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

December 6, 2018

Mr. Peter P. Sena, III
President and Chief Nuclear Officer
PSEG Nuclear LLC – N09
P.O. Box 236
Hancocks Bridge, NJ 08038

SUBJECT: HOPE CREEK GENERATING STATION - SAFETY EVALUATION REGARDING IMPLEMENTATION OF HARDENED CONTAINMENT VENTS CAPABLE OF OPERATION UNDER SEVERE ACCIDENT CONDITIONS RELATED TO ORDER EA-13-109 (CAC NO. MF4458; EPID NO. L-2014-JLD-0040)

Dear Mr. Sena:

On June 6, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13143A334), the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-13-109, "Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," to all Boiling Water Reactor licensees with Mark I and Mark II primary containments. The order requirements are provided in Attachment 2 to the order and are divided into two parts to allow for a phased approach to implementation. The order required each licensee to submit an Overall Integrated Plan (OIP) for review that describes how compliance with the requirements for both phases of Order EA-13-109 would be achieved.

By letter dated June 25, 2014 (ADAMS Accession No. ML14177A508), PSEG Nuclear LLC (the licensee) submitted its Phase 1 OIP for Hope Creek Generating Station (Hope Creek) in response to Order EA-13-109. At 6-month intervals following the submittal of the Phase 1 OIP, the licensee submitted status reports on its progress in complying with Order EA-13-109 at Hope Creek, including the combined Phase 1 and Phase 2 OIP in its letter dated December 28, 2015 (ADAMS Accession No. ML15362A580). These status reports were required by the order, and are listed in the attached safety evaluation. By letters dated May 27, 2014 (ADAMS Accession No. ML14126A545), and August 10, 2017 (ADAMS Accession No. ML17220A328), the NRC notified all Boiling Water Reactor Mark I and Mark II licensees that the staff will be conducting audits of their implementation of Order EA-13-109 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 12, 2015 (Phase 1) (ADAMS Accession No. ML14332A154), August 2, 2016 (Phase 2) (ADAMS Accession No. ML16103A320), and May 4, 2018 (ADAMS Accession No. ML18120A165), the NRC issued Interim Staff Evaluations (ISEs) and an audit report, respectively, on the licensee's progress. By letter dated July 25, 2018 (ADAMS Accession No. ML18206A964), the licensee reported that Hope Creek is in full compliance with the requirements of Order EA-13-109, and submitted a final integrated plan for Hope Creek.

The enclosed safety evaluation provides the results of the NRC staff's review of Hope Creek's hardened containment vent design and water management strategy for Hope Creek. The intent of the safety evaluation is to inform Hope Creek on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Order EA-13-109. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 2515-193, "Inspection of the Implementation of EA-13-109: Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions" (ADAMS Accession No. ML17249A105). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Dr. Rajender Auluck, Senior Project Manager, Beyond-Design-Basis Engineering Branch, at 301-415-1025, or via e-mail at Rajender.Auluck@nrc.gov.

Sincerely,

Nathan T. Sanfilippo, Chief
Beyond-Design-Basis Engineering Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-354

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

TABLE OF CONTENTS

1.0 **INTRODUCTION**

2.0 **REGULATORY EVALUATION**

2.1 **Order EA-13-109, Phase 1**

2.2 **Order EA-13-109, Phase 2**

3.0 **TECHNICAL EVALUATION OF ORDER EA-13-109, PHASE 1**

3.1 **HCVS Functional Requirements**
3.1.1 Performance Objectives
3.1.1.1 Operator Actions
3.1.1.2 Personnel Habitability – Environmental (Non-Radiological)
3.1.1.3 Personnel Habitability – Radiological
3.1.1.4 HCVS Control and Indications
3.1.2 Design Features
3.1.2.1 Vent Characteristics
3.1.2.2 Vent Path and Discharge
3.1.2.3 Unintended Cross Flow of Vented Fluids
3.1.2.4 Control Panels
3.1.2.5 Manual Operation
3.1.2.6 Power and Pneumatic Supply Sources
3.1.2.7 Prevention of Inadvertent Actuation
3.1.2.8 Monitoring of HCVS
3.1.2.9 Monitoring of Effluent Discharge
3.1.2.10 Equipment Operability (Environmental/Radiological)
3.1.2.11 Hydrogen Combustible Control
3.1.2.12 Hydrogen Migration and Ingress
3.1.2.13 HCVS Operation/Testing/Inspection/Maintenance

3.2 **HCVS Quality Standards**
3.2.1 Component Qualifications
3.2.2 Component Reliability and Rugged Performance

3.3 **Conclusions for Order EA-13-109, Phase 1**

4.0 **TECHNICAL EVALUATION OF ORDER EA-13-109, PHASE 2**

4.1 **Severe Accident Water Addition (SAWA)**
4.1.1 Staff Evaluation
4.1.1.1 Flow Path
4.1.1.2 SAWA Pump
4.1.1.3 SAWA Analysis of Flow Rates and Timing
4.1.2 Conclusions

4.2 **Severe Accident Water Management (SAWM)**
4.2.1 Staff Evaluation

4.2.1.1 Available Freeboard Use
4.2.1.2 Strategy Time Line
4.2.2 Conclusions

4.3 **SAWA/SAWM Motive Force**
4.3.1 Staff Evaluation
4.3.1.1 SAWA Pump Power Source
4.3.1.2 DG Loading Calculation for SAWA/SAWM Equipment

4.4 **SAWA/SAWM Instrumentation**
4.4.1 Staff Evaluation
4.4.1.1 SAWA/SAWM Instruments
4.4.1.2 SAWA Instruments and Guidance
4.4.1.3 Qualification of SAWA/SAWM Instruments

4.5 **SAWA/SAWM Severe Accident Considerations**
4.5.1 Staff Evaluation
4.5.1.1 Severe Accident Effect on SAWA Pump and Flowpath
4.5.1.2 Severe Accident Effect on SAWA/SAWM Instruments
4.5.1.3 Severe Accident Effect on Personnel Actions

4.6 **Conclusions for Order EA-13-109, Phase 2**

5.0 **HCVS/SAWA/SAWM PROGRAMMATIC CONTROLS**

5.1 Procedures
5.2 Training

6.0 **CONCLUSION**

7.0 **REFERENCES**

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO ORDER EA-13-109

PSEG NUCLEAR LLC

HOPE CREEK GENERATING STATION

DOCKET NO. 50-354

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 at 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) during applicable severe accident conditions.

On June 6, 2013 [Reference 1], the NRC issued Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions". This order requires licensees to implement its requirements in two phases. In Phase 1, licensees of boiling-water reactors (BWRs) with Mark I and Mark II containments shall design and install a venting system that provides venting capability from the wetwell during severe accident conditions. In Phase 2, licensees of BWRs with Mark I and Mark II containments shall design and install a venting system that provides venting capability from the drywell under severe accident conditions, or, alternatively, those licensees shall develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions.

By letter dated June 25, 2014 [Reference 2], PSEG Nuclear LLC (PSEG, the licensee) submitted a Phase 1 Overall Integrated Plan (OIP) for Hope Creek Generating Station (HCGS, Hope Creek) in response to Order EA-13-109. By letters dated December 19, 2014 [Reference 3], June 18, 2015 [Reference 4], December 19, 2015 (which included the combined Phase 1 and Phase 2 OIP) [Reference 5], June 29, 2016 [Reference 6], December 22, 2016 [Reference 7], June 27, 2017 [Reference 8], and December 19, 2017 [Reference 9], the licensee submitted 6-month updates to its OIP. By letters dated May 27, 2014 [Reference 10], and August 10, 2017 [Reference 11], the NRC notified all BWR Mark I and Mark II licensees that the staff will be conducting audits of their implementation of Order EA-13-109 in accordance with NRC Office of

Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" [Reference 12]. By letters dated February 12, 2015 (Phase 1) [Reference 13], August 2, 2016 (Phase 2) [Reference 14], and May 4, 2018 [Reference 15], the NRC issued Interim Staff Evaluations (ISEs) and an audit report, respectively, on the licensee's progress. By letter dated July 25, 2018 [Reference 16], the licensee reported that full compliance with the requirements of Order EA-13-109 was achieved, and submitted its Final Integrated Plan (FIP).

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 improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a 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 17]. 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 18], to the Commission. This paper included a proposal to order licensees to implement the installation of a reliable hardened containment venting system (HCVS) for Mark I and Mark II containments. As directed by the Commission in staff requirements memorandum (SRM)-SECY-12-0025 [Reference 19], the NRC staff issued Order EA-12-050, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents" [Reference 20], which required licensees to install a reliable HCVS for Mark I and Mark II containments.

While developing the requirements for Order EA-12-050, the NRC acknowledged that questions remained about maintaining containment integrity and limiting the release of radioactive materials if the venting systems were used during severe accident conditions. The NRC staff presented options to address these issues for Commission consideration in SECY-12-0157, "Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments" [Reference 21]. In the SRM for SECY-12-0157 [Reference 22], the Commission directed the staff to issue a modification to Order EA-12-050, requiring licensees with Mark I and Mark II containments to "upgrade or replace the reliable hardened vents required by Order EA-12-050 with a containment venting system designed and installed to remain functional during severe accident conditions." The NRC staff held a series of public meetings following issuance of SRM SECY-12-0157 to engage stakeholders on revising the order. Accordingly, as directed by the Commission in SRM-SECY-12-0157, on June 6, 2013, the NRC staff issued Order EA-13-109.

Order EA-13-109 requires that BWRs with Mark I and Mark II containments have a reliable, severe-accident capable HCVS. Attachment 2 of the order provides specific requirements for implementation of the order. The order shall be implemented in two phases.

2.1 Order EA-13-109, Phase 1

For Phase 1, licensees of BWRs with Mark I and Mark II containments are required to design and install a venting system that provides venting capability from the wetwell during severe accident conditions. Severe accident conditions include the elevated temperatures, pressures, radiation levels, and combustible gas concentrations, such as hydrogen and carbon monoxide, associated with accidents involving extensive core damage, including accidents involving a breach of the reactor vessel by molten core debris.

The NRC staff held several public meetings to provide additional clarifications on the order's requirements and comments on the proposed draft guidance prepared by the Nuclear Energy Institute (NEI) working group. On November 12, 2013, NEI issued NEI 13-02, "Industry Guidance for Compliance with Order EA-13-109," Revision 0 [Reference 23] to provide guidance to assist nuclear power reactor licensees with the identification of measures needed to comply with the requirements of Phase 1 of Order EA-13-109. The NRC staff reviewed NEI 13-02, Revision 0, and on November 14, 2013, issued Japan Lessons-Learned Project Directorate (JLD) interim staff guidance (ISG) JLD-ISG-2013-02, "Compliance with Order EA-13-109, 'Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Performing under Severe Accident Conditions'" [Reference 24], endorsing, in part, NEI 13-02, Revision 0, as an acceptable means of meeting the requirements of Phase 1 of Order EA-13-109, and on November 25, 2013, published a notice of its availability in the *Federal Register* (78 FR 70356).

2.2 Order EA-13-109, Phase 2

For Phase 2, licensees of BWRs with Mark I and Mark II containments are required to design and install a venting system that provides venting capability from the drywell under severe accident conditions, or, alternatively, to develop and implement a reliable containment venting strategy that makes it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions.

