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

May 4, 2017

Mr. Scott Northard
Site Vice President
Northern States Power Company - Minnesota
Prairie Island Nuclear Generating Plant
1717 Wakonade Drive East
Welch, MN 55089-9642

SUBJECT: PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0834, MF0835, MF0832, AND MF0833)

Dear Mr. Northard:

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

By letter dated February 26, 2013 (ADAMS Accession ML13060A379), Northern States Power Company - Minnesota (NSPM, the licensee), doing business as Xcel Energy, submitted its OIP for Prairie Island Nuclear Generating Plant (PINGP), Units 1 and 2, 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 27, 2014 (ADAMS Accession No. ML14030A540), and August 20, 2015 (ADAMS Accession No. ML15224B396), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated January 14, 2016 (ADAMS Accession No. ML16014A754), NSPM reported full compliance with Order EA-12-049 at PINGP, Unit 2. By letter dated December 13, 2016 (ADAMS Accession No. ML16351A208), NSPM submitted a compliance letter and Final Integrated Plan for PINGP, Units 1 and 2, 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. ML13060A363), NSPM submitted its OIP for PINGP in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the attached safety evaluation. By letters dated November 14, 2013 (ADAMS Accession No. ML13311A486), and August 20, 2015 (ADAMS Accession No. ML15224B396), the NRC issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated December 8, 2015 (ADAMS Accession No. ML15343A342), NSPM submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051 at PINGP, Units 1 and 2.

The enclosed safety evaluation provides the results of the NRC staff's review of NSPM's strategies for PINGP. The intent of the safety evaluation is to inform NSPM 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 Peter Bamford, Orders Management Branch, PINGP Project Manager, at 301-415-2833 or at Peter.Bamford@nrc.gov.

Sincerely,

John P. Boska

John P. Boska, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-282 and 50-306

Enclosure:
Safety Evaluation

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# SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

# NORTHERN STATES POWER COMPANY - MINNESOTA

# PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2

# DOCKET NOS. 50-282 AND 50-306

## 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 December 10, 2015, following submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, Revision 2, "Diverse and

Flexible Coping Strategies (FLEX) Implementation Guide," [Reference 6] to the NRC to provide revised specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06, Revision 2, and on January 22, 2016, issued Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," [Reference 7], endorsing NEI 12-06, Revision 2, with exceptions, additions, and clarifications, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (81 FR 10283).

2.2 Order EA-12-051

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## 3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 26, 2013 [Reference 10], Northern States Power Company - Minnesota (NSPM, the licensee), doing business as Xcel Energy, submitted an Overall Integrated Plan (OIP) for Prairie Island Nuclear Generating Plant (PINGP, Prairie Island), Units 1 and 2, in response to Order EA-12-049. By letters dated August 26, 2013 [Reference 11], February 26, 2014 [Reference 12], August 25, 2014 [Reference 13], February 26, 2015 [Reference 14], August 25, 2015 [Reference 15], February 24, 2016 [Reference 16], and August 17, 2016 [Reference 17], the licensee submitted six-month updates to the OIP. By letter dated October 20, 2014 [Reference 18], the licensee corrected the second six-month update. By letter dated August 28, 2013 [Reference 36], 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 44]. By letters dated February 27, 2014 [Reference 19], and August 20, 2015 [Reference 20], the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated January 14, 2016 [Reference 43], NSPM reported full compliance with Order EA-12-049 at PINGP, Unit 2. By letter dated December 13, 2016 [Reference 21] the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved for PINGP, Units 1 and 2, 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.

Prairie Island, Units 1 and 2, are Westinghouse pressurized-water reactors (PWRs) with a dry ambient pressure containment. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in its FIP, is summarized below. The approach is somewhat different if the plant receives warning of a pending flood.

In Phase 1, immediately following the loss of power, each unit's reactor will trip and the plant will initially stabilize at no-load reactor coolant system (RCS) temperature and pressure conditions, with reactor decay heat removal via steam release to the atmosphere through the steam generator (SG) power operated relief valves (PORVs) and/or main steam safety valves (MSSVs). Natural circulation of the RCS will develop to provide core cooling and the turbine driven auxiliary feedwater (TDAFW) pumps will provide flow from the condensate storage tanks (CSTs) (if available) to the SGs to makeup for steam release. At the initiation of the event, operators will enter the station's emergency operating procedure (EOP) for the loss of all safeguards ac power. According to the licensee's FIP, while performing this procedure, the control room staff will declare an ELAP after determining that no alternate ac source is available. It is expected that an ELAP will be declared within 20 minutes of the initiating event. This EOP directs entry into the FLEX support guidelines (FSGs) and other abnormal operating procedures (AOPs), as appropriate.

A rapid RCS cooldown, approximately 100 degrees Fahrenheit (°F) per hour, is initiated within the first 2 hours of the event. This minimizes the adverse effects of high temperature RCS coolant on reactor coolant pump (RCP) shaft seal performance and reduces SG pressure to allow for eventual auxiliary feedwater (AFW) injection from a portable pump when, or if, the TDAFW pumps become unavailable. The cooldown is accomplished by using the SG PORVs to release steam. When the PORV air accumulators are exhausted, the valves may be operated locally using the valve hand wheels. The cooldown continues until the SG pressure reaches 350 pounds per square inch gauge (psig). This SG pressure is high enough to prevent safety injection (SI) accumulator nitrogen gas from entering the RCS. Makeup to the SGs continues to be supplied from the TDAFW pumps with flow being controlled locally in the AFW pump rooms. The normal and preferred source of water for the TDAFW pumps is from the three cross-connected 150,000 gallon CSTs. The CSTs are expected to survive seismic and flood events, but are not tornado missile protected.

The backup water source for the SGs is the cooling water (CL) system using the diesel-driven cooling water pumps (DDCLPs). The suction supply to the DDCLPs is from a safeguards bay inside the plant Screenhouse that is supplied from the Mississippi River through the normal intake or from a dedicated emergency cooling water intake line. With the assumed loss of the CSTs, the TDAFW pumps would automatically trip on low suction pressure, protecting the pump from damage due to a loss of the suction water supply. Aligning the CL system to the suction of the TDAFW pumps requires local manual operation of two motor operated valves (MOVs) per pump and then locally restarting the TDAFW pump. Each DDCLP has its own dedicated diesel engine and does not rely on ac power. The speed of the DDCLP is reduced within 2 hours to ensure its associated fuel oil day tank (FODT) contains sufficient fuel oil to support approximately eight hours of DDCLP operation.

The RCS cooldown will proceed to 350 psig SG pressure, which corresponds to a core inlet temperature of approximately 435°F. With RCS conditions stabilized at this temperature, natural circulation will continue to remove decay heat. During this time the RCS inventory decreases due to ongoing RCS leakage. The licensee will establish forced flow RCS makeup prior to reaching reflux cooling conditions in the RCS, which is projected to occur approximately 32 hours into the event.

The power supply to essential instrumentation is from the inverters, which are powered from the safeguard batteries during the initial hours of an ELAP event. Load shedding will be performed in order to extend battery operational times. The strategy for the load shedding will be to reduce the load on the batteries through use of relatively simple actions (opening dc panel breakers and pulling fuses). The load shedding will focus on reducing the overall load while maintaining essential instrumentation and controls. It is expected to commence within 30 minutes of the ELAP, with the first portion completed within 60 minutes and the final portion of the load shed completed within 90 minutes after initiation of an ELAP event. The licensee's battery depletion calculation predicts that shedding these loads will extend the limiting battery life to 11.5 hours.

The Phase 2 coping strategy for reactor core cooling involves removing decay heat by releasing steam from the SGs while continuing to provide makeup to the SGs from the TDAFW pump. As in Phase 1, water will be supplied to the TDAFW pump from either the CST (if available) or the CL system using a DDCLP. Within the 8 hour period of available onboard diesel fuel supply to the DDCLP, a portable 480 Volts ac (Vac) FLEX diesel generator (DG) will be deployed to repower a motor control center (MCC) in the plant Screenhouse. This MCC supplies power to a fuel oil transfer pump that will automatically refill the associated FODT from the associated fuel oil storage tank (FOST). The same FLEX DG will be used to repower battery chargers on both units. As a backup to the TDAFW pump, a portable FLEX SG/SFP makeup pump may be connected to either of the FLEX connection points installed downstream of the motor driven auxiliary feedwater (MDAFW) pumps. Note that PINGP has one MDAFW pump and one TDAFW pump per unit. The AFW system cross-connect valves (located downstream of each MDAFW pump) will be used to supply flow to the opposite unit from where the connection is made. A diesel-driven hydraulic FLEX submersible pump provides the required lift to supply the suction of the SG/SFP makeup pump if the Mississippi River is its water supply source.

The Phase 3 coping strategy for reactor core cooling involves continuing the Phase 2 strategy. Additional equipment will also be available from the National SAFER [Strategic Alliance for FLEX Emergency Response] Response Center (NSRC). This equipment provides redundancy to the on-site FLEX equipment along with additional capabilities such as water treatment and RCS boration. According to the licensee, the onsite emergency response organization will determine how to use these additional capabilities. Two 4 kilovolt (kV), 1000 kilowatt (kW) combustion turbine generators (CTGs) for each unit will be supplied from the NSRC in order to supply power to one of the two safeguard 4 kV buses on each unit. By restoring a safeguard 4 kV bus, power can be restored to the safeguard 480 Vac buses via the 4160/480 Vac transformers to power selected 480 Vac loads, such as the SI accumulator isolation valves. Isolating the accumulators to prevent nitrogen injection allows the SG pressure to be reduced below 350 psig. Restoring safeguards 4 kV power provides the option to repower a MDAFW pump to supply feedwater to the SG and reduce SG pressure below that required to provide the motive force for the TDAFW pump.

The PINGP SFP is a common two compartment pool shared by both units. It is located inside an enclosed structure that is contained within a common Auxiliary Building. Upon initiation of the ELAP event, the SFP will heat up due to the unavailability of the normal cooling system. The licensee has determined that boiling could start as soon as 33 hours after the start of the event. The licensee plans to pre-stage makeup water source hoses in the vicinity of the SFP by this time. Ventilation to prevent excessive steam accumulation is accomplished by opening the Auxiliary Building roll-up doors.

Regarding the containment safety function, the Phase 1 coping strategy involves verifying containment isolation per established procedures and monitoring containment pressure using installed instrumentation. The Phase 2 actions are similar with the necessary instrumentation eventually receiving power from the FLEX DGs. The Phase 3 coping strategy for containment involves restoring at least one containment fan coil unit (FCU) using the NSRC-provided CTGs to power a safeguards 4 kv bus, followed by restoration of a safeguard 480 Vac bus. Once a 480 Vac bus has been repowered, an FCU fan may be restarted. Cooling water to the containment FCU would be supplied from the installed DDCLP.

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

### 3.2 Reactor Core Cooling Strategies

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

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

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

### 3.2.1 Core Cooling Strategy and RCS Makeup

#### 3.2.1.1 Core Cooling Strategy

##### 3.2.1.1.1 Phase 1

As stated in the licensee's FIP for PINGP, Units 1 and 2, the heat sink for core cooling in Phase 1 would be provided by the two SGs on each unit, which will be fed simultaneously by each unit's TDAFW pump with inventory supplied from the three CST's. The three CST's are shared between both units and have a combined minimum useable capacity of 100,000 gallons per unit, but are not robust to all applicable hazards. In the event that the CSTs are not available, the TDAFW pumps will automatically shutdown due to low suction pressure. The low suction pressure shutdown provides protection for the pump. The TDAFW pump can subsequently be aligned to take suction from the CL system with water provided by the DDCLP's.

The DDCLPs take suction from a safeguards bay inside the plant Screenhouse. The suction bay is provided with an unlimited supply of water from the Mississippi River. This water is supplied either through the normal intake or the dedicated emergency cooling water intake line. The emergency cooling water intake line is robust to all applicable hazards and takes suction from an intake crib designed to exclude trash. Each DDCLP is driven by its own associated diesel engine and has no reliance on ac power. Fuel for DDCLP operation is initially available for up to 8 hours.

Following the postulated ELAP, the reactors will trip and the plant will stabilize at no-load RCS temperature and pressure. Decay heat will be removed by steam release from the SGs to the atmosphere. This will be accomplished by the SG PORVs or MSSVs. The PORVs have an associated air accumulator that will initially supply pressurized air for valve operation. Following the depletion of these accumulators, if no operator action is taken to control the PORVs manually, the MSSVs will lift to release steam and remove decay heat. During the ELAP event, after the air accumulators are exhausted, the licensee plans to operate the SG PORVs manually (locally) using the valve hand wheels.

The PINGP's Phase 1 strategy directs operators to commence a cooldown and depressurization of the RCS within 2 hours of the initiation of the event. Over a period of approximately 2 hours, PINGP will rapidly cool down the RCS from post-trip conditions until a SG pressure of 350 psig is reached. A minimum SG pressure of 350 psig is set to avoid the injection of nitrogen gas from the SI accumulators into the RCS while maximizing the injection of borated water. Cooldown and depressurization of the RCS significantly extends the expected coping time because it provides for an initial addition of RCS inventory offsetting the volume lost due to system leakage and temperature related contraction, as well as providing an initial boration of the RCS. The cooldown will also minimize the effects of the high temperature RCS coolant on the performance of the RCP seals and allow for injection of AFW into the SGs from the portable FLEX pump in the event of a failure of the TDAFW pump(s).

3.2.1.1.2 Phase 2

Prairie Island's FIP states that the primary strategy for core cooling in Phase 2 would be to continue using the SGs as a heat sink, with SG secondary inventory being supplied by the TDAFW pumps. Although functionality of the TDAFW pump is expected throughout Phase 2, the licensee will pre-stage a submersible pump in combination with a portable diesel-driven SG/SFP FLEX pump that is capable of backing up this essential function. These pumps will be deployed such that they are available for use within 24 hours after the initiation of the ELAP event.

According to PINGP's FIP, the credited supply of water to the AFW system in Phase 2 will be pumped by either the DDCLP's or the portable SG/SFP pump. In both cases the water supply is taken from the Mississippi River and is essentially unlimited. In the event that the SG/SFP pump needs to be utilized, it will take suction from the associated FLEX submersible pump that will be deployed in one of three possible locations. The preferred location is adjacent to the Screenhouse near the intake canal, an alternate is through a manhole inside the Screenhouse to a suction source from the emergency intake, or another location is from the discharge basin.

In the event that the FLEX SG/SFP pump is required to back up the TDAFW pump function, one of two pumps rated for a capacity of 500 gallons per minute (gpm) at 500 psig and one of two submersible pumps with a capacity of 500 gpm at 105 feet will be used. The submersible pump, located as described above, will discharge to the diesel-driven SG/SFP pump, which will discharge via hoses to FLEX connection points located downstream of each MDAFW pump. The hose will be connected to one of the two connection points and flow can be established to both units through cross connect valves located downstream of the MDAFW pumps.

A 480 Vac FLEX DG will be deployed within the first 8 hours to repower the DDCLP fuel transfer pump. This will allow for the automatic refill of the DDCLP fuel oil day tank, which initially contains fuel for up to eight hours of operation, from the fuel oil storage tank. The same DG will be used to repower a battery charger.

3.2.1.1.3 Phase 3

Per the PINGP FIP, the licensee's core cooling strategy for Phase 3 begins with a continuation of the Phase 2 strategy with supplemental equipment provided from the NSRC. Core cooling will continue to be provided by the SGs with feedwater supplied by either the TDAFW pump, the diesel-driven FLEX SG/SFP pump, or by Phase 3 equipment provided by the NSRC. Phase 3 pumps from the NSRC can connect to the Phase 2 connection points and inject into the SGs to provide cooling. In addition, water purification from the NSRC can be used to treat feedwater, providing cleaner water to reduce any heat transfer degradation in the SGs due to the potential use of raw makeup water.

Prairie Island's long-term strategy is to continue to remove core heat through the steaming of the SGs. In Phase 3, Prairie Island plans to utilize the NSRC CTGs to restore power to one of the 4 kV buses in each unit. Using the associated transformers and breakers, the licensee intends to restore power to the SI accumulator discharge valves and possibly a MDAFW pump. This combination will allow the licensee the option to depressurize the SGs further without the concerns of injecting nitrogen gas into the RCS and losing the motive force for TDAFW pump operation. The onsite emergency response organization will determine how to utilize the available NSRC capabilities as Phase 3 progresses.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Following the reactor trip at the start of the event, operators will isolate RCS letdown pathways and confirm the existence of natural circulation flow in the RCS. A small amount of RCS leakage will occur through the low-leakage RCP seals, but because the expected inventory loss would not be sufficient to drain the pressurizer prior to the RCS cooldown, its overall impact on the RCS behavior will be minor. Although the RCS cooldown planned for implementation between 2 and 4 hours into the event would be expected to drain the pressurizer and create a vapor void in the upper head of the reactor vessel, ample RCS volume should remain to support natural circulation flow throughout Phase 1. Likewise, there is no need to initiate boration during this period, since the assumed reactor operating history implies that a substantial concentration of xenon-135 would be present in the reactor core. As operators depressurize the RCS, injection of the borated inventory from the nitrogen-pressurized accumulators will occur. Following depressurization of the SGs to 350 psig, the licensee's procedures direct maintaining SG pressure constant to prevent the injection of nitrogen. Accumulator isolation will be accomplished later, in Phase 3, once electrical power is restored to the appropriate isolation valves.

3.2.1.2.2 Phase 2

In Phase 2, RCS inventory control and boration is accomplished with a portable DG that repowers an MCC in each unit. The repowered MCC's will be used to energize a charging pump on each unit. In the course of cooling and depressurizing the SGs to a target pressure of 350 psig, a significant fraction of the accumulator liquid inventory will inject into the RCS, filling volume vacated by the thermally induced contraction of RCS coolant and system leakage. RCS boration will commence using a portable FLEX DG and the repowered charging pumps at a projected time of 11.5 hours into the event, with a time constraint of no later than 32 hours into the event. With low-leakage Flowserve N-9000 RCP seals installed on all RCPs, PINGP calculates that RCS makeup is not necessary to prevent the loss of natural circulation for at least 32 hours. Therefore, the injection of borated RCS makeup water will be available before entry into reflux cooling becomes a concern.

The charging pump will be aligned to take suction from the refueling water storage tank (RWST) for each unit, with a volume of at least 265,000 gallons of borated water. The RWSTs are maintained at a boron concentration of 2600 to 3500 parts per million (ppm). Licensee calculations maintain that 8900 gallons of borated water will be injected from the SI accumulators within the 36 hour period. According to the licensee, this injection from the SI accumulators will provide adequate shutdown margin. In the event that the SI accumulator injection is not adequate, there is sufficient time to inject borated water from the RWST using the charging system.

3.2.1.2.3 Phase 3

The Phase 3 strategy for indefinite RCS inventory control and sub-criticality is simply a continuation of the Phase 2 strategy, with backup generators, a high pressure pump, water treatment equipment and a mobile boration unit available from the NSRC. To facilitate the use of higher quality water for RCS makeup, as necessary, the FIP states that the licensee will use water purification equipment from the NSRC to treat water that will be used for core cooling, and to supply the mobile boration unit.

As described previously, the licensee intends to isolate the SI accumulators in Phase 3. During the audit process, the NRC staff questioned whether the setpoint and timing of accumulator isolation accounted for containment heat-up under the specified conditions. In response, the licensee provided the staff with calculation 178599.51.2001, "Prairie Island Steam Generator Pressure Determination," Revision 2. This calculation describes the methodology utilized in determining the initial SG pressure targeted for the initial cooldown. This calculation conservatively used the technical specification minimum accumulator level and the maximum nitrogen gas pressure. The licensee calculated that the SG could be depressurized to 250 psig under these conditions. To account for possible non-conservatisms, the calculation added 100 psi resulting in the final SG pressure of 350 psig. The licensee's containment temperature analysis was performed by CF.PX.00.OPS.046, "Prairie Island Containment Pressure and Temperature," Revision 0. This calculation determined that over a 75 hour period containment temperature would rise from an initial temperature of 120°F to a final temperature of 218°F during an ELAP event. Using the ideal gas law, the licensee estimated that if the accumulator gas temperatures follow the containment temperature, this temperature rise would result in an accumulator pressure rise of 49.7 psi, well within the 100 psig margin allocated for this setpoint. Based on the information provided by the licensee, as confirmed by a staff review, the NRC staff concludes that adequate margin to preclude the injection of accumulator nitrogen is available during the postulated event, prior to accumulator isolation.

3.2.2 Variations to Core Cooling Strategy for Flooding Event

The probable maximum flood (PMF) at the PINGP site occurs as a result of flooding on the Mississippi River and is postulated to have sufficient warning time to prepare the plant site for the arrival of flood waters. The sequence of the postulated flooding event is described in Section 3.5.2 of this safety evaluation. Given the available warning time, the FLEX strategy differs for a flooding event. During the warning time, the site installs certain flood protection and mitigation devices, pre-deploys the NSRC equipment within the flood-protected area of the site, and places both PINGP units in cold shutdown, prior to water reaching the site grade level. All of these actions are contained in the licensee's procedure AB-4, "Flood". If an ELAP then occurs in combination with the flooding, the NSRC generators would be available to repower a safeguards bus in each unit. While the NSRC generators are being connected to the plant electrical distribution system, the RCS will heat up, the SGs will re-pressurize, natural circulation will develop, and the TDAFW pumps can eventually be used to provide feedwater to the SGs. Once electrical power is restored, the NSRC generators will have sufficient capacity to operate the normal plant shutdown systems. The licensee's overall flooding strategy is further evaluated in Section 3.14.3 of this safety evaluation.

