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

September 27, 2016

Vice President, Operations
Grand Gulf Nuclear Station
Entergy Operations, Inc.
P.O. Box 756
Port Gibson, MS 39150

SUBJECT: GRAND GULF NUCLEAR STATION, UNIT 1 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0954 AND MF0955)

Dear Sir or Madam:

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 27, 2013 (ADAMS Accession No. ML13059A316), Entergy Operations, Inc. (Entergy, the licensee) submitted its OIP for Grand Gulf Nuclear Station, Unit 1 (GGNS) in response to Order EA-12-049. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the attached safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits," (ADAMS Accession No. ML082900195). By letters dated February 19, 2014 (ADAMS Accession No. ML14007A718), and November 24, 2015 (ADAMS Accession No. ML15308A298), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated May 24, 2016 (ADAMS Accession No. ML16145A523), Entergy submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 26, 2013 (ADAMS Accession No. ML13064A417), Entergy submitted its OIP for GGNS 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 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 letters dated November 25, 2013 (ADAMS Accession No. ML13316B986), and November 24, 2015 (ADAMS Accession No. ML15308A298), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated May 24, 2016 (ADAMS Accession No. ML16145A523), Entergy submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051.

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

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

Sincerely,

Mandy K. Halter

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

Docket No.: 50-416

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

ENTERGY OPERATIONS, INC.

GRAND GULF NUCLEAR STATION, UNIT 1

DOCKET NO. 50-416

1.0 INTRODUCTION

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

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

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

2.0 REGULATORY EVALUATION

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

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

2.1 Order EA-12-049

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

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

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

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

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

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

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

2.2 Order EA-12-051

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 27, 2013 [Reference 10], Entergy Operations, Inc. (Entergy, the licensee) submitted an Overall Integrated Plan (OIP) for Grand Gulf Nuclear Station, Unit 1 (GGNS, Grand Gulf) in response to Order EA-12-049. By letters dated August 28, 2013 [Reference 11], February 28, 2014 [Reference 12], August 26, 2014 [Reference 13], February 19, 2015 [Reference 14], August 28, 2015 [Reference 48], and February 25, 2016 [Reference 49], the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 [Reference 15], the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" [Reference 36]. By letters dated February 19, 2014 [Reference 16] and November 24, 2015 [Reference 17], the NRC issued an Interim Staff Evaluation (ISE) and an audit report on the licensee's progress. By letter dated May 24, 2016 [Reference 18], the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP).

3.1 Overall Mitigation Strategy

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

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

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

3. There is no core damage initially.
4. There is no assumption of any concurrent event.
5. Because the loss of ac power presupposes random failures of safety-related equipment (emergency power sources), there is no requirement to consider further random failures.

Grand Gulf is a General Electric boiling-water reactor (BWR) Model 6 with a Mark III containment. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below.

At the onset of an ELAP, the reactor is assumed to trip from full power. The main condenser is unavailable due to the loss of circulating water. Decay heat is removed when the safety relief valves (SRVs) open on high pressure and dump steam from the reactor pressure vessel (RPV) to the suppression pool located in the containment. Makeup to the RPV is provided by the reactor core isolation cooling (RCIC) turbine-driven pump, which is normally aligned to take suction from the condensate storage tank (CST). Because the CST is not protected from all postulated hazards, the licensee's mitigation strategy assumes that the RCIC pump suction realigns to the suppression pool. Within 2 hours, the operators take manual control of the SRVs to perform a controlled cooldown and depressurization of the reactor. The cooldown of the primary system is stopped when reactor pressure reaches a control band of 200 pounds per square inch gauge (psig) to 400 psig to ensure sufficient steam pressure to operate the RCIC pump. When the suppression pool temperature reaches approximately 170 degrees Fahrenheit (°F) (in about 3 hours after the initial ELAP) the RCIC suction will be locally manually aligned to the upper containment pool (UCP), which is located in the containment, in order to maintain a cool source of cooling water supply to the RCIC pump and turbine, as well as to maintain net positive suction head (NPSH) for the RCIC pump. The RPV makeup will continue to be provided from the RCIC system until the gradual reduction in RPV pressure resulting from diminishing decay heat requires a transition to Phase 2 methods. Prior to depletion of the UCP inventory supporting RCIC injection (in about 20 hours after the initial ELAP) RPV depressurization will commence again to reduce RPV pressure to less than 100 psig and allow initiation of RPV injection with the FLEX pump for decay heat removal. The FLEX pump will take suction from one of the two standby service water (SSW) basins, which serve as the UHS at the plant.

Grand Gulf has a Mark III containment with hydrogen igniters inside containment. Before the suppression pool temperature exceeds approximately 190 °F, (in about 4 hours after the initial ELAP) the containment will be vented to the atmosphere via the modified 20-inch diameter containment vent path to limit containment pressurization and minimize the containment temperature increase until equipment from a National Strategic Alliance of FLEX Emergency Response (SAFER) Response Center (NSRC) can be set up for cooling of the suppression pool in Phase 3. One portable diesel generator (DG) to power hydrogen igniters is stored in each of the two FLEX storage buildings (FSBs) and one will be deployed to repower one train of the containment hydrogen igniters. The local initiation of the single train of hydrogen igniters will be manually performed when directed by the emergency operating procedures (EOPs).

The SFP is located in the auxiliary building. To maintain SFP cooling capabilities, the licensee stated that the required action is to establish the water injection lineup before the environment on the SFP operating floor degrades due to boiling in the pool so that personnel can access the operating floor 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 in approximately 5 hours for a full core offload and approximately 12 hours for a design-basis heat load after the start of the ELAP. The earliest that fuel in the SFP could be uncovered from boil-off for the worst case full core offload (outage conditions only) is approximately 57 hours and the earliest that fuel in the SFP could be uncovered from a normal core offload (design basis heat load) is approximately 132 hours. The licensee determined that habitability on the SFP operating floor area could become compromised after boiling commences, so valve lineups and hose deployments are planned prior to that time.

To makeup to the SFP, the licensee has a primary and alternate strategy to account for the condition of the pool. If the operating floor is accessible and habitable, the primary SFP strategy is to connect FLEX hoses to a diesel-powered FLEX pump. The discharge ends of these hoses are either routed all the way to the SFP, with the discharge ends positioned over the edge of the pool or connected to nozzles that spray the water over the spent fuel. If the operating floor is not accessible or habitable, the alternate strategy is to connect a FLEX hose from a diesel-powered FLEX pump to an existing connection on the fuel pool cooling and cleanup (FPCCU) piping which then directs the water into the SFP.

The operators will perform dc bus load stripping within the initial 2 hours following event initiation to ensure safety-related battery life is extended up to 12 hours. Following dc load stripping and prior to battery depletion, one 300 kilowatt (kW), 480 volt alternating current (Vac) generator will be deployed from an FSB. This portable generator will be used to repower essential battery chargers within 11 hours of ELAP initiation, as well as repowering an associated battery room exhaust fan and the high pressure core spray (HPCS) DG fuel oil storage tank fuel transfer pump.

In addition, an NSRC will provide high capacity pumps and large combustion turbine generators (CTGs) which could be used to restore one residual heat removal (RHR) cooling train to cool the core in the long term. There are two NSRCs in the United States.

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

3.2 Reactor Core Cooling Strategies

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

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

3.2.1 Core Cooling Strategy and RPV Makeup

3.2.1.1 Phase 1

Per the GGNS FIP, the injection of cooling water into the RPV will be accomplished using the RCIC system. The RCIC system suction is initially lined up to the CST and will pump water into the RPV from the CST if the CST is available. However, the CST is not protected against seismic and windborne missile hazards, and thus cannot be credited to be available in all FLEX scenarios. On CST low level or suppression pool high level, RCIC suction will automatically transfer to the suppression pool via the action of dc-powered CST level instrumentation, valves, and interlocks. This swap-over function is protected from all applicable hazards.

The RCIC pump will be used to supply water to the RPV for the ELAP event. The RCIC pump is powered by a turbine using steam from the RPV and is robust with respect to design-basis external hazards. The RCIC pump is designed to start automatically on low level in the RPV. In the event that RCIC does not automatically start, procedural guidance directs the operators to manually start the pump. The RCIC system valves are powered by a 125 volt direct current (Vdc) bus and are used to control the cooling flow to the RPV in order to maintain the RPV level within its desired control band.

Pressure control of the RPV is accomplished using the SRVs, which are controlled using power from the 125 Vdc buses with air pressure for opening and spring pressure for closing. At approximately 1 hour after the initiation of the event, operators will enter the ELAP procedure, and at about 2 hours the RPV pressure will be reduced using SRVs at a rate that cools the RPV at less than 100 °F per hour. After this point, the RPV pressure is maintained between 200 and 400 psig to allow enough steam pressure for continued operation of the RCIC system. The normal air supply to the dc-powered air-assisted SRVs is provided by the instrument air system, which is assumed to be lost in a FLEX scenario. Each of the SRVs utilized for automatic depressurization has backup air accumulators and receivers.

At approximately 3 hours after the start of the ELAP event, SRV blowdown and RCIC pump exhaust will have caused suppression pool temperature to reach 170 °F based on thermal-hydraulic calculations. At this point the elevated suppression pool temperature may begin to challenge RCIC NPSH and impact RCIC durability. The RCIC suction source is then transferred to the UCP, providing cooler water for injection to the RPV. Since the UCP is located at a higher elevation than the suppression pool, sufficient NPSH is ensured for the RCIC pump based on the licensee's evaluation for continued operation during Phase 1 coping.

In its FIP, the licensee described modifications that include the replacement of the manual operator on the UCP drain inboard containment isolation valve with a battery-powered dc motor operator (controlled from the auxiliary building) and the installation of a piping system which would allow RCIC suction from the UCP. At approximately 3 hours after initiation of the ELAP event, when the suppression pool temperature exceeds 170 °F, the operators will manually align RCIC suction to the UCP and adjust the RCIC flow controller to maintain level in accordance with the FLEX support guidelines (FSGs). At approximately 4 hours after the initiation of the ELAP event, when the suppression pool temperature exceeds 190 °F, the modified EOP vent is opened to remove containment heat. The vent will remain open for the duration of the event. In its FIP, the licensee states that RCIC can provide adequate core cooling for at least 20 hours into the ELAP event during Phase 1.

Station batteries and the Class 1E 125 Vdc distribution system provide power to RCIC systems and instrumentation. The dc load shedding is accomplished within 2 hours of event initiation to extend the battery capacity to power the Phase I systems and instrumentation. After load shedding, the installed batteries can maintain the necessary voltage for about 12 hours. Prior to battery depletion, a FLEX DG is deployed and used to recharge the Division I and Division II batteries.

3.2.1.2 Phase 2

For the Phase 2 core cooling strategy, GGNS relies on FLEX components that consist of one 480 Vac diesel generator and one 500 gallon per minute (gpm) diesel-driven makeup pump supported by a 500 gallon fuel tank trailer and portable fans to cool the main control room (MCR). A complete set of FLEX equipment is stored in each of two FSBs. Only one FSB is credited to survive a tornado event. The GGNS strategy for coping during Phase 2 encompasses about 99 hours from the ELAP event initiation and includes primary and alternate core cooling strategies.

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. To support this operation a 480 Vac FLEX DG will be utilized to repower two load centers. These load centers will power associated Division I and II battery chargers, ensuring that dc-powered components in the RCIC system will continue to have power. Additionally, the battery chargers will provide dc power to critical instrumentation.

Per the FIP, in order to maintain the continued use of the SRVs four portable nitrogen bottles will be stored in each of the FLEX buildings. These bottles will be connected at approximately 40 hours after initiation of the event and will replenish the air receivers and accumulators associated with the SRVs that are part of the automatic depressurization system. Tools which will be necessary to perform this evolution are located in a seismically-restrained box inside the auxiliary building on the 139 foot elevation level.

Per the FIP, at approximately 20 hours after the initiation of the ELAP event, the volume in the UCP is expected to be depleted. At this point the RCIC pump will no longer be available. The licensee's primary strategy is to pump water from the UHS to the RPV. For this strategy GGNS has a diesel-driven FLEX pump in each FSB. Water drawn into the FLEX pump must pass through a suction strainer. The primary and alternate suction sources for FLEX pumps are SSW Basin A and SSW Basin B, respectively. Each pump is provided with an additional suction strainer to facilitate the swapping of strainers. One FLEX pump is expected to be aligned at approximately 11 hours, with suction from one of the two SSW basins, in order to pump water to the SFP. This pump can readily be aligned to deliver flow from the SSW basin, through safety related underground piping to the HPCS diesel room, with newly installed FLEX hose connections there which will allow the delivery of water to either the RHR 'C' piping (primary injection path to the RPV) or the low pressure core spray (LPCS) system (alternate injection path to the RPV) via connections on the condensate and refueling water storage and transfer (CRWST) system.

Per the FIP, to facilitate the pumping of water from the UHS to the RPV, pressure in the RPV must be lowered. Prior to FLEX pump injection, SRVs will be opened to depressurize the RPV to less than 100 psig. At this pressure the FLEX diesel pump will be able to transfer water from the SSW basin, through the designated piping and into the RPV.

An alternate RPV injection method postulates the unavailability of the underground piping and delivers the UHS water for core cooling directly via hoses to the connections on the CRWST system piping which connects to the primary and alternate injection paths. As this alternate method allows for a flowpath to the RPV in the event that any single piping system fails, NRC staff considers this an acceptable method of compliance with the guidance for alternate injection paths in NEI 12-06, Revision 0, Section 3.2.2.

The usage of the SSW basins will provide adequate volume for the core cooling strategy into phase 3. Each of the two diesel-driven pumps is rated for 500 gpm at 146 psig. During a site visit NRC staff reviewed calculations associated with the pump sizing and NPSH. These calculations demonstrated that a single FLEX pump can provide the required flow rates necessary to satisfy the requirements for both the core cooling and the SFP spray strategies simultaneously.

3.2.1.3 Phase 3

The Phase 3 strategy includes the use of equipment from the NSRC. Grand Gulf continues the use of Phase 2 equipment, or replacements as necessary. Water level in the SSW basins will decrease during Phase 2. At approximately 99 hours after the ELAP the FLEX pumps will not have sufficient NPSH to pump water from the SSW basins. Pumps with hoses or water transportation trucks supplied from offsite can provide water from the Mississippi River. The NSRC-supplied equipment can be used to provide makeup to the SSW basins for infinite core cooling from the Mississippi River. Water can be pumped from the river to the SSW basins using the NSRC makeup pump and submersible pump and conveyed by using 9900 feet of flexible hose supplied from offsite. The Phase 3 alternate method consists of transitioning from Phase 2 coping by repowering the RHR pump B and associated motor operated valves to establish shutdown cooling using the RHR system. In table 4 of the FIP, the licensee states that NSRC-supplied equipment will include an RPV makeup pump rated at 500 gpm, a submersible pump rated at 1000 gpm, a low pressure/medium flow pump rated at 2500 gpm, a low pressure/high flow pump rated at 5000 gpm, two 4160 Vac generators, and one 4160 Vac distribution system.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

The licensee stated during the audit process that GGNS is classified as a wet site for the beyond-design-basis events based on the updated flood level from Probable Maximum Precipitation (PMP). The north FSB and south FSB are both above the bounding flood elevation from local intense precipitation (LIP). The deployment path from the south FSB may be inundated by maximum water depth of 1.5 feet from the LIP event, however, the maximum flood water level will drop significantly within 2 hours while FLEX deployment is not needed for about 6 hours. The licensee stated that the deployment path from the north FSB will be below the reevaluated probable maximum flood level, however, the deployment path from the south FSB will remain accessible for transportation of FLEX equipment. Effects of on-site flooding are discussed in Section 3.5.2. The licensee's core cooling and makeup strategy implementation remain the same for a flooding event.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

In NEI 12-06, Section 3.2 states that installed equipment designed to be robust with respect to design-basis external events is assumed fully available for use in mitigating the effects of an ELAP. In addition, Condition 6 of NEI 12-06, Section 3.2.1.3, states that permanent plant equipment contained in structures with designs that are robust with respect to the applicable hazard(s) is available. The Grand Gulf updated final safety analysis report (UFSAR), Section 3.2.1.1, states that all Seismic Category I structures, systems, and components (SSCs) are designed to withstand the appropriate seismic loads, Seismic Design, and other applicable loads without loss of function. Section 3.3 of the UFSAR states that Seismic Category I structures, and structures that contain systems, equipment, and components required for safe shutdown after a tornado are designed to withstand the tornado and extreme wind phenomena applicable to GGNS. Section 3.4.1.3 of the UFSAR states that Seismic Category I structures that may be affected by external floods are designed to withstand the design-basis floods applicable to GGNS. In addition, UFSAR Tables 3.2-1 and 3.2-1 list the seismic and tornado qualifications, respectively, of the SSCs at GGNS.

Phase 1:

The licensee's Phase 1 core cooling FLEX strategies for GGNS rely on its existing RCIC system to remove heat from the RPV using water from the suppression pool and the UPC. In addition, the licensee relies on its station batteries and 125 Vdc distribution system for powering critical instrumentation and for remote RCIC system operation.

The licensee's primary core cooling strategy uses the turbine-driven RCIC pump to supply water to the RPV, with the steam usage by RCIC assisting with RPV depressurization. The RCIC pump auto starts on low RPV level or high suppression pool level. If needed, operators can manually start the RCIC pump using existing station procedures. As described in the FIP and UFSAR Tables 3.2-1 and 3.3-1, the RCIC pump, its steam supply, and RCIC piping and valves are Seismic Category I, tornado-protected components. The RCIC pump is located within the Seismic Category I auxiliary building and is protected from all applicable external hazards. The RCIC steam supply, and RCIC piping and valves are located within portions of the Seismic Category I containment and auxiliary buildings, and are protected from all applicable external hazards. Based on the location and design of the RCIC system, as described in the FIP and the UFSAR, the RCIC system should be available to support Phase 1 core cooling during an ELAP.