The NRC staff, following a similar process, held several meetings with the public and stakeholders to review and provide comments on the proposed drafts prepared by the NEI working group to comply with the Phase 2 requirements of the order. On April 23, 2015, NEI issued NEI 13-02, "Industry Guidance for Compliance with Order EA-13-109," Revision 1 [Reference 25] to provide guidance to assist nuclear power reactor licensees with the identification of measures needed to comply with the requirements of Phase 2 of Order EA-13-109. The NRC staff reviewed NEI 13-02, Revision 1, and on April 29, 2015, the NRC staff issued JLD-ISG-2015-01, "Compliance with Phase 2 of Order EA-13-109, 'Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Performing under Severe Accident Conditions'" [Reference 26], endorsing, in part, NEI 13-02, Revision 1, as an acceptable means of meeting the requirements of Phase 2 of Order EA-13-109, and on April 7, 2015, published a notice of its availability in the *Federal Register* (80 FR 26303).

3.0 TECHNICAL EVALUATION OF ORDER EA-13-109, PHASE 1

Hope Creek is a single unit General Electric BWR with a Mark I primary containment system. To implement the Phase 1 requirements of Order EA-13-109, the licensee modified the existing hardened containment vent piping from the suppression pool/torus air space to remove a pipe elbow at the effluent release point outside the reactor building (RB), in order to achieve a vertical release. The release point is above all adjacent structures except for the RB dome. The HCVS is initiated via manual action from the Main Control Room (MCR) until power is transferred to the Primary Operating Station (POS) as part of ELAP load shedding. The POS at HCGS is at the Remote Shutdown Panel (RSP) that will be treated as the main operating location for Order EA-13-109. The HCVS may also be operated from the Remote Operating

Station (ROS) at the appropriate time based on procedural guidance in response to plant conditions from observed or derived symptoms. The ROS includes a nitrogen (N2) system to provide motive force for operation of the air-operated Hardened Torus Vent (HTV) valves, and a separate N2 bottle to manually breach a rupture disk. Hope Creek is taking an alternate approach to vent monitoring. Instead of monitoring the temperature and pressure of the vent piping as an indication of flow, Hope Creek will be using the currently installed dual-element flow monitor (high/low range), which is part of the existing HTV radiation monitoring system. The vent flow signal will be displayed at the POS and the ROS. The HCVS has the motive force capacity to operate for 24 hours with installed equipment. Replenishment of the motive force will be by use of portable equipment once the installed motive force is exhausted. Venting actions will be capable of being maintained for a sustained period of up to 7 days.

3.1 HCVS Functional Requirements

3.1.1 Performance Objectives

Order EA-13-109 requires that the design and operation of HCVS shall satisfy specific performance objectives including, minimizing the reliance on operator actions and plant operators' exposure to occupational hazards such as extreme heat stress and radiological conditions, and accessibility and functionality of HCVS controls and indications under a broad range of plant conditions. Below is the staff's assessment of how the licensee's HCVS meets the performance objectives required by Order EA-13-109.

3.1.1.1 Operator Actions

Order EA-13-109, Attachment 2, Section 1.1.1 requires that the HCVS be designed to minimize the reliance on operator actions. Relevant guidance is found in NEI 13-02, Section 4.2.6 and HCVS-FAQ [Frequently Asked Questions]-01.

In its FIP, the licensee stated that the operation of the HCVS was designed to minimize the reliance on operator actions in response to the hazards identified in NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," that are applicable to the plant site. Operator actions to initiate the HCVS vent path can be completed by plant personnel and include the capability for remote-manual initiation from the HCVS control station.

After initial valve line-up at the ROS, the vent system is initiated and operated from the POS located at the RSP near the MCR at 137 feet (ft.) elevation of the Auxiliary Building (AB). The ROS is located in the electrical chase (Room 5301) at 102 ft. elevation of the AB. The ROS includes a N2 system to provide motive force for operation of the air-operated HTV valves, and a separate N2 bottle to manually breach the rupture disk. The ROS includes an argon system for purging the vent line if hydrogen is present in the containment. Argon purging is performed prior to the initial venting under severe accident conditions, and after the HTV valve is closed if hydrogen is present. A list of the remote manual actions for plant personnel to open the HCVS vent path is provided in FIP Table 3-1, "HCVS Operator Actions". A HCVS extended loss of alternating current (ac) power (ELAP) Failure Evaluation Table (Table 3-2), which shows alternate actions that can be performed, is provided in the FIP.

The licensee also stated that permanently installed electrical power and pneumatic supplies are available to support operation and monitoring on the HCVS for a minimum of 24 hours. After 24 hours, available plant personnel will be able to connect supplemental electric power and pneumatic supplies for sustained operation of the HCVS for a minimum of 7 days.

A FLEX portable generator will be used to recharge the Class 1E batteries. Nitrogen bottles can provide pneumatic motive force.

The NRC staff reviewed the HCVS Operator Actions Table, compared it with the information contained in the guidance document NEI 13-02, and determined that these actions should minimize the reliance on operator actions. The actions are consistent with the types of actions described in the guidance found in NEI 13-02, Revision 1, as endorsed, in part, by JLD-ISG-2013-02 and JLD-ISG-2015-01, as an acceptable means of implementing applicable requirements of Order EA-13-109. The NRC staff also reviewed the HCVS Failure Evaluation Table and determined the actions described adequately address all the failure modes listed in the guidance provided by NEI 13-02, Revision 1, which include: loss of normal ac power, long-term loss of batteries, loss of normal pneumatic supply, loss of alternate pneumatic supply, and solenoid operated valve failure.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design should minimize the reliance on operator actions, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.1.2 Personnel Habitability – Environmental

Order EA-13-109, Attachment 2, Section 1.1.2 requires that the HCVS be designed to minimize plant operators' exposure to occupational hazards, such as extreme heat stress, while operating the HCVS system. Relevant guidance is found in: NEI 13-02 Sections, 4.2.5 and 6.1.1; NEI 13-02, Appendix I; and HCVS-FAQ-01.

The POS and ROS are protected from all external hazards and remain accessible during a range of plant conditions, including severe accident conditions. Protection from external hazards is achieved by the POS and ROS being located in the safety related AB. Design and installation of new HCVS equipment is in accordance with HCGS design processes and seismic criteria. In the FIP, Table 2 contains the evaluation of the acceptability of the POS and ROS locations with respect to severe accident temperature and radiological conditions.

Except for the ROS area, the NRC staff reviewed heat-up calculations as part of Order EA-12-049 compliance. The operation of the HCVS does not affect the heat-up calculations for the MCR or the Technical Support Center. The NRC staff audited calculation PSEG104-CALC-007 "GOTHIC Modeling of Auxiliary Building Extended Loss of AC Power FLEX Response for Hardened Vent," Revision 1 (PSEG Vendor Technical Document (VTD) 432611). This calculation shows that the ROS (Room 5301) starts at approximately 102 degrees Fahrenheit (°F) and remains relatively constant (cools slightly) for 72 hours. The POS starts at approximately 76°F with the peak temperature of 94.6°F at 168 hours. Based on these evaluations, the NRC staff concludes that the temperature conditions should not inhibit operator actions needed to initiate and operate the HCVS during an ELAP with severe accident conditions.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to personnel habitability during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.1.3 Personnel Habitability – Radiological

Order EA-13-109, Attachment 2, Section 1.1.3 requires that the HCVS be designed to account for radiological conditions that would impede personnel actions needed for event response. Relevant guidance is found in: NEI 13-02, Sections 4.2.5 and 6.1.1; NEI 13-02 Appendices D, F, G and I; HCVS-FAQ-01, -07, -09 and -12; and HCVS-WP [White Paper]-02.

The licensee performed calculation PSEG Vendor Technical Document (VTD) Number 432634 (001) "Hope Creek Hardened Containment Vent System Dose Evaluation," which documents the dose assessment for designated areas inside the Hope Creek RB (outside of containment) and outside the Hope Creek RB caused by the sustained operation of the HCVS under the beyond-design-basis severe accident condition of an ELAP. Calculation VTD 432634 was performed using NRC-endorsed HCVS-WP-02 [Reference 27] and HCVS-FAQ-12 [Reference 28] methodologies. Consistent with the definition of sustained operations in NEI 13-02, Revision 1, the integrated whole body gamma dose equivalent[1] due to HCVS operation over a 7-day period was determined in the licensee's dose calculation to be no greater than 10 rem[2]. The 7-day dose determined in the calculation due to HCVS operation is a conservative maximum integrated radiation dose over a 7-day period with ELAP and fuel failure starting at reactor shutdown. For the sources considered and the methodology used in the calculation, the timing of HCVS vent operation or cycling of the vent will not create higher doses at personnel habitability and equipment locations (i.e., maximum doses determined in the calculation bound operational considerations for HCVS vent operation).

The licensee determined the expected dose rates in all locations requiring access following a beyond-design-basis ELAP. The licensee's evaluation indicates that for the areas requiring access in the early stages of the ELAP the expected dose rates would not be a limiting consideration. For those areas where expected dose rates would be elevated at later stages of the accident, the licensee has determined that the expected stay times would ensure that operations could be accomplished without exceeding the emergency response organization (ERO) emergency worker dose guidelines.

The licensee calculated the maximum dose rates and 7-day integrated whole body gamma dose equivalents for the MCR and the ROS. The calculation demonstrates that the integrated whole body gamma dose equivalent to personnel occupying defined habitability locations, resulting from HCVS operation under beyond-design-basis severe accident conditions, will not exceed 10 rem.

The NRC staff notes that there are no explicit regulatory dose acceptance criteria for personnel performing emergency response actions during a beyond-design-basis severe accident. The Environmental Protection Agency (EPA) Protective Action Guides (PAG) Manual, EPA-400/R-16/001, "Protective Action Guides and Planning Guidance for Radiological Incidents," provides emergency worker dose guidelines. Table 3.1 of EPA-400/R-16/001 specifies a guideline of 10

---

[1] For the purposes of calculating the personnel whole-body gamma dose equivalent (rem), it is assumed that the radiation units of Roentgen (R), radiation absorbed dose (rad), and Roentgen equivalent man (rem) are equivalent. The conversion from exposure in R to absorbed dose on in rad is 0.874 in air and < 1 in soft tissue. For photons, 1 rad is equal to 1 rem. Therefore, it is conservative to report radiation exposure in units of R and to assume that 1 R = 1 rad = 1 rem.

[2] Although radiation may cause cancer at high doses and high dose rates, public health data do not absolutely establish the occurrence of cancer following exposure to low doses and dose rates — below about 10,000 mrem (100 mSv). https://www.nrc.gov/about-nrc/radiation/health-effects/rad-exposure-cancer.html

rem for the protection of critical infrastructure necessary for public welfare such as a power plant and a value of 25 rem for lifesaving or for the protection of large populations. The NRC staff further notes that during an emergency response, areas requiring access will be actively monitored by health physics personnel to ensure that personnel doses are maintained as low as reasonably achievable.

The NRC staff audited the licensee's calculation of the expected radiological conditions to ensure that operating personnel can safely access and operate controls and support equipment. Based on the expected integrated whole body dose equivalent in the MCR and ROS and the expected integrated whole body dose equivalent for expected actions during the sustained operating period, the NRC staff agrees that the mission doses associated with actions taken to protect the public under beyond-design-basis severe accident conditions will not subject plant personnel to an undue risk from radiation exposure.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to personnel habitability during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.1.4 HCVS Controls and Indications

Order EA-13-109, Attachment 2, Section 1.1.4 requires that the HCVS controls and indications be accessible and functional under a range of plant conditions, including severe accident conditions, ELAP, and inadequate containment cooling. Relevant guidance is found in: NEI 13-02 Sections 4.1.3, 4.2.2, 4.2.3, 4.2.4, 4.2.5, and 6.1.1; NEI 13-02 Appendices F, G and I; and HCVS-FAQs-01 and -02.

