, as defined by NEI 12-06, and would be available following an ELAP-inducing event.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-1, specifies that containment pressure, suppression pool temperature, and suppression pool level are key containment parameters which should be monitored by repowering the appropriate instruments.

The Clinton FIP states that suppression pool level and containment pressure instrumentation is available prior to and after dc load shedding of the dc busses during an ELAP event for up to 6 hours. Availability after 6 hours is dependent on actions to restore ac power to the Division 1 battery charger (primary strategy) or the safety-related swing battery charger (alternate strategy). With regard to suppression pool temperature monitoring, the FIP states that temperature readings of the suppression pool may be manually obtained using existing site procedure 4200.01 C003, "Monitoring CNMT Temperatures During a SBO." The licensee stated during the audit process that the indication is obtained by using a MCR termination cabinet and a Fluke 45 meter (or equivalent), or RTD resistance bridge, and correlating a resistance to a temperature reading.

Based on this information, the licensee should have the ability to appropriately monitor the key containment parameters as delineated in NEI 12-06, Table 3-1.

3.4.4.2 Thermal-Hydraulic Analyses

The licensee performed calculation CL-MISC-009, "MAAP Analysis to Support FLEX Initial Strategy," Rev. 5, to demonstrate the effectiveness of the proposed containment heat removal strategy. The calculation utilized the MAAP computer code, version 4.0.5, to model the heat-up and pressurization of the containment under ELAP conditions.

As stated in the FIP, Case 18 of this calculation models the containment response with the licensee's specific containment heat removal strategy being employed at the times described in Section 3.4.2 above. It assumes that the reactor has been operating at 100 percent power for 100 days (as specified in NEI 12-06, Section 2) when the ELAP event occurs. During an ELAP event, the containment will begin to heat up and pressurize due to the discharge of the SRVs, leakage from the recirculation system, and the RCIC system exhaust steam as described in the core cooling strategy of Section 3.2.1. Under these conditions and with the employment of the heat removal strategy, Case 18 concludes that the containment parameters of pressure and temperature in the drywell reach maximum values of 29.2 pounds per square inch absolute (psia) and 254 °F and then stabilize or decrease in the first 72 hours following an ELAP-inducing event. Furthermore, it concludes that the pressure in the wetwell reaches a maximum value of 24.9 psia, and the temperature in the wetwell (air space) reaches 186 °F. As stated in the Section 3.4 introduction, each of these values is below their respective UFSAR limit (the air space differential of 1 °F is deemed negligible). The 185 °F design limit for the wetwell (liquid) temperature is calculated to be exceeded by a peak value of approximately 25 °F. A justification for exceeding this temperature limit is discussed in Section 3.4.4.1.1.

During the audit, the NRC staff identified a potentially non-conservative assumption in Case 18 regarding the initial level of the suppression pool. The licensee assumed that the level of the suppression pool was at its Technical Specification maximum value, which would model more heat capacity than what may actually be present. In response, the licensee ran sensitivity Case 19, which assumed the suppression pool level was at its minimum Technical Specification value. This sensitivity case showed that the suppression pool temperature at the time of SPMU initiation was only 2.5 °F higher in sensitivity Case 19 than the Case 18 results with the suppression pool at its maximum level. Given other conservative assumptions in the calculation (i.e. initial suppression pool temperature, margin in the available RHR heat exchanger tube-side flow rate, and the initial SPMU pool temperature), the 2.5 °F difference is negligible regarding the overall success of the proposed strategy to maintain containment functions following an ELAP event.

3.4.4.3 FLEX Pumps and Water Supplies

The capability of the FLEX systems to perform their function with respect to the containment heat removal strategy is discussed in Section 3.2.3.5.

3.4.4.4 Electrical Analyses

For the maintenance of the containment function, the main electrical loads are an SF pump to circulate the suppression pool water through an RHR heat exchanger, and the hydrogen igniters. The cooling water on the tube side of the RHR heat exchanger will be supplied by a diesel-powered FLEX pump. The NRC staff reviewed calculation EAD-FLEXGEN-1, CPS 4306.01P001, "FLEX Electrical Connections," Rev. 0, CPS 4306.01C001, "FLEX Electrical Connection Hard Cards," Rev. 0, conceptual single line electrical diagrams, the separation and isolation of the FLEX DGs from the Class 1E emergency diesel generators, and procedures that direct operators how to align, connect, and protect associated systems and components. Based on the NRC staff's review, the calculations confirmed that one FLEX diesel generator should have sufficient capacity and capability to supply the necessary loads following an ELAP. Refer to Section 3.2.3.6 above for additional analysis.

3.4.5 Conclusions

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

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06, Revision 0, provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of site-specific BDBEEs leading to an ELAP and LUHS.

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

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

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related interim staff guidance in JLD-ISG-2012-01 [Reference 7]. Coincident with the issuance of the order, on March 12, 2012, the NRC staff issued a Request for information Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.54(f) [Reference 19] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in responses to the requests for information and the requirements for Order EA-12-049 and related rulemaking to address beyond-design-basis external events (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated November 21, 2014 [Reference 27]). The Commission provided guidance in a Staff Requirements Memorandum (SRM) to COMSECY-14-0037 [Reference 20]. The Commission approved the staff's recommendations that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly impact the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 45], the NRC staff informed the licensees that the implementation of mitigation strategies should continue, as described in licensee's OIPs, and that the related NRC safety evaluations and inspections will rely on the guidance provided in JLD-ISG-2012-01, Rev. 0 [Reference 7] and the related industry guidance in Revision 0 to NEI 12-06 [Reference 6]. The reevaluations may also identify issues to be entered into corrective action programs consistent with the OIPs submitted in accordance with Order EA-12-049.

The licensee has submitted its flood hazard reevaluation report (FHRR) [Reference 21]. The NRC staff has issued an interim response [Reference 28] to the FHRR and concluded that the licensee's reevaluated flood hazards information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049. The NRC staff also stated that all the reevaluated flood hazard mechanisms at Clinton are bounded by the current design-basis. The licensee developed its OIP for mitigation strategies in February 2013 [Reference 10] by considering the guidance in NEI 12-06 and its design-basis hazards. Therefore, this safety evaluation makes a determination based on the OIP and FIP, and notes that since the design-basis bounds the reevaluated flood hazard, the licensee's mitigation strategies will be sufficient to address the reevaluated flood hazard also.

Per the 50.54(f) letter, licensees were also asked to provide a seismic hazard screening and evaluation report (SHSR) to reevaluate the seismic hazard at their site. The licensee completed an SHSR [Reference 23] in March 2014, and the NRC staff completed an assessment of this report in October 2015. The results are discussed in Section 3.5.1 below. This safety evaluation makes a determination based on the OIP and FIP, and notes the possibility of future actions by the licensee if the licensee's SHSR identifies a seismic hazard which exceeds the current design-basis seismic hazard.

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

3.5.1 Seismic

In its FIP, the licensee stated that seismic hazards are applicable to the Clinton site. In its SHSR, the licensee stated that per UFSAR Section 2.5.2, the safe shutdown earthquake (SSE) peak ground acceleration for Clinton is 0.26 of the acceleration due to gravity (0.26g) peak horizontal ground acceleration at the site's surface elevation of 736 feet. 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 the frequency range that affects structures, such as the numbers above, is often used as a shortened way to describe the hazard.

As previously discussed, the NRC issued a 50.54(f) letter [Reference 19] that requested facilities to reevaluate the site's seismic hazard. In addition, the 50.54(f) letter requested that licensees submit, along with the hazard evaluation, an interim evaluation and actions planned or taken to address the reevaluated hazard where it exceeds the current design-basis.

Based on the results of its SHSR, the licensee determined that the design-basis seismic hazard (the SSE) was higher than the reevaluated seismic hazard except at frequencies above 10 Hz. The licensee stated that it will not need to perform a risk evaluation (1-10 Hz) or a spent fuel pool evaluation, but will perform a high-frequency evaluation. The plant components most susceptible to high frequency vibrations are mostly electrical relays. The EPRI Report 3002000704 [Reference 25], referred to as the Augmented Approach, was developed as the process for evaluating selected critical plant equipment prior to completing plant seismic risk evaluations. The NRC endorsed this report by letter dated May 7, 2013 [Reference 26]. The Augmented Approach outlines a process for responding to the seismic evaluation requested in the NRC's 50.54(f) letter, and provides some guidance for high frequency evaluations. This Augmented Approach provides assurances that FLEX credited equipment (both currently installed and new) would retain function during and after a beyond-design-basis seismic event.

The NRC staff completed its review of Clinton's SHSR, as documented by letter dated October 19, 2015 [Reference 61]. The staff concluded that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, appropriately characterized the site given the information available, and met the intent of the guidance for determining the reevaluated seismic hazard. The staff also concluded that the reevaluated seismic hazard for Clinton is suitable for other activities associated with the NTTF Recommendation 2.1, "Seismic." In reaching this determination, the staff confirmed the licensee's conclusion that the licensee's ground motion response spectrum (GMRS) for the Clinton site is bounded by the SSE in the 1 to 10 Hz range, but exceeds the SSE in a portion of the frequency range above 10 Hz. As such, a seismic risk evaluation and SFP evaluation are not merited, and the licensee is not required to submit an expedited seismic hazard report, however, a high-frequency confirmation is merited. The NRC review and acceptance of the licensee's high frequency confirmation will complete the seismic hazard evaluation identified in Enclosure 1 of the 50.54(f) letter.

As the licensee's seismic reevaluation activities are completed, the licensee will enter appropriate issues into the corrective action program. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

In its FIP, the licensee stated that the design-basis flood results discussed in UFSAR Sections 2.4.3 and 2.4.8 show that runoff into Lake Clinton from heavy rainfall causes a probable maximum flood (PMF) which will raise the lake level at the station site to elevation 708.9 feet. Superimposing the wind wave effect due to a sustained 40 mph wind acting on the PMF water level will result in wave runup elevations of 711.9 feet and 713.8 feet for significant waves and maximum (1 percent) waves, respectively, at the station site. The station's seismic Category I structures with grade elevation of 736 feet will not be affected by the PMF design conditions. The FLEX equipment stored in the FSB located next to the lake at level 701 feet would be affected and will be moved to higher elevations upon receiving warning of rising lake levels.

The flood reevaluation considered the eight flood-causing mechanisms and a combined effect flood required by the 50.54(f) letter. The reevaluation showed a PMF level of 713.3 feet in Lake Clinton, which is bounded by the current design basis (CDB). The reevaluated local intense precipitation (LIP) level of 736.8 feet is also bounded by the CDB. The licensee stated that the CDB bounds the reevaluated hazard for all applicable flood-causing mechanisms, combined-effect floods, associated effects, and flood event duration parameters. The reevaluation of other potentially flood causing mechanisms were either deemed not relevant to Clinton or were bounded by the CDB PMF and LIP.

The NRC staff issued an interim response to the FHRR [Reference 28] and concluded that the licensee's reevaluated flood hazards information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049. The NRC staff then issued a staff assessment of the FHRR [Reference 62], followed by a correction to the staff assessment [Reference 63], documenting the basis for these conclusions. The staff stated that because the reevaluated flood hazard mechanisms at Clinton are bounded by the CDB, it is unnecessary for the licensee to perform an integrated assessment or focused evaluation for external flooding.

In its FIP, the licensee also looked at the possibility for internal flooding and stated that there is the potential that RCIC pump seal leakage could require water removal from the RCIC pump room. Additionally, the control building basement could accumulate seismically induced leakage from fluid systems within the control building, including plant service water, plant chilled water, component cooling water, and cycled and makeup condensate. The licensee stated that it has developed a water removal strategy for the auxiliary building (RCIC room) and control building basements that transfers accumulated water to the unused Unit 2 diesel generator fuel oil storage tank rooms where the potentially contaminated water can be sequestered and prevented from flowing back to Lake Clinton. These large empty rooms serve as a seismically robust storage area for water pumped from the auxiliary and control buildings. Water will be transferred using 120 Vac submersible pumps powered from the portable FLEX power carts stored on the 736 foot elevation of the control building. Temporary hoses and cables will be used to connect the submersible pumps.

During the audit process, the licensee stated that the area subjected to internal flooding which could potentially impact the mitigation strategies is on elevation 702' of the control building where electrical substations 1F and 1G are located. These substations are used to re-energize the SF pumps in Phase 2 to provide makeup to the RPV and to remove heat from the suppression pool. The licensee concluded that the small amount of water intrusion that the substations could experience would not impact the internal bus bars. Re-energizing the bus would still be possible after the occurrence of the design internal flooding event.

The licensee has appropriately screened in this external hazard and identified the hazard levels for reasonable protection of the FLEX equipment.

3.5.3 High Winds

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.

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

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that Clinton is located at 40° 10' 19.5" North latitude and 88° 50' 3" West longitude. In NEI 12-06 Figure 7-2, Recommended Tornado Design Wind Speeds for the 1E-6/year Probability Level indicates Clinton is in Region 1, which corresponds to a recommended tornado design wind speed of 200 mph. Therefore, Clinton screens in for an assessment for high winds and tornados, including missiles produced by these events. Although the licensee did not address the impact of a hurricane in the integrated plan, Clinton is beyond the range of high winds from a hurricane per NEI 12-06 Figure 7-1. The NRC staff concludes that a hurricane hazard is not applicable and need not be addressed.

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 their 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 35^{th} Parallel should provide the capability to address extreme snowfall with snow removal equipment. Finally, all sites except for those within Level 1 and 2 of the maximum ice storm severity map contained in Figure 8-2 should address the impact of ice storms.

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the Clinton site is located at 40° 10' 19.5" North and 88° 50' 3" West. In addition, Clinton is located within the region characterized by EPRI as ice severity level 5 (NEI 12-06, Figure 8-2, Maximum Ice Storm Severity Maps). Consequently, Clinton is subject to severe icing conditions that could also cause catastrophic destruction to electrical transmission lines. The licensee concludes that Clinton screens in for an assessment for snow, ice, and extreme cold hazard. In its FIP, the licensee presented results for maintaining the FSB internal temperatures based on -22 °F outside temperature.

In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the Clinton 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. Central Illinois summers are warm and humid, with periods of extremely hot weather over 100 °F. The Clinton 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 adequately addresses the requirements of the order.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

In its FIP, the licensee stated that Clinton has constructed a single hardened FLEX storage structure of approximately 3,000 square feet that will meet the requirements for the external events identified in NEI 12-06, such as earthquakes, storms (high winds, and tornadoes), extreme snow, ice, extreme heat, and cold temperature conditions. The FLEX storage building is located inside the Protected Area (PA) fence on the southeast portion of the circulating water screen house (CWSH) at elevation 699'-0", over the existing Unit 2 SX pump room foundations at the shore of Lake Clinton. This location does not protect against the PMF flood elevation of approximately 715 feet. The licensee described compensatory actions to be taken during the flood warning period which are discussed in section 3.6.1.2 below.

Portable equipment stored in the FSB include: two trailer-mounted diesel-driven FLEX pumps (N and N+1), two sets of FLEX suction booster pumps (N and N+1), powered from the diesel on the trailer, one trailer-mounted 500 kW, 480 Vac diesel generator (N+1), one diesel fuel transport trailer with a fuel capacity of 500 gallons, one 6.5 kW portable generator used for the FLEX storage building power, two portable fuel transfer pumps, two satellite communications trailers, and one tractor with front loader used as a tow vehicle and for debris removal and other miscellaneous portable debris removal equipment. Additionally, a water distribution manifold, and hoses and cabling for connecting the FLEX equipment are located in the FSB.