During normal operation, the RCIC suction is aligned to the non-seismic, non-missile-protected CST. If the CST is damaged, the RCIC suction automatically transfers to the suppression pool on low CST level. The automatic transfer of the RCIC suction to the suppression pool is a safety-related function and is accomplished with Seismic Category I components located in the Seismic Category I auxiliary building. If the automatic transfer function is unavailable, operators can manually align the RCIC suction to the suppression pool using existing station procedures. As described in the FIP, and Tables 3.2-1 and 3.3-1 of the UFSAR, the suppression pool is a Seismic Category I structure located in the Seismic Category I containment building, and is protected from all applicable external hazards. Based on the design and location of the suppression pool, as described in the FIP and the UFSAR, the suppression pool should be available to support Phase 1 core cooling during an ELAP.

During the initial stages of Phase 1 core cooling, heat generated by the reactor is dissipated by steam release through the exhaust of the RCIC turbine into the suppression pool. If that is not sufficient to remove all the heat, operators will open SRVs, which also release steam into the suppression pool. In order to maintain adequate net positive suction head (NPSH) for the RCIC pump, operators will manually align the RCIC suction to the UPC before the suppression pool temperature reaches 170 °F. As described in the FIP, the UPC is located within the Seismic Category I containment and is protected from all applicable external hazards. Based on the location and design of the UPC, as described in the FIP, the UPC should be available to support Phase I core cooling during an ELAP.

During Phase 1 core cooling, the licensee relies on the station batteries and the 125 Vdc distribution system to power key instrumentation and RCIC control valves. As described in the FIP, and UFSAR Tables 3.2-1 and 3.3-1, the Class 1E 125 Vdc system is a Seismic Category I, tornado protected system. The Class 1E 125 Vdc systems, including batteries, are housed in Seismic Category I structures and are protected from all applicable external hazards. Based on the location and design of the Class 1E 125 Vdc systems, as described in the FIP and the UFSAR, the 125 Vdc systems, including the batteries, should be available to support Phase I core cooling during an ELAP.

<u>Phase 2:</u>

The licensee's Phase 2 core cooling strategy relies on the continued use of the RCIC pump supplying water to the RPV from the UCP and relieving heat to the suppression pool via the RCIC turbine exhaust as described above. In addition, the licensee relies on the CRWST system, RHR "C" train, LPCS system, HPCS system service water (SW) return line, SRVs and associated instrument air, and the Class 1E 125 Vdc distribution system.

During Phase 2, once the water in the UCP is depleted, the licensee will supply water to the RPV via a portable FLEX pump taking suction from one of the SSW basins. As described in the FIP, and Tables 3.2-1 and 3.3-1 of the UFSAR, the SSW cooling basins are Seismic Category I, tornado-resistant structures and are protected from all applicable external hazards. Based on the design of the SSW basins, as described in the FIP and the UFSAR, the SSW basins should be available to support Phase 2 core cooling during an ELAP.

The portable FLEX pump discharges into the HPCS SW return line via portable hoses and FLEX connections. The HPCS SW return line is part of the SSW system and runs underground from the SSW basin "A" valve room to the HPCS diesel generator room. As described in the FIP and Tables 3.2-1 and 3.3-1 of the UFSAR, the SSW system is a Seismic Category I, tornado-protected system and is protected from all applicable external hazards. Based on the design and location of the HPCS SW return line, as described in the FIP and the UFSAR, the HPCS SW return line should be available to support Phase 2 core cooling during an ELAP.

In order to inject water to the RPV from the FLEX pump, the HCPS SW return line will be cross connected via portable hoses and FLEX connections to the CRWST system, which can supply water to the RHR "C" train or the LPCS system, both of which have injection paths to the RPV. As described in the FIP and Tables 3.2-1 and 3.3-1 of the UFSAR, the RHR and LPCS systems are Seismic Category I, tornado-protected systems. Both systems are located within the Seismic Category I auxiliary and containment buildings and are protected from all applicable external hazards. The sections of the CRWST system used to connect to the RHR and LPCS systems are located in the Seismic Category I auxiliary building and are protected from all applicable external hazards. Based on the design and location of the CRWST system, the RHR "C" train, and the LPCS system, as described in the FIP and the UFSAR, these systems should be available to support Phase 2 core cooling during an ELAP.

In order to inject water into the RPV using a portable FLEX pump, the license depressurizes the RPV using SRVs which are part of the automatic depressurization system (ADS). The SRVs are air-operated valves with Class 1E 125 Vdc powered solenoids. As described in the FIP and Tables 3.2-1 and 3.3-1 of the UFSAR, the ADS including the SRVs, air receivers, air accumulators, interconnecting piping, and associated valves is a Seismic Category I system. The SRVs are located in the Seismic Category I containment building and are protected from all applicable external hazards. The applicable ADS instrument air system is located in the Seismic Category I containment and auxiliary buildings and is protected from all applicable hazards. Based on the design and location of the ADS SRVs and applicable instrument air system, as described in the FIP and the UFSAR, the SRVs should be available to support Phase 2 core cooling during an ELAP.

Phase 3:

For Phase 3 core cooling, the licensee plans to continue the Phase 2 strategies discussed above while augmenting the onsite portable equipment with NSRC-supplied equipment. In addition, if needed the licensee can use the NSRC equipment to repower and place in service the RHR and SSW systems.

3.2.3.1.2 Plant Instrumentation

The GGNS plan includes monitoring instrumentation in the control room. The instrumentation will be powered by safety-related 120 Vac inverters supplied from the safety-related batteries. The batteries will be maintained for indefinite coping using battery chargers powered by the FLEX diesel generators.

As described in Entergy's FIP for GGNS, instrumentation for the following parameters is credited for all phases of core cooling and RPV inventory control:

- RPV Level
- RPV Pressure
- Suppression Pool Water Level
- Suppression Pool Temperature
- Containment Pressure

The instrumentation identified by the licensee to support its core cooling strategy is consistent with the recommendations specified in the guidance of NEI 12-06.

The instrumentation is available both prior to and after load shedding of dc busses during Phase 1. The 125 Vdc battery chargers for station batteries will be repowered by FLEX portable diesel generators to maintain availability of instrumentation during Phase 2 and 3. In addition, the instrument indications would be continuously accessible throughout the ELAP event.

In accordance with NEI 12-06 Section 5.3.3.1, guidelines for obtaining critical parameters locally are provided in a FLEX Support Guideline (FSG). Should it be required, the licensee will use guidance that provides a list of key parameters, locations, and equipment needed to obtain local readings of key parameters. Guideline FSG 05-S-01-FSG-007, Revision 0, "Loss of Control/Instrumentation Power, provides alternate methods for obtaining critical parameters if key parameter instrumentation is unavailable. 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 review of the licensee's analysis of containment thermal-hydraulic behavior is provided 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 Nuclear Station, Unit 2. Currently, maintenance and development of the code is carried out under the direction of the Electric Power Research Institute (EPRI).

To provide analytical justification for their mitigating strategies in response to Order EA-12-049, a number of licensees for BWRs and pressurized-water reactors (PWRs) completed analysis of the ELAP event using Version 4 of the MAAP code (MAAP4). Although MAAP4 and predecessor code versions have been used by industry for a range of applications, such as the analysis of severe accident scenarios and probabilistic risk analysis (PRA) evaluations, the NRC staff had not previously examined the code's technical adequacy for performing best-estimate simulations of the ELAP event. In particular, due to the breadth and complexity of the physical phenomena within the code's calculation domain, as well as its intended capability for rapidly simulating a variety of accident scenarios to support PRA evaluations, the NRC staff observed that the MAAP code makes use of a number of simplified correlations and approximations that should be evaluated for their applicability to the ELAP event. Therefore, in support of the reviews of licensees' strategies for ELAP mitigation, the NRC staff audited the capability of the MAAP4 code for performing thermal-hydraulic analysis of the ELAP event for both BWRs and PWRs. The NRC staff's audit review involved a limited review of key code models, as well as confirmatory analysis with the TRACE 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 NRC staff's review of EPRI's June 2013 technical report, as supplemented by further discussion with the code vendor, audit review of key sections of the MAAP code documentation, and confirmation of acceptable agreement with NRC staff simulations using the TRACE code, the NRC staff concluded that, under certain conditions, the MAAP4 code may be used for best-estimate prediction of the ELAP event sequence for BWRs.

The NRC staff issued an endorsement letter dated October 3, 2013 [Reference 54], 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.

During the audit process, the NRC staff verified that the licensee's MAAP calculation, along with an associated addendum, addressed the limitations from the NRC staff's endorsement letter. The licensee utilized the generic roadmap and response template that had been developed by EPRI to support consistency in individual licensee's responses to the limitations from the endorsement letter. In particular, based upon review of the MAAP calculation documentation, the staff concluded that appropriate inputs and modeling options had been selected for the code parameters expected to have dominant influence for the ELAP event. The NRC staff further observed that the limitations imposed in the endorsement letter, particularly those concerning the RPV collapsed liquid level being maintained above the reactor core and the primary system cooldown rate being maintained within Technical Specification limits, were satisfied. Specifically, the licensee's analysis calculated that GGNS would maintain the collapsed liquid level in the reactor vessel above the top of the active fuel region throughout the analyzed ELAP event. The licensee calculated the minimum RPV water level above the top of active fuel is 2.9 feet shortly after the RPV is depressurized for Phase 2 core makeup. By maintaining the reactor core fully covered with water, adequate core cooling is assured for this event. Additionally, the licensee's fulfillment of the endorsement letter condition regarding the primary system cooldown rate signifies that thermally-induced volumetric contraction and other changes in primary system thermal-hydraulic conditions should proceed relatively slowly with time, which supports the NRC staff's confidence in the predictions of the MAAP code. Furthermore, the NRC staff conclusion that the licensee should be capable of maintaining the entire reactor core submerged throughout the ELAP event is consistent with the staff's expectation that the licensee's flow capacity for primary makeup (i.e., using the installed RCIC pump and, subsequently, FLEX pumps) should be sufficient to support adequate heat removal from the reactor core during the analyzed ELAP event, including potential losses due to expected primary leakage.

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

3.2.3.3 Recirculation Pump Seals

An ELAP event would result in the interruption of cooling to the recirculation pump seals, potentially resulting in increased leakage due to the distortion or failure of the seals, elastomeric O-rings, or other components. Sufficient primary make-up 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 licensee's calculations for GGNS assumed a leakage rate at normal RPV operating pressure of 66 gpm. This leakage rate includes 18 gpm per recirculation pump seal in accordance with NRC Generic Letter 91-07. In addition, the licensee's calculation assumed an additional primary system leakage rate equal to the Technical Specification LCO 3.4.5 limit of 30 gpm. Thus, between the two recirculation pumps and the additional primary system leakage, the total primary leakage rate assumed for GGNS during the ELAP event was 66 gpm at normal operating reactor pressure.

In the GGNS FIP, the licensee discussed system response to the variation of seal leakage rate as a function of RPV pressure in the thermal-hydraulic simulation. The initial seal leakage rate was assumed to be 66 gpm. This leak rate was based on a leakage area of 1.02E-03 ft^2. During the first hour after the ELAP event, as the RPV underwent injection from the RCIC system, the MAAP analysis showed that subcooling of the liquid increased and the inventory loss rate increased to a maximum of 136 gpm. As the RPV was depressurized the seal leakage rate was reduced. The leakage rate was assumed to be between 28 and 80 gpm when the RPV is depressurized at 2 hours after the ELAP initiation. The leakage rate was further reduced to 17 gpm after 20 hours when the RPV was depressurized to 100 psig prior to injection using a FLEX pump. The licensee concluded that the RPV water level continued to be above the top of the active fuel throughout the simulation period.

During the onsite 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 has Model CAN8 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 station blackout (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 the licensee for GGNS is reasonable in light of the similarity of the CAN2A and CAN8 seal designs. The staff further notes that the recirculation pump design for GGNS 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, GGNS 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.

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

3.2.3.4 Shutdown Margin Analyses

As described in its UFSAR, GGNS's design is such that the control rods provide adequate shutdown margin under all anticipated plant conditions, with the assumption that the highest-worth control rod remains fully withdrawn. Grand Gulf Technical Specification Section 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 FLEX Pumps and Water Supplies

As described in the licensee's FIP, the licensee credits one portable pump for core cooling FLEX strategies. The portable FLEX pump is a trailer-mounted, diesel engine driven, centrifugal pump. The FLEX pump can take suction from the SSW basins and provides a backup RPV injection method in the event that the RCIC pump can no longer perform its function. The licensee credits the portable pump as the motive force for both RPV injection and SFP makeup. The licensee has two RPV FLEX pumps on site, which satisfies the N+1 requirement of NEI 12-06.

In accordance with NEI 12-06, Section 11.2, the licensee performed calculations MC-Q1111-14008, Revision 0, "Grand Gulf Nuclear Station FLEX Phase 2 Pump Sizing Calculation," and MC-Q1111-14007, Revision 0, "Grand Gulf Nuclear Station FLEX Pump Net Positive Suction Head Available Calculation for a Beyond Design Basis External Event." The NRC staff reviewed the calculations to determine if the licensee used standard evaluation methods, and proper assumptions and inputs, and compared the results of the calculation to the actual design specifications of the procured pumps. The licensee's calculations uses classical hydraulic analysis head loss and pressure gradient methods, and includes all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX strategy water supply using the most limiting set of conditions for RPV injection concurrent with SFP makeup. The calculations determined the minimum required flow rate, minimum discharge pressure, and minimum net positive suction head available (NPSHa) for a pump to be able to perform its required function. Comparison of the actual pump performance data and the sizing criteria of the calculation shows that the FLEX pump should have the capacity needed to perform the required function for supporting core cooling.

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

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to the equipment and instrumentation used to mitigate the ELAP and LUHS. The electrical strategies described in the FIP are practically identical for maintaining or restoring core cooling, containment, and SFP cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this SE.

The NRC staff reviewed the licensee's conceptual electrical single-line diagrams in the FIP, and the summary of calculations for sizing the FLEX generators and station batteries. The staff also reviewed the licensee's evaluations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of the loss of heating, ventilation, and air conditioning (HVAC) caused by the event.

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

During the first phase of the ELAP event, GGNS would rely on the Class 1E station batteries to provide power to key instrumentation for monitoring parameters and power to controls for SSCs used to maintain the key safety functions (reactor core cooling, RPV inventory control, and containment integrity). The GGNS Class 1E station batteries and associated dc distribution systems are located within the control building and auxiliary building, which are Seismic Category I structures. The Class 1E station batteries and associated dc distribution systems are therefore protected from the applicable extreme external hazards. Licensee procedures 05-1-02-I-7, "Extended Loss of AC Power (ELAP)," Revision 0, and 05-S-01-FSG-004, "ELAP DC Bus Load Shed and Management," Revision 0, direct operators to conserve dc power during the event by stripping non-essential loads. Plant operators will strip or shed unnecessary loads to extend battery life until backup power is available. Plant operators would commence load shedding within 1 hour and complete load shedding within 2 hours from the onset of an ELAP/LUHS event.

Grand Gulf has two Class 1E station batteries separated in two safety divisions, Division I (1A3) and Division II (1B3). The station batteries were manufactured by C&D Technologies. The Class 1E station batteries have type LCR-33 cells. The licensee noted and the staff confirmed that the Division I and Division II battery capacity could be extended up to 12.10 and 14.02 hours, respectively, by shedding non-essential loads.

During the onsite audit, the licensee stated that it had followed the guidance in NEI White Paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13241A186), when calculating the duty cycle of the batteries. This paper was endorsed by the NRC (ADAMS Accession No. ML13241A188). In addition to the White Paper, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended Battery Operation in Nuclear Power Plants," in May of 2015. The testing provided additional validation that the NEI White Paper method was technically acceptable. The NEI White Paper commits to using the methodology of the Institute of Electrical and Electronic Engineers (IEEE) Standard 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," to evaluate the effects of load shedding on battery runtime. In engineering calculation EC-Q1111-14001, "Station Division I Battery 1A3 and Division II Battery 1B3 Discharge Capacity during Extended Loss of AC Power," Revision 0, the licensee stated that the evaluations were performed using the methodology of IEEE Standard 485-2010, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications." The NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI White Paper.

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

The NRC staff reviewed the licensee's dc coping calculation EC-Q1111-14001, "Station Division I Battery 1A3 and Division II Battery 1B3 Discharge Capacity during Extended Loss of AC Power," Revision 1, which verified the capability of the dc system to supply the required loads during the first phase of the GGNS FLEX mitigation strategy plan for an ELAP. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the non-essential loads that would be shed within 2 hours to ensure battery operation for least 12 hours.

Based on the staff's review of the licensee's analysis, the battery capacity, the discharge rates for the Class 1E station batteries, and the licensee's procedures, the NRC staff finds that GGNS dc systems have adequate capacity and capability to power the loads required to mitigate the consequences during Phase 1 of an ELAP provided that the 480 Vac FLEX DG is used to energize the battery chargers, and the dc load shedding is completed, within the times assumed in the licensee's analysis.