Accessibility of the controls and indications for the environmental and radiological conditions are addressed in Sections 3.1.1.2 and 3.1.1.3 of this safety evaluation, respectively.

The Hope Creek HCVS instrumentation components are located in AB Rooms 3576 (POS), 5301 (ROS), 5539, and 5541, Reactor Building Room 4317, Control/Diesel Vestibule Room 5335, and the MCR. The severe accident water addition (SAWA) flow instrument is fixed in installed piping in two locations; Truck Bay Room 5315 for non-flooded conditions and AB Radwaste Pipe Chase Room 3187 and adjacent corridor Room 3197. Regarding the functionality of the HCVS controls and indications, the licensee evaluated the environmental conditions and impacts for the components (switches, control devices, instrumentation sensors, transmitters and indicators, etc.) required for HCVS venting operations. Hope Creek design change packages (DCPs) DCP 80113941 Revision 3 and DCP 80113942 Revision 3 were made available for NRC audit via the electronic portal (eportal) and detail design considerations for the instrumentation. The licensee also made available VTD 432889 Revision 2, "Hope Creek Generating Station Severe Accident Water Addition Personnel and Equipment Environmental Qualification Report." The licensee also provided a complete list of the instrumentation components, their locations, the anticipated environmental conditions and qualification details in Table 1 of the FIP.

The NRC staff reviewed the instrumentation and controls (I&C) configuration in Hope Creek's FIP and confirmed the qualification summary information provided in Table 1 for each channel based on an eportal audit of Hope Creek documents DCP 80113942 Revision 3 and VTD 432889 Revision 2. The NRC staff reviewed the following channels that support HCVS operation: HTV Flow; HTV High Range Radiation; Class 1E Inverter Voltage; N2 Supply

Pressure; Drywell Pressure; and Torus Water Level. The NRC staff notes that Drywell Pressure and Torus Water Level are declared Hope Creek post-accident monitoring (PAM) variables as described in Regulatory Guide 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants," and the existing qualification of these channels is considered acceptable for compliance with Order EA-13-109 in accordance with the guidance in NEI 13-02, Appendix C, Section C.8.1. The NRC staff reviewed the licensee's evaluation and confirmed that the HCVS instrumentation should be adequate to support HCVS venting operations and capable of performing its intended function during ELAP and severe accident conditions.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to the accessibility and functionality of the HCVS controls and indications during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2 Design Features

Order EA-13-109 requires that the HCVS shall include specific design features, including specifications of the vent characteristics, vent path and discharge, control panel, power and pneumatic supply sources, inadvertent actuation prevention, HCVS monitoring, equipment operability, and hydrogen control. Below is the staff's assessment of how the licensee's HCVS meets the performance objectives required by Order EA-13-109.

3.1.2.1 Vent Characteristics

Order EA-13-109, Attachment 2, Section 1.2.1 requires that the HCVS have the capacity to vent the steam/energy equivalent of one percent of licensed/rated thermal power (unless a lower value is justified by analyses), and be able to restore and then maintain containment pressure below the primary containment design pressure and the primary containment pressure limit. Relevant guidance is found in NEI 13-02, Section 4.1.1.

The FIP states that the decay heat absorbing capacity of the suppression pool and the HTV capacity are such that the HCVS has the capability to maintain containment pressure at or below the lower of the containment design pressure (62 pounds per square inch gauge (psig)) or the Primary Containment Pressure Limit (PCPL) (65 psig). The NRC staff audited calculation VTD 432633, "Suppression Pool Energy Capacity," which shows that the suppression pool has sufficient capacity to absorb the energy released into the torus for the first 3 hours following an ELAP event, with approximately 60 percent margin, using 3900 megawatts thermal (MWt) reactor power (versus 3902 MWt current reactor thermal power). Calculation HC-MISC-005, "MAAP [Modular Accident Analysis Program] Analyses to Support FLEX Initial Strategy," Revision 8 include cases using 3902 MWt reactor power and support anticipatory venting at 4 hours based on torus water temperature of 200°F, and demonstrate acceptable containment response (i.e., containment design pressure is not exceeded). For the severe accident case, HCGS is bounded by the Boiling Water Rectors Owners Group (BWROG) reference plant analyses BWROG-TP-15-008, "Severe Accident Water Addition Timing," September 2015 [Reference 32], and BWROG-TP-15-011, "Severe Accident Water Management Supporting Evaluations," October 2015 [Reference 33]. The calculation also determined the required flow for the steam equivalent of 1 percent of 3917 MWt (102 percent of current licensed reactor power of 3840mWt) at 54.4 psig is 147,108 pound per hour (lb/hr). The RELAP5 thermal-hydraulic program was used to simulate two-phase flow in piping systems. The REFORC computer code was used to determine flow generated forces in piping. Vent capacity with torus pressure at 54.4 psig is 168,000 lb/hr. The staff's audit of these calculations confirmed the licensee's evaluation.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design characteristics, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.2 Vent Path and Discharge

Order EA-13-109, Attachment 2, Section 1.2.2 requires that the HCVS discharge the effluent to a release point above main plant structures. Relevant guidance is found in: NEI 13-02 Section 4.1.5; NEI 13-02 Appendix H; and HCVS-FAQ-04.

The HCVS consists of a 12-inch pipe tapping into the 24-inch Containment Atmosphere Control System piping between containment isolation inboard and outboard valves, 1GSV-028 and 1GSV-027, respectively. The HTV valves 1GSV-201 and 1GSV-028 are normally closed and remotely operated butterfly valves, which are opened from the MCR to initiate venting. Valve 1GSV-201 is located on the 12-inch pipe and valve 1GSV-028 is located on the 24-inch pipe. The motive force for operating valve 1GSV-028 (using pneumatic actuator 1GSHV-4964) and valve 1GSV-201 (using pneumatic actuator 1GSHV-11541) is provided by the instrument air system or the backup nitrogen system located near the vent piping at the 102 ft. elevation of the RB. The HCVS containment isolation valves (H1GS- HV-11541 and H1GS-HV-4964) are shown to have a disc design differential pressure of 65 psig per VTDs 315211 and 315212, respectively. The PCPL is 65 psig. During the audit, the NRC staff requested information demonstrating the actuators can open the valves under expected differential pressure and that the actuator maintains operability under severe accident conditions for the duration of the coping mission time.

On their ePortal, the licensee provided evaluations of the primary containment isolation valves. The NRC staff audited the evaluations and noted that the inboard primary containment isolation valve (PCIV) actuator may not have sufficient torque to fully open the valve under maximum anticipated differential pressure. Procedure HC.OP-EO.ZZ-0318, "Containment Venting (EOP-0318)," specifies opening the inboard PCIV first as the downstream piping is pressurized, the pressure across the inboard PCIV is equalized, which allows the inboard PCIV to fully open. For subsequent HCVS operation, the inboard PCIV will be kept open and the downstream valve cycled as required.

The HCGS HTV release point is located above main plant structures with the exception of the RB dome. By letters dated June 21, 2016, and September 7, 2016 [References 34 and 35], PSEG requested relaxation from compliance with Order EA-13-109 Phase 1 Requirement 1.2.2 and associated guidance in NEI 13-02, Revision 1, based on the adequate atmospheric dispersion that would be achieved while venting at the current release point height, and disadvantages of modifying the vent piping to achieve compliance (e.g., increased line resistance would reduce the capacity of the vent flow path). The relaxation was approved by the NRC staff in a letter dated September 30, 2016 [Reference 36].

Guidance document NEI 13-02, Section 5.1.1.6 provides guidance that missile impacts are to be considered for portions of the HCVS. The NRC-endorsed NEI white paper, HCVS-WP-04, "Tornado Missile Evaluation for HCVS Components 30 Feet Above Grade," Revision 0 [Reference 29], provides a risk-informed approach to evaluate the threat posed to exposed portions of the HCVS by wind-borne missiles. The white paper concludes that the HCVS is unlikely to be damaged in a manner that prevents containment venting by wind-generated missiles coincident with an ELAP or loss of normal access to the ultimate heat sink, for plants that are enveloped by the assumptions in the white paper.

In Technical Evaluation 80115583-0860, HCGS evaluated the vent pipe robustness with respect to wind-borne missiles against the requirements contained in HCVS-WP-04. The evaluation demonstrated that the pipe was robust with respect to external missiles per HCVS-WP-04 in that:

1. HCGS HTV piping that is less than 30 feet above grade is protected by the walls of the RB. The RB is a Seismic Category I structure and is designed to provide protection from the design basis tornado wind and missiles.

2. The exposed piping greater than 30 feet above grade has the following characteristics:
   a. The total vent pipe exposed area is 129 square feet which is less than the 300 square feet criterion.
   b. The pipe is made of schedule 40 steel, and the pipe components have no small tubing susceptible to missiles.
   c. There are sources of missiles located in the proximity of the exposed HCVS components. There is an unrestrained material laydown and storage space for the maintenance shop containing potential missiles, located immediately south of the RB. The licensee utilized a probabilistic risk assessment-based evaluation to justify that the HCGS site-specific target area coupled with HCGS site-specific quantity of missiles, when combined together into a probabilistic value, show a probability which is less than the probabilities used as the basis for formulating Assumption 2C in white paper HCVS-WP-04.

3. HCGS maintains a large cutoff saw as part of the FLEX equipment. This saw is capable of cutting the vent pipe should it become damaged such that it restricts flow to an unacceptable level.

4. HCGS maintains severe weather preparedness procedures that would require the plant be shut down prior to the arrival of sustained hurricane force winds on site.

The licensee's evaluation determined that the HCVS pipe is adequately protected from all external events and no further protection is required. The NRC staff audited the information provided and also verified that the normally-closed, fail-closed containment isolation valves can be opened under accident differential pressures using procedural controls. As noted earlier, the NRC staff also approved a relaxation for the stack discharge location.

Based on the evaluation above, the NRC staff concludes that the licensee's location and design of the HCVS vent path and discharge, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.3 Unintended Cross Flow of Vented Fluids

Order EA-13-109, Attachment 2, Section 1.2.3 requires that the HCVS include design features to minimize unintended cross flow of vented fluids within a unit and between units on the site.

Relevant guidance is found in: NEI 13-02, Sections 4.1.2, 4.1.4, and 4.1.6; and in HCVS-FAQ-05.

In its FIP, the licensee states that HCGS is a single unit plant so there is no potential of cross flow of vented fluids between units.

Hope Creek uses the Containment Pre-purge Cleanup System (CPCS) outboard containment isolation valves 1GSHV-4962 and 1GSHV-4963 for isolation between the HTV and CPCS to prevent unintended cross flow of vented fluids. These containment isolation valves are air operated valves (AOVs) and they are normally closed, air-to-open and spring-to-close. Valves 1GSHV-4962 and 1GSHV-4963 are not operated during HTV operation under ELAP or severe accident conditions. These valves are leak tested in accordance with 10 CFR Part 50, Appendix J [Reference 30].

