STAFF'S SAFETY EVALUATION REPORT WITH OPEN ITEMS NUSCALE DCA, CHAPTER 20, "MITIGATION OF BEYOND-DESIGN-BASIS EVENTS"

SPECIAL NOTE: This PRELIMINARY PHASE 2 CHAPTER 20 SAFETY EVALUATION (SE), is based on Chapter 20 of the NuScale design certification application, Rev. 2. However, NuScale plans to revise this chapter of the application. Accordingly, this SER chapter, while useful for illuminating the issues unique to the review of mitigation strategies for the NuScale design, may not reflect the NuScale revised approach and associated NRC review of that revised approach.

This chapter of the safety evaluation report (SER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's (staff) evaluation of the mitigation strategies proposed in NuScale Power LLC's (the applicant's) design certification application (DCA) in anticipation of certain requirements being codified in Title 10 of the Code of Federal Regulations (10 CFR) 50.155, "Mitigation of beyond-design-basis events." The rule makes Order EA-12-049 and Order EA-12-051 generically applicable. Because NuScale submitted the DCA before the Commission decided to adopt the requirements in 10 CFR 50.155, the applicant wrote the DCA in terms of the two Orders. Although the recently approved regulation in 10 CFR 50.155 does not apply to applicants for design certification, NuScale is voluntarily seeking the NRC's approval of its proposal to use installed design features for mitigation of beyond-design-basis external events. When the rule becomes effective, a new section in the rule, 10 CFR 52.80(d), will require an applicant for a combined license (COL) under Part 52 to describe in its application how the application satisfies the rule. Accordingly, the staff review, as documented in this SER chapter, is written in terms of the requirements stated in 10 CFR 50.155.

20.1 Mitigating Strategies for Beyond Design-Basis External Events

20.1.1 Determining Applicable Extreme External Hazards

20.1.1.1 *Introduction*

In this section of the SER, the staff evaluates whether the equipment and ultimate heat sink (UHS) that are credited and utilized in the mitigation strategies for beyond-design-basis external events (BDBEE) are reasonably protected and will be available following BDBEE. The staff also reviewed the structures credited to provide protection for installed mitigation equipment and cooling inventories with regard to whether they are designed to be robust consistent with the guidelines in Nuclear Energy Institute (NEI) 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 2.

20.1.1.2 *Summary of Application*

DCA Part 2, Tier 1: None

DCA Part 2, Tier 2: In DCA Part 2, Tier 2, Section 20.1.1, "Determining Applicable Extreme External Hazards," the applicant considered seismic, flooding, high winds (including applicable missiles), snow, ice, and extreme temperatures hazards for BDBEE. DCA Part 2, Tier 2, Section 20.1.2, "Extended Loss of AC and Loss of Ultimate Heat Sink Design Assessment," discusses how the NuScale design maintains core cooling, containment, and spent fuel pool (SFP) cooling following an extended loss of alternating current (ac) power (ELAP) and loss of normal access to the ultimate heat sink (LUHS) event. The applicant in DCA Part 2, Tier 2, Section 20.1.2.2.2, "Applicable Systems, Structures, and Components," stated, in part, that the LUHS, as defined in NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," is not plausible, and the UHS is credited for maintaining the key safety functions.

ITAAC: None

Technical Specifications: There are no Technical specifications applicable to the BDBEE.

Technical Reports: TR-0816-50797, Revision 0, "Mitigation Strategies for Extended Loss of AC Power Event," incorporated by reference in DCA Part 2, Tier 2, Chapter 20.1, Revision 2.

20.1.1.3 *Regulatory Basis*

The regulatory basis for the staff's review of BDBEE mitigation strategies consists of the following guidance documents:

- The Japan Lesson-Learned Project Directorate Interim Staff Guidance (JLD-ISG)-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for BDBEE," (ML15357A163), provides guidance regarding BDBEE mitigation strategies, and endorses with exceptions, additions, and clarifications, the methodologies described NEI 12–06, Revision 2, (ML16005A625). Because 10 CFR 50.155 codifies the requirements in Order EA-12-049, JLD-ISG-2012-01, Rev. 1 also applies to the corresponding requirements of that regulation.

- NEI 12-06, Revision 2, guidance provides an acceptable means of meeting the requirements of Order EA-12-049, with exceptions, additions, and clarifications described in JLD-ISG-2012-01, Revision 1. In addition, NEI 12-06, Revision 2, provides an approach for diverse and flexible mitigation strategies (FLEX) that will increase defense-in-depth for BDBEE scenarios to address an ELAP and LUHS occurring simultaneously at all units on a site. Because 10 CFR 50.155 codifies the requirements in Order EA-12-049, NEI 12-06, Rev. 2, also applies to the requirements of that regulation.

- NEI 12-02, Revision 1, "Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable Spent Fuel Pool (SFP) Instrumentation," as it relates to SFP instruments. Because 10 CFR 50.155 codifies the requirements in Order EA-12-051, NEI-12-01, Rev. 1, also applies to the corresponding requirements of that regulation.

20.1.1.4 *Technical Evaluation*

The staff reviewed whether the equipment and UHS that are credited and utilized in the mitigation strategies for BDBEE are adequately protected and will be available following BDBEE. The staff also reviewed whether the structures credited to provide protection for installed mitigation equipment and cooling inventories are designed to be robust. The NEI 12-06, Appendix A, defines "robust design" as the design of a structure, system, and component (SSC) that either meets the current plant design basis for the applicable external hazard(s) or the current NRC design guidance for the applicable hazard (e.g., Regulatory Guide (RG) 1.76, Revision 1); or has been shown by analysis or test to meet or exceed the current design basis.

Section 50.155(c)(ii) specifies that equipment used for mitigation strategies must be protected from external events. The staff conducted its review following the guidance provided in Interim Staff Guidance JLD-ISG-2012-01, Revision 1, that endorsed industry Guidance in NEI 12-06, Revision 2. NEI 12-06 provides criteria for the storage and protection of equipment used for FLEX mitigation strategies for applicable site-specific external events.

In Section 20.1.3.1, the applicant stated that Phase 1 of the FLEX mitigation strategies relies on installed plant equipment. NEI 12-06, Section 3.2, addresses a baseline assumption that installed plant equipment associated with FLEX strategies is fully available following a design-basis external event and addresses an initial condition that permanent plant equipment is available and contained in structures with a robust design against seismic events, floods, high winds, and associated missiles.

Evaluation of External Hazards

NEI 12-06, Section 4.1, identifies seismic, external flooding, high winds (including applicable missiles), snow, ice, and extreme cold and high temperatures as site-specific external hazards. NEI 12-06 further states that the installed plant equipment and onsite portable equipment used for mitigation must be protected against the above external hazards. According to NEI 12-06, Revision 2, such equipment should be designed to be robust and housed in robust buildings.

The DCA Part 2, Tier 2, Section 20.1.1 identifies combined license (COL) Item 20.1-1 through COL Item 20.1-5, to address the site-specific external hazards. In COL Items 20.1-1 – 20.1-5, the applicant stated that the COL applicant that references the NuScale design is required to ensure that equipment and structures credited for FLEX strategies are designed to be available following a site-specific seismic hazard and other applicable site-specific external flood, high winds/missile protection, snow, ice and extreme cold, and high temperature hazards. In Section 3.0 of TR-0816-50797, the applicant identified the following NuScale DCA sections for the design criteria for the above external hazards.

- Seismic events are addressed in DCA Part 2, Tier 2, Section 3.7.1, “Seismic Design Parameters.”
- External flooding is addressed in DCA Part 2, Tier 2, Section 3.4.2, “Protection of Structures Against Flood from External Sources.”
- Storms such as hurricanes, high winds, and tornadoes (including missiles) are addressed in DCA Part 2, Tier 2, Sections 3.3, “Wind and Tornado Loadings,” and 3.5, “Missile Protection.”
- Snow and ice storms are addressed in DCA Part 2, Tier 2, Section 3.8.4, “Other Seismic Category I Structures.”
- Extreme cold and heat are addressed in DCA Part 2, Tier 2, Table 2.0-1, “Site Design Parameters.”

The staff reviewed and documented its safety findings in Section 3.8 of the SER for the seismic Category I Reactor Building (RXB) and Control Building (CRB) structures for the design basis external hazards identified above. Based on the staff review documented in Section 3.8 of this SER, the staff concludes that the seismic Category I RXB and CRB structures are adequately designed against these design basis external hazards.

For site-specific hazards, NuScale states that the COL applicant will determine the applicability of site-specific hazards. If the design criteria specified in the NuScale DCA does not bound the expected site-specific hazards, then the COL applicant will address the expected external hazards in its FLEX strategies. The staff will review the site-specific external hazards in the COL applications.

Protection of Equipment

The NuScale DCA Part 2, Tier 2, Section 20.1 describes mitigating strategies for BDBEE and states that the FLEX equipment credited in the mitigation strategies is required to be available following BDBEE. In Section 9.0 of TR-0816-50797-P, Revision 0, the applicant stated that the installed credited FLEX equipment is safety-related and the RXB and CRB structures are credited to provide protection and storage for mitigation equipment and cooling inventories. In Section 3.0 of TR-0816-50797, the applicant stated that the inherent coping time of the NuScale Power Plant design is greater than 72 hours, which is significant time to transport equipment from an off-site or remote storage location.

In the DCA, Tier 2, Section 20.1.2, the applicant provided a design assessment of safety functions following a simultaneous ELAP and LUHS event. TR-0816-50797-P, Revision 0, discusses strategies to mitigate an ELAP and addresses the requirements and guidance for the COL applicant. The applicant referenced Interim Staff Guidance JLD-ISG-2012-01 for developing guidance, implementing, and maintaining mitigation strategies, and NEI 12-06 methodology to establish baseline coping capability. The applicant's approach to protect the FLEX equipment from external hazard is consistent with the guidance in NEI 12-06, Revision 2, Section 5.3.1, "Protection of FLEX Equipment," which states that the FLEX equipment should be stored in a structure that meets the plant's design basis and that SSCs should be evaluated and protected from seismic interactions to ensure that unsecured and/or non-seismic components do not damage the equipment. The staff's guidance in JLD-ISG-2012-01, Revision 1, provides an acceptable method for protecting the equipment from external event as described in Section 5 to NEI 12-06, Revision 2.

In Section 5.0 of TR-0816-50797-P, Revision 0, the applicant provided a description of the structures credited for protection of permanent plant equipment and included classifications, locations, and structural functions credited for protection. The RXB and CRB structures are classified as seismic Category I structures that are designed to withstand the effect of an applicable design basis external event including seismic events, external floods, and high winds and associated missiles so that the permanent plant equipment credited for NuScale mitigation strategies remains protected from the event. In Section 5.11 of TR-0816-50797-P, Revision 0, the applicant provided a description of the UHS system that is credited for core cooling and SFP cooling and makeup water. The UHS pool walls and pool liner are designed to seismic Category I requirements and are completely contained within the seismic Category I RXB.

For site-specific hazards, the applicant stated that the COL applicant will confirm and ensure that equipment and structures credited for FLEX strategies are designed to be available following applicable site-specific external hazards. The applicant identified seismic, external flooding, high winds (including applicable missiles), snow, ice, and extreme cold and high temperatures as site-specific external hazards. As described in DCA Part 2, Tier 2, Section 20.1, COL Items 20.1-1 through COL 20.1-5, COL applicants referencing NuScale design will need to ensure that equipment and structures credited for FLEX strategies are designed to be available following a site-specific seismic hazard and other applicable site-specific external flood, high winds/missile protection, snow, ice and extreme cold, and high temperature hazards.

In the design of seismic Category I structures that house plant equipment and are credited for NuScale mitigation strategies, the applicant also considered potential adverse seismic interaction effects between these structures with SSCs that are not seismic Category I. The RXB and CRB are seismic Category I structures that are credited to provide protection and storage for mitigation equipment and cooling inventories. With regards to potential adverse seismic interaction effects between seismic Category I SSCs and SSCs that are not seismic Category I, the applicant in DCA Part 2, Tier 1, Sections 3.11 and 3.13 for the RXB and CRB respectively, committed to ensure that where a potential for adverse seismic interaction exists, the SSCs that are not seismic Category I will not impair the ability of seismic Category I SSC to perform their safety functions during or following a safe shutdown earthquake (SSE).

Simultaneous ELAP and LUHS Event

In Section 5.11.3 of TR-0816-50797-P, Revision 0, the applicant stated that the UHS is the only plant system heat sink credited for coping with ELAP. The UHS is a large pool of water consisting of the combined water volume of the reactor pool, the refueling pool, and the SFP, and is housed in the RXB. The UHS pool walls and pool liner are designed to seismic Category I requirements. The RXB is a safety-related, seismic Category I building and is designed to withstand design basis external events including earthquakes, floods, high winds (including associated missiles), and extreme temperatures. NEI 12-06 defines a LUHS as the loss of ability to provide a forced flow of water, i.e., loss of service water or circulating water pump with no prospect of recovery; under this definition, the loss of the NuScale UHS is not plausible because the NuScale UHS does not employ any service water or circulating water pumps.

The staff reviewed seismic Category I RXB and CRB structures including UHS which provide protection to on-site installed FLEX equipment and provided its safety evaluation findings in Section 3.8 of the SER. Based on the staff review documented in SER Section 3.8, the staff concludes that the seismic Category I RXB and CRB structures are adequately designed for the design basis external hazards.