The licensee's Phase 2 strategy includes repowering 480 Vac buses within 11 hours after initiation of an ELAP event using a 300 kilowatt (kW) 480 Vac FLEX DG. The 480 Vac FLEX DG will supply power to load centers 15BA6 and 16BB6. In its FIP, the licensee stated that the 300 kW 480 Vac FLEX DG is capable of repowering the two 125V battery chargers, the HPCS DG fuel oil storage tank transfer pump, the containment vent UPS, and a battery room exhaust fan. The NRC staff reviewed engineering change (EC) document EC-Q1111-14002, "FLEX Strategy - Portable Diesel Generator System Sizing, Revision 1, procedures 05-S-01-FSG-004 and 05-S-01-FSG-005, "Initial Assessment and Flex Equipment Staging, Revision 0, conceptual single line diagrams, and the separation and isolation of the 480 Vac FLEX DG from the Class 1E emergency diesel generators. Based on the NRC staff's review, the minimum required loads for the Phase 2 300 kW 480 Vac FLEX DG is approximately 243 kW. The Phase 2 strategy also includes repowering the hydrogen igniters using a 15 kW 240 Vac FLEX DG. The NRC staff reviewed calculation EC-50275, "FLEX Basis EC," Revision 2. Based on the NRC staff's review, the maximum running load on the 15 kW 240 Vac FLEX DG is 4.4 kW. Therefore, one 300 kW 480 Vac and one 15 kW 240 Vac FLEX DG have sufficient capacity to support the electrical loads required for the licensee's Phase 2 strategies.

For Phase 3, the licensee plans to continue the Phase 2 coping strategy with additional assistance provided from offsite equipment and resources. The offsite resources that will be provided by an NSRC includes two 1-megawatt (MW) 4160 Vac combustion turbine generators (CTGs), one 1100 kW 480 Vac CTG, and a 4160 Vac distribution panel (including cables and connectors). Each portable 4160 Vac CTG is capable of supplying approximately 1 MW, but two CTGs will be operated in parallel using the distribution panel to provide a total of approximately 2 MW. The NRC staff reviewed the licensee's EC document EC-Q1111-14002. Based on the NRC staff review, GGNS minimum required loads for the Phase 3 4160 Vac CTGs is approximately 1829 kW. Based on the margin available for the 4160 Vac CTGS and the 480 Vac CTG providing backup to the Phase 2 portable FLEX DG, the NRC staff finds that the 4160 Vac and 480 Vac equipment being supplied from an NSRC have sufficient capacity and capability to supply the required loads.

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

3.2.4 Conclusions

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

3.3 Spent Fuel Pool Cooling Strategies

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

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

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

Part of the licensee's FIP defines strategies capable of mitigating a simultaneous ELAP and loss of normal access to the UHS by providing the capability to maintain or restore SFP cooling. The NRC staff reviewed the licensee's FIP to determine whether the strategies outlined in the FIP, if implemented appropriately, would maintain or restore SFP cooling following the loss of all ac power and access to the UHS. As part of its review, the NRC staff reviewed simplified flow diagrams, engineering drawings, summaries of calculations for sizing the FLEX pumps, and summaries of calculations that addressed the heat up rates of the SFP following a loss of normal cooling functions during an ELAP. The ELAP causes a loss of cooling for the SFP. As a result, the pool water will heat up and eventually boil off. The licensee's response is to provide makeup water. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP. The sections below address the response during plant operation at power. The effects of an ELAP with full core offload to the SFP is addressed in Section 3.11.

The NRC staff discussed the SFP cooling portion of the GGNS mitigation strategy for an ELAP event with the licensee's staff and performed a walk-down of the licensee's SFP cooling strategies during an onsite audit. The walk-down focused on the areas where SFP cooling FLEX equipment will be stored, deployed, and operated, the connection points to the existing piping systems, and the hose runs from the deployed FLEX pumps. The licensee's basic FLEX strategy for maintaining SFP cooling is to monitor SFP level utilizing the SFP level instrumentation installed in accordance with NRC Order EA-12-051 and initiating SFP makeup as soon as resources are available but prior to SFP water level reaching the top of the fuel.

3.3.1 Phase 1

For Phase 1 SFP cooling, the licensee credits the large inventory and heat capacity of the water in the SFP. Following the loss of SFP cooling, the SFP will slowly heat up and eventually begin to boil. As described in the FIP, using the most limiting non-outage, design-basis decay heat load, and SFP starting temperature, the SFP would begin to boil in approximately 11.91 hours after the loss of SFP cooling with the level reaching the top of the fuel in approximately 132 hours. The licensee's initial coping strategy for SFP cooling is to allow evaporative cooling of the SFP while monitoring SFP level using instrumentation installed as required by NRC Order EA-12-051. Although SFP makeup is commenced during Phase 2, as described in the FIP the licensee plans to deploy makeup hoses prior to the SFP reaching 212 °F in order to minimize personnel entering the area during high heat and humidity conditions which may occur in later phases. In addition, the licensee will establish a vent pathway, by opening auxiliary building doors, to minimize condensation of steam from the boiling SFP.

3.3.2 Phase 2

In accordance with NEI 12-06, Table 3-1 and Appendix D, the licensee has developed three baseline SFP cooling strategies. The strategies use a portable injection source to provide makeup via connection to spent fuel pool cooling piping without having to access the refueling floor, via hoses on the refueling floor, and via spray using portable monitor nozzles from the refueling floor. As described in the FIP, personnel will align a portable FLEX pump drawing water from the one of the SSW basins to maintain a sufficient amount of water above the top of the fuel assemblies for cooling and shielding purposes.

The licensee's first method provides water, at a rate that matches boil-off, directly to the SFP from the SSW basin through a fire hose. As described in its FIP, the licensee will deploy hoses inside the SFP area prior to the SFP reaching 212 °F in order to minimize the need for personnel access to the SFP area. Prior to initiating SFP makeup, the licensee will route hoses in the auxiliary building and connect to the hose deployed from the SFP area for completion of the flexible hose flow path for direct makeup to the SFP.

The licensee's second method provides water at a rate of 250 gpm, which also accounts for any overspray, to the SFP using the portable FLEX pump taking suction from the SSW basin and discharging to the SFP through a fire hose connected to a monitor spray nozzle. The spray strategy consists of deploying hoses connected to two monitor spray nozzles secured to handrails on each side of the SFP. As described in its FIP, the licensee will deploy the monitor nozzles and associated hoses prior to the SFP reaching 212 °F in order to minimize the need for personnel access to the SFP area, which may have degraded environmental conditions during an ELAP. As with method 1, prior to initiating SFP spray, the licensee will route hoses in the auxiliary building and connect to the hose deployed from the SFP area for completion of the flexible hose flow path for spray cooling to the SFP.

The licensee's third method provides water, at a rate that matches boil-off, to the SFP using the portable FLEX pump taking suction from the SSW basin and discharging through fire hoses connected to an existing flush connection located on the FPCCU system piping. This method would allow the licensee to provide makeup water to the SFP without having to access to the SFP area.

3.3.3 Phase 3

For Phase 3 SFP cooling, the licensee plans to continue using Phase 2 strategies and equipment. Personnel will continue monitoring SFP level and adding inventory as necessary using the portable FLEX pump. Once NSRC equipment arrives on site, the licensee can use the equipment to replace depleted on-site Seismic Category 1 water inventories. As described in the FIP, as resources become available, the licensee can take action to transition away from extended Phase 2 coping strategies, and use the NSRC-supplied equipment to return the SFP cooling pumps and heat exchangers to service.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

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

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any operator actions. However, the licensee does establish a ventilation path to cope with temperature, humidity, and condensation from evaporation or boiling of the SFP. Prior to the SFP reaching 212° F personnel will establish a ventilation path by manually opening auxiliary building doors to vent the SFP area to atmosphere. The licensee performed an evaluation in engineering change EC50275, Revision 2, "FLEX Basis EC", Section 3.1.30, to confirm that the selected vent path provides a flow rate that exceeds the SFP boil off rate. The NRC staff reviewed the evaluation and concluded that the vent path should provide adequate ventilation to minimize condensation of steam in the auxiliary building SFP area. As described in its FIP, the licensee will establish a ventilation path prior to the onset of boiling in the SFP.

The licensee's Phase 2 and Phase 3 SFP cooling strategy involves the use of the portable FLEX pump with suction from the SSW basin to supply water to the SFP. The flow path from the SSW basin to the auxiliary building is the same as described in Section 3.2.3.1.1 of this evaluation for core cooling. In the auxiliary building, a gated wye with two hose connections is provided; one connection for reactor core cooling makeup and one for SFP makeup. The licensee will connect flexible hose to one of the two hose connections of the gated wye in the auxiliary building and then connect the hose to installed FPCCU piping for makeup to the SFP. As described in the FIP, and Tables 3.2-1 and 3.3-1 of the UFSAR, the applicable portions of the FPCCU system are Seismic Category I, tornado-protected components. The components are located within the Seismic Category I auxiliary building and are protected from all applicable external 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 credited water sources for an ELAP event is discussed in Section 3.10.3.

3.3.4.1.2 Plant Instrumentation

In its FIP, the licensee stated that the instrumentation for SFP level will meet the requirements of Order EA-12-051. Furthermore, the licensee stated that these instruments will have initial local battery power with the additional capability to be powered from portable dc batteries if necessary. 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 accordance with NEI 12-06, the licensee performed calculation MC-Q1111-14003, Rev. 000, "Grand Gulf Nuclear Station Water Requirements and Availability for a Beyond Design Basis External Event," to determine the SFP heat up times and boil off rates given the design-basis operating decay heat load of 1.9E07 British thermal units per hour (Btu/hr). The calculation determined that, with no operator action, following a loss of SFP cooling the pool would boil in approximately 12 hours and the water level would decrease to the top of the fuel in about 132 hours. Makeup water at a rate of 39 gpm is needed to maintain water level once bulk boiling commences.

3.3.4.3 FLEX Pumps and Water Supplies

As described in its FIP, the licensee's SFP cooling strategy relies on a portable FLEX pump to provide SFP makeup during Phase 2. The portable FLEX pump is the same pump as described in Section 3.2.3.5 of this evaluation and is sized to provide RPV injection concurrent with SFP makeup.

In accordance with NEI 12-06, Section 11.2, the licensee performed calculations MC-Q1111-14008, Revision 0, "Grand Gulf Nuclear Station FLEX Phase 2 Pump Sizing Calculation", and MC-Q1111-14007, Revision 0, "Grand Gulf Nuclear Station FLEX Pump Net Positive Suction Head Available Calculation for a Beyond Design Basis External Event". The NRC staff reviewed the calculations to determine if the licensee used standard evaluation methods, and proper assumptions and inputs, and compared the results of the calculation to the actual design specifications of the procured pumps. The licensee's calculations uses classical hydraulic analysis head loss and pressure gradient methods, and includes all pumps, valves, hoses, strainers, elevations, and line distances for the FLEX strategy water supply using the most limiting set of conditions for RPV injection concurrent with SFP makeup. The calculations determined the minimum required flow rate, minimum discharge pressure, and minimum net positive suction head available (NPSHa) for a pump to be able to perform its required function. Comparison of the actual pump performance data and the sizing criteria of the calculation shows that the FLEX pump should have the capacity needed to perform the required function for supporting SFP cooling.

As described in its FIP, the licensee's long-term strategy for SFP cooling is to continue the Phase 2 strategy. However, once supplemented by portable equipment delivered from the NSRC, the licensee can, if needed, supply water from the Mississippi River to replenish depleted on-site water inventories.

3.3.4.4 Electrical Analyses

The licensee's FIP defines strategies capable of mitigating a simultaneous loss of all ac power and loss of normal access to UHS resulting from a BDBEE, by providing the capability to maintain or restore core cooling, containment, and spent fuel pool cooling at the GGNS site.

The NRC staff performed a comprehensive analysis of the licensee's electrical strategies, which includes the SFP cooling strategy. The only electrical components credited by the licensee as part of its SFP cooling strategies, outside of instrumentation to monitor spent fuel pool level (which is described in other areas of this SE), are NSRC-supplied 4160 Vac CTGs. The staff reviewed EC document EC-Q1111-14002 and determined that the NSRC-supplied 4160 Vac CTGs have sufficient capacity and capability to power the plant spent fuel pool cooling systems, if necessary.

3.3.5 Conclusions

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

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06, Table 3-1, provides some examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to effectively maintain containment functions during all phases of an ELAP event. One such approach is venting containment to keep pressure below limits. Grand Gulf is a BWR with a Mark III containment. Grand Gulf is equipped with an EOP containment vent capable of performing the necessary pressure control and heat removal functions associated with an ELAP event. Specifically, GGNS will commence containment venting for containment heat removal when the suppression pool temperature exceeds 190 °F to maintain containment pressure below design conditions and to minimize the resultant containment temperature increase above design conditions.

The licensee performed a containment evaluation, XC-Q1111-14005, "Grand Gulf Core and Containment Analysis of FLEX Strategies," Rev. 000, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the containment venting heat removal strategy and concluded that the pressure and temperature in the drywell remain below the respective UFSAR Table 6.2-1 drywell design limits of 30 psig and 330 °F for at least 72 hours following an ELAP-inducing event. The drywell is a structure made primarily of reinforced concrete with a steel cap located inside the containment building, which contains the reactor vessel. Breaching the drywell does not breach the containment building. Furthermore, the calculation concludes that the pressure in the wetwell (also referred to as the suppression pool, which is located in the bottom of the containment building) also remains below the containment design limit of 15 psig for at least 72 hours. The calculated peak containment temperature of 233 °F and the calculated peak suppression pool water temperature of 226 °F exceed their design value of 215 °F. A justification for exceeding this temperature design limit is discussed in Section 3.4.4.1.1 of this SE.

Additionally, although core damage 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 GGNS FIP indicates a capability is provided to re-power a division of hydrogen igniters with a portable power supply following an ELAP-inducing event as a contingency action that addresses containment integrity. The FLEX procedures, GGNS Off-Normal Event Procedure (ONEP) 05-1-02-1-7, Revision 0, "Extended Loss of AC Power (ELAP)" and GGNS FLEX Support Guideline (05-S-01-FSG-012, Revision 0, "Alternate Containment Cooling and Hydrogen Control," contain the steps needed to repower the hydrogen igniters using a FLEX portable diesel generator. A total of two 240 Vac 15 kW portable diesel generators are stored and available for deployment, one in each of the FLEX storage buildings.

3.4.1 Phase 1

During Phase 1, containment integrity is maintained by normal design features of the containment, such as the containment isolation valves and the modified EOP containment vent path. Decay heat will be transmitted to the suppression pool via RCIC steam exhaust and SRV operations. As the suppression pool heats up, the containment atmosphere will begin to heat up and slightly pressurize. The modified EOP containment vent path will be opened when the suppression pool temperature exceeds 190 °F (approximately 4 hours after the start of the event). This action limits increases in containment pressure and temperature throughout the event. The vent path remains open to remove containment heat for the duration of the event until the "normal" design basis decay heat removal function has been adequately restored, at which time the vent flow will subside and eventually cease, allowing the valves in the vent path to be closed.

The Phase 1 coping strategy for containment includes monitoring containment pressure, suppression pool temperature, suppression pool level, drywell pressure and containment air temperature. Instrumentation indication is available in the main control room (MCR). The installed Class 1E DC distribution system will provide power for this instrumentation. Following DC load shed the Station Division I Battery 1A3 and Division II Battery 1B3 will maintain voltage above minimum requirements and will be capable of supplying power to the required loads for approximately 12 hours and 14 hours, respectively. Prior to battery depletion, a FLEX generator (1FLEXS009 or 1FLEXS010) will be deployed to power the battery chargers to maintain the instrumentation for the duration of the event.

3.4.2 Phase 2

During Phase 2, permanently installed plant equipment is used to maintain containment integrity throughout the duration of the event. The nitrogen bottles that are used to operate the air operated valves (AOVs) in the modified EOP containment vent path are of sufficient capacity to maintain the vent path open for over 72 hours which is also sufficient time to deploy and connect additional nitrogen bottles from either FLEX storage building or offsite resources. Similarly, the UPS used to operate the AOVs in the modified EOP containment vent path is of sufficient capacity to power the solenoid valves for 27 hours. A portable cable deployed from either FLEX storage building will connect the 480 Vac 300 kW DG (1FLEXS009 or 1FLEXS010) to the UPS after 24 hours to ensure long-term power for the solenoid valves. The 480 Vac 300 kW portable FLEX generator (1FLEXS009 or 1FLEXS010) is required to repower the station battery chargers at approximately 11 hours into the event to maintain dc power including the monitoring instrumentation and is therefore readily available to power the AOVs for the modified EOP containment vent path.

Therefore, the strategy for Phase 2 is the continuation of the Phase 1 strategy (use of the modified EOP containment vent path), critical instrumentation powered by the FLEX generator (1FLEXS009 or 1FLEXS010), and the hydrogen igniters available to be powered by a portable FLEX generator (1FLEXS011 or 1FLEXS022).

3.4.3 Phase 3

The GGNS FIP states that the Phase 3 strategy for long-term containment integrity is to continue the use of the strategy of Phase 1 and Phase 2 (containment venting and availability of the hydrogen igniters) with no immediate reliance on equipment from the NSRC.

During plant recovery, operation of the vent path and the residual heat removal (RHR) system will support the continued safe removal of decay heat from the RPV and containment, further reducing containment temperature and pressure which will ensure containment integrity is maintained.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

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

3.4.4.1.1 Plant SSCs

Containment:

As stated in Section 6.2.1.1 of the GGNS UFSAR, the containment system employs the drywell and pressure suppression features of the BWR-Mark III containment concept. The containment is a reinforced concrete structure in the form of a right circular cylinder with hemispherical dome and flat circular foundation mat. 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 GGNSS natural phenomena such as seismic, tornado, wind loads, external missiles, and floods. Section 3.8.1 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.