FLEX equipment is also located within the PA inside the safety-related Diesel Generator Building. FLEX equipment located in the diesel generator building include: one 500 kW, 480 Vac diesel generator (N, permanently installed), one water distribution manifold (permanently installed) and miscellaneous hoses, cables and tools. Four portable power carts, submersible pumps for water removal, portable fans and various hoses and cables are also stored in the auxiliary building and the control building.

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

3.6.1.1 Seismic

In its FIP, the licensee stated that the FSB consists of a safety-related, cast-in-place floor slab and non-safety-related precast wall and roof panels. The FSB walls and roof are non-safety-related, but are seismically robust per the guidance of NEI 12-06, and are designed according to seismic Category I requirements. New structures located outside the CWSH and FSB, including the vehicle door missile barriers and vehicle deployment ramp, are non-safety-related, but are seismically robust per the guidance of NEI 12-06, and are designed according to seismic Category I requirements.

Large FLEX portable equipment such as FLEX pumps, gantry crane, portable FLEX generator, portable fuel trailer, tractor with front loader, and satellite communications trailers are secured with tie-down straps to floor anchors integrated into the floor slab inside the FSB to protect them during a seismic event.

The primary FLEX 500 kW diesel powered generator is permanently mounted and seismically installed in the Diesel Generator Building, which is a seismic Category I structure. The water distribution manifold is permanently installed on the 762 foot elevation of the DG building and anchored to the floor to prevent movement. The manifold is seismically robust and located such that it is physically separated from non-seismically supported components that could potentially damage the manifold by seismic interaction. The licensee stated that the manifold can withstand an SSE with margin.

3.6.1.2 Flooding

The FLEX equipment stored in the FSB is located on elevation 701 feet and thus is susceptible to flooding. In the event of increasing lake levels, the FLEX equipment stored in the FSB will be moved to an elevation above the expected flood level. In the FIP, the licensee stated that the site is not susceptible to rapidly developing flooding events such as dam failures, seiches and tsunamis. Therefore, a flooding event at Clinton provides adequate warning time to protect equipment in response to an impending flood by moving the FLEX equipment stored in the FSB to higher ground. The FLEX generator located inside the DG building is protected from flooding. The station's seismic Category I structures with grade elevation of 736 feet will not be affected by the PMF design conditions.

3.6.1.3 High Winds

As stated in the FIP, Clinton has constructed a single hardened FLEX storage structure of approximately 3,000 square feet that will meet the requirements for the external events identified in NEI 12-06, such as storms with high winds, and tornadoes. Therefore the FLEX equipment stored in the FSB are protected from high winds, tornados and tornado borne missiles.

During the audit process the licensee stated that the diesel generator, auxiliary, and control buildings are seismically robust buildings and protected from tornadoes and missiles; thus the FLEX diesel driven generator, water distribution manifold and miscellaneous hoses and cables stored in the those buildings are also protected from the high wind hazard.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee stated that the equipment used to support the FLEX strategies is stored either inside the plant or in the FLEX storage building which is protected from snow, ice, and extreme cold in accordance with NEI 12-06, and is temperature controlled. Similarly, the FLEX equipment stored in the DG building is protected from extreme cold and heat in the same manner as all the other equipment stored in the building.

During the audit process, the licensee stated that the FLEX building will have wall mounted electric heaters and will be insulated in order to maintain the building at or above freezing during an outdoor temperature of -22 °F. Two manually controlled exhaust fans with dampers will be installed at openings in the west building wall in order to reduce room temperatures when needed. The FLEX DG is protected from low temperature with a jacket water heater to ensure that it will function during extreme cold temperatures.

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). 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 finds that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment for RPV makeup and core cooling, SFP makeup 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 adequately addresses the requirements of the order.

3.7 Planned Deployment of FLEX Equipment

3.7.1 Means of Deployment

The licensee stated in its FIP that a large tractor with a front end loader is stored in the FSB for equipment hauling and debris removal. Debris removal would be necessary to support deploying the fuel trailer to refuel FLEX equipment or to move the FLEX (N+1) 500 kW DG to near the diesel generator building in the case that the primary FLEX DG, which is permanently staged inside the DG building, becomes unavailable. The Clinton mitigation strategies rely on operating the FLEX pump inside the FSB, with suction through the floor of the FSB, and operating the FLEX diesel generator inside the DG building and thus minimizing the need to clear debris along the haul paths.

3.7.2 Deployment Strategies

The licensee stated in its FIP, that UFSAR Section 2.5.4.8 was reviewed to perform a limited evaluation of the liquefaction potential outside the power block area for aa SSE event. The licensee concluded that there are no liquefaction susceptible soils within the area of the principal structures for a SSE event with a maximum horizontal acceleration equal to 0.26g at the foundation level. Therefore, the likelihood of liquefaction at the site for a SSE event with a maximum horizontal acceleration equal to 0.26g is low.

The licensee further stated that the haul paths from the A1 staging area (FSB location at the lake) to the A2 staging area (south of the diesel generator building) have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

During all BDBEE, except for flooding, the major FLEX equipment is pre-staged and does not require deployment. The FLEX pump in the FSB is stored in its deployed position and only requires connection of hoses. The submersible suction booster pumps are lowered into the lake access hatches inside the FSB using winches. Similarly, the FLEX DG permanently mounted in the DG building only requires connection of portable cables to the electrical riser and portable cables connected from the riser to the relevant motor control centers. In the event the FLEX DG pre-staged in the DG building becomes unavailable, the N+1 DG stored in the FSB will be deployed and staged on the south side of the DG building, and connected to the electrical riser using portable cables.

During an impending flood event, the FLEX equipment will be moved from the FSB to a grade elevation above the PMF level. Plant procedure 4303.02, "Abnormal Lake Level," Rev. 12b, contains steps to relocate the FLEX equipment stored in the FSB. The procedure provides for monitoring the rising lake level and describes measures to be taken based on incremental changes in lake level. At lake elevation 697 feet, which is two feet below the FSB floor elevation of 699 feet, all FLEX equipment stored in the FSB will be moved to higher ground. One trailer-mounted FLEX pump along with its two submersible suction booster pumps will be moved from the FSB and placed along the lakeside road above the flood level. The discharge will be connected with hoses to the FLEX manifold pipe connection located inside the DG building, elevation 726 feet, and the suction booster pumps will be deployed into the lake to provide water to the suction.

The PMF height for Clinton is 713.8 foot elevation; since the FLEX manifold piping taps in at approximately the 726 foot level of the Diesel Generator Building and runs up to the 762 foot level (736 feet is site grade), the manifold is protected from flooding. Debris removal would not be required during the flood warning time as the equipment will be moved from the FSB before flood waters reach the haul paths.

3.7.3 <u>Connection Points</u>

3.7.3.1 <u>Mechanical Connection Points</u>

Preferred RCS Cooling and Suppression Pool Cooling

In its FIP, the licensee stated that its preferred Phase 2 core cooling strategy uses the SF pump, with suction from the suppression pool, to supply water to the RHR steam condensing piping. The SF pump discharge then passes through the shell side of either RHR heat exchanger. The tube side of the RHR heat exchanger is cooled by the SX system being supplied by the FLEX pump taking suction from the UHS. After passing though the RHR heat exchanger, flow can be directed back to the suppression pool to cool the suppression pool, or to the RPV for RPV level control. The SF pump discharge is routed via temporary hose from the 737' level up to the 762' level where it connects to the RHR steam condensing piping. This 6" high temperature hose is pre-staged on the 762' level so it can be deployed down to the 737' level. As described in Table 3.2-1 of the Clinton UFSAR, Rev. 15, the RHR system is a seismic Category 1 system located in the Auxiliary Building and the Containment, so the system is protected from all applicable hazards. During the onsite audit, the licensee stated that the previously abandoned-in-place steam condensing piping was installed during initial construction as safety-related piping. The licensee further stated the only piping change made installed a blank flange to block steam from entering this piping. The licensee provided calculation EMD-025440, "Subsystem 1 RH-07A Piping Analysis," Rev. 3, which showed the RHR piping system is qualified to operate in its required configuration following a BDBEE. The licensee stated that the connecting valves will be manually stroked to verify that they are functional and can be reliably used to implement the containment heat removal FLEX strategy. Furthermore, the staff noted that the steam condensing mode piping design pressures and temperatures exceed the expected temperature and pressure of the suppression pool water that will be circulated through the RHR heat exchanger during an ELAP event. For details related to the robustness of the SF pumps and piping see Section 3.2.3.1.1.

Alternate RCS Cooling

As described in the Clinton FIP date July 15, 2015, the licensee also has a strategy to makeup to the RPV from the UHS using the portable FLEX pump. The FLEX pump discharge is routed to the Diesel Building FLEX manifold, as described below. From the Diesel Building FLEX manifold, cooling water flow can be routed directly to the RPV via hose connection from the FLEX manifold to one of two connection points. The first connection point is in the LPCS system, with flow to the RPV via LPCS Injection Shutoff Valve 1E21-F005. The hose route is located entirely in the Diesel Building and the Auxiliary Building and the LPCS connection is located in the Fuel Building. The second connection point hose route is entirely in the Diesel Building and Auxiliary Building and terminates at the RHR-C LPCI injection header with flow to the RPV via LPCI Injection Spray Valve 1E12-F042C. Both of these valves are outside containment and can be operated manually. As described in the Clinton UFSAR Table 3.2-1, both the RHR and LPCS systems are seismic Category 1 systems. These systems are located in the Auxiliary Building or Containment so they are protected from all applicable hazards.

FLEX Pump Connection

The FLEX pump, which draws on the UHS is pre-staged in the FSB. After a BDBEE the FLEX pump suction booster submersible pumps are lowered into the UHS through access hatches inside the FSB. The discharge of the FLEX pump is connected using hoses to a pipe manifold in the FSB, which is permanently connected to the abandoned Unit 2 shutdown service water pipe. The FLEX Pump discharge connections are inside the FSB and are protected from all hazards except the flood hazard. During a flood event the licensee has sufficient time to relocate the FLEX equipment above the flood level.

During the audit review, the licensee stated that the Unit 2 safety-related SX piping was installed at the same time and to the same standards as the safety-related Unit 1 SX piping. The licensee provided EC 394583, "Fukushima FLEX - Evaluation of Unit 2 Div 2 SX Pipe 2SX02AB Buried Piping Integrity in Support of FLEX Strategies – FLEX Makeup Water," Rev. 0. This evaluation showed the Unit 2 SX piping can withstand all applicable design basis external events. A pressure test of the Unit 2 piping was performed for added assurance that the piping was appropriate for this beyond-design-basis application. The pipe was pressurized with air at 125 psi for 10 minutes in accordance with Clinton Work Order 01684636, "CM 2SX02AB-30" Air Test FUK-FLEX, EC 394583," dated 12/10/13, and no appreciable leakage was identified.

If the Unit 2 SX piping is not available, such as during a beyond-design-basis flooding event, hose will be deployed between the FLEX pump and the Diesel Building FLEX manifold in the plant. Furthermore, the licensee committed to have enough hose to provide a flow path directly from the FLEX pump at the screen house to the FLEX manifold in the Diesel Building, thus if the SX piping fails, the licensee will have another method to deliver water to the FLEX manifold.

The Diesel Building FLEX manifold is located in the DG building so it is protected from the applicable hazards. Furthermore, the licensee performed calculation IP-M-0810, "Piping Analysis of FX Piping in the Diesel Generator Building," Rev. 1, to analyze pipe stresses, displacements, valve accelerations and support loads for FLEX manifold and for the 12" FLEX branch line connecting the existing 30" Unit 2 SX piping to the manifold. The analysis found that the piping would survive a design basis earthquake with the highest stress case using approximately 40% of its allowable stress.

During the audit process, the licensee stated that the FLEX pump will take suction from an existing opening inside the FSB, which is located on the screen house deck. Water will be routed from the UHS to the plant via the unused seismically robust Unit 2 SX piping. This location bypasses the U1 traveling screens and is not susceptible to frazil ice. It is not susceptible to ice blockage since the inlet to the screen house from the UHS is at 670 foot elevation, 5 feet below the design water level of the UHS. There is a warming line to the inlet to the screen house, designed to maintain a minimum water temperature of 40 °F in the winter.

All hose connections are inside the Diesel Generator Building, the auxiliary building, the control building, the spent fuel pool building, and the FSB, all of which are robust structures thus protecting the connections from all hazards.

3.7.3.2 <u>Electrical Connection Points</u>

The Clinton electrical strategy uses a FLEX generator that is permanently installed on elevation 762 feet of the diesel generator building. In its FIP, the licensee stated that a new seismically designed electrical riser consisting of conduit and electrical connection boxes has been constructed in the control building spanning between the 702 and 825 foot elevations. The FLEX generator energizes the electrical riser. Portable cables to make the interconnections are stored in close proximity to the 480 Vac substations that require power following a BDBEE. These substations have been fitted with seismically designed bus inserts. The cables are used to connect the electrical connection boxes on the riser to the bus inserts that will energize the substations.

The primary strategy is to repower the Division 1 equipment and the alternate strategy is to repower Division 2 equipment. All electrical connection points are located in either the auxiliary building or the control building. Both buildings are seismic Category I structures providing protection of the connection points from all hazards. During the onsite audit, the staff observed that portions of the riser system were very close to block walls (control building 762 foot elevation). The licensee stated that these block walls were seismically analyzed and the walls were determined to be structurally adequate for SSE loads and therefore would not fail and damage the panel which is seismically mounted to the floor.

Except for the case where the FLEX DG is unavailable and the N+1 FLEX DG is deployed from the FSB, all electrical connections are made indoors. If the N+1 DG must be deployed, it is staged outside the diesel generator building. Portable electrical cables are used to connect the FLEX generator with the riser. The cables are routed through the robust auxiliary building and control building.

The licensee's electrical strategy includes a primary and alternate method to repower key equipment and instruments utilized in FLEX strategies. Operators in the MCR will decide which strategy to use for core cooling, containment integrity, and SFP cooling.

The electrical connection points in the licensee's strategy are the seismically installed bus inserts in the 480 Vac substations. The electrical path from the FLEX diesel generator to the primary or alternate connection points consists of a combination of seismically robust conduit and connection boxes (riser), and cables stored on reels in seismically robust cabinets (except Control Building 825' elevation, which has reels but not cabinets). The location of the cable reels was chosen to facilitate cable deployment between the riser and the substations that need to be energized.

The licensee's electrical strategy requires the deployment of nine (9) 4/0 cables (three per phase), located on reels inside fixed storage cabinets between the FLEX DG in the Diesel Generator Building and electrical panel 1FX01E in the adjacent Control Building on the same elevation. There are three reel cabinets in the Diesel Generator Building that contain the cables that connect to the FLEX DG. These cables are routed through a rollup door that separates the two buildings. Three reel cabinets in the Control Building contain the cables that connect to 1FX01E and to the cables routed from the FLEX diesel generator. For specific details of the electrical cable deployment pathways, see the primary and alternate strategy discussion in Section 7.1, "Electrical Strategy," of the licensee's FIP.

3.7.4 Accessibility and Lighting

A lighting review by the licensee evaluated the lighting available to make required piping and electrical connections, perform instrumentation monitoring and the associated travel paths to the various areas. The licensee stated in the FIP that battery powered (Appendix "R") emergency lights, backed up by LED hard hat lamps and battery operated LED lights, provide adequate lighting for all primary connection points in the BDBEE strategies. The Appendix "R" emergency lights are designed and periodically tested to ensure the battery pack will provide a minimum of 8 hours of lighting with no external ac power sources.

Once the FLEX generator has repowered portions of the vital 480 Vac system, standby lighting cabinets (SLC) in Division 1 or Division 2 will light large areas of the plant. The primary (Division 1) electrical strategy will energize an SLC that lights the control and diesel generator buildings, and the alternate (Division 2) electrical strategy will energize an SLC that lights the auxiliary and fuel buildings. The LED tripod lights are staged in the FLEX DG room to provide additional lighting during Phases 2 and 3.