The staff also reviewed NuScale DCA Part 2, Tier 2, Section 20.1, for provisions to assure seismic, environmental, and functional capability of active mechanical equipment to perform its intended function as part of the mitigation strategies to ensure core cooling, containment function, and SFP cooling capabilities during an ELAP resulting from a BDBEE. The staff issued several requests for additional information (RAIs) to NuScale to resolve staff questions on the information provided in the DCA submittal. In its response to the RAIs, the applicant revised the DCA to clarify specific information with respect to mitigation strategies to ensure core cooling, containment function, and SFP cooling capabilities during an ELAP resulting from a BDBEE. In general, in this Section of the SER, the staff documents its review of the revised DCA information and its compliance with the applicable NRC regulations.

The NuScale mitigating strategies utilize installed active valves but does not utilize installed pumps or dynamic restraints.

NuScale DCA Part 2, Tier 2, Section 20.1.2.2, identified the following valves credited to maintain the key safety functions following BDBEE that results in an ELAP event. The key safety functions are maintaining core cooling, containment and SFP cooling capabilities.

1. Containment isolation valves (CIVs), which isolate the Containment Vessel (CNV), fail-safe to their closed position.

2. The decay heat removal system (DHRS) actuation valves fail-safe to the open position, and the main steam isolation valves (MSIVs) and feedwater isolation valves (FWIVs) fail-safe to the closed position to place the DHRS passive condensers in service.

3. The emergency core cooling system (ECCS) valves that are designed fail-safe to their open position.

The staff review is described in the following paragraphs.

As a result of the staff RAIs, the applicant supplemented the original DCA information to identify all safety-related installed valves credited in the mitigation strategies and the provisions for design, manufacture, testing, installation, and surveillance to provide assurance of the seismic, environmental, and functional capability of all safety-related installed valves to perform their intended functions as part of the mitigation strategies to ensure core cooling, containment function, and SFP cooling capabilities during an ELAP (ML17304B482). The applicant also provided supplemental information to indicate whether any safety-related valves (including appurtenances) used as part of the mitigating strategies for an ELAP will have performance requirements that exceed their original safety-related design and performance specifications. The applicant stated that DCA Part 2, Tier 2, Section 20.1, credits valves in the CNTS (CIVs), DHRS, and ECCS, and DCA Part 2, Tier 2, Table 3.2-1, provides information on classification, seismic category, and quality group classification for the system valves. The applicant also stated that none of the valves have performance requirements that exceed their safety-related design and performance criteria. The staff verified that all safety-related valves credited for the mitigation strategies are listed in DCA Part 2, Tier 1, Table 2.8-1, “Equipment Qualification,” and that ITAAC 1, 3, and 6 in DCA Part 2, Tier 1, Table 2.8-2, specify seismic, environmental qualification, and functional qualification for these valves. The staff also verified that these valves are included in the inservice testing program (IST) described in DCA Part 2, Tier 2, Section 3.9.6, “Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints.” Based on the above, the staff finds that the applicant identified all safety-related installed valves credited in the mitigation strategies and described provisions to assure seismic, environmental, and functional capability of the safety-related installed valves to perform their intended functions as part of the mitigation strategies to ensure core cooling, containment function, and SFP cooling capabilities during an ELAP event at a NuScale nuclear power plant.

The applicant provided supplemental information to identify all installed valves that are not safety-related but are credited in the mitigation strategies and provisions for design, manufacture, testing, installation, and surveillance to provide assurance of the seismic, environmental, and functional capability of all such valves to perform their intended functions as part of the mitigation strategies to ensure core cooling, containment function, and SFP cooling capabilities during an ELAP (ML17304B482). The applicant stated that valves that are not safety-related are not relied upon to maintain key safety functions following an ELAP. The staff finds the applicant’s response acceptable because the design relies only on safety-related valves to maintain the key safety functions and the valve designs include provisions to assure seismic, environmental, and functional capability of the safety-related installed valves to perform their intended functions as part of the mitigation strategies to ensure core cooling, containment integrity, and SFP cooling capabilities during an ELAP.

20.1.1.5 *Combined License Information Items*

The DCA Part 2, Tier 2, Section 20.1 list the following COL information items for COL applicants to address the mitigation strategies:

Table 20.1-1 NuScale Combined License Information Items for Section 20.1

Item No.	Description	DCA Part 2, Tier 2 Section
20.1-1	A COL applicant that references the NuScale Power Plant design certification will ensure equipment and structures credited for FLEX strategies are designed to be available following a site-specific seismic hazard.	20.1
20.1-2	A COL applicant that references the NuScale Power Plant design certification will determine if a flood hazard is applicable at the site location. If a flood hazard is applicable, then the COL applicant will ensure equipment and structures credited for FLEX strategies are designed to be available following a site-specific flood (including wave action) hazard.	20.1
20.1-3	A COL applicant that references the NuScale Power Plant design certification will determine if high wind and applicable missile hazards are applicable at the site location. If high wind and applicable missile hazards are applicable, then the COL applicant will ensure equipment and structures credited for FLEX strategies are designed to be available following a site-specific high wind and applicable missile hazards.	20.1
20.1-4	A COL applicant that references the NuScale Power Plant design certification will determine if snow, ice and extreme cold temperature hazards are applicable at the site location. If snow, ice and extreme cold hazards are applicable, the COL applicant will ensure equipment and structures credited for FLEX strategies are designed to be available following a site-specific snow, ice or extreme cold temperature hazard.	20.1
20.1-5	A COL applicant that references the NuScale Power Plant design certification will determine if extreme high temperature hazard is applicable at the site location. If extreme high temperature hazard is applicable, the COL applicant will ensure equipment and structures credited for FLEX strategies are designed to be available following a site-specific extreme high temperature hazard.	20.1

The staff has determined that the proposed COL items are appropriate because the COL applicant will determine the site-specific external hazards and to ensure that the on-site installed equipment and structure credited for FLEX strategies are protected and available following a BDBEE.

20.1.1.6 *Conclusion*

The staff evaluated NuScale DCA, Tier 2, Section 20.1, regarding equipment protection mitigation strategies for BDBEE. For the reasons described above, the staff finds that the applicant's approach is consistent with the guidance in NEI 12-06, Revision 2, for the storage and protection of equipment for FLEX mitigation strategies for applicable external hazards. All permanent installed, safety-related equipment and UHS that are credited and utilized in the mitigation strategies for BDBEE are housed inside the RXB and CRB. The RXB and CRB are safety-related seismic Category I structures and are designed for design basis external hazards including seismic events, floods, high winds and associated missiles. The staff's review and safety evaluation of the seismic Category I RXB and CRB structures for the design basis external hazards is provided in Section 3.8 of the SER that concludes that the design of these structures for design basis external hazards is acceptable.

Based on the above findings, the staff concludes that the structures credited to provide protection and storage for installed mitigation equipment and cooling inventories are designed to be robust in accordance with the guidelines in NEI 12-06. On this basis, the FLEX equipment and the UHS housed in the RXB and CRB credited in the mitigation strategies will be protected from the applicable external hazards, consistent with the provisions of 10 CFR 50.155(c)(ii), and will be available following BDBEE.

The staff also concludes that the provisions in the DCA for the seismic, environmental, and functional capability of active mechanical equipment to perform its intended function as part of the mitigation strategies to ensure core cooling, containment function, and SFP cooling capabilities during an ELAP resulting from a BDBEE are acceptable and meet the applicable NRC requirements and guidance. This conclusion is based on the applicant having specified provisions in the DCA that will ensure the active mechanical equipment will perform its intended function as part of the mitigation strategies to ensure core cooling, containment function, and SFP cooling capabilities during an ELAP resulting from a BDBEE. The applicant has also specified the appropriate actions for a COL applicant to address that are related to site-specific activities.

20.1.2 Extended Loss of AC Power and Loss of Ultimate Heat Sink Design Assessment

20.1.2.1 *Introduction*

The staff's review of the electric power systems available for BDBEE includes NuScale DCA Part 2, Tier 2, Chapter 20, "Mitigation of Beyond-Design-Basis Events," Revision 2, Section 20.1, "Mitigating Strategies for Beyond Design Basis External Event," and Technical Report (TR)-0816-50797-Proprietary, Revision 0, "Mitigation Strategies for Extended Loss of AC Power Event." The focus of the staff's review is on the capability and capacity of the NuScale electric power systems to mitigate the consequences of a BDBEE.

20.1.2.2 *Summary of Application*

DCA Part 2 Tier 1: None

DCA Part 2, Tier 2: In DCA Part 2, Tier 2, Section 20.1.1, "Determining Applicable Extreme External Hazards," the applicant considered seismic, flooding, high winds (including applicable missiles), snow, ice, and extreme temperatures hazards for BDBEE. DCA Part 2, Tier 2, Section 20.1.2, "Extended Loss of AC and Loss of Ultimate Heat Sink Design Assessment," discusses how the NuScale design maintains core cooling, containment function, and SFP cooling following an ELAP and LUHS event. In DCA Part 2, Tier 2 Section 20.1.2.2.2, "Applicable Systems, Structures, and Components," the applicant stated, in part, that the LUHS, as defined in NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," is not plausible, and the UHS is credited for maintaining the key safety functions.

ITAAC: None

Technical Specifications: There are no TS applicable to the BDBEE.

Technical Report (TR): TR-0816-50797, Revision 0, “Mitigation Strategies for Extended Loss of AC Power Event,” incorporated by reference in DCA Part 2, Tier 2, Chapter 20.1, Revision 2.

20.1.2.3 *Regulatory Basis*

The regulatory basis for the staff’s review of BDBEE mitigation strategies consists of the following guidance documents:

- The Japan Lesson-Learned Project Directorate Interim Staff Guidance (JLD-ISG)-2012-01, Revision 1, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for BDBEE,” (ML15357A163) dated January 22, 2016, provides guidance regarding BDBEE mitigation strategies, and endorses with exceptions, additions, and clarifications, the methodologies described NEI 12–06, Revision 2, (ML16005A625), dated December, 2015. Because 10 CFR 50.155 codifies the requirements in Order EA-12-049, JLD-ISG-2012-01, Rev. 1 also applies to the corresponding requirements of that regulation.

- NEI 12-06, Revision 2, guidance provides an acceptable means of meeting the requirements of Order EA-12-049, with exceptions, additions, and clarifications described in JLD-ISG-2012-01, Revision 1. In addition, NEI 12–06, Revision 2, provides an approach for diverse and flexible mitigation strategies (FLEX) that will increase defense-in-depth for BDBEE scenarios to address an ELAP and LUHS occurring simultaneously at all units on a site. Because 10 CFR 50.155 codifies the requirements in Order EA-12-049, NEI 12-06, Rev. 2, also applies to the corresponding requirements of that regulation.

- NEI 12-02, Revision 1, “Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable Spent Fuel Pool (SFP) Instrumentation,” as it relates to SFP instruments. Because 10 CFR 50.155 codifies the requirements in Order EA-12-051, NEI 12-02, Rev. 1 also applies to the corresponding requirements of that regulation.

20.1.2.4 *Technical Evaluation*

Background

This section of the safety evaluation addresses electric power for equipment needed to maintain key safety functions during a BDBEE. JLD-ISG-2012-01, Revision 1, stated that the purpose of establishing mitigation strategies for BDBEE is to maintain or restore key safety functions, which include core cooling, containment function, and SFP cooling. A three-phased approach described in JLD-ISG-2012-01, Revision 1, and NEI 12-06, Revision 2, includes an initial phase (Phase 1), which relies on plant equipment, the transition phase (Phase 2) which relies on onsite FLEX equipment, and final Phase (Phase 3) which relies on offsite equipment and consumables. The applicant explained that TR-0816-50797-P, Revision 0, provides an assessment of the NuScale Power Plant response to an ELAP event, and addresses the COL applicant actions and guidance for developing the site-specific FLEX mitigating strategies.

Based on the NuScale design being inherently different from the assumptions or design features considered in the development of the strategies detailed in NEI 12-06, the applicant provided an alternative method to NEI 12-06 for satisfying the intent of JLD-ISG-2012-01. In DCA Part 2, Tier 2, Section 20.1.3.2, "Phase 2," the applicant stated that a FLEX strategy for a transition phase is not needed for the NuScale Power Plant design and the coping time utilizing installed plant equipment is greater than 72 hours.

The staff evaluated the proposed mitigation strategy in regard to monitoring of plant conditions for the first 72 hours after a beyond-design-basis external event. The application, however, does not provide for monitoring of the plant conditions after an initial 72 hours period. Accordingly, the staff is limiting its review of this topic to the first 72 hours after a beyond-design-basis external event.

JLD-ISG-2012-01, Revision 1, states that Section 3 of NEI 12-06, Rev. 2, provides performance attributes, general criteria, and baseline assumptions for use in the development and implementation of the strategies and guidelines. JLD-ISG-2012-01, Revision 1, also states that NEI 12-06, Revision 2, provides criteria and assumptions for analyses to establish a baseline coping capability. Furthermore, JLD-ISG-2012-01, Revision 1, explains that assumptions described in NEI 12-06 Section 3.2.1.3, "Initial Conditions," include a loss-of-offsite power (LOOP) affecting all units at a plant site and the specification that "design-basis installed sources of emergency on-site ac power and station blackout (SBO) alternate ac power sources are assumed to be not available and not imminently recoverable." The staff's review of the baseline coping capability assumptions described in TR-0816-50797-P, Revision 0, corresponding to the assumptions in NEI 12-06, Revision 2, Section 3.2.1.3, is discussed below.