As stated in Section 3.4, the peak containment temperature of 233 °F and the peak suppression pool water temperature of 226 °F exceed their design values of 215 °F by 18 °F and 11 °F, respectively. Containment temperature and suppression pool water temperature exceed the design value of 215 °F at about 7.5 hours after the start of the ELAP event. The peak containment temperature occurs at approximately 20.5 hours after the start of the ELAP event and the peak suppression pool temperature occurs at about 21.5 hours after the start of the ELAP event. As the event progresses, the suppression pool water temperature drops below the design value of 215 °F at about 144 hours into the event and at the same time containment temperature returns to about 2 degrees above the design value where both remain for the duration of the ELAP event.

During the audit process, the licensee provided the NRC staff with GGNS calculation CC-Q1M10-14001, Revision 0, "Evaluation of Containment Wall for FLEX Strategy" and EC50275, Revision 2, "FLEX Basis EC" in order to confirm the structural integrity of the containment wall and structures for the analyzed conditions associated with the FLEX strategy. The method of analysis used to evaluate the existing containment wall was based on the following steps: the design calculations, CC-Q1M10-10001, Rev. 0, "Evaluation of Containment Wall for Extended Power Uprate," were reviewed 1) for thermal loading conditions to establish the maximum design temperature used in the analysis; 2) to identify the critical load combinations; 3) to identify the most critical locations in the containment wall; and 4) to ensure that the stresses and strains in the concrete, reinforcing steel and liner plate did not exceed the allowable limits. Based on calculation CC-Q1M10-14001, it was determined that the structural integrity of the existing containment wall is satisfactory subject to the small temperature increases at the peak temperatures associated with the FLEX strategy as described in the FLEX Basis engineering evaluation, EC50275.

Regarding the potential consequences of the elevated containment and suppression pool water temperature, the NRC staff finds that the exceedance of the design limit described above has been adequately justified to demonstrate that there will not be significant adverse effects. Thus, it is reasonable that the structural integrity of the containment will be maintained under the expected ELAP conditions.

EOP Vent Path:

To support FLEX strategies, the existing EOP containment vent path was modified. A new 20" diameter butterfly type AOV was installed inside of containment on a new 20" tee branch installed on the containment vent line upstream of the inboard containment isolation valve (1M41F034) such that the new 20" AOV opens directly into containment, bypassing the non-safety related/nonqualified charcoal filtration train to establish a modified vent path directly to the atmosphere. The new 20" AOV is remotely operated from a new alternate control panel

(1M41P001) seismically installed outside of containment, but nearby in the auxiliary building. The new 20" AOV is designed to operate without reliance on normal instrument air or normal ac power.

The two existing air operated 20" diameter primary containment isolation valves (PCIVs) and the two existing air operated 20" diameter secondary containment isolation valves (SCIVs) that are downstream of the new 20" AOV initially fail closed upon the loss of power event; however, following modification they are remotely opened from the new alternate control panel (1M41P001) without reliance on normal instrument air or normal ac power.

To support the new alternate control panel (1M41P001) and operation of the five AOVs, independent nitrogen bottles are seismically installed in the auxiliary building next to the control panel. Also, an independent UPS and associated batteries are installed in panel 1M41P001. The nitrogen bottles have sufficient capacity to power and maintain the vent path open for at least 72 hours while the UPS batteries have sufficient capacity to power the AOV solenoid valves for at least 27 hours prior to which time additional onsite and offsite resources will be available.

For the AOVs, each additional air bottle will counteract leakage for more than 36 hours (PC-N1M41-14001). Considering that only 2 bottles are required to support the 72 hour duration, and 4 bottles are installed, more than 144 hours is available and sufficient time exists to deploy and connect an additional nitrogen supply from either FLEX storage buildings or offsite resources.

The UPS power supply (1M41PS01) for operation of the AOVs is sufficient for at least 27 hours following the ELAP considering the required single cycle of the five solenoid valves. A temporary cable will be routed from a convenience receptacle on the 480V FLEX diesel generator (1FLEXS009 or 1FLEXS010) within 27 hours to repower the UPS. There is sufficient capacity on the 480V FLEX diesel generator (1FLEXS009 or 1FLEX010) to carry the load of the AOV solenoid valve UPS integral to the control panel 1M41P001.

Hydrogen Igniters

Section 6.2.5.2.2.2 of the UFSAR states that the hydrogen igniters are powered from Class IE power panels that have a normal offsite and an alternate onsite diesel ac power supply. In addition, the hydrogen ignition system is designed as a seismic Category I system. Therefore, the igniters are expected to function when powered from a FLEX generator after a BDBEE.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-1 specifies that containment pressure, suppression pool level, and suppression pool temperature are key containment parameters which should be monitored by repowering the appropriate instruments. The licensee's FIP states that in addition to the key containment parameters required by NEI 12-06, listed above, the installed Class 1E dc distribution system will also provide power for instrumentation to monitor drywell pressure and containment air temperature.

The above instrumentation is available prior to and after load shedding of the dc buses during Phase 1. Continued availability during Phases 2 and 3 is maintained by repowering the 125

Vdc battery chargers for the station 125 Vdc batteries using either FLEX portable diesel generator (1FLEXS009 or 1FLEXS010).

Portable FLEX equipment is supplied with the local instrumentation needed to operate the equipment. The use of these instruments is detailed in the associated FSGs for use of the equipment. These procedures are based on inputs from the equipment suppliers, operation experience, and expected equipment function in an ELAP.

Guideline 05-S-01-FSG-007, Revision 0, "Loss of Control/Instrumentation Power," provides alternate methods for obtaining critical parameters if key instrumentation is unavailable. Therefore, 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 <u>Thermal-Hydraulic Analyses</u>

The licensee performed calculation XC-Q1111-14005, "Grand Gulf Core and Containment Analysis of FLEX Strategies," Rev. 000, to demonstrate the effectiveness of the proposed containment heat removal strategy. The calculation utilized the MAAP computer code, Version 4.0.6, to model the heat-up and pressurization of the containment under ELAP conditions.

As stated in the FIP, Case B (baseline) of this calculation models the containment response with the licensee's specific containment venting heat removal strategy being employed at the time described in Section 3.4.1 above. It assumes that the reactor has been operating at 100 percent power for 100 days (as specified in NEI 12-06, Rev. 0, Section 2) when the ELAP event occurs. Furthermore, 1) approximately 2 hours following the onset of the ELAP event the containment heat capacity temperature limit (HCTL) curve is reached, and operators reduce reactor pressure without exceeding the technical specifications temperature change limit of 100 °F/hr and then maintain reactor pressure between 200 to 400 psig; 2) approximately 3 hours following the onset of the ELAP event the suppression pool temperature exceeds 170 °F, and operators swap RCIC suction from the suppression pool to the upper containment pool (UCP); 3) approximately 4 hours following the onset of the ELAP event the suppression pool temperature exceeds 190 °F and operators open the modified EOP containment vent and maintain it open throughout the rest of the event; and 4) approximately 20 hours following the onset of the ELAP event, UCP level available for RCIC suction is depleted and operators depressurize the RPV to allow water injection to the RPV from the portable diesel driven FLEX makeup pump (1FLEXC001 or 1FLEXC002).

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 (66 gpm), 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 containment venting heat removal strategy, Case B concludes that the containment parameters of pressure and temperature in the drywell reach maximum values of 5.73 psig and 242 °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 3.26 psig. As stated in the Section 3.4 introduction, each of these values is below their respective UFSAR design limit. The 215 °F design limit for the wetwell air space and wetwell liquid temperature is calculated to be exceeded by 18 °F and 11 °F, respectively. A justification for exceeding this temperature limit is discussed in Section 3.4.4.1.1 and determined that the structural integrity of the existing containment wall subject to the increased temperature of 233 °F is satisfactory. Because the RCIC pump is not taking suction from the wetwell once the wetwell temperature is greater than 170 °F, exceeding these design values will not impact RCIC operation.

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 3.2.2.5.

3.4.4.4 Electrical Analyses

The licensee performed a containment evaluation based on the boundary conditions described in Section 2 of NEI 12-06 to determine the temperature and pressure increase in the containment building resulting from an ELAP. Based on the results of the evaluation, the licensee developed required actions to ensure maintenance of containment integrity and required instrumentation function. With an ELAP initiated with GGNS in Modes 1-4, containment cooling is lost for an extended period of time. Therefore, containment temperature and pressure will slowly increase. Structural integrity of the containment building due to increasing containment pressure is not expected to be challenged during the first few days of an ELAP/LUHS event. However, with no cooling in the containment, temperatures in the containment are expected to rise and could reach a point where continued reliable operation of key instrumentation might be challenged. The licensee's evaluation of its strategy to vent containment before the suppression pool temperature exceeds 190 °F concludes that key parameter instruments subject to the containment environment will remain functional. Therefore, actions to further reduce containment temperature and pressure will not be required immediately.

The licensee's Phase 1 coping strategy for containment includes monitoring vital instrumentation (containment pressure, suppression pool temperature, suppression pool level, drywell pressure, and containment air temperature) using installed equipment, and venting containment before the suppression pool temperature exceeds 190 °F. The licensee's Phase 2 coping strategy is to continue monitoring vital instrumentation using installed equipment and power the containment hydrogen igniters using a 15 kW portable FLEX DG. The licensee's Phase 3 coping strategy is to continue the Phase 1 and Phase 2 strategy with equipment supplied by an NSRC as a backup.

Based on a review of licensee document EC-Q1111-14002, the NRC staff determined that the electrical equipment available onsite (e.g., a 480 Vac FLEX DG) supplemented with the equipment that will be supplied from an NSRC (e.g., one 480 Vac and two 4160 Vac CTGs), there is sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure, if necessary, to ensure that key components including required instrumentation remain functional.

3.4.5 Conclusions

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

3.5 Characterization of External Hazards

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

Characterization of the applicable hazards for a specific site includes the identification of realistic timelines for the hazard, characterization of the functional threats due to the hazard, development of a strategy for responding to events with warning, and development of a strategy for responding to events without warning. The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; severe storms with high winds; ice and extreme cold; and extreme high temperatures.

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design-basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 19] (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a proposed rule, titled "Mitigation of Beyond-Design-Basis Events," hereafter called the MBDBE rule, which was published for comment in the Federal Register on November 13, 2015 [Reference 50]. The proposed MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" [Reference 45]. The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 20]. The Commission approved the staff's recommendations that licensees would need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly impact the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 [Reference 37], the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC SEs and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, Revision 0, and the related industry guidance in NEI 12-06, Revision 0. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049. As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H [Reference 51]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 52]. The licensee's MSAs will evaluate the mitigating strategies described in this SE using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

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

3.5.1 Seismic

In its FIP, the licensee described the current design-basis seismic hazard, the safe shutdown earthquake (SSE). As described in UFSAR Section 2.5, the SSE seismic criteria for the site is 15 percent of the acceleration due to gravity (0.15g) peak horizontal ground acceleration. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the number above, is often used as a shortened way to describe the hazard.

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

3.5.2 Flooding

In its FIP, the licensee described that the site was originally designated as a dry site for FLEX based on GGNS UFSAR Appendix 3A which identified the plant as a dry site based on the plant grade elevation being 30 feet (ft.) greater than the probable maximum flood (PMF) level. After consideration of the need for flood barriers for probable maximum precipitation (PMP) and the guidance of NEI 12-06, the licensee has classified GGNS as a wet site for beyond-design-basis events. Reevaluation of flooding due to Local Intense Precipitation (LIP) has resulted in a flooding height of 133.7 ft. above mean sea level (MSL) versus the current licensing basis of 133.25 ft. MSL which is based on PMP. Consideration of this revised flooding analysis is not required to comply with Order EA-12-049, however, the licensee decided to address the impact of PMP on the FLEX strategies in accordance with NEI 12-06 (Sections 6.2.2 and 6.2.3 (including sub-sections 6.2.3.1 through 6.2.3.4)) including credit taken for existing site mitigating actions directing deployment of sandbags up to an elevation of 134.5 ft. MSL.

With regard to ground water in-leakage concerns, during the audit the licensee stated that plant grade is 132.5 ft. MSL and the design ground water level at the GGNS site is at elevation 114.5 ft. MSL, which will not be exceeded by the regional ground water level or the perched water table at the site. The licensee stated that analyses have been conducted which demonstrate that this ground water level has no effect on safe operation of GGNS.

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

3.5.3 High Winds

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

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

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

Grand Gulf USFAR Section 2.1.1.1 describes that the coordinates for GGNS are 32 degrees, 0 minutes, 27 seconds north latitude and 91 degrees, 2 minutes, 53 seconds west longitude. In NEI 12-06 Figure 7-2, Recommended Tornado Design Wind Speeds for the 1E-6/year Probability Level, indicates the site is in Region 1, where the tornado design wind speed exceeds 130 mph. Therefore, the plant screens in for an assessment for high winds and tornados, including missiles produced by these events. In NEI 12-06, Figure 7-1, the site also meets the criteria to consider hurricanes.

Therefore, high-wind hazards are applicable to the plant site. The licensee has appropriately screened in the high wind hazard and characterized the hazard in terms of wind velocities and wind-borne missiles.

3.5.4 Snow, Ice, and Extreme Cold

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

In its FIP, regarding the determination of applicable extreme external hazards, the licensee stated that the site is located at 32 degrees, 0 minutes, 27 seconds north latitude, below the 35^{th} parallel. Per NEI 12-06, Section 8.2.1, the site is far enough south that it does not have to provide the capability to address extreme snowfall with snow removal equipment. However, the site is located within the region characterized by EPRI as ice severity level 4 (NEI 12-06, Figure 8-2, Maximum Ice Storm Severity Maps). Consequently, the site is subject to severe icing conditions that could cause severe damage to electrical transmission lines. The licensee concludes that the plant screens in for an assessment for ice and extreme cold hazard. In its FIP, the licensee stated that FLEX equipment is protected from severe temperatures.

Grand Gulf UFSAR Table 2.3-3, Temperature Means and Extremes at Post Office Building, Vicksburg, MS, indicates the record minimum temperature for years 1938-66 was 2 °F occurring in January 1962.

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

3.5.5 Extreme Heat

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. Mississippi summers are warm and humid, with limited periods of extremely hot weather over 100 °F. Therefore, extreme high temperatures are considered in the development of the FLEX coping strategy.

Grand Gulf UFSAR Table 2.3-3, Temperature Means and Extremes at Post Office Building, Vicksburg, MS, indicates the record maximum temperature for years 1938-66 was 101 °F occurring in both July 1943 and August 1963.

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

3.5.6 Conclusions

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

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

In its FIP, the licensee stated that GGNS portable FLEX equipment will be stored in two onsite FSBs. Each FSB will contain one set of the FLEX equipment required for successful implementation of the coping strategies.

During the audit the licensee described the construction of the two FSBs as "pre-engineered metal buildings". Information in the FIP indicates that the floor and foundations are made of concrete slabs.

In its FIP, the licensee stated that the FSBs have an overall footprint of 70 ft. x 90 ft. each. This size was developed based on the equipment to be stored within the buildings. Arrangement of all items to be stored in the FSBs was established based on optimizing ease of deployment. The location of the two FSBs, as well as the primary and alternate deployment routes to the plant protected area from each location are shown in Figure 3 of the FIP. From information provided during the audit, the two FSBs are referred to as the "north" and "south" FSBs. The north FSB was constructed on "Site 1" and the south FSB was constructed on "Site 4."

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

3.6.1.1 Seismic

In its FIP, the licensee stated that the FSBs are designed for seismic loading determined per building code American Society of Civil Engineers (ASCE) 7-10, *Minimum Design Loads for Buildings and Other Structures*. During the audit process, the licensee stated that the ASCE 7-10 design specifications used a seismic loading that was less than the SSE. In its response to open items from the audit in the compliance letter [Reference 18], the licensee stated that an analysis was performed to evaluate the FSB design relative to the forces generated by an SSE. The license determined that the design input wind speed of 165 mph requires the FSBs to withstand forces even greater than the forces produced by an SSE. The licensee's evaluation concluded that the wind loading case induced reaction forces in the governing design elements (braces) which were a minimum of twice the magnitude induced by the SSE loading case.

In its FIP, the licensee stated that a calculation evaluated the rigid body sliding and rocking of unanchored equipment to determine the required separation distance of the equipment within the FSBs to ensure that they are protected from seismic interactions. Including conservatism, this distance was chosen to be 15 inches. Equipment tie downs have been provided in the FSBs, but will only be used for equipment that is stored closer than 15 inches apart and could be damaged by interaction with other equipment.

The NRC staff concludes that the FSBs should have adequate capacity to provide reasonable protection of the equipment and facilitate its deployment following a seismic event.

3.6.1.2 Flooding

In its FIP, the licensee stated that protection of FLEX equipment against external flooding events was evaluated in accordance with Section 6.2.3.1.1.a of NEI 12-06, which states that the FLEX equipment is protected from floods if it is stored above the flood elevation determined in the most recent site flood analysis. The licensee's recent flooding re-evaluation determined that flooding due to LIP is the re-evaluated controlling event for GGNS. The predicted maximum flood elevation resulting from the LIP in the vicinity of the storage building at Site 4 is 133.5 ft. MSL. Only the storage building at Site 4 is included in the area covered by the most recent LIP reanalysis. Due to its remote location and grade elevation, Site 1 is not included in the most recent LIP reanalysis; however, the LIP reanalysis supports a maximum expected depth of 0.1 ft. to 0.2 ft. based upon the adjacent modeled areas. Site 1 is located such that the top-of-slab elevation is at an elevation of 163 ft. and Site 4 has a top-of-slab elevation of 133.2 ft. The foundation (slab) designs of both storage buildings include an internal spill containment curb extending 0.5 ft. above the top-of-slab. In its FIP, the licensee stated that this results in an "effective top-of-slab" elevation of 163.5 ft. for Site 1 and 133.7 ft. for Site 4, which are both above the actual projected maximum flood elevations due to LIP of 163.2 ft. and 133.5 ft., respectively.