3.2.3 Staff Evaluations

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

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

3.2.3.1.1 Plant SSCs

Core Cooling - Phase 1

As stated in FIP Section 2.3.1, the TDAFW pump will provide flow to the SGs to make up for steam released through the SG PORVs and/or the MSSVs. Each unit has one safety-related TDAFW pump, and it is located in the Design Class I[1] portion of the Turbine Building. According to the licensee, this portion of the Turbine Building protects the TDAFW pump from all applicable external hazards. In the FIP, Section 2.3.4 states that the TDAFW pump starts automatically during an ELAP event; however, it could be started locally or remotely from the Main Control Room (MCR), if needed. The normal and preferred source of water for the TDAFW pump is from three cross-connected CSTs. However, the Design Class I CL system is also available. See Section 3.10 of this safety evaluation for further discussion of the robustness of these water sources. Based on the safety-related classification of the TDAFW pump and its location within the Design Class I portion of the Turbine Building, the NRC staff concludes that the TDAFW pump is robust and should be available at the start of an ELAP event, consistent with NEI 12-06, Section 3.2.1.3.

In the FIP, Section 2.3.1 describes the licensee's capability to start the TDAFW pump locally. The TDAFW pump automatically starts following an ELAP event with flow to the SGs being controlled locally in the AFW pump room. However, if the CSTs could not supply water as a result of the BDBEE, then the TDAFW pump would trip on low suction pressure. Operators would then need to align the safety-related CL system by manually operating MOVs and then locally restarting the TDAFW pump in accordance with an existing plant procedure. Based on the existing procedural guidance, the NRC staff concludes that the licensee should be able to start the pump locally consistent with NEI 12-06, Table D-1 in a timely manner.

In the FIP, Section 2.9.1 states that the credited supply to the TDAFW pump is the installed DDCLP. There are two DDCLPs in the CL system. Each one has its own dedicated diesel engine and does not rely on ac power. Fuel oil is supplied by an associated FODT, which is

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1. According to the PINGP, Units 1 and 2, Updated Safety Analysis Report (USAR), Section 1.2.1, "Design Class I" systems and components are designed so that no loss of function would occur in the event of a Design-Basis Earthquake (DBE). In addition, structures and equipment designated as Design Class I are designed, or protective measures are taken in plant design, to withstand all environmental factors, including tornados. In the USAR, 12.2.1.1 also states that PINGP has a "Design Class I*" classification, which indicates that these items have been originally designed or have been subsequently analyzed or tested to Design Class I, DBE loading (dynamic) only, and that these items are treated as Design Class III items in all other respects. Thus for the purposes of an NEI 12-06, Revision 2 classification, the NRC staff concludes that Design Class I SSCs are robust for all applicable hazards and Design Class I* SSCs are robust for DBE only.

located in the Design Class I portion of the Screenhouse and has sufficient capacity to support approximately eight hours of DDCLP operation. In the FIP, Section 2.3.4 describes the operation of the DDCLPs. Within 2 hours of an ELAP event, the speed of one of the DDCLPs is reduced to conserve fuel. The other one is shut down to preserve its fuel supply. The DDCLPs take suction from a safeguards bay inside the Screenhouse that is supplied with river water through the normal intake or a Design Class I Emergency Cooling Water Intake that is robust for all applicable external hazards. Based on the safety-related classification of the CL system, including the DDCLPs, the NRC staff concludes that the DDCLPs are robust and the CL system is expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3. In addition, based on the operation of the DDCLPs to conserve fuel and their capability of using a Design Class I Emergency Cooling Water Intake, the NRC staff concludes that the DDCLPs should be able to supply water to the TDAFW pumps throughout Phase 1. Although the DDCLPs are the credited water source at PINGP following a design-basis accident, the staff concludes that the licensee's strategy for their use regarding the "loss of normal access to the UHS" provision of Order EA-12-049 is acceptable because: (1) the PINGP USAR [Reference 46], Section 10.4.1.2, describes the motor-driven CL pumps as the "normal" motive force for the operation of the cooling water system; (2) the DDCLPs draw water from an independent Design Class I Emergency Cooling Water Intake structure that consists of a 36 inch diameter pipe buried 40 feet below the normal circulating water intake canal; (3) the DDCLPs are Design Class I and are located in the Design Class I portion of the Screenhouse; (4) the DDCLPs do not require ac power to operate; and (5) the licensee's FLEX timeline supports using the DDCLPs as a water source.

Steam will be released from the SGs using the SG PORVs to initiate cooldown of the RCS. FIP Section 2.3.4 states that the PORVs are safety-related, missile protected, seismically qualified valves located in the Design Class I Auxiliary Building. Based on the safety-related classification of the SG PORVs and their location within the Design Class I Auxiliary Building, the NRC staff concludes that the PORVs are robust and that they should be available at the start of an ELAP event, consistent with NEI 12-06, Section 3.2.1.3.

Core Cooling - Phase 2

The licensee's Phase 2 core cooling strategy continues to use the SGs as the heat sink. The TDAFW pump will continue to supply makeup water to the SGs from CSTs (if available) or the CL system. The CL system uses DDCLPs to supply river water to the TDAFW pump. As stated in FIP Section 2.3.2, the DDCLP's associated FODT can support about eight hours of operation. Therefore, the licensee will deploy a 480 Vac FLEX DG during this 8-hour time period to repower a fuel oil transfer pump which will automatically refill the FODT from a FOST. The mitigating strategy requires only one of two DDCLPs and the associated fuel oil transfer pump to be in operation. The FODTs and fuel oil transfer pumps are part of the Design Class I CL system so they should be protected all applicable external hazards.

The licensee can deploy a FLEX SG/SFP makeup pump (in combination with a diesel-driven submersible pump) to supply river water to the SGs. The FLEX makeup pump discharge will be directed through either of the FLEX connection points installed downstream of each MDAFW pump. The MDAFW pump piping is safety-related and protected from the postulated external events.

Core Cooling - Phase 3

In the FIP, Section 2.3.3 states that the licensee's Phase 3 strategy is a continuation of the Phase 2 strategy. The NSRC equipment such as pumps will be received and will provide redundancy to onsite FLEX equipment and some NSRC equipment can be used to treat site makeup water for core cooling.

In the FIP, Section 2.3.3 also describes the potential for the licensee to repower installed equipment during Phase 3. The licensee will receive two CTGs for each unit and could then repower an MDAFW pump from this power source. The MDAFW pump would supply makeup water to the SGs and allow the SG pressure to be reduced below that required to run a TDAFW pump.

RCS Makeup - Phase 1

The licensee's Phase 1 RCS inventory control FLEX strategy relies on Flowserve N-9000 low leakage seals. As described in FIP Sections 2.3.1 and 2.3.2, RCS makeup capability must be established within 32 hours to prevent the onset of reflux cooling.

RCS Makeup - Phase 2

The licensee's Phase 2 RCS inventory strategy for PINGP will use installed charging pumps to supply RCS makeup from the installed RWSTs if adequate makeup is not supplied from the SI accumulators. The licensee has one RWST per unit. In the FIP, Section 2.3.2 states that within the first 32 hours following an ELAP event, a 480 Vac FLEX DG will be connected to a MCC on each unit to power an installed charging pump. Per the licensee's FIP, the charging pumps are expected to be powered within 11.5 hours following initiation of the ELAP event. Only one charging pump is required per unit, and they are located in the Design Class I Auxiliary Building. Because the charging pumps are located within the Design Class I Auxiliary Building, and the licensee's plan contains provisions to provide electrical power for pump operation during an ELAP event, the NRC staff concludes that the charging pumps should be available during Phase 2 to supply RCS makeup.

RCS Makeup - Phase 3

The licensee's Phase 3 RCS inventory strategy for PINGP does not rely on any additional installed plant SSCs other than those discussed in Phase 2. The NSRC equipment will be received and will provide redundancy to onsite equipment. In addition, mobile boration units and water treatment equipment will be received from NSRC to support indefinite coping.

3.2.3.1.2 Plant Instrumentation

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

- RCS temperature (hot and cold leg)
- RCS wide range pressure
- Reactor vessel level
- SG level

- SG pressure
- AFW pump flow
- Neutron flux/startup rate
- CST level
- Pressurizer level
- RWST level
- Core Exit Themocouples (CETs)
- DC Bus voltage

The installed safety-related station batteries power all of these instruments. A portable FLEX DG will be deployed within 8 hours from the ELAP event initiation to repower a battery charger on each unit, within 11.5 hours, prior to battery depletion, thus maintaining these indications.

The licensee's FIP states that, as recommended by Section 5.3.3 of NEI 12-06, procedures have been developed to read the above instrumentation locally using a portable instrument, where applicable. Also, as described in the FIP, the portable FLEX equipment credited in the licensee's mitigating strategies is supplied with the supporting materials necessary for taking local readings. FLEX Support Guideline (FSG)-007, "Loss of Instrumentation or Control Power", provides guidance for obtaining alternate readings for the following parameters:

- RCS hot leg temperature
- RCS cold leg temperature
- RCS wide range pressure
- SG pressure
- SG wide range level
- AFW pump flow
- Containment pressure
- Neutron flux
- CST level
- Pressurizer level
- RWST level
- CETs

Based on the FIP review, the NRC staff concludes that instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event is consistent with, or exceeds, the recommendations specified in the endorsed guidance of NEI 12-06. Based on the information provided by the licensee, the NRC staff concludes that indication for the above instruments should be available and accessible continuously throughout the ELAP event.

3.2.3.2 Thermal-Hydraulic Analyses

PINGP's mitigating strategy for reactor core cooling is based, in part, on a generic thermal-hydraulic analysis performed for a reference Westinghouse two-loop reactor using the NOTRUMP computer code. The NOTRUMP code and corresponding evaluation model were originally submitted in the early 1980s as a method for performing licensing-basis safety analyses of small-break loss-of-coolant accidents (LOCAs) for Westinghouse PWRs. Although NOTRUMP has been approved for performing small-break LOCA analysis under the conservative Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 Appendix K paradigm and constitutes the current evaluation model of record for many operating PWRs, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of the ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of NOTRUMP and other thermal-hydraulic codes used for these analyses. The NRC staff's review included performing confirmatory analyses with the TRACE code to obtain an independent assessment of the duration that reference reactor designs could cope with an ELAP event prior to providing makeup to the RCS.

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

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

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

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

During the PINGP audit, the NRC staff evaluated a comparison of the generic analysis values from WCAP-17601-P and PWROG-14064-P to the PINGP plant-specific values. The NRC staff concurred that the plant parameters were conservative. Prairie Island has installed low-leakage Flowserve N-9000 seals, therefore, the seal leakage expected for PINGP is significantly less than that assumed in the generic NOTRUMP analysis case. The NRC staff concluded based on licensee evaluation that the licensee could maintain natural circulation flow in the RCS for approximately 32 hours during the ELAP event prior to requiring RCS makeup. The RCS makeup would be available per the licensee's mitigating strategy at approximately 11.5 hours after the initiation of the ELAP event. This provides significant margin until the 32 hour period elapses.

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

3.2.3.3 Reactor Coolant Pump (RCP) Seals

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

Flowserve N-9000 seals are installed on the RCPs at PINGP, Units 1 and 2. The N-9000 is a hydrodynamic seal that was developed by Flowserve in the 1980s. One of the design objectives for the N-9000 seal was to provide low-leakage performance under loss-of-seal-cooling conditions during events such as a station blackout. In support of industry efforts to address the ELAP event, the PWROG submitted to the NRC staff a Flowserve paper titled, "White Paper on the Response of the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of All Power (ELAP)" [Reference 47]. The N-Seal white paper contains information regarding the expected leakage rates over the course of an ELAP event for each PWR at which Flowserve N-Seals are currently installed. By dated November 12, 2015 [Reference 48], the staff endorsed the leakage rates described in the white paper for the beyond-design-basis ELAP event, subject to certain limitations and conditions.

During the audit, the licensee addressed the status of its conformance with the white paper and the limitations and conditions in the NRC staff's endorsement letter. In particular, the licensee confirmed that the plant design and planned mitigation strategy for PINGP is consistent with the information assumed in the calculation performed by Flowserve. Additionally, the peak cold-leg temperature prior to the RCS cooldown assumed in Flowserve's analysis was found to be bounded by the saturation temperature corresponding to the lowest setpoint for MSSV lift pressure. Based on its audit review, the NRC staff further considered the endorsement letter's condition on the density of the coolant leaking from the RCS to be addressed inasmuch as: (1) a conservative RCP seal leakage assumption was used for the determination of the time to enter reflux cooling, and (2) shutdown margin calculations considering maximum RCS leakage were performed on an appropriate volumetric basis.

The plant-specific calculations summarized in the Flowserve white paper determined that PINGP's FLEX scenario does not exceed the design margin demonstrated in the 1988 station blackout test, such that increased leakage during the ELAP event due to elastomer failure or other causes is not expected. In the site-specific thermo-hydraulic analysis, the licensee has assumed a mass loss rate from the Flowserve seal package of 2.625 gpm per pump, plus an additional mass loss rate of 1 gpm of unidentified RCS leakage for a total RCS mass loss rate of 6.25 gpm per unit. The NRC staff observes that this flow rate was chosen using a volumetric flow rate slightly higher than the controlled-bleed-off rate in the Flowserve white paper.

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

#### 3.2.3.4 Shutdown Margin Analyses

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

- the cooldown of the RCS and fuel rods adds positive reactivity

- the concentration of xenon-135, which (according to the core operating history assumed in NEI 12-06) would

    - initially increase above its equilibrium value following reactor trip, thereby adding negative reactivity
    - peak at roughly 12 hours post-trip and subsequently decay away gradually, thereby adding positive reactivity

- the passive injection of borated makeup from nitrogen-pressurized accumulators due to the depressurization of the RCS, which adds negative reactivity

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

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

Section 2.3.9 in the PINGP FIP, Shutdown Margin Analysis, describes the strategy and boration necessary to maintain shutdown margin following the initiation of the ELAP event. The licensee's supporting analysis, OC-PX-2012-021, "Prairie Island Subcritical Cooldown," dated December 26, 2012, determined that xenon would maintain a shutdown margin of 1 percent for at least 36 hours following a reactor trip from full power with an accompanying cooldown to 420°F. As described in Section 2.3.1 of the FIP, the strategy calls for a SG depressurization to 350 psig, corresponding to a core inlet temperature of 435°F. Under these conditions SDM is maintained for the first 36 hours of the event. In the shutdown margin section of the FIP, PINGP states that FLEX options would supply negative reactivity by injecting borated water into the RCS employing initially the SI accumulator and later by the charging pump if needed. Per the licensee's analysis, this strategy will ensure that a shutdown margin of 1 percent is maintained to a temperature of 350°F and following xenon decay. In order to make certain that acceptable boric acid concentration is supplied to the RCS, injection is provided for reactivity control beginning before 32 hours, and is required to be completed before 36 hours, following the initiation of the ELAP event. Per the licensee's FIP, Table 2, "Sequence of Events Timeline," the MCC's supplying the charging pumps should be energized at approximately 11.5 hours following the initiation of the ELAP event. This provides adequate time to fulfill the boration requirement, including a one-hour mixing time should the charging pumps be needed for an RCS boration.

The primary strategy that PINGP employs for RCS borated makeup is the injection from the SI accumulators. The licensee also has the capability of injecting from a charging pump taking suction from the RWST. The FIP indicates that the injection from the SI accumulators of 8,900 gallons, at the technical specification minimum boron concentration of 2,300 ppm, would meet the shutdown margin requirement of 1 percent at limiting cycle conditions. Calculation 178599.51.2001, "Prairie Island Steam Generator Pressure Determination," Revision 2, states that SI accumulator injection commences within the first 8.5 hours following the initiation of an ELAP, and the entire credited volume of the SI accumulators is injected within the first 13.5

hours. This timing is well before the required 36 hours needed. Furthermore, as an additional defense in depth measure the ELAP response procedure and guidelines include steps which are to be completed prior to 36 hours to guarantee that either: (1) verifying that sufficient SI Accumulator injection has occurred, or (2) injecting sufficient boron water from the RWST by means of the charging pump.

Toward the end of an operating cycle, when RCS boron concentration reaches its minimum value, some PWR licensees may need to vent the RCS to ensure that their FLEX strategies can inject a volume of borated coolant that is sufficient to satisfy shutdown margin requirements. According to the shutdown margin section of the FIP, venting is not anticipated to be necessary. However, if RCS venting is needed to support injection of borated water, the licensee's procedural direction would be to use the repowered reactor head vent valves.

The NRC staff's audit review of the licensee's shutdown margin calculation determined that credit was taken for uniform mixing of boric acid during the ELAP event. The NRC staff had previously requested that the industry provide additional information to justify that borated makeup would adequately mix with the RCS volume under natural circulation conditions potentially involving two-phase flow. In response, the PWROG submitted a position paper, dated August 15, 2013 (withheld from public disclosure due to proprietary content), which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability limits intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. By letter dated January 8, 2014 [Reference 49], the NRC staff endorsed the above position paper with three conditions:

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

The NRC staff review of the licensee's plan concludes that this condition is satisfied because the licensee's timing for establishing borated makeup acceptably considered both the maximum and minimum RCS leakage conditions expected for the analyzed ELAP event.

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

The NRC staff review of the licensee's plan concludes that this condition is satisfied because the licensee's timing, as well as defense in depth measures, for establishing borated makeup would be prior to RCS flow decreasing below the expected flow rate corresponding to single-phase natural circulation for the analyzed ELAP event.

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

The NRC staff review of the licensee's plan concludes that this condition is satisfied because the licensee's timing for establishing borated makeup allows a 1-hour period to account for boric acid mixing; furthermore, during this 1-hour period, the RCS flow rate would exceed the single-phase natural circulation flow rate expected during the analyzed ELAP event. Further, the NRC staff's audit review indicated that the shutdown margin calculations are generally consistent with the PWROG's position paper, including the three additional conditions imposed in the NRC staff's endorsement letter.

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

3.2.3.5 FLEX Pumps and Water Supplies

The licensee relies on two different portable diesel-driven pumps during Phase 2. The licensee plans to use a SG/SFP diesel-driven makeup pump in combination with a submersible diesel-driven pump as backup to the TDAFW pump. In the FIP, Table 3 states the performance criteria (e.g., flow rate, discharge pressure, and head) for the Phase 2 FLEX portable pumps. In addition, FIP Table 1 shows performance criteria for the FLEX Phase 3 NSRC pumps. As shown in FIP Table 1, the NSRC pumps have at least the capacity of the FLEX Phase 2 portable pumps and therefore provide redundancy to the on-site FLEX equipment. Section 3.2.3.1.1 of this safety evaluation provides a discussion of these FLEX pumps in terms of the licensee's core cooling strategies and Section 3.10 of this safety evaluation provides a detailed discussion of the availability and robustness of each water source.

The SG/SFP diesel-driven makeup pump takes suction from the submersible diesel-driven pump and provides makeup to the SGs as backup to the TDAFW pump. As shown in FIP Table 3, the makeup pump has a rating of 500 gpm at 500 psig discharge pressure. FIP Section 2.3.2 states that together the makeup pump and submersible pump are designed to provide the SG required makeup rate, which is less than 100 gpm per unit at a SG pressure of 350 psig; and also provide the required SFP makeup. The SG/SFP makeup pump is trailer-mounted and stored in the FLEX Storage Building. Two pumps are available to satisfy the "N+1" provision of NEI 12-06.

The submersible diesel-driven pump provides the required lift to supply the suction of the SG/SFP makeup pump. As shown in FIP Table 3, the submersible pump has a rating of 500 gpm at 105 feet total dynamic head. In the FIP, Section 2.3.10 states that the submersible pump in combination with the makeup pump are designed to provide the required flow under the limiting scenario, a seismic event resulting in the loss of the downstream Lock and Dam No. 3. The normal supply is river water from the intake canal. If the normal supply is not available, river water will be supplied from the intake bay through the seismically qualified emergency intake line. The submersible pump is trailer-mounted and stored in the FLEX Storage Building. Two pumps are available to satisfy the "N+1" provision of NEI 12-06.

During the audit process, the NRC staff reviewed the licensee's hydraulic analysis, which is included in Evaluation EC 22374-09, "Evaluation of the SFP Spray and Steam Generator Make-Up for a Post-Seismic Event," Revision 2. This analysis shows that the makeup pump in combination with the submersible pump can provide a SFP spray flow of 500 gpm while also supplying 200 gpm (i.e., 100 gpm per unit) of makeup to the SGs. As described in Section 3.3

of this safety evaluation, the licensee has determined that providing SFP spray is not required by the NRC-endorsed version of NEI 12-06 that the PINGP plan is based on. Based on the capacity of the FLEX pumps, with consideration for the analysis shown in EC 22374-09, Revision 2, the NRC staff concludes that the FLEX pumps should provide at least the required SG makeup of 100 gpm per unit in addition to the required SFP flow. In addition, the NRC staff confirmed that flow rates and pressures evaluated in the hydraulic analysis were reflected in the licensee's plan, based upon the FLEX pumps' description and the respective FLEX connections being made as directed by the FSGs. During the onsite audit, the NRC staff conducted a walkdown of the hose deployment routes for the FLEX pumps to confirm that the pump staging locations, hose distance runs, and connection points were consistent with the hydraulic analysis and FIP description.

In the FIP, Section 2.7 describes protection of FLEX equipment that is located in the FLEX Storage Building. This building is designed to withstand the site-specific design-basis loads for high wind hazards (including tornado and tornado missile loads), environmental conditions, and the safe shutdown earthquake (SSE); however, it is not designed to protect equipment against the design-basis flood. In this case, NSRC FLEX equipment is credited. The licensee's flooding strategy is discussed in detail in Section 3.14.3 of this safety evaluation.

Based on the staff's review of the FLEX pumping capabilities at PINGP, the storage of FLEX equipment, and the redundancy provided by NSRC equipment as described in the FIP, the NRC staff concludes that the portable FLEX pumps should be available and perform as intended to support core cooling during an ELAP event consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to the equipment and instrumentation used to mitigate the ELAP and loss of normal access to the UHS. The electrical strategies described in the licensee's 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 safety evaluation.