The trailer-mounted FLEX pumps in the FSB have battery operated "Scene Lights" which provide sufficient lighting in the FSB to support the UHS water supply strategy.

3.7.5 Access to Protected and Vital Areas

The licensee has contingencies in place to provide access to areas required for the ELAP response if the normal access control systems are without power.

3.7.6 Fueling of FLEX Equipment

In its FIP, the licensee stated that the general coping strategy for supplying fuel oil to diesel-driven FLEX equipment is:

1) maintain the FLEX equipment fuel tanks at least 80% full while in storage,

2) maintain a 500 gallon reserve in the trailer-mounted fuel tank stored in the FSB,

3) replenish supplies with fuel stored in an installed emergency diesel generator fuel oil storage tank (FOST).

Fuel is obtained from the FOST by re-powering the installed emergency diesel generator fuel oil transfer pump and pumping fuel oil to the associated emergency diesel generator day tank. A pre-staged portable 120 Vac fuel transfer pump can take suction from the day tank by removing a flange on the top of the day tank and routing a pre-staged suction hose into the day tank. The discharge of the portable fuel transfer pump is routed outside to the south side of the diesel generator building through an engineered port in the diesel generator building outside wall. A pre-staged tee is connected to the hose outside.

The installed emergency diesel generator fuel oil transfer pump is supplied from an MCC that is repowered by the FLEX generator. The portable 120 Vac fuel transfer pump is powered from one of the four portable power cart assemblies located within the plant to provide a power supply for low voltage portable equipment.

The FLEX diesel-driven pump used to supply makeup and cooling water to the plant is stored in its final deployment location, inside the FSB. The trailer-mounted pump has an installed 400 gallon fuel tank. A trailer-mounted 500 gallon fuel tank with a 12 Vdc fuel transfer pump is also stored inside the FLEX storage building. The FLEX pump will run on its stored fuel and then be refueled from the fuel trailer. Once the fuel trailer contents have been pumped to the FLEX pump fuel tank, the fuel trailer will be attached to a towing vehicle and deployed to the south side of the diesel generator building and filled using a hose attached to the pre-staged tee. The fuel trailer would then be returned to the FLEX storage building to refuel the FLEX pump. CPS 4306.01P008, "FLEX Diesel Oil Supply," Rev. 0, contains refueling instruction for the FLEX equipment.

The FLEX generator in the diesel generator building is refueled by deploying a fuel hose from the FLEX generator room on the 762 foot elevation of the diesel generator building to outside grade level. The hose is attached to the pre-staged tee and refueling of the generator can occur as needed through the remainder of the BDBEE.

The plant Technical Specifications requires that each emergency diesel generator FOST contain at least a 7 day supply of fuel oil. The licensee stated that the fuel oil level equivalent to a 7 day supply at the maximum post-loss-of-coolant accident load demand for the Division 1 diesel generator is 51,000 gallons (primary strategy), for the Division 2 diesel generator is 45,000 gallons (alternate strategy). The quantity of fuel oil required in the FLEX mitigation strategy can be provided from one of these FOSTs for well over 30 days. The Emergency Response Organization would be able to transfer fuel oil, if needed, from the opposite division, and another 29,500 gallons of fuel oil in the Division 3 storage tank could be used as well. It is expected that the emergency response organization can ensure delivery of replenishment fuel as required within the times identified above.

The portable fuel transfer pump is capable of 10 gallons per minute (gpm) flow. It would take one hour (conservatively) to refill the fuel trailer from the diesel generator day tank. The fuel trailer dc pump can deliver 25 gpm. It would take one-half hour (conservatively) to refill the FLEX pump assuming it was nearly empty. The FLEX pump can run fully loaded with an 80 percent full tank for 12.5 hours. Given that the FLEX generator can be refueled without the use of the fuel trailer, these delivery rates are well above the full load usage rate of all FLEX Phase 2 portable equipment.

The licensee stated that the estimated fuel oil consumption for the FLEX pump at full load is 25.4 gallons per hour and for the FLEX generator at full load is 34.4 gallons per hour. The FLEX haul vehicle, three 5.5 kW generators used for communications equipment and the 6.5 kW generator used for FLEX storage building backup power represent a negligible added fuel usage on the FLEX refueling strategy.

During the onsite audit, the licensee stated that the quality of fuel stored in the FLEX equipment will be confirmed through a periodic testing program. Additionally, the staff walked down the refueling strategy with licensee representatives.

3.7.7 Conclusions

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

3.8 Considerations in Using Offsite Resources

3.8.1 Clinton SAFER Plan

There are two National SAFER Response Centers (NSRCs) (Memphis area and Phoenix area) established to support nuclear power plants in the event of a BDBEE. In its FIP, the licensee stated that it has established contracts with Pooled Equipment Inventory Corporation (PEICo) to participate in the process for support from the NSRCs as required. Each NSRC holds five sets of equipment, four of which will be able to be fully deployed to Clinton when requested. The fifth set allows removal of equipment from availability to conduct maintenance cycles. In addition, Clinton BDBEE equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

By letter dated September 26, 2014 [Reference 23], the NRC staff issued its staff assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER response plans to meet the Phase 3 requirements of Order EA-12-049.

3.8.2 Staging Areas

In its FIP, the licensee stated that in the event of a BDBEE and subsequent ELAP/LUHS condition, equipment will be moved from an NSRC to a local assembly area designated as Staging Area "C". For Clinton, Staging Area "C" is the Decatur Illinois Airport. From there, equipment would be taken by ground transportation to the Clinton site and staged at Staging Area "B", which is located outside the protected area on the north end of the plant. Equipment can be delivered from Staging Area "C" by helicopter if ground transportation is not possible. The licensee stated that communications will be established between the Clinton site and the SAFER team via satellite phones and required equipment would be moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. The order at which equipment is delivered is identified in the Clinton SAFER Response Plan documented in procedure CC-CL-118-1001.

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 adequately addresses 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 Clinton, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The key areas identified for all phases of execution of the FLEX strategy activities are the RCIC Pump Room, Main Control Room (MCR), Battery Rooms, NSPS Inverter Rooms, and Containment.

The licensee's Phase 1 core cooling FLEX strategy relies on the RCIC pump as the motive force for providing water to the RPV. The FIP states that procedure 4306.01P010, "FLEX Ventilation," Rev. 0, "FLEX Equipment Staging," directs personnel to open the doors to the RCIC pump room within 6 hours of the initiating event. In addition, the procedure directs personnel to install a temporary portable ventilation fan, and the RCIC room cooler and supply fan is repowered as part of the licensee's Phase 2 FLEX strategy. During the onsite portion of the audit, the licensee provided the staff with calculation 2013-01301, "Transient Analysis of RCIC Pump Room for Extended Loss of AC Power", Rev. 0. The calculation showed that, both with and without the RCIC gland seal compressor running, if the doors to the RCIC instrument room and the RCIC pump room were opened at 42 hours after the ELAP event and a portable fan is placed to provide 9500 cubic feet per minute (cfm) of air flow to the room at 59.5 hours, then each of the rooms remained below their 145 °F limit. Based on these licensee documents, and the procedures for opening up RCIC pump room doors and setting up portable exhaust fans, the staff finds it reasonable that the RCIC pump will remain available during an ELAP event with loss of normal ventilation.

During the onsite audit, the licensee also provided information regarding the heat-up of the LPCS pump room, Auxiliary Building 707', which contains the suppression pool clean-up (SF) pumps. The licensee stated that during an ELAP the only source of heat addition to the room would be the operation of the SF pumps. The licensee also stated that the SF pumps are rated for a pumped fluid temperature of 250 °F, and the current MAAP analysis showed a maximum suppression pool temperature of 210 °F. The licensee also stated that room access doors may be propped open as required during an ELAP event.

During the audit, the licensee stated that the FLEX generator room in the Diesel Generator Building will have its own heating, ventilation, and air conditioning (HVAC) to maintain acceptable temperatures. The licensee stated that the FLEX generator is air-cooled, and no supplemental cooling is required with the radiator operating properly. The licensee also stated that per EC 392335, "Fukushima FLEX Internal Generator 480 VAC Connections Required to Support NRC EA-12-049 FLEX Response," a supplemental fan was included in the construction of the FLEX generator room that will circulate air in the room and exhaust additional air from the room to maintain margin to the 122 °F maximum operating temperature for the FLEX diesel generator.

During the audit, the licensee discussed the design and procurement of FLEX equipment regarding the ability to operate in a high temperature environment. The licensee also stated that the FLEX equipment operated outdoors is designed to operate over the outdoor temperature range of -22 °F to 112 °F, which are the site temperature extremes per the Clinton UFSAR, Rev. 15, Table 2.3-1.

The NRC staff reviewed calculation 3C10-0390-001, "Main Control Room Temperature Transient Following Station Blackout," Rev. 0, which modeled the MCR temperature transient when all MCR cooling is lost due to an SBO event. The MCR temperature reaches a peak value of 119 °F at a time of 30 minutes after the onset of an SBO. A portable exhaust fan is then turned on and MCR temperature reduces to approximately 110 °F and stays at approximately 110 °F for the duration of an SBO event. Calculation IP-M-0409, "Main Control

Room Temperature Rise During Station Blackout (SBO) Based on Temperature Survey," Rev. 0, determined that the MCR temperature would be 107 °F for SBO conditions based on actual temperature data obtained when both trains of the control room HVAC were off and with no exhaust fan assumed to operate.

Based on the above, the NRC staff finds that using the exhaust fan during an ELAP should keep MCR temperature less than 110 °F. Deployment of the exhaust fan is covered by plant procedure CPS 4200.01, "Loss of AC Power," Rev. 0, for a Station Blackout or FLEX Support Guide CPS 4306.01P010, "FLEX Ventilation," Rev. 0, if the event is determined to be an ELAP. The licensee's FLEX strategy modified the SBO strategy by substituting an ac-powered fan for the gasoline-powered fan used in the SBO strategy. The ac fan can be powered from the same portable generator staged in the MCR area for the satellite phones, or from a power cart.

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

Calculation VX-50, "Inverter Room Heatup and Battery Room H2 Generation Following a BDBEE," Rev. 1, modeled the primary strategy (Division 1) with the assumption that the battery room exhaust fan and battery charger are repowered after 8 hours instead of the expected 5.5 hours. Based on the analysis, the 1A1 Battery room has a final temperature of 112 °F at the end of a 100 hour run. The 1B1 Battery room has a final temperature of 125.5 °F at the end of a 100 hour run. The 1B1 Battery is not credited in the primary strategy.

The licensee modeled the alternate strategy (Division 2) in the same calculation using the same assumptions. In the alternate strategy the swing battery charger is supplying the Division 1 dc bus. The 1A1 Battery room has a final temperature of 117 °F at the end of a 100 hour run. The 1B1 Battery room had a final temperature of 115.5 °F at the end of a 100 hour run.

The Clinton Division 1 and Division 2 safety-related batteries were manufactured by C&D Technologies. The qualification testing performed by C&D Technologies demonstrated the ability to perform under elevated operating temperature environments. The testing results indicate that the battery cells will perform as required in excess of 200 days under an estimated 122 °F operating temperature as identified in calculations VX-49, "Room Heatup Analysis in the Control and Auxiliary Buildings (El. 781') in the Event of a Design Basis Accident," Rev. 1, and VX-50 (described above).

The elevated temperature also has an impact by increasing the charging current required to maintain the float charging voltage set by the charger. The elevated charging current will in turn increase cell water loss through an increase in gassing. Based on guidance in the EPRI Stationary Battery Guide: Design, Application, and Maintenance: Revision of TR-100248, the electrolyte level will reach the top of the Division 1 battery cell plates in 56 days and the Division 2 battery cell plates in 45 days. Based on this, periodic water addition will be required or the float charging voltage reduced per the guidance contained in the C&D Technologies vendor manual. If battery cell plate uncovery were to occur, failure issues associated with plates being exposed would involve the potential development of sulfation and a subsequent reduction in capacity. If loss or failure of a battery string were to occur, the battery charger has the capability to carry the anticipated loads indefinitely provided ac power remains available to power the charger.

The temperature transient calculated in VX-50 (106 °F) is bounding for both Division 1 and Division 2 NSPS Inverter Rooms. The maximum temperature expected in this room for a Design-Basis Accident (DBA) event is 122 °F. Per the strategy assumed by this analysis, operators will open the Division 1 and Division 2 NSPS Inverter Room doors and power portable fans 8 hours after the occurrence of an ELAP event. The fans must have a 10,000 cfm or greater total capacity in order to maintain habitable conditions in the Division 1 and 2 NSPS Inverter Rooms, based on the results of this analysis. The fans draw air from the Unit 2 side of Control Building elevation 781' via staged flexible duct to ensure a sufficient reservoir of cool air. Should an NSPS inverter fail, power to NSPS distribution panels could be readily restored by using the FLEX generator to power 480 Vac buses and bypass the inverter.

The licensee issued EC 401985, "EQ Review of FLEX Components in the Containment and Drywell," to show that the electrical equipment in containment will function in the high temperature environment for as long as it is needed to provide the FLEX function. The NRC staff's review focused on the actuators for the SRVs and the RPV level instruments.

As part of its evaluation, the licensee reviewed equipment subjected to FLEX post BDBEE ambient conditions in the drywell and containment (i.e. wetwell) to assess the functionality of the selected instruments/devices under elevated temperatures and pressures for an extended duration. The selected devices are those that FLEX strategies depend on to be functional after a BDBEE. These FLEX ambient conditions are, in some aspects, somewhat more severe than the DBA conditions that the equipment was originally qualified for.

The licensee's evaluation showed that the equipment meets the required DBA conditions, but also have shown capabilities, either through testing or analysis, that exceed those conditions and can be expected to perform their required functions under post beyond design basis conditions for an extended period of time.

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

3.9.1.2 Loss of Heating

In NEI 12-06, Section 3.2.2, guideline (12) states that heat tracing is used at some plants to ensure cold weather conditions do not result in freezing important piping and instrumentation systems with small diameter piping. In the Clinton FIP, the licensee stated that no outside staged equipment is credited for FLEX that would need heat tracing to prevent freezing.

In calculation 2013-01301, "Transient Analysis of RCIC Pump Room for Extended Loss of AC Power", Rev. 0, the licensee states that it is expected that the initial temperature in the RCIC pump room would be approximately 90 °F. Operation of the RCIC pump involves steam flow through the turbine and associated piping. The RCIC pump is located in a temperature-controlled area and is relied upon immediately at the start of ELAP event. The staff finds it reasonable that low outside temperatures would not have an adverse effect on the RCIC pump because of its location in a temperature-controlled area, steam flow through the components provides a heat load, and the components are in use early in the ELAP event.

The licensee stated during the audit process that the FLEX equipment operated outdoors is designed to operate down to the minimum temperature of -22 °F. During the audit, the licensee provided EC 392343, "Fukushima FLEX Install a Seismic Storage Building Including Electrical," Rev. 0, which states that the FLEX building will be designed to maintain the FLEX equipment functional with an outdoor temperature as low as -22 °F prior to the BDBEE.

The battery rooms are in the interior of the Auxiliary Building and the battery rooms are normally maintained at approximately 77 °F. In the event of an ELAP, the battery room temperatures are expected to rise with loss of ventilation. Therefore, reaching the minimum pilot cell temperature limit of 65 °F is not expected.