Electrical Power System Evaluation

The following staff review is limited to the first 72 hours of a BDBEE.

Section 3.2.1.3, of the NEI 12-06 lists initial plant conditions and assumptions that should be utilized in developing FLEX mitigating strategies. The applicant provided the NEI 12-06, Section 3.2.1.3, list of initial event conditions and assumptions in TR-0816-50797, Revision 0, Section 4.2.3, and stated that NEI 12-06 provides a generic list of event initial conditions and assumptions to apply while determining the baseline coping capability.

In TR-0816-50797-P, Revision 0, Section 4.2, "Baseline Coping Capability Criteria, Conditions, and Assumptions," the applicant stated, "baseline coping assumptions have been established on the presumption that other than the ELAP and the LUHS: 1) plant equipment that is designed to be robust, with respect to design basis external events, is assumed to be fully available, and 2) plant equipment that is not robust is assumed to be unavailable." The staff understands that in addition to considering an ELAP and LUHS, the plant equipment relied upon is robust with respect to design basis external events. In TR-0816-50797-P, Revision 0, Table 1-2, "Definitions," the applicant defined robust as the design of SSC either meets the current plant design basis for the applicable external hazards, or the current NRC design guidance for the applicable hazard (e.g., RG 1.76, Revision 1), or has been shown by analysis or test to meet or exceed the current design basis.

TR-0816-50797-P, Revision 0, Section 4.2.3, "Initial Event Conditions and Assumptions," states that initial event assumption Number 1 assumes a LOOP from an external event with no prospect for recovery of the offsite power for an extended period. In TR-0816-50797-P, Revision 0, Section 5.3.2, "System Response to an Extended Loss of Alternating Current Power," the applicant stated, in part, that 13.8 kilo-Volt (kV) and switchyard system (EHVS), medium voltage ac electrical distribution system (EMVS), and low voltage ac electrical distribution system (ELVS) are assumed to be unavailable per initial event assumption Number 1 following a BDBEE.

TR-0816-50797-P, Revision 0, Section 4.2.3, initial event assumptions Number 3, 7, and 9; shown below; relate to the electric power systems:

- Item 3 states that station batteries and associated direct current (dc) buses along with ac power from buses fed by station batteries through inverters remain available.
- Item 7 states that plant equipment that is contained in structures with designs that are robust for the applicable hazard is available.
- Item 9 states that installed electrical distribution system, including inverters and battery chargers, remain available provided they are protected consistent with current station design.

In Section 5.11.3 of TR-0816-50797-P, Revision 0, the applicant stated that the UHS is the only plant system heat sink credited for coping with ELAP. The UHS is a large pool of water consisting of the combined water volume of the reactor pool, the refueling pool, and the SFP and is housed in the RXB. In DCA Part 2, Tier 2, Section 20.1, the applicant explained that power is needed for four UHS level instruments during a BDBEE scenario and is provided from the EDSS-C. In DCA Part 2, Tier 2, Section 20.1.4, “Spent Fuel Pool and Reactor Pool Level Instrumentation,” the applicant stated that the UHS level instruments and their power supplies are physically and electrically separated and independent. In DCA Part 2, Tier 2 Section 20.1.4.2, “Description,” the applicant stated that “power to the redundant level instruments is from separate bus sources such that the loss of one supply will not result in a loss of power supply function to both divisions of UHS level instrumentation.” In addition, DCA Part 2, Tier 2 Section 20.1.2.2, “Applicable Systems, Structures, and Components,” states, in part, that the four level instruments are used to monitor the UHS and SFP with two level instruments positioned in the SFP area, one level instrument in the refueling pool (RFP) area, and one level instrument is positioned in the reactor pool (RP) area.

The applicant stated in TR-0816-50797-P, Revision 0, Section 5.6.3, “System Response to an Extended Loss of Alternating Current Power,” that per Section 4.2.3 initial event assumptions Numbers 3, 7, and 9, the highly reliable direct current power system (EDSS) batteries and the associated distribution system are assumed to survive the BDBEE and remain fully available. TR-0816-50797-P, Revision 0, Section 5.6.1, “System Design,” states that the EDSS is the source of 125 Volts dc power to plant loads such as the module protection system (MPS), plant protection system (PPS), neutron monitoring system, safety display and indication system (SDIS), and main control room (MCR) emergency lighting. TR-0816-50797-P, Revision 0, Section 5.6.1, further states that the EDSS design consists of two separate and independent portions; the EDSS-common (EDSS-C), and the EDSS – module specific (EDSS-MS). The EDSS-MS and EDSS-C structures, systems, and components are qualified to seismic Category I standards and are located within seismic Category I areas of the RXB and CRB.

The initial conditions and assumptions in the NEI 12-06, Revision 2, and JLD-ISG-2012-01, Revision 1, assume that station batteries, which are usually safety-related (i.e., qualified to seismic Category I standards, would remain available following a BDBEE since they are considered robust. While the EDSS batteries are not “safety-related,” this assumption is supported by the NuScale baseline coping capability described in TR-0816-50797-P, Revision

0, Section 4.2 which assumes that plant equipment that is designed to be robust with respect to design basis external events is assumed to be fully available for BDBEE. This is due to the station batteries and associated direct current power system components being qualified to seismic Category I standards and installed in Class I structures that are considered robust. Therefore, the staff finds that the initial assumptions described in TR-0816-50797-P, Revision 0, Section 5.6.3 following a BDBEE are consistent with the NEI 12-06, Revision 2, guidance, which is endorsed by JLD-ISG-2012-01, Revision 1. COL Items 20.1-1, 20.1-2, 20.1-3, 20.1-4, and 20.1-5, described in DCA Part 2, Tier 2, Section 20.1 are provided to ensure equipment and structures credited for FLEX strategies are designed to be available following a site-specific hazard for the COL applicant that references the NuScale design certification.

In DCA Part 2, Tier 2, Section 8.3.2, "Direct Current Power Systems," the applicant noted that the 72-hour battery duty cycle for the EDSS-C provides a minimum of 72 hours of power for equipment supporting Post Accident Monitoring (PAM). In response to a BDBEE, TR-0816-50797-P, Revision 0, Section 5.6.1, states, in part, that the EDSS-C provides power to the instrumentation and controls equipment to track PAM variables. The PAM variables are provided in TR-0816-50797-P, Revision 0, Section 5.9, "SDIS," and include SFP water level, which is monitored by the UHS instruments following a BDBEE. The staff's review and evaluation on EDSS capability and capacity, including EDSS-C, is in Section 8.3.2 of this report. Based on the above and the staff's evaluation documented in Section 8.3.2 of this safety evaluation, the staff finds that EDSS-C will be available following a BDBEE and has the capacity to support the PAM loads for a minimum of 72 hours.

The UHS level instruments power supplies, the EDSS-C, are physically and electrically separated and independent, as described in DCA Part 2, Tier 2, Section 20.1.4. The staff evaluated the separation measures of the EDSS in Section 8.3.2 of this report. DCA Part 2, Tier 2, Section 20.1.4.2 states that associated cabling of the UHS instruments is protected by both physical and electrical separation such that a failure in one channel will leave another channel functional. The staff's evaluation of electrical separation is in Section 8.3 of this report.

EDSS-C also provides power for emergency lighting. The evaluation pertaining to emergency lighting is discussed in Section 9.5.3 of this report.

In DCA, Tier 2, Section 20.1.2.2, the applicant stated that DHRS actuation valves are designed fail-safe which use stored energy and do not require any operator actions or electric power to perform this function. In the fail-safe position, the DHRS passive condensers are in service and closed natural circulation loop is established transferring core decay heat to the UHS. ECCS valves are designed fail-safe to their open position and do not require any operator actions or electric power to perform this function. In the fail-safe position, a closed natural circulation loop is established in which decay heat is transferred from the core to the UHS. Therefore, the staff did not need to perform a review of electrical systems for the purpose of establishing core cooling since the NuScale design is such that core cooling can be accomplished passively during a BDBEE with transfer of heat to the UHS.

Based on the above, the staff finds that the NuScale electrical power system has adequate capability and capacity to support the first 72 hours of mitigation strategies for BDBEE, and is consistent with the NEI 12-06, Revision 2, and JLD-ISG-2012-01, Revision 1, guidance.

20.1.2.5 *Combined License Information Items*

NuScale has proposed COL Item 20.1-8 for a COL applicant to address the development of procedures, training and qualification program for operations, maintenance, testing and calibration of UHS level instruments.

Table 20.1-2 NuScale Combined License Information Items for Section 20.1

Item No.	Description	DCA Part 2, Tier 2 Section
20.1-8:	A COL applicant that references the NuScale Power Plant design certification will develop procedures, training, and a qualification program for operations, maintenance, testing, and calibration of ultimate heat sink level instrumentation to ensure the level instruments will be available when needed and personnel are knowledgeable in interpreting the information as addressed in Nuclear Energy Institute (NEI) 12-02.	20.1

The staff reviewed the COL item and determined that developing qualification program for operations, maintenance, testing, and calibration of ultimate heat sink level instrumentation is the responsibility of the COL applicant and this COL item will ensure that the COL applicant will address these requirements of 10 CFR 50.155(e).

20.1.2.6 *Conclusion*

The staff has reviewed the first 72 hours of the mitigation strategies for BDBEE that is applicable to the NuScale electric power system design and evaluated its conformance with relevant NRC guidance in JLD-ISG-2012-01, Revision 1. Based on the review above, the staff concludes that the design conforms to the applicable guidance, as it relates to the capability and capacity of the NuScale electric power systems to mitigate the consequences of a BDBEE for 72 hours following a BDBEE. The application does not include information regarding whether the electric power system capability and capacity conforms with NRC guidance in JLD-ISG-2012-01, Revision 1, in the period after 72 hours following a BDBEE. Accordingly, the staff finding is limited to 72 hours following a beyond-design-basis external event.

20.1.3 Mitigating Strategies for an Extended Loss of AC Power Event

20.1.3.1 *Introduction*

Following the Fukushima Dai-Ichi event, the Commission established additional requirements to manage and mitigate external events that are beyond the design basis of a nuclear plant. These are found in NRC Commission paper 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,” (ML12039A103). The staff followed the guidance for satisfying the Commission directives regarding BDBEE mitigation strategies in Japan Lesson-Learned Project Directorate JLD-ISG-2012-01, Revision 1, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” (ML15357A271), which endorsed with clarifications the methodologies described in NEI 12–06, Revision 2, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” (ML16005A625).

DCA Part 2, Tier 2, Section 20.1 addresses the mitigation strategies for an extended ELAP and LUHS resulting from a BDBEE. The DCA indicates that NuScale plant is designed to maintain core cooling, containment, and SFP cooling capabilities independent of ac or dc power sources, for an extended duration. The applicant provided an assessment of the plant responses to an ELAP event and guidance for developing the site-specific FLEX mitigating strategies

20.1.3.2 *Summary of Application*

DCA Part 2, Tier 1: There is no Tier 1 information in the DCA for the mitigation strategies for BDBEE.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 20.1, "Mitigating Strategies for Beyond Design-Basis External Events (BDBEE)," discusses the mitigating strategies that address an ELAP and LUHS resulting from a BDBEE.

ITAAC: There are no ITAAC items for this area of review.

Technical Specifications: There are no TS for this area of review.

Technical Reports: NuScale Technical Report, TR-0816-50797-NP (ML17005A120), "Mitigation Strategies for Extended Loss of AC Power Event," provides an assessment of the NuScale plant response to an ELAP event.

20.1.3.3 *Regulatory Basis*

The requirements and guidance for the staff's review of BDBEE mitigation strategies are as follows:

- SRM-SECY-12-0025, dated March 9, 2012, "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," dated March 9, 2012, issued Order EA-12-049.

- SRM-M190124A: Affirmation Session-SECY-16-0142: Final Rule: Mitigation of Beyond-Design-Basis-Events, with enclosures (ML19023A038)

- Order EA-12-049, dated March 12, 2012, "Issuance of Order to Modify Licenses regarding Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," addressed the requirements for mitigation strategies for BDBEE and will be codified in 10 CFR 50.155.

- The Japan Lesson-Learned Project Directorate Interim Staff Guidance JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," endorsed the methodology described in NEI industry guidance document NEI 12-06 Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," with exceptions and clarifications. Because 10 CFR 50.155 codifies the requirements in Order EA-12-049, JLD-ISG-2012-01, Rev. 1 also applies to the corresponding requirements of that regulation.

20.1.3.4 *Technical Evaluation*

SRM-SECY-12-0025, dated March 9, 2012, approved the issuance of orders for BDBEE as necessary for ensuring continued adequate protection under the 10 CFR 50.109(a)(4)(ii) exception to the Backfit Rule. Order EA-12-049 addressed the requirements for mitigation strategies for BDBEE. The Commission recently approved a rule, 10 CFR 50.155, that will codify the requirements of Order EA-12-049. Although neither the new rule nor Order EA-12-049 applies to the NuScale design certification, the applicant included the information of NuScale mitigation strategies for BDBEE in DCA, Tier 2, Section 20.1, and indicated its desire for NRC review.

NEI 12-06 states that the primary FLEX objective is to develop a plant-specific capability for coping with a simultaneous ELAP and LUHS event for an indefinite period through a combination of plant equipment and FLEX equipment. The applicant believes that the NuScale is designed to provide such capability with only installed plant equipment for a sufficient duration to satisfy the requirements, without need for portable or offsite resources.