The NRC staff reviewed the licensee's FIP which has conceptual electrical single-line diagrams and the summary of calculations for sizing the FLEX generators and station batteries. The NRC 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, all installed sources of emergency on-site ac power, and the station blackout alternate ac source.

During the first phase of the ELAP event, the licensee would rely on the safety-related Class 1E batteries to provide power to key instrumentation and applicable dc components. The PINGP Class 1E station batteries and associated dc distribution systems are located within the Turbine Building, at locations that are designed to meet applicable design-basis external hazards. Licensee guidelines (FSGs) direct operators to conserve dc power during the event by stripping non-essential loads. Operators will strip or shed unnecessary loads to extend battery life until backup power is available. The plant operators would commence load shedding within 30 minutes of the ELAP with the first portion complete within 60 minutes and the final portion of the load shed completed within 90 minutes after initiation of an ELAP event.

Prairie Island has four Class 1E 125 Volts-dc (Vdc) station batteries (11, 12, 21, and 22). The 125 Vdc batteries were manufactured by C&D Technologies. The 125 Vdc batteries are model LCR-25 with a capacity of 1800 ampere-hours (AH). The coping time for batteries 11 and 21 is 12.5 hours. The coping time for batteries 12 and 22 is 11.5 hours.

The NEI White Paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," dated August 27, 2013 [Reference 51], provides guidance for calculating extended duty cycles of batteries (i.e., beyond 8 hours). By letter dated September 16, 2013, this paper was endorsed by the NRC [Reference 52]. In addition to the white paper, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended Battery Operation in Nuclear Power Plants," in May of 2015 [Reference 53]. The testing provided additional validation that the NEI white paper method was technically acceptable. The NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI white paper.

The NRC staff reviewed the licensee's dc coping calculation ENG-EE-199, "FLEX Strategy Battery Depletion Calculation," Revision 0, to assess the capability of the dc system to supply power to the required loads during the first phase of the PINGP 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 90 minutes to ensure battery operation for at least 11.5 hours.

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

The licensee has three 480 Vac 300 kW FLEX DGs available to support the Phase 2 strategy. Two FLEX DGs are required for implementation of the electrical strategy and the third DG is considered a backup for the other two DGs. The third DG thus is intended to fulfill the role of the "N+1" DG. This strategy is considered to be an alternative to guidance outlined in NEI 12-06 due to the licensee's function-based use of the DGs, as opposed to a unit-based strategy. The alternative evaluation is discussed in Section 3.14.1 of this safety evaluation.

One FLEX DG is used to repower a fuel oil transfer pump and a battery charger for each unit. The fuel oil transfer pump will be repowered within 8 hours. The battery chargers will be repowered within 11.5 hours to maintain availability of instrumentation to monitor key parameters. The second FLEX DG is used to repower the charging pumps in each unit. The charging pumps are projected to be repowered at approximately 11.5 hours to maintain RCS inventory.

During the audit process, the NRC staff reviewed licensee calculation ENG-EE-202, "FLEX 480V Portable Diesel Generator Sizing," Revision 0, conceptual single line diagrams, and the separation and isolation of the FLEX DGs from the emergency diesel generators (EDGs). Based on the NRC staff's review of calculation ENG-EE-202, the minimum required loads for the licensee's Phase 2 strategy are 171.9 kW (fuel oil transfer pump, battery chargers, and various other loads) and 236.1 kW (charging pumps). The licensee's calculations took the FLEX cable lengths into consideration (i.e., ensured that the voltage drop did not exceed the minimum voltage required at the limiting component). Therefore, the staff concludes that the 300 kW FLEX DGs are adequate 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/resources. The offsite resources that will be provided by an NSRC includes four 1-megawatt (MW) 4160 Vac CTGs, two 1100 kW 480 Vac CTGs, and distribution panels (including cables and connectors). Two 4160 Vac CTGs for each unit will supply power to one of the two safeguard 4 kV buses on each unit. By restoring a safeguard 4160 Vac bus, power can be restored to the safeguard 480 Vac buses via the 4160/480 Vac transformers to power selected 480 Vac loads. Based on the NRC staff's review of licensee calculation 178599.51.3005, "Prairie Island — 4 kV Generator Sizing Evaluation," Revision 0, the loads to be powered by the Phase 3 CTGs total approximately 1591 kW per unit. These loads fall within the rating of the two 4160 Vac Phase 3 CTGs operating together. In its FIP, the licensee stated the specific loads to be repowered will be determined by the emergency response organization based on the recovery needs. Based on its review, the NRC staff finds that the equipment being supplied from either of the NSRCs has sufficient capacity and capability to supply the required loads during Phase 3.

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 turbine generators 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, except as noted in Section 3.14 of this safety evaluation, and should adequately address the requirements of the order.

### 3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Revision 2, Table 3-2 and Appendix D, summarizes an approach consisting of two separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for: (1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design-basis heat load; and (2) makeup via connection to spent fuel pool cooling piping or other alternate location capable of exceeding the boil-off rate for the design-basis heat load. However, in JLD-ISG-2012-01, Revision 1 [Reference 7], the NRC staff did not fully accept this approach and added another requirement to either have the capability to provide spray flow to the SFP, or complete an SFP integrity evaluation which demonstrates that a seismic event would have a very low probability of inducing a crack in the SFP or its piping systems so that spray would not be needed to cool the spent fuel. The evaluation must use the reevaluated seismic hazard that is described in Section 3.5.1 of this safety evaluation if it is higher than the site's current SSE.

During the audit process the NRC staff confirmed that the licensee performed a SFP integrity evaluation, as specified in JLD-ISG-2012-01, Revision 1. The licensee documented the results of this evaluation and the effect of removing SFP spray from its FLEX strategies in EC 27057, "Reconciliation of U1 and U2 EC FLEX Strategy Implementation with NEI 12-06, Revision 2," Revision 0. As stated in FIP Section 2.4.2 and Attachment 3 of EC 27057, the reevaluated seismic hazard is bounded by the existing SSE. Attachment 6 of EC 27057 assesses the PINGP SFP against the criteria in Section 3.3 of Electric Power Research Institute (EPRI) 3002007148, "Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation." Section 3.3 of EPRI 3002007148 specifies evaluation criteria for low ground motion response spectrum (GMRS) sites and includes site, structural, and non-structural parameters. The licensee's evaluation in Attachment 6 of EC 27057 shows compliance to the EPRI 3002007148, Section 3.3 criteria. Based on the licensee's evaluation in EC 27057 and demonstration of compliance to EPRI 3002007148, Section 3.3 criteria; the NRC staff concludes that the licensee's SFP integrity evaluation is acceptable, and that the licensee has demonstrated that SFP spray flow is not needed.

As described in NEI 12-06, Section 3.2.1.7, and JLD-ISG-2012-01, Section 2.1, strategies that must be completed within a certain period of time should be identified and a basis that the time can be reasonably met should be provided. In NEI 12-06, Section 3, provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is beyond-design-basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters, and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. In NEI 12-06, Section 3.2.1.2 describes the initial plant conditions for the at-power mode of operation; Section 3.2.1.3 describes the initial conditions; and Section 3.2.1.6 describes SFP initial conditions. In NEI 12-06, Section 3.2.1.1 provides the acceptance criterion for the analyses serving as the technical basis for establishing the time constraints for the baseline coping capabilities to maintain SFP cooling. This criterion is keeping the fuel in the SFP covered with water.

The ELAP causes a loss of cooling in the SFP. As a result, the pool water will heat up and eventually start to boil off. The licensee's response is to provide makeup water. During the event, the licensee selects the SFP makeup method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP. The effects of an ELAP with full core offload to the SFP is addressed in Section 3.11 of this safety evaluation. The licensee's strategy is summarized as follows:

### 3.3.1 Phase 1

During Phase 1, operators will monitor SFP level using the instrumentation installed per Order EA-12-051. Following a loss of SFP cooling after an ELAP event, the SFP will gradually heat up due to decay heat. As described in FIP Section 2.4.6, under non-outage conditions, boiling is not expected to occur for more than 33 hours following an ELAP event. Therefore, no actions, other than monitoring level are needed during Phase 1.

3.3.2 Phase 2

During Phase 2, the licensee will ensure makeup water is available to the SFP. Consistent with Action Item 28 in FIP Table 2, it will stage makeup water hoses in the vicinity of the SFP within 33 hours of the ELAP event. If the SFP deck is inaccessible, then an alternative connection point is used at the SFP skimmer connection point one floor below the SFP deck. The SG/SFP diesel-driven makeup pump in combination with a submersible diesel-driven pump will supply river water to the SFP. The makeup pump discharge can be routed to the SFP skimmer connection (not requiring access to the SFP deck), or routed through hoses on the SFP deck to provide direct makeup to the pool.

3.3.3 Phase 3

The Phase 3 strategy is a continuation of the Phase 2 strategy but includes the capability to restore normal SFP cooling. Two 4 kV CTGs from the NSRC will be supplied for each PINGP unit. In the FIP, Section 2.4.3 states that this equipment will provide the licensee with the option to repower a component cooling water pump, a SFP cooling pump, and associated equipment needed to restore normal SFP cooling or makeup. In addition, FIP Table 1 includes NSRC water treatment equipment which can provide an indefinite clean water source.

3.3.4 Staff Evaluations

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

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) the SFP cooling system is intact, including attached piping.

In the FIP, Section 2.4.6 indicates that boiling is not expected to occur for more than 33 hours during a normal, non-outage ELAP event. The licensee's sequence of events timeline in the FIP shows that operators deploy hoses for SFP makeup from 12 to 24 hours following event initiation. This action is performed well within the time period for which the SFP area remains habitable. Furthermore, FIP Section 2.4.4 describes establishing SFP ventilation to prevent excessive steam accumulation in the Auxiliary Building. Operators will open the Auxiliary Building roll-up doors to provide airflow and provide a pathway to release steam generated by SFP boiling.

The licensee's Phase 1 SFP cooling strategy does not require any operator actions other than monitoring SFP level using installed instrumentation. The licensee's Phase 2 SFP cooling strategy includes the use of a diesel-driven SG/SFP makeup pump in combination with a submersible diesel-driven pump to supply river water to the SFP from the intake canal (if available), the intake bay within the Screenhouse, or the discharge basin. The makeup pump discharges directly to the SFP through hoses staged during Phase 2, or alternatively, discharges to the SFP through an existing flanged connection point to the SFP Skimmer System. In Phase 3 the licensee is able to provide supplemental cooling options for the SFP using equipment from the NSRC. Based on the licensee's FIP description, the staff concludes that the licensee has established provisions to provide for SFP cooling during the postulated event, consistent with the provisions of NEI 12-06, Revision 2, as endorsed. The NRC staff's evaluation of the robustness and availability of FLEX connection points for the FLEX pumps is discussed in Section 3.7.3.1 of this safety evaluation. Furthermore, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3 of this safety evaluation.

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. The NRC staff's review of the SFP level instrumentation, including the primary and back-up channels, the display to monitor the SFP water level and environmental qualifications to operate reliably for an extended period are discussed in Section 4 of this safety evaluation.

3.3.4.2 Thermal-Hydraulic Analyses

As described in FIP Sections 2.4.1 and 2.4.6 and Calculation ENG-ME-477, "Spent Fuel Pool Time to Boiling," Revision 2, the SFP is not expected to boil for at least 33 hours under non-outage conditions, but may boil in as soon as 8 hours under outage conditions with a full core offload. Under the more limiting outage conditions of a full core offload, the licensee's analysis shows the SFP level will remain above the fuel assemblies for more than 56 hours.

In the FIP, Sections 2.4.1 and 2.4.6 and Calculation ENG-ME-477 describe two evaluated scenarios: (1) non-outage conditions (i.e., without a recently discharged full core offload) with both units having been operated at 100 percent rated thermal power for at least 100 days; and (2) outage conditions with a full core offload (i.e., maximum design-basis heat load from 1,362 normally discharged fuel assemblies plus a freshly offloaded core). Under full core offload conditions, the licensee's analysis determined a boil-off rate of 65.6 gpm.

The licensee's calculation specifies an acceptance criterion that conservatively requires the boil-off rate to be less than 100 gpm. Under the postulated ELAP conditions, FSG-11, "Alternate SFP Makeup and Cooling" will be utilized for SFP makeup. During the audit process the NRC staff confirmed that FSG-11 includes the FLEX pumps and water sources described in the licensee's FIP.

The licensee determined the boil-off rate at the maximum design-basis heat load is significantly less than 100 gpm. Therefore, providing a makeup capability of 100 gpm will maintain adequate SFP level above the fuel for an ELAP occurring during normal power operation as well as one occurring during a full core offload. Consistent with the guidance in NEI 12-06, Section 3.2.1.6, the NRC staff concludes that the licensee has sufficient SFP makeup capability to ensure an adequate level of the SFP at the maximum design-basis SFP heat load.

3.3.4.3 FLEX Pumps and Water Supplies

As described in FIP Section 2.4.2, when the SFP level reaches elevation 752.5 feet (approximately 23 feet of water above the stored fuel), actions will be taken to provide makeup to the SFP. During Phase 2, the licensee's SFP cooling strategy relies on FLEX pumps to supply SFP makeup. The licensee relies on a diesel-driven SG/SFP makeup pump in combination with a diesel-driven submersible pump to supply river water to the SFP. These pumps are shared between the core cooling and SFP functions and are discussed in Section 3.2.3.5 of this safety evaluation. In the FIP, Table 3 states the performance criteria (e.g., flow rate, discharge pressure, and head) for the Phase 2 FLEX portable pumps. In addition, FIP Table 1 shows NSRC pumps having at least the capacity of the FLEX Phase 2 portable pumps. The NSRC pumps provide redundancy to the on-site FLEX Equipment.

The licensee's hydraulic analysis is included in Evaluation EC 22374-09, "Evaluation of the SFP Spray and Steam Generator Make-Up for a Post-Seismic Event," Revision 2. This analysis shows that the makeup pump in combination with the submersible pump can provide a SFP spray flow of 500 gpm while also supplying 200 gpm (i.e., 100 gpm per unit) of makeup to the SGs. As described in Section 3.3 of this safety evaluation, the licensee's SFP structural evaluation provides a basis to remove the need for SFP spray and therefore, a review of the analysis indicates that the pump has significant hydraulic margin. Based on the capacity of the FLEX pumps, with consideration for the analysis shown in EC 22374-09, Revision 2, the NRC staff concludes that the FLEX pumps should provide at least the required SFP makeup of 65.6 gpm. Furthermore, the NRC staff concludes that the FLEX equipment is capable of supporting the SFP cooling strategy, and it is expected to be available during an ELAP event.

3.3.4.4 Electrical Analyses

The licensee's Phase 1 and Phase 2 electrical strategy is to monitor SFP level using installed instrumentation (the capability of this instrumentation is described in other areas of this safety evaluation). In its FIP, the licensee stated that SFP level instrumentation has a backup battery capacity that will provide power to the instrumentation for 7 days, if necessary. Long-term power supply for the level instrumentation is described in Section 4.2.6 of this safety evaluation.

The licensee's Phase 3 electrical strategy is to continue with the Phase 1 and Phase 2 strategy and use equipment supplied by an NSRC to restore normal SFP cooling. Power would be restored to a component cooling water pump, a SFP cooling pump, and the associated equipment needed to restore normal SFP cooling or makeup. As described in Section 3.2.3.6 of this safety evaluation, the NRC staff reviewed licensee calculation 178599.51.3005 and determined that the 4160 Vac CTGs should have sufficient capacity and capability to supply the loads during Phase 3 of an ELAP, including those supporting SFP cooling.

Based on its review, the NRC staff finds that the licensee's strategy is acceptable to restore or maintain SFP cooling indefinitely during an ELAP.

3.3.5 Conclusions

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

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06, Table 3-2, provides some examples of acceptable approaches for demonstrating the baseline capability of the strategies to effectively maintain containment functions during all phases of an ELAP event. One such approach is for a licensee to perform an analysis demonstrating that containment pressure control is not challenged. Prairie Island, Units 1 and 2 have dry ambient pressure containments.

The licensee performed a containment evaluation, CF.PX.OPS.046, "Prairie Island Containment Pressure and Temperature for a RCP Small Seal Leak during an Extended Station Blackout," Revision 0, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the strategy of containment isolation and monitoring containment pressure using installed instrumentation and concluded that, even with the licensee taking no mitigating actions related to removing heat from containment, the containment parameters of pressure and temperature remain well below the respective USAR Section 5.2.1.1 design limits of 46 psig and 268°F for several days. From its review of the evaluation, and the licensee's FIP, the NRC staff notes that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

3.4.1 Phase 1

The licensee's containment analysis shows that the structural integrity of the Reactor Containment Building, due to increasing containment pressure, will not be challenged for a minimum of 75 hours following a BDBEE ELAP event. For Modes 1 through 4, the analysis shows that with no operator actions, containment pressure will slowly increase to 20.9 psig over 75 hours and containment temperature will slowly increase to 218°F over the same 75-hour period. Since 20.9 psig and 218°F are below the containment design pressure and temperature limits described in USAR Section 5.2.1.1, no mitigation actions are necessary to maintain or restore containment cooling during Phases 1 or 2.

The Phase 1 coping strategy for containment integrity involves verifying containment isolation per procedure ECA-0.0, "Loss of All Safeguards AC Power," and monitoring containment pressure using installed instrumentation. Containment pressure will be available via essential plant instrumentation.

3.4.2 Phase 2

The licensee's containment analysis shows that there are no mitigation actions necessary or planned, to maintain or restore containment cooling during Phase 2 for events initiating in Modes 1 through 4. Containment temperature and pressure are expected to remain below design limits for more than 75 hours; however, containment status will continue to be monitored.

The Phase 2 coping strategy for containment integrity is to continue monitoring containment pressure using installed instrumentation. Phase 2 activities to repower instrumentation (via repowering a battery charger) ensures that the essential containment pressure instrumentation remains available.

3.4.3 Phase 3

The Phase 3 strategy for containment integrity involves reducing containment temperature and pressure, and ensuring continued functionality of instrumentation to monitor key parameters using existing plant systems, Phase 2 and/or Phase 3 FLEX equipment.

The Phase 3 coping strategy includes restoring at least one containment FCU. The NSRC will supply two 1,000 kW 4 kV portable CTGs for each unit. These CTGs will be used to repower one of the two safeguard 4 kV buses on each unit. By restoring a safeguard 4 kV bus, power can be restored to the safeguard 480 Vac buses via the 4160/480 Vac transformers. Once a 480 Vac bus has been repowered, one of the FCU fans may be restarted. Cooling Water to the containment FCU would be supplied from the DDCLP.

3.4.4 Staff Evaluations

3.4.4.1 Availability of SSCs

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

In the USAR, Section 5.1 states that the Reactor Containment Vessel is a cylindrical steel pressure vessel with hemispherical dome and ellipsoidal bottom which houses the reactor pressure vessel, the SGs, RCPs, the reactor coolant loops, the accumulators of the SI system, the primary coolant pressurizer, the pressurizer relief tank, and other branch connections of the RCS. The net free volume is 1.32E6 cubic feet with maximum design limits of 46 psig and 268°F.

The Reactor Containment Vessel is completely enclosed by the Shield Building. The Shield Building has the shape of a right circular cylinder with a shallow dome roof. An annular space of 5 feet is provided between the wall of the Reactor Containment Vessel and the Shield Building. A 7-foot clearance is also provided between the roofs of the structures. The Reactor Containment Vessel is supported on a grout base that was placed after the vessel construction was complete and tested. Both the Reactor Containment Vessel and the Shield Building are supported on a common foundation slab.

The staff notes from the USAR review that the Reactor Containment Vessel is safety-related and seismically qualified. It acts as a closed vessel, and is therefore not subject to external flooding issues. The site limited extreme temperatures will not have a significant effect on the containment as the containment is a large mass which will act as a heat sink to disperse any heating or cooling effects. It is therefore protected from all applicable hazards and is expected to be available during an ELAP event.

Containment Fan Coil Units (FCUs)

The containment air cooling system, which consists of four FCUs, a duct distribution system, and the associated instrumentation and controls, is designed to recirculate and cool the containment atmosphere in the event of a loss-of-coolant or main steam line break accident and thereby ensure that the containment pressure cannot exceed its design value. The containment FCUs, ducting, and associated FCU cooling water valves are safety-related components. All FCU-related equipment is located within the Design Class I Reactor Containment Vessel or Design Class I portion of the Auxiliary Building. Therefore, the equipment is protected from all applicable external events and is expected to be available during an ELAP event.

Cooling Water

See Section 3.2.3.1.1 above, for the discussion on the robustness of the cooling water system and DDCLP.

Safeguards 4 kV and 480 Vac Distribution System

The primary and alternate connection points for the SAFER 4 kV CTGs are located within the Design Class I portions of the Turbine Building and D5/D6 Building. The safeguard electrical distribution system is also located within the Design Class I portions of the Turbine Building, D5/D6 Building, and Auxiliary Building. Therefore, the equipment is protected from all applicable external events and is expected to be available during an ELAP event.

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2, specifies that containment pressure is a key parameter which should be monitored by repowering the appropriate instruments. The licensee's FIP states that instrumentation is available to monitor containment pressure during all phases of the containment integrity strategy. Indicators for the instruments are located in the MCR. Instruments used to monitor these parameters will be available after the load stripping of the dc buses.

In the unlikely event that the instrument bus infrastructure is damaged, alternate procedures for obtaining local indication of critical parameters is provided in FSG-7, "Loss of Vital Instrumentation or Control Power," Revision 0, as required by NEI 12-06.