Based on its review of the licensee's battery room assessment, the NRC staff finds that the Clinton safety-related batteries should perform their required functions at the expected temperatures as a result of loss of heating during an ELAP event, and that the FLEX equipment should also perform its required function.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. The licensee's ventilation strategy is to repower the battery room exhaust fans during Phase 2. The licensee's procedures also identify an alternative ventilation strategy to open the battery room doors and use portable fans. Each of the licensee's ventilation strategies are adequate to limit the hydrogen concentration in the battery rooms to less than 2 percent, which is less than the combustible limit for hydrogen gas.

The NRC staff reviewed the licensee's calculation, VX-050, "Inverter Room Heatup and Battery Room H2 Generation Following a BDBEE," Rev. 1, to verify that hydrogen gas accumulation in the vital battery rooms will not reach combustible levels while HVAC is lost during an ELAP.

Based on its review of the licensee's calculation, the NRC staff concluded that hydrogen accumulation in the safety-related battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP since the licensee plans to repower the battery room exhaust fans when the battery chargers are repowered during Phase 2, or initiate an alternative ventilation strategy.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

During the audit, the licensee provided a copy of 3C10-0390-001, "Rev to EC 334887 Extended Power Uprate – Deferred Calcs and Documents," Rev. 1. This calculation concluded that, when the mitigating actions of opening and closing specified doors in conjunction with starting an exhaust fan and opening cabinet panels, the Main Control Room temperature peaks at 119 °F, and quickly decreases and stabilizes at approximately 107 °F. The licensee stated that a toolbox approach,(e.g. rotation of personnel), would be employed if further actions were required to ensure that operators could carry out the overall mitigation strategy. The licensee's procedure, CPS FSG 4306.01P010, "FLEX Ventilation," Rev. 0, directs the operators to take the appropriate actions corresponding with the analysis assumptions.

3.9.2.2 Spent Fuel Pool Area

See Section 3.3.4.1.1 above for the detailed discussion of ventilation and habitability considerations in the SFP Area. In general, the licensee plans to complete hose deployment and spay nozzle setup on the SFP refueling floor before conditions degrade to the point that it affects habitability, due to boiling in the SFP. The licensee also has the ability to add water to the SFP from the service water header emergency makeup supply line without going on the refueling floor.

3.9.2.3 Other Plant Areas

FLEX Storage Building (FSB)

The trailer-mounted, diesel-powered FLEX pump will be operated inside the FSB (the water suction is through the floor of the FSB). In Engineering change EC 392343, "Fukushima FLEX Install A Seismic Storage Building Including Electrical," Section 1 (Specifics of Change), identified that 2 manually controlled exhaust fans with dampers will be installed at openings in the west building wall of the FSB in order to reduce room temperatures when needed and provide fresh air changes for ventilation of hazardous fumes during operation of the diesel-powered pumps. Two gravity backdraft dampers will be installed at openings in the east building wall in order to provide intakes for fresh air. The licensee stated no ducting will be required for the ventilation system. Weather hoods will be installed over air intake and exhaust openings. The ventilation openings will be protected from tornado missiles in order to protect the FLEX equipment inside the building. The exhaust fans will be powered by a small FLEX generator located in the FSB. Should the ventilation system fail and the FLEX pump need to operate near the UHS access hatches, the licensee stated during the audit that the FLEX pump will be moved onto the roadway outside the FSB prior to operating the diesel-powered pump.

Diesel Generator Building

The FLEX diesel generator permanently located on the 762' elevation of the Diesel Generator Building has a fan in the diesel exhaust air ducting which forces the exhaust gases outside the building through louvers in the room housing the generator. Doors are blocked open to allow outside air to flow into the FLEX diesel generator room from louvers in the adjacent unused Unit 2 fan room. This should prevent the buildup of hazardous fumes during operation of the generator.

3.9.3 Conclusions

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

3.10 Water Sources

3.10.1 Reactor Coolant System Make-Up

Phase 1

In its FIP, the licensee stated that the preferred source of RPV makeup in Phase 1 is the RCIC pump with suction from the suppression pool. While using RCIC to supply water to the RPV, makeup travels through the common ECCS suction strainer, preventing solids >3/32" from being injected. Per the Clinton UFSAR, Table 3.2-1, Rev. 15, the RCIC system (except for the RCIC storage tank) is seismic Category I, as is the suppression pool, the auxiliary building and the containment. The RCIC system is located in the auxiliary building and the containment. The suppression pool is located in the containment. This provides assurance that the RCIC system, taking suction from the suppression pool, will be available during a BDBEE.

Phase 2 and 3

When the RCIC pump becomes unavailable, suppression pool water remains the preferred source and is provided to the RPV by the SF pumps. Suppression pool water is pumped through an RHR heat exchanger shell side using an SF pump and part of the flow can be aligned to the RPV through the low pressure coolant injection valve. The SF pump suction strainer prevents solids >1/8" from entering the RPV.

The licensee stated that the suppression pool offers a relatively clean source of makeup water to the RPV, first using the RCIC pump and later from the SF pump operating in a suppression pool cooling mode. At the beginning of the event, the suppression pool is near reactor quality water. At about 5.5 hours into the event, water from the upper containment pool (which is also high quality water) is drained to the suppression pool. Once the FLEX pump is available, water addition from the UHS will be used to maintain suppression pool level due to RCS leakage into the drywell. This will degrade suppression pool water quality, but the suppression pool will remain a favorable water source. The licensee's calculations, as stated in the FIP, show that the amount of UHS makeup water should not exceed 16% of the volume of the suppression pool over the first 72 hours. Lake water added to the suppression pool will also pass through FLEX strainer boxes that preclude objects larger than 7/16" from entering the FLEX submersible pump. Furthermore, debris added to the suppression pool will have an opportunity to settle out in the relatively large suppression pool volume rather than being piped directly into the RPV.

An alternate method for RPV makeup in Phase 2, which is only used if the methods above are not available, is from the UHS using the FLEX pump located in the FSB. Water from the UHS is supplied to the FLEX manifold in the DG building and aligned to either the LPCS or RHR-C header connection points for injection to the RPV. As described in Clinton FSAR, Rev. 15, Table 3.2-1, the UHS is a seismic Category 1 structure. The normal elevation of Clinton lake is 690 feet. The UHS has a surface elevation of 675 feet created by a submerged dam, with a volume of 1054 acre-feet. The UHS is a submerged section of Lake Clinton which is only visible if the main dam fails, resulting in lowering water levels. As the UHS is a seismic Category I structure and is not susceptible to hazards such as tornadoes, it should be available as a water source for the events considered in this safety evaluation.

During the audit process, the NRC staff identified a concern regarding the potential for inadequate core cooling due to blockage of the fuel assemblies due to the suspended and dissolved solids in the raw lake water. The licensee stated that once RCIC is no longer available, the Clinton core cooling strategy uses makeup to the RPV from the suppression pool using the SF pump and the LPCI flow path that is available while in the FLEX suppression pool cooling lineup. The LPCI injection point is inside the RPV core shroud, which allows flooding of the fuel assemblies from the top, if the bottom nozzle area becomes clogged. While some degradation of suppression pool water quality will occur due to maintaining the suppression pool level with lake water, the quality of the suppression pool water will be significantly better than raw lake water.

The licensee further stated that in March 2014, the Boiling Water Reactor Owners Group (BWROG) Fukushima Response Committee issued report BWROG-TP-14-006, "Raw Water Issue: Fuel Inlet Blockage from Debris." This report concluded that, "BWR fuel can be adequately cooled when the core inlet is postulated to be fully blocked from debris injected with the makeup coolant. The fuel is effectively cooled when the inside shroud is flooded, and this is accomplished by either injecting makeup coolant inside the shroud or by maintaining the water level above the steam separator return elevation if injecting makeup in the downcomer." If alternate RPV makeup must be used at Clinton, injection is directly to the RPV from the FLEX pump taking suction on the UHS, and the injection points are LPCI injection or LPCS injection which both inject inside the shroud.

Recently approved changes to the BWROG Emergency Procedure Guidelines/Severe Accident Guidelines (EPG/SAG) support the development of procedural direction to maintain reactor water levels above the steam separator return elevation if needed, which allows for spill-over of water from outside the core shroud to inside the core shroud.

Another issue with the use of raw water injection is that, as a result of boiling in the core, dissolved and suspended solids could precipitate or settle out on the surface of fuel pins and/or lower regions of the core, thereby degrading heat transfer or restricting coolant flow passages. Although not specifically analyzed for Clinton, Exelon has performed analysis for its PWRs that evaluates the degradation of heat transfer in steam generators by the same fouling mechanisms. In the worst case, the analysis determined that a deposition of approximately 6 cubic feet of debris occurs in a 72-hour period in a steam generator. The resulting heat transfer degradation from the effective reduction in U-tube surface area from deposited solids and the buildup of scale caused by the boiloff of raw water was calculated to be 6.2%. This level of degradation is well below the threshold at which heat transfer capacity is effectively lost. The licensee determined through a qualitative comparison that a similar conclusion (that heat transfer capacity would not be severely degraded) should apply to Clinton. Based on the above, the licensee has concluded that use of raw water for FLEX strategy implementation at Clinton during an ELAP will not inhibit adequate core cooling for at least 72 hours.

Clinton's procedural guidance prioritizes the use of higher quality water sources. A clean but non-robust RCIC storage tank is referenced in the FLEX Support Guide 4306.01P005, FLEX RCIC Operation, as a water source for RPV makeup. The operators can use this water source if it is available, but per NEI 12-06 it cannot be assumed to be available as it is a non-robust source.

NRC staff agrees the FLEX strategy provides adequate time for the licensee to make arrangements for water filtration units or recovery methods with reduced reliance on raw water for RPV makeup, and therefore preclude core blockage and fuel plating from adversely impacting core cooling. For both the primary and alternate core cooling strategies, further arrangements may be necessary for extended coping, and should be considered as an ELAP event progresses.

The NRC staff considered the relative cleanliness of the primary water source and the analysis provided above, and the fact that sufficient instrumentation will be available to the operators to confirm an adequate RPV water level for the analyzed ELAP event, and concluded that the licensee has an acceptable strategy to provide makeup water to the RPV.

3.10.2 Suppression Pool Make-Up

Initial makeup to the suppression pool will be from draining the upper containment pool to the suppression pool once the dump valves are repowered. Additional makeup to the suppression pool will be from the UHS in order to compensate for RCS leakage which stays in the drywell basement. A temporary hose from the FLEX manifold in the DG building to the LPCS header or the RHR-C header can supply UHS water as needed to the suppression pool using the LPCS test return to suppression pool valve or the RHR-C test valve to the suppression pool. These two valves are located outside the primary containment and can be operated manually with the hand wheel or electrically via the FLEX generator. See Section 3.10.1 for specifics on the UHS. The licensee determined that approximately 187,000 gallons of lake water are added to the approximately 1,174,000 gallons of relatively clean suppression pool water during the first 72 hours of the event. This will result in less than 16 percent "contamination" of the suppression pool water.

3.10.3 Spent Fuel Pool Make-Up

Makeup to the spent fuel pool is from the UHS in all three phases of the BDBEE. See Section 3.10.1 for specifics on the UHS. Makeup is provided via hoses directly into the pool, or using spray nozzles on the refueling floor, or through the seismically qualified emergency makeup line to the SFP from either the Division 1 or the Division 2 SX supply header.

3.10.4 Containment Cooling

Water makeup to the containment will be to the suppression pool as described in Section 3.10.2 above. Containment cooling will be accomplished by running an SF pump in a suppression pool cooling lineup using the RHR heat exchanger, with the tube side of the RHR heat exchanger cooled by lake water, as described in Section 3.4.2 above.

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 adequately addresses the requirements of the order.

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on a BDBEE occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the BDBEE occurs with the plant at power, the mitigation strategy initially focuses on the use of a pump coupled to a steam-powered turbine to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 38 hours are available to implement makeup before boil-off results in the water level in the SFP dropping to the top of the fuel racks, which is close to uncovering 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 a steam-powered pump such as RCIC (which typically occurs when the RCS has been cooled below about 300 °F), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes" [Reference 30], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 31], the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

The position paper provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. The NRC staff concludes that the position paper provides an acceptable approach for demonstrating that the licensees are capable of implementing mitigating strategies in shutdown and refueling modes of operation. In its FIP, the licensee stated that it plans to follow the guidance in this position paper.

During the audit process, the licensee referenced the Exelon Position Paper, EXC-WP-03, "FLEX Guidance for Shutdown/Refueling Modes," Rev 1, which includes use of a defense in depth approach to outages and will take risk appropriate steps in preparation for outages. The licensee stated that its approach is fully consistent with the NEI position paper on shutdown/refueling modes and the NRC endorsement letter of the NEI position paper.

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

3.12 Procedures and Training

Procedures

In its FIP, the licensee stated that the FLEX strategy support guidelines have been developed in accordance with BWROG guidelines. FLEX Support Guidelines (FSGs) will provide available, pre-planned FLEX strategies for accomplishing specific tasks in the Emergency Operating Procedures (EOPs). The licensee stated that 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 plant procedure Clinton 4306.01 "Extended Loss of AC Power / Loss of Ultimate Heat Sink" to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Clear criteria for entry into FSGs will ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to accomplish FLEX strategies or supplement EOPs, the ELAP flowchart, EOP, Severe Accident Mitigation Guidelines, or Extreme Damage Mitigation Guidelines will direct the entry into and exit from the appropriate FSG procedure.

Training

In its FIP, the licensee stated that Clinton's Nuclear Training Program has been revised to assure personnel proficiency in the mitigation of BDBEEs is adequate and maintained. These programs and controls were developed and have been implemented in accordance with the Systematic Approach to Training (SAT) Process.

Using the SAT process, Job and Task analyses were completed for the new tasks identified applicable to the FLEX mitigation strategies. The licensee stated that based on the analysis, training for Operations was designed, developed and implemented for Operations continuing training. "ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training" certification of simulator fidelity is considered to be sufficient for the initial stages of the BDBEE scenario training. Full scope simulator models have not been explicitly upgraded to accommodate FLEX training or drills. Overview training on FLEX Phase 3 and associated equipment from the SAFER NSRCs was also provided to station operators. Upon SAFER equipment deployment and connection in an event, turnover and familiarization training on each piece of SAFER equipment will be provided to station operators by the SAFER deployment/operating staff.

The licensee stated in its FIP that initial training has been provided and periodic training will be provided to site emergency response leaders on beyond-design-basis (BDB) emergency response strategies and implementing guidelines. Personnel assigned to direct the execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints.

The licensee further stated that where appropriate, integrated FLEX drills will be conducted periodically; with all time-sensitive actions evaluated over a period of not more than 8 years. The licensee asserted that it is not required to connect/operate temporary/permanently installed equipment during these drills.

Therefore, the NRC staff finds that the licensee has adequately addressed the procedures and training associated with FLEX because the procedures have been issued and a training program has been established and will be maintained in accordance with NEI 12-06, Section 11.6.

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter dated October 3, 2013 [Reference 32], which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 33], the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs. Preventative maintenance templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued.

In its FIP, the licensee stated that periodic testing and preventative maintenance of the FLEX equipment conforms to the guidance provided in Institute of Nuclear Power (INPO) AP-913. In NEI 12-06 Section 11.5 endorses the guidance of INPO AP 913, "Equipment Reliability Process," and the EPRI associated bases to define site specific maintenance and testing. The licensee stated that a fleet procedure has been developed to address preventative maintenance (PM) using EPRI templates or manufacturer provided information/recommendations, equipment testing, and the unavailability of equipment.