DCA, Tier 2, Section 20.1 discusses NuScale mitigating strategies to address an ELAP and LUHS resulting from BDBEE.

DCA Part 2, Tier 2, Section 20.1.2, “Extended Loss of AC Power and Loss of Ultimate Heat Sink Design Assessment,” states the following:

> “This section discusses the inherent coping capability of the NuScale Power Plant design to maintain the key safety functions following an ELAP and an LUHS event. The key safety functions are maintaining core cooling, containment and spent fuel pool cooling.”

DCA Part 2, Tier 2, Section 20.1.2.2, “Applicable Systems, Structures, and Components,” states the following:

> “The ultimate heat sink (UHS) is a large pool of water consisting of the combined water volumes of the reactor pool (RP), refueling pool (RFP) and spent fuel pool (SFP), as described in DCA Part 2, Tier 2, Section 9.2.5. Each NuScale Power Module (NPM) is partially immersed in the UHS. Since the NPMs are partially immersed and in direct contact with the UHS, there is no need for UHS piping or motive force such as service water or circulating water pumps to provide cooling functions following BDBEE. Therefore, the loss of the UHS, as defined in NEI 12-06, is not plausible. No other heat sink is credited for maintaining the key safety functions.”

To address NEI 12-06 guidance, DCA Part 2, Tier 2, Section 20.1.3 provides a summary of the NuScale three-phase strategies and the design capability for three key safety functions (core cooling, containment function, and SFP cooling) following an ELAP. The staff review is discussed in the following sections.

20.1.3.4.1 *Three-Phase Approach*

NEI-12-06 provides guidance on the three-phase approach for the mitigation strategies:

Phase 1: Coping with installed plant equipment, Phase 2: Coping with installed plant equipment and onsite portable (FLEX) equipment, and

Phase 3: Coping with both onsite portable (FLEX) equipment and offsite resources in addition to installed equipment.

DCA Part 2, Tier 2, Section 20.1.3.1 describes the proposed three-phase approach used for the NuScale.

Phase 1: The key safety functions are maintained for greater than 30 days with installed plant equipment. No operator actions or supplemental equipment are necessary to perform these functions.

Phase 2: A FLEX strategy for a transition phase (Phase 2) is not needed for the NuScale plant design.

Phase 3: The baseline coping capability utilizing installed plant equipment is greater than 30 days. Sufficient time is available for detailed planning and procurement of offsite equipment, if necessary to maintain the key safety functions. Due to this extended baseline coping capability, the Phase 3 FLEX strategy is to monitor UHS pool level, utilizing the level instruments described in DCA Part 2, Tier 2, Section 20.1.4, and add inventory to the UHS via the SFP assured makeup line, if necessary.

20.1.3.4.2 *Three-Key Safety Functions*

TR-0816-50797, Section 5.0, states that to develop a FLEX strategy, the baseline coping capability of the NuScale plant design must be determined. The determination is made by evaluating the status of the three key safety functions during the integrated plant.

The staff's review of the three key functions of core cooling, containment function, and spent fuel cooling following an ELAP is in the following SER sections: Section 20.1.3.4.2.1 for core cooling, Section 20.1.3.4.2.2 for containment function, and Section 20.1.3.4.2.3 for SFP cooling. Specifically, the staff will review whether the design capacities and capabilities of the permanently installed SSCs in the NuScale design, as described in the FSAR, are capable of providing adequate core cooling, containment, SFP cooling, and SFP level instrumentation consistent with the requirements of 10 CFR 50.155(b)(1), (c) and (e) for 72 hours following a beyond-design-basis external event.

20.1.3.4.2.1 *Core Cooling*

The regulations in 10 CFR 50.155 require in part, development of guidance and strategies to maintain or restore core cooling following a BDBEE. The strategies must be capable of mitigating a loss of all ac power.

NEI 12-06, Table 3-2, "PWR FLEX Baseline Capability Summary," provides some examples of acceptable methods for demonstrating the baseline coping capability of the reactor core strategies to maintain reactor core cooling safety functions during an ELAP event.

DCA Part 2, Tier 2, Section 8.4, "Station Blackout," describes the NuScale plant response for a duration of 72 hours, which is consistent with SECY-94-084 and SECY-95-132 regarding onsite coping with safety-related equipment. SBO transient analysis assumptions are consistent with NEI 12-06 initial conditions, such as all 12 reactors operating at full power, loss of all ac power, dc power available, and no manual operator actions. During the loss of all ac power, the reactor is automatically tripped with all control rods fully inserted upon receipt of a MPS actuation signal due to high pressurizer pressure. After CIVs are closed, the reactor core cooling is maintained by the automatic opening of the DHRS valves. For approximately 24 hours, reactor core decay heat is removed by natural circulation through the steam generator and DHRS heat exchanger to the reactor pool which serves as the UHS. DHRS cooling results in a continuing decrease in reactor coolant system (RCS) pressure and temperature. At approximately 24 hours, the ECCS is actuated by the MPS timer which removes EDSS power to ECCS trip valves and subsequent opening of the ECCS reactor vent valves and reactor recirculation valves (RRV). As a result, reactor pressure vessel (RPV) rapidly decreases as the containment pressure increases until equilibrium is reached and the ECCS becomes the primary method of decay heat removal from the RPV to the containment where heat is transferred through the containment wall to the UHS.

The staff conducted an audit of documents that supported the applicant's conclusions in the DCA Part 2, Chapter 20 and TR-0816-50797, related to extended long-term core cooling as it relates to core cooling (ML19151A658). The audit objectives were to evaluate detailed calculations, analyses, and bases underlying NuScale's DCA Part 2 Chapter 20 and assess the methodology and analysis supporting NuScale's extended long-term cooling conclusions in TR-0816-50797.

Based on the audit documents, which included the SBO transient analysis referenced by calculations supporting the conclusions in Chapter 20, the staff observed large fluctuations of the following parameters: (1) steam generator water level from 18-24 hours during DHRS operation and 24-47 hours during ECCS operation, (2) energy transfer rates from 18-24 hours, (3) ECCS flow rates from 24-72 hours, (4) core exit and lower riser void fractions from 18-72 hours, and (5) core temperatures from 18-24 hours. To ensure the accuracy of the response, the staff reviewed the SBO assumptions and code as described in NuScale's DCA Part 2 Chapter 8. The NRELAP5 code is used to predict the plant response to the SBO event. The code is described in NuScale's DCA Part 2 Chapter 15. The assumptions were selected to maximize the SBO transient response. The staff concluded that the SBO model is acceptable. Therefore, the staff submitted a request for additional information, RAI 9486, Question 20.01-17, for the applicant to identify the mechanism(s) responsible for the large fluctuations during DHRS operation from 18 to 24 hours, ECCS operation beyond 24 hours, and provide an explanation of the effects on the core parameters due to these fluctuations.

The staff determined that NuScale's response to Question 20.01-17 did not fully address the staff concerns. Beginning in December 2018, the staff conducted a follow-up audit with the objective to better understand the detailed calculations, analyses, and bases underlying NuScale's SBO transient analysis and thermal-hydraulic parameters of specific time frames during the first 72 hours (ML18348B076). In addition, the staff wanted to better understand the methodology and analysis supporting NuScale's response to Question 20.01-17 that during equilibrium ECCS operation, the water levels in the riser, downcomer, and CNV are all closely coupled with oscillations in the downcomer level to cause corresponding oscillations in the reactor recirculation valve (RRV) liquid flow rate with flow reversal.

After review of audit documents and public meetings with NuScale, the staff confirmed the methodology supporting NuScale's response (ML18179A531) regarding oscillatory behavior in the RRV during equilibrium ECCS operation acceptable. However, NuScale will provide supplemental information to address the remaining issue related to core cooling during DHRS operation. Specifically, this issue relates to whether core cooling is adequate during interruption of natural circulation prior to ECCS actuation while on DHRS cooling when riser level falls below the DHRS inlet. Question 20.01-17 is noted as **Open Item 20.1.4.2.1-2** pending supplemental information from the applicant.

Section 15.0.6 of this SER evaluates the potential for boron dilution due to boron volatility. Boron plate-out on the upper core internals due to extended ECCS operation without operator action to inject boron via chemical and volume control system (CVCS) could result in a subsequent return to power, which could exacerbate boron redistribution and core dilution over time and challenge core cooling while on extended ECCS operation. This issue is described in Section 15.0.6 of this SER relative to RAI 8930, Question 15-27 using Chapter 15 methodologies, assumptions and acceptance criteria for long-term cooling. Although all control rods are assumed to insert into the core in response to BDBEE conditions, boron plate-out is a physical phenomenon that could potentially cause re-criticality, even with nominal assumptions with no operator action, as discussed in DCA Part 2, Tier 2 Section 15.0.6. The staff's review in this area is ongoing; and therefore, this is being tracked as **Open Item 20.1.4.2.1-4**. This section will be updated as it relates to mitigating strategies for BDBEE once the staff's concerns are resolved.

Regarding core cooling instrumentation, NuScale's DCA Part 2, Tier 2, Section 20.1.2.2 describes that instrumentation remain available as needed to confirm proper CIV positions and verify that the natural circulation passive cooling is established following the event. Consistent with NEI 12-06, monitored parameters that provide assurance to a plant operator that core cooling is established include valve position, RPV water level, core exit temperature, and containment water level. In the NuScale design, instrumentation and display associated with core cooling are robustly protected and designed to the environmental conditions of an ELAP event and are expected to remain available after the event. Information on these key parameters is available in the control room as long as dc power is available. DC electrical power is expected to be available for a minimum of 72 hours. As discussed in Section 20.1.2.4 of this report, the staff is limiting its review to the first 72 hours of the applicant's mitigation strategy (i.e., the first two phases of the applicant's strategy).

The open items stated above need to be resolved before the staff reaches a conclusion regarding core cooling is adequate and acceptable

20.1.3.4.2.2 *Containment Function*

The regulations in 10 CFR 50.155 require in part, development of guidance and strategies to maintain or restore containment following a BDBEE. The strategies must be capable of mitigating a beyond-design-basis external event assuming a loss of all ac power.

The staff-endorsed industry guidance, NEI 12-06, Table 3-2, provides examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to maintain containment functions during an extended loss of ac power. One such approach is to perform an analysis demonstrating that containment pressure control is not challenged.

In the NuScale DCA Part 2, Tier 2, Section 20.1, "Mitigating Strategies for Beyond Design-Basis External Events," the applicant stated the following:

> The containment heat removal capability of the CNV is described in Section 6.2.2, and the natural circulation process after ECCS initiation is described in Section 6.3. Once natural circulation is established, core cooling

and containment integrity are assured by maintaining sufficient inventory in the UHS.

NuScale's DCA Part 2, Tier 2, Section 20.1 references technical report TR-0816-50797, "NuScale Power LLC, Mitigation Strategies for Extended Loss of AC Power Event" (ML17005A110). This technical report provides information that supports the results summary provided in DCA Part 2, Tier 2, Section 20.1. This technical report is also incorporated by reference into the DCA, as identified in DCA Part 2, Tier 2, Table 1.6-2, "NuScale Referenced Technical Reports."

In TR-0816-50797, Section 6.3, "Containment," the applicant described the containment response following an extended loss of all ac power. TR-0816-50797-P, Revision 0, indicates that the containment function is established and maintained by plant safety-related systems for many days following an extended loss of all ac power without operator action. TR-0816-50797-P, Revision 0, also states that containment temperature and pressure do not approach values that could adversely affect the integrity of containment. TR-0816-50797-P, Revision 0, justification for stating that the containment function is maintained over the long-term is based on the analysis of the cooling capability of the ECCS, which includes the containment vessel walls and the reactor pool (i.e., ultimate heat sink). The staff's review of the core cooling capability of the ECCS is discussed in Section 20.1.4.3.2.1 of this report.

As described in Section 20.1.4.3.2.1 of this report, the applicant's station blackout analysis described in DCA Part 2, Tier 2, Section 8.4 is referenced by calculations supporting the conclusions in DCA Part 2, Tier 2, Section 20. In DCA Part 2, Tier 2, Section 8.4, the applicant described an integrated plant response to a loss of all ac power with assumptions that are consistent with NEI 12-06 initial conditions (e.g., all reactors operating at power) and the NuScale's mitigating strategies technical report. Specifically, during a loss of all ac power, the CIVs automatically close following receipt of a MPS actuation, which establishes containment of reactor coolant. The closing of safety-related CIVs occurs without operator action and requires no electrical power. Containment isolation valve position indication is available in the control room to verify valve closure. Indication is powered from the EDSS.