3.4.4.2 Thermal-Hydraulic Analyses

During the audit process, the NRC staff reviewed analysis CF.PX.OPS.046, "Prairie Island Containment Pressure and Temperature for a RCP Small Seal Leak during an Extended Station Blackout," Revision 0, which was based on the boundary conditions described in Section 2 of NEI 12-06. In this calculation, the licensee utilized the CONTEMPT-LT/028 version 94271 computer code to determine the containment pressure and temperature response during an ELAP. The only additions of heat and mass to the containment atmosphere under ELAP conditions are the heat loads from the reactor coolant system and main steam system (e.g., from the surfaces of hot equipment and the leakage of reactor coolant from the RCP seals). Specifically, the licensee's engineering evaluation models the containment conditions for operating Modes 1 through 4 in which the SGs are available to remove RCS heat. The RCS heat sink is maintained in Phase 1, which relies on installed plant equipment and on-site resources, by feeding the SGs using the TDAFW pump while steaming to the atmosphere via the PORVs and/or the MSSVs. A rapid RCS cooldown (near 100°F/hour) is initiated within the first 2 hours of the event. The cooldown continues until the SG pressure reaches 350 psig. The licensee replaced the original Westinghouse RCP seals with Flowserve N-9000 seals. The seal leakage is assumed to be 2.625 gpm per each of the two RCPs and an unidentified leakage limit of 1 gpm, for a total RCS leakage rate of 6.25 gpm into containment. These leakage rates were conservatively held constant for the first 75 hours of the event, i.e., no credit was taken for decease in leakage rates as the RCS is depressurized. At 75 hours into the event, the seal leakage was increased 1.7 gpm per RCP. The analysis also modeled the restoration of a single containment FCU at 75 hours into the event, i.e., containment cooling restored as a Phase 3 activity.

Using the input described above, the maximum containment pressure reached is 20.9 psig at the 75-hour period and the maximum temperature reaches 218°F at the same time period. The maximum values calculated are well below the USAR design parameters of 46 psig and 268°F, so the NRC staff concludes that the licensee has adequately demonstrated that there is significant margin before a limit would be reached.

3.4.4.3 FLEX Pumps and Water Supplies

The containment coping strategies do not credit a FLEX pump. The water for cooling the containment FCU during Phase 3 is supplied by an installed DDCLP.

3.4.4.4 Electrical Analyses

The licensee's Phase 1 coping strategy for containment involves verifying containment isolation and monitoring containment pressure using installed instrumentation. The MCR indication for containment pressure is available for the duration of the ELAP/loss of normal access to the UHS. The licensee's strategy to power instrumentation using the Class 1E station batteries is identical to what was described in Section 3.2.3.6 of this safety evaluation and is adequate to ensure continued containment monitoring.

The licensee's Phase 2 coping strategy is to continue monitoring containment pressure using installed instrumentation. The licensee's strategy to repower instrumentation using the 480 Vac 300 kW FLEX DGs is identical to what was described in Section 3.2.3.6 of this safety evaluation and is adequate to ensure continued containment monitoring.

The licensee's Phase 3 coping strategy is to reduce containment pressure utilizing existing plant systems restored by off-site equipment and resources during Phase 3. The licensee's strategy involves restoring at least one containment FCU for indefinite containment cooling. The FCU would be supplied power from the 4160 Vac CTGs supplied from an NSRC. As described in Section 3.2.3.6 of this safety evaluation, the NRC staff reviewed licensee calculation 178599.51.3005 and determined that the 4160 Vac CTGs should have sufficient capacity and capability to supply the loads during Phase 3 of an ELAP, including those supporting the containment function.

Based on its review, the NRC staff finds that the licensee's electrical strategy is acceptable to restore or maintain containment indefinitely during an ELAP.

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 adequately addresses the requirements of the order.

3.5 Characterization of External Hazards

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

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

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

References to external hazards within the licensee's mitigating strategies and this safety evaluation are consistent with the guidance in NEI-12-06 and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) [Reference 22] (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 45]. 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 42]. The Commission provided guidance in an SRM to COMSECY-14-0037 [Reference 23]. 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 safety evaluations 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 seismic and flood mitigating strategies assessments (MSAs) (if required) per the guidance in NEI 12-06, Revision 2, Appendices G and H [Reference 6]. The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 [Reference 7]. The licensee's MSAs will evaluate the mitigating strategies described in this safety evaluation using the revised hazard information and, if necessary, make changes to the strategies or equipment. The licensee has submitted MSAs for both seismic [Reference 54] and flooding [Reference 55, non-public] at PINGP. The NRC staff has reviewed both of these MSAs and issued corresponding assessment letters [References 56 and 57 for seismic and flooding, respectively].

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

### 3.5.1 Seismic

The licensee's FIP refers to the PINGP USAR [Reference 46], Sections 1.2.1 and 1.2.2, to describe the design-basis seismic parameters for the site. The USAR states that all systems, structures, and components designated Design Class I are designed so that there is no loss of function in the event of the DBE acting in the horizontal (0.12g) and vertical (0.08g) directions simultaneously. The current NRC terminology for the DBE is the SSE, and the licensee's FIP confirms that the two terms are synonymous at PINGP. The two terms are used interchangeably in this safety evaluation. The results of the licensee's seismic hazard reevaluations required by the 50.54(f) letter were submitted to the NRC on March 27, 2014 [Reference 40]. The licensee's conclusion of the reevaluated hazard was that in the frequency ranges of 1-10 Hertz (Hz), as well as from 10 – 100 Hz, the SSE bounds the reevaluated hazard. The NRC staff assessment of this submittal, dated December 15, 2015 [Reference 41], confirmed that the licensee's re-evaluated seismic hazard is bounded by the SSE in the frequency range of 1-100 Hz.

Since the licensee is using the SSE as its seismic evaluation criteria, the NRC staff concludes that the licensee has appropriately screened in this external hazard and properly identified the hazard level to be evaluated.

3.5.2 Flooding

In the FIP the licensee described that in PINGP USAR Section 2.4.3.5, the current design bases flood for the PINGP is a flood on the Mississippi River. The flood is a relatively slow event, developing over several days with actions based on three-day forecasts of river water level. Finished site grade is at elevation 695 feet (above mean sea level (MSL). Maximum predicted flood water level is 703.6 feet with wave run-up to elevation 706.7 feet. Site grade would be flooded for approximately 13 days. According to the licensee's FIP, based on flood analysis information in PINGP USAR Appendix F, access to the site could be impacted for up to approximately 20 days. During the audit process the NRC staff observed that the licensee's flood procedure, AB-4 "Floods," Revision 50, indicates that the site access road will start to flood at an elevation below the site grade (688 feet MSL), thus the longer projected restriction on site access as compared to the time flood waters are above the site grade. The main powerhouse structure consisting of the Reactor Buildings, the Auxiliary and Fuel Handling Building, the Turbine Building, the D5/D6 Diesel Generator Building, and the pump section of the Screenhouse structure are protected against the probable maximum flood of 703.6 feet. The top of the substructure and/or superstructure flood protection walls are at 705.0 feet, and are designed to resist the PMF. These structures are capable of withstanding the hydrostatic forces associated with the PMF and associated maximum wave run-up to 706.7 feet. Some water leakage would occur whenever wave action exceeds 705 feet on certain portions of the Turbine Building and Auxiliary Building walls. However, according to the licensee, this leakage is expected to be minimal and easily managed by sump pumps. During the audit process, the NRC staff observed that the licensee's flood procedure will deploy these pumps, with associated generators, during the flood warning period, and that these pumps could also be utilized to manage any ground water intrusion that might occur while the site is inundated.

The large non-robust internal flooding sources at PINGP are condenser hot well, the reactor makeup water tanks, lube oil reservoir, heater drain tank, and the backwash storage and receiving tanks. These sources are located in the Turbine Building. The total volume of these tanks is less than the available volume of the condenser pit. Therefore, the licensee's FIP indicates that rupture of the internal non-robust tanks will not affect the mitigating strategies.

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 miles per hour (mph) exceeds 1E-6 per year, the site should address hazards due to extreme high winds associated with hurricanes using the current licensing basis for hurricanes.

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

In the FIP the licensee described that the PINGP site is located at 92° 37' 9" West longitude and 44° 37' 3" North latitude. The PINGP USAR Section 12.2.1.3 describes the design bases wind loads as follows: (Note that the tornado wind velocity exceeds that on Figure 7-2 of NEI 12-06, Revision 2):

- Wind speed for the PINGP site is 100 mph
- Design bases tornado loadings are a pressure drop equal to 3 pounds per square inch (psi) in 3 seconds, peripheral wind velocity of 300 mph with a forward progression of 60 mph
- The design tornado driven missile was assumed equivalent to an airborne 4" x 12" x 12' plank travelling end-on at 300 mph, or a 4,000 lb. automobile flying through the air at 50 mph and at not more than 25 feet above ground level.
- The tornado loading used in design of the D5/D6 Building consists of the following:
  - A lateral force caused by a funnel of wind having a rotational speed of 290 mph and maximum translation speed of 70 mph.
  - A pressure drop of 3.0 psi, the rate of pressure drop being 2.0 psi/second

The site is beyond the range of high winds from a hurricane per NEI 12-06, Figure 7-1. The NRC staff concludes that a hurricane hazard is not applicable.

Therefore, high-wind (tornado) 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 <u>Snow, Ice, and Extreme Cold</u>

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

In its FIP, regarding the determination of applicable extreme external hazards, the licensee described that in PINGP USAR Section 12.2.1.3, the design-basis for the PINGP snow load is 50 pounds per square foot of horizontal projected area for structures and components exposed to snow. The PINGP USAR is not specific with regards to values for design for ice or cold. However, the extreme cold temperature recorded in the Twin Cities is -34°F based on temperature data available from the University of Minnesota.

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

### 3.5.5 Extreme Heat

In the section of its FIP regarding the determination of applicable extreme external hazards, the licensee described that the PINGP USAR is not specific with regards to values for design for heat. However, the extreme hot temperature recorded in the Twin Cities is 108°F based on temperature data available from the University of Minnesota.

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 described that the storage location for the portable FLEX equipment is the FLEX Storage Building. The FLEX Storage Building provides storage and protection for the portable FLEX equipment such that the equipment can be deployed following all external events except for flooding. The FLEX Storage Building is located within the PINGP owner controlled area and outside the protected area, southwest of the power block.

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

3.6.1.1 Seismic

In its FIP, the licensee described that the FLEX Storage Building is designed to withstand the site specific design-basis loads for the SSE in accordance with the provisions of NEI 12-06. In addition, the licensee described that an evaluation of the components stored in the FLEX Storage Building has been performed to determine appropriate measures to prevent seismic interactions. According to the licensee's FIP, non-seismic components within the FLEX Storage Building attached to the ceiling or walls whose failure could result in damage to equipment required for deployment after an event are seismically supported. This includes, but is not limited to, the security camera, fire suppression system, lights, and ventilation equipment. The evaluation also showed that the FLEX equipment and trailers would not fall over (tip over or overturn) nor slide when subjected to the seismic accelerations applicable to PINGP.

3.6.1.2 Flooding

In its FIP, the licensee described that the FLEX Storage Building is not designed to protect from the site design-basis flood. Therefore, the PINGP FLEX strategy during a design-basis flood relies on the expected warning time and pre-deployment of NSRC equipment to the site prior to the site grade flooding.

3.6.1.3 High Winds

In its FIP, the licensee described that the FLEX Storage Building is designed to withstand the site specific design-basis loads for high wind hazards (including tornado and tornado missile loads), in accordance with the provisions of NEI 12-06.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee described that the FLEX Storage Building is designed to withstand ambient temperatures from -34°F to 108°F. During extreme cold, the building will maintain a minimum temperature of 40°F using thermostatically controlled unit heaters. No mechanical cooling is provided since the building is designed to only store equipment and the FLEX equipment stored in the building was specified to operate between -40°F and 120°F.

3.6.1.5 Conclusions

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

3.6.2 Availability of FLEX Equipment

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

For SG and SFP makeup, the licensee provided a list of equipment in the FIP that meets the "N+1" requirement. This includes two 100 percent capacity SG/SFP diesel-driven makeup pumps and two 100 percent submersible diesel-driven pumps to provide lift for the SG/SFP diesel pumps. These pumps can supply SGs in both units and the SFP.

In its FIP, the licensee stated that the PINGP FLEX strategy for portable power supplies is different than that outlined in NEI 12-06 in that the sets are not divided by unit, but rather are divided by functions across both units. The PINGP FLEX strategy for portable power supplies is considered an alternative method to the provisions of NEI 12-06 for complying with Order EA-12-049. The strategy requires two 480 Vac generators that are each capable of supplying either:

- The battery rooms and Screenhouse MCCs for both units, or
- The charging pumps for both units.

According to the licensee, the generators are identical in capacity, a total of two generators are sufficient to address all functions for both units and three generators are sufficient to meet the intent of the "N+1" criteria. This alternative is discussed in Section 3.14.1 of this safety evaluation.

In its FIP, the licensee also stated that the "N+1" provision for hoses and cables is satisfied by providing additional hose and cable equivalent to at least 10 percent of the total length of each type/size of hose or cable necessary for the "N" capability. For each type/size of hose or cable needed for the "N" capability, at least 1 spare of the longest single section/length is provided. Based on the FIP description, the NRC staff concludes that incorporating this provision into the plan meets the guidance of NEI 12-06, Revision 2, Section 3.2.2.

Other FLEX support equipment provided for mitigation of BDBEE, but not directly supporting a credited FLEX strategy for maintaining a key safety function, is not required to have "N+1" capability. However, these items are covered by procedures that subject them to inventory checks, requirements, and any maintenance and testing that are needed to ensure they can perform their required functions.

Based on the number of portable FLEX pumps, FLEX DGs, the FLEX DG alternative evaluation in Section 3.14.1 of this safety evaluation, and the support equipment identified in the FIP and during the audit review, the NRC staff concludes that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment consistent with the "N+1" recommendation in Section 3.2.2.16 of NEI 12-06.

## 3.7 Planned Deployment of FLEX Equipment

### 3.7.1 Means of Deployment

In its FIP, the licensee described that the for the seismic and high wind hazards, FLEX equipment will be deployed to various locations using an equipment deployment truck stored in the FLEX Storage Building. The debris removal equipment required to support the implementation of the FLEX strategies is also stored inside the FLEX Storage Building. Therefore, the debris removal equipment is protected from the applicable external hazards and will remain functional and deployable. This debris removal equipment includes a D8 Caterpillar dozer, an F-450 truck, an F-550 truck with plow, and miscellaneous equipment such as cutters, chain saws, and pry bars. According to the licensee's FIP, deployment of the debris removal equipment and the Phase 2 FLEX equipment from the FLEX Storage Building is not dependent on offsite power because the equipment doors may be opened manually. For the flooding hazard, equipment will be obtained from the NSRC prior to the flood affecting the site.

3.7.2 Deployment Strategies

In its FIP, the licensee described that as a backup AFW supply, a portable FLEX SG/SFP makeup pump may be connected to one of the two available FLEX connection points. A FLEX submersible pump provides the required lift to supply the suction to the SG/SFP makeup pump. The submersible pump will deployed from the FLEX Storage Building to a location near the selected water source. The preferable location is near the intake canal adjacent to the Screenhouse, or through a manhole inside the Screenhouse to provide communication with the water source from the emergency intake bay. A third location would be the discharge basin. Similarly the SG/SFP makeup pump will be deployed to a location outside one of two (east or west) Turbine Building roll-up doors. Hoses will be connected from the submersible pump to the SG/SFP makeup pump. From the SG/SFP makeup pump, hoses will be routed to the Design Class 1 AFW pump room where it will be connected to one of the FLEX connection points located down stream of either MDAFW pump. There are multiple external deployment routes from the FLEX Storage Building to the equipment staging areas inside the protected area. The preferred path is through the southwest security gate which does not require power to be opened and which is used for transport of dry casks from the protected area to the dry cask storage pad. Other deployment paths into the protected area are available.

In its FIP, the licensee described that the results of five sets of cone penetration tests performed for the FLEX Storage Building site were evaluated for liquefaction of the soil in accordance with the provisions of NRC Regulatory Guide 1.198 for the PINGP SSE. Based on the results of the evaluation it was concluded that the FLEX Storage Building site is not susceptible to liquefaction.

The licensee also described that repairs to deployment paths can be made by the equipment that is stored in the FLEX Storage Building. Therefore, the equipment is protected from external events and will be available to clear a path from the FLEX Storage Building to the deployment locations. Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift (e.g., helicopters), or via ground transportation. Debris removal for the pathway between the site and the NSRC receiving staging area locations and from the various plant access routes may be required. The same debris removal equipment used for onsite pathways may also be used to support debris removal to facilitate road access to the site once necessary haul routes and transport pathways onsite are clear.

In addition, the licensee described that access to the UHS may be accomplished via the emergency cooling water intake line. The top of the intake crib on this line is approximately 10 feet below the normal river water elevation, assuring that it would not be affected by the surface ice that forms on the Mississippi River in vicinity of the PINGP site. According to the licensee, the formation of surface ice precludes the formation of frazil ice at the sub-surface intake structure.

In its FIP, the licensee stated that a portable 480 Vac FLEX DG will be deployed to repower a MCC in the plant Screenhouse to power a fuel oil transfer pump that will automatically refill the associated FODT from the associated FOST. The deployment of the 480 Vac FLEX DGs involves transporting the generator from the FLEX Storage Building to a location near the Screenhouse. The preferable location is between the Screenhouse and the Turbine Building. Cables are then connected to the generator and the FLEX power receptacle located near the desired MCC. The MCC and receptacle are located within the Design Class I (i.e., robust) portion of the Screenhouse. In order to access the connection point from the FLEX DG, the cabling will be routed through part of the Screenhouse that is not designed for Design Class I loads. However, the structural steel framing main load carrying members of this portion of the Screenhouse are Design Class I and are analyzed for the postulated seismic condition. Debris removal equipment will be available to clear debris in the Screenhouse to facilitate access, if needed.

In its FIP, the licensee also described that the strategy for maintaining power to essential instrumentation involves using a 480 Vac FLEX DG that will be used to repower a battery charger on each unit. Cables are connected to the generator and a receptacle located near the MCC to be repowered. The MCC and receptacle are located within the Design Class I aisle of the Turbine Building. There are three paths evaluated through the Turbine Building to the battery rooms. Each route traverses an area that has been analyzed for seismic loads with the exception of a small area near the battery room doors. This area of the deployment route is adjacent to the exterior wall of a Design Class I structure which lessens the potential debris sources for the pathway. Due to the small area near the battery room doors not being analyzed for seismic loads, none of the multiple deployment paths through the Turbine Building to the battery rooms are fully compliant with the NEI 12-06 description of through a "robust" structure, and therefore, do not meet the provisions of NEI 12-06, Section 5.3.2, consideration 2. Based on not meeting the endorsed NEI 12-06 guidance, the deployment of cables through the Turbine Building is treated as an alternative method of compliance with Order EA-12-049. Refer to Section 3.14.2 of this safety evaluation for additional discussion regarding this alternative strategy.

In its FIP, the licensee described the credited RCS makeup strategy is to repower an installed charging pump on each unit. The deployment of a 480 Vac FLEX DG to repower the charging pumps involves transporting the DG from the FLEX Storage Building to a location outside one of two (east or west) Turbine Building roll-up doors or alternatively outside the Auxiliary Building (east or west) roll-up door. Cables are then connected to the DG and a receptacle located near the MCC to be repowered. The MCC and receptacle are located within the Auxiliary Building, a Design Class I structure. The preferred and shortest deployment route to the MCCs in the Auxiliary Building is through the Turbine Building. This route is along the exterior of a Class 1 structure. Alternate paths exist to route the cables through either of the two Auxiliary Building roll-up doors in the fuel receipt area of the Auxiliary Building. The alternate paths are entirely through Design Class I*and Class I structures. The route through the Design Class I* area is relatively open and includes a small amount of potential debris sources. If necessary, the licensee states that any debris generated from the event can be moved or the cables deployed around the debris.

In its FIP, the licensee described that for the flood hazard the strategy to mitigate an ELAP during a design-basis flood involves using the NSRC CTGs and the equipment associated with operation of the generators to repower installed equipment. The NSRC equipment would be requested in time to ensure delivery to the PINGP site staging area prior to the site access road flooding. The NSRC CTGs and associated equipment would be deployed to the Turbine Building deck prior to the site grade flooding. The site's flood procedure places both units in cold shutdown prior to flooding of the site grade. Two of the NSRC CTGs would be used to repower a safeguards bus on each unit. The two remaining CTGs are available as spares for redundancy and defense-in-depth. The deployment of these CTGs provides power to all necessary plant equipment for SG and RCS makeup and plant cooling. Cooling water needed to remove heat from the component cooling systems and containment FCU would be supplied by the DDCLP. The strategy does not require the use of the PINGP FLEX portable pumps or 480 Vac generators. However, fuel oil transfer equipment and the CTG exhaust ducting stored in the FLEX Storage Building would be used. All connection points for the NSRC CTGs are located within the flood protected area.

### 3.7.3 Connection Points

#### 3.7.3.1 Mechanical Connection Points

In the FIP, Section 2.19 describes the licensee's flood strategy. This strategy relies on offsite NSRC equipment to repower installed plant equipment. No portable pumps are used for SG and SFP makeup and therefore mechanical FLEX connection points also not used in response to the postulated flood. The following discussion is relevant to the postulated external events other than flooding.

Primary and Alternate SG Makeup Connections

In the FIP, Section 2.3.5 describes the FLEX connections used by the SG/SFP makeup pump to supply makeup water to the SGs. The makeup pump will discharge into either of two FLEX connection points. These connection points are within the AFW pump room downstream of each MDAFW pump. In addition, cross-connects are located downstream of each MDAFW pump so that SGs for one or both units can be supplied from either of the FLEX connection points. The AFW pump room is located within the Design Class I portion of the Turbine Building. This room protects the connection points from all applicable external hazards.