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

3.14 Alternatives to NEI 12-06, Revision 0

3.14.1 FLEX Electrical Distribution

In its FIP, the licensee identified the Clinton electrical strategy as an alternative strategy. This includes the use of a new permanently installed FLEX diesel generator and FLEX electrical distribution (riser). This DG is seismically installed on elevation 762 feet in the diesel generator building. The licensee stated that the FLEX DG will power equipment used in the Phase 2 FLEX strategies through a new seismically installed FLEX electrical riser system and temporary, portable electrical cables from the riser system to the existing electrical distribution system. The FLEX electrical riser system is used to power necessary equipment by connecting electrical cables from the riser system to the necessary buses or equipment. This is an alternative from the guidance in NEI 12-06, Revision 0, Section 3.2.2. The licensee identified this as an alternative approach due to the reliance on a single permanently installed plant structure (i.e., the electrical riser system) and components (a pre-staged diesel generator) in lieu of reliance on deployment and alignment of a portable generator to accomplish ELAP mitigation through primary and alternate connections.

The location of the FLEX generator in the DG building and the location of the FLEX electrical riser system in the control building protects them from each of the hazards delineated in NEI 12-06. The decision to install the generator in the DG building provides the operators with fewer challenges in implementing the electrical strategy. The licensee stated that the containment cooling strategy for Clinton requires 480 Vac power at 5.5 hours after the event in order to energize the dump valves which will be used to drain the upper containment pool to the suppression pool. It also requires placing suppression pool cooling in service within 8 hours after the event, by using the FLEX generator to power an SF pump to circulate the suppression pool water and a FLEX pump to supply UHS water to an RHR heat exchanger. Installing the generator and riser allows resources to be applied to establishing the required electrical and mechanical lineups that would otherwise be used deploying the generator from a remote location. The licensee does have a backup (N+1) FLEX generator in the FSB, which can be moved next to the DG building and used to energize the FLEX electrical riser using portable cables. The licensee also has identified primary and alternate buses and equipment to be powered from the FLEX riser. Due to the robust installation of the FLEX generator and the FLEX electrical riser and their protection from all applicable hazards, the NRC staff approves this alternative as being an acceptable method of compliance with the order.

3.14.2 FLEX Water Distribution

In its FIP, the licensee identified as an alternative strategy, the use of FLEX water manifolds in the FSB and in the DG building. The FLEX water manifold in the FSB allows for either of the diesel-driven FLEX pumps located in the FSB to provide water into the unused Unit 2 SX supply line, which carries the water from the FSB to the plant. The FLEX manifold in the DG building has hose connections to route the water from the SX supply line to those components that need water, such as RPV makeup, SFP makeup, and suppression pool makeup. If the SX supply line is not available, the licensee has the capability of using temporary hose from the FLEX pump to the FLEX manifold in the DG building. This strategy is also used during flood scenarios, when the FLEX pumps are moved out of the FSB as the FSB is below the flood level. There are multiple ways to hook up to the components being supplied by the FLEX manifold in the DG building, but in the current strategies all the water must pass through the FLEX manifold in the

DG building. This is an alternative from the guidance in NEI 12-06, Revision 0, Section 3.2.2, to have primary and alternate connections for the FLEX strategies. The licensee justified this approach as an acceptable alternative to the NEI guidance by stating that the FLEX manifolds, by their locations in the FSB and the diesel generator building, are reasonably protected from all applicable external hazards, are seismically robust and are physically separated from non-seismically supported components thus protected from potential damage due to seismic interaction with nearby components. Therefore, the licensee concluded that the FLEX manifolds at Clinton will be available to support the FLEX mitigation strategies for the BDBEE. The NRC staff notes that the single SX supply line from the FSB to the DG building manifold might also be considered as an alternative from the guidance in NEI 12-06, Revision 0, Section 3.2.2. However, the staff notes that if the SX supply line is unavailable, the licensee is capable of stringing temporary hose from the FLEX pump in the FSB to the hose connection on the FLEX manifold in the DG building, which bypasses the SX supply line and is an alternate connection which conforms to the guidance in NEI 12-06. The licensee also uses this alternate connection during flood scenarios, when the FLEX pumps are moved out of the FSB as the FSB is below the flood level. Due to the robust installation of the FLEX manifolds with protection from all applicable hazards, the NRC staff approves this alternative as being an acceptable method of compliance with the order.

3.14.3 Reduced Set of Hoses and Cables As Backup Equipment

In its fourth six month update [Reference 14], the licensee also has taken an alternative approach to the NEI 12-06 guidance for hoses and cables. In NEI 12-06, Section 3.2.2 states that in order to assure reliability and availability of the FLEX equipment required to meet these capabilities, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where "N" is the number of units on-site. Thus, a single-unit site would nominally have at least two portable pumps, two sets of portable ac/dc power supplies, two sets of hoses & cables, etc. The NEI on behalf of the industry submitted a letter to the NRC [Reference 34] proposing an alternative regarding the quantity of spare hoses and cables to be stored on site. The alternative proposed was that that either a) 10 percent additional lengths of each type and size of hoses and cabling necessary for the N capability plus at least one spare of the longest single section/length of hose and cable be provided or b) that spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any FLEX strategy. The licensee has committed to following the NEI proposal. By letter [Reference 35], the NRC agreed that the alternative approach is reasonable, but that the licensees may need to provide additional justification regarding the acceptability of various cable and hose lengths with respect to voltage drops, and fluid flow resistance. The NRC staff approves this alternative as being an acceptable method of compliance with the order.

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 28, 2013 [Reference 36], the licensee submitted its OIP for Clinton in response to Order EA-12-051. By letter dated June 7, 2013 [Reference 37], the NRC staff sent a Request for Additional Information (RAI) to the licensee. The licensee provided a response to the RAI by letter dated July 3, 2013 [Reference 38]. By letter dated November 15, 2013 [Reference 39], the NRC staff issued an Interim Staff Evaluation (ISE) and RAI to the licensee.

By letters dated August 28, 2013 [Reference 40], February 28, 2014 [Reference 41], August 28, 2014 [Reference 42], and February 27, 2015 [Reference 43], the licensee submitted status reports for the Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable spent fuel pool instrumentation (SFPI), which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated July 15, 2015 [Reference 44], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee has installed a SFPI system designed by Westinghouse. The NRC staff audited Westinghouse' s SFPI system design specifications, calculations and analyses, test plans, and test reports in support of the NRC staff review of licensees' OIPs in response to Order EA-12-051. The staff issued an audit report on August 18, 2014 [Reference 45].

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 April 27, 2015 [Reference 17], 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

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

> All licensees identified in Attachment 1 to this Order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system [Level 1], (2) level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck [Level 2], and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred [Level 3].

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

> Level 1 indicated level on either primary or backup instrument channel of greater than 26 feet 8' ¼ inches (elevation 754') plus instrument accuracy above the top of the storage racks based on the design accuracy of the instrument channel and

a resolution better than 1 foot for both the primary and backup instrument channels.

Level 2 indicated level on primary or backup instrument channel of greater than 10 feet (elevation 737.31') plus instrument channel accuracy above the top of the storage racks based on specification of this level as adequate in NRC JLD-ISG-2012-03 and NEI 12-02, the specified design accuracy of the instrument channel, and the relatively low sensitivity of dose rates to changes in water depth at this level.

Level 3 indicated level on either the primary or backup instrument channel of greater than 0 feet (elevation 727.31') plus instrument channel accuracy above the top of the storage racks based upon the design accuracy of the instrument channel for both the primary and backup instrument channels.

By letter dated June 7, 2013 [Reference 37] the NRC staff sent a RAI to the licensee. In RAI-1 the staff inquired, in part, how the location of Level 1 identified in the OIP represents the higher of the two points described in the NEI 12-02 guidance. The licensee provided a response by letter dated July 3, 2013 [Reference 38], in which it stated that the SFP at Clinton has skimmers and scuppers located at the 754' elevation that the SFP water will flow into when it reaches that elevation. From there the water is routed to surge tanks from which the Fuel Pool Cooling and Cleanup (FC) pumps draw suction. The suction trip of the pumps is at an approximate 720.75' elevation. Thus the 754' elevation reflects the higher of the two points noted in NEI 12-02, Section 2.3.1. The NRC staff found the response acceptable.

Based on the discussion above, the NRC staff finds that the licensee's proposed Levels 1, 2 and 3 are consistent with NEI 12-02 guidance, as endorsed, by JLD-ISG-2012-03, and 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 the primary and backup instrument channels level sensing components will be located and permanently mounted in the SFP. The primary and backup instrument channels will provide continuous level indication over a minimum range of approximately 26.86 feet from the high pool level elevation of 754.17' to the top of the spent fuel racks at elevation 727.31'.

By letter dated Feb 28, 2013 [Reference 40], the licensee submitted the first six month status report, in which it stated, in part, that:

> Level Indication instrumentation was selected consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02. The instrument is a guided wave radar system. It provides the capability to reliably monitor the spent fuel pool water level under normal and anticipated adverse environmental conditions.
>
> The sensor input to the system is a guided wave radar probe. Using the principle of time domain reflectometry (TDR) to detect the SFP water level, microwave signals are pulsed down the cable probe and reflected back from the water surface. This is used to determine the level of the water in the pool.
>
> Each water level measurement channel includes a flexible stainless-steel sensor cable probe suspended in the spent fuel pool from a seismic Category 1 bracket attached to the operating deck or to a raised curb at the side of the pool. The cable probe extends to just above the top of the spent fuel racks. The sensor electronics are mounted in seismic and missile protected areas outside of the building housing the SFP to minimize exposure to elevated radiation and environmental conditions which could result from a postulated loss of water inventory in the pool. There is an interconnecting cable between the sensor cable probe and sensor electronics.
>
> The sensor electronics provide an instrument standard analog signal to a remote enclosure that will be installed in an accessible location. This enclosure contains the Uninterruptable Power Supply (UPS), backup battery, and water level display. The enclosure also includes the capability to connect an emergency or temporary external power source as part of the FLEX mitigating strategies.

The NRC staff reviewed the Westinghouse's SFPI system design specifications, calculations and analyses, test plans, and test reports [Reference 45] and found the SFPI design and qualification process reasonable.

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

4.2.2 <u>Design Features: Arrangement</u>

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

> The proposed plan is to install SFP level sensors in the southwest corner and on the east side of the SFP separated in excess of 20 feet. The sensors themselves will be mounted, to the extent practical, near the pool walls and below the pool curb to minimize their exposure to damaging debris and not interfere with SFP activities. Instrument channel electronics and power supplies will be located in seismic and missile protected areas either below the SFP operating floor or in buildings other than the Fuel Building.

> The areas to be selected will provide suitable radiation shielding and environmental conditions for the equipment consistent with instrument manufacturer's recommendations. Equipment and cabling for power supplies and indication for each channel will be separated equivalent to that provided for redundant safety related services.

By letter dated June 7, 2013 [Reference 37], the NRC staff sent an RAI to the licensee. In RAI-5 the staff inquired, in part, how the two channels of the proposed level measurement system meet this requirement so that the potential for a common cause event to adversely affect both channels is minimized to the extent practicable.

The licensee provided a response by letter dated February 27, 2015 [Reference 43], which was further clarified in the FIP, in which it stated that the two channel locations of the probe and mounting meet the requirements of NEI 12-02 section 3.2. More specifically, to ensure adequate channel separation, one level sensor probe is being mounted approximately on the northwest corner of the pool while the other level sensor probe is being mounted near the southeast side of the pool. This means the two level sensor probes are separated by a distance of approximately 43 ½' which is a longer distance than the shorter dimension of the spent fuel pool as specified by NEI 12-02 guidance.

During the onsite audit, the staff performed a walkdown and noticed that while the primary and backup SFPI probes were sufficiently separated, the metal cable conduits for the primary and backup SFPI channels were routed side by side, three inches apart, for a portion of the conduit run from the column where the conduits attached toward the Fuel Building wall. It was also not clear to the staff if the cable tray that houses the primary channel cable was rigid enough to provide the missile protection for the cable. In response, Clinton proposed several solutions to address the staff concern. After discussions with the licensee and walkdowns, the staff found the following proposed solution acceptable:

> Design changes will made to provide further separation for the channels in the Fuel Building as below:
>
> When the channels leave the spent fuel area, they will be routed on either face of a 2 feet column (which is seismically mounted). Then they will be routed approximately 10 feet into a cable tray system. For these 10 feet, the channel conduits will be provided maximum practicable separation of approximately 6'-2". When in cable trays, the primary channel will be routed in a robust cable tray and the secondary channel will be routed in its own conduit outside the cable tray. The cable tray provides the reasonable protection to the primary channel. Both channels will be supported by seismically installed support hangers.
>
> Structural Design Criteria DC-SD-01 CP provides guidance for load combination of component supports and various structures. The subject cable tray and conduit support, are designed to be redundant in the safety related building. The issue being raised is, if both supports and cable tray can survive due to an impact caused by internally generated missiles.

> The supports that hold the cable trays are designed seismically. They will survive during a seismic event. If the supports or the cable trays are subjected to be hit by a missile, the cable tray (though a non-safety related component) is robust, as it's built on 14 GA material (refer to specification K-2980) and is strong enough in resisting significant force. The seismically installed supports are robust as well to meet the design basis seismic standards for Clinton.
>
> In conclusion, with the supports being designed seismically, as required per DC-SD-01-CP requirement, and the cable tray being robust enough, the supports and cable tray should be able to survive an internal missile impact.
>
> Structural calculations IP-S-0303 and IP-S-0311 will be revised, as required, to address the structural adequacy of conduit supports due to additional separation being provided from the column to the cable tray in the fuel handling building.

The NRC staff found the responses acceptable as they reasonably addressed the staff's concerns with respect to separation by modifying the SFPI cable conduits routing to the extent practical.

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

Based on the discussion above, the NRC staff finds that, if implemented appropriately, the licensee's proposed arrangement for the SFP level instrumentation is consistent with NEI 12-02 guidance, as endorsed, by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.3 <u>Design Features: Mounting</u>

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

> Design of the mounting of the sensors in the SFP shall be consistent with the seismic Class I criteria. Installed equipment will be verified to be seismically adequate for the seismic motions associated with the maximum seismic ground motion considered in the design of the plant area in which it is installed.

By letter dated June 7, 2013 [Reference 37] the NRC staff sent an RAI to the licensee. In RAI-3 the staff requested the licensee to address the methodology and design criteria that will be used to estimate the total loading on the mounting devices, inclusive of design basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing or other effects that could accompany such seismic forces. This RAI was carried over to the ISE the NRC staff sent to the licensee by the letter dated November 15, 2013 [Reference 39], as RAI-2. In addition, the NRC staff requested, in RAI-3 of the ISE, the analyses used to verify the design criteria and methodology for seismic testing of the SFPI and the electronics units, including design-basis maximum seismic loads and the hydrodynamic loads that could result from pool sloshing or other effects that could accompany such seismic forces. In RAI-4 of the ISE, the NRC staff requested, for each of the mounting attachments, a description of design inputs and the methodology that was used to qualify the structural integrity of the affected structures/equipment.