During a loss of all ac power, high energy fluid (i.e., reactor coolant) is released into the NuScale containment vessel when the ECCS valves open. The ECCS valves open at approximately 24 hours due to MPS actuation. During the 24-hour period prior to the ECCS valves opening, a significant amount of cooling occurs by passive heat transfer between the RCS and the UHS (i.e., reactor pool) through operation of the DHRS. Therefore, by the time the ECCS valves open at approximately 24 hours, the pressure in the reactor vessel is significantly reduced. The results of the applicant's containment analysis during a loss of all ac power is depicted in Figure 8.4-3, "Station Blackout Containment Vessel Pressure" and Figure 8.4-4, "Station Blackout Containment Vessel Temperature." As shown in these figures, NuScale's peak containment pressure and temperature in response to a loss of all ac power occurs when the ECCS valves open. These peak containment conditions are well below the containment design limits and continue to decrease over time as the natural circulation process is established through operation of the ECCS. Because the analysis of a loss of all ac shows the containment pressure and temperature conditions remaining well below containment design limits, the applicant concludes that containment pressure control is not challenged, and the containment function is maintained. Regarding containment instrumentation, NuScale's DCA Part 2, Tier 2, Section 20.1.2.2 describes that instrumentation remains available to verify that the containment function is established following the event. Consistent with NEI 12-06, monitored containment parameters that provide assurance to a plant operator that the containment function is achieved are containment isolation valve position indication and containment pressure. In the NuScale design, instrumentation associated with containment isolation valve position and containment pressure are safety-related and can be expected to remain available after the event that led to the loss of all ac power. Information on these containment key parameters is available in the control room as long as electrical power is available. Electrical power is expected to be available for a minimum of 72 hours.

As discussed above, NuScale's analyzed peak containment pressure and temperature conditions in response to a loss of all ac power remain well below the containment design limits using installed plant systems. In addition, as discussed in Section 20.1.3.4.2.1 of this report, the applicant's approach (i.e., NRELAP5) used in the analysis is acceptable. However, due to the close coupling between core cooling and containment, reaching a staff conclusion that the containment function is maintained for at least 72 hours is dependent on the analysis of the cooling capability of the ECCS, which includes the containment vessel walls and the reactor pool (i.e., ultimate heat sink). The staff's review of the cooling capability of the ECCS is discussed in Section 20.1.4.3.2.1 of this report and contains open items. These open items need to be resolved before the staff reaches a conclusion regarding containment.

20.1.3.4.2.3 *Spent Fuel Pool Cooling*

DCA Part 2, Tier 2, Section 20.1.3.1, states that the SFP cooling function is maintained by submergence of the spent fuel in the UHS. The NuScale safety-related UHS is a large pool of water where the NPMs and spent fuel are housed.

DCA Part 2, Tier 2, Section 9.2.5.2.3, states the following:

> "During an event where loss of electric power occurs, the volume of water already in the pool provides the inventory for the necessary heat removal. Upon loss of power, the reactor pool cooling and SFP cooling systems shut down. The UHS water expands as it heats and eventually begins to boil. Heat continues to be removed from the pool through boiling and evaporation, removing enough heat to maintain the spent fuel and fuel in the NPMs sufficiently cool to prevent fuel damage. The design is such that UHS water boil-off will continue to remove heat from the power modules and spent fuel for greater than 30 days without the need for operator action, makeup water, or electric power."

DCA Part 2, Tier 2, Section 20.1.2.2, states that the UHS is sized such that sufficient inventory is available to provide spent fuel cooling for greater than 30 days without the need for operator actions. Further, the applicant's ELAP UHS thermal analyses in TR-0816-50797, Section 6.4, confirmed this UHS cooling capability for longer than 30 days following initiation of an ELAP. The only plant parameter used to ensure the function is SFP level indication.

The SFP level instrumentation is assumed to survive the BDBEE and remains fully available for a duration beyond the time necessary for the associated FLEX strategy function to be established and monitored. DCA Part 2, Tier 2, Sections 20.1.2.2 and 20.1.4, provide information on level instrument in the SFP. The review of the SFP level instrument is documented in Section 20.1.4 of this SER.

TR-0816-50797, "Mitigation Strategies for Extended Loss of AC Power Event," Section 5.11.1, states the following:

> “Water level in the UHS is maintained at 94 ft during normal operations and temperature is maintained at an average of 100 degrees F.
>
> The UHS system includes four level detectors, one each for the RP and RFP, and two for the SFP. Each level instrument includes a backup battery power supply independent of the site distribution network and local readout capability located in an operator-accessible area away from the pool area.
>
> The UHS system design includes an assured makeup line to the SFP. The line is furnished with standard fire protection connectors external to the RXB that facilitate hookup of emergency water sources. The assured makeup line is designed to allow water to be gravity fed to the SFP at a minimum rate of 100 gpm.
>
> The UHS pool walls and pool liner are designed to seismic Category I requirements and are completely contained within the seismic Category I RXB. The four pool level instruments are seismically mounted, environmentally qualified. The assured makeup line is designed to seismic Category I requirements and is protected from external natural phenomena.
>
> The UHS system is assumed to survive the BDBEE and remain fully available during the period when the system functions necessary for FLEX strategy implementation are required. The ELAP results in the transfer of heat from the DHRS and ECCS to the UHS.”

The staff’s evaluation of the heat removal functional capability of the UHS is in Section 9.2.5 of this SER, where the thermal analysis of the UHS for extended loss of ac power is discussed with the design basis assumptions (such as initial pool level and temperature) being more limiting than the analysis for ELAP. As discussed in SER Section 9.2.5 for design basis accidents that the UHS is designed to remove the heat from the power modules and spent fuel for more than 72 hours by water boiling-off without the need for operator action, makeup water, or electric power. However, the staff identified two assumptions being used differently between DCA Tier 2 Section 9.2.5 and Section 20.1.3. First is the assumption of using nominal pool level and temperature as the initial conditions for the ELAP thermal analysis, as compared to using Technical Specification limits in Section 9.2.5. As a result, more and cooler water in the UHS are assumed for ELAP analysis. Secondly, in Section 9.2.5, the UHS heat load is assumed from a design basis accident (DBA) in one NPM and an orderly shutdown and cooldown of the remaining NPMs. For ELAP, all NPMs are in orderly shutdown and cooldown, which means less heat load as compared to the heat load being assumed in SER Section 9.2.5. Accordingly, the staff finds that the heat load resulting from an ELAP is bounded by the accident being evaluated in SER Section 9.2.5 for the first 72 hours. Beyond 72 hours in ELAP, heat can be removed by both installed equipment and offsite resources. However, the application does not address the need for offsite resources (makeup water to the UHS) beyond 72 hours. Therefore, the staff concludes that the UHS cooling capability for ELAP is adequate for 72 hours.

The only plant parameter used to ensure the cooling function of core, containment, and SFP is SFP level indication. The staff determines that even though the thermal analysis indicates there will be sufficient water in the UHS to remove the heat load as designed for extended period, monitoring the SFP level is necessary all the time in ELAP to confirm and ensure the cooling function being satisfied. However, NuScale has not provided adequate information in the DCA regarding the power supply to level instrument beyond 6 days. As indicated above in SER Section 20.1.4, the staff concludes that SFP level instrumentation is adequate for 6 days following a beyond-design-basis external event.

Additionally, the staff reviewed TR-0816-50797, “Mitigation Strategies for Extended Loss of AC Power Event,” Section 6.5.1, for refueling mode. In preparation for refueling, the most restrictive core cooling conditions for a NPM in transition occurs when the NPM is lifted to the maximum lift height and an ELAP occurs during this brief period. The staff met with NuScale staff on June 28, 2017, to discuss the refueling mode operation and associated thermal analysis. The discussion was focused on heat removal analysis for the lifted NPM, including, methodology, assumptions, and results of sufficient decay heat removal from UHS for an extended period (ML17172A231).

The staff reviewed NuScale’s additional calculations related to keeping the NPM sufficiently cool while the module is held up by the crane during an ELAP event and confirmed that there is enough submergence in the pool to keep the NPM cool for at least 72 hours.

DCA Part 2, Tier 2, Section 20.1.2.2, states that a robust makeup line with an external connection point for providing inventory to the SFP is available to support SFP makeup following a BDBEE. The staff reviewed the SFP makeup line against the guidance in NEI 12-06 and issued RAI 8923, requesting NuScale to explain how its design is consistent with the NEI guidance relating to robust design of a primary and an alternate connection or delivery point for SFP makeup.

In its response to RAI 8923 (ML17222A177), the applicant indicated as follows: The combined volume of the refueling pool and reactor pool is considered as the primary source of makeup to the SFP in a beyond-design-basis event. The combined volume provides for a safety-related source of inventory with passive makeup capability that is already installed and immediately available. The UHS was designed to be large enough to eliminate the need for short-term inventory addition following a beyond-design-basis event that results in an extended loss of ac power. Without any addition of water, UHS level remains sufficient to support the three key safety functions (core cooling, containment function, and SFP cooling) for more than 50 days.

The applicant explained further as follows: The alternate method of SFP makeup included in the design is the UHS makeup line. The makeup line is designed to be seismic Category I and is protected from external natural phenomena. The makeup line includes a connection external to the RXB to facilitate the connection of water sources. It routes water directly to the SFP and is sufficiently sized to gravity fill at a rate that exceeds the pool boil off rate.

Based on above, the staff reviewed and finds acceptable NuScale’s response to RAI 8923 because the large volume of the water in the pool provides sufficient margin for the heat removal function. The staff also concluded that the UHS makeup will not be needed until 72 hours after an ELAP according to NuScale mitigation strategy Phase 3.

Appendix B to TR-0816-50797 provides an evaluation of NuScale’s approach to the strategies prescribed by NEI 12-06 for the three key safety functions including SFP cooling. NEI 12-06 recommends makeup via hoses on refueling floor with FLEX injection source. Appendix B to TR-0816-50797 indicates that the recommended NEI 12-06 method is not needed for the NuScale design because the intended purpose of the recommendation, which is to ensure sufficient SFP inventory exits to cool the spent fuel during an ELAP, is inherently satisfied in the NuScale design because of the sufficient UHS water inventory.

NEI 12-06 recommends makeup with FLEX injection source via connection to SFP cooling piping or other alternate location. Appendix B to TR-0816-50797 indicates that this method is provided for in the NuScale plant and included in the mitigation strategy to exceed SFP boil-off and provide a means to supply SFP makeup without accessing the refueling floor. The staff's review of this issue is addressed in RAI 8923 as discussed above.

NEI 12-06 also recommends that SFP designs include vent pathways for steam and condensate from the SFP. Appendix B to TR-0816-50797 indicates that this method is not applicable to the NuScale plant design because access to the SFP area is not necessary and the equipment needed for coping in the SFP area is designed for the steam and condensate environment.

In addition, DCA Part 2, Tier 2, Section 9.2.5.2.3, "Operation During Abnormal and Accident Conditions," states that during accident conditions with a loss of electric power, to prevent pressurization in the UHS area of the RXB, the passive RXB exhaust ventilation system controls the release of airborne radioactive material from inside of the RXB, including from pool water evaporation. The staff's evaluation of this issue is documented in Section 9.4.2 of this SER.

NEI 12-06 recommends confirming the SFP level instrument to be adequate for SFP cooling. Appendix B of the TR indicates that the recommended method is provided in the NuScale design and included in NuScale mitigation strategy. However, the staff identified the inadequacy of the post 72-hour monitoring capability for level instrument power supply as an **Open Item**. Detailed staff evaluation of the SFP level instrument is in Section 20.1.4 of this SER.

20.1.3.5 *Ventilation Capability*

The staff reviewed ventilation-related strategies outlined in DCA Part 2, Tier 2, Section 6.4, "Control Room Ventilation," and Section 9.4.1, "RXB Ventilation." The review guidelines, outlined in NEI-12-06, Revision 2, Section 3.2.1.8, "Effects of Loss of Ventilation," are to verify that the effects of loss of heating, ventilation, and air conditioning (HVAC) in an ELAP event can be addressed consistent with NUMARC 87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," or by plant-specific thermal hydraulic calculations. NUMARC 87-00, Section 2.7, "Effects of Loss of Ventilation," discusses technical bases for equipment operability outside containment and control room habitability. The staff reviewed NuScale Technical Report, EC-B060-4543, Revision 0, "GOTHIC Passive Cooling of NuScale Control Room Building," as well as TR-0816-50797 and confirmed that equipment qualification is not challenged under the ELAP or SBO scenario. Specifically, the GOTHIC Code is approved by the NRC and the staff reviewed the input to the Code and confirmed that the input were in appropriate ranges.

Control Room Building Ventilation Systems (CRVS and CRHS)

At the initiation of the ELAP event, the control room ventilation system (CRVS) stops performing HVAC functions, the control room envelope (CRE) is isolated, and the control room habitability system (CRHS) actuates to pressurize the MCR. As a result, the environmental conditions in the MCR are maintained by passive cooling and the flow of breathing air from the CRHS.

The CRHS SSCs required to provide breathing air inventory to the CRE for at least 72 hours are specified to be designed to seismic Category I criteria. These SSCs are the air storage bottles and the supply piping and components (including the regulating valves and actuation valves) to the CRE. The CRE isolation dampers, pressure relief piping and components are also specified to be designed to seismic Category I criteria.

The PPS monitors for and detects the loss of ac power at event initiation. As a result, the PPS removes power from both CRE supply line isolation valve solenoids and both CRE pressure relief valve solenoids. This places the CRHS in service and allows air to flow from the air bottles into the CRE. The CRHS continues to supply air to the CRE for a minimum of 72 hours.

During an ELAP, the key safety functions are established and maintained by the automatic responses of safety-related equipment. These responses occur in the 24 hours following initiation of the event, with the ECCS valves opening at the 24-hour mark to cool down reactor coolant. Although no operator action is required, indications are available in the MCR to verify that the systems have responded as designed. This is based on the assumption that the EDSS is available.