In the FIP, Section 2.9.1 describes the staging locations for the SG/SFP makeup pump and the submersible pump. The makeup pump will be deployed outside of either the east or west roll-up door of the Turbine Building. The submersible pump will be deployed to one of three locations. The licensee's preferred location is the intake canal adjacent to the Screenhouse. However, it may alternatively be deployed through a manhole in the Screenhouse. This location provides access to the intake bay through which water is supplied through the emergency intake line. Third, it may be deployed to the discharge basin. A hose will connect the submersible pump to the SG/SFP makeup pump. In addition, a hose will be routed from the discharge of the makeup pump to one of the FLEX connection points in the Turbine Building AFW pump room.

RCS Inventory Control/Makeup

In the FIP, Section 2.3.3 states that a FLEX portable DG will be used to repower an installed charging pump to supply RCS makeup from installed RWSTs. However, FIP Section 2.3.5 states that during Phase 3, NSRC will supply two mobile boration units and two high pressure injection pumps. This equipment will serve as backup to the primary and alternate charging pumps and will be used to provide borated makeup into the RCS via one of two available reconfigured SI pump discharge check valves.

SFP Cooling

The same FLEX pumps used for SG makeup are also used for SFP cooling and therefore their staging locations are not repeated here; however, FIP Section 2.9.3 describes hose deployment paths from the makeup pump to the SFP. Hoses are run from the pump through the Auxiliary Building roll-up doors and into the Fuel Receipt Area of the Auxiliary Building. This area is a Design Class I* structure designed for seismic loads. Afterwards, hoses are routed up the stairs to the SFP or, alternatively, to the SFP skimmer connection which is an existing flanged connection point. If the stairwell is not passable, then hoses can be routed through Design Class I and Class I* areas of the Auxiliary Building and down through a drop area opening to the SFP area.

Given the design and location of the primary and alternate connection points, as described in the above paragraphs, the staff finds that at least one of the connection points should be available to support core and SFP cooling via the SG/SFP makeup pump in combination with the submersible pump during an ELAP caused by an external event, consistent with NEI 12-06 Section 3.2.2. In addition, the licensee has proposed an alternative to the provisions of NEI 12-06, Section 5.3.2 for deployment of hoses to a FLEX connection point for SG makeup. This is evaluated in Section 3.14.2 of this safety evaluation.

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 a BDBEE that result in an ELAP.

During Phase 2, the licensee's electrical connection strategy for supplying power to equipment required to maintain or restore core cooling, containment, and SFP cooling is to use a combination of permanently installed and portable components. The licensee strategy is to use two 300 kW FLEX DGs to supply power to certain MCCs to repower the fuel oil transfer pump, battery chargers, and charging pumps.

Fuel Oil Transfer Pump MCC Connection

The licensee's strategy is to deploy a 300 kW FLEX DG from the FLEX Storage Building to an area between the Screenhouse and Turbine Building. FLEX cables would be connected between the FLEX DG and a FLEX power receptacle. FLEX safety-related breakers are installed in MCCs that supply power to the fuel oil transfer pumps for each DDCLP. The MCCs would be connected to the FLEX power receptacles via FLEX cables. These MCCs and receptacles are located within the Design Class 1 portion of the Screenhouse. The licensee's strategy only requires one of the two DDCLPs and the associated fuel oil transfer pump to be in operation. Therefore, the MCC receptacle for supplying power to the fuel oil transfer pump for the other DDCLP is the alternate connection. According to the licensee's FIP, post modification testing was performed to ensure the wiring of the receptacles provided the proper phase rotation. During the audit process the staff confirmed that licensee guidelines 1[2] FSG-4 provide instructions for connecting a Phase 2 300 kW FLEX DG and repowering the fuel oil transfer pumps.

Battery Charger MCC Connection

The licensee's strategy to repower the battery chargers is to utilize the same FLEX DG that repowers the fuel oil transfer pump(s). FLEX cables would be connected between the FLEX DG and a FLEX power receptacle (one per unit). FLEX safety-related breakers are installed in MCCs that that supply power to the battery chargers (one MCC per train per unit for a total of four). The MCCs would be connected to the FLEX power receptacles via FLEX cables. The MCCs and receptacles are located within the Design Class 1 portion of the Turbine Building. The licensee's strategy only requires one train of instruments per unit. Therefore, the receptacle/MCC that would repower the battery charger for the other train is the alternate connection. During the audit process the NRC staff confirmed that licensee guidelines 1[2] FSG-4, provide instructions for connecting a Phase 2 300 kW FLEX DG and repowering the battery chargers.

Charging Pump MCC Connection

The licensee's strategy is to deploy a second 300 kW FLEX DG from the FLEX Storage Building to a location outside one of the Turbine building roll-up doors or alternatively outside an Auxiliary Building roll-up door. FLEX cables would be connected between the FLEX DG and a FLEX power receptacle (one per unit). FLEX safety-related breakers are installed in MCCs that supply power to the charging pumps (one MCC per train per unit for a total of four). The MCCs would be connected to the FLEX power receptacles via FLEX cables. The MCCs and receptacles are located within the Design Class 1 portion of the Auxiliary Building. The licensee's strategy only requires one charging pump per unit. Therefore, the receptacle/MCC that would repower the charging pump for the other train is the alternate connection. According to the licensee's FIP, post modification testing was performed to ensure the wiring of the receptacles provided the proper phase rotation. During the audit process, the NRC staff confirmed that licensee guidelines 1FSG-1, "Long Term RCS Inventory Control," Revision 1, and 2FSG-1, "Long Term RCS Inventory Control," Revision 2, provide instructions for connecting a Phase 2 300 kW FLEX DG and repowering the charging pumps.

For Phase 3, the licensee will receive four 1 MW 4160 Vac and two 1100 kW 480 Vac CTGs from an NSRC. The NSRC supplied 4160 Vac CTGs will be deployed outside of the Turbine building west roll-up door and north of the Unit 1 Turbine Building. Power will be restored to the Unit 1 (15 or 16) and Unit 2 (25 or 26) 4160 Vac safeguard buses. The 4160 Vac CTGs will be connected directly to the safeguard buses. Licensee guidelines FSG-15, "Isolation and Repower Bus 15 During ELAP," Revision 0, FSG-16, "Isolation and Repower Bus 16 During ELAP," Revision 0, FSG-25, "Isolation and Repower Bus 25 During ELAP," Revision 1, and FSG-26, "Isolation and Repower Bus 26 During ELAP," Revision 1 were reviewed by the staff during the audit process to confirm that instructions have been provided for connecting the 4160 Vac CTGs and for verifying proper phase rotation.

3.7.4 Accessibility and Lighting

In its FIP, the licensee stated that lighting is required for operator actions and access in the plant to implement actions associated with the procedures. Available lighting will be the battery-backed 10 CFR 50 Appendix R light units. These lights have an 8-hour capacity battery power supply and are located in areas having equipment needed to safely shut down the plant and along access routes to this equipment. In addition, portable lighting such as head lamps and flashlights will be available for personnel to use. During the audit process the staff confirmed that the PINGP Appendix R lights were designed to be available after a seismic event, and are therefore seismically robust, by reviewing the licensee's design change package 82Y240, "Appendix R Fire Protection Modification, Part B - Emergency Lighting," dated January 19, 1982. The staff also reviewed licensee procedure TP 1826, "Out Plant Safe Shutdown Equipment Check," Revision 21, to confirm the availability of flashlights and head lamps for operations personnel.

3.7.5 Access to Protected and Vital Areas

In its FIP, the licensee stated that security doors and gates that rely on electric power to operate opening and/or locking mechanisms will be opened using keys that are provided to duty operations personnel. The licensee also stated that extra keys are available.

During the audit process, the staff confirmed these FIP provisions by reviewing procedure 5AWI-5.3.0, "Key and Seal Control," Revision 14, and FP-OP-C00-22, "Shift Relief and Turnover," Revision 0.

3.7.6 Fueling of FLEX Equipment

In its FIP, the licensee described that all FLEX equipment and support equipment with onboard fuel tanks are fueled while in standby so that the equipment is available without any required fueling at the initiation of the event. The fuel tanks on the major pieces of equipment have been specified to provide enough fuel to run for approximately 12 hours without refueling. The equipment tanks contain Number 1 (#1) diesel fuel to support startup operations during cold weather conditions.

In addition, the licensee described that the primary source for refueling the FLEX equipment during non-flood conditions is the heating boiler fuel oil storage tanks, if available. These tanks are below grade and have a nominal capacity of 35,000 gallons each. Access to the tanks is through manhole covers to the pits and then through manhole covers on the tanks. These tanks are non-safety-related and are not documented as seismically robust. In the event that these tanks are not available, fuel will be obtained from the safety-related (i.e., seismically robust, protected from high winds. and associated missiles) diesel generator FOSTs, for the EDGs D1 and D2. These four FOSTs are below grade and have a nominal capacity of 19,500 gallons each. The fuel consumption rate for all the Phase 2 diesel engines is approximately 75 gallons per hour, thus these tanks provide a sufficient supply to allow time to arrange replenishment from off-site sources. The access to these tanks is through manhole covers to the tank pits and then through the manhole covers on the tanks. Equipment is available to remove both sets of manhole covers. The fuel in these tanks is Number 2 (#2) diesel and provisions exist to add cold weather additives to the fuel that is extracted for refueling of FLEX equipment during cold weather. The diesel fuel in the FOSTs is routinely sampled and tested to assure fuel quality is

maintained to American Society for Testing and Materials (ASTM) standards. The FIP did not explicitly state how the fuel stored in the FLEX equipment would be maintained. However, Section 2.18.7 of the FIP states that the licensee will follow the EPRI guideline for the FLEX equipment maintenance and test program. The NRC staff reviewed the endorsed EPRI guideline and confirmed that it recommends performing fluid analysis to check for age and contamination issues. Based on the above, the NRC staff finds that the FLEX equipment should be properly maintained (including fluids) and available at the start of a BDBEE.
In its FIP, the licensee described that the strategies for delivery of the fuel to the FLEX equipment involves extracting the fuel from one of the tanks using a diesel-driven pump and transferring it to a 264 gallon transportable container on the bed of a truck. The truck is then moved near the FLEX equipment and the fuel transferred to the fuel tank of the equipment through a separate transfer pump that is integral to the transportable container. Based on the maximum fuel consumption rate (i.e., 22.7 gallons per hour for the 480 Vac portable generators) and refueling a minimum of 200 gallons, the frequency of refueling the equipment is greater than eight hours. The FLEX equipment, transfer pumps, hoses, and equipment needed to extract the fuel from the storage tanks and transfer it to the FLEX equipment is stored in the FLEX Storage Building. Thus, this refueling equipment is protected from all postulated external events except flooding.

In the FIP the licensee stated that for the flooding event, diesel fuel will be supplied from the safety-related Unit 1 EDG day tanks to the fuel cubes for the NSRC 4 kV CTGs located on the Turbine Building deck. The diesel fuel will be transferred from the day tanks by portable fuel oil transfer pumps. The fuel oil transfer pumps will be located within the flood protected area of the Turbine Building. A check valve off the Unit 1 EDG day tanks will be reconfigured during the ELAP to provide connection to the fuel transfer pumps. Once the 4 kV safeguards buses are repowered, the installed fuel transfer pumps will be repowered and fuel will be transferred from the Unit 1, safety-related FOSTs to the Unit 1 EDG day tanks to provide fuel for continuous operation. According to the licensee's FIP, the site's flood procedure contains provisions to maintain all safeguards fuel oil storage tanks full until the access road becomes impassable.

#### 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 PINGP SAFER Plan

In its FIP, the licensee described that the industry established two NSRCs that house backup equipment that may be used by the sites and additional equipment for long-term recovery to support licensee's needs during BDBEE events. One facility is located in Phoenix, Arizona, and the other is in Memphis, Tennessee. The licensee has established contracts with the Pooled Equipment Inventory Company (PEICo) to participate in the process for support of the NSRCs as required. Upon request, PEICo will provide one complete set of equipment from a NSRC to the PINGP site. In addition, the PINGP onsite FLEX equipment hose and cable end fittings are standardized or provided with transitions fittings to accommodate the equipment supplied from the NSRC. In the event of a BDBEE and subsequent ELAP/loss of normal access to the UHS condition, equipment will be moved from the NSRC to a local assembly area established by the SAFER team. The NSRC equipment will begin arriving at the PINGP designated site staging locations within 24 hours from the initial request.

By letter dated September 26, 2014 [Reference 24], the NRC staff issued its assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER response plans to meet the Phase 3 requirements of Order EA-12-049.

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

### 3.8.2 Staging Areas

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a Primary (Area "C") and an alternate (Area "D"), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas "C" and/or "D", the SAFER team will transport the Phase 3 equipment to the on-site Staging Area "B" for interim staging prior to it being transported to the final location in the plant (Staging Area "A") for use in Phase 3. For PINGP Staging Area "D" is not used. In its FIP, the licensee stated that Staging Area "C" is the Newport Service Center at 3000 Maxwell Avenue in Newport, Minnesota. Staging Area "B" is the site ball field directly across from the PINGP gate. The primary route from Staging Area "C" to Staging Area "B" is approximately 30 driving miles. The alternate route is approximately 44 driving miles. The primary and alternate access routes cross several bridges. However, air-lift capability is available to circumvent damage to these bridges and routes, if needed. There are multiple local staging locations (Staging Area "A") described in the licensee's FIP.

### 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 PINGP, 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. The licensee performed a loss of ventilation analysis to quantify the maximum steady state temperatures expected in specific areas related to FLEX mitigation strategy implementation to ensure the environmental conditions remain acceptable and within equipment qualification limits. FIP Section 2.11.1 identifies key areas for all phases of execution of the FLEX strategy activities. The key areas identified for all phases of execution of the licensee's FLEX strategy activities are the MCR, AFW Pump Room, Battery Room (Class 1E batteries, chargers, and inverters), DDCLP Room, and Containment. Because loss of ventilation also affects personnel habitability, these areas are discussed in Section 3.9.2 of this safety evaluation; however, they are also discussed here in terms of equipment temperature limits and equipment operability. However, the FIP did not include the space where the PORVs or the charging pumps are located. During the audit process, the licensee provided additional information regarding the PORV and charging pump spaces.

Main Control Room

The licensee's FIP indicates that the MCR was evaluated for a scenario with no forced cooling against an acceptance criteria of 120°F. During the audit process the NRC staff reviewed the supporting calculation to confirm acceptable results. For this scenario the licensee performed calculation EVAL-XCELPI12-02, Revision 1, "Main Control Room, Cable Spreading Room and Computer Room PRA [probabilistic risk assessment] Room Heat-Up Evaluation with Loss of HVAC," which provides a room heat-up evaluation after a loss of HVAC for the MCR, cable spreading room (CSR, also known as the relay room) and computer room. This calculation uses the Generation of Thermal-Hydraulic Information for Containments (GOTHIC) version 7.2a computer program in its evaluation of several scenarios over a period of 36 hours following loss of ventilation and states that the MCR and CSR are limited to 120°F to protect safeguards instrument racks. As shown in EVAL-XCELPI12-02, the CSR does not exceed 120°F with normal heat loads, even with dampers closed to the atmosphere at the start of an ELAP event and remaining closed afterwards. Thus the CSR meets the acceptance criteria with no required operator action. However, the MCR would exceed 120°F, and requires mitigating actions to prevent exceeding the calculation's acceptance criteria.

In the FIP, Section 2.11.1 states that operators are instructed to open doors in the early steps of the licensee's procedure for loss of all ac power. As described in FIP Section 2.11.1, Section 6.3.2-C in EVAL-XCELPI12-02 shows that when the doors between the MCR and Turbine Building are opened, at a point where the MCR temperature reaches 119°F (or 11.7 hours after loss of ventilation), temperature will initially drop and then climb slowly to 114°F after 36 hours. This scenario involves summer Turbine Building conditions with reduced heat loads in the MCR, consistent with conditions that could be expected during an ELAP. However, FIP Table 2 shows operators opening MCR doors at 1 hour after the start of an ELAP event, which is much earlier than occurs in the licensee's calculation. The staff review of the licensee's calculation notes that opening doors early, at approximately the 1 hour point, reduces MCR temperature further throughout the 36-hour period. Procedures 1ECA-0.0, "Loss of All Safeguards AC Power," Revision 27 and 2ECA-0-0, "Loss of All Safeguards AC Power," Revision 30, provide guidance to open these doors (typically within 1 hour) during an ELAP event. The staff also notes that the licensee has the capability to install a portable fan in accordance with an applicable licensee procedure, C37.9 AOP1, "Loss of Control Room Cooling." The fan would provide additional capability to lower temperatures in the MCR.

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

AFW Pump Room

The licensee performed calculation ENG-ME-021, "Auxiliary Feedwater Pump Room Heat-Up," Revision 2D, which calculates AFW pump room temperatures over a 48-hour period following an ELAP. Revision 2D documents changes to AFW pump room heat up as a result of replacing Instrument Air compressors. It concludes that heat loads have decreased and therefore the replacement of air compressors does not affect the overall calculations for the room and existing data is bounding. Revision 2D contains a markup of Revision 2C, but Revision 2C contains the assumptions, criteria, calculations, and results that are relevant to this discussion; therefore, it is referenced in this section.

The licensee's acceptance criteria stated in Section 3.1 of ENG-ME-021, Revision 2C is to ensure equipment can perform its required design functions and not be adversely affected by the temperature changes in the AFW pump room. The licensee compared the temperature profile in the AFW pump room to equipment capabilities. Using HEATSINK model runs, the licensee found AFW pump room temperature can reach 128°F to 132°F after 39 hours (See Table 4 in ENG-ME-021, Revision 2C). Section 7.3 of ENG-ME-021, Revision 2C evaluates equipment in the AFW pump room against this temperature increase. The licensee evaluated the following equipment: MDAFW pumps, MOVs, MCCs, hot shutdown panels, control switches, pressure switches, distribution panels, transformers, and cables. The licensee determined that the equipment was either qualified to a temperature higher than that which would be reached in the AFW pump room or would have sufficient capability to perform its required design functions at the elevated temperature. In addition, Section 8 of ENG-ME-021, Revision 2C describes margin built into the calculations. For example, no credit is taken for temperatures in adjoining areas dropping at night or weather changes which would result in lower temperatures in the AFW pump room; and no credit is taken for operator actions to lower temperature in the AFW pump room. However, operator actions are taken. In the FIP, Section 2.11.1 indicates that certain applicable doors are opened and this action would lower temperature in the AFW pump room. Procedures 1[2] ECA-0.0 provide guidance to operators to open the doors and monitor room temperature throughout an ELAP event.

Based on the licensee's calculations and availability of procedures to monitor and maintain temperatures, the NRC staff finds that equipment in the AFW pump room should perform its required design functions and not be adversely impacted by loss of ventilation as a result of an ELAP event

Battery Rooms (Batteries, Chargers, and Inverters)

The licensee performed calculation EVAL-XCELPI11-01, "Battery Rooms 11, 12, 21 and 22 and Bus Rooms 15, 16, 111 and 121 Room Heat-Up Evaluations with Loss of HVAC for PRA and SDP," Revision 1, which modeled the transient temperature response in the battery rooms for 24 hours after a loss of HVAC. The analysis showed that battery rooms 11 and 21 reach 120°F at 18.6 and 18.4 hours respectively, and battery rooms 12 and 22 remain below 120°F, reaching 98.7°F and 98.4°F, respectively. The analysis also showed that if battery room doors are opened at 18 hours the temperature in battery rooms 11 and 21 drop to less than 100°F and remain steady. The temperature in the battery rooms 12 and 22 remain steady at around 98°F. During the audit process, the NRC staff confirmed that procedures 1[2] ECA-0.0 provide guidance to operators to open these doors (typically within 1 hour) and monitor battery room temperature throughout an ELAP event.

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

DDCLP Room

In the FIP, Section 2.11.1 states that the temperature limit for the DDCLP room is 135°F. In addition, FIP Section 2.11.1 describes a test the licensee conducted to determine the temperature response in the DDCLP room with the ventilation system not functioning. At an outside ambient air temperature of 85°F, the temperature in the room did not exceed 100°F over a 90 minute testing period. In addition, the licensee states in FIP Section 2.11.1 that during Phase 2, a portable DG will repower the Screenhouse Roof Exhaust Fan for the DDCLP room. Action Item 16 in FIP Table 2 shows the 480 Vac DG being started and selected Screenhouse loads being energized within 8 hours after the postulated ELAP. During the audit process, the NRC staff reviewed the licensee's test results, including the temperature trend near the end of the 90-minute test. The NRC staff concludes that the test results and steps to ventilate the room should keep the temperature below the limiting temperature, thus allowing the DDCLPs to perform their intended function during the postulated ELAP/loss of normal access to the UHS.

SG PORV Space and Charging Pump Rooms

In its FIP, the licensee did not address the heat-up of the Auxiliary Building, specifically the PORV space and charging pump rooms. Thus the NRC staff reviewed these areas during the audit process, to assess areas in the Auxiliary Building that are necessary for the success of the overall strategy. The staff notes that if the SG PORV areas were to heat up such that the supporting electrical equipment for remote operation were to fail, the operators can locally operate the PORVs using installed hand wheels. The licensee's emergency procedures specifically direct operators to operate the valves locally if remote operability is not available. The NRC staff also notes that the licensee's Phase 2 Staffing Assessment [Reference 50], submitted in response to the NRC's 50.54(f) letter dated March 12, 2012 [Reference 22], regarding NTTF Recommendation 9.3, Emergency Preparedness – Staffing, allocates resources for local operation of the SG PORVs. Thus, the staff concludes that the SG PORVs should be available for mitigating the ELAP event despite the fact that the conditions in that space were not addressed in the licensee's FIP.