By letter dated February 27, 2015 [Reference 43], the licensee provided a response, in which it stated, in part, that:

> All SFPIS [spent fuel pool instrumentation system] equipment will be designed in accordance with the Clinton Power Station (CPS) Safe Shutdown Earthquake (SSE) design requirements. The vendor, Westinghouse, evaluated the structural integrity of the mounting brackets in calculation CN-PEUS-14-13. The GTSTRUDL model was used by Westinghouse to calculate the stresses in the bracket assembly, considers load combinations for the dead load, live load and seismic load on the bracket. The reactionary forces calculated from these loads became the design inputs to design the mounting bracket anchorage to the refuel floor to withstand a Safe Shutdown Earthquake (SSE).
>
> The seismic loads are obtained from the Clinton Power Station response spectra curves (Reference UFSAR Chapter 3 Figures 3.7 for CPS). The following methodology was used in determining the stresses on the bracket assembly:
>
> - Frequency analysis, taking into account the dead weight and the hydrodynamic mass of the structure, is performed to obtain the natural frequencies of the structure in all three directions.
> - SSE response spectra analysis is performed to obtain member stresses and support reactions.
> - Modal responses are combined using the Ten Percent Method per U.S. NRC Regulatory Guide 1.92, Revision 1, "Combining Modal Responses and Spatial Components in Seismic Response Analysis." This method is endorsed per Chapter 3 of the Updated FSAR Revision 11 for CPS.
> - The seismic loads for each of the three directions are combined by the Square Root of the Sum of Squares (SRSS) Method.
> - Sloshing analysis is performed to obtain liquid pressure and its impact on bracket design.
> - The seismic results are combined with the dead load results and the hydrodynamic pressure results in absolute sum. These combined results are compared with the allowable stress values.
>
> Sloshing forces were obtained by analysis. The Total Integrated Dose (TID)-7024, Nuclear Reactors and Earthquakes, 1963, by the U.S. Atomic Energy Commission, approach has been used to estimate the wave height and natural frequency. Horizontal and vertical impact force on the bracket components will be calculated using the wave height and natural frequency obtained using TID-7024 approach. Using this methodology, sloshing forces are calculated and added to the total reactionary forces

that would be applicable for bracket anchorage design. The analysis also determines that the level probe can withstand a credible design basis seismic event. During the design-basis event, the SFP water level is expected to rise and parts of the level sensor probe are assumed to become submerged in water. The load impact due to the rising water and submergence of the bracket components have also been considered for the overall sloshing impact. Reliable operation of the level measurement sensor with a submerged interconnecting cable has been demonstrated by analysis of previous Westinghouse testing of the cable, and the vendor's cable qualification. Boron build up on the probe has been analyzed to determine the potential effects on the sensor.

Clinton specific calculations for mounting details associated with Transmitter and SFPLI Monitors have been completed as part of the Engineering Change (EC 392333) package for the modification. The methods used in the calculations followed Institute of Electrical and Electronics Engineers (IEEE) Standard 344-2004 and IEEE Standard 323-2003 for seismic qualification of the instrument.

The level sensor, which is one long probe, is suspended from the launch plate via coupler/connector assembly. The launch plate is a subcomponent of the bracket assembly, which is mounted to the refuel floor via anchors.

The bracket assembly that supports the sensor probe and launch plate will be mechanically connected to the Fuel Building structure. The mechanical connection consists of four concrete expansion anchors that will bolt the bracket assembly to the Fuel Building structure via the base plate. The concrete expansion anchors are designed to withstand an SSE and will meet the CPS seismic related installation requirements.

During the onsite audit, the licensee provided supplemental responses to RAI-3 and RAI-4, in which it stated, in part, that the design criteria used in Calculations IP-S-0302, "Evaluation of SFPI Sensor Mounting Bracket Anchor Plate Detail", and IP-S-0303, "Evaluate Mounting Details for Level Transmitters, Electronics Enclosures, Pull Box and Non-Standard Conduit Supports," and EC 392333 meet the requirements to withstand an SSE and will meet the Clinton safety related installation requirements for mounting the readout displays and transmitters in the Auxiliary Building and Control Building. The methods used in the calculations follow IEEE Standard 344-2004 and IEEE Standard 323-2003 for seismic qualification of the instruments.

The staff found the responses acceptable and verified it by reviewing the following:

- CN-PEUS-14-13, "Seismic Analysis of the SFP Mounting bracket at Clinton Power Station," Rev. 0
- IP-S-0302, "Evaluation of SFPI Sensor Mounting Bracket Anchor Plate Detail", Rev. 0
- IP-S-0303, "Evaluate Mounting Details for Level Transmitters 1LT-FC221A and 1LT-FC221B, Electronics Enclosures 1PL115JA and 1PL115JB, Pull Box 1PB8188K and Non-Standard Conduit Supports SWP2-1000, SWSA-1000, SWSA-1001, WV-1000, WV-1001 and WV-1002," Rev. 1A
- EC 392333, "Fukushima Spent Fuel Pool Level Instrumentation," Rev. 001

Based on its review of the above documents and walkdowns, the NRC staff found that (a) the maximum span for the conduit supports (15 ft) exceeds the maximum allowable span (13 ft 6 in) per Clinton Calculation SDQ45-00DG05 and (b) the conduit support distance from the bend line exceeds the maximum allowable distance (3 ft). In response to the staff's concern, the licensee provided Calculation IP-S-0311, "Evaluation of Non-Standard Conduit, Conduit Supports and Cable Tray Hangers in Support of the New Spent Fuel Pool Level Instrumentation," Rev.1, which analyzed the allowable span violation and bend line distance violation for individual affected supports. The staff reviewed this calculation and found it acceptable.

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

4.2.4 Design Features: Qualification

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

> Reliability will be established through the use of an augmented quality assurance process (e.g., a process similar to that applied to the site fire protection program).
>
> Temperature, humidity and radiation levels consistent with the conditions in the vicinity of the SFP and the area of use considering normal operation, event and post-event conditions for no fewer than seven days post-event or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049 (FLEX). Examples of post-event (beyond-design-basis) conditions to be considered are:
>
> - radiological conditions for a normal refueling quantity of freshly discharged (100 hour) fuel with SFP water level 3 as described in Order EA-12-051,
> - temperature of 212 degrees F and 100% relative humidity environment,
> - boiling water and/or steam environment,
> - the impact of FLEX mitigating strategies.

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-5 the staff inquired as to (a) method(s) to demonstrate the reliability of the permanently installed equipment under beyond-design-basis ambient temperature, humidity, shock, vibration, and radiation conditions, (b) testing and/or analyses that will be conducted to provide assurance that the equipment will perform reliably under the worst-case credible design-basis loading at the location where the equipment will be mounted. Include a discussion of this seismic reliability demonstration as it applies to the level sensor, control boxes, electronics, or read-out and re-transmitting devices, and (c) method(s) that will be used to confirm the reliability of the permanently installed equipment such that following a seismic event the instrument will maintain its required accuracy.

By letter dated February 27, 2015 [Reference 43], the licensee provided a response, in which it stated, in part, that:

Beyond Design Basis Environment — Westinghouse qualified the components (probe, connector, cable) of the Spent Fuel Pool Instrumentation System (SFPIS) located in the SFP area to the beyond design basis environment. Components of the system were subjected to beyond design basis conditions of heat and humidity, thermal and radiation aging mechanisms. This testing confirmed functionality of these system components under these beyond design basis environmental conditions. Westinghouse performed testing to ensure aging of the components in the SFP area will not have a significant effect on the ability of the equipment to perform following a plant design basis earthquake.

Mild Environment — Westinghouse qualified the system components (display panel, sensor) that reside in the mild environment conditions to determine that the components can satisfactorily perform to those conditions. Westinghouse has determined that aging does not have a significant effect on the ability of the equipment to perform following a plant design basis earthquake. The habitability of the monitor display locations will be maintained as part of the FLEX strategies, and therefore, the readout display in the Auxiliary and Control Buildings will not be subject to harsh environmental or radiological conditions.

Shock and Vibration — SFPIS pool side brackets will be analyzed for Safe Shutdown Earthquake design requirements per NRC order EA-12-051 and NEI 12-02 guidance. SFPI pool side brackets for both the primary and backup Westinghouse SFP measurement channels are being permanently installed and fixed to rigid refuel floors, which are Seismic Category 1 structures. The SFPI system components, such as level sensor and its mounting bracket were subjected to seismic testing, including shock and vibration test requirements. The results for shock and vibration tests were consistent with the anticipated shock and vibration expected to be seen by mounted equipment. The level monitoring electronics is enclosed in a NEMA-4X housing which is a seismic rated stainless steel housing as well. These housings will be mounted to a seismic qualified wall and structure and will contain the active electronics, and aid in protecting the internal components from vibration induced damage.

The seismic adequacy of the SFPIS components is demonstrated by vendor testing and analysis in accordance with below listed standards:

- IEEE 344-2004, "IEEE Recommended Practice for Seismic Qualification of Class 1E Electrical Equipment for Nuclear Power Generating Stations"
- IEEE-323-1974, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations"
- USNRC Regulatory Guide 1.100, Rev. 3
- USNRC Regulatory Guide 1.92, Rev. 1

The NRC staff reviewed Westinghouse's SFPI system design specifications, calculations and analyses, test plans, and test reports [Reference 45] and found the SFPI design and qualification process reasonable.

The NRC staff reviewed the Clinton environmental conditions for the locations where the SFPI equipment will be located to verify whether these conditions are enveloped by the equipment qualifications. The summary of the review is as follows:

The level sensor probe, coax coupler and connector assembly, launch plate and pool side bracket assembly, and coax cable are designed and qualified to operate reliably in the below specified environmental conditions.

Parameter	Normal	BDB
Temperature	50-140°F	212°F
Pressure	Atmospheric	Atmospheric
Humidity	0-95% Relative Humidity (RH)	100% (saturated steam)
Radiation Total Integrated Dose (TID) γ (above pool)	1E03 rad	1E07 rad
Radiation TID γ (12" above top of fuel rack)	1E09 rad (probe and weight only)	1E07 rad

The level sensor transmitter and bracket, electronics display enclosure and bracket are designed and qualified to operate reliably in the below specified environmental conditions.

Parameter	Normal	BDB
Temperature	50-120°F	140°F
Pressure	Atmospheric	Atmospheric
Humidity	0-95% RH	0-95% (non-condensing)
Duration	3 days	3 days
Radiation TID γ	≤ 1E03 rad γ	≤ 1E03 rad γ

During the onsite audit the staff verified the response by reviewing the following:

- Engineering Change (EC) 392333, "Fukushima Spent Fuel Pool Instrumentation," Rev. 1
- LTR-SFPIS-13-35, "Basis for Radiation Dose Requirement and Clarification of Production Equivalency of Electronics Enclosure Used for Seismic and EMC Testing," Rev. 0

In EC 392333 it states, in part, that per Calculation DC-ME-09-CP, the environmental conditions of the areas where the SFPI components located are as below:

- Fuel Building: 65 to 147 °F, 5 to 96% RH, 1E06 rad γ TID (probes)
- Auxiliary Building: 65 to 104 °F, 5 to 90% RH, 1E04 rad γ TID (primary location)
- Control Building: 65 to 147 °F, 5 to 60% RH, 1E04 rad γ TID (alternate location)

LTR-SFPIS-13-35 states, in part:

> Westinghouse radiation analysis team provided a one-foot-above-the rack dose rate at a value that was slightly less than 7E+03 roentgen per hour (R/hr). The first conservatism is to assume the same dose rate at the top of the pool when the water is at level 3. For the purposes of calculating a maximum reasonable dose, this rate was increased to 1E+04 R/hr. For seven days (168 hours) the total dose is 1.68E+06 R, which was rounded up to 2E+06 R, and then multiplied by 5, to allow for some margin. This resulted in 1E+07 R for the TID.
>
> Under normal conditions at one-foot-above-the-rack TID is calculated as follows: the dose rate at one foot above the fuel is approximately 7E+03 rad/hr, which is rounded up 1E+04 rads/hr. The normal operation dose (40 years) at the HJTC location (Level 3, 1 foot above the fuel rack) would be (1E+04 rad/hr X 350400 hrs) = 3.5E+09 rad. However, for a normal operational time period of 10 years, which is 25 percent of the 40 year period, the dose value would be rounded up to 1E+09 rad.

EC 392333, Rev. 1, states:

> For the primary channel transmitter at Elevation 762' of the Auxiliary Building, the straight line distance from the pool to the transmitter is approximately 123.3 feet. For conservatism, using a distance of 100 feet and using 3 foot thickness for all walls, an overall dose rate for the area can be obtained. Based on Design Analysis BYR13-187 Table 7.4-1 (which lists calculated dose rates as a function of distance) and Table 7.3-4 (which lists wall thickness scaling factors), the dose rate is 3.80E+01 rem/hr x 2.151E-10 = 8.17E-09 rem/hr at the primary channel transmitter during a BDBEE when the water in the SFP is at the top of the fuel assemblies.
>
> For the primary channel electronics enclosure at Elevation 781' of the Auxiliary Building, the straight line distance from the pool to the electronics enclosure is approximately 134.1 feet. For conservatism, using a distance of 125 feet and using 3 foot thickness all walls and floors, an overall dose rate for the area can be obtained. Based on BYR13-187 Table 7.4-1 (which lists calculated dose rates as a function of distance) and Table 7.3-4 (which lists wall thickness scaling factors), the dose rate is 2.89E+01 rem/hr x 2.151E-10 = 6.22E-09 rem/hr at the primary channel electronic box during a BDBEE when the water in the SFP is at the top of the fuel assemblies.
>
> For the backup channel electronics enclosure and transmitter at Elevation 762' of the Control Building, the straight line distance from the pool to the transmitter and enclosure is approximately 123.3 feet. For conservatism, using a distance of 125

> feet and using 3 foot thickness for all walls, an overall dose rate for the area can be obtained. Based on BYR13-187 Table 7.4-1 (which lists calculated dose rates as a function of distance) and Table 7.3-4 (which lists wall thickness scaling factors), the dose rate is 3.80E+01 rem/hr x 2.151E-10 = 8.17E-09 rem/hr at the backup channel transmitter and electronics box during a BDBEE when the water in the SFP is at the top of the fuel assemblies.
>
> NRC Order EA-12-051 requires that 7 days (168 hours) with the water level at the top of the fuel rack in the SFP be considered to establish TID. Using the dose rate of either the primary transmitter or backup transmitter and electronics box (the most conservative dose rates) of 8.17E-09 rad/hr, and a duration of 168 hours, the 7 day TID can be calculated as 1.37E-06 rad. This dose is considered negligible and will not impact the operation of the SFP equipment.

Based on the above responses, the NRC staff found the Westinghouse SFPI equipment qualifications envelope the environmental conditions of Clinton's SFPI locations.

Depending on the installation configurations, Westinghouse provided two types of SFP cable connectors, a straight connector or a 90-degree connector. Both of them originally were qualified for a 15-month life. Westinghouse upgraded the aging qualification for the 90-degree connector, through testing, to 10 years for harsh environment. The test included radiation aging, thermal aging and steam tests. The straight connector's aging qualification was upgraded to 10 years for non-harsh environment. The straight connector can be installed at the SFP side only with additional installation requirements. During the onsite audit, the NRC staff inquired as to Clinton's SFPI cable connector configuration. The licensee provided the response stating that Clinton will install 90-degree connectors at the pool side and straight connectors at the transmitter ends. Westinghouse has qualified both these connectors to 10-year life for a BDB condition. However, the straight connectors were not qualified to 10 years at the pool side by Westinghouse while the 90-degree connectors were.

The NRC staff also inquired about an assessment of potential susceptibilities of Electromagnetic Interference (EMI) and Radio-frequency Interference (RFI) in the areas where the SFP instruments are located and how to mitigate those susceptibilities. In response, the licensee stated that during the site acceptance test, including tests at pool side, the transmitter and display box will be tested to determine if a "NO RADIO ZONE" needs to be established based on the performance of the instrument. As required, "NO RADIO ZONE" will be established. Clinton generated Work Order 01690894 with the following task instructions:

> In accordance with EC 392333, CC-AA-107, Attachment 1 perform the following verifications: Operate a radio in close proximity to the SFP level probes, transmitters, and electronics boxes and verify that no interference is introduced. If any interference is noted, establish a "NO RADIO ZONE" that covers the entire area where interference is noticed.