The NRC staff reviewed the information provided and agrees that the use of primary containment isolation valves is acceptable for prevention of inadvertent cross-flow of vented fluids and meets the guidance provided in NEI 13-02, HCVS-FAQ-05, "HCVS Control and Boundary Valves."

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design limits the potential for unintended cross flow of vented fluids, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.4 Control Panels

Order EA-13-109, Attachment 2, Section 1.2.4 requires that the HCVS be designed to be manually operated during sustained operations from a control panel located in the main control room or a remote but readily accessible location. Relevant guidance is found in: NEI 13-02, Sections 4.2.2, 4.2.4, 4.2.5, 5.1, and 6.1; NEI 13-02, Appendices A and H.; and HCVS-FAQs-01 and -08.

The licensee stated, in part, in Section 1.2.4 of its FIP that the POS is located by the RSP near the MCR at the 137 foot elevation and has key-lock switches with position indication for the HTV valves. The POS also provides vent effluent flow and radiation indication. Drywell pressure and torus water level indications are available in the MCR and must be relayed by radio to the POS. The POS is protected from external hazards and remains accessible during severe accident conditions. Operation of the POS is maintained during the loss of AC power. The NRC staff reviewed the FIP Section 1.2.4 and Table 1 and found the Hope Creek POS design met the criteria of Order EA-13-109, Attachment 2, Section 1.2.4.

The licensee also stated, in part, in Section 1.2.5 of the FIP that the ROS is located two floors below the MCR in the Aux Building Room 5301. The ROS includes an N2 system to provide motive force for operation of the air-operated HTV valves. The ROS also includes an Argon system to purge the vent line if hydrogen is present in the containment. The ROS also provides vent effluent flow and radiation indication. Drywell pressure and torus water level indications are available in the MCR. The ROS is protected from external hazards and remains accessible during severe accident conditions. Operation of the ROS is maintained during a loss of ac power. The NRC staff reviewed FIP Section 1.2.5 and Table 1 and found the Hope Creek ROS design appears to have met the criteria in Attachment 2, Section 1.2.4 of the order.

Based on the evaluation above, the NRC staff concludes that the licensee's location and design of the HCVS control panels, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.5 Manual Operation

Order EA-13-109, Attachment 2, Section 1.2.5 requires that the HCVS, in addition to meeting the requirements of Section 1.2.4, be capable of manual operation (e.g., reach-rod with hand wheel or manual operation of pneumatic supply valves from a shielded location), which is accessible to plant operators during sustained operations. Relevant guidance is found in NEI 13-02, Section 4.2.3 and in HCVS-FAQs-01, -03, -08, and -09.

Hope Creek installed a ROS to provide an alternate location with the capability for manually operation of HCVS. The ROS includes a pressurized nitrogen system to provide pressurized nitrogen gas to actuators 1GSHV-4964 (for valve 1GSV-028) and 1GSHV-11541 (for valve 1GSV-201) so that these valves can be actuated from a remote but easily accessible location. The second function of the N2 system at the ROS is to create an exhaust path from the vent ports of solenoid valves 1GSSV-4964 and 1GSSV-11541 to Room 5301 in the AB, to enable closing of HTV valves 1GSV-028 and 1GSV-201 without electrical control power. As part of the audit process, the NRC staff audited the drawings and evaluation documents. The NRC staff's audit confirmed that the actions appear to be consistent with the guidance.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for manual operation, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.6 Power and Pneumatic Supply Sources

Order EA-13-109, Attachment 2, Section 1.2.6 requires that the HCVS be capable of operating with dedicated and permanently installed equipment for at least 24 hours following the loss of normal power or loss of normal pneumatic supplies to air operated components during an ELAP. Relevant guidance is found in; NEI 13-02, Sections 2.5, 4.2.2, 4.2.4, 4.2.6, and 6.1; NEI 13-02, Appendix A; HCVS-FAQ-02; and HCVS-WPs-01 and -02.

Pneumatic Sources Analysis

For the first 24 hours following the event, the motive supply for the HCVS HTV valves will be two nitrogen gas bottles that are permanently installed in the ROS. These bottles have been sized such that they can provide motive force for at least 8 cycles of operation during 24 hours. The two bottles are aligned in parallel, with each bottle capable of supplying motive force to both HCVS HTV valves 1GSV-208 and 1GSV-201. A separate bottle is also provided to manually breach rupture disk 1GSPSE-11554.

The licensee stated that the calculation in VTD 432632, "Backup Nitrogen Supply for Hardened Vent," Revision 1, determined the required pneumatic supply storage volume and supply pressure set point required to operate the HCVS HTV valves (1GSV-028 and 1GSV-201) for 24 hours following a loss of normal pneumatic supplies during an ELAP. The licensee also stated that the calculation determined that two bottles (filled to a minimum pressure of 1800 psig each) can provide sufficient capacity for operation of the HCVS HTV valves for 24 hours following an

ELAP. In the FIP, the licensee stated that only eight venting cycles are needed in the first 24 hours. The NRC staff audited the calculation in VTD 432632 and confirmed that there should be sufficient pneumatic supply available to provide motive force to operate the HCVS HTV valves for 24 hours following a loss of normal pneumatic supplies during an ELAP.

Power Source Analysis

In its FIP, the licensee stated that during the first 24 hours of an ELAP event, Hope Creek would rely on the 125 Volt (V) direct current (dc) Class 1E "D" battery 1DD411 to provide power to HCVS components. After 24 hours, FLEX generators can be credited to repower the station instrument buses and/or the battery charger to recharge the Class 1E "B" 125 VDC battery 1BD411. Battery 1DD411 and 1BD411 are part of the safety-related HCGS 125 VDC system and are installed in the AB, where they are protected from all external hazards. Licensee procedure HC.OP-AB.ZZ-0135(Q), "Station Blackout // Loss of Offsite Power// Diesel Generator Malfunction," Revision 43, directs operators to maintain power to 120 VAC distribution panels, that are fed from their respective "B" and "D" Class 1E 125 VDC batteries and inverters. These distribution panels provide power to the POS and ROS for hardened torus vent operation. Battery 1DD411 and 1BD411 are manufactured by C&D Technologies. The batteries are model LCU-27 with a nominal capacity of 1950 ampere-hours (AH). During the audit period, the licensee provided an evaluation for battery 1DD411 and 1BD411 including incorporation into the FLEX diesel generator (DG) loading calculation.

The NRC staff audited licensee calculation E-4.6(Q), "Hope Creek 125 VDC Beyond Design Base Event Battery Sizing Calculation," Revision 1, which verified the capability of battery 1DD411 to supply power to the required loads during the first phase of the Hope Creek venting strategy for an ELAP event. The licensee's evaluation identified the required loads and the non-essential loads that would be shed within 1.5 hours to ensure battery 1DD411 operation for at least 24 hours.

The licensee's strategy includes repowering the 1BD411 battery charger within 24 hours after initiation of an ELAP. The licensee's strategy relies on one of the two permanently installed 480 Vac 600 kilowatt (kW) FLEX DGs located on the Unit 2 Reactor Building roof, or one of the two FLEX DGs in an Outdoor FLEX Storage Area. Only one of the FLEX DGs are required for the HCVS electrical strategy. The 480 Vac FLEX DG would provide power to the HCVS loads in addition of loads addressed under Order EA-12-049.

The NRC staff also audited licensee calculation E-15.16, "Hope Creek FLEX Electrical System Loading Analysis," Revision 1, which includes "B" battery charger 1BD413 and inverter 1BD481 in the FLEX DG loading calculation. Based on its audit of calculation E-15.16, the NRC staff confirmed` that the FLEX DGs appears to have sufficient capacity and capability to supply the necessary loads during an ELAP event.

Electrical Connection Points

The licensee's strategy is to supply power to HCVS components using a combination of permanently installed and portable components. Connecting the 600 kW FLEX DG was addressed under Order EA-12-049 compliance and documented in the NRC staff's safety evaluation (Reference 37). The NRC staff audited plant procedure HC.OP-EO.ZZ-0401(Q), "FLEX Electrical – Phase 2," Revision 3, which provides direction for connecting the permanent and portable 600 kW FLEX DGs.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for reliable operation with dedicated and permanently installed equipment, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.7 Prevention of Inadvertent Actuation

Order EA-13-109, Attachment 2, Section 1.2.7 requires that the HCVS include means to prevent inadvertent actuation. Relevant guidance is found in NEI 13-02, Section 4.2.1.

In its FIP, the licensee stated that emergency operating procedures (EOPs) provide clear guidance that the HCVS is not to be used to defeat containment integrity during any design basis transients and accidents. In addition, the HCVS was designed to provide features to prevent inadvertent actuation due to equipment malfunction or operator error. The containment isolation valves must be open to permit vent flow. The HCVS features to prevent inadvertent actuation include key lock switches at the POS and locked closed valves at the ROS, which are acceptable methods of preventing inadvertent actuation per NEI 13-02.

In the POS, key-lock control switches prevent inadvertent actuation of HTV valves 1GSV-028 and 1GSV-201. Turning one key-lock switch per HTV valve at the POS control panel activates the transfer relays in the POS panel, opening the control circuits connecting to the MCR and closing the control circuits at the POS. A second key-lock switch per HTV valve is used to operate the valve. In the ROS, inadvertent actuation is prevented by locking closed nitrogen system hand valves 1KBV-319 and 1KBV-321, which are used to operate the HTV valves by remote-manual action if control power at the POS is lost.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to prevention of inadvertent actuation, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.8 Monitoring of HCVS

Order EA-13-109, Attachment 2, Section 1.2.8 requires that the HCVS include means to monitor the status of the vent system (e.g. valve position indication) from the control panel required by Section 1.2.4. In addition, Order EA-13-109 requires that the monitoring system be designed for sustained operation during an ELAP. Relevant guidance is found in: NEI 13-02, Section 4.2.2 and HCVS-FAQs-01, -08, and -09.

The licensee stated, in part, in Section 1.2.8 of the FIP that the Hope Creek HCVS system includes indications at the POS for HTV valve position, vent pipe effluent flow and vent pipe effluent radiation level. The NRC staff noted that effluent flow indication is an acceptable alternative to vent pipe effluent temperature indication. The NRC staff reviewed the FIP Section 1.2.8 and Table 1 and found the Hope Creek design appears to have met the criteria in Attachment 2, Section 1.2.8 of the order.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for the monitoring of key HCVS instrumentation, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.9 Monitoring of Effluent Discharge

Order EA-13-109, Attachment 2, Section 1.2.9 requires that the HCVS include means to monitor the effluent discharge for radioactivity that may be released from operation of the HCVS. In addition, Order EA-13-109 requires that the monitoring system provide indication from the control panel required by Section 1.2.4 and be designed for sustained operation during an ELAP. Relevant guidance is found in NEI 13-02, Section 4.2.4; and HCVS-FAQs-08 and -09.