To demonstrate compliance with 10 CFR 50.49, NuScale Calculation, EC-B060-4543, established the environmental conditions due to operation of the CRB passive cooling system. NuScale used a GOTHIC 8.1 model of the CRB to perform room heat-up analysis under the ELAP and SBO scenario. The focus of this calculation is on vital areas and equipment of the CRB. The vital areas and equipment include the CRE, MPS, PPS/Safety Display and Indication (SDI), and EDSS battery/equipment. The Normal dc Power System (EDNS), Plant Control System (PCS), and Module Control System (MCS) are input that contribute to the overall heat loads of the vital areas. The length of time under which the CRB is analyzed is 96 hours. It was assumed that CRHS emergency air bottles are capable of maintaining pressurization for 96 hours. The calculations showed that CRE Wet Bulb Globe Temperature remains below the acceptance criteria, 90 ºF, for more than 96 hours. Post accident Monitoring System (PAM) loads are energized for 96 hours and involve EDSS/PPS/SDI equipment. The calculations showed that PAM batteries and equipment rooms are below the acceptance criteria, 122 ºF, and 85 percent relative humidity, for more than 96 hours.

As stated in DCA Part 2, Tier 2, Section 6.4.2.3, there is an external air connection point that will allow the connection of a post 72-hour air supply from off-site air bottles to supply air and pressurization to the CRE for extended accident conditions if needed.

Reactor Building Ventilation System (RBVS)

The RBVS serves no safety-related or risk-significant function, is not credited for mitigation of design-basis accidents and has no safe shutdown function.

Two level instruments are positioned in the SFP area, one instrument in the RFP area, and one level instrument is positioned in the reactor pool area. According to DCA Part 2, Tier 2, Section 20.1.4.2, the four UHS level instruments and the associated cabling are qualified to operate following a BDBEE in the conditions of seismic Category I, concentrated borated water environment, temperature of approximately 212 ºF and 100 percent relative humidity.

As stated in DCA Part 2, Tier 2, Section 20.1.4.2, a replaceable battery that is isolated from faults on the normal power supply provides an alternate source of power independent from the plant ac and dc power systems. Batteries are designed for easy replacement to power UHS monitoring level instruments indefinitely.

Based on the above, the staff finds that the applicant's approach described above is consistent with the guidance found in NEI 12-06, as endorsed by JLD-ISG-2012-01, and that the requirements of 10 CFR 50.155 can be met by a licensee with respect to maintaining CRB or RXB ventilation capability.

20.1.3.6 *Combined License Information Items*

COL items related to this Section are discussed in Section 20.1.1 of this report.

20.1.3.7 *Conclusion*

Due to the unresolved Open Items in this Section, as described above, the staff is currently unable to make a safety finding with respect to the acceptability of NuScale's mitigating strategies for an ELAP event.

20.1.4 Spent Fuel Pool and Reactor Pool Level Instrumentation

20.1.4.1 *Introduction*

As a result of the Fukushima Dai-Ichi event, additional requirements have been established to manage and mitigate external events that are beyond the design-basis of the plant. DCA Part 2, Tier 2, Section 20.1 addresses the NuScale conformance with the requirements contained in NRC Orders EA-12-049 and EA-12-051, which will be codified in 10 CFR 50.155. DCA Part 2, Tier 2, Section 20.1.4 "Spent Fuel Pool and Reactor Pool Level Instrumentation," specifically addresses EA-12-051. The water level instrumentation is described as being consistent with the guidelines of NEI 12-02

20.1.4.2 *Summary of Application*

DCA Part 2, Tier 1: None.

DCA Part 2, Tier 2: The design basis and complete description of the spent fuel instrumentation can be found in DCA Part 2, Tier 2, Section 20.1.4, "Spent Fuel Pool and Reactor Pool Level Instrumentation."

ITAAC: None.

Technical Specifications: No technical specifications are provided for the SFP level instrumentation, however, Design Certification Application, Part 4, "Generic Technical Specifications" LCO 3.5.3 "Ultimate Heat Sink," is related to the UHS (which includes the SFP) water level.

20.1.4.3 *Regulatory Basis*

The applicable requirements and guidance for reliable SFP instrumentation are established or described in the following:

- SRM-M190124A: Affirmation Session-SECY-16-0142: Final Rule: Mitigation of Beyond-Design-Basis-Events, with enclosures (ADAMs Accession No. ML19023A038)

- JLD-ISG-2012-03, Revision 0, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation," issued August 29, 2012, endorses NEI 12-02, Revision 1, "Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with

Regard to Reliable Spent Fuel Pool Instrumentation," with exceptions and clarifications. Because 10 CFR 50.155 codifies the requirements in Order EA-12-051, JLD-ISG-2012-03, Rev. 0, also applies to the corresponding requirements of that regulation.

20.1.4.4 *Technical Evaluation*

NEI 12-02, Revision 1, "Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," provides an acceptable approach for satisfying the applicable requirements. In DCA Part 2, Tier 2, Section 20.1.4, the applicant discussed how the UHS level instruments meet the requirements of Commission Order EA-12-051, which will be codified in 10 CFR 50.155(e). In Attachment 2 to Order EA-12-051, the Commission states that trained personnel shall be able to identify the following pool water level conditions:

Level 1 - level that is adequate to support operation of the normal fuel pool cooling system,

Level 2 - level that is adequate to provide substantial radiation shielding for a person standing on the SFP operating deck, and

Level 3 - level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.

DCA Part 2, Tier 2, Section 20.1.4.1, describes the design basis of the four UHS level instruments. It also states that all four instruments are capable of monitoring Levels 1 and 2. The two SFP level instruments are capable of monitoring Level 3, if water level drops below the weir wall elevation. The two-level instruments in the reactor pool and refueling pool areas are capable of monitoring the level of the water above the fuel in the reactor core when the NPM is disassembled in the refueling pool during refueling.

In order to identify the three key water levels identified in Commission Order EA-12-051, Section 20.1.4.1 reference Table 9.2.5-1. The staff reviewed the table and confirmed that the Section 20.1.4.1 identifies the three key water levels as described in Commission Order EA-12-051.

20.1.4.4.1. **Instruments:**

Commission Order EA-12-051, Attachment 2, Section 1.1, states that the instrumentation shall consist of a permanent fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor SFP water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.

DCA Part 2, Tier 2, Section 20.1.4.2, states that the UHS pools are provided with four (two in the SFP, one in the refueling pool, and one in the reactor pool) wide range instruments capable of monitoring water level from the top of the stored fuel to the operating deck.

The staff identified that the two SFP instrument channel are designed to monitor the SFP level from the top of the stored fuel to the operating deck. The level instrument channels are able to monitor the SFP water level from the weir (connecting the SFP to the other UHS pools) up to the operating deck. The staff evaluated the applicant's instruments description and determined that crediting these four permanently installed instruments as primary and backup channels follows the guidance provided by JLD-ISG-2012-03 and are in conformance with Commission Order EA-12-051 and 10 CFR 50.155(e) in regard to instruments.

20.1.4.4.2. **Arrangement:**

Commission Order EA-12-051, Attachment 2, Section 1.2, states that the SFP level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the SFP. This protection may be provided by locating the safety-related instruments to maintain instrument channel separation within the SFP area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the SFP structure.

In DCA Part 2, Tier 2, Section 20.1.4.1, the applicant stated that SFP level instruments are separated to reduce the potential for falling debris or missiles affecting both channels of instrumentation. In addition, the other two instruments in the UHS are located in separate pools, which also provides missile protection.

The staff evaluated the applicant's description of the level instruments and determined that the equipment description would ensure that the SFP level instruments are arranged in a manner that provides reasonable protection against missiles; therefore, the staff concludes that these features follow the guidance provided by JLD-ISG-2012-03 and are in conformance with Commission Order EA-12-051 and 10 CFR 50.155(e) in regard to arrangement.

20.1.4.4.3. **Mounting:**

Commission Order EA-12-051, Attachment 2, Section 1.3 states that the installed instrument channel equipment within the SFP shall be mounted to retain its design configuration during and following the maximum seismic ground motion considered in the design of the SFP structure.

In DCA Part 2, Tier 2, Section 20.1.4.1, the applicant identified the level instruments design to seismic Category I standards and the mounting and associated cabling are installed as seismic Category I.

The staff evaluated the applicant's description of the level instruments and determined that the equipment description and the seismic classification of the components are acceptable to assure that the SFP level instruments are mounted in a manner that provides reasonable protection against seismic events; therefore, the staff concludes that these features follow the guidance in JLD-ISG-2012-03 and are in conformance with Commission Order EA-12-051 and 10 CFR 50.155(c) in regard to mounting.

20.1.4.4.4. **Qualification:**

Commission Order EA-12-051, Attachment 2, Section 1.4, states that the level instrument channels shall be reliable at temperature, humidity, and radiation levels consistent with the SFP water at saturation conditions for an extended period.

In DCA Part 2, Tier 2 Section 20.1.4.1, the applicant indicated that the level instruments and the associated cabling are qualified to remain operation under the following environmental conditions:

- SSE seismic event (seismic Category I).

- Concentrated borated water environment.

- Temperature of approximately 212 degrees Fahrenheit (ºF) and 100 percent relative humidity.

- Boiling water or steam environment.

- Radiological conditions existing from a normal refueling with a freshly discharged fuel batch that remains covered with SFP water (Level 3).

In TR-0816-50797, “Mitigation Strategies for Extended Loss of AC Power Event," Revision 0, Section 5.6.2, “Equipment Qualification,” the applicant stated that the EDSS SSCs are qualified to seismic Category I standards and are located within seismic Category I areas of the RXB and CRB. In TR-0816-50797, Revision 0, Section 5.11.2, “Equipment Qualification,” the applicant stated that the four pool level instruments are seismically mounted, environmentally qualified, and designed to meet the guidance of NEI 12-02. NEI 12-02 provides guidance for SFP instrumentation design features to ensure that reliable level indication is provided for each SFP in response to BDBEEs.

In RAI 9110, Question 20.01-5, the staff requested that the applicant discuss the methodology for environmental qualification or the basis for the capability of the UHS instrument cabling to remain functional under BDBEE conditions. In its response to RAI 9110, Question 20.01-5 (ML17289A672), the applicant stated, “for harsh environment applications, such as those for pool level instruments and their cabling, qualification program implementation will follow Institute of Electrical and Electronic Engineers (IEEE) Standard (Std.) 323-2003, “IEEE Std. for Qualifying Class 1E equipment for Nuclear Power Generating Stations.””

The pool instruments and cabling are subject to a harsh environment as shown in DCA Part 2, Tier 2, Table 3.11-1, “List of Environmentally Qualified Electrical/I&C and Mechanical Equipment Located in Harsh Environments.” Additionally, DCA Part 2, Tier 2, Section 3.11.2.1, “Environmental Qualification of Electrical Equipment,” states, “Electrical equipment identified to be in a harsh location … are [sic] environmentally qualified by type testing or type testing and analysis using the guidance of IEEE Std. 323-1974.”

Since the applicant has stated in the DCA Part 2, Tier 2, Section 3.11.2.1, that the guidance and methodology in IEEE Std. 323-1974 will be used for the environmental qualification of equipment in harsh environment.

Additionally, DCA Part 2, Tier 2, Table 3.2-1, states that the pool level instruments are classified as augmented quality (AQ-S) in accordance with IEEE Std. 497-2002 CORR 1, which incorporates IEEE Std. 323-1974. The staff evaluated the applicant’s description of the level instruments provided in the DCA and determined that the qualification requirements presented are consistent with the criteria discussed in the guidance and will be qualified in accordance with IEEE Std. 323-1974, which is endorsed by the NRC in RG 1.89, “Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants,” Revision 1. Therefore, the staff concludes that these features follow the guidance provided by JLD-ISG-2012-03 and are in conformance with Commission Order EA-12-051 and 10 CFR 50.155(e) in regard to qualification.

20.1.4.4.5. **Independence:**

Commission Order EA-12-051, Attachment 2, Section 1.5, states that the primary instrument channel shall be independent of the backup instrument channel.

The DCA Part 2, Tier 2, Section 20.1.4, states that the all instrument channels are physically and electrically independent. The instrument channels are permanently installed and power supply to these instruments is addressed in DCA Part 2, Tier 2, Section 8.3.2. The staff finds that the design description follows the guidance provided by JLD-ISG-2012-03 and is in conformance with Commission Order EA-12-051 and 10 CFR 50.155(e) in regard to independence.

20.1.4.4.6. **Power Sources:**

Commission Order EA-12-051, Attachment 2, Section 1.6 states that the instrumentation channels shall provide for power connections from sources independent of the plant ac and dc power distribution systems, such as portable generators or replaceable batteries. Power supply designs should provide for quick and accessible connection of sources independent of the plant ac and dc power distribution systems. Onsite generators used as an alternate power source and replaceable batteries used for instrument channel power shall have sufficient capacity to maintain the level indication function until offsite resource availability is reasonably assured.

DCA Part 2, Tier 2, Section 20.1.4.1, indicates that the four UHS level instruments are supplied by the EDSS with interface through the PPS. The redundant level instruments are powered from separate bus sources. Additionally, a replaceable battery that is isolated from faults on the normal power supply provides an alternate source of power independent from the plant ac and dc power systems. DCA Part 2, Tier 2, Section 9.2.5.6.2, states that the electrical distribution system allows for the connection of alternate power in order to power the level instruments.

The staff evaluated the applicant's description of the instrument power connections. The staff noted that the instruments can be powered by the EDSS or a replaceable battery that is independent of the plant power distribution systems. The EDSS system is capable of powering the pool level instruments for at least 72 hours following the postulated event. The replaceable battery is capable of providing an additional 72 hours of level monitoring. The staff finds that the combination of EDSS and replaceable battery is capable of providing at least 6 days of pool level monitoring.