3.6.1.3 High Winds

In its FIP, the licensee noted that NEI 12-06 Section 7.3.1 allows for FLEX storage locations with sufficient separation distance to be designed using building design code ASCE 7-10 regarding high winds. The plant-specific evaluated separation distance minimizes the probability that a single tornado would damage both FSBs. At least one full set of FLEX equipment should remain deployable following the high wind event. The licensee performed an evaluation to determine a reasonable separation distance that bounds a large majority of tornados in the region of the site based on the 90th percentile tornado width and data covering 1973 to 2012; the separation distance was determined to be 990 ft. Separation of the storage building locations by at least this perpendicular distance to the predominant tornado path for the geographical location of GGNS provides reasonable assurance that one set of FLEX equipment will remain deployable. Per the evaluation, based on the historical record, the axis of separation considered tornado paths from the southwest to the northeast. Based on the building locations the storage buildings are located at a distance of approximately 1500 ft. from each other perpendicular to the predominant tornado paths thus exceeding the calculated separation distance of 990 ft.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee described that accumulation of ice is the only extreme cold weather precipitation event that required consideration in the development of the GGNS FLEX coping strategy. The design of the storage buildings utilized the design procedure found in ASCE 7-10, which determined a nominal ice thickness of 0.5 in. Using the density of ice of 56 pounds per cubic foot and an adjusted design ice thickness of 1 in., the resultant uniform ice load was determined to be 5 pounds per square foot (psf). This is less than the 20 psf roof live load per ASCE 7-10. Therefore, the ice load will not overstress the storage building.

In its FIP, the licensee stated that protection of FLEX equipment from impacts due to freezing weather is performed in accordance with NEI 12-06, which states that equipment should be maintained in a manner that ensures it will function when called upon. In accordance with Section 8.3.1.b of NEI 12-06 the storage of equipment may be in a structure designed to or evaluated equivalent to ASCE 7-10 for the plant's design basis for the snow, ice and cold conditions. As stated in the FIP, the plant's design basis low temperature is -1 °F. Protection of the FLEX equipment from impacts due to extreme cold during storage is not dependent on central heating. Electrical receptacles are provided for local heating elements, which may be necessary depending on the equipment, equipment fluids, and fuel storage requirements. Procedure revisions have been developed to provide guidance for protection of stored equipment against cold weather in the case of a loss of power to the storage buildings.

In its FIP, the licensee stated that for the design of the storage buildings, a maximum indoor temperature limit of 120 °F was used with respect to the extreme ambient temperature. Protection of the FLEX equipment from impacts due to extreme high ambient temperatures during storage is dependent on installed fans providing building ventilation. Procedure revisions have been developed to provide guidance for protection of stored equipment against high ambient temperatures in the case of a loss of power to the storage buildings. With respect to storage, preventive maintenance of the FLEX equipment will detect abnormal effects on FLEX equipment due to prolonged periods of extreme temperatures.

3.6.1.5 Conclusions

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

3.6.2 Availability of FLEX Equipment

Section 3.2.2 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an N+1 capability, where "N" is the number of units on site). It is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare.

In its FIP, the licensee states that the equipment stored and maintained at the GGNS FLEX storage areas necessary for the implementation of the FLEX strategies in response to a BDBEE at GGNS is listed in Table 7 of the FIP, "BWR Portable Equipment Stored On-Site." Table 7 identifies the quantity, applicable strategy, and capacity/rating for the major FLEX equipment components only. Details regarding fittings, tools, hose lengths, consumable supplies, etc. are not in Table 7.

Information provided during the audit includes a drawing showing the FSB equipment layout plan. One complete set of FLEX equipment is stored in each of the two FSBs. The major equipment in each FSB corresponds to the FLEX equipment listed in Table 7 of the FIP. Included is a FLEX auxiliary trailer for hoses, etc., which would include some items not detailed in Table 7, such as fittings, tools, hose lengths, consumable supplies, etc., that are not stored elsewhere.

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.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee stated that the location of the two FSBs, as well as the primary and alternate deployment routes to the plant protected area from each location, are shown in Figure 3 and continued on Figure 2 of the FIP.

Drawing C7643, reviewed by the NRC staff during the audit, shows the general haul paths from the two FSBs and NSRC staging area B to the plant protected area boundary.

3.7.1 Means of Deployment

In Table 7 of the FIP, one FLEX tow vehicle is listed for storage in each of the two FSBs. These are described as "3500 Chevrolet 4WD Pickup Truck, V8 Turbocharged Diesel, 23,000 lb. towing capacity." Also included in Table 7 is a FLEX front end loader for debris removal, described as "Case 821F, four-wheel drive (or equivalent)," listed for storage in each FSB. As previously discussed, snow removal capability is not warranted for GGNS.

In its FIP, the licensee stated that an assessment performed for removal of debris along the primary and alternate deployment routes concluded that a front-end loader would be sufficient to remove any debris by 6 hours after the event if two people are deployed at 1 hour after the initiating event when the ELAP is declared. Therefore, the front-end loader stored in each FSB is utilized to meet the deployment timeline. Additional debris removal equipment for personnel safety, that is stored in a seismically restrained storage cabinet installed in the control building, includes equipment such as flashlights; razor wire cutters and razor wire protective clothing; goggles and vapor respirator protection; and equipment to confirm lighting poles are de-energized when encountered before removal.

3.7.2 Deployment Strategies

In its FIP, the licensee stated that a subsurface exploration was performed to evaluate the engineering properties of the subsurface soils along the travel paths. The potential for soil liquefaction along the equipment deployment paths during a seismic event was determined to be low, with the maximum vertical settlement at the test locations following strong shaking estimated to be less than one inch.

With regard to deployment of a FLEX pump to access water from the UHS, in its FIP the licensee stated that prior to transition to Phase 2, a FLEX pump will be deployed to either standby service water (SSW) basin A (primary) or SSW basin B (alternate) from either FSB storage building and will be placed on the concrete directly next to the railing surrounding the basin. This pump will be deployed early in the event (in approximately 11 hours) for SFP makeup capability prior to when it will be required for reactor core cooling (in approximately 20 hours). A 6 inch diameter suction hose and strainer designed to prevent large debris from entering the pump suction will be lowered into the SSW basin to provide suction to the portable

FLEX pump. Hoses will be attached to the discharge of the pump and routed to their destination.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Section 3.2.2 of NEI 12-06 states that the portable pumps for core and SFP functions are expected to have primary and alternate connection or delivery points. At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site equipment but the secondary connection point can require reconfiguration if the licensee can show that adequate time and resources are available to support the reconfiguration. In addition, NEI 12-06, Table C-1 states that primary and alternate injection points should establish capability to inject through separate divisions/trains (i.e., should not have both connections in one division/train). The licensee's FIP describes the use of a portable FLEX pump that connects to existing plant system piping via FLEX connections to support core and SFP cooling

Core Cooling

The licensee credits the portable FLEX pump as a backup to the RCIC pump for RPV injection. The FLEX pump can take a suction from the SSW basins and discharges into the HPCS SW return line via portable hoses and FLEX connections. The HPCS SW return line is part of the SSW system and runs underground from the SSW basin "A" valve room near the SSW basins to the HPCS diesel generator building next to the auxiliary building. The FLEX connections are located in the SSW "A" valve room. As described in the FIP and Tables 3.2-1 and 3.3-1 of the UFSAR, the SSW system, including the valve room, is a Seismic Category I, tornado-protected system and is protected from all applicable external hazards. Based on the design and location of the HPCS SW return line, as described in the FIP and the UFSAR, the HPCS SW return line and FLEX hose connections should be available to support Phase 2 core cooling during an ELAP. However, if the HPCS SW system piping between the SSW basin "A" valve room and the HPCS diesel generator building is unavailable, 700 feet of portable hose will be available to be deployed and routed from the FLEX pump discharge to the gated wye hose connection point in the auxiliary building.

In order to inject water in to the RPV from the FLEX pump, the HCPS SW return line is cross connected via portable hoses and FLEX connections in the diesel generator room to either the RHR "C" train or the LPCS system. From the diesel generator building hose connection, a hose will be routed to the auxiliary building where the hose will be fitted with a gated wye to allow diversion of flow for core cooling and SFP cooling. The primary and alternate connection locations for reactor core cooling are located inside the RPV instrument test room in the auxiliary building. A portable hose will be connected to one of the two hose connections on the gated wye and then connected to either the primary or alternate core cooling hose connection valve locations located approximately 25 feet from the gated wye. The primary core cooling connection allows RPV injection via the RHR "C" system. The alternate connection allows RPV injection via the LPCS system. As described in the FIP and Tables 3.2-1 and 3.3-1 of the UFSAR, the RHR and LPCS systems are Seismic Category I, tornado-protected systems. Both systems and FLEX connections are located within the Seismic Category I auxiliary and containment buildings and are protected from all applicable external hazards. Based on the design and location of the RHR "C" train and LPCS system, as described in the FIP and the

UFSAR, these systems, and the corresponding FLEX connections, should be available to support Phase 2 core cooling during an ELAP.

SFP cooling

For SFP cooling, the licensee credits the same portable FLEX pump and flow path as described above for RPV injection up to the gated wye in the auxiliary building. From the wye, the licensee can directly inject into the SFP via a portable hose over the edge of the pool, via portable hose and spray monitor nozzles, or via portable hose connected to FPCCU system piping. As described in the FIP, and Tables 3.2-1 and 3.3-1 of the UFSAR, the applicable portions of the FPCCU system are Seismic Category I, tornado-protected components. The applicable FPCCU piping and FLEX connections are located within the Seismic Category I auxiliary building and are protected from all applicable external hazards. Based on the design and location of the FPCCU system, as described in the FIP and the UFSAR, the applicable FPCCU piping and the corresponding FLEX connections should be available to support Phase 2 SFP cooling during an ELAP.

3.7.3.2 Electrical Connection Points

Electrical connection points are only applicable for Phases 2 and 3 of the licensee's mitigation strategies for an ELAP. During Phase 2, the licensee has developed a primary and alternate strategy for supplying power to equipment required to maintain or restore core cooling, containment, and SFP cooling using a combination of permanently installed and portable components. Although there is one portable 480 Vac 300 kW FLEX DG in each of the two FSBs, only one is credited for the FLEX strategy, in case one FSB is damaged by a tornado or other hazard. The primary 480 Vac FLEX DG staging location is west of the control building and the alternate staging location is southwest of the auxiliary building.

For Phase 2, the licensee's strategy is to use permanently installed connection cabinets (primary and alternate) to connect the 480 Vac 300 kW FLEX DG to the divisional 480 Vac load centers LC 15BA6 and 16BB6. The primary 480 Vac FLEX DG connection cabinet is installed in the northwest corner of the control building Division II switchgear area and is connected to FLEX connection cabinet B located in the southwest corner of the control building Division II switchgear area. The alternate 480 Vac FLEX DG connection cabinet is installed in the auxiliary building miscellaneous equipment area and is also connected to FLEX connection cabinet B. Portable FLEX cables connect FLEX connection cabinet A and B. FLEX connection cabinets A and B supply power to LC 15BA6 and 16BB6. The primary 480 Vac FLEX DG connection cabinet also connects to a FLEX disconnect switch which connects to motor control center (MCC) 17B11 to power the fuel oil transfer pump. Procedures 05-S-01-FSG-004 and 05-S-01-FSG-005 provide guidance for connecting the 480 Vac FLEX DG. Procedure 05-S-01-FSG-004 provides guidance for verifying proper phase rotation when connecting the 480 Vac FLEX DG.

For Phase 3, the licensee will receive two 1 MW 4160 Vac CTGs and one 1100 kW 480 Vac CTG from the NSRC. The two 1-MW 4160 Vac CTGs could be connected to 4160 Vac vital bus 16AB. The NSRC-supplied 4160 Vac CTGs will be staged in front of the control building. The NSRC-supplied 480 Vac CTG will be staged in the vicinity of the plant's portable 480 Vac FLEX DG, to be used if necessary. Procedure 05-S-01-FSG-001, "Long Term Reactor Vessel Cooling," Revision 0, provides guidance for connecting NSRC-supplied 4160 Vac FLEX CTGs. The NRC staff noted that procedure 05-S-01-FSG-001 did not provide guidance for verifying the proper phase rotation of the NSRC generators. In condition report CR 2016-06961, the licensee stated that a phase rotation check would be added for the NSRC generators.

Based on a review of conceptual single-line electrical diagrams and station procedures, the NRC staff finds that the licensee's approach is acceptable given the protection and diversity of the power supply pathways, the separation and isolation of the FLEX DG from the Class 1E emergency diesel generators, and the availability of procedures to direct operators how to align, connect, and protect associated systems and components.

3.7.4 Accessibility and Lighting

In its FIP, the licensee stated that doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following a BDBEE and subsequent ELAP event, FLEX coping strategies require the routing of hoses and cables to be through various barriers in order to connect FLEX equipment to the plant's fluid systems and electrical systems. For this reason, certain barriers (gates and doors) will be opened and remain open. Access to the plant protected area during a BDBEE is addressed in the FSGs and FSG support procedures. This suspension of normal administrative controls is acknowledged and is acceptable during the implementation of FLEX coping strategies.

With regard to lighting, in its FIP the licensee stated that following the BDBEE, emergency lighting is retained for the MCR. Following shedding of non-essential dc loads, the Division II station batteries have the capacity to feed the MCR emergency lighting for up to 13 hours. After 11 hours the battery chargers are powered from the FLEX 480 Vac 300 kW DG, and the battery chargers power the dc loads. The standard equipment of operators with duties in the plant (outside the MCR) includes flashlights; therefore, flashlights would be available to operations personnel immediately following the start of the event. Additionally, portable flashlights are provided in control room evacuation bags located in the control building operations work area. FSGs address lighting requirements during the ELAP.

Although not otherwise discussed in the FIP, the Table 7 list of FLEX equipment stored onsite includes eight FLEX diesel-driven portable light towers, described as 1000 W metal halide lamps.

3.7.5 Access to Protected and Vital Areas

In its FIP, the licensee stated that there are no strategy-dependent security doors or gates that rely on electric power to operate to open and/or locking mechanisms that are barriers of concern. The security force will initiate an access contingency upon loss of all ac/dc power as part of the security plan. Access to the owner-controlled area, the plant protected area, and areas within the plant structures will be controlled under this access contingency as implemented by security personnel.

3.7.6 Fueling of FLEX Equipment

In its FIP, the licensee stated that the FLEX strategies for maintenance and support of safety functions involve several elements including the supply of fuel to diesel-engine-driven generators, pumps, hauling vehicles, etc. To ensure adequate fuel exists to meet the strategy, all diesel-driven FLEX equipment stored in the FLEX storage buildings is maintained with a full tank of diesel fuel. Additional fuel will be needed to replenish the fuel used by the diesel-driven equipment for the duration of the event.

GGNS has three 76,000-gallon safety-related underground fuel oil storage tanks and three 550-gallon safety-related fuel oil day tanks which supply the two standby DGs and the high pressure core spray (HPCS) DG. The minimum required storage volume of the storage tanks for the standby DGs is 68,744 gallons. The minimum required storage volume of the storage tank for the HPCS DG is 44,616 gallons.

The strategy for refueling the diesel-driven portable equipment is to use fuel oil from the safety-related systems to fill a FLEX fuel trailer. The licensee stated that initially operators will gravity drain fuel oil from the HPCS DG day tank and then pump additional fuel oil out of the HPCS DG fuel oil storage tank using the HPCS DG fuel oil transfer pump powered by the FLEX 480 Vac 300 kW DG. The installed HPCS transfer pump will transfer diesel fuel from the underground storage tank to a FLEX portable 500-gallon fuel trailer via flexible hose connected to the HPCS DG fuel oil transfer pump discharge strainer located in the HPCS DG room. The 500-gallon fuel trailer will be towed around the site to the various equipment staging locations to refill the fuel tanks. A dc motor-driven fuel pump on the fuel trailer will be used to pump fuel from the trailer-mounted tank to FLEX equipment fuel tanks. Fuel from the HPCS DG fuel oil storage tank can be transferred to all FLEX equipment in approximately 3.5 hours. The FLEX MCR ventilation fan DG, which is started at 10 hours after the event to provide MCR ventilation, has a small fuel tank and is the first FLEX component that requires refueling at 5.9 hours after it starts operating. Based on the fuel tank size of this portable DG (4.6 gallons), a 28-gallon portable tank cart is stored and deployed with the generator to refill this tank. Using this cart will provide enough fuel to last for at least 30 hours, which is sufficient time until the 500-gallon tank can be used to refuel this DG.

The refueling cycle for the 500-gallon fuel trailer will start at approximately 26 hours after the start of the BDBEE to refuel the diesel-driven FLEX makeup pump following the initial filling of the fuel trailer from the HPCS DG fuel oil storage tank and considering that the diesel-driven FLEX makeup pump is initially started 11 hours after the start of the BDBEE. All FLEX equipment can be refueled within 3.5 hours, therefore this refueling strategy ensures that all diesel-run FLEX equipment will be refueled following a BDBEE. Refueling requirements are shown in Table 3 of the FIP. The 3.5-hour refueling cycle using the fuel trailer will be repeated periodically. For the first 72 hours after deployment, calculated diesel fuel usage is approximately 3,726 gallons, based on a fuel consumption rate of 1,242 gallons per day. As discussed above, the minimum required diesel fuel oil volume of the HPCS DG fuel oil storage tank is 44,616 gallons, which is sufficient fuel to supply the FLEX equipment for approximately 35.9 days following a BDBEE. In addition to the HPCS DG fuel oil storage tanks, the two standby DG fuel oil storage tanks contain a combined minimum required fuel oil volume of over 137,000 gallons that could also be available if required. Because there is a large volume of onsite diesel fuel available, diesel refueling will be procedurally controlled by the fuel oil levels in the equipment and not necessarily by the timing. Similarly, as staffing levels allow, use of the 28-gallon portable cart tanks for small loads may transition to use either the 500-gallon fuel trailers or the NSRC-supplied equipment.