The licensee stated, in Section 1.2.9 of its FIP that the Hope Creek HCVS radiation monitoring system consists of a new high range ion chamber detector RD-2B adjacent to the HTV vent pipe, and radiation monitor 1SPRY-11542A, which is installed in panel 1MC267A in Room 5335 at the 102 foot elevation of the AB. The NRC staff noted that the licensee also provided recording capability at the POS and additional indication of vent effluent radiation at the ROS. The NRC staff reviewed the FIP Section 1.2.9 and Table 1 and found the Hope Creek design appears to have met the criteria in Appendix 2, Section 1.2.4 of the order.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for the monitoring of effluent discharge, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.10 Equipment Operability (Environmental/Radiological)

Order EA-13-109, Attachment 2, Section 1.2.10 requires that the HCVS be designed to withstand and remain functional during severe accident conditions, including containment pressure, temperature, and radiation while venting steam, hydrogen, and other non-condensable gases and aerosols. The design is not required to exceed the current capability of the limiting containment components. Relevant guidance is found in NEI 13-02 Sections 2.3, 2.4, 4.1.1, 5.1 and 5.2; NEI 13-02 Appendix I; and HCVS-WP-02.

Environmental

In its FIP, the licensee stated that during non-flood scenarios, the SAWA flow path uses a portable FLEX diesel driven pump deployed at the Service Water Intake Structure. Two FLEX DGs are permanently installed on the Unit 2 RB roof. Because both are staged outside, they will not be adversely impacted by loss of ventilation. During a flood scenario, the SAWA flow path uses permanently installed motor-driven submersible pumps located in a room on the 54' elevation of the turbine building and uses one of the two FLEX DGs that are located on the Unit 2 RB roof. In its FIP, the licensee also stated that the normal maximum ambient temperature is 104°F, and ambient room temperature is not a concern during SAWA operation because the pumps are designed to operate under submerged conditions. Based on the location and design of the equipment, the NRC staff concurs that the equipment should not be impacted by loss of ventilation.

As discussed above in Section 3.1.1.2, the licensee performed calculation PSEG104-CALC-007 (VTD 432611), which predicts the temperature profile in the AB following an ELAP. The licensee determined that the temperature at the 137 foot elevation where the POS is located is expected to remain below 95°F. The licensee also determined that the temperature at the 102 foot elevation where the ROS is located is expected to remain relatively constant at 104°F. The licensee plans to implement passive cooling actions such as opening AB stairwell doors to the outside. Licensee procedure HC.OP-AB.ZZ-0135 provides guidance to open doors in the AB. Licensee calculation PSEG104-CALC-007 also addressed the temperature response in the battery rooms 1DD411 and 1BD411. The temperature response in battery room 1DD411 and 1BD411 is expected to reach 99.7°F and 105.1°F, respectively. Ventilating the battery rooms was addressed under Order EA-12-049 compliance and documented in staff's safety evaluation (Reference 37).

Based on expected AB temperatures remaining below 120°F (the temperature limit, as identified in NUMARC-87-00) and battery room temperatures remaining below the maximum temperature limit (122°F) of the batteries (as specified by the battery manufacturer C&D Technologies), the NRC staff concludes that the HCVS electrical equipment in the AB and Class 1E station batteries appears to not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Radiological

The licensee's calculation VTD 432634 (001) "Hope Creek Hardened Containment Vent System Dose Evaluation," documents the dose assessment for both personnel habitability and equipment locations associated with event response to a postulated ELAP condition. The NRC staff audited calculation VTD 432634 and noted that the licensee used conservative assumptions to bound the peak dose rates for the analyzed areas. For the sources considered and the methodology used in the dose calculation, the timing of HCVS vent operation or cycling of the vent will not create higher doses at personnel habitability and equipment locations (i.e., maximum doses determined in the calculation bound operational considerations for HCVS vent operation). The NRC staff's audit confirmed that the anticipated severe accident radiological conditions appear to not impact the operation of necessary equipment or result in an undue risk to personnel from radiation exposure.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to equipment operability during severe accident conditions, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.11 Hydrogen Combustible Control

Order EA-13-109, Attachment 2, Section 1.2.11 requires that the HCVS be designed and operated to ensure the flammability limits of gases passing through the system are not reached; otherwise, the system shall be designed to withstand dynamic loading resulting from hydrogen deflagration and detonation. Relevant guidance is found in NEI 13-02, Sections 4.1.7, 4.1.7.1, and 4.1.7.2; NEI 13-02, Appendix H; and HCVS-WP-03.

In NEI 13-02, Section 4.1.7 provides guidance for the protection from flammable gas ignition for the HCVS system. The NEI issued a white paper, HCVS-WP-03, "Hydrogen/Carbon Monoxide Control Measures," Revision 1, endorsed by the NRC [Reference 31], which provides methods to address control of flammable gases. One of the acceptable methods described in the white paper is the installation of an active purge system (Option 3), that ensures the flammability limit of gases passing through the system is not reached.

In its FIP, the licensee stated that to prevent a detonable mixture from developing in the pipe, a manually operated purge system is installed to purge oxygen from the vent pipe with argon prior to initial venting during severe accident conditions. The argon purge is also used to purge hydrogen from the pipe after a period of venting if hydrogen is suspected to be in the containment, but the potential for air ingress due to steam condensation in between venting cycles creates the potential for a flammable mixture in the HTV piping. Therefore, during an accident scenario where hydrogen is expected the first time that the HTV path is opened, the venting strategy per EOP-318, "Containment Venting," Revision 12, is to keep the vent path open for as long as possible, which reduces hydrogen concentration in containment during subsequent vent cycles. The installed capacity for the gas purge system has been sized for eight purges within the first 24 hours of the ELAP. The licensee performed evaluation Vendor Technical Document (VTD) 432631, "Compressed Gas Purge System for Containment Hardened Vent," Revision 1, which computes the number of compressed argon cylinders, required to purge the hardened containment vent line eight times for the first 24 hours after shutdown and the number of compressed nitrogen cylinders, required to breach the rupture disc. Additionally, the minimum argon bottle pressure is determined by the selected argon filling time of 20 minutes and the minimum nitrogen bottle pressure is determined by the selected nitrogen filling time of 10 minutes. The calculation determined that the minimum bottle pressure required to fill the HCVS piping from AOV H1GS-GS-HV-11541 to the discharge at elevation 248'-5" is 2500 psig, which can fill the HCVS vent pipe with argon for one purge within 20 minutes. Eight argon bottles (Type Airgas 2HP) are sufficient for eight purge cycles for the first 24 hours after an ELAP. The calculation also determined that the minimum bottle pressure for the breaching of the rupture disc (PSE-11554) is 1600 psig, within 10 minutes. One nitrogen bottle (Type Airgas 200) is sufficient to be used for rupturing the disc. The design allows for argon bottle replacement for continued operation past 24 hours. The NRC staff confirmed that the licensee's design appears to be consistent with Option 3 of white paper HCVS-WP-03. The NRC staff also audited the licensee's analysis and confirmed the installed purge system capacity is sufficient. The NRC staff confirmed that the licensee's design appears to be consistent with Option 3 of white paper HCVS-WP-03 and that the use of the argon purge system in conjunction with the HCVS venting strategy meets the requirement to prevent a detonable mixture from developing in the pipe.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design ensures that the flammability limits of gases passing through the system are not reached, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.12 Hydrogen Migration and Ingress

Order EA-13-109, Attachment 2, Section 1.2.12 requires that the HCVS be designed to minimize the potential for hydrogen gas migration and ingress into the RB or other buildings. Relevant guidance is found in NEI 13-02, Section 4.1.6; NEI 13-02, Appendix H; HCVS-FAQ-05; and HCVS-WP-03.

The HCVS vent discharges above the cylindrical portion of the RB as noted in Section 3.1.2.2. The RB is a concrete structure with no ventilation penetrations near the HCVS discharge. As discussed in Section 3.2.1.3, the only interfacing system with the HCVS is the CPCS and there are two parallel interface isolation valves separating the CPCS and the HCVS discharge piping. The interface valves between the HCVS and the CPCS are AOVs and they are normally closed (air-to-open and spring-to-close). Upon initiation of an ELAP and associated loss of instrument air, the valves would automatically shut due to spring pressure or loss of power to the solenoid. Therefore, no additional power is necessary. When closed, the leakage is minimized. Testing and maintenance will be performed to ensure that the valves remain leak-tight within established leakage criteria. The NRC staffs review confirmed that the proposed design appears to be consistent with the guidance and meets the design requirements to minimize the potential of hydrogen gas migration into other buildings.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design minimizes the potential for hydrogen gas migration and ingress, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.1.2.13 HCVS Operation/Testing/Inspection/Maintenance

Order EA-13-109, Attachment 2, Section 1.2.13 requires that the HCVS include features and provisions for the operation, testing, inspection and maintenance adequate to ensure that reliable function and capability are maintained. Relevant guidance is found in NEI 13-02, Sections 5.4 and 6.2; and HCVS-FAQs-05 and -06.

In the HCGS FIP, Table 3-3 includes testing and inspection requirements for HCVS components. The NRC staff reviewed Table 3-3 and agrees that the implementation of these testing and inspection requirements for the HCVS will ensure reliable operation of the systems.

In its FIP, the licensee stated that the maintenance program was developed using the guidance provided in NEI 13-02, Sections 5.4, and 6.2 and utilizes the standard Electric Power Research Institute (EPRI) industry preventive maintenance process for the maintenance calibration and testing for the HCVS components. The NRC staff reviewed the information provided and confirmed that the licensee has implemented adequate programs for operation, testing, inspection and maintenance of the HCVS.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for operation, testing, inspection, and maintenance, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.2 HCVS QUALITY STANDARDS

3.2.1 Component Qualifications

Order EA-13-109, Attachment 2, Section 2.1 requires that the HCVS vent path up to and including the second containment isolation barrier be designed consistent with the design basis of the plant. Items in this path include piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication components. Relevant guidance is found in NEI 13-02 Section 5.3.

The licensee stated in Section 2.1 of its FIP that the HCVS upstream of and including the second containment isolation valve (1GSV-201) and penetrations are designed consistent with the design basis of primary containment including pressure, temperature, radiation, and seismic loads. The NRC staff reviewed the FIP and audited the Hope Creek DCPs (DCP 80113941 Revision 3 and DCP 80113942, Revision 3) and found that the Hope Creek HCVS appears to be consistent with the design bases of the plant.

During the audit period, the licensee provided a discussion on the operations of the existing containment isolation valves (H1GS-HV-11541 and H1GS-HV-4964) relied upon for the HCVS.

These HCVS containment isolation valves are shown to have a disc design differential pressure of 65 psig per VTDs 315211 and 315212, respectively. The PCPL is 65 psig. The licensee provided valve/actuator information that shows the actuator capability and margin calculations for the two existing PCIVs. The evaluation determined that the inboard PCIV actuator may not have sufficient torque to fully open the valve under maximum anticipated differential pressure. Procedures specify opening the inboard PCIV first. As the downstream piping is pressurized, the pressure across the inboard PCIV is equalized, which allows the inboard PCIV to fully open. For subsequent HCVS operation, the inboard PCIV will be kept open and the downstream valve cycled as required. The NRC staff audited this information and confirmed the actuator can develop greater torque than the PCIVs' unseating torque.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to component qualifications, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.2.2 <u>Component Reliability and Rugged Performance</u>

Order EA-13-109, Attachment 2, Section 2.2 requires that all other HCVS components be designed for reliable and rugged performance that is capable of ensuring HCVS functionality following a seismic event. These items include electrical power supply, valve actuator pneumatic supply and instrumentation (local and remote) components. Relevant guidance is found in NEI 13-02, Sections 5.2 and 5.3.