Regarding the charging pump rooms the staff reviewed engineering analysis EC-22374-07, "Impact of an Extended Loss of Ventilation (HVAC) Systems on Rooms Required to Support FLEX Mitigating Strategies," Revision 0 during the audit process. This evaluation referenced calculation ENG-ME-059, "Appendix R – Charging Pump Room Cooling," Revision 1. The calculation determined the maximum temperature for the charging pump rooms while the pumps run continuously for 72 hours with no forced cooling. This analysis found that the charging pumps rooms would reach a maximum temperature of 126°F in 72 hours, which the analysis states is below any mechanical component operating limit. The staff also notes that additional RCS makeup capability from the NSRC should be available before 72 hours have elapsed. Based on its review of the licensee's analysis, and also considering the eventual delivery of the backup NSRC equipment, the staff concludes that the capability for RCS makeup should remain available during an ELAP event.

Containment

The licensee performed evaluation CF.PX.00.OPS.046, "Prairie Island Containment Pressure and Temperature for a RCP Small Seal Leak During an Extended Station Blackout," dated 8/31/2015, which modeled the transient temperature and pressure response in the containment following an ELAP event. The analysis shows that pressure and temperature will not exceed the containment design limits of 60.7 pounds per square inch absolute (psia) and 268°F. The containment pressure and temperature will slowly increase to 35.6 psia and containment temperature will slowly increase to 218°F over 75 hours. Therefore, the instrumentation in containment should remain functional during an ELAP. The analysis also shows that after containment cooling is restored via the FCU, containment pressure and temperature decrease and stabilize to less than 20 psia and 120°F, respectively.

Prairie Island will receive offsite resources and equipment from an NSRC between approximately 24 and 72 hours after the onset of an ELAP event. The NRC staff finds that it is reasonable to expect that the licensee could utilize these resources to reduce or maintain temperatures within Containment. Based on temperatures remaining below the design limits of the required equipment and the availability of offsite resources to restore containment cooling within 75 hours, the NRC staff finds that the electrical equipment in Containment should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

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

3.9.1.2 Loss of Heating

The licensee stores portable FLEX equipment in the FLEX Storage Building. This building is designed to withstand ambient air temperatures down to -34°F and maintain a minimum temperature of 40°F inside. In addition, FIP Section 2.7 states that FLEX equipment was specified to operate between -40°F and 120°F. Section 8.3.1 of NEI 12-06 states that FLEX equipment should be maintained at a temperature within a range to ensure it is likely to function when called upon. The NRC staff concludes that by maintaining temperature in the FLEX Storage Building to at least 40°F, the FLEX equipment's low temperature specification would not be reached and therefore, the equipment should be available to function when called upon consistent with Section 8.3.1 of NEI 12-06.

In addition to the protection of FLEX equipment stored in the FLEX Storage Building, FIP Section 2.11.2 states that major components for FLEX strategies are provided with cold weather packages to protect the equipment from extreme cold weather. According to the licensee, hoses that are routed outside and pumps that are located outside would have positive flow. With positive flow, the hoses and pumps would be protected from freezing. During the audit review the NRC staff confirmed that the licensee's procedures include cautions regarding sub-freezing outside temperatures. For example, 1[2]FSG-3 "Alternate Low Pressure Feedwater" and 1[2]FSG-11 "Alternate SFP Makeup and Cooling" state that sub-freezing outside temperatures can cause water in the FLEX SG/SFP makeup pump or hoses to freeze and that continuous flow is necessary to prevent freezing. In addition, FIP Section 2.6.4 describes access to the UHS via the Emergency Cooling Water Intake line. This line is approximately 10 feet below the normal river water level and therefore not affected by surface ice. Because cold weather packages are part of the licensee's equipment, procedures specify maintaining positive flow during sub-freezing conditions, and the UHS remains accessible in extreme cold conditions, the NRC staff finds that equipment such as pumps and hoses should be available to support the FLEX mitigation strategy during extreme cold weather events.

The Class 1E Battery Rooms are located in the turbine building, such that outside air temperature should not adversely impact battery performance. Temperatures in the battery rooms are not expected to be sensitive to extreme cold conditions due to their location in the turbine building, the concrete walls isolating the rooms from the outdoors, and lack of forced outdoor air ventilation during early phases of the ELAP event. At the onset of the event, the Class 1E Battery Rooms would be at their normal operating temperature and the temperature of the electrolyte in the cells would build up due to the heat generated by the batteries discharging and during recharging. The heat generated from equipment (batteries, battery charger, and inverters) in the battery rooms should be sufficient to ensure batteries remain above their minimum temperature of 60°F. Based on the above, the NRC staff finds that PINGP Class 1E station batteries should perform their required functions as a result of loss of normal heating during an ELAP event.

Based on the information above, the NRC staff finds the station equipment required to support the FLEX mitigation strategy should perform the required functions at the expected temperatures as a result of loss of heating during an ELAP event consistent with NEI 12-06 Sections 3.2.2.12 and 8.3.2.

#### 3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. The NRC staff reviewed licensee calculation 178599.51.2019, "Prairie Island Battery Room Hydrogen

Removal," Revision 0, to verify that hydrogen gas accumulation in the battery rooms will not reach combustible levels while HVAC is lost during an ELAP. The licensee's calculation showed that hydrogen concentration in the battery rooms would remain less than 1 percent. During the audit process that staff confirmed that the licensee's procedures 1[2] ECA-0.0 provide guidance to open doors (typically within 1 hour) to provide ventilation in the battery rooms to preclude a significant buildup of hydrogen concentration.

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

3.9.2 Personnel Habitability

In the FIP, Section 2.12 states that the licensee evaluated personnel habitability during an ELAP event in conjunction with its equipment operability evaluation and determined personnel habitability would be acceptable. In the FIP, Section 2.11.1 summarizes the licensee's loss of ventilation evaluation for the key areas of its FLEX strategy. The key areas are the MCR, AFW pump room, battery rooms, and DDCLP room. For the DDCLP room, the licensee used testing to evaluate the temperature response to loss of ventilation. The licensee performed calculations for the other areas. In addition to these four key areas, the licensee describes SFP Ventilation in FIP Section 2.4.4; therefore, it is also discussed here. The areas evaluated are described in the sections that follow.

3.9.2.1 Main Control Room

As described previously the licensee evaluated MCR temperatures in Calculation EVAL-XCELPI12-02. The licensee's MCR evaluations included combinations of mitigating actions at normal and reduced heat loads in which doors or access panels are opened and a portable fan is installed in the door between the MCR and Turbine Building. With the reduced heat load scenario the temperature reaches about 114°F. If a fan is used in addition to opening doors, then the temperature in the MCR at 36 hours can be reduced further by about 8 to 10°F. This case is summarized in Table 7.1-C in EVAL-XCELPI12-02. In the FIP, Table 2 shows operators opening MCR doors at 1 hour after the start of an ELAP event. Because FIP Section 2.11.1 specifies opening doors in accordance with the licensee's emergency procedures, and the licensee's analysis supports a demonstration of temperatures at a level consistent with long-term habitability, the NRC staff concludes that MCR habitability should be acceptable.

3.9.2.2 Spent Fuel Pool Area

In the FIP, Section 2.4.4 states that Auxiliary Building roll-up doors will be opened to prevent excessive steam accumulation. This action provides ventilation pathways in the Auxiliary Building and allows steam generated by SFP boiling to escape. As described in FIP Section 2.4.1, operators have at least 33 hours before boiling begins during non-outage conditions. To avoid habitability concerns, Action Item 28 in FIP Table 2 specifies that operators deploy hoses for SFP makeup between 12 and 24 hours following an ELAP event. Because ventilation is established and hoses are deployed well before SFP boiling would occur, no additional mitigating actions are required for personnel habitability. Note that the licensee determined boiling may occur in as soon as 8 hours for outage conditions; however, it states in FIP Section

2.4.2 that additional personnel would be available to install hoses in the vicinity of the SFP. Therefore, personnel actions should also be completed prior to SFP boiling during outage conditions, and no additional mitigating actions would be required.

3.9.2.3 Other Plant Areas

In addition to the MCR, the licensee's FIP describes a loss of ventilation in the AFW pump room and the DDCLP Room. The staff also considered the PORV spaces, which were not included in the FIP. These areas are described as follows.

AFW Pump Room

As described previously in this safety evaluation, the licensee's AFW pump room temperature analysis concluded that temperatures could reach 128 to 132°F after 39 hours. However, the calculation does not credit opening doors in the AFW pump room which would lessen the heat up. Action Item 18 in FIP Table 2 shows that operators will open these doors within 4 hours of the event's initiation. In addition, ENG-ME-021 (Attachments 7 and 8, referenced from Revision 2C and contained within Revision 2D), shows that the AFW pump room would reach a temperature of 120 to 122°F at 4 hours. Based on these projected temperatures, the NRC staff concludes that the AFW pump room should be accessible for personnel to perform local actions and to open doors consistent with the licensee's sequence of events timeline. The staff also concludes that opening doors would help mitigate further temperature increases and that intermittent access for actions such as controlling makeup flow to the SGs as described in FIP Section 2.3.1 should be feasible.

DDCLP Room

The DDCLP room is located in the Screenhouse. As previously described in this safety evaluation, the licensee predicts that, based on test data, the room temperature would not exceed 100°F during Phase 1. In addition, the licensee's FIP states that during Phase 2, a portable DG will repower the Screenhouse Roof Exhaust Fan for the DDCLP room. This action will help mitigate temperature increases in the room. In the FIP, Section 2.3.4 describes operator actions to reduce the speed of one DDCLP and to shut down the other one. As shown by Action Item 4 in FIP Table 2, reducing the speed of the DDCLP is projected to occur early (i.e., between 20 and 40 minutes after the event) and within the time period evaluated in the licensee's test. Although FIP Section 2.6.5 identifies an extreme outdoor air temperature of 108°F, as compared to the test being performed at an 85°F ambient temperature, a staff review of the test trend, while considering mean daily time-averaged maximum temperatures for areas near the plant site, indicates that the DDCLP room should remain accessible to personnel such that the strategy can be performed successfully. The staff notes that actions to reduce the speed of the DDCLP are projected to occur early in the event and, in addition, a fan would mitigate temperature increases in the room during Phase 2. This would allow operators to access the room on an intermittent basis, should that be required.

PORV Space

The licensee did not specifically analyze the spaces where the SG PORVs are located. Part of the licensee's strategy is that if remote operation is not available, local manual operation using installed hand wheels will be used to control the PORVs. During the audit process, the licensee stated that operation of the PORVs would be an intermittent activity and operators could return to a lower temperature area between valve adjustments. The staff agrees with this assessment of how the valves would need to be operated, if local manual operation is necessary. To assess how this local operation would be controlled, considering the potential for high temperatures, the staff reviewed the licensee's procedure, FP-OP-COO-01, "Conduct of Operations," Revision 19. This procedure states that the operations group must ensure that their activities are conducted in compliance with the site safety rules, which include considerations for high heat environments. During the audit process, the NRC staff also noted that the licensee's guideline, FSG-5, "Initial Assessment and FLEX Equipment Staging," Revision 2, contains a cautionary note for operators to consider environmental and safety conditions before dispatching personnel into the plant. Thus, the staff concludes that appropriate controls for entry into a potentially high heat area will be implemented by the licensee such that PORV operation and any subsequent actions by the operator(s) dispatched to the PORV area will be successful, as assumed in the licensee's strategy.

The NRC staff finds the above strategies in the MCR, SFP area, AFW pump room, DDCLP room, and SG PORV spaces are consistent with NEI 12-06, Section 3.2.2.11 such that station personnel can safely enter and perform the necessary actions to support the FLEX mitigation strategy during 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 Steam Generator Makeup

In its FIP, the licensee described that during an ELAP, the preferred water supply to the SGs is from the CSTs. There are three CSTs located at PINGP. The combined minimum useable volume is 100,000 gallons per operating unit per the plant Technical Specifications. Nominal volume of the CSTs is 150,000 gallons per tank. The CSTs are located on the east side of the Unit 1 Turbine Building (one tank) and the west side of the Unit 2 Turbine Building (2 tanks), and are approximately 400 feet apart. The CSTs are cross-connected, such that the water in the three CSTs is available to both units' TDAFW pumps. The CSTs are not seismically designed. However, the licensee has performed analyses to demonstrate there is reasonable assurance that the CSTs will be available following a seismic event, and are thereby considered to be robust for seismic events. While the tanks are not designed to survive tornado missiles, they are located such that substantial portions of the tanks are protected from tornado missiles by Class I structures.

In its FIP, the licensee also described that if the CSTs are not available, such as for a postulated tornado, the CL system would provide water from the Mississippi River to the TDAFW pumps from one of the two DDCLPs. Each DDCLP has its own dedicated diesel engine and does not rely on ac power. The speed of the DDCLP is reduced within 2 hours, to ensure its associated FODT contains sufficient fuel oil to support approximately eight hours of DDCLP operation. The suction supply to the DDCLP is from a safeguards bay inside the plant Screenhouse that is supplied from the normal intake or from a dedicated emergency cooling water intake line. As described in PINGP USAR Section 10.4.1.2.2, the emergency cooling water intake line can provide water to maintain safe shutdown for both units after a DBE. This intake is a 36 inch pipe buried approximately 40 feet below the circulating water intake canal water level in non-liquefiable soil, connecting the screenwell to a submerged intake crib in a branch channel of the Mississippi River. This emergency cooling water intake line is a Design Class I structure as is the approach canal that supplies its intake crib from the main channel of the Mississippi River. If the emergency cooling water intake line is the only source of wafer available to the DDCLPs, operator actions are necessary to reduce the system demand to within the capacity of the line. Operators would initiate actions to reduce CL system flow demand based on decreasing bay water level. As described in PINGP USAR Section 10.4.1.2.2, there are 3.3 hours available to perform these actions. As a backup to the TDAFW pump, the capability to connect a portable diesel-driven pump (i.e., the SG/SFP makeup pump) is included in the overall strategy. The source of water for this pump is the Mississippi River.

3.10.2 Reactor Coolant System Makeup

In its FIP the licensee described that the credited source of water for RCS makeup is the RWSTs. PINGP has one RWST per unit, located in the Auxiliary Building. The RWSTs are part of the SI system for each unit. Their location in the Auxiliary Building provides protection from postulated external events such as high winds. In addition, the PINGP USAR, Section 6.2.2.2, states that "...all associated components, ... of the Safety Injection System are designed to Class I seismic criteria." The RWSTs contain a minimum of 265,000 gallons of borated water each with a minimum concentration of 2,600 ppm. Makeup to the RCS is provided by repowered charging pumps, via a 480 Vac portable DG.

3.10.3 Spent Fuel Pool Makeup

In its FIP, the licensee stated that the credited makeup source to the SFP during an ELAP is the same portable diesel-driven pump (i.e., the SG/SFP makeup pump) that is used as a backup to the TDAFW pump. The water source for this portable diesel-driven pump is the Mississippi River.

3.10.4 Containment Cooling

No specific equipment or water supplies are required for containment cooling.

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 TDAFW pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the reactor vessel 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 56 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the TDAFW pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300°F), another strategy must be used for decay heat removal. The NRC-endorsed strategy is described in NEI 12-06. Section 3.2.3 provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. In its FIP, the licensee stated that it would follow this guidance. Specifically, the FIP states that PINGP has enhanced its shutdown risk process by including ELAP functions in its shutdown safety assessment process and that that contingency plans will be developed if outage work places the plant in a configuration that would impact the mitigating strategies.

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 described that the inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible 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 EOP or AOP strategies, the EOP or AOP directs the entry into and exit from the appropriate FSG procedure.

According to the licensee, FSGs have been developed in accordance with PWROG guidelines. The FSGs provide instructions for implementing available, pre-planned FLEX strategies to accomplish specific tasks in the EOPs or AOPs. The FSGs are used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

Procedural interfaces have been incorporated into the loss of ac power EOP to include appropriate kick-outs to FSGs to implement the mitigating strategies. The loss of ac power EOP will remain the controlling procedure for an ELAP event. The FSGs have been reviewed and validated by the involved groups to the extent practical to ensure that implementation of the associated FLEX strategy is feasible. Specific FSG validation was accomplished via table top evaluations and walkthroughs of the guidelines when appropriate.

### 3.12.2 Training

In its FIP, the licensee described that NSPM'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 a graded approach in accordance with the systematic approach to training (SAT) process. According to the licensee, initial training has been provided and periodic training will be provided to site emergency response leaders on BDBEE 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, instructions, and mitigating strategy time constraints.

### 3.12.3 Conclusions

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

## 3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter to the NRC dated October 3, 2013 [Reference 38], which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 [Reference 39], the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs.

In its FIP, the licensee described that initial component level testing, consisting of factory acceptance testing and site acceptance testing, was conducted to ensure the portable FLEX equipment can perform its required FLEX strategy design functions. Factory acceptance testing verified that the portable equipment performance conformed to the manufacturers rating for the equipment as specified in the purchase order. Verification of the vendor test documentation was performed as part of the receipt inspection process for each of the affected pieces of equipment and included in the applicable vendor technical manuals. Site acceptance testing confirmed portable equipment delivered to the site functioned and was not damaged in transport to the site.

According to the licensee, the portable BDBEE equipment that directly performs a FLEX mitigation strategy for the core cooling, containment, or SFP cooling is subject to periodic maintenance and testing in accordance with the provisions of NEI 12-06 and Institute of Nuclear

Power Operations (INPO) document AP-913, "Equipment Reliability Process Description". Additional FLEX support equipment that requires maintenance and testing will have preventive maintenance (PM) completed to ensure it will perform its required functions during a BDBEE.

The PM procedures and test procedures are based on the templates contained within the EPRI preventive maintenance basis database. The PM templates include activities such as:

- Periodic static inspection
- Fluid analysis
- Periodic operational verifications
- Periodic performance tests

According to the licensee, manufacturer provided information/recommendations were used when templates were not available from EPRI. The corresponding maintenance strategies were developed and documented. The performance of the PMs and test procedures are controlled through the site work order process. Performance verification testing of FLEX equipment is scheduled and performed as part of the PINGP PM process. A fleet procedure was established to ensure the unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core cooling, containment, and SFP cooling will be managed such that risk to mitigation strategy capability is minimized. Maintenance/risk guidance conforms to the guidance of NEI 12-06 as follows:

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

The NRC staff 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 2

#### 3.14.1 FLEX DG Configuration

The guidance in NEI 12-06 Revision 2, Section 3.2.2, states that a site should have sufficient equipment to address all functions at all units onsite plus one additional spare (an "N+1" capability, where "N" is the number of units on-site). The licensee's Phase 2 electrical strategy calls for two 480 Vac 300 kW FLEX DGs: one DG to repower a fuel oil transfer pump as well as the battery chargers for both units, and the second DG to repower a charging pump on each unit. Thus, while each unit requires portions of two DGs for the strategy's success (implying two spares would be needed to meet the provisions of NEI 12-06), the licensee's strategy allocates the FLEX DGs by function, not by unit. Therefore in the FIP, the licensee identified having three (versus four) 480 Vac FLEX DGs as an alternative to NEI 12-06. The licensee's justification for the alternative stated that this is acceptable because of the following:

- The PINGP FLEX strategies for portable power supplies are not divided by unit, but rather are divided by functions across both units.
- Since the generators are identical in capacity, a total of two generators is sufficient to address all functions for all units and three generators are sufficient to meet the "N+1" criteria.

The NRC staff concludes that the licensee's strategy meets the intent of the NEI 12-06 provision for an "N+1" capability. Since the DGs are interchangeable, should either of the two DGs credited in the strategy fail, or otherwise be unavailable, the third DG could replace the unavailable DG and the strategy would maintain sufficient power capacity. Moreover, the staff observes that the timing and logistics of the licensee's strategy make allocating the DGs in this manner an efficient and logical alternative.

3.14.2 <u>Turbine Building Deployment Paths</u>

In NEI 12-06 Rev 2, Section 5.3.2.2 states that at least one connection point of FLEX equipment will require access through a seismically robust pathway. However, the licensee's FLEX strategy deploys cables, hoses, and other FLEX equipment through the Turbine Building which has a mixed classification, so none of the deployment paths are completely through robust buildings as specified by NEI 12-06. However, in its FIP, the licensee stated that this alternative to NEI 12-06 is acceptable because of the following:

- The main structure of the Turbine Building is robust (expected to remain standing) following a seismic event.
- They have multiple spatially diverse deployment paths that operators can use to deploy FLEX equipment.
- The deployment paths are adjacent to the Class I (seismically robust) structure within the Turbine Building.

During the onsite audit, the license had not determined how they would meet the provisions of 5.3.2.2 of NEI 12-06, but the staff did walk down the deployment paths the licensee had developed at that time. Subsequent to the onsite audit, the licensee revised the pathway assessment 178599.50.2200-04, "Prairie Island Debris Removal Assessment," Revision 2, to include drawings and pictures explaining the multiple deployment paths, along with an explanation of the seismic classification of the different areas in the Turbine Building. Based on the licensee's FIP description, supplemented by the audit review and walk down, the staff concludes that at least one deployment pathway should be available following a seismic event and therefore the licensee's alternative is acceptable.

3.14.3 <u>Flooding Strategy</u>

The licensee's strategy for responding to a flooding event differs from the other postulated external events. For a flooding event, the licensee uses a projected 3-day warning time to establish certain conditions that support the overall strategy for maintaining the core cooling, SFP makeup, and containment functions should the flooding event coincide with an ELAP and loss of normal access to the UHS. The significant aspects of the flood preparation procedure, as it relates to Order EA-12-049 compliance, are the shutdown of both units to cold shutdown and the pre-staging of the Phase 3 equipment from the NSRC within the flood protected area of the site prior to the flood waters reaching the site grade.

In NEI 12-06, Revision 2 contains provisions for the use of warning time in developing a FLEX strategy. Section 6.2.2 states that the use of warning time is permissible as long as plant response actions include appropriate triggers for the implementation of plant response actions. Section 6.2.3.1 states that equipment can be pre-located to a position protected from the flood prior to the arrival of potentially damaging flood levels, including movement before access is restricted. Section 6.2.3.2 allows crediting of actions associated with the cooldown, including RCS boration.