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

4.2.5 Design Features: Independence

In its OIP, the licensee stated that the primary instrument channel will be independent of the backup instrument channel. This independence will be achieved through physical and electrical separation of each channels' components commensurate with hazard and electrical isolation needs.

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-7 the staff inquired (a) how the two channels of the proposed level measurement system meet this requirement so that the potential for a common cause event to adversely affect both channels is minimized to the extent practicable and (b) how each level measurement system, consisting of level sensor electronics, cabling, and readout devices will be designed and installed to address independence through the application and selection of independent power sources, the use of physical and spatial separation, independence of signals sent to the location(s) of the readout devices, and the independence of the displays.

By letter dated February 27, 2015 [Reference 43], the licensee provided a response, in which it stated, in part, that:

> The two channel locations of the spent fuel probe and mounting meet the requirements of NEI 12-02 section 3.2 — Arrangement. More specifically, to ensure adequate channel separation, one level sensor probe is being mounted approximately on the northwest corner of the pool while the other level sensor probe is being mounted near the center of the east wall of the pool. This means the two level sensor probes are separated by a distance of approximately 34' which is a longer distance than the shorter dimension of the spent fuel pool as specified by NEI 12-02 guidance. The independent power sources are described in the Clinton Power Station EC 392333 and consist of powering each train from a separate Motor Control Center.

In the FIP, the licensee further stated that:

> To ensure adequate channel separation, the level sensor for the primary channel is mounted in the northwest corner of the pool and the level sensor for the backup channel is mounted near the southeast side of the pool. The two sensors are separated by a distance of approximately 43 ½' which is a longer distance than the shorter dimension of the spent fuel pool specified by the NEI 12-02 guidance. The indication for the primary channel is located in the Auxiliary Building while the indication for the backup channel is located in the Control Building.

The NRC staff found the response adequately addresses the independence requirements. The staff verified the response by reviewing EC 392333, "Fukushima Spent Fuel Pool Level Instrumentation," Rev. 001. However, during the onsite audit, the staff performed the walkdown and noticed that while the primary and backup SFPI probes were sufficiently separated, the cable conduits for the primary and backup SFPI channels were routed side by side, three inches apart, for a portion of the conduit run from the column where the conduits attached toward the Fuel Building wall. The evaluation of the cable conduits' physical separation was discussed in Subsection 4.2.2, "Design Features: Arrangement" and found acceptable.

Based on the discussion above, the NRC staff finds the licensee's proposed design, with respect to instrument channel independence, is consistent with NEI 12-02 guidance, as endorsed, by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.2.6 Design Features: Power Supplies

In its OIP, the licensee stated that:

> Each channel will be normally powered from a different 120 Vac bus. Upon loss of normal ac power, individual channel installed batteries will automatically maintain continuous channel operation. The batteries will be replaceable and be sized to maintain channel operation until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049. Additionally, each channel will have provisions for connection to another suitable power source.

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-8 the staff inquired as to (a) a description of the electrical ac power sources and capabilities for the primary and backup channels and (b) the results of the calculation depicting the battery backup duty cycle requirements demonstrating that its capacity is sufficient to maintain the level indication function until offsite resource availability is reasonably assured.

By letter dated February 27, 2015 [Reference 43], the licensee provided a response, in which it stated that:

> A detailed description of the electrical AC power sources is included in the EC 392333 Design Summary. The Westinghouse Report, WNA-CN-00300-GEN, provides the results of the calculation depicting the battery back-up duty cycle. This calculation demonstrates that battery capacity is 4.22 days to maintain the level indication function to the display. Therefore, the Clinton Power Station readout display of level indication will be available for greater than 72 hours of operation. The results of the calculation meet the NEI 12-02 requirements.

During the audit, the staff inquired how the SFPI instruments will be powered during an ELAP event and prior to the depletion of the back-up batteries. Since the SFP level instrument is powered by non-safety related power sources, during an ELAP event these power sources will be shed off the buses and will not have power.

In response to the staff's concern, the licensee provided a supplemental response to RAI-8, in which it stated that the normal power feed to the SFPI system electronics boxes will be provided from 120/208VAC lighting panels 1LL24EB (RLC 124) and 1LL49EB (RLC 149). During the ELAP event, both channels will lose power. The SFPI system will operate on the battery backup power (for up to 72 hrs). Prior to 72 hrs, operators will restore the power to the SFPI channels by provided a FLEX DG backed power source per FLEX FSG procedure CPS 4306.01P007.

The staff found the responses adequately addressed the power supplies requirements and verified these responses by reviewing the following:

- Drawing E03-1FC00, "External Wiring Diagram Spent Fuel Pool Level Instrumentation System FC," Rev. 0
- Drawing E02-1AP03, "Electric Loading Diagram Clinton Power Station Unit 1 Clinton, Illinois," Rev. AB
- Drawing E03-1AP00, "External Wiring Diagram Aux Bldg 480V Riser 1A (1AP68A) Aux Bldg 480V Riser 1A (1AP69A) Clinton Power Station Unit 1 Illinois Power Company Clinton, Illinois," Sheet 28, Rev. F
- Drawing E03-1AP00, "Control Bldg 480V Riser A (0AP39E) Control Bldg 480V Riser B (0AP40A) Clinton Power Station Unit 1 Clinton, Illinois," Sheet 31, Rev. E
- FLEX FSG procedure 4306.01, "Extended Loss of AC/Loss of Ultimate Heat Sink," Attachment CPS 4306.01P007, "FLEX Spent Fuel Pool Makeup"

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

4.2.7 <u>Design Features: Accuracy</u>

In its OIP, the licensee stated that:

> The instrument channels will be designed to maintain their design accuracy following a power interruption or change in power source without recalibration. Instrument channel accuracy, to be determined during detailed design, will consider Spent Fuel Pool conditions (e.g., saturated water, steam environment, etc.), as well as, other applicable radiological and environmental conditions and include display accuracy. Instrument channel accuracy will be sufficient to allow trained personnel to determine when the actual level exceeds the specified lower level of each indicating range (levels 1, 2 or 3) without conflicting or ambiguous indications.

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-9 the staff inquired as to (a) the expected instrument channel accuracy performance under both normal SFP water level conditions (approximately Level 1 or higher) and at the BDB conditions (i.e., radiation, temperature, humidity, post-seismic and post-shock conditions) that would be present if the SFP water level were at the Level 2 and Level 3 datum points; and (b) the methodology that will be used for determining the maximum allowed deviation from the instrument channel design accuracy that will be employed under normal operating conditions as an acceptance criterion for a calibration procedure to flag to operators and to technicians that the channel requires adjustment to within the design accuracy under normal conditions.

By letter dated February 27, 2015 [Reference 43] the licensee provided a response, in which it stated, in part, that:

> Westinghouse documents WNA-CN-00301-GEN and WNA-DS-02957-GEN describe the channel accuracy under both (a) normal SFP level conditions and (b) at the Beyond Design Basis (BDB) conditions that would be present if SFP level were at Level 2 and Level 3 datum points. Each instrument channel will be accurate to within ±3" during normal spent fuel pool level conditions. The instrument channels will retain this accuracy after BDB conditions, in accordance with the above Westinghouse documents. This value is within the channel accuracy requirements of the Order (±1 foot).
>
> Westinghouse document WNA-TP-04709- describes the methodology for routine testing/calibration verification and calibration methodology. This document also specifies the required accuracy criteria under normal operating conditions. Clinton Power Station calibration and channel verification procedures will follow the guidance and criteria provided in this document. Instrument channel calibration will be performed if the level indication reflects a value that is outside the acceptance band established in the Clinton Power Station calibration and channel verification procedures forecast for issuance in the first quarter of 2015.
>
> Instrument channel loop accuracy and set point deviation/error is addressed in the EC 392333 as defined in Westinghouse document WNA-CN-00301-GEN.
>
> Functional check will be performed once per refueling cycle for Clinton Power Station. Per Westinghouse document WNA-TP-04709-GEN calibration on a SFP level channel is to be completed within 60 days of a planned refueling outage considering normal testing scheduling allowances (e.g. 25%). This is in compliance with the NEI 12-02 guidance for Spent Fuel Pool Instrumentation.

The NRC staff reviewed the Westinghouse's SFPI system design specifications, calculations and analyses, test plans, and test reports [Reference 45] and found the SFPI design with respect to the system accuracy reasonable.

During the onsite audit, since the calibration procedure was not available for review, the NRC staff requested Clinton to ensure that the accuracy acceptance criteria, channel check and in-situ test instructions would be included in the site calibration procedure. In response, Clinton provided the following:

Action Request AR# 01633580-52 will address the calibration procedure development at Clinton. The following elements will be included in the calibration procedure:

1. The procedure should include acceptance criteria for instrument accuracy
2. The procedure should include channel check (as-found = as-left)
3. The procedure should include in-situ test post calibration.

The licensee subsequently made the calibration procedures available for review. The NRC staff reviewed and found them acceptable.

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

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

In its OIP, the licensee stated that:

> Instrument channel design will provide for routine testing and calibration consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02. Details will be determined during detailed design engineering.

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-10 the staff inquired as to (a) the capability and provisions the proposed level sensing equipment will have to enable periodic testing and calibration, including how this capability enables the equipment to be tested in-situ; (b) how channel checks and functional checks will be performed, and the frequency at which they will be conducted; and (c) preventive maintenance tasks are required to be performed during normal operation, and the planned maximum surveillance interval that is necessary to ensure that the channels are fully conditioned to accurately and reliably perform their functions when needed. By letter dated February 27, 2015 [Reference 43] the licensee provided a response, in which it stated, in part, that:

> Westinghouse calibration procedure WNA-TP-04709-GEN and functional test procedure WNA-TP-04613-GEN describe the capabilities and provisions of SFPI periodic testing and calibration, including in-situ testing. Clinton Power Station will use these documents as the basis for doing the SFPI periodic testing and calibration.
>
> The level displayed by the channels will be verified per the Clinton Power Station administrative and operating procedures, as recommended by Westinghouse vendor technical manual WNA-GO-00127-GEN. If the level is not within the required accuracy per Westinghouse recommended tolerance in WNA-TP-04709-GEN, channel calibration will be performed.
>
> Functional checks will be performed per Westinghouse functionality test procedure WNA-TP-04613-GEN at the Westinghouse recommended frequency. Calibration tests will be performed per Westinghouse calibration procedure WNA-TP-04709-GEN at the Westinghouse recommended frequency. In accordance with Clinton Power Station maintenance and operating programs, CPS will

develop calibration, functional test, and channel verification procedures per Westinghouse recommendations to ensure reliable, accurate and continuous SFPI functionality by March 31, 2015. This action will be tracked as part of the EC 392333 Design Attribute Review process as defined in CC-AA-102, "Design Input and Configuration Change Impact Screening" procedure.

By March 31, 2015, CPS will develop preventive maintenance tasks for the SFPI per Westinghouse recommendation identified in the technical manual WNA-GO-00127-GEN to assure that the channels are fully conditioned to accurately and reliably perform their functions when needed. This action will be tracked as part of the EC 392333 Design Attribute Review process as defined in CC-AA-102, "Design Input and Configuration Change Impact Screening" procedure.

During the onsite audit, the NRC staff raised the concern that (a) the Clinton calibration procedure was not available to review to ensure functional check, channel check and in-situ test were included in the procedure, and (b) the preventive maintenance tasks for surveillance and maintenance were not in place to ensure the SFPI channels are fully conditioned to accurately and reliably perform their functions.

In response, the licensee stated that the following will be generated to address the staff's concern:

- Action Request AR# 01633580-52 will address the calibration procedure development at Clinton. The following elements will be included in the calibration procedure:

  1. The procedure should include acceptance criteria for instrument accuracy
  2. The procedure should include channel check (as-found = as-left)
  3. The procedure should include in-situ test post calibration.

- AR# 01673118-16 will address the channel verification procedure development.

- The following PM's will be developed per AR# 01714991-01:

  1. SFPI battery replacement – every 3 years
  2. Channel Verification – daily
  3. 90 degree and straight connectors, coupler assembly, coax cable replacements – every 88.7 years
  4. System calibration – every 12 months
  5. Probe replacement – every 40 years
  6. Transmitter replacement – every 7 years
  7. Verify power source – every 4 days
  8. Perform camera inspection of the probe – every year

The NRC staff found the responses acceptable. The licensee subsequently submitted the calibration procedures for NRC review. The NRC staff reviewed and found them acceptable.

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

4.2.9 Design Features: Display

In its OIP, the licensee stated that:

> The primary and backup instrument displays will be located at the control room, alternate shutdown panel, or other appropriate and accessible location. The specific location will be determined during detailed design. An appropriate and accessible location will include the following characteristics:
>
> - occupied or promptly accessible to the appropriate plant staff giving appropriate consideration to various drain down scenarios,
> - outside the area surrounding the SFP floor (e.g., an appropriate distance from the radiological sources resulting from an event impacting the Spent Fuel Pool),
> - inside a structure providing protection against adverse weather, and
> - outside of any very high radiation areas or locked high rad area during normal operation

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-11 the staff inquired as to (a) the specific location for the primary and backup instrument channel display; (b) if a display will be located somewhere other than the control room or alternate shutdown panel, describe the evaluation used to validate that the display location can be accessed without unreasonable delay following a BDB event. Include the time available for personnel to access the display as credited in the evaluation, as well as the actual time (e.g., based on walk-throughs) that it will take for personnel to access the display. Additionally, include a description of the radiological and environmental conditions on the paths personnel might take. Describe whether the display location remains habitable for radiological, heat and humidity, and other environmental conditions following a BDB event. Describe whether personnel are continuously stationed at the display or monitor the display periodically.

By letter dated February 27, 2015 [Reference 43] the licensee provided a response, in which it stated, in part, that:

> Clinton Power Station will have a display near the Remote (alternate) Shutdown Panel as shown on the attached sketch NRC RAI Question 1. This location was selected since it has been proven that it can be accessed without unreasonable delay during an event including a BDB event and is analyzed for Remote Shutdown Panel design basis accident radiation and habitability conditions. Time to access this display is the same as that addressed in the UFSAR for access to the Remote Shutdown Panel. This area BDB condition is addressed in RAI #6, "Environmental Conditions Outside of the Spent Fuel Pool Area". The Display Enclosure (monitor) will be periodically checked as part of Operator rounds.

During the onsite audit, the NRC staff raised the concern that the response did not specify the actual time that it will take for Operators to access the displays. In response, Clinton provided a supplemental response including the following:

> Time taken to reach the primary channel is 5 minutes from the MCR. Time taken to reach the backup channel is 10 minutes from the MCR. These are conservative values considering there will be no lights in the area.

Based on the discussion above, the NRC staff finds that the licensee's proposed location and design of the SFP instrumentation displays is consistent with NEI 12-02 guidance, as endorsed, by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.3 Evaluation of Programmatic Controls

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that:

> Personnel performing functions associated with these SFP level instrumentation channels will be trained to perform the job specific functions necessary for their assigned tasks (maintenance, calibration, surveillance, etc.). This training will be consistent with equipment vendor guidelines, instructions and recommendations. The Systematic Approach to Training (SAT) will be used to identify the population to be trained and to determine the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service.

Based on the discussion above, the NRC staff finds that the licensee's proposed plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFPI and the provision of alternate power to the primary and backup instrument channels, including the approach to identify the population to be trained, is consistent with NEI 12-02 guidance, as endorsed, by JLD-ISG-2012-03, and adequately addresses the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its OIP, the licensee stated that:

> Procedures will be developed using guidelines and vendor instructions to address the maintenance, operation and abnormal response issues associated with the primary and backup channels of SFP instrumentation. Procedures will also address the following situations:
>
> - If, at the time of an event or thereafter until the unit is returned to normal service, an instrument channel ceases to function, its function will be recovered within a period of time consistent with the emergency conditions that may exist at the time.