In its FIP, the licensee states that the torus vent up to and including the second containment isolation barrier is designed consistent with the design basis of the plant. These items include piping, piping supports, containment isolation valves, containment isolation valve actuators and containment isolation valve position indication components. As noted earlier, HCGS HTV piping, valves, and supports that are less than 30 feet above grade are protected by the walls of the RB. The RB is a Seismic Category I structure and is designed to provide protection from the design basis tornado wind and missiles.

The HCGS PCPL is 65 psig, which corresponds to a temperature of 312°F. Guidance in NEI 13-02, Revision 1 suggests a 350°F value for HCVS design temperature based on the highest PCPL among the Mark I and II plants. The HCGS HTV piping design conservatively uses 350°F and 65 psig.

Protection from external hazards is provided by the POS and ROS being located in the safety related, seismic Class 1 Auxiliary Building. Design and installation of new HCVS equipment is in accordance with HCGS design processes and seismic criteria

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design, with respect to component reliability and rugged performance, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

3.3 Conclusions for Order EA-13-109, Phase 1

Based on its review, the NRC staff concludes that the licensee has developed guidance and a HCVS design that, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.0 TECHNICAL EVALUATION OF ORDER EA-13-109, PHASE 2

As stated above in Section 2.2, Order EA-13-109 provides two options to comply with the Phase 2 Order requirements. Hope Creek has elected the option to develop and implement a reliable containment venting strategy that makes it unlikely the licensee would need to vent from the containment drywell before alternate reliable containment heat removal and pressure control is reestablished.

For this method of compliance, the order requires licensees to meet the following:

- The strategy making it unlikely that a licensee would need to vent from the containment drywell during severe accident conditions shall be part of the overall accident management plan for Mark I and Mark II containments;

- The licensee shall provide supporting documentation demonstrating that containment failure as a result of overpressure can be prevented without a drywell vent during severe accident conditions; and

- Implementation of the strategy shall include licensees preparing the necessary procedures, defining and fulfilling functional requirements for installed or portable equipment (e.g. pumps and valves), and installing the needed instrumentation.

Relevant guidance is found in NEI 13-02, Sections 4, 5 and 6; and Appendices C, D, and I.

4.1 Severe Accident Water Addition

The licensee plans to use both pre-installed electric motor-driven SAWA pumps and portable, diesel-driven FLEX pumps to provide SAWA flow for the flooded and non-flooded conditions respectively. Both conditions take suction from their designated water sources and the path ways are aligned to lead into one train of the Residual Heat Removal (RHR) system and then into the reactor pressure vessel (RPV). The pre-installed SAWA pumps will receive power from the FLEX DG. The portable FLEX pumps will be deployed prior to initiating SAWA flow. The licensee states in its FIP that the operator locations for deployment and operation of the SAWA equipment are either shielded from direct exposure to the vent line or a significant distance from the vent line so dose will be maintained below ERO exposure guidelines. Once SAWA flow is initiated, operators will have to monitor and maintain SAWA flow and ensure refueling the FLEX equipment as necessary.

4.1.1 Staff Evaluation

4.1.1.1 Flow Path

The SAWA injection flow path for the non-flooded scenario uses the portable diesel FLEX pump deployed at the Service Water Intake Structure. The suction source is the Delaware River and the FLEX pump discharges to a new manifold at the AB truck bay. The inventory from the Delaware River has an unlimited capacity for the non-flooded scenario. The flow path continues from the pump manifold through new piping that ties into the existing 'B' RHR/Service Water cross-tie for injection into the RPV. The FLEX pump and associated equipment are stored in the on-site FLEX storage areas and are protected from external hazards consistent with NRC Order EA-12-049 requirements. Flow can be controlled within the range of 100 gallons per minute (gpm) to 500 gpm, consistent with the BWROG reference plant analyses described in NEI 13-02, Revision 1.

The SAWA injection flow path for the flooded scenario uses three new pre-installed motor-driven submersible pumps onto a pump skid located on the 54-foot elevation of the Turbine Building (TB). The primary condensate pump suction header was modified with a 6-inch tie-in connection to provide water from the main condensers to the SAWA pumps, using a hard suction hose. The inventory from the primary condensate header is approximately 430,560 gallons, which can be used for 31 hours when the SAWA pumps are throttled to 100 gpm after the first 8 hours. The portable FLEX pumps are later used with suction from the Delaware River once the flood waters on site have receded. The pump skid has two pumps aligned to the condenser that can provide the required flow rate of 500 gpm to the RPV. The pump skid also has one pump aligned to take suction from the floor of the TB when flooded. The discharge piping from the pump skid extends to the 77 foot elevation of the TB and ties into the condensate transfer and storage line 1-AP-055, which ties into the "A" RHR system for injection into the RPV. Flow can be controlled within the range of 100 gpm to 500 gpm, consistent with the BWROG reference plant analyses described in NEI 13-02, Revision 1.

4.1.1.2 SAWA Pump

In its FIP, the licensee states that different pumps will be used to provide SAWA flow for the non-flooded and flooded scenarios. For the non-flooded scenario, the portable diesel FLEX pump is a variable speed pump that has a nominal flow rate of 1500 gpm and can maintain the pressures required for RPV injection during an ELAP. The licensee indicated in its FIP that the portable FLEX pump would be deployed in time to meet the eight-hour RPV injection time constraint. The portable FLEX pump would also be available for SFP cooling, which would not be required until SAWA flow demands are significantly reduced. For the flooded scenario, three electric motor-driven SAWA pumps are permanently installed in the TB specifically for a SAWA flooding event, and are not used for SFP cooling for FLEX. Each pump is capable of providing 250 gpm for the RPV injection. The portable FLEX diesel pump would be deployed as needed to provide longer term SFP cooling, and could also be used for RPV injection in lieu of the motor-driven SAWA pumps.

During the audit, the NRC staff audited calculation H-1-FLX-MDC-4022, "FLEX Hydraulic Model," Revision 1, which determined that the required SAWA flowrate of 500 gpm to each unit was within the capacity of the pre-installed SAWA pumps and portable FLEX pump.

The NRC staff audited the flow rates and pressures evaluated in the hydraulic analysis and confirmed that the equipment is capable of providing the needed flow. Based on the NRC staff's review of the FLEX pumping capabilities at Hope Creek, as described in the above hydraulic analyses and the FIP, it appears that the licensee has demonstrated that its pre-installed pumps and portable FLEX pump should perform as intended to support SAWA flow.

4.1.1.3 SAWA Analysis of Flow Rates and Timing

The licensee developed the overall accident management plan from the BWROG Emergency Procedure Guidelines and Severe Accident Guidelines (EPG/SAG) and NEI 13-02, Appendix I. The SAWA/SAWM implementing procedures are integrated into the HCGS Severe Accident Management Guidelines (SAMGs). In particular, EPG/SAG, Revision 3, when implemented with Emergency Procedures Committee Generic Issue 1314, allows throttling of SAWA in order to protect containment while maintaining the wetwell vent in service. The SAMG flow charts direct the use of the hardened vent as well as SAWA/SAWM when the appropriate plant conditions have been reached.

The licensee used the validation guidance in Appendix E to NEI 12-06, Revision 1 and procedure OP-AA-102-106, "*Operator Response Time Program,*" to demonstrate the portable diesel FLEX pump or the motor-driven SAWA pumps can be deployed and commence injection in less than 8 hours. The studies referenced in NEI 13-02, Revision 1 demonstrate that establishing flow within 8 hours will protect the containment. Guidance document NEI 13-02, Appendix I establishes an initial water addition rate of 500 gpm based on EPRI Technical Report 3002003301, "Technical Basis for Severe-Accident Mitigating Strategies." The initial SAWA flow rate will be approximately 500 gpm. After roughly 4 hours, during which the maximum flow rate is maintained, the SAWA flow will be reduced. The reduction in flow rate and the timing of the reduction will be based on stabilization of the containment parameters of drywell pressure and wetwell level.

The licensee used the referenced plant analysis included in NEI 13-02, Revision 1 and EPRI Technical Report 3002003301 to demonstrate that SAWA flow could be reduced to 100 gpm after 4 hours of initial SAWA flow rate and containment would remain protected. At some point, as torus level begins to rise, indicating that the SAWA flow is greater than the steaming rate due to containment heat load, SAWA flow can be reduced as directed by SAMG guidelines.

The licensee performed Technical Evaluation 80115232-0380, which shows that the reference plant analyses are applicable to Hope Creek and that the SAWA/SAWM strategy can prevent containment failure due to overpressure without the use of a drywell vent.

In its FIP, the licensee stated that the wetwell vent was designed and installed to meet NEI 13-02, Revision 1 guidance and is sized to prevent containment overpressure under severe accident conditions. Hope Creek will follow the guidance (flow rate and timing) for SAWA/SAWM described in BWROG-TP-15-008, "Severe Accident Water Addition Timing," [Reference 32] and BWROG-TP-15-011 "Severe Accident Water Management" [Reference 33]. The wetwell will be opened prior to exceeding the PCPL value of 65 psig. The licensee also referenced analysis included in BWROG-TP-15-008, which demonstrates adding water to the reactor vessel within 8-hours of the onset of the event will limit the peak containment drywell temperature significantly reducing the possibility of containment failure due to temperature. Drywell pressure can be controlled by venting the suppression chamber through the suppression pool.

The NRC staff audited the information referenced above. Technical Evaluation 80115232-0380 noted that the reference plant has a torus freeboard of 525,000 gallons. Hope Creek has a torus freeboard of 655,000 gallons. Both the reference plant and Hope Creek assume SAWA flow of 500 gpm starting at 8 hours. The reference plant reduces SAWA flow to 100 gpm at 12 hours. Hope Creek reduces SAWA flow to 100 gpm at 14 hours.

Based on the evaluation above, the NRC staff concludes that the licensee's HCVS design allows for reliable operation with dedicated and permanently installed equipment, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.1.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed SAWA guidance that, if implemented appropriately, will make it unlikely that the licensee would need to vent from the containment drywell during severe accident conditions following an ELAP event, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.2 Severe Accident Water Management

The strategy for HCGS to preclude the necessity for installing a hardened drywell vent, is to implement the containment venting strategy utilizing SAWA and SAWM. This strategy consists of the use of the Phase 1 wetwell vent and SAWA hardware to implement a water management strategy that will preserve the wetwell vent path until alternate reliable containment heat removal can be established. According to the FIP, once SAWA is initiated, the operators will monitor the response of containment from the MCR to determine that venting and SAWA are operating satisfactorily, maintaining containment pressure low to avoid containment failure. Stable or slowly rising trend in torus level with SAWA at the minimum flow rate indicates water on the drywell floor up to the vent pipe or downcomer openings. After some time, as decay heat levels decrease, the operators will be able to reduce SAWA flow to keep the core debris cool while avoiding overfilling the torus to the point where the torus vent is submerged.

Reference plant Analyses BWROG-TP-011 demonstrates that for a reference plant starting water addition at a high rate of flow and throttling after approximately 4-hours will not increase the suppression pool level to that which could block the suppression chamber HCVS.

4.2.1 Staff Evaluation

4.2.1.1 Available Freeboard Use

Generic assessment BWROG TP-15-011, demonstrates that the Mark I (and Mark II) fleet is bounded by the reference plant analyses. This study addressed how suppression pool level control could be achieved in a manner that maintains long term function of the wetwell vent, and determined if there would be adverse effects by controlling (limiting) flow rate. The licensee developed Technical Evaluation 80115232-0380, which shows that the reference plant analyses are applicable to Hope Creek and that the SAWA/SAWM strategy can prevent containment failure due to overpressure without the use of a drywell vent.