Therefore, onsite fuel oil supplies could provide onsite diesel-driven FLEX equipment diesel fuel for well beyond 30 days. The onsite fuel and methods described above can also be used to refuel the Phase 3 NSRC equipment as necessary.

3.7.7 Conclusions

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

3.8 Considerations in Using Offsite Resources

3.8.1 GGNS SAFER Plan

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

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

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

The NRC staff noted that the licensee's SAFER Response Plan contains (1) SAFER control center procedures, (2) NSRC procedures, (3) logistics and transportation procedures, (4) staging area procedures, which include travel routes between staging areas to the site, (5) guidance for site interface procedure development, and (6) a listing of site-specific equipment (generic and non-generic) to be deployed for FLEX Phase 3.

3.8.2 Staging Areas

In general, up to four staging areas for NSRC-supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a Primary (Area C) and an Alternate (Area D), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas C and/or D, the SAFER team will transport the Phase 3 equipment to the on-site Staging Area B for interim staging prior to it being transported to the final location in the plant (Staging Area A) for use in Phase 3. For GGNS, Alternate Staging Area D is the Natchez Adams County Airport. Staging Area C is the Vicksburg Tallulah Regional Airport. Staging Area B is the ESC laydown area west-northwest of the plant protected area. There are multiple Staging Area A's for individual FLEX components for use.

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

3.8.3 Conclusions

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

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at Grand Gulf, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The primary concern with regard to ventilation is the heat buildup which occurs with the loss of forced ventilation in areas that continue to have heat loads. A loss of ventilation analysis was performed to quantify the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability or accessibility and within equipment limits. The key areas identified for all phases of execution of the FLEX strategy activities are the MCR, RCIC Room, Battery Room, Switchgear Room, and Containment.

Main Control Room:

The licensee performed calculation XC-Q1111-14001, Rev. 1, "Control Room Heatup for Extended Loss of AC Power," which modeled the transient temperature response in the MCR for 120 hours following an ELAP. The calculation uses the GOTHIC (Generation of Thermal-Hydraulic Information for Containments) version 7.2b computer program. To maintain the control room below the maximum temperature of 110 °F the following actions will be taken: the control building stairway door to the roof will be opened within 1 hour of the initiating event; 13 control building doors will be opened within 4 hours of the initiating event; and two 3,000 cubic feet per minute (cfm) (minimum) fans will be staged to exhaust air from the MCR into the corridor within 10 hours of the initiating event. Ventilation for the MCR will be via any two portable fans (1FLEXC005 through 1FLEXC008), powered by a portable 6 kW diesel generator (1FLEXS012 or 1FLEXS013). These actions will draw air into the MCR through the stairwell open to the atmosphere on elevation 133'0" (and hot air is exhausted through the MCR through doors up through an additional stairwell to the roof. The heat up evaluation determined that the maximum temperature reached 120 hours after the start of the event is approximately 106 °F. Procedures 05-1-02-I-7 and 05-S-01-FSG-005 provide guidance for control room staff to evaluate the control room temperature and take actions as necessary.

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 expects that the equipment in the MCR should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

RCIC Room:

The licensee performed calculation XC-Q1111-14003, Rev. 000, "Grand Gulf Nuclear Station RCIC Pump Room Heatup for Extended Loss of AC Power," which modeled the RCIC room transient temperature response for 120 hours following an ELAP. The calculation uses the GOTHIC version 7.2b computer program. Acceptance criterion for maximum RCIC room temperature is 212 °F. Four cases were analyzed in this calculation to evaluate different possible scenarios associated with shedding or not shedding the RCIC gland seal compressor following the BDBEE. The optimum strategy was determined to be to shed the RCIC gland seal compressor within 30 minutes of the BDBEE (the calculation assumes it is shed at time zero to conservatively maximize room heat up) as detailed in procedure 05-1-02-I-4, Rev. 050, "Loss of AC Power," and then re-energize the RCIC gland seal compressor when the station battery chargers are re-powered by the FLEX 480 Vac 300 kW diesel generator (1FLEXS009 or 1FLEXS010) at 11 hours. The maximum room temperature reached is 193 °F for this case. This recommended action is based on extending the installed battery discharge capacity and minimizing areas of increased airborne contamination outside the RCIC room that would otherwise result due to the shutdown of the gland seal compressor if the room doors were opened to provide room cooling even though opening the doors is an acceptable strategy for maintaining adequate temperatures. Personnel are not required to enter the RCIC room during Phase 1 since remote operation from the control room remains available. Based on the above, the staff finds it reasonable that the RCIC pump will remain available during an ELAP event with loss of normal ventilation.

Battery Room and Switchgear Room:

The licensee performed calculation MC-QSZ77-09004, Rev. 000, "Alternate Ventilation for Safeguard Switchgear and Battery Rooms," which evaluates the heat up of the control building safeguard switchgear and battery rooms. Ventilation for the battery rooms and switchgear rooms is provided by using the FLEX diesel generator (1FLEXS009 or 1FLEXS010) to repower an installed battery room exhaust ventilation fan (1Z77C001A). Prior to repowering the installed ventilation fan, the control building safeguard switchgear and battery room doors, and control building stairway roof door will be opened within 1 hour after the initiating event to provide natural circulation. The calculation assumes normal operating heat loads. Since the SBO battery and switchgear room heat loads will be less than normal operation heat loads with no ac power available, opening the required doors by 1 hour after the initiating event maintains these rooms below 120 °F. Procedures 05-1-02-I-7 and 05-S-01-FSG-004 provide guidance for operators to evaluate the battery room and switchgear room temperatures and take actions as necessary.

Non-safety related electrical equipment in the switchgear rooms will be de-energized during the ELAP, therefore, the load on the transformers feeding the breakers will be reduced. The heat load in the rooms is primarily comprised of the heat generated by electrical equipment and will decrease after a loss of power due to the loss of non-safety related electrical switchgear.

Analysis GGNS92-0002 documents that load centers 15BA6 and 16BB6 including all associated devices, i.e. breakers, are expected to function properly at an elevated temperature of 120 °F for a 100 day period.

Based on the above, the NRC staff finds that the licensee's ventilation strategy will maintain the battery room temperature below the maximum temperature limit (122 °F) of the batteries, as specified by the battery manufacturer (C&D Technologies) and maintain the switchgear room temperature below 120 °F (the temperature limit, as identified in NUMARC-87-00, Revision 1, for electronic equipment to be able to survive indefinitely). Therefore, the NRC staff finds that the batteries and switchgear equipment should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Containment

See Section 3.4.4.4 of this SE for the NRC staff's evaluation of the licensee's mitigating strategy for maintaining containment temperature within the design limit of credited instrumentation and equipment.

3.9.1.2 Loss of Heating

The licensee FLEX strategy utilizes HPCS service water (SW) lines that are potentially subjected to freezing conditions. Analysis GGNS-SA-14-00002, Rev. 000, "Further Development of Grand Gulf FLEX Strategy Analytical Bases and Conceptual Design," discusses concerns associated with freezing of non-heat traced lines in the HPCS SW system. As stated in SDC-P41, Rev. 004, "System Design Criteria for Standby Service Water System," the siphon connection between the two standby SSW basins is installed below grade and is therefore protected from freezing. Similarly, HPCS SW basin piping that is being utilized is either below grade or in heated rooms and protected from freezing. Following a BDBEE resulting in an ELAP, heating is lost in the SSW Basin A valve room, such that the 6 inch and 10 inch nominal diameter pipes are potentially subject to freezing conditions as an event progresses if they are not drained or if flow is not established through the piping in a reasonable time frame. Flow could be reasonably established through the 6 inch tee connection in the SSW Basin A valve room since the room temperature is expected to remain above freezing for an extended period of time based on the results of similar evaluations for the SSW pump house, MC-Q1Y47-09002, Rev. 0, "SSW Pump House Temperature During Station Blackout (SBO)," and flow for SFP makeup is established within -11 hours of the initiating BDBEE. Discounting this conclusion, however, during implementation of the FLEX strategy subject to freezing conditions, the alternate RPV and SFP makeup strategy (hoses run from the basin to the Auxiliary Building) in lieu of the HPCS SW piping could be used if necessary. Based on analysis IP-CALC-13-00058, Rev. 001, "Freezing of Unit 3 Coolant Sources for FLEX Event (EC 45784)," performed at the Indian Point Energy Center located in a region that experiences colder temperatures than GGNS, hose freezing is not a concern for the flow rates required by the RCS and SFP makeup strategies. Therefore, the GGNS FLEX strategy does not depend on heat tracing for any required equipment after the initiation of the event.

The impact on the performance of the safety-related batteries based on low temperatures is minimal. The safety-related batteries are located in the interior of the control building such that outside air temperature would not impact battery performance. In addition, during battery discharge the battery will be producing heat which will keep electrolyte temperature above the room temperature. Based on its review of the licensee's battery room assessment, the NRC staff finds that GGNS safety-related batteries should perform their required functions during a loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3 is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. The NRC staff reviewed licensee calculation E0046, "Hydrogen Gas Evolution from Class 1E + Non Class 1E Battery," Revision 1 to verify that hydrogen gas accumulation in the 125 Vdc Vital Battery rooms will not reach combustible levels while HVAC is lost during an ELAP. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. In its FIP, the licensee stated the time for the battery rooms to reach a concentration of 2 percent hydrogen is approximately 24 hours under worst case conditions. The battery room exhaust ventilation fan 1Z77C001A will be repowered from the 480 Vac FLEX DG via Load Center 15BA6 prior to 24 hours. The battery room exhaust ventilation fan will provide the necessary hydrogen removal from the battery rooms in addition to providing ventilation. Procedures 05-1-02-I-7 and 05-S-01-FSG-004 provide guidance for opening doors and restoring battery room ventilation to provide cooling and prevent a buildup of hydrogen in the battery rooms.

Based on its review of the licensee's calculation and battery room ventilation strategy, the NRC staff finds that hydrogen accumulation in the GGNS safety-related battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

The personnel habitability for the MCR was evaluated in calculation XC-Q1111-14001, Rev. 1, "Control Room Heatup for Extended Loss of AC Power," which modeled the transient temperature response in the MCR for 120 hours following an ELAP. As discussed in Section 3.9.1.1 above, the licensee's FLEX strategy to maintain MCR habitability is to open various doors and provide forced ventilation via portable fans. The heat up evaluation determined that the maximum temperature reached 120 hours after the start of the event is approximately 106 °F.

Based on MCR temperatures remaining below 110 °F (the temperature limit, as identified in NUMARC-87-00, for personnel habitability), the NRC staff expects that the personnel in the MCR should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

3.9.2.2 Spent Fuel Pool Area

Per NEI 12-06 guidance, a baseline capability for SFP cooling is to provide a vent pathway for steam and condensate from the SFP. In order to establish a vent pathway for steam and condensate, local auxiliary building doors 1A601 (elevation 208') and 1A605 (roof elevation 229') will be opened to vent the SFP area to the atmosphere creating a chimney effect. The licensee performed an evaluation, EC 50275, Rev. 2, FLEX Basis Engineering Evaluation," which determined that the selected vent path provides a flow rate that exceeds the SFP boil off rate. The flow rate calculated through the vent pathway was determined to be 12,763 cfm, which is greater than the boil off rate of the SFP. The operators are directed to open these doors to create the SFP area vent pathway at 4 hours.

In addition to providing a ventilation path prior to SFP boiling, (approximately 5 hours for a full core offload and approximately 12 hours for a design-basis heat load), the spray monitor nozzles and hoses stored in the SFP area will be positioned and routed outside of the SFP area prior to SFP boiling. Since makeup to the pool is not required prior to pool boiling, the SFP area hoses do not require complete routing or connection to the associated FLEX supply hose prior to SFP boiling. Taking this action prior to SFP boiling will provide the capability for SFP spray and makeup via hoses without entering the operating floor later in the event when the area may become inaccessible.

3.9.2.3 Other Plant Areas

Auxiliary Building:

The licensee performed calculation XC-Q1111-15002, Rev. 0, "GGNS FLEX Auxiliary Building Heat-Up," which determined that every area in the auxiliary building requiring operator actions will be accessible following an ELAP event.

3.9.3 Conclusions

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

3.10 Water Sources

3.10.1 RPV Make-Up

In its FIP, the licensee stated that RPV makeup will be via RCIC, and that the RCIC suction is normally aligned to the CST. However, the CST is not credited for FLEX because the CST is not seismically designed or protected from missiles. However, the CST could be utilized as the initial source of RPV makeup if the CST survives the initiating event. The suppression pool is the initial source of water for RCIC for ELAP/LUHS events which result in the loss of the CST. If RCIC suction is aligned to the suppression pool, when the suppression pool temperature approaches an upper limit (in about 3 hours) RCIC suction is transferred to the UCP because the increasing suppression pool temperature could adversely affect the operation of RCIC.

At approximately 20 hours, the UCP supply available for RCIC suction will be nearing depletion. Two SRVs are then opened to depressurize the RPV to less than 100 psig and allow initiation of Phase 2 flow from the diesel-driven FLEX pump to start feeding the RPV. This pump will take suction from one of the two SSW basins (the plant UHS), which are designed to survive the applicable hazards.

Over time, the water in the SSW basins decreases as it is pumped out by the FLEX pump. Adding water to the SSW basins will support indefinite operation of the FLEX pump. Any method to provide basin makeup is acceptable provided at least 23,000 gallons per hour can be provided by 99 hours after event initiation. Offsite supplied pumps using hoses or water transportation trucks will provide water from the Mississippi River via public access roads from the Port of Port Gibson, from Grand Gulf Military Park, or from the owner-controlled access road from the site barge slip located on the Mississippi River. When NSRC equipment arrives at the site, an NSRC-supplied pump and submersible pump can be deployed to the river to provide makeup to the SSW basin. This will provide for indefinite core cooling and SFP makeup.

3.10.2 Suppression Pool Make-Up

In its FIP, the licensee stated that at approximately 3 hours, RCIC suction is transferred from the suppression pool to the UCP because of increasing suppression pool temperature. The available volume in the UCP is depleted at approximately 20 hours. Before that time the RPV will be manually depressurized to less than 100 psig to allow initiation of Phase 2 flow from the diesel-driven FLEX pump to start feeding the RPV. This pump will take suction from one of the two SSW basins, which are robust. Makeup is not needed or provided to the suppression pool or the UCP.

3.10.3 Spent Fuel Pool Make-Up

In its FIP, the licensee stated that for the three SFP makeup strategy methods, a diesel-driven FLEX pump will be deployed and available at approximately 11 hours after the start of the event to take suction from one of the SSW basins (the plant UHS), which are robust. The diesel-driven FLEX pump is sized to simultaneously provide the required makeup flows for reactor core cooling and SFP makeup.

3.10.4 Containment Cooling

Grand Gulf has a Mark III containment that will be cooled via containment venting as needed during Phases 1 and 2, and no water source for cooling is required. The strategy for long-term containment integrity will be the continued use of containment venting with no immediate reliance on equipment from the NSRC.

3.10.5 Conclusions

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

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven RCIC pump to provide the water 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 57 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

During refueling, spent fuel assemblies may be located in the UCP inside containment prior to transfer to the SFP in the auxiliary building. If UCP level decreases due to boil-off, the licensee plans to use a FLEX pump to add water to the UCP, as stated in guideline FSG-011. The licensee stated in the FIP that the current plant analysis for a full core offload to the UCP during refueling shows that it would take about 49 hours before boil-off results in the water level in the UCP dropping far enough to uncover fuel assemblies. The licensee has strategies to replenish the water before any fuel is uncovered.

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 any RPV head bolts have been detensioned, since the RPV pressure boundary is compromised, and heating up to produce steam to run RCIC is not advisable), another strategy must be used for decay heat removal. On September 18, 2013, NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes" [Reference 38], which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 [Reference 39], the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

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

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

3.12 Procedures and Training

3.12.1 Procedures

In its FIP, the licensee stated that the inability to predict all actual plant BDBEEs and conditions that require the use of FLEX equipment makes it impractical to provide specific procedural guidance. As such, the FSGs provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs ensures 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 supplement EOPs, Abnormal Operating Procedures

(AOPs)/Off Normal Event Procedures (ONEPs), or other plant strategies, the EOPs, AOP/ONEPs, Severe Accident Mitigation Guidelines (SAMGs), or Extreme Damage Mitigation Guidelines (EDMGs) direct the entry into and exit from the appropriate FSG procedure. The FSGs provide available, pre-planned FLEX strategies for accomplishing specific tasks in these procedures or guidelines. The FSGs are used to supplement (not replace) the existing procedure structure that establishes command and control for events.

Procedural interfaces have been incorporated into procedure 05-1-021-4, "Loss of AC Power," to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, by direct or indirect procedural interfaces with the Loss of AC Power AOP/ONEP, appropriate reference to the FSGs has been incorporated into the following AOPs/ONEPs:

- 05-1-02-VI-1 "Flooding"
- 05-1-02-VI-2, "Hurricanes, Tornados, And Severe Weather"
- 05-S-02-VI-3, "Earthquake"

3.12.2 Training

In its FIP, the licensee stated that Entergy'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.