- If, at the time of an event or thereafter until the unit is returned to normal service, an instrument channel component must be replaced, it may be replaced with a commercially available component that may or may not meet all of the qualifications noted above to maintain instrument channel functionality.

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-12 the staff inquired as to a list of the procedures addressing operation (both normal and abnormal response), calibration, test, maintenance, and inspection procedures that will be developed for use of the SFP instrumentation.

During the onsite audit, the licensee provided a list of procedures as follows:

- AR 1673118-16 will develop Operating procedures. The following procedures will be developed for SFPI for operation of the system. Other procedures may be developed as well, per the review of EC 398278 package by the operations procedure writer.

  - Channel Verification Procedure: Verify both channels indicate same level.

  - Compensatory Actions Procedure: Provide guidance for taking compensatory actions when either one or both channels are out of service per CC-CL-118.

  - Verify Power Source: A task for operators to verify power source for primary and backup channels per the PM frequency.

- AR# 01633580-52 will address the calibration procedure development at Clinton. The following elements will be included in the calibration procedure:

  1. The procedure should include acceptance criteria for instrument accuracy
  2. The procedure should include channel check (as-found = as-left)
  3. The procedure should include in-situ test post calibration.

- FLEX FSG procedure CPS 4306.01P007 will be implemented to restore power to SFPI post ELAP, within 72 hours.

- CC-CL-118 procedure addresses guidance for Compensatory actions to restore the channels (one of two).

The licensee subsequently submitted the calibration procedures for NRC review. The NRC staff reviewed and found them acceptable.

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

4.3.3 Programmatic Controls: Testing and Calibration

In its OIP, the licensee stated that:

> The testing and calibration of the instrumentation will be consistent with vendor recommendations or other documented basis. Calibration will be specific to the mounted instruments and the displays as determined during the modification review process.

By letter dated November 15, 2013 [Reference 39], the NRC staff sent an RAI to the licensee. In RAI-13 the staff inquired as to the following:

a. Information describing the maintenance and testing program the licensee will establish and implement to ensure that regular testing and calibration is performed and verified by inspection and audit to demonstrate conformance with design and system readiness requirements. Include a description of your plans for ensuring that necessary channel checks, functional tests, periodic calibration, and maintenance will be conducted for the level measurement system and its supporting equipment.

b. A description of how the guidance in NEI 12-02 Section 4.3 regarding compensatory actions for one or both non-functioning channels will be addressed.

c. A description of what compensatory actions are planned in the event that the non-functioning instrument channel cannot be restored to functional status within 90 days.

By letter dated February 27, 2015 [Reference 43] the licensee provided a response, in which it stated that:

> Performance tests (functional checks) and Operator performance checks will be described in detail in the vendor operator's manual, and the applicable information is planned to be contained in plant operating procedures.
>
> Operational performance tests are planned to be performed periodically as recommended by the equipment vendor.
>
> Channel functional tests per plant procedures with limits established in consideration of vendor equipment specifications are planned to be performed at appropriate frequencies established equivalent to or more frequently than existing SFPI.
>
> Manual calibration and performance checks are planned to be performed in a periodic scheduled fashion with additional maintenance on an as-needed basis when flagged by the system's automated diagnostic testing features.

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

SFPI channel/equipment maintenance/preventative maintenance and testing program requirements to ensure design and system readiness are planned to be established in accordance with Exelon's processes and procedures and in consideration of vendor recommendations to ensure that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance is performed (and available for inspection and audit). Subject maintenance and testing program requirements are planned to be developed during the SFPI modification design process.

Both primary and backup SFPI channels incorporate permanent installation (with no reliance on portable, post-event installation) of relatively simple and robust augmented quality equipment. Permanent installation coupled with stocking of adequate spare parts reasonably diminishes the likelihood that a single channel (and greatly diminishes the likelihood that both channels) is (are) out-of-service for an extended period of time. Planned compensatory actions for unlikely extended out-of-service events will be controlled by CC-CL-118, "Site Implementation of Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program Implementation," and are summarized as follows:

# Channel(s) Out-of-Service	Required Restoration Action	Compensatory Action if Required Restoration Action not completed within Specified Time
1	Restore Channel to functional status within 90 days (or if channel restoration not expected within 90 days, then proceed to Compensatory Action	Immediately initiate action in accordance with note below
2	Initiate action within 24 hours to restore one channel to functional status and restore one channel to functional status within 72 hours.	Immediately initiate action in accordance with note below

Note: Initiate an Issue Report to enter the condition into the Corrective Action Program. Identify the equipment out of service time is greater than the specified allowed out of service time, develop and implement an alternate method of monitoring, determine the cause of the non-functionality, and the plans and schedule for restoring the instrumentation channel(s) to functional status.

The NRC staff found the response acceptable and verified it by reviewing CC-CL-118, "Site Implementation of Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program," Rev. 0A.

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

4.4 Conclusions for Order EA-12-051

In its letter dated July 15, 2015 [Reference 44], 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 finds that, if implemented appropriately, the licensee's plans conform to the guidelines of NEI 12-02, as endorsed, by JLD-ISG-2012-03. Based on the evaluations above, the NRC staff concludes that if the SFP level instrumentation is installed at Clinton according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013 the NRC staff started audits of the licensee's progress on these the EA-12-049 and EA-12-051 orders. The staff conducted an onsite audit in March 2015. The licensee reached its final compliance date on May 17, 2015, and has declared that the Clinton reactor is in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to and which NRC staff has evaluated to be satisfactory for compliance with these orders. 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. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs which if implemented appropriately will adequately address the requirements of Orders EA-12-049 and EA-12-051.

6.0 REFERENCES

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

2. SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," February 17, 2012 (ADAMS Accession No. ML12039A103)

3. SRM-SECY-12-0025, "Staff Requirements – 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," March 9, 2012 (ADAMS Accession No. ML120690347)

4. Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," March 12, 2012 (ADAMS Accession No. ML12054A736)

5. Order EA-12-051, "Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," March 12, 2012 (ADAMS Accession No. ML12054A679)

6. Nuclear Energy Institute document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0, August 21, 2012 (ADAMS Accession No. ML12242A378)

7. JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," August 29, 2012 (ADAMS Accession No. ML12229A174)

8. Nuclear Energy Institute 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, dated August 24, 2012 (ADAMS Accession No. ML12240A307)

9. JLD-ISG-2012-03, "Compliance with Order EA-12-051, Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," August 29, 2012 (ADAMS Accession No. ML12221A339)

10. Clinton Power Station, Unit 1 Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated February 28, 2013 (ADAMS Accession No. ML13064A274)

11. Clinton, Unit 1 First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated August 28, 2013 (ADAMS Accession No. ML13241A241)

12. Clinton, Unit 1 Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated February 28, 2014 (ADAMS Accession No. ML14059A429)

13. Clinton, Unit 1 Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated August 28, 2014 (ADAMS Accession No. ML14248A231)

14. Clinton, Unit 1 Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated February 27, 2015 (ADAMS Accession No. ML15058A513)

15. Letter from Jack R. Davis (NRC) to All Operating Reactor Licensees and Holders of Construction Permits, "Nuclear Regulatory Commission Audits of Licensee Responses to Mitigation Strategies Order EA-12-049," August 28, 2013 (ADAMS Accession No. ML13234A503)

16. Letter from Jeremy S. Bowen (NRC) to Michael J. Pacilio (Exelon) dated December 17, 2013, regarding Clinton Power Station Unit 1 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 - Mitigating Strategies (ADAMS Accession No. ML13225A571)

17. Letter from John Boska (NRC) to Bryan Hanson (Exelon) dated April 27, 2015, regarding Clinton Power Station, Unit No.1 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (Adams Accession No. ML15100A051)

18. Clinton, Unit 1, Report of Full Compliance with March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigating Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated July 15, 2015, (ADAMS Accession No. ML15198A115)

19. U.S. Nuclear Regulatory Commission, "Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," March 12, 2012, (ADAMS Accession No. ML12053A340)

20. SRM-COMSECY-14-0037, "Staff Requirements – COMSECY-14-0037 – Integration of Mitigating Strategies For Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," March 30, 2015, (ADAMS Accession No. ML15089A236)

21. Exelon Generation Company, LLC, Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report (FHRR), dated March 12, 2014 (ADAMS Accession Nos. ML14079A419 and ML14079A420)

22. Exelon Generation Company, LLC, Seismic Hazard and Screening Report (Central and Eastern United States (CEUS) Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident dated March 31, 2014 (ADAMS Accession No. ML14091A011)

23. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), "Staff Assessment of National SAFER Response Centers Established In Response to Order EA-12-049," September 26, 2014 (ADAMS Accession No. ML14265A107)

24. EPRI Report 1025287, Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic (ADAMS Accession No. ML12333A170)

25. EPRI Final Draft Report, 3002000704, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Near-Term Task Force Recommendation 2.1: Seismic (ADAMS Accession No. ML13102A142)

26. NRC endorsement of Augmented Approach letter dated May 7, 2013 (ADAMS Accession No. ML13114A949)

27. COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated November 21, 2014 (ADAMS Accession No. ML14309A256)

28. Letter from Tekia Govan (NRC) to Bryan C. Hanson (Exelon), "Clinton Power Station, Unit No. 1 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation," dated September 3, 2015 (ADAMS Accession No. ML15212A010)

29. NRC letter, "Final Screening and Prioritization Results Regarding Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident" dated October 3, 2014 (ADAMS Accession No. ML14258A043)

30. NEI Position Paper: "Shutdown/Refueling Modes", dated September 18, 2013 (Adams Accession No. ML13273A514)

31. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of NEI Position Paper: "Shutdown/Refueling Modes", dated September 30, 2013 (ADAMS Accession No. ML13267A382)

32. Letter from Nicholas Pappas (NEI) to Jack R. Davis (NRC) regarding FLEX equipment maintenance and testing dated October 3, 2013 (ADAMS Accession No. ML13276A573)

33. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of the use of the EPRI FLEX equipment maintenance report, dated October 7, 2013 (ADAMS Accession No. ML13276A224)

34. Letter from Nicholas Pappas (NEI) to Jack R. Davis (NRC) regarding alternate approach to NEI 12-06 guidance for hoses and cables, dated May 1, 2015 (ADAMS Accession No. ML15126A135)

35. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding NRC endorsement of NEI's alternative approach to NEI 12-06 guidance for hoses and cables, dated May 18, 2015 (ADAMS Accession No. ML15125A442)

36. Clinton Power Station, Unit 1, Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated February 28, 2013 (ADAMS Accession No. ML13059A306)

37. Letter from Blake Purnell (NRC) to Michael J. Pacilio (Exelon) dated June 7, 2013, regarding Clinton Power Station, Unit No. 1 – Request for Additional Information Regarding Overall Integrated Plan For Reliable Spent Fuel Pool Instrumentation (ADAMS Accession No. ML13134A093)

38. Clinton Power Station, Unit 1, Response to Request for Additional Information – Overall Integrated Plan in Response to Commission Order Modifying License Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated July 3, 2013 (ADAMS Accession No. ML13186A002)

39. Letter from Blake Purnell (NRC) to Michael J. Pacilio (Exelon) dated November 15, 2013, regarding Clinton Power Station, Unit 1 – Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan For Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation (ADAMS Accession No. ML13280A326)

40. Clinton, Unit 1, First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated August 28, 2013 (ADAMS Accession No. ML13241A237)

41. Clinton Power Station, Unit 1, Second Six Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated February 28, 2014 (ADAMS Accession No. ML14062A058)

42. Clinton Power Station, Unit 1, Third Six Month-Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated August 28, 2014 (ADAMS Accession No. ML14248A213)

43. Clinton, Unit 1, Fourth Six Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated February 27, 2015 (ADAMS Accession No. ML15058A622)

44. Clinton, Unit 1, Report of Full Compliance with March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated July 15, 2015 (ADAMS Accession No. ML15198A113)

45. Letter from Jason Paige (NRC) to Joseph W. Shea (TVA) dated August 18, 2014 regarding Watts Bar Nuclear Plant, Units 1 and 2, Report for the Westinghouse Audit in Support of Reliable Spent Fuel Instrumentation Related to Order EA-12-051 (ADAMS Accession No. ML14211A346)

46. Clinton Power Station (CPS) FLEX Suppression Pool (SP) Piping Modifications Fluid Flow Evaluation", Rev. 0

47. CPS 4306.01P005, "FLEX RCIC Operation," Rev. 0.

48. CPS 4306.01P009, "FLEX ADS Air Supply," Rev. 0

49. IP-S-0295, "FLEX Seismic Analysis of SF Components," Rev. 0,

50. IP-M-0809, "Hydraulic Evaluation for FLEX Diesel Pump Sizing," Rev. 1

51. CPS 4306.01, "Extended Loss of AC Power/Loss of Ultimate Heat Sink," Rev. 0

52. CPS 4306.01P010, "FLEX Ventilation," Rev. 0

53. EC 394583, "Fukushima FLEX - Evaluation of Unit 2 Div 2 SX Pipe 2SX02AB Buried Piping Integrity in Support of FLEX Strategies - FLEX Makeup Water," Rev. 0

54. CPS 4306.01P007, "FLEX Spent Fuel Pool Makeup," Rev. 0

55. VF-54, "SFP Area Conditions Following a BDBEE," Rev. 8

56. CPS 4306.01C010, "FLEX Ventilation Hard Cards," Rev. 0

57. CPS 4306.01P010," FLEX Ventilation," Rev. 0

58. Clinton Work Order 01684636, "CM 2SX02AB-30" Air Test FUK-FLEX, EC 394583," dated 12/10/13

59. EC 392335, "Fukushima FLEX Internal Generator 480 VAC Connections Required to Support NRC EA-12-049 FLEX Response," Rev. 1

60. EC 392343, "Fukushima FLEX Install a Seismic Storage Building Including Electrical," Rev. 0

61. Letter from Frankie Vega (NRC) to Bryan Hanson (Exelon), Clinton Power Station, Unit No. 1, Staff Assessment of Information Provided Pursuant to Title 10 of the Code Of Federal Regulations Part 50, Section 50.54(f), Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident (TAC No. MF3783), dated October 19, 2015 (ADAMS Accession No. ML15281A226)

62. Letter from Tekia Govan (NRC) to Bryan C. Hanson (Exelon), "Clinton Power Station, Unit No. 1 – Staff Assessment of Response to Request for Information Pursuant to 10 CFR 50.54(f) – Flood-Causing Mechanisms Reevaluation," dated October 27, 2015 (ADAMS Accession No. ML15279A134)

63. Letter from Tekia Govan (NRC) to Bryan C. Hanson (Exelon), "Clinton Power Station, Unit No. 1 – Correction to Staff Assessment of Response to Request for Information Pursuant to 10 CFR 50.54(f) – Flood-Causing Mechanisms Reevaluation," dated November 18, 2015 (ADAMS Accession No. ML15321A034)

64. Clinton, Unit 1, Revised Final Integrated Plan - Mitigating Strategies NRC Order EA-12-049, dated December 14, 2015 (ADAMS Accession No. ML15349A911)

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Date: December 23, 2015

of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the attached safety evaluation. By letters dated November 15, 2013 (ADAMS Accession No. ML13280A326), and April 27, 2015 (ADAMS Accession No. ML15100A051), 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 July 15, 2015 (ADAMS Accession No. ML15198A113), Exelon submitted its 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 Clinton. The intent of the safety evaluation is to inform Exelon on whether or not its integrated plans, if implemented as described, provide a reasonable path for compliance with Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

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

Sincerely,

/RA/

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

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