The NRC staff audited Technical Evaluation 80115232-0380. Reference plant has a Torus freeboard of 525,000 gallons. Hope Creek has a Torus freeboard of 655,000 gallons. Both the reference plant and Hope Creek assume SAWA flow of 500 gpm starting at 8 hours. The reference plant reduces SAWA flow to 100 gpm at 12 hours. Hope Creek reduces SAWA flow to 100 gpm at 14 hours. The NRC staff concurs that there is sufficient freeboard such that operators will have the time necessary to monitor wetwell water level and reduce flow before the water rises to a level where the wetwell vent path becomes blocked.

4.2.1.2 Strategy Time Line

As noted above, the SAWA/SAWM strategy is based on BWROG generic assessments in BWROG-TP-15-008 and BWROG-TP-15-011. Hope Creek used the referenced plant analysis and will use an initial SAWA flow rate of 500 gpm. This initial flow rate will be established within 8 hours of the loss of all RPV injection following an ELAP/severe accident and will be maintained for 4 hours before reduction to the wetwell vent preservation flow rate. The reduction in flow rate and the timing of the reduction will be based on stabilization of the containment parameters of drywell pressure and wetwell level. As noted in Section 4.1.1.3, the licensee used the referenced plant analysis to demonstrate that SAWA flow could be reduced to 100 gpm after 4 hours of initial SAWA flow rate and containment would be protected. The NRC staff also notes that Hope Creek freeboard volume (655,000 gallons) is larger than the referenced plant freeboard volume (525,000 gallons). At some point, the wetwell level will begin to rise indicating that the SAWA flow is greater than the steaming rate due to containment heat load such that flow can be reduced. The reduction in flow rate and the timing of the reduction will be based on stabilization of the containment parameters of drywell pressure and wetwell level.

4.2.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed SAWM guidance that should I make it unlikely that the licensee would need to vent from the containment drywell during severe accident conditions following an ELAP event, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.3 SAWA/SAWM MOTIVE FORCE

4.3.1 Staff Evaluation

4.3.1.1 SAWA Pump Power Source

As described above, the licensee plans to use pre-installed SAWA pumps and portable diesel-driven FLEX pump to provide SAWA flow for flooded and non-flooded scenarios. For the flooded scenario, the FLEX DG provides power to the three motor-driven pumps and has the fuel capacity to run for greater than 12 hours before refueling is needed. Operators will refuel the FLEX DG in accordance with Order EA-12-049 procedures. For the non-flooded scenario, the portable FLEX pump has a fuel capacity to also run for greater than 12 hours. However, the operators are directed by EOP-410, "Severe Accident Water Addition from River (Non-Flood Condition)," Revision 0, to adjust the pump flow rate and initiate refueling of the FLEX pump if it is intended to run greater than 6 hours. The licensee states in Section IV.C.9.6.1 that Hope Creek will have enough onsite fuel supply to last more than 7 days.

4.3.1.2 DG Loading Calculation for SAWA/SAWM Equipment

In its FIP, the licensee lists drywell pressure, torus level instruments, and SAWA flow instruments as required for SAWA and SAWM implementation. The drywell pressure and torus level instruments are used to monitor the condition of containment. These instruments are powered initially by Class 1E station batteries until the FLEX DG is connected, at which time they are powered by FLEX DG systems for the sustained operating period. The licensee also stated that the SAWA/SAWM flow instruments are annubar flow elements and the flow meters do not require electric power.

The NRC staff audited licensee calculation E-4.6(Q), which verified the capability of the Class 1E station batteries to supply power to the required loads (e.g. drywell pressure and torus level instruments) during the first phase of the HCGS FLEX mitigation strategy plan for an ELAP event. The NRC staff also audited licensee calculation E-15.16, which verified that one FLEX DG is capable of supplying power to two of the three new motor-driven SAWA submersible pumps. The total kW and kilovolt-ampere (kVA) loading is less than the FLEX DG rating of 600 kW and 750 kVA. The NRC staff confirmed that the Class 1E station batteries and 600 kW FLEX DGs should have sufficient capacity and capability to supply the necessary SAWA/SAWM loads during an ELAP event.

4.3.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has established the necessary motive force capable to implement the water management strategy, and, if implemented appropriately, it appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.4 SAWA/SAWM Instrumentation

4.4.1 Staff Evaluation

4.4.1.1 SAWA/SAWM Instruments

In Section IV.C.10 of the Hope Creek FIP, the licensee described the SAWA flow instrument for both flooded and non-flooded conditions. Both SAWA flow configurations use a fixed annubar flow element which produce a differential pressure based on flow range of 0-600 gpm. The annubar flow element differential pressure drives a mechanical flow indicator that indicates 0-600 gpm. The non-flooded condition flow element is installed on a new 4" line located near the stairway in Truck Bay Room 5315 and the flow meter is installed next to the element. The flooded condition element is installed on an existing 6" line located inside Room 3187 on the 75 ft. elevation of the radwaste area of the AB. The meter is in the adjacent corridor, which is designated as Room 3197. The licensee also stated that existing plant instrumentation for torus water level and containment pressure are also used for SAWA flow control.

4.4.1.2 SAWA Instruments and Guidance

The wetwell level indication (1BJLI-4805-1) range is from 0-180 inches. This range extends from 7'-10" above the bottom of the wetwell to 6'-2" below the bottom of the wetwell vent line, covering the range of interest for SAWA operation. The wetwell level indicator is in the MCR.

Drywell pressure instrument (1GSPR-4960A2) range is -5 – 250 psig. The PCPL at Hope Creek is 65 psig. The drywell pressure indicator is in the MCR.

The SAWA flow meters use annubar flow elements and mechanical flow indicators. The non-flooded condition flow element (1BCFE-0100) is installed on a new 4" line located near the stairway in Truck Bay Room 5315 and the flow meter (1BCFI-0100) is installed next to the element. The flooded condition element (1APFE-0100) is installed on an existing 6" line located inside Room 3187 on the 75 ft. elevation of the radwaste area of the AB. The meter (1APFI-0100) is in the adjacent corridor, designated as Room 3197. The instrument range is 0-600 gpm. The anticipated range during use is 100 – 500 gpm.

4.4.1.3 Qualification of SAWA/SAWM Instruments

Drywell pressure and torus water level are declared Hope Creek post-accident monitoring (PAM) variables as described in Regulatory Guide 1.97 and the existing qualification of these channels is considered acceptable for compliance with Order EA-13-109 in accordance with the guidance in NEI 13-02, Appendix C, Section C.8.1.

The flow meters are permanently installed in the truck bay and the radwaste area of the Auxiliary Building. Anticipated radiation in the truck bay area is negligible. Anticipated radiation in the radwaste area is 1000 R/hr max with a 4.4 E6 Total Integrated Dose. The flow elements and meters are mechanical with no electrical parts and are not significantly affected by radiation. The flow elements are also not affected by temperature. The maximum ambient temperature at the flow meter locations will be 113°F. The flow meters are qualified to operate up to 180°F.

The licensee also stated that the SAWA flow instrumentation is rugged, commercial grade equipment seismically mounted in safety-related areas of the plant that are protected from all external hazards.

4.4.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has in place the appropriate instrumentation capable to implement the water management strategy, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.5 SAWA/SAWM Severe Accident Considerations

4.5.1 Staff Evaluation

4.5.1.1 Severe Accident Effect on SAWA Pump and Flowpath

To address SAWA/SAWM severe accident dose considerations the licensee performed a detailed radiological analysis documented as PSEG Nuclear LLC VTD Number 432902 (001) "Hardened Containment Vent System Phase II Radiation Dose Assessment." This calculation analyzed the dose at different locations and times where operator actions will take place during FLEX/SAWA/SAWM activities. The analyzed locations include the MCR, ROS, and travel paths for hose routing.

In its FIP, the licensee states that for the non-flooded condition, the portable FLEX diesel pumps are stored in outdoor FLEX storage areas or temporarily stored in areas within the HCGS RB that are flood-protected and have mild radiological environments. The licensee states that for the flooded condition, three electric motor-driven SAWA pumps are permanently installed on the 54-foot elevation of the TB in an area that has negligible dose rates. The NRC staff reviewed the information and agrees that there will be no significant issues with radiation dose rates at the SAWA pump control location and there will be no significant dose to the SAWA pumps.

The licensee also states that the SAWA flow path inside the RB consists of piping that will be unaffected by the radiation dose and that hoses will only be run in locations that are shielded from significant radiation dose or that have been evaluated for the integrated dose effects over the period of sustained operation. The NRC staff reviewed the information and agrees that the SAWA flow path will not be adversely affected by radiation effects due to the severe accident conditions.

4.5.1.2 Severe Accident Effect on SAWA/SAWM Instruments

Hope Creek's SAWA strategy relies on three instruments: wetwell level, drywell pressure and SAWA flow. The licensee states in its FIP that the drywell pressure and wetwell level instruments are safety-related and qualified for post-accident use as described in Regulatory Guide 1.97 and the existing qualification of these channels is considered acceptable for compliance with Order EA-13-109 in accordance with the guidance in NEI 13-02, Appendix C, Section C.8.1.

To address SAWA/SAWM severe accident conditions the licensee performed two calculations; Calculation 432902 "Hardened Containment Vent System Phase II Radiation Dose Assessment," documents the dose rates for designated areas inside the Hope Creek reactor building (outside of containment) and outside the Hope Creek reactor building caused by the sustained operation of the HCVS under the beyond design basis severe accident condition of an ELAP; and, Calculation PSEG VTD 432889, "Severe Accident Water Addition Personnel and Equipment Environmental Qualification Report," documents the total dose to both instruments and personnel based expected periods of usage and expected stay times. Calculation PSEG VTD 432889 determined that equipment credited for an event requiring SAWA/SAWM would not exceed the required integrated dose limitations. The NRC staff audited these calculations and determined that the licensee used conservative assumptions to assess the post-accident conditions at HCGS.

4.5.1.3 Severe Accident Effect on Personnel Actions

The licensee performed Calculation PSEG VTD 432889, "Severe Accident Water Addition Personnel and Equipment Environmental Qualification Report." This summary report calculated stay times based on dose rates calculated in Calculation 432902 "Hardened Containment Vent System Phase II Radiation Dose Assessment" for all anticipated post-accident activities to ensure that personnel would not be subjected to excessive radiation doses. The NRC staff audited these calculations and determined that the licensee used conservative assumptions to assess the expected total integrated personnel dose in all areas that may require access during a beyond design basis ELAP. The NRC staff audited the licensee's evaluation and agrees that the mission doses associated with actions taken to protect the public under beyond design basis severe accident conditions should not subject plant personnel to an undue risk from radiation exposure.

4.5.2 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has considered the severe accident effects on the water management strategy, and, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

4.6 Conclusions for Order EA-13-109, Phase 2

Based on its review, the NRC staff concludes that the licensee has developed guidance and a water management strategy that, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

5.0 HCVS/SAWA/SAWM PROGRAMMATIC CONTROLS

5.1 Procedures

Order EA-13-109, Attachment 2, Section 3.1 requires that the licensee develop, implement, and maintain procedures necessary for the safe operation of the HCVS. Furthermore, Order EA-13-109 requires that procedures be established for system operations when normal and backup power is available, and during an ELAP. Relevant guidance is found in NEI 13-02, Sections 6.1.2 and 6.1.2.1.