Initial training has been provided and periodic training will be provided to site emergency response leaders on BDB emergency response strategies and implementing guidelines. Personnel assigned to direct the execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints.

Operator training for BDBEE accident mitigation has not been given undue weight (in comparison with other training requirements). The testing/evaluation of operator knowledge and skills in this area has been similarly weighted.

3.12.3 Conclusions

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

3.13 Maintenance and Testing of FLEX Equipment

In its FIP, the licensee stated that maintenance and testing of FLEX equipment is governed by the Entergy Preventive Maintenance (PM) Program as described in ENDC-324. The Entergy PM program is consistent with INPO AP-913 and utilizes the EPRI Preventive Maintenance (PM) Basis Database as an input in development of fleet-specific Entergy PM Basis Templates. Based on this, the Entergy fleet PM program for FLEX equipment follows the guidance in NEI

12-06, Section 11.5. The PMs have been developed for both the "Standby" condition and the "Deployed" condition for the FLEX Portable and Support Equipment.

The Entergy PM Basis Templates include activities such as:

- Periodic Static Inspections
- Operational Inspections
- Fluid analysis
- Periodic functional verifications
- Periodic performance verification tests

The Entergy PM Basis Templates provide assurance that stored or pre-staged FLEX equipment is being properly maintained and tested. In those cases, where EPRI templates were not available for the specific component types, PM actions were developed based on manufacturer provided information/recommendations.

Additionally, the Emergency Response Organization (ERO) performs periodic facility readiness checks for equipment that is outside the jurisdiction of the normal PM program and considered a functional aspect of the specific facility (emergency planning (EP) communications equipment such as UPSs, radios, batteries, battery chargers, satellite phones, etc.). These facility functional readiness checks provide assurance that the EP communications equipment outside the jurisdiction of the PM Program is being properly maintained and tested.

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

3.14 Alternatives to NEI 12-06, Revision 0

Neither the licensee or the NRC staff identified any alternatives to the guidance in NEI 12-06.

3.15 Conclusions for Order EA-12-049

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

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 26, 2013 [Reference 24], the licensee submitted its OIP for GGNS in response to Order EA-12-051. By letter dated July 30, 2013 [Reference 25], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided a response by letter dated August 29, 2013 [Reference 26]. By letter dated November 25, 2013 [Reference 27], the NRC staff issued an Interim Staff Evaluation (ISE) and RAI to the licensee.

By letters dated August 28, 2013 [Reference 28], February 28, 2014 [Reference 29], August 27, 2014 [Reference 30], February 18, 2015 [Reference 31], August 28, 2015 [Reference 32], and February 25, 2016 [Reference 33], the licensee submitted status reports for the Integrated Plan.

The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFP level instrumentation which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated May 24, 2016 [Reference 35], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved. By letter dated July 29, 2016 [Reference 53], the licensee submitted responses to the NRC RAIs.

The licensee has installed a SFP level instrumentation system designed by Mohr Test and Measurement LLC. The NRC staff reviewed the vendor's SFP level instrumentation system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on August 27, 2014 [Reference 34].

The NRC 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 November 24, 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

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

- Level 1 is Elevation 204 feet 8 inches. This level is established based on the water level at which siphon break occurs. This elevation is above the point where the fuel pool cooling pumps trip.

- Level 2 is Elevation 192 feet 2.125 inches or 10 ft. above the top of the fuel rack in the SFP.

- Level 3 is Elevation 182 feet 2.125 inches. This level is defined as the highest point of any fuel rack seated in the spent fuel pool, where fuel remains covered.

The NRC staff found the licensee's selection of the SFP measurement levels adequate based on the following:

- Level 1 is designated based on the level at which siphon break occurs. The elevation represents this level is above the point where the fuel pool cooling pumps trip. Thus, the designated Level 1 setpoint would allow the licensee to identify a level in the SFP adequate to support operation of the normal SFP cooling system and represent the higher of the options described in NEI 12-02.
- Level 2 meets first option described in NEI 12-02 for Level 2, which is 10 feet (+/- 1 foot) above the highest point of any fuel rack seated in the SFPs. The designed Level 2 represents the range of water level where any necessary operations in the vicinity of the SFP can be completed without significant dose consequences from direct gamma radiation from the SFP consistent with NEI 12-02.

- Level 3 represents the highest point of any fuel storage rack seated in the SFP, where the fuel remains covered. This level designation meets the NEI 12-02 specifications of the highest point of the fuel racks where the fuel remains covered.

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

4.2 Evaluation of Design Features

Order EA-12-051 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 NRC staff's assessment of the design features of the SFP level instrumentation.

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the primary and backup instrument channels are permanent, fixed channels. The instrument channels will provide level indication through the use of Guided Wave Radar (GWR) technology through the principle of Time Domain Reflectometry (TDR). Guideline FSG-011, Revision 1, shows that the instrument provides a single continuous span from above Level 1 to the 182' 8.125" elevation, within 6 inches of the top of the spent fuel racks.

The NRC staff notes that while the measurement range specified for Grand Gulf's SFP level instrumentation will cover the designated Levels 1 and 2, it does not extend fully down to the Level 3 elevation, stopping approximately 6 inches above that level elevation. However, in accordance with guideline FSG-011, Revision 1, operators will take action to initiate water make-up before the SFP water level reaches the 183' 2.125" elevation. This level setpoint is within the span of the SFP level instruments. Since water make-up to the SFP will be initiated prior to SFP water level reaching Level 3, the staff concludes that actions to initiate water make-up are not delayed unnecessarily and therefore are consistent with NEI-12-02 guidance.

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

4.2.2 Design Features: Arrangement

In its OIP, the licensee stated that separation of the channels/probes reduces the potential for falling debris or missiles affecting both channels of instrumentation. This placement, coupled with separate routing paths for cables and use of rigid conduit, provides reasonable protection against falling debris and structural damage. The location of the display/processors is in the control building. This building provides adequate protection against the effects of temperature, flood, humidity, radiation, seismic events, and missile hazards. In its OIP, the licensee also provided a sketch depicting the SFP instrument locations and conduit routings of both primary and back-up level instrument channels. The SFP instrumentation (SFPI) probes are located at the northwest and southwest corners of the SFP.

The NRC staff noted that there is sufficient separation between the probes. However, during the onsite audit walkdown, the staff observed that the cable conduits for both instrument channels were routed within less than or equal to 3 feet of each other on the north and west walls of the auxiliary building, elevation 208'. This conduit arrangement does not appear to meet the requirements of Order EA-12-051 that:

> 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.

In response to the staff's concerns, in its letter dated May 24, 2016, [Reference 35], the licensee stated that:

> Unlike a typical BWR Mark I or II refuel floor, a Mark III (GGNS) has a concrete enclosed, seismic qualified structure surrounding the SFP. Given the location inside a robust structure and the evaluated absence of credible internal missiles, GGNS used a minimum of 3'-0" separation between Channel-A and Channel-B SFPI conduits with one exception. The exception is a short run in the elevator area where intervening structures are credited. A minimum 3'-0" distance is considered to maintain reasonable separation to meet the requirements of NRC Order EA-12-051. This is based on the conduit separation meeting the plant design basis for missile hazards for safety related circuits because there are no credible missile hazards in the area that could affect these conduits. The specific reasons a minimum of 3'-0" separation is acceptable is because:
>
> - The conduits are installed on the inside walls of a Seismic Category I concrete structure providing protection from all external hazards.
> - Permanently installed equipment located on the refuel floor has been evaluated for internal missile hazards.
>   - No credible internal hazards exist due to the location of installed equipment on the refuel floor.
>   - Overhead cranes in the area of interest are seismically qualified.
> - Procedural guidance provides reasonable assurance that there will be no transient missile hazards in the area.
>
> Additionally, in the area of concern where minimum separation is used, i.e. 3'-0", intervening structures provide additional assurance that randomly postulated missiles will not simultaneously damage both redundant channels of instrumentation. Also, this area is a narrow pathway next to the SFP that is not conducive to its use as an equipment storage/work area.

The NRC staff found the licensee's justification for the conduit separation reasonable. The seismic qualified structure surrounding the GGNS's SFP coupled with the administrative procedures should minimize the possibility of missiles that may result from damage to the structure over the SFP.

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

4.2.3 Design Features: Mounting

For Grand Gulf's SFP level instrument mounting, in its OIP the licensee stated that both the primary and backup system will be installed as Seismic Category I to meet the NRC JLD-ISG-2012-03 and NEI 12-02 guidance requirements. Other hardware stored in the SFP will be evaluated to ensure that it does not adversely interact with the SFP instrument probes during a seismic event.

In its letter dated July 29, 2016 [Reference 53], the licensee further stated that the probe mounting bracket is designed as Seismic Category I with all interaction ratios (IRs) less than one (1.0), as documented in analysis CC-N1G41-14001. Conservative hydrodynamic forces (sloshing) within the pool caused by a seismic event, as documented in NAI-1725-004, are used as input to the SFPI mounting bracket design to ensure the probe will remain in place and functional during and after a BDBEE. The equipment supports for the displays, batteries, and isolation transformers meet or exceed the GGNS design basis seismic response spectra, as detailed in calculations 425A.4520 and 425A.4521. Conduit routing throughout the auxiliary and control buildings are seismically mounted using both new and existing supports. The majority of new supports are installed in accordance with the conduit support drawing series "Conduit Support General Notes", of which Note 1 states that "All supports and bracing are Seismic Category I and shall be fabricated and installed as "Q" items." A small number of new supports are engineered for specific locations, while maintaining the seismic design criteria. Existing supports used for SFPI conduit routing already support safety-related conduits and/or trays and were previously seismically qualified. The licensee indicated that the following are design inputs and criteria used in Calculation CC-N1G41-14001:

- All new structural steel member shapes and built up sections and their properties are derived from the 13th edition of AISC Steel Construction Manual. Design of the structural steel members is per the 9th edition of AISC Steel Construction Manual and Structural Design Guide 27 of Stainless Steel, AISC.

- The bracket is qualified as a seismic structure. This evaluation designs the bracket with seismic considerations per Civil Design Criteria Manual to meet Seismic Category II requirements. Throughout this calculation, the SSE is considered for design loading.

- The dead weight of the probe provided by the vendor is 45 lbs.

- Hydrodynamic and seismic loads on the probe are provided by the vendor.

- Seismic accelerations of the mounting bracket structure are per C-196. Based on the GT-STRUDL analysis, it is concluded that this mounting bracket is rigid (response frequency is 127 Hz [Hertz], which is greater than 100 Hz), therefore the ZPA [Zero Period Acceleration] value of 1g is used.

- The load combination is D +L+ SSE+ Hydrodynamic/Sloshing.

- All IRs are less than 1.00.

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

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

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

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

As for Grand Gulf's augmented quality process, in its OIP the licensee stated that augmented quality requirements will be applied to all components in the instrumentation channels for:

- design control
- procurement document control
- instructions, procedures, and drawings
- control of purchased material, equipment, and services
- inspection, testing, and test control
- inspections, test, and operating status
- nonconforming items
- corrective actions
- records
- audits

The NRC staff finds that, if implemented appropriately, the licensee's approach of augmented quality assurance process appears to be consistent with NEI 12-02 guidance, and should adequately address the requirements of the order.

4.2.4.2 Equipment Reliability

The NRC staff reviewed the Mohr SFP level instrumentation's qualification and testing during the vendor audit for temperature, humidity, radiation, shock and vibration, and seismic [Reference 34]. The staff further reviewed the anticipated GGNS seismic, radiation, and environmental conditions during the onsite audit [Reference 17].

4.2.4.2.1 Temperature, humidity, and radiation

For the expected temperature, humidity, and radiation conditions at GGNS and equipment qualifications, in its OIP the licensee stated that components in the area of the SFP will be designed for the temperature, humidity, and radiation levels expected during normal, 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. Equipment located in the SFP will be qualified to withstand a total accumulated dose of expected lifetime at normal conditions plus accident dose received at post event conditions with SFP water level within 1 foot of the top of the fuel rack seated in the SFP. The probe and cable in the SFP area are robust components that are not adversely affected by expected radiation, temperature, or humidity. The areas selected for display/processor installation are considered mild environments.

In its letter dated July 29, 2016 [Reference 53], the licensee further stated that the primary and backup SFPI channel displays for GGNS are located in the lower cable room (LCR) in the control building. The control building cooling subsystem is not operational following a BDBEE. Calculation M3.1 0.001 states that the LCR can be maintained at 104 °F without cooling due to the reduction in heat load due to deenergized equipment and heat that is lost to surrounding rooms; therefore, following a BDBEE, the LCR will remain below the maximum design temperature. There is sufficient cooling margin within the LCR, due to the flow of heat to surrounding rooms, to dissipate the minimal heat addition of the SFPI equipment. The SFPI vendor, Mohr, has successfully tested its system electronics to a nominal temperature range of 14 °F to 131 °F and humidity range of 5 percent to 95 percent relative humidity (RH). Humidity in the LCR is regulated by the non-safety related control building cooling subsystem; normal operation maintains between 10 percent and 60 percent RH. During an extended loss of ac power, the non-safety-related control building HVAC system is no longer available. Assuming the control building doors remain closed, the temperature increase in the LCR is primarily due to sensible heat from electrical cables and equipment. Even if the upper limits of the humidity and temperature occur simultaneously, the maximum temperature condition of 104 °F and 60 percent RH is bounded by the 116.6 °F and 71 percent RH test case presented in Mohr Report # 1-0410-1. In the event that outside air is introduced to the LCR due to open doors or HVAC system connections to other rooms, ASHRAE [American Society of Heating, Refrigerating and Air-Conditioning Engineers] defines the 0.4 percent dehumidification condition to be 84 °F dry-bulb with 77 percent RH for Jackson, Mississippi. Similarly, 90 °F dry-bulb, with about 66 percent RH is defined for a 0.4 percent evaporation condition. The maximum RH in the LCR is bounded by the outside conditions with the assumption that the control building doors are opened. The maximum humidity condition of 77 percent RH is bounded by the 89.6 °F and 96 percent RH test case presented in Mohr Report # 1-0410-1. Hence, the operational humidity range of 5-95 percent encompasses all expected conditions for the LCR and the sensor electronics are capable of continuously performing their required function under the expected humidity conditions.

The NRC staff notes that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to temperature, humidity and radiation. The equipment qualification envelops the anticipated radiation, temperature, and humidity conditions during a BDBEE. The equipment environmental testing demonstrated that the SFP instrumentation will maintain its functionality during the expected BDB conditions.

4.2.4.2.2 Shock and Vibration

In its letter dated July 29, 2016 [Reference 53], the licensee stated that Mohr Report 1-0410-5 adequately addresses the requirements for general robustness of the enclosures. The probe and repairable head are essentially a coax cable system that is considered inherently resistant to shock and vibration. The probes and repairable head are evaluated to be adequately designed for resilience against shock and vibration. The new probe mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects. The probes will be affixed to the bracket using a machine screw connection designed with proper thread engagement. The indicator and battery enclosures will be mounted in the LCR. The equipment is not affixed or adjacent to any rotating machinery that would cause vibration effects in the area of installation. The new instrument mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects. Similarly, the effects of shock on the supporting fixtures for the instruments are not a credible threat; all existing equipment in the vicinity of the new SFPI equipment is qualified seismically such that there are no expected impacts from adjacent objects during the BDBEE or design-basis earthquake requirements imposed by NEI 12-02.

The NRC staff found that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to shock and vibration qualifications.

4.2.4.2.3 Seismic

In its letter dated July 29, 2016 [Reference 53], the licensee stated that the vendor, Mohr, prepared a series of generic seismic qualification reports for the SFP level instrument which bound GGNS's seismic criteria. The qualification reports envelop all components of the new SFP level instrumentation required to be operational during a BDBEE and post-event. Therefore, the licensee stated, the SFP instrumentation and electronic units are acceptable for use at the site.

The NRC staff notes that the licensee adequately addressed the equipment reliability of SFP level instrumentation with respect to seismic qualification. The equipment's seismic qualifications envelop the anticipated seismic condition during a BDBEE. Further discussion of the instrument channel's mounting design is described in Sub-section 4.2.3, "Design Features: Mounting". During the onsite audit, the staff reviewed the vendor's factory acceptance test reports and found the SFPI design and qualification process acceptable. However, the NRC staff learned that there were incidents at other nuclear facilities, in which Mohr's SFPI equipment experienced failures of the filter coil (also called the choke). The staff requested the licensee to address the impact of Mohr's SFPI equipment failures on the SFP level instrument.

In response to the staff's concerns, in its letter dated May 24, 2016, [Reference 35], the licensee stated that the vendor (Mohr) has determined the source of the failures is a miniature surface mount common-mode choke component used on the Video and Digicomp printed circuit boards within the EFP-IL Signal Processor. The replacement boards have equivalent substitute components that are less susceptible to transient electrical events. The substitute components have equivalent size, mass, and solder attachment technique as the original component such that there is no impact to the system mechanical characteristics. The components demonstrate equivalent electrical performance such that EMC characteristics are not significantly changed. The vendor-recommended repair has been implemented on the GGNS system per condition report CR-HQN-2015-0345. Proprietary Mohr Report 1-1010-2: EFP-IL MOD 1 Modification Package addresses continued equipment qualification following the repair.

During the onsite audit, the NRC staff reviewed condition report CR-HQN-2015-0345 and found the licensee's approach to address the equipment failure appropriate. The staff also reviewed the Mohr EFP-IL MOD 1 Modification Package, Revision 0, dated July 16, 2015, as summarized below.