The staff determined that the level instrument channel, as described, does not address the instrument channel power supply requirements after the replaceable batteries have been depleted. Therefore, the staff finding regarding the adequacy of SFP instrumentation power supplies is limited to 6 days. The applicant indicated that a revision of Tier 2 Section 20.1.4 will be issued addressing the period beyond 6 days. Should the applicant revise Tier 2, Section 20.1.4 to include this information, the staff will revisit this finding. In view of the above, the staff concludes that the SFP level instrumentation power supplies are adequate for 6 days following a beyond-design-basis external event and comply with 10 CFR 50.155(e) for that duration.

20.1.4.4.7. **Accuracy:**

Commission Order EA-12-051, Attachment 2, Section 1.7, states that the instrument shall maintain its designed accuracy following a power interruption or change in power source without recalibration.

In DCA Part 2, Tier 2, Section 20.1.4, the applicant stated that the level instruments are design to maintain the minimum accuracy following a power interruption or change in power source without requiring recalibration.

The staff evaluated the applicant's description of the level instruments and determined that the level instruments were designed to retain calibration following a power interruption; therefore, the staff concludes that this feature follows the guidance provided by JLD-ISG-2012-03 and are in conformance with Commission Order EA-12-051 and 10 CFR 50.155(e) in regard to accuracy.

20.1.4.4.8. **Testing:**

Commission Order EA-12-051, Attachment 2, Section 1.8, states that the instrument channel design shall provide for routine testing and calibration.

DCA Part 2, Tier 2, Section 20.1.4, indicates that the level instruments are design to allow for testing and calibration in-situ. The applicant also proposed COL Item 20.1-8, which tasks the COL applicant to develop procedures, training and qualification program for operations, maintenance, testing, and calibration of UHS level instrumentation.

The staff reviewed the applicant's system description and identified that the permanently installed instrument channels are normally used to monitor the SFP level and will be subject to routine testing and calibration in accordance with plant procedures. The staff evaluated the applicants proposed COL Item 20.1-8 and agrees that asking the COL applicants to develop a procedure for the maintenance, testing, and calibration of the level instruments ensures the instrument is maintain operable during the plant life. Accordingly, the staff concludes that these design features follow the guidance provided by JLD-ISG-2012-03 and are in conformance with Commission Order EA-12-051 and 10 CFR 50.155(e) in regard to testing.

20.1.4.4.9. **Display**:

Commission Order EA-12-051, Attachment 2, Section 1.9, states that trained personnel shall be able to monitor the SFP water level from the control room, the alternate shutdown panel, or another appropriate and accessible location. The display shall provide on-demand or continuous indication of SFP water level.

The DCA indicates that the level instruments provide display in the MCR and the remote shutdown station. The instruments also initiate high, or low, level alarms, both locally and in the MCR to alert operators of pool level conditions.

The staff evaluated the applicant's description of the level instruments and determined that the instruments are design to provide indication of the pool water level in the MCR and the remote shutdown station; therefore, the staff concludes that these feature follows the guidance provided by JLD-ISG-2012-03 and are in conformance with Commission Order EA-12-051 and 10 CFR 50.155(e) in regard to displays.

20.1.4.5 *Combined License Information Items*

Commission Order EA-12-051, Attachment 2, Section 2, states that the SFP instrumentation shall be maintained available and reliable through appropriate development and implementation of a training program. Personnel shall be trained in the use and the provision of alternate power to the safety-related level instrument channels. Procedures shall be established and maintained for the testing, calibration, and use of the primary and backup SFP instrument channels, and processes shall be established and maintained for scheduling and implementing necessary testing and calibration of the primary and backup SFP level instrument channels to maintain the instrument channels at the design accuracy.

In DCA, Tier 2, Section 20.1.4, the applicant identified COL Item 20.1-8, which states

Table 20.1-3 NuScale Combined License Information Items for Section 20.1

Item No.	Description	DCA Part 2, Tier 2 Section
20.1-8	A COL applicant that references the NuScale Power Plant design certification will develop procedures, training, and a qualification program for operations, maintenance, testing, and calibration of ultimate heat sink level instrumentation to ensure the level instruments will be available when needed and personnel are knowledgeable in interpreting the information as addressed in NEI 12-02	20.1

The staff reviewed the COL item and determined that developing procedures and training is the responsibility of the COL applicant and this COL item will ensure that the COL applicant will address the training and procedure requirements presented in NRC Order EA-12-051 and 10 CFR 50.155.

20.1.4.6 *Conclusion*

The staff evaluated the information provided in the applicant's DCA Part 2, Tier 2, Section 20.1.4, and TR-0816-50797, Revision 0, related to the SFP water level instrumentation, and determined that the proposed level instruments are designed in accordance with the guidance provided in JLD-ISG-2012-03 for at least 6 days after a beyond-design-basis external event. Therefore, these instruments are considered to be reliable, able to withstand beyond-design-basis natural phenomena, and monitor key SFP level parameters for six days following a beyond-design-basis external event., as described in Commission Order EA-12-051 and required by 10 CFR 50.155(c) In view of the above, the staff concludes that the SFP level instrumentation satisfies 10 CFR 50.155(c) for 6 days following a beyond-design-basis external event.

20.2 <u>Loss of Large Areas of the Plant due to Explosions and Fires</u>

20.2.1 Introduction

This attachment documents the staff's evaluation of how the design and mitigation strategies for the NuScale Power Plant meet the requirements of 10 CFR 50.54(hh)(2).

20.2.2 Summary of Application

DCA Part 2, Tier 1: There is no Tier 1 information for the area of review.

DCA Part 2, Tier 2: DCA Part 2, Tier 2, Section 20.2, “Loss of Large Areas of the Plant due to Explosions and Fires,” describes the results of the NuScale Power Plant response to a Loss of Large Area (LOLA) given in Technical Report TR-0816-50796 with no security-related information.

ITAAC: There are no ITAAC items for this area of review.

Technical Specifications: There are no technical specifications for this area of review.

Technical Reports: Technical Report TR-0816-50796 documents an assessment evaluating the NuScale Power Plant response to a LOLA event using the guidance in NEI 06-12, “B.5.b Phase 2 and 3 Submittal Guideline,” Revision 3. The report defines LOLA criteria and identifies the design features that meet those criteria and expected combined license applicant requirements.

20.2.3 Regulatory Basis

The following NRC regulations contain the relevant requirements for this review:

Title 10 CFR 50.54(hh)(2) requires each licensee to develop and implement guidance and strategies to maintain or restore core cooling, containment, and SFP cooling capabilities under the circumstances associated with LOLAs of the plant due to explosions or fire and to include strategies in the following areas:

- Firefighting;
- Operations to mitigate fuel damage; and
- Actions to minimize radiological release.

The guidance in SRP Section 19.4, “Strategies and Guidance to Address Loss of Large Areas of the Plant due to Explosions and Fires,” lists acceptance criteria adequate to meet the above requirements, as well as review interfaces with other SRP sections.

20.2.4 Technical Evaluation

The staff reviewed the DCA in accordance with SRP Section 19.4. The staff considers conformance with the guidance in NEI 06-12, Revision 3, as an acceptable method in satisfying the Commission’s requirements in 10 CFR 50.54(hh)(2).

Identification of Key Safety Functions

The applicant stated that the generic pressurized water reactor (PWR) key safety functions identified in NEI 06-12, Subsection 4.2.3.1, “Identification of Key Safety Functions,” are all applicable to the NuScale Power Plant. The PWR key safety functions are as follows:

- RCS inventory control;
- RCS heat removal;
- Containment isolation;

- Containment integrity; and
- Release mitigation.

The applicant did not identify any new key safety functions for the NuScale Power Plant. NEI 06-12 states that for each safety function the applicant should identify the minimal set of equipment for both a primary and alternate means of satisfying the key safety function.

The applicant stated that the NuScale design maintains RCS inventory, RCS heat removal, containment isolation, and containment integrity without additional strategies. The primary and alternate means to maintain these functions are spatially separated per the guidance of NEI 06-12.

Evaluation of Key Safety Function – RCS Inventory Control

The purpose of this safety function is to ensure that the core remains covered with water. The applicant stated that the NPM does not require water injection to keep the core covered during transient or accident scenarios. Containment isolation is the primary means for RCS inventory control. During a loss of the reactor pressure barrier, RCS inventory is maintained within the CNV if containment is isolated. When the ECCS or DHRS are actuated, the core will remain covered.

The ECCS functions by recirculating coolant condensed in containment and returning it to the RPV utilizing natural recirculation. The ECCS is a safety-related system available to provide heat removal from the RPV. The ECCS can provide decay heat removal for at least 72 hours without modulation, automatic or manual, after the initiating event. All safety-related functions of ECCS are designed using passive operating principles and fail in an actuated configuration upon initiation signal or loss of dc power. No electrical power or support systems are required for successful operation of ECCS.

The DHRS is a passive core cooling safety system consisting of two independent and redundant trains. Each train alone has the capability to provide sufficient heat removal to satisfy the safety function. The DHRS functions by utilizing the steam generators (SGs) to remove heat from the primary coolant. The generated steam is condensed and returned to the SG as subcooled liquid. Flow is driven by natural circulation and heat is rejected to the UHS.

An alternate means is the use of the chemical volume and control system (CVCS.) The CVCS is a means of RCS inventory control during normal operation, startup, and shutdown. Success of this system to perform this key function requires at least one CVCS makeup pump running. The CVCS makeup pumps are located in the north gallery space and in the south gallery space of the RXB elevation 50 ft. The RXB elevation of 50-ft is underground and protected from external events. The CVCS makeup pumps are provided with backup power via the backup power supply system. Accordingly, the CVCS is acceptable as an alternate means of providing this safety function.

The staff finds this acceptable because the applicant identified the primary and alternate means of meeting this safety function consistent with NEI 06-12.

Evaluation of Key Safety Function – RCS Heat Removal

The purpose of this key safety function is to remove the decay heat from the core and transfer it to the UHS. The applicant stated that the primary means for heat removal during steady state, startup and hot shutdown operations are the energy conversion systems.

The energy conversion systems, which includes condensate and feedwater, main steam, and turbine generator systems, are the means of heat removal during normal plant operations. Successful operation requires an open flow path with at least one of three condensate pumps and one of three feedwater pumps operating. An open flow path means steam flows from the SGs to the condenser, as well as condensate flows from the condenser back to the SGs. A containment isolation signal will isolate this flow path. Supporting systems include condenser air removal, instrument air, circulating water, and site cooling water systems.

The alternate means for RCS heat removal is the DHRS, followed by the ECCS, when the ECCS valves open. Evaluation of the DHRS and ECCS is described above.

The staff finds this acceptable because the applicant identified the primary and alternate means of meeting this safety function consistent with NEI 06-12.

<u>Evaluation of Key Safety Function – Containment Isolation</u>

The purpose of this key safety function is to ensure no leakage paths exist that would allow gaseous and particulate radiation to escape containment. The applicant stated that the NuScale Power Plant relies on containment isolation to accomplish this function. Containment isolation is performed by the containment system. The CIVs for interfacing systems, with the exception of feedwater and main steam, have dual valve, single body CIVs outside of the containment. This isolation capability is located under the biological shield. This dual containment isolation capability may be considered the primary and alternate means of performing this function. A loss of dc power to those valves will result in their repositioning to their safe or accident response position.

The staff finds this acceptable because the applicant identified the primary and alternate means of meeting this safety function consistent with NEI 06-12.

<u>Evaluation of Key Safety Function – Containment Integrity</u>

The purpose of this key safety function is to ensure the containment fission product barrier is maintained to minimize or prevent radiological release outside containment. The applicant stated that the CNV is designed for high pressures and passive heat transfer between the CNV shell and the UHS. The CNV temperature and pressure are maintained due to the partial immersion of the CNV in the UHS. Severe accident analyses have shown that even during a severe accident where the core relocates to the bottom of the RPV, the RPV will not be breached and the CNV remains intact due to the passive cooling capabilities of the RPV and CNV containing the inventory from ECCS initiation or safety relief actuation. This function is accomplished passively by heat exchange between the RPV, CNV and immersion in the UHS.

The guidance in NEI 06-12, Chapter 4, "Actions for New Plants," states that it is recognized that new plants typically have more safety trains that are more spatially separated than for current US operating plants. Additionally, some new designs employ passive features that may be more or less susceptible to damage from the effects of large fires and explosions. Therefore, new plants may not need all of the mitigation strategies or may need additional strategies to satisfy the key safety functions. The staff reviewed information on the ultimate heat sink, and containment systems provided in NuScale's Loss of Large Area Technical Report TR-0816-

50796, and in DCA Part 2, Tier 2 Section 9.2.5, "Ultimate Heat Sink," and Section 6.2, "Containment Systems." The staff finds this acceptable because the applicant provided information on how this key safety function is accomplished by passive SSCs, which are less susceptible to damage than those in current operating plants.

Evaluation of key Safety Function – Release Mitigation

The purpose of this key safety function is to minimize a radiological release assuming severe core damage has occurred and a radiological release is imminent or in progress. The applicant stated that the RPV is located within the CNV and that the CNV is partially immersed in the UHS. The UHS is the primary means to perform this function. There is no explicit alternate means to perform this function.