As indicated in the licensee's FIP, the flooding strategy deviates from other NEI 12-06 provisions because it uses a larger set of installed plant equipment to mitigate the event as opposed to the portable equipment used for other elements of the migrating strategies. In addition it does not use an installed connection point for the NSRC CTGs. Instead it uses a procedural direction to reconfigure a connection to the selected electrical busses to support use of the NSRC CTGs.

The licensee's USAR, Section 2.4.3.5, describes the design-basis flooding scenario in detail. The event is a slowly developing flooding event on the Mississippi River. The rise of the river occurs over a 12 day span and the licensee's compensatory actions are based on a 3 day projected river level. During the audit process the NRC staff reviewed the licensee's procedures AB-4, "Flood," Revision 50, and D117, "External Flooding Contingency Actions," Revision 1. The review of these procedures confirmed that trigger points and provisions for shutting the units down, contacting the NSRC, and moving the NSRC equipment into the flood-protected area are provided. The staff also reviewed the licensee's FSGs for connecting the NSRC CTGs to the appropriate electrical busses.

The licensee's strategy for core cooling assumes that since the plant was preemptively placed in cold shutdown, that a loss of ac power (for example, if the plant EDGs fail while in the flooded condition) will result in an RCS heat-up and a transition to natural circulation. Success of the strategy depends on the availability of the TDAFW pumps and SGs to perform their intended functions even though the event initiates in a mode where these components may not be required to be operable per the PINGP technical specifications. The staff reviewed the controlling procedure for the flooding event, AB-4, to ensure that there were no operational provisions that would preclude the availability of the TDAFW pump or SGs following an ELAP-generated heat-up from cold shutdown, should those components be needed. The use of installed plant equipment powered by the NSRC CTGs is an appropriate strategy in this instance because it takes advantage of the time afforded by preemptively placing each unit in a cold shutdown condition, and allows the plant operators to utilize protected equipment whose operational features would be familiar. The strategy to connect the CTGs to the plant electrical distribution system is done in accordance with established procedural direction, and the NRC staff concludes that it is feasible to be performed in the timeframe provided. Finally, the staff observes that while the minimum of 3 days to accomplish the necessary site flooding preparations appears feasible, margin exists in the timeline based on the projected 12-day river rise. This would allow for the necessary decisionmaking regarding shutting the plant down, contacting the NSRC, and pre-staging equipment to proceed in a controlled manner. Based on the licensee's FIP description, USAR flooding event description, and the plant procedural direction discussed above, the staff finds that the licensee's proposed alternative to the provisions of NEI 12-06 regarding the flooding strategy is acceptable.

Order EA-12-049 requires a three phased approach to mitigating BDBEEs. This approach involves an initial phase to maintain or restore core cooling, containment, and SFP cooling capabilities using installed equipment and resources, a transition phase providing sufficient portable onsite equipment and consumables to maintain or restore these functions until they can be accomplished with offsite resources, and a final phase that obtains sufficient offsite resources to sustain the functions indefinitely. The staff concludes that the licensee's flooding strategy meets these requirements. Specifically, the staff concludes that the licensee's use of a combination of installed plant equipment and the NSRC equipment, as described in the FIP, fulfills the Order EA-12-049 requirements for all three phases.

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

### 3.15 Conclusions for Order EA-12-049

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

## 4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 26, 2013 [Reference 25], the licensee submitted its OIP for PINGP in response to Order EA-12-051. By email dated July 11, 2013 [Reference 26], the NRC staff sent a request for additional information (RAI) to the licensee. The licensee provided a response by letter dated August 6, 2013 [Reference 27]. By letter dated November 14, 2013 [Reference 28], the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 26, 2013 [Reference 29], February 26, 2014 [Reference 30], August 25, 2014 [Reference 31], February 26, 2015 [Reference 32], and August 25, 2015 [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 December 8, 2015 [Reference 35], the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

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

The staff performed an onsite audit to review the implementation of SFP level instrumentation related to Order EA-12-051. The scope of the audit included verification of whether the: (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 of Order EA-12-051. By letter dated August 20, 2015 [Reference 20], the NRC issued an audit report on the licensee's progress.

## 4.1 Levels of Required Monitoring

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

> Level 1 is the level that is adequate to support operation of the normal fuel pool cooling system. This level will be based on the top of the cooling system suction pipe location, which is about four feet below the normal pool water level. The minimum level is 21 feet and 1¾ inches above the top of the racks (36 feet and 3¾ inches from the bottom of the pool). This level will be adequate to assure the normal fuel pool cooling system is available for cooling the spent fuel pool....
>
> Level 2 represents the range of water where any necessary operations in the vicinity of the spent fuel pool can be completed without significant dose consequences from direct gamma radiation from the stored spent fuel pool. Based on the guidance in Section 2.3 of NEI 12-02, Level 2 is 10 feet (+/- 1 foot) above the top of the spent fuel rack, which corresponds to 25 feet and 8 inches from the bottom of the spent fuel storage pool.
>
> Level 3 is the level where the fuel remains covered and action to implement make-up water addition should no longer be deferred. Level 3 will be greater than 6 inches above the top of the racks or 15 feet and 8 inches above the pool bottom. This level will be adequate to ensure the fuel remains covered... This level is based on the guidance provided by NEI 12-02 (i.e., +/- one foot of the highest point of the fuel racks in the spent fuel pool).

By letter dated August 25, 2015 [Reference 33], the licensee also stated that Level 1 is also above the minimum water height evaluation for adequate net positive suction head (NPSH) of the SFP pumps.

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

- Level 1 is adequate for normal SFP cooling system operation; it is also sufficient for NPSH and represents the higher of the two points described in NEI 12-02 for this level.

- Level 2 meets first option described in NEI 12-02 for Level 2, which is more than 10 feet above the top of the fuel racks seated inthe SFP.

- Level 3 is above the highest point of any fuel storage rack seated in the SFP. This level allows the licensee to initiate water make-up with no delay meeting the NEI 12-02 specifications of the highest point of the fuel racks seated in the SFP. Meeting the NEI 12-02 specifications of the highest point of the fuel racks conservatively meets the Order EA-12-051 requirement of a level where the fuel remains covered.

Based on the evaluation above, the NRC staff finds that the licensee's 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. Below is the staff's assessment of the design features of the SFP level instrumentation.

### 4.2.1 Design Features: Instruments

Prairie Island, Units 1 and 2, share a SFP which is comprised of two separate pools and a fuel transfer canal. The use of the SFP gates divides the common SFP into the two separate pools, which are each monitored by one channel of SFP level instrumentation. By letter dated August 25, 2015 [Reference 33], the licensee stated that installing the SFP pneumatic sealed gates is treated the same as if an instrument is out of service for any reason per the guidance in NEI 12-02. This includes a 90-day limitation on use of the pool divided gates that isolate the common pool into pools 1 and 2. The licensee also stated that implementation of the requirement is accomplished by instructions in the procedure used to install the weir gates and in the procedure used to ensure necessary compensatory measures are in place for equipment important to BDB compliance that is removed from service. Compensatory measures if the weir gates are installed include steps necessary to ensure availability of normal alarms and proper functioning of the indication channel in each pool validated by direct visual monitoring.

The staff finds compensatory measures described above to be consistent with the provisions of NEI 12-02. During the onsite audit, the staff reviewed Procedure D58.5.3, "Spent Fuel Pool (Divider) Gate Removal/Replacement," Revision 7, and verified that the licensee included actions taken when the weir gate is installed for more than 90 days.

In its OIP, the licensee stated that the primary and backup instrument channel level sensing component will be a new fixed guided wave radar system capable of measuring Levels 1, 2, and 3 discussed in the SFP level section. In its RAI response letter dated August 6, 2013 [Reference 27], the licensee stated that the proposed level sensor range will indicate from Level 3 up to the normal pool water level. The licensee provided a sketch depicting that the proposed level measurement range is 24 feet 3¾ inches from the normal pool level elevation to 6 inches above the top of the spent fuel racks.

The NRC staff notes that the measurement range specified for PINGP SFP level instrumentation fully covers Levels 1, 2, and 3, as described in Section 4.1 above.

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

4.2.2 Design Features: Arrangement

By letter dated August 25, 2015, the licensee stated, in part, that:

> The instrument arrangement and redundant cable routing of the spent fuel instrumentation system meets the requirements of NRC Order EA-12-051 and the guidance of NEI 12-02. Those requirements include:
>
> - Maintain instrument channel separation within the spent fuel pool area,
> - Cabling for power supplies and indications for each channel should be routed separately from cabling for the other channels.
>
> NSPM has installed a fixed probe in each of the two connected spent fuel storage pools at PINGP. The probes are mounted in the northwest corner of SFP #1 and in the northeast corner of SFP #2. Both the primary and backup displays are located in the control room. The primary Spent Fuel Pool Level Instrumentation (SFPI) cable routing from the SFP #2 to the Unit 1 Control Room uses existing penetrations and cable trays. The backup SFPI cable routing from the SFP #1 to Unit 2 Control Room uses existing embedded conduits, penetrations and cable tray system. Cable for each channel is routed in separate conduits and cable trays to provide additional separation.

During the onsite audit, the staff walked down to the primary and backup SFPI channels. The NRC staff noted that there is sufficient channel separation between the primary and back-up level instruments, sensor electronics, and routing cables to provide reasonable protection against loss of indication of SFP level due to missiles that may result from damage to the structure over the SFP.

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

4.2.3 Design Features: Mounting

By letter dated August 25, 2015, the licensee stated, in part, that:

> A site-specific structural calculation documents the design of the structural support bracket for the SFPI level probes at PINGP. The SFP level probes and the associated support brackets are classified as non-safety related. However, the support design considers the site-specific seismic loading requirements for Class I equipment....
>
> The structural members of the brackets are designed using a static equivalent force that is assumed to bound the actual forces in all directions due to seismically induced fluid forces acting on the bracket. The vertical static equivalent force acting on the bracket is then superimposed with the inertial and hydrodynamic forces and moments acting on the probe, which were all provided by the vendor.

A dynamic analysis was performed using seismically induced water impact forces on the supporting bracket structure. The results of the dynamic analysis were reconciled with the site-specific structural calculation.

The supporting structure for the probes is designed as a rigid support. The basis for acceptance of the structural components, welds, etc., is the AISC [American Institute of Steel Construction] Manual of Steel Construction, 9th edition. Only the properties of new structural members are per AISC Manual of Steel Construction, 13th edition.

As described in the PINGP USAR, Section 12.2.1.4.3.1.1, the stresses resulting from both the horizontal and vertical acceleration are combined to obtain the resulting earthquake stresses. The resultant combination, even for design-basis earthquakes, is relatively small based on the support bracket member's small weight. A conservative vertical static equivalent seismic acceleration of 1.0 is used and bounds the effects of the bracket's seismic forces acting in the horizontal direction.

The support bracket's natural frequency is greater than 55 Hz. The actual horizontal acceleration of the Auxiliary Building at the 755 foot elevation for a natural frequency greater than 33 Hz is $g_h = 0.244$. The actual vertical acceleration of the Auxiliary Building for natural frequency greater than 33 Hz is $g_v = 0.125$. Therefore, using a vertical acceleration of 1.0 bounds the actual design-basis value.

The seismically induced fluid force is the controlling design load and this condition is similar to the maximum design basis earthquake load. Thus, the allowable stresses are limited to 150 percent of AISC allowable for structural members in accordance with the PINGP USAR Table 12.2-5.

For the design of the structural connections (welds and bolts), the allowable stresses are conservatively limited to 100 percent of normal code allowable. Stainless steel Hilti Kwik Bolt 3 allowable are based on the ultimate value per the North American Product Technical Guide, Hilti Catalog, and 2011 Edition using a safety factor of 4.0. The structural support component properties are adjusted to an environmental design temperature of 212°F....

The calculation concludes that the probe support and the existing support structure are structurally adequate.

The mounting bracket is attached to the refueling floor using four one-inch diameter by 12 inch long Hilti Kwik Bolt 3 bolts with a nine inch minimum embedment in the structural concrete. The SFP probe support bracket is made up of ASTM A240 plate material and ASTM A554 HSS [Hollow Structural Section] shapes. Welding is in accordance with AWS D1.6.

Bolts are used to secure the instrument probe to the spent fuel bracket supports. A construction change was issued in order to include a slot in the bracket to facilitate the installation of the probe per a recommendation from the probe vendor.

The licensee's letter dated August 25, 2015, further states that:

> The display unit is mounted to the Control Room walls by 3/8 inch diameter Hilt Kwik Bolt 3 concrete expansion anchors with a minimum embedment of 1-5/8 inches through a Unistrut P1000 (or an approved equivalent). Anchors are located to provide rigid support mounting to approximate the tested configuration in the MOHR report 1-0410-6. The displays are located in the Control Room at the 735'-0" elevation of the Auxiliary Building. The envelope of the safe shutdown earthquake (SSE) North-South and East- West horizontal accelerations for 34 Hz frequency (rigid) for the next highest elevation of the Auxiliary Building is 0.236 g. The vertical acceleration is 0.124 g. The Signal Processor measures 10.0 inches by 12.0 inches by 8.3 inches and weighs 27.9 lbs. The battery enclosure measures 12.0 inches by 14.0 inches by 6.3 inches and weighs 41.6 lbs. The capacity of a single 3/8 inch diameter Hilti Kwik Bolt 3, with minimum embedment of 1-5/8 inches and a factor of safety of 4, is 855 lbs. in tension and 1197 lbs. in shear. The shear and tension loads from display unit and battery are very small compared to the large capacity of the anchors. Therefore, the 3/8 inch diameter Hilti Kwik Bolt 3 anchors are acceptable for the applied loading.

During the onsite audit, the NRC staff reviewed the mounting specifications and seismic analyses for the SFPI, including the methodology and design criteria used to estimate the total loading on the mounting devices. The staff also reviewed the design inputs and the methodology used to qualify the structural integrity of the affected structures for each of the SFPI mounting attachments. Based on the review, the staff found the criteria established by the licensee adequately account for the appropriate structural loading conditions, including seismic and hydrodynamic loads.

Based on the licensee's description, supplemented by the onsite audit review, the NRC staff finds that the licensee's 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.

In its OIP, the licensee stated that the primary and backup channels will be qualified through the use of an augmented quality assurance process that meets the requirement of NRC JLD-ISG-2012-03 and NEI 12-02.

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

4.2.4.2 Instrument Channel Reliability

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

> The instrument channel reliability shall be demonstrated via an appropriate combination of design, analyses, operating experience, and/or testing of channel components for the following sets of parameters, as described in the paragraphs below:
>
> - conditions in the area of instrument channel component use for all instrument components,
> - effects of shock and vibration on instrument channel components used during any applicable event for only installed components, and
> - seismic effects on instrument channel components used during and following a potential seismic event for only installed components.
>
> Equipment reliability performance testing was performed to (1) demonstrate that the SFP instrumentation will not experience failures during beyond-design-basis (BDB) conditions of temperature, humidity, emissions, surge, and radiation, and (2) to verify those tests envelope the plant-specific requirements.

The NRC staff reviewed the MOHR SFP level instrumentation's qualification and testing for temperature, humidity, radiation, shock and vibration, and seismic during the vendor audit [Reference 34]. The staff also reviewed the anticipated PINGP environmental conditions during the onsite audit [Reference 20]. Below is the staff's assessment of the equipment reliability of PINGP SFP level instrumentation.

4.2.4.2.1 Shock and Vibration

By letter dated August 25, 2015, the licensee stated that:

> MOHR report 1-0410-16, "MOHR SFP-1 Level Probe Assembly Shock and Vibration Test Report", Revision 0, documents the test procedures performed to demonstrate that requirements outlined in NEI 12-02 for shock and vibration have been met.
>
> The new probe mounting components and fasteners are seismically qualified and designed as rigid components inherently resistant to vibration effects. The probes are affixed to the bracket using a screw connection designed with proper thread engagement and lock washers. The probes and repairable heads were evaluated for resilience against shock and vibration and were found to meet the requirements of NEI 12-02 for shock and vibration resistance.
>
> The system is required to demonstrate compatibility with anticipated no seismic mechanical shock and vibration loading. MOHR 1-0410-5, "MOHR EFP-IL System Shock and Vibration Test Report," Revision 0, contains the shock and vibration test documentation.

The staff reviewed shock and vibration testing during the vendor audit at the MOHR facilities and found it acceptable.

4.2.4.2.2 Seismic

By letter dated August 25, 2015, the licensee stated that:

> The SFP level probe assembly has been tested and evaluated to justify the acceptability of use for the application. MOHR 1-0410-9, "MOHR SFP-1 Level Probe Assembly Seismic Analysis Report," Revision 2, concludes that the level probe assembly meets JLD-ISG-[20]12-03 and IEEE [Institute of Electrical and Electronics Engineers] 344-2004 requirements for adequacy of seismic design and installation for SFPI with attention to seismic and hydrodynamic effects. Physical testing documented in MOHR report 1-0410-9 demonstrates that impact with the pool liner does not affect probe performance and is unlikely to damage the pool liner.
>
> Seismic qualification on the basis of the MOHR report discussed above is predicated on 1) a seismic event bounded by the 5.384 g required response spectra described within the report, 2) the installation of the probe within 12 inches of the pool wall in both horizontal axes, and 3) the seismic event starting with a nominal operating water level being at or above 18 inches from the flange of the probe. The 5.384 g seismic event evaluated with a 5% damping ratio within the MOHR report bounds the site-specific seismic acceleration values of 0.244g horizontally and 0.125g vertically within the Auxiliary Building. The PINGP installation meets the requirements of the MOHR report, including locating the probe within 12 inches of the pool wall and the probe flange being 18 inches from the nominal operating water level.
>
> MOHR 1-0410-15, "MOHR EFP-IL SFPI System Uncertainty Analysis," Revision 0, concludes that the EFP-IL signal processor and EFP-BATT batteries have been qualified for specified seismic loads per IEEE 344-2004. The testing demonstrates that seismic loading produce no significant effect on level measurement.
>
> The SFP-1 probe has been qualified for specified seismic and hydrodynamic loads using IEEE 344-2004 methodology. No significant effect on level measurement is anticipated due to seismic and hydrodynamic loading of the probe in the SFP environment.

The staff reviewed seismic testing during the vendor audit at MOHR's facilities and found it acceptable. Further seismic qualifications of the SFP level instrumentation mounting is addressed in Subsection 4.2.3, "Design Features: Mounting," of this evaluation.

4.2.4.2.3 Radiation, Temperature, and Humidity

By letter dated August 25, 2015, the licensee stated that:

> MOHR SFP-1 Level Probe Assembly
>
> Temperature and Humidity
>
> Post design-basis external event, the SFP is expected to remain at or above the minimum ambient temperature of the Auxiliary Building (65°F) as called out in the site-specific PINGP Environmental Specification. Maximum accident condition

temperature and humidity directly above the SFP will likely be in a condensing steam environment, which conservatively will be no greater than 212°F (the temperature of boiling water at atmospheric pressure) and 100% non-condensing relative humidity. The SFP cooling is restored or makeup water is provided to the SFP during phase 3 of an event as described in PINGP's OIP. The temperature is not expected to be greater than 194°F for more than 500 days after the event. Based on the vendor analysis results in MOHR Report 1-0410-2, "MOHR SFP-1 level Probe Assembly Material Qualification Report," Revision 2, the sensitive materials in the probe head will not be challenged under the conditions of following a BDBEE....

Radiation

Based on MOHR Report 1-0410-2, the most radiation sensitive component is qualified to 1E10 Rads. A site-specific calculation evaluated several cases with different pool configurations to determine the limiting dose rate at the location of the limiting probe material. Using the highest dose rate, the total integrated dose for the limiting probe material is 1.04E09 Rads. Therefore, the SFP level probe assembly is suitable for the service life in the spent fuel pool environment.

MOHR EFP-IL and EFP-BATT (Display and Battery)

Temperature and Humidity

The electronics enclosures are installed within the Control Room. The minimum and maximum design temperatures under normal and post-accident conditions are 65°F and 120°F, respectively. Additionally, the relative humidity for the Control Room during normal and post-accident conditions is 50%. MOHR has successfully tested its system electronics for a temperature range of 14°F to 131°F and a relative humidity range of 5% to 95%. The MOHR values for temperature and relative humidity bound the conditions shown above. Therefore, the electronics enclosures are capable of continuously performing their required function under the expected conditions...

Radiation

[The] Control Room is considered a mild environment with no expected radiation.

During the onsite audit, the staff reviewed calculations 178599.51.2011, "Prairie Island – Dose at SFP level Instrument", Revision 1 and EVAL-XCELPI12-02, "Main Control Room, Cable Spreading Room and Computer Room PRA Heat-Up Evaluation with Loss of HVAC," Revision 1 to confirm that the conditions at the locations where the SFPI are positioned are bounded by the conditions in the MOHR test report.

4.2.4.2.4 Electromagnetic Compatibility

During the onsite audit, the NRC staff inquired about an assessment of potential susceptibilities of Electromagnetic Interferences (EMI) and Radio-Frequency Interference (RFI) in the areas where the SFP instruments are located and how to mitigate those susceptibilities. The EFP-IL signal processor/display and EFP-BATT batteries are located in the MCR behind the control panels. According to the licensee's letter dated August 25, 2015, this location is a radio restriction area. Furthermore, there are no transmitting devices installed in closed proximity of the EFP-IL and EFP-BATT equipment installed area. In addition, during the onsite audit, the staff noted that new instrument cables routed from the SFP to the MCR are shielded and are installed in rigid steel conduit where practical and in instrument cable trays to limit the effect of EMI/RFI. The isolation transformer being installed in the power circuit of each SFPI channel will limit the introduction of any noise or harmonics into the SFPI equipment from the instrument busses and vice versa. Thus, EMI/RFI effect on the SFPI equipment is not a concern for this area. During the audit process, the staff noted that the licensee had performed in-situ RFI testing for the Spent Fuel Pool Level instrumentation probes per the Work Order 00508223-54, "EC 23555 Perform Radio Frequency Test," to confirm acceptable performance in the vicinity of the probe location.