In EFP-IL MOD 1, Mohr provided evaluation of the following hardware modifications:

- In-place replacement of the miniature T1 surface mount choke on the 01-EFP-IL-50001 board with an equivalent component.
- In-place replacement of the miniature T1 surface mount choke on the 01-EFP-IL-50006 board with an equivalent component.
- Incorporation of a fusible link in the 01-EFP-IL-50204 cable assembly.
- Full electrical isolation added to the 01-EFP-IL-50007 (USB interface) board.

Below is the summary of the vendor's evaluation of the above modifications:

T1 Choke Replacement Evaluation

Temperature and Humidity
The replacement choke has an operating temperature range of -40 °C to +85 °C, exceeding the -10 °C to +55 °C requirement. Non-condensing humidity does not alter performance of this component.

Electromagnetic Compatibility (EMC)
There is no change to EMC qualification. The choke demonstrates equivalent or higher impedance to common mode noise.

Shock and Vibration
The mass differences are 0.002% and 0.47% for 01-EFP-IL-50001 enclosure mass and the board mass respectively and 0.0003% and 0.18% for 01-EFP-IL-50006 enclosure mass and the board mass respectively.

Seismic

Qualification by similarity to existing qualified equipment is permitted by IEEE Std. 344-2004. Replacement of the T1 choke does not significantly alter equipment mass, mass distribution, or other mechanical characteristics.

Fusible Link Evaluation:

The 01-EFP-IL-50204 Fusible Link is added to the existing power board power cable. One Fusible Link is used per EFP-IL signal processor.

Temperature and Humidity
The Fusible Link's fuses are rated for -55 °C to +125 °C and 100% relative humidity per MIL-STD-201 Method 106.

Electromagnetic Compatibility (EMC)
There is no change to EMC qualification. The Fusible Link uses insulated wiring and connectors identical in configuration to the remainder of the previously qualified cable assembly and expected emissions are unchanged.

Shock and Vibration
The Fusible Link uses insulated wiring and connectors identical in configuration to the remainder of the cable assembly and is secured using identical tie-down and strain-relief methods which have been previously qualified.

The Fusible Link contributes approximately 0.14% enclosure mass, well within the expected variation of the unmodified EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

The connectors are qualified by the manufacturer for vibration conditions per EIA 364-28 and shock loading at 50g. The connector rated minimum pull force is 8.0 lbf per wire terminal, for a total rating of 80.0 lbf for the 10 wire connector, equivalent to 2086 g loading assuming Fusible Link mass of 17.4 g.

The Littelfuse fuse lead axial pull force is rated at 7 lbs per MIL-STD-202, which is equivalent to 182 g static loading per fuse (two fuses per cable), assuming cable mass of 17.4 g and conservatively neglecting stress shielding by cable wiring and insulation.

Seismic
The Fusible Link contributes approximately 0.14% enclosure mass, well within the expected variation of the unmodified EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

Electrical Isolation Evaluation:

The front panel USB board 01-EFP-IL-50007 has been modified through addition of the component to provide galvanic USB isolation and enhance ESD protection (±15 kV)

Temperature and Humidity

The additional component is rated for normal operation at -40 °C to +85 °C. The component is a hermetic plastic BGA package that is not susceptible to elevated humidity.

Electromagnetic Compatibility (EMC)
There is no change to EMC qualification. The isolation technology within the additional component is compliant with applicable standards including radiated emissions limit per IEC 61000/CISPR 22. The device reduces the equipment's already low radiated emissions when the USB device is in use because it isolates and prevents noise on internal data and power lines from propagating to external devices connected to the front-panel USP port. The device is not active when USB devices are not in use.

Shock and Vibration
There is insufficient mass difference to alter the equipment shock and vibration response characteristics. The additional component is a rugged, compact, encapsulated surface-mount BGA package enveloped in size and mass by other components in the system. Surface mount components as a class are not susceptible to required levels of shock and vibration when mounted within the EFP-IL equipment enclosures.

Seismic
The nominal difference in enclosure mass is trivial at 0.014, well within the expected variation of EFP-IL signal processor enclosure mass due to manufacturing tolerances of system components.

The NRC staff found the vendor adequately addressed the staff concern with regard to the modified equipment qualifications. The temperature and humidity ratings of the replacement parts envelop the expected GGNS conditions during a BDB event. According to Mohr's evaluation, there is no indication that new electromagnetic emissions are introduced by the replacement parts. The mass differences are not significant to alter the seismic, shock, and vibration response characteristics.

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

4.2.5 Design Features: Independence

In its OIP, the licensee stated that the primary instrument channel will be independent of the backup instrument channel. Independence is obtained by physical separation of components between channels and the use of normal power supplied from separate 120 Vac battery-backed instrument buses. The distribution panel for the primary channel receives power from a different 120 Vac battery-backed instrument bus than the distribution panel for the backup channel. Both instrument buses receive normal ac from a single 480 Vac MCC but separate battery backup sources. Therefore, loss of any one 120 Vac instrument bus does not result in loss of normal 120 Vac power for both instrument channels.

The NRC staff noted that the licensee adequately addressed the instrument channel independence. The primary instrument channel is physically and electrically independent of the backup instrument channel. The instrument channels' physical separation is discussed in Sub-section 4.2.2, "Design Features: Arrangement". With the licensee's proposed power arrangement, the electrical functional performance of each level measurement channel would be considered independent of the other channel, and the loss of one power supply would not affect the operation of the other independent channel under BDBEE conditions.

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

4.2.6 Design Features: Power Supplies

In its OIP, the licensee stated that each instrument channel is normally powered from a 120 Vac 60 Hz plant distribution panel to support continuous monitoring of SFP level. The distribution panel for the primary channel receives power from a different 120 Vac battery-backed instrument bus than the distribution panel for the backup channel. Both instrument buses receive normal ac from a single 480 Vac MCC, but have separate battery backup sources. On loss of normal 120 Vac power from the instrument bus, each channel's internal UPS automatically transfers to a dedicated backup battery. If normal power is restored, the channel will automatically transfer back to the normal ac power. The backup batteries are maintained in a charged state by commercial-grade uninterruptible power supplies. The batteries are sized to be capable of supporting intermittent monitoring for a minimum of 3 days of operation. This provides adequate time to allow the batteries to be replaced or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049. An external connection permits powering the system from any portable dc source.

In its letter dated July 29, 2016 [Reference 53], the licensee provided further details on the SFP level instrument's normal ac power sources, as summarized below, to illustrate the electrical independence of the instrument channels. Power for the new instrumentation is supplied from 120 Vac panels 1P199 and 1L143. The 120 Vac power for Channel-A [primary channel] is supplied from power panel 1P199, which is supplied from transformer 1X199 powered from 480 Vac balance of plant MCC 13B12. The 120 Vac power for Channel-B [backup channel] is supplied from lighting panel 1L143, which is supplied from lighting transformer 1X143 powered from 480 Vac balance of plant MCC 14B21.

During the onsite audit, the NRC staff enquired as to the power restoration strategy following an ELAP and prior to depletion of the back-up battery. By letter dated July 29, 2016 [Reference 53], the licensee provided a response in which it stated that procedure 05-S-01-FSG-011 contains the instructions for connecting an external dc source via provided cable to provide power beyond the 7-day battery life.

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

4.2.7 Design Features: Accuracy

In its OIP, the licensee stated that the absolute system accuracy is better than ± 3 inches. This accuracy is applicable for normal conditions and the temperature, humidity, chemistry, and radiation levels expected for BDBEE conditions.

In its letter dated August 29, 2013 [Reference 26], the licensee further stated that the instrument channel level accuracy will be specified as ± 3.0 inches for all expected conditions. The instrument channel accuracy performance would be approximately ±1 percent of span (based on the sensitive range of the detector). In general relative to normal operating conditions, any applicable calibration procedure tolerances (or acceptance criterion) are planned to be established based on manufacturer's stated/recommended reference accuracy (or design accuracy). The methodology used is planned to be captured in plant procedures and/or programs.

The NRC staff noted that the licensee's instrument channel design accuracy is sufficient for maintaining the instrument channels within their designed accuracy prior to a significant drift occurrence. The licensee has demonstrated that the instrument channels will maintain the designed accuracy following a power source change or interruption without the need of recalibration. If implemented properly, the instrument accuracy should not be significantly affected by BDBEE conditions.

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

4.2.8 Design Features: Testing

For testing the design features of the SFP level instrument, in its letter dated August 29, 2013 [Reference 26], the licensee stated that the level instrument automatically monitors the integrity of its level measurement system using in-situ capability. Deviation of measured test parameters from manufactured or as-installed configuration beyond a configurable threshold prompts operator intervention. Periodic calibration checks of the signal processor electronics to extrinsic National Institute of Standards and Technology (NIST) standards can be achieved through the use of standard measurement and test equipment. The probe itself is a perforated tubular coaxial waveguide with defined geometry and is not calibrated. It is planned to be periodically inspected electromagnetically using TDR at the probe hardline cable connector to demonstrate that the probe assembly meets manufactured specification and visually to demonstrate that there has been no mechanical deformation or fouling. Each instrument electronically logs a record of measurement values over time in non-volatile memory that is compared to demonstrate constancy, including any changes in pool level, such as that associated with the normal evaporative loss/refilling cycle. The channel level measurements can be directly compared to each other (i.e., regular cross-channel comparisons). The two displays are installed in close proximity to each other, thus simplifying cross channel checks. Direct measurements of SFP level may be used for diagnostic purposes if cross-channel comparisons are anomalous.

For the SFP level instrument functional test, in its letter dated August 29, 2013 [Reference 26], the licensee stated that performance tests (functional checks) are automated and/or semi-automated (requiring limited operator interaction) and are performed through the instrument menu software and initiated by the operator. There are a number of other internal system tests that are performed by system software on an essentially continuous basis without user intervention but which can also be performed on an on-demand basis with diagnostic output to the display for the operator to review. Other tests such as menu button tests, level alarm, and alarm relay tests are only initiated manually by the operator. Performance checks are described in detail in the Vendor Operator's Manual, and the applicable information is planned to be contained in plant operating procedures. Performance tests are planned to be performed periodically as recommended by the equipment vendor, for instance quarterly but no less often than the calibration interval of 2 years. Channel functional tests per operations 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 spent fuel pool instrumentation. Manual calibration and operator 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.

The NRC staff noted that the licensee adequately addressed the testing requirements of the SFP level instruments. GGNS' SPF level instrument is designed to provide the capability for routine testing and calibration including in-situ testing/calibration. By comparing the levels in the instrument channels and the maximum level allowed deviation for the instrument channel design accuracy, the operators could determine if recalibration or troubleshooting is needed.

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

4.2.9 Design Features: Display

In its letter dated February 18, 2015 [Reference 31], the licensee stated that the SFP level instrument displays will be located in the LCR which is in the control building, one floor below the control room. This room is accessible from the control room via two separate stairwells in a Seismic Category I structure and therefore can be accessed without unreasonable delay following a BDB event. Therefore, an evaluation of the time it takes to access the display is not required. The stairways to the display location and the LCR are in mild radiation environments. Habitability will be assured by heat stress countermeasures and rotation of personnel. Personnel are not typically continuously stationed at the displays, the displays will be monitored periodically. The site FLEX Support Guidelines will provide guidance for personnel to evaluate the room temperature and take actions as necessary. In addition, site procedures already use passive cooling technologies for response personnel.

The NRC staff noted that the licensee adequately addressed the display requirements. If implemented properly, the displays will provide continuous indication of SFP water level. The displays are located in seismically qualified buildings and the accessibility of the LCR following an ELAP event is considered acceptable. During the onsite audit, the staff walked down and verified that the SFPI display locations should be promptly accessible and should remain habitable.

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

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the SFPI shall be maintained available and reliable through appropriate development and implementation programmatic controls, including training, procedures, and testing and calibration. Below is the NRC staff's assessment of the programmatic controls for the SFPI.

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that the systematic approach to training (SAT) will be used to identify the population to be trained and to determine both the initial and continuing elements of the required training. Training will be completed prior to placing the instrumentation in service. The NRC staff finds that the use of SAT to identify the training population and to determine both the elements of the required training is acceptable. The licensee's proposed plan to train personnel in the operation, maintenance, calibration, and surveillance of the SFPI and the provision of alternate power to the primary and backup instrument channels, including the approach to identify the population to be trained, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and should adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

For procedures related to the SFP level instrumentation, in its letter dated February 18, 2015 [Reference 31], the licensee stated that the calibration and test procedures are provided in the technical manuals developed by Mohr. The objectives are to measure system performance, determine if there is a deviation from normal tolerances, and return the system to normal tolerances. Diagnostic procedures developed by Mohr are provided as automated and semi-automated routines in the system software alerting the operator to abnormal deviation in selected system parameters such as battery voltage, loop continuity, and TDR waveform of the transmission cable. The technical objective of the diagnostic procedures is to identify system conditions that require operator attention to ensure continued reliable liquid level measurement. Manual diagnostic procedures are also provided in the event that further workup is determined to be necessary. Maintenance procedures developed by Mohr are provided in the technical manual. These allow a technician trained in EFP-IL system maintenance to ensure that system functionality is maintained. An operation procedure will provide sufficient instructions for operation and use of the system. Entergy procedures will be developed in accordance with the vendor manuals provided by Mohr and Entergy procedures and processes. FLEX Support Guidelines will provide sufficient instructions for use of the SFPI following a BDBEE.

In its letter dated July 29, 2016 [Reference 53], the licensee provided a list of GGNS procedures related to the SFP level instrumentation as shown in Table 1 below.

Table 1 - Grand Gulf SFP Level Instrumentation Procedures

Procedure	Objective
05-S-01-FSG-11	To provide actions to restore SFP level using an alternate makeup source for a BDBEE resulting in an ELAP. This procedure includes remote SFPI display locations and a procedure for how and when to connect an external DC source to power the SFP level indicator.
Technical Requirements Manual (TRM)	Provides compensatory actions for SFPI out of service.

As for the site-specific calibration procedure, during the onsite audit, the licensee stated that a fleet template will be used for site-specific calibration and channel functional testing. Arkansas Nuclear One's calibration procedure will be adapted for GGNS, as stated in corrective action #1 of condition report CR-GGN-2015-06134. The NRC staff reviewed a copy of Arkansas Nuclear One's calibration procedure and found it adequately addressed the necessary tasks to ensure the SFP level instrument maintains its design function and accuracy. The NRC staff noted that the licensee adequately addressed the SFP level instrument procedure requirements. The procedures had been established for the testing, surveillance, calibration, and operation of the primary and backup SFP level instrument channels.

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

4.3.3 Programmatic Controls: Testing and Calibration

In its letter dated August 27, 2014 [Reference 30], the licensee stated that SFP level instrument equipment maintenance/preventative maintenance [PM] and testing program requirements will be established in accordance with Entergy's processes and procedures and in consideration of vendor recommendations to ensure that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance are performed (and available for inspection and audit).

In its letter dated February 18, 2015 [Reference 31], the licensee further stated that calibration or channel functional testing original methodology is completed based on vendor stated installation accuracy and to incorporate a comparison of SFPI channels to actual pool level as well as a channel comparison between the two channels.
During the onsite audit the NRC staff enquired information about the SFP level instrumentation PM program. In its letter dated July 29, 2016 [Reference 53], the licensee provided a list of PM tasks related to Grand Gulf's SFP level instrumentation as shown in Table 2 below.

Table 2 - GGNS SFP Preventive Maintenance Tasks

CONDITIONS	REQUIRED ACTIONS	COMPLETION TIME
Channel Calibration Check (Operator Rounds)	To validate that the Mohr instruments (both channels) are displaying correct SFP level within the accuracy of the instruments and that the date stamp on the display is indicating correctly	1 Day
Channel Check/Panel Functional Check	To check each channel against each other for comparison and to perform functional assessments of each panel	1 Year
Signal Processor Clock Battery Replacement	To prevent failure of the onboard clock battery and adverse impact to the signal processor operating system	10 Years

During the onsite audit, the NRC staff also enquired as to the compensatory measures for out-of-service SFPI channel(s). In response, licensee stated that control of compensatory actions for out of service SFPI channel(s) will be controlled by inclusion in the Plant's Technical Requirements Manual (TRM) as shown in Table 3 below. The staff verified the licensee's response by reviewing GGNS TRM, Section 6.10.1, "Spent Fuel Pool Level Instrumentation," Rev. LBDCR 16015.

Table 3 - SFP Level Instrumentation Compensatory Measures

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. The primary or back-up SFP level instrument does not meet the FUNCTIONAL requirements.	A.1 Restore SFP level instrument to FUNCTIONAL status.	90 days
B. Action A.1 completion time not met	B.1 Implement compensatory measures.	Immediately
C. The primary and back-up SFP level instruments do not meet the FUNCTIONAL requirements.	C.1 Initiate actions to restore one of the channels of instrumentation. **AND** C.2 Implement compensatory measures.	24 hours 72 hours

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

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

4.4 Conclusions for Order EA-12-051

In its letter dated May 24, 2016 [Reference 35], the licensee stated that it met the requirements of Order EA-12-051 by following the guidelines of NEI 12-02. Guidance document NEI 12-02 was endorsed by the NRC in 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. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at GGNS according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013 the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit at GGNS in October 2015 [Reference 17]. The licensee reached its final compliance date on March 25, 2016, and has declared that GGNS is in compliance with the orders. The purpose of this SE is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that if implemented appropriately should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

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Date: September 27, 2016

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 letters dated November 25, 2013 (ADAMS Accession No. ML13316B986), and November 24, 2015 (ADAMS Accession No. ML15308A298), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated May 24, 2016 (ADAMS Accession No. ML16145A523), Entergy submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051.

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

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

Sincerely,

/RA/
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