The applicant stated that a release below the UHS water level will be scrubbed by the UHS. There are penetrations below the water level and a release at such a location is bounded by a release above the water line. A more likely and more conservative release point that would require mitigation is above the UHS water line, more specifically on the top of the CNV where there are numerous penetrations. These penetrations are located underneath the biological shield. If the release were to extend into the RXB, a release could occur through one of several RXB exterior openings.

Because the success criteria for meeting this safety function is not satisfied by existing redundant spatially separated equipment, the applicant provided a mitigation strategy complaint with NEI 06-12 guidance in Section 4.3.3.1 of the TR-0816-50796, Rev. 0. This strategy, "Portable Sprays," is evaluated below.

The staff finds this acceptable because the applicant identified the primary, the UHS, and alternate means, "Portable Sprays," of meeting this safety function consistent with NEI 06-12.

Phase 1 - Enhanced Fire Fighting Capabilities

NEI 06-12 guidance lists 31 Phase 1 firefighting and operational strategies that should be considered by an applicant when developing its mitigative strategies in order to meet the requirements of 10 CFR 50.54(hh)(2). The applicant stated that all Phase 1 strategies listed in NEI 06-12, except the enhancement for supplying the fire protection ring header, will be COL items.

Evaluation – Supplying the Fire Protection Ring Header

One of the Phase 1 firefighting mitigative strategies listed in NEI 06-12 is to develop a means for an alternate water supply feed for the fire protection yard main loop in the event that the normal water supply source is lost.

The applicant stated that the NuScale Power Plant features that address the firefighting capabilities for a LOLA event are included in the fire protection system (FPS) design. Specifically, the FPS includes an underground yard fire main loop. Hydrants are provided on the yard fire main loop in accordance with the National Fire Protection Association (NFPA) Standard 24, "Standard for the Installation of Private Fire Service Mains and Their Appurtenances," at intervals up to 250 ft and located on all four sides of the RXB. The lateral to each hydrant is controlled by an isolation valve. The NuScale design will successfully support supplying the underground fire water ring main using a portable diesel-driven pump. External water sources available for makeup to the yard fire main loop are the two fire protection supply tanks which each contain at least 300,000 gallons of water. There are several connections in the yard main that can support supplying the yard main using a portable diesel-driven pump and valves that can isolate damaged section(s) when required. The staff finds this acceptable because it follows the guidance in NEI 06-12.

Phase 2 - Measures to Mitigate Damage to Fuel in the Spent Fuel Pool

NEI 06-12 Section 2.0, "Spent Fuel Pool Strategies," states that the SFP strategies are not required for sites that have SFPs that are below grade and cannot be drained. The applicant stated that the NuScale SFP is located below grade and cannot be drained.

The applicant stated that the bottom elevation of the SFP is located at RXB elevation 25 ft, and the SFP operating deck is located at RXB elevation 100 ft. Grade elevation for the RXB is elevation 100 ft. Therefore, the SFP is located below grade. The SFP has a normal water level of approximately RXB elevation 94 ft. If the SFP is breached, the SFP water inventory would drain into the gallery rooms outside the SFP at RXB elevation 24 ft and above. An analysis shows that the minimum water level in the SFP after a maximum postulated drain down event is approximately 50 ft RXB elevation, which results in approximately 25 ft of water in the SFP. This level adequately covers the spent fuel assemblies and provides margin of coverage above the top of spent fuel. The minimum level in the pool for adequate spent fuel dose rate shielding is 20 ft.

Because the SFP is below grade and cannot be drained the staff finds that the SFP strategies are not required for the NuScale design.

Phase 3 - Measures to Mitigate Damage to Fuel in the Reactor Vessel and to Minimize Radiological Release

The NEI 06-12 guidance lists eight Phase 3 strategies that should be considered by an applicant when developing its mitigative strategies in order to meet the requirements of 10 CFR 50.54(hh)(2). Phase 3 mitigative strategies are intended to restore or maintain core cooling in order to mitigate potential damage to fuel in the reactor system and to mitigate potential radiological releases through the containment. The applicant stated that six of the strategies do not pertain to the NuScale design. The applicant has provided design enhancements for one of the strategies. The applicant stated that the strategy for "Command and Control EDMG," will be a COL item.

<u>Evaluation - Makeup to RWST in Order to Supply ECCS Long Term</u>

As described in Section 3.3.1 of NEI 06-12, the objective of this strategy is to provide a large volume makeup source to the reactor water storage tank (or equivalent) in order to supply the ECCS long term.

The applicant stated that the NuScale design does not require RCS makeup. The NuScale design does not use refueling water storage tanks or equivalent. All safety-related functions of ECCS are designed using passive operating principles and fail in an actuated configuration upon initiation signal or loss of dc power. No electrical power or support systems are required for successful operation of ECCS. Because the NuScale design does not require RCS makeup the staff finds that the applicant does not need a strategy for this item.

<u>Evaluation – Manually Depressurize SGs to Reduce Inventory Loss</u>

As described in Section 3.3.2 of NEI 06-12, the objective of this strategy is to provide a power-independent means to depressurize SGs by locally, manually opening atmospheric dump valves (or SG operated relief valves) in order to reduce SG pressure and RCS temperature and pressure.

The applicant stated that the NuScale design does not depressurize the SGs during an accident. Adequate heat removal is achieved using passive systems. Because the NuScale design does not require depressurization of SGs in order to reduce inventory loss, the staff finds that the applicant does not need a strategy for this item.

Evaluation – Manual Operation of Turbine-Driven Pumps

As described in Section 3.3.3 of NEI 06-12, the objective of this strategy is to provide a power-independent means to provide core cooling and prevent or delay core damage.

The applicant stated that the NuScale design does not include an auxiliary feedwater system. No turbine-driven safety-related pumps are included in the design. Adequate heat removal is achieved using passive systems. Because the NuScale design does not and need not include an auxiliary feedwater system or turbine-driven safety-related pumps to provide adequate heat removal, the staff finds that the applicant does not need a strategy for this item.

Evaluation – Manually Depressurize SGs and use Portable Pump

As described in Section 3.3.4 of NEI 06-12, the objective of this strategy is to provide a low pressure makeup source to provide SG makeup and core cooling.

The applicant stated that the NuScale design does not depressurize the SGs during an accident. Adequate heat removal is achieved using passive systems. Because the NuScale design does not require depressurization of SGs in order to reduce inventory loss, the staff finds that the applicant does not need a strategy for this item.

Evaluation – Makeup to CST/AFWST

As described in Section 3.3.5 of NEI 06-12, the objective of this strategy is to provide a makeup source to the condensate storage tank (CST)/auxiliary feedwater storage tank (AFWST) in order to supply AFW long term.

The applicant stated that the NuScale design does not include a CST or an AFWST. Adequate heat removal is achieved through passive systems and does not require the addition of water to the steam generators. Because the NuScale design does not need a CST or an AFWST to provide makeup water, the staff finds that the applicant does not need a strategy for this item.

Evaluation – Containment Flooding with Portable Pump

As described in Section 3.3.6 of NEI 06-12, the objective of this strategy is to provide a power independent means to inject water into the containment to flood the containment floor and cover core debris.

The intent of this strategy is to flood containment after severe core damage and RPV failure and is typically a backup strategy for containment sprays or ECCS injection systems. The applicant stated that the NuScale design does not require a containment spray system because the containment floods as a result of ECCS actuation or lifting of safety relief valves. The CNV is partially immersed in the UHS. The amount of inventory in the UHS and the prevention of pool draining inherent in the plant design preclude the need for an additional mitigation strategy. Because the containment floods as a result of ECCS actuation or lifting of safety relief valves, and since the CNV is partially immersed in the UHS, the UHS inventory is very large, and the design prevents pool draining, the staff finds that the applicant does not need a strategy for this item.

Evaluation – Portable Sprays

As described in Section 3.3.7 of NEI 06-12, the objective of this strategy is to provide a means to reduce the magnitude of any fission product releases by spraying.

The applicant indicated that the FPS has standpipe hose connections in accordance with NFPA 14 and RG 1.189, "Fire Protection for Nuclear Power Plants," Revision 2. The applicant describes the FPS as follows: Standpipes are installed within each stairway and exit corridors. Also, standpipes, hose connections, and hydrants are provided for manual firefighting in areas containing equipment required for safe plant shutdown and in yard areas of the plant. Therefore, the applicant expects that the standpipe connections may be used to supply water to portable monitor nozzles for use in spraying potential release points to reduce fission product releases. The applicant states that a portable pump will also be available and will be used to spray a radiological release including plant structures that cannot be sprayed from the FPS due to physical layout or equipment limitations. The FPS is described in DCA Part 2, Tier 2, Section 9.5.1. Procedures and guidance for this strategy will be developed by the COL applicant to support implementation. The staff finds the standpipes, hose connections, hydrants, and portable pumps acceptable because the applicant's strategy follows the guidance in NEI 06-12 Section 3.3.7.

20.2.5 Combined License Information Items

Table 19.4-1 lists the COL information item numbers and descriptions related to LOLA, from DCA Part 2, Tier 2, Table 1.8-2.

Table 19.4-1 NuScale Combined License Information Items for Section 19.4

Item No.	Description	DCA Part 2, Tier 2 Section
20.2-1	A COL applicant that references the NuScale Power design certification will develop enhanced firefighting capabilities by implementing the guidance in NRC guidance document "Developing Mitigating Strategies/Guidance for Nuclear Power Plants to Respond to Loss of Large Areas of the Plant in Accordance with B.5.b of the February 25, 2002, Order" dated February 25, 2005 (Reference 20.2-3). The enhanced firefighting capabilities should address the expectation elements listed in Section 4.1.3 of the Technical Report TR-0816-50796.	20.2

20.2-2	A COL applicant that references the NuScale Power design certification will provide a means for water spray scrubbing using fog nozzles and the availability of water sources, and address runoff water containment issues (sandbags, portable dikes, etc.) as an attenuation measure for mitigating radiation releases outside containment.	20.2

20.2.6 Conclusion

Based on the staff's review of the information provided by the applicant, the staff concludes that the applicant has adequately followed the guidance of SRP 19-04 and NEI 06-12. The staff finds, as documented in the review above, that the applicant has provided sufficient information regarding Phase 1, 2, and 3, design enhancements at this stage that could be used by a COL applicant in developing its mitigative strategies in order to meet the requirements of 10 CFR 50.54(hh)(2).

20.3 Integration with Emergency Procedures

The applicant has identified COL Item 20.3-1 to address integration with emergency procedures. There are no regulatory requirements available to the staff to evaluate this subsection for beyond-design-basis-events associated with a DCA. Therefore, the staff did not evaluate COL Item 20.3-1.

Item No.	Description	DCA Part 2, Tier 2 Section
20.3-1	A COL applicant that references the NuScale Power Plant design certification will ensure that the severe accident management guidelines, diverse and flexible coping strategies support guidelines (FSGs), and extensive damage mitigation guidelines are integrated with the emergency operating procedures consistent with Recommendation 8.1 of SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan."	20.3

20.4 Enhanced Emergency Response Capabilities for Beyond-Design-Basis Events

The applicant has identified COL Items 20.4-1 through 20.4-6 to address enhanced emergency response capabilities for beyond design basis events. There are no regulatory requirements available to the staff to evaluate enhanced emergency response capabilities for beyond design basis events associated with a DCA. Therefore, the staff did not evaluate COL Items 20.4-1 through 20.4-6.

Item No.	Description	DCA Part 2, Tier 2 Section

20.4-1	A COL applicant that references the NuScale Power Plant design certification will perform an analysis that demonstrates the Emergency Response Organization staff has the ability to implement the strategies of the emergency operating procedures, severe accident mitigation guidelines, FLEX support guidelines, and extensive damage mitigation guidelines. The analysis will be performed with the off-site response organization access to on-site being impeded. The event shall be a loss of all on-site and off-site alternating current power and loss of normal access to the ultimate heat sink.	20.4
20.4-2	A COL applicant that references the NuScale Power Plant design certification will develop a supporting Emergency Response Organization structure with defined roles and responsibilities to implement the strategies of the emergency operating procedures, severe accident mitigation guidelines, FLEX support guidelines, and extensive damage mitigation guidelines.	20.4
20.4-3	A COL applicant that references the NuScale Power Plant design certification will develop and describe at least one onsite and one offsite communications system capable of remaining functional during an extended loss of alternating current power including the effects of the loss of the local communications infrastructure.	20.4
20.4-4	A COL applicant that references the NuScale Power Plant design certification will develop, implement, and maintain the training and qualification of personnel that perform activities in accordance with FLEX support guidelines, severe accident mitigation guidelines, and extensive damage mitigation guidelines. The training and qualification on these activities will be developed using the systems approach to training as defined in 10 CFR 55.4 except for elements already covered under other NRC regulations.	20.4
20.4-5	A COL applicant that references the NuScale Power Plant design certification will develop drills or exercises that demonstrate the ability to transition to one or more of the strategies and guidelines of the emergency operating procedures, FLEX support guidelines, severe accident mitigation guidelines, and extensive damage mitigation guidelines using only the station communication equipment designed to be available following an extended loss of alternating current including effects of the loss of the local communications infrastructure.	20.4
20.4-6	A COL applicant that references the NuScale Power Plant design certification will develop and describe the means to be used for determining the magnitude of, and for continually assessing the impact of, the release of radioactive materials to the environment including releases from all reactor core and spent fuel pool sources.	20.4