Based on the licensee's August 25, 2015 letter, supplemented by the audit review, the staff concludes that the licensee has adequately assessed, via testing and administrative controls, the potential for radio frequency interference and electromagnetic interference.

The NRC staff finds that the PINGP SFPI qualification process adequate. However, the staff has learned of operating experience at other nuclear facilities, in which the MOHR's SFPI experienced failures of the filter coil (or choke). 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 vendor has developed and qualified substitute components that are less susceptible to transient electrical events. During the audit process the staff confirmed that the licensee had implemented the vendor recommended repair at PINGP for both SFPI channels through the site corrective action program.

Based on the evaluation above, the NRC staff finds that the licensee's 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 <u>Design Features: Independence</u>

By letter dated August 25, 2015, the licensee stated that:

> The design provides two identical, non-safety related, wide-range level instruments that feed two independent trains of non-safety related cable and indicators to provide a highly reliable remote display of SFP water level. Physical separation of the two channels is accomplished by mounting the probes in separate corners of the SFP and separately routing cable and conduit. The indicators (displays) are located in the Control Room behind the control panels...
>
> Each channel is normally powered by an independent 120VAC source. Therefore, loss of any one power supply does not result in loss of normal 120VAC power for both instrument channels.

During the onsite audit, the staff performed a walkdown to the SFPI channels. The staff noted that the primary instrument channel is independent of the backup instrument channel and is installed consistent with recommendations for channel independence in NEI 12-02.

Based on the evaluation above, the NRC staff finds that the licensee's 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

By letter dated August 25, 2015, the licensee stated that:

> The level indicating channels are independent and redundant. Power sources and capabilities are as follows:
>
> - Primary power for the level indicating channels and the displays are installed in the Control Room.
> - Each channel is normally powered by an independent 120VAC source. Therefore, loss of any one power supply does not result in loss of normal 120VAC power for both instrument channels.
> - Each channel is provided with a battery back-up power supply capable of powering the channel for seven days. This provides adequate time to allow the batteries to be replaced with a fresh battery or until off-site resources can be deployed by the mitigating strategies of Order EA-12-049.
> - On loss of normal 120VAC power, each channel automatically transfers to a dedicated backup battery. If normal power is restored, the channel will automatically transfer back to the normal AC power. Instrument accuracy and performance are not affected by restoration of power or sources.

During the onsite audit, the staff reviewed drawings NF-74564-2, "120/208 A.C. UPS Distribution Panel 3133, 3143, 4133 & 4143 One Line Diagram," Revision 77 and NF-88597, "Circuit Diagram Computer UPS 33, 43, 34 & 44," Revision A and confirmed that the power supplies for the level indicating channels are from different distribution panels and a loss of one power supply will not result in loss of ac power for both channels.

Based on the evaluation above, the NRC staff finds that the licensee's 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

By letter dated August 25, 2015, the licensee stated that:

> The published minimum accuracy specification under (a) normal SFP conditions (Level 1) and also (b) BDBEE conditions (Level 2 and 3) is approximately +/- 3 inches based on the vendor's system uncertainty analysis. This exceeds the NEI 12-02 water level measurement accuracy recommendation of +/-1 foot.
>
> The level measurement system typical accuracy, excluding boric acid deposition effects, is +/- 1.0 inch. The maximum accuracy, excluding boric acid deposition effects, is +/- 3.0 inches.

> In general, any applicable calibration procedure tolerances or acceptance criteria are established based on manufacturer's recommended reference or design accuracy. The methodology used is formally captured in the request to create and schedule these procedures.
>
> MOHR Signal Processor Technical Manual was used as input to calibration procedures to ensure the instruments are maintained within the design accuracy. The system is not significantly affected by borated water or boric acid that might deposit on the probe surface. However, the maintenance strategy includes instructions to perform a washout procedure per the MOHR Level Probe Assembly Technical Manual if a significant error in level measurement is found (greater than or equal to 3 inches) during calibration.
>
> In order to maintain the channel accuracy of 3 inches, level verification check is performed periodically to verify the accuracy of a channel. If significant error (i.e. 3 inches of measurement error) is detected, a calibration and/or a routine boric acid deposition washout is performed in accordance with vendor's recommended procedures to maintain the channel accuracy of 3 inches. The surveillance performance frequency is controlled through tasks in the PM program. The request to add these tasks to the PM program has been formally made within the current nuclear NSPM process.

The NRC staff notes that the instrument accuracy of +/- 3 inches is within the accuracy of +/- 1 foot as recommended in NEI 12-02. The staff also notes that the licensee uses the manufacturer's design accuracy as acceptance criteria in procedures developed to take corrective action for the SFPI.

Based on the licensee's description combined with staff observations, the NRC staff concludes that the licensee's 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 <u>Design Features: Testing</u>

By letter dated August 25, 2015, the licensee stated that:

> MOHR's vendor manual provides a description of the capability and provisions the level sensing equipment has for periodic testing and calibration, including how this capability enables the equipment to be tested in-situ. Periodic testing and calibration of the SFP level instrumentation has been established in conjunction with the requirements of the MOHR vendor operation and technical manuals. The request to add these tasks to the PM program has been formally made within the current NSPM process.
>
> The SFP level indication consists of two redundant fixed channels. This provides reasonable assurance that at least one channel is available to monitor SFP level. Each instrument electronically logs a record of measurement values over time in non-volatile memory that can be compared to demonstrate consistency, including any changes in pool level, such as that associated with the normal evaporative loss/refilling cycles. The channel level measurements are directly compared to each other (i.e., regular cross- channel comparisons). Control Room Logs are used to record the levels daily

for each channel. Recorded level measurements and/or level histories and log files are compared to each other. If a significant difference in level is detected between the two channels, corrective actions are initiated to investigate and resolve the cause of the level difference between the two channels. Existing permanently installed SFP level instrumentation and direct SFP level measurements may be used for diagnostic purposes if cross- channel comparisons are anomalous.

Functional checks are automated and/or semi-automated requiring limited operator or technician interaction. The functional checks are performed through the instrument menu software and initiated by the operator or technician. There are a number of other internal system tests that are performed by system software on an essentially continuous basis without user intervention but can also be performed on an on-demand basis with diagnostic output to the display for the operator or technician to review. Other tests, such as menu button tests, level alarm, and alarm relay tests, are only initiated manually by the operator or technician. At a minimum, functional checks are performed at a frequency commensurate with vendor requirements.

Control Room Logs have been updated to verify on a once per day basis that there are no errors and that the batteries are fully charged. This ensures that there are no system faults, that the normal power is available, and that the battery system is charged on a daily basis.

Calibration checks are described in detail in the Vendor Operator's Manual, and the applicable information is contained in plant procedures or preventive maintenance tasks. At a minimum, calibration checks are performed at a frequency commensurate with vendor requirements.

Channel calibration tests, which include a time-domain reflectometer (TDR) calibration check, probe and transmission cable health checks, and clock calibration are performed every two years per vendor's recommendation and within 60 days of a planned refueling outage considering allowances (e.g. 25 percent) per NEI 12-02, Section 4.3.

The NRC staff notes that these tasks appear to be consistent with the vendor recommendations. The staff also notes that the licensee will perform a periodic channel check to confirm that the two spent fuel pool level instrument channels are reading within the equipment design accuracy

Based on the licensees letter dated August 25, 2015, as confirmed during the audit review, the NRC staff finds that the licensee's SFPI 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.

4.2.9 Design Features: Display

In its letter dated August 25, 2015, the licensee stated that the primary and backup instrument channel displays are located in the MCR behind the control panels.

The NRC staff notes that the NEI guidance for "Display" specifically mentions the MCR as an acceptable location for the SFP instrumentation displays as it is occupied or promptly accessible, outside the area surrounding the SFP, inside a structure providing protection against adverse weather and outside of any Very High Radiation Areas or Locked High Radiation Areas during normal operation.

Based on the location within the MCR, the NRC staff finds that the licensee's 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 spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation programmatic controls, including training, procedures, and testing and calibration. Below is the NRC staff's assessment of the programmatic controls for the spent fuel pool instrumentation.

### 4.3.1 Programmatic Controls: Training

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

> Training on the new instrumentation will be provided to the necessary personnel, as determined by plant processes and procedures. NSPM's Systematic Approach to Training (SAT) will be used to identify the population to be trained, and the initial and continuing elements of the required training.

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

### 4.3.2 Programmatic Controls: Procedures

In its letter dated August 25, 2015, the licensee provided a listing and a description of the procedures applicable to the SFPI design change. During the audit process the staff reviewed a sampling of these procedures. Based on the licensee's description and the audit review, the staff concludes that procedures have been developed for SFPI operation, calibration, test, maintenance, and inspection and that these procedures are consistent with the recommendations from the vendor.

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

4.3.3 Programmatic Controls: Testing and Calibration

By letter dated August 25, 2015, the licensee stated that:

> Functional checks are automated and/or semi-automated 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 without user intervention but can also be performed on an on-demand basis with diagnostic output to the display for the operator to review. The self-checking function will detect any errors in the system and provide alerts on the display. Control Room Logs are updated to verify that there are no error alerts and that the batteries are fully charged once per day. This ensures that there are no system faults, that the normal power is available, and that the battery system is charged on a daily basis.
>
> Functional checks are described in detail in the Vendor Technical Manual, and the applicable information is being created in plant procedures and preventive maintenance tasks. Functional tests are planned to be performed periodically at appropriate frequencies established equivalent to, or more frequently than, vendor requirements.
>
> Spent fuel pool instrumentation (SFPI) channel/equipment maintenance/preventative maintenance and calibration requirements to ensure design and system readiness are being established in accordance with NSPM processes and procedures and in consideration of vendor recommendations. This ensures that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance are performed.
>
> The primary or back-up instrument channel can be out of service for testing, maintenance, and/or calibration for up to 90 days provided the other channel is functional. Additionally, compensatory actions must be taken if the instrumentation channel is not expected to be restored, or is not restored, within 90 days.
>
> For a single channel that is not expected to be restored, or is not restored, within 90 days, the compensatory actions will include steps necessary to ensure availability of normal alarms and proper function of the remaining indication channel validated by direct visual monitoring of the spent fuel pool level.
>
> The use of the SFP gates divides the SFP into two separate pools, which are each monitored by one channel of SFP level instrumentation. If the gate is placed into service, then the above actions apply.
>
> If both channels become non-functioning then actions are initiated within 24 hours to restore one of the channels of instrumentation and to implement compensatory actions within 72 hours. Compensatory actions include steps necessary to ensure availability of normal alarms and increased direct visual monitoring of spent fuel pool level.
>
> For a single channel that is not expected to be restored, or is not restored, within 90 days, the compensatory actions include steps necessary to ensure availability of

> normal alarms and proper function of the remaining indication channel validated by direct visual monitoring of spent fuel pool level.

The licensee's letter dated August 25, 2015, also states that:

> The following Preventative Maintenance Change Request (PMCR) tracks the creation of calibration and maintenance tasks and procedures for the SFP level instruments:
>
> PMCR 1431335, New Maintenance PM for Spent Fuel Pool Instrumentation: Spent Fuel Pool Instrumentation channel preventative maintenance and calibration are being established in accordance with PINGP processes and procedures. Maintenance and calibration activities are being created within the PM process with frequencies established in consideration of vendor recommendations.
>
> - PM for EFP-IL signal processor/indicator device: Diagnostic tests on the EFP-IL signal processor/indicator device, which include Memory Test, Battery Test, Temperature Compensation Test, and Scan Test are performed every six months to verify system functionality per vendor's recommendation.
> - PM for EFP-IL signal processor/indicator and EFP-BATT battery devices: Equipment maintenance, and calibration tests, which include battery replacement, memory card replacement, TOR calibration check, probe and transmission cable health checks, and clock calibration are performed every two years per vendor's recommendation and are within 60 days of a planned refueling outage considering allowances (e.g., 25%) per NEI 12- 02 section 4.3.
> - PM for EFP-IL signal processor/indicator and SFP-1 probe devices: Level verification check is performed periodically to verify the accuracy of a channel. If significant error (i.e., $\geq$ 3 inches of measurement error) is detected, a calibration and/or a routine boric acid deposition washout are performed in accordance with vendor's recommendation procedures to ensure the channel accuracy of 3 inches is maintained.

Based on the licensee's description, as supplemented during the audit review, the staff concludes that the maintenance and tests activities are consistent with MOHR recommendations. The staff also finds that the compensatory actions for non-functional SFPI channels appear to be consistent with those recommended by NEI 12-02.

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

## 4.4 Conclusions for Order EA-12-051

In its letter dated December 8, 2015 [Reference 35], the licensee stated that compliance with the requirements of Order EA-12-051 was achieved using the guidance of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff finds that, if implemented appropriately, the licensee has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFP level instrumentation is installed at PINGP according to the licensee's design, it should adequately address the requirements of Order EA-12-051.

## 5.0 CONCLUSION

In August 2013 the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit in May 2015 [Reference 20]. The licensee declared that both of the reactors are in compliance with the orders by letters dated December 13, 2016 [Reference 21], and December 8, 2015 [Reference 35], for Orders EA-12-049 and EA-12-051, respectively. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and designs that if implemented appropriately should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

## 6.0 REFERENCES

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

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

3. SRM-SECY-12-0025, "Staff Requirements – SECY-12-0025 - Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," March 9, 2012 (ADAMS Accession No. ML120690347)

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

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

6. Nuclear Energy Institute document NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 2, December 2015 (ADAMS Accession No. ML16005A625)

7. JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Revision 1, January 22, 2016 (ADAMS Accession No. ML15357A163)

8. Nuclear Energy Institute document NEI 12-02, "Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," Revision 1, August 24, 2012 (ADAMS Accession No. ML12240A307)

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

10. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2013 (ADAMS Accession No. ML13060A379)

11. NSPM Letter to NRC, "Prairie Island, First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 26, 2013 (ADAMS Accession No. ML13239A094)

12. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2014 (ADAMS Accession No. ML14057A771)

13. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 25, 2014 (ADAMS Accession No. ML14237A512)

14. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2015 (ADAMS Accession No. ML15057A323)

15. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Fifth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 25, 2015 (ADAMS Accession No. ML15237A403)

16. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Sixth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 24, 2016 (ADAMS Accession No. ML16057A061)

17. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Seventh Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 17, 2016 (ADAMS Accession No. ML16230A521)

18. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) CORRECTED," dated October 20, 2014 (ADAMS Accession No. ML14295A761)

19. Letter from Jeremy S. Bowen (NRC) to NSPM, "Prairie Island Nuclear Generating Plant Units 1 and 2 Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies)," dated February 27, 2014 (ADAMS Accession No. ML14030A540)

20. Letter from Peter J. Bamford (NRC) to NSPM, "Prairie Island Nuclear Generating Plant, Units 1 and 2 - Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051," dated August 20, 2015 (ADAMS Accession No. ML15224B396)

21. NSPM Letter to NRC, "Notification of Full Compliance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Prairie Island Nuclear Generating Plant, Units 1 and 2, dated December 13, 2016 (ADAMS Accession No. ML16351A208)

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

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

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

25. NSPM Letter to NRC, "Prairie Island, Units 1 and 2 - Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated February 26, 2013 (ADAMS Accession No. ML13060A363)

26. Email from Thomas Wengart (NRC) to Lynne Gunderson (Xcel Energy), regarding Request for Additional Information Concerning the Prairie Island Nuclear Generating Plant Overall Integrated Plan for Reliable Spent Fuel Pool Instrumentation, dated July 11, 2013 (ADAMS Accession No. ML13205A355)

27. NSPM Letter to NRC, "Prairie Island, Units 1 and 2,Responses to Request for Additional Information Regarding Prairie Island Nuclear Generating Plant's Overall Integrated Plan Submitted in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051)," dated August 6, 2013 (ADAMS Accession No. ML13219A859)

28. Letter from Scott P. Wall (NRC) to NSPM, "Prairie Island Nuclear Generating Plant, Units 1 and 2 - Interim Staff Evaluation and Request for Additional Information Regarding the Overall Integrated Plan for Implementation of Order EA-12-051, Reliable Spent Fuel Pool Instrumentation," dated November 14, 2013 (ADAMS Accession No. ML13311A486)

29. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant Units 1 and 2, First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Requirements for Reliable Spent Fuel Pool

Instrumentation (Order Number EA-12-051)," dated August 26, 2013 (ADAMS Accession No. ML13239A093)

30. NSPM Letter to NRC, "Prairie Island, Units 1 and 2, Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051) (TAC Nos. MF0832 and MF0833)," dated February 26, 2014 (ADAMS Accession No. ML14057A647)

31. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051) (TAC Nos. MF0832 and MF0833)," dated August 25, 2014 (ADAMS Accession No. ML14237A485)

32. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051) (TAC Nos. MF0832 and MF0833)," dated February 26, 2015 (ADAMS Accession No. ML15057A306)

33. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant's Fifth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Requirements for Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051) (TAC Nos. MF0832 and MF0833)," dated August 25, 2015 (ADAMS Accession No. ML15237A444)

34. Letter from John Boska (NRC) to Lawrence J. Weber, dated August 27, 2014, regarding Donald C. Cook Nuclear Plant, Units 1 and 2, Report for the Onsite Audit of MOHR Regarding Implementation of Reliable Spent Fuel Instrumentation Related to Order EA-12-051 (ADAMS Accession No. ML14216A362)

35. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant, Units 1 and 2, Completion of Required Action by NRC Order EA-12-051, Reliable Spent Fuel Pool Instrumentation (TAC Nos. MF0832 and MF0833)," dated December 8, 2015 (ADAMS Accession No. ML15343A342)

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

37. Letter from William Dean (NRC) to Power Reactor Licensees, "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design Bases External Events," September 1, 2015 (ADAMS Accession No. ML15174A257)

38. Letter from Nicholas Pappas (NEI) to Jack R. Davis (NRC) regarding FLEX Equipment Maintenance and Testing, October 3, 2013 (ADAMS Accession No. ML13276A573)

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

40. NSPM letter to NRC, "PINGP Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54f Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated March 27, 2014 (ADAMS Accession No. ML14086A628)

41. Letter from Frankie Vega (NRC) to NSPM, "Staff Assessment of Information Provided Pursuant to Title 10 of the *Code Of Federal Regulations* Part 50, Section 50.54(f), Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-ichi Accident and Staff Closure of Activites Associated with NTTF Recommendation 2.1, "Seismic"," dated December 15, 2015 (ADAMS Accession No. ML15341A162)

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

43. NSPM Letter to NRC, "Notification of Compliance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Prairie Island Nuclear Generating Plant, Unit 2, dated January 14, 2016 (ADAMS Accession No. ML16014A754)

44. NRC Office of Nuclear Reactor Regulation Office Instruction LIC-111, "Regulatory Audits," December 16, 2008 (ADAMS Accession No. ML082900195)

45. U.S. Nuclear Regulatory Commission, "Mitigation of Beyond-Design-Basis Events," *Federal Register*, Vol. 80, No. 219, November 13, 2015, pp. 70610-70647

46. NSPM Letter to NRC, "Updated Safety Analysis Report (USAR) Revision 34," dated June 3, 2016 (ADAMS Accession No. ML16168A330)

47. Letter from Jack Stringfellow (PWROG) to NRC, regarding Flowserve White Paper on N-Seal RCP Seal Package Response to ELAP, dated August 5, 2015 (ADAMS Accession No. ML15222A356)

48. Letter from Jack R. Davis (NRC) to Jack Stringfellow (PWROG), regarding Flowserve White Paper on N-Seal RCP Seal Package Response to ELAP, dated November 12, 2015 (ADAMS Accession No. ML15310A094)

49. Letter from Jack R. Davis (NRC) to Jack Stringfellow (PWROG), regarding Boron Mixing, dated January 8, 2014 (ADAMS Accession No. ML13276A183)

50. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant Phase 2 Staffing Assessment in Response to March 12, 2012, Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Recommendations of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, Enclosure 5, Recommendation 9.3, Emergency Preparedness - Staffing, Requested Information Items 1, 2, and 6," dated May 28, 2015 (ADAMS Accession No. ML15154A564, non-public)

51. Letter from Nicolas Pappas (NEI) to Jack R. Davis (NRC), "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern," dated August 27, 2013 (ADAMS Accession No. ML13241A186)

52. Letter from Jack R. Davis (NRC) to Joseph E. Pollock (NEI), regarding Battery Life Issue NEI White Paper, dated September 16, 2013 (ADAMS Accession No. ML13241A188)

53. NUREG/CR-7188, "Testing to Evaluate Extended Battery Operation in Nuclear Power Plants," May 2015 (ADAMS Accession No. ML15148A418)

54. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant, Units 1 and 2 - NEI 12-06, Appendix H, Revision 2, H.4.1 Path 1: GMRS ≤ SSE, Mitigating Strategies Assessment (MSA) Report for the New Seismic Hazard Information," dated October 26, 2016 (ADAMS Accession No. ML16302A465)

55. NSPM Letter to NRC, "Prairie Island Nuclear Generating Plant, Units 1 and 2, Mitigating Strategies Flood Hazard Assessment (MSA) Submittal," dated December 13, 2016 (ADAMS Accession No. ML16351A212, non-public)

56. Letter from Frankie Vega (NRC) to NSPM, "Prairie Island Nuclear Generating Plant, Units 1 and 2 - Staff Review of Mitigation Strategies Assessment Report of the Impact of the Reevaluated Seismic Hazard Developed in Response to the March 12, 2012, 50.54(f) Letter," dated November 8, 2016 (ADAMS Accession No. ML16309A158)

57. Letter from Lauren K. Gibson (NRC) to NSPM, "Prairie Island Nuclear Generating Plant, Units 1 and 2 – Flood Hazard Mitigation Strategies Assessment," dated April 13, 2017 (ADAMS Accession No. ML16309A158)

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Date: May 4, 2017

PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 DATED MAY 4, 2017

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