In its FIP, the licensee states that a site-specific program and procedures were developed following the guidance provided in NEI 13-02, Sections 6.1.2, 6.1.3 and 6.2. They address the use and storage of portable equipment including routes for transportation from the storage locations to deployment areas. In addition, the procedures have been established for system operations when normal and backup power is available, and during ELAP conditions. The FIP also states that provisions have been established for out-of-service requirements of the HCVS and the compensatory measures. In the FIP, Section V.B provides specific time frames for out-of-service requirements for HCVS functionality.

The FIP also provides a list of key areas where either new procedures were developed or existing procedures were revised. The NRC staff audited the overall procedures and programs developed, including the list of key components included, and noted that they appear to be consistent with the guidance found in NEI 13-02, Revision 1. The NRC staff determined that procedures developed appear to be in accordance with existing industry protocols. The provisions for out-of-service requirements appear to reflect consideration of the probability of an ELAP requiring severe accident venting and the consequences of a failure to vent under such conditions.

Based on the evaluation above, the NRC staff concludes that the licensee's procedures for HCVS/SAWA/SAWM operation, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the Order.

5.2 Training

Order EA-13-109, Attachment 2, Section 3.2 requires that the licensee train appropriate personnel in the use of the HCVS. Furthermore, Order EA-13-109 requires that the training include system operations when normal and backup power is available, and during an ELAP. Relevant guidance is found in NEI 13-02, Section 6.1.3.

In its FIP, the licensee stated that all personnel expected to perform direct execution of the HCVS/SAWA/SAWM actions will receive necessary training. The training plan has been developed per the guidance provided in NEI 13-02, Section 6.1.3 and will be refreshed on a periodic basis as changes occur to the HCVS actions, systems, or strategies. In addition, training content and frequency follows the systems approach to training process. The NRC staff reviewed the information provided in the FIP and confirmed that the training plan is consistent with the established systems approach to training process.

Based on the evaluation above, the NRC staff concludes that the licensee's plan to train personnel in the operation, maintenance, testing, and inspection of the HCVS design and water management strategy, if implemented appropriately, appears to be consistent with NEI 13-02 guidance, as endorsed by JLD-ISG-2013-02 and JLD-ISG-2015-01, and should adequately address the requirements of the order.

6.0 CONCLUSION

In June 2014, the NRC staff started audits of the licensee's progress in complying with Order EA-13-109. The staff issued an ISE for implementation of Phase 1 requirements on February 12, 2015 [Reference 13], an ISE for implementation of Phase 2 requirements on August 2, 2016 [Reference 14], and an audit report on the licensee's responses to the ISE open items on May 4, 2018 [Reference 15]. The licensee reached its final compliance date on May 9, 2018, and has declared that Hope Creek is in compliance with the order, in letter dated July 25, 2018 [Reference 16].

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance that includes the safe operation of the HCVS design and a water management strategy that, if implemented appropriately, should adequately address the requirements of Order EA-13-109.

7.0 REFERENCES

1. Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," June 6, 2013 (ADAMS Accession No. ML13143A321)

2. Letter from PSEG Nuclear LLC to NRC, "Hope Creek Generating Station – Phase 1 Overall Integrated Plan in Response to June 6, 2013, Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions Phase 1 (Order Number EA-13-109)," dated June 25, 2014 (ADAMS Accession No. ML14177A508)

3. Letter from PSEG Nuclear LLC to NRC, "First Six-Month Status Report For Phase 1 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order Number EA-13-109)," dated December 19, 2014 (ADAMS Accession No. ML14353A076)

4. Letter from PSEG Nuclear LLC to NRC, "Second Six-Month Status Report For Phase 1 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order Number EA-13-109)," dated June 18, 2015 (ADAMS Accession No. ML15173A026)

5. Letter from PSEG Nuclear LLC to NRC, "Hope Creek Generating Station – Phase 1 (Updated) and Phase 2 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order EA-13-109)," dated December 28, 2015 (ADAMS Accession No. ML15362A580)

6. Letter from PSEG Nuclear LLC to NRC, "Fourth Six-Month Status Report For Phases 1 and 2 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order Number EA-13-109)," dated June 29, 2016 (ADAMS Accession No. ML16181A210)

7. Letter from PSEG Nuclear LLC to NRC, "Fifth Six-Month Status Report For Phases 1 and 2 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order Number EA-13-109)," dated December 22, 2016 (ADAMS Accession No. ML16358A254)

8. Letter from PSEG Nuclear LLC to NRC, "Sixth Six-Month Status Report For Phases 1 and 2 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order Number EA-13-109)," dated June 27, 2017 (ADAMS Accession No. ML17178A300)

9. Letter from PSEG Nuclear LLC to NRC, "Seventh Six-Month Status Report For Phases 1 and 2 Overall Integrated Plan in Response to June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation

Under Severe Accident Conditions (Order Number EA-13-109)," dated December 19, 2017 (ADAMS Accession No. ML17354A772)

10. Nuclear Regulatory Commission Audits of Licensee Responses to Phase 1 of Order EA-13-109 to Modify Licenses With Regard To Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions, dated May 27, 2014 (ADAMS Accession No. ML14126A545)

11. Nuclear Regulatory Commission Audits of Licensee Responses to Phase 2 of Order EA-13-109 to Modify Licenses With Regard To Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions, dated August 10, 2017 (ADAMS Accession No. ML17220A328)

12. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195)

13. Letter from NRC to PSEG Nuclear LLC, "Hope Creek Generating Station– Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Phase 1 of Order EA-13-109 (Severe Accident Capable Hardened Vents)," dated February 12, 2015 (ADAMS Accession No. ML14332A154)

14. Letter from NRC to PSEG Nuclear LLC, "Hope Creek Generating Station- Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Phase 2 of Order EA-13-109 (Severe Accident Capable Hardened Vents)," dated August 25, 2016 (ADAMS Accession No. ML16223A853)

15. Letter from NRC to PSEG Nuclear LLC, "Hope Creek Generating Station– Report for The Audit of Licensee Responses to Interim Staff Evaluations Open Items Related to NRC Order EA-13-109 to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," dated August 2, 2016 (ADAMS Accession No. ML16103A320)

16. Letter from PSEG Nuclear LLC to NRC, "Hope Creek Generating Station, Report of Full Compliance with Phase 1 and Phase 2 of June 6, 2013 Commission Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (Order Number EA-13-109)," dated July 25, 2018 (ADAMS Accession No. ML18206A964)

17. SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 (ADAMS Accession No. ML111861807)

18. 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)

19. 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)

20. Order EA-12-050, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents," March 9, 2012 (ADAMS Accession No. ML12054A694)

21. SECY-12-0157, "Consideration of Additional Requirements for Containment Venting Systems for Boiling Water Reactors with Mark I and Mark II Containments", November 26, 2012 (ADAMS Accession No. ML12325A704)

22. SRM-SECY-12-0157, "Staff Requirements - SECY-12-0157, "Consideration Of Additional Requirements For Containment Venting Systems For Boiling Water Reactors With Mark I And Mark II Containments", March 19, 2013 (ADAMS Accession No. ML13078A017).

23. NEI 13-02, "Industry Guidance for Compliance with Order EA-13-109," Revision 0, November 12, 2013 (ADAMS Accession No. ML13316A853)

24. Interim Staff Guidance JLD-ISG-2013-02, "Compliance with Order EA-13-109, Severe Accident Reliable Hardened Containment Vents," November 14, 2013 (ADAMS Accession No. ML13304B836).

25. NEI 13-02, "Industry Guidance for Compliance with Order EA-13-109," Revision 1, April 23, 2015 (ADAMS Accession No. ML15113B318).

26. Interim Staff Guidance JLD-ISG-2015-01, "Compliance with Phase 2 of Order EA-13-109, Severe Accident Reliable Hardened Containment Vents," April 29, 2015 (ADAMS Accession No. ML15104A118).

27. NEI Industry White Paper – HCVS-WP-02, "Sequences for HCVS Design and Method for Determining Radiological Dose from HCVS Piping," Revision 0, October 30, 2014 (ADAMS Accession No. ML14358A038)

28. Letter from NEI to NRC, "Hardened Containment Venting System (HCVS) Phase 1 and 2 Overall Integrated Plan Template," Revision 1, dated September 28, 2015, and Frequently Asked Questions (FAQs) 10, 11, 12, and 13 (ADAMS Accession No. ML15273A141).

29. NEI Industry White Paper – HCVS-WP-04, "Missile Evaluation for HCVS Components 30 Feet Above Grade," Revision 0, August 17, 2015 (ADAMS Accession No. ML15244A923)

30. Appendix J to 10 Code of Federal Regulations Part 50, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors"

31. NEI Industry White Paper – HCVS-WP-03, "Hydrogen/Carbon Monoxide Control Measures," Revision 1, October 2014 (ADAMS Accession No. ML14295A442)

32. BWROG-TP-15-008, "BWROG Fukushima Response Committee, Severe Accident Water Addition Timing," September 2015

33. BWROG-TP-15-011, "BWROG Fukushima Response Committee, Severe Accident Water Management Supporting Evaluations," October 2015

34. PSEG Letter LRN16-0041, "HCGS Request for Relaxation from the Hardened Containment Vent Release Point Height Requirement," June 21, 2016 (ADAMS Accession No. ML16174A086)

35. PSEG Letter LRN16-0148, "Supplemental Information Regarding HCGS Request for Relaxation from the Hardened Containment Vent Release Point Height Requirement", September 7, 2016, (ADAMS Accession No. ML16251A309)

36. NRC Letter to PSEG, "HCGS Relaxation of the Release Point Height Requirement of NRC Order EA-13-109", September 30, 2016, (ADAMS Accession No. ML16256A655)

37. NRC Letter to PSEG, "Hope Creek Generating Station – Safety Evaluation Regarding Implementation of Mitigating Strategies And Reliable Spent Fuel Pool Instrumentation Related To Orders EA-12-049 And EA-12-051," June 30, 2017 (ADAMS Accession No. ML17125A266)

Principal Contributors: Rajender Auluck
Bruce Heida
Brian Lee
Kerby Scales
Kevin Roche
Steve Wyman
John Parillo

Date: December 6, 2018

SUBJECT: HOPE CREEK GENERATING STATION - SAFETY EVALUATION REGARDING IMPLEMENTATION OF HARDENED CONTAINMENT VENTS CAPABLE OF OPERATION UNDER SEVERE ACCIDENT CONDITIONS RELATED TO ORDER EA-13-109 DATED December 6, 2018

DISTRIBUTION:
PUBLIC
PBEB R/F
RidsNrrDorlLpl1 Resource
RidsNrrPMHopeCreek Resource
RidsNrrLaSLent Resource
RidsRgn1MailCenter Resource
NSanfilippo, NRR
RAuluck, NRR
BLee, NRR
RidsACRS_MailCTR Resource

ADAMS Accession No. ML18290A876

OFFICE	NRR/DLP/PBEB/PM	NRR/DLP/PBMB/LA	OGC	NRR/DLP/PBEB/BC
NAME	RAuluck	SLent	BHarrris	NSanfilippo
DATE	10/22/18	10/22/18	11/2/18	12/6/18

OFFICIAL RECORD COPY