Evaluation of Natural Hazards Other than Seismic and Flooding

Table of Contents

Acronyms

ac	alternating current
ACRS	Advisory Committee on Reactor Safeguards
ADAMS	Agencywide Documents Access and Management System
ANS	American Nuclear Society
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
BWR	boiling water reactor
CFR	Code of Federal Regulations
EDG	emergency diesel generator
EGM	enforcement guidance memorandum
ELAP	extended loss of alternating current power
EPRI	Electric Power Research Institute
ESWS	essential service water system
FERC	Federal Energy Regulatory Commission
FHRR	flooding hazard reevaluation report
FLEX	Diverse and Flexible Coping Strategies
GI	Generic Issue
GL	Generic Letter
GSI	Generic Safety Issue
IAEA	International Atomic Energy Agency
IN	Information Notice
IP	inspection procedure
IPEEE	individual plant examination of external events
ISG	interim staff guidance
MBDBE	mitigation of beyond-design-basis events
NERC	North American Electric Reliability Corporation
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NTTF	Near-Term Task Force
PRA	probabilistic risk assessment
PRM	petition for rulemaking
PWR	pressurized water reactor
RCP	reactor coolant pump
RES	Office of Nuclear Regulatory Research
RIS	Regulatory Issue Summary
SRP	standard review plan
SSCs	systems, structures, and components
SEP	systematic evaluation program
STS	standard technical specification
UHS	ultimate heat sink
USAR	updated safety analysis report

1.0 Summary

As described in SECY-15-0137, "Proposed Plans for Resolving Open Fukushima Tier 2 and 3 Recommendations," dated October 29, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15254A008) the staff undertook a series of screening-type evaluations to determine if external hazards other than seismic and flooding warranted regulatory actions, such as requesting information pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.54(f) or requiring changes to plant designs or procedures in accordance with 10 CFR 50.109, "Backfitting." The screening-type evaluations for external hazards other than seismic and flooding cover a variety of potential natural events beyond the current licensing basis that were either: (1) not addressed within existing licensing basis documents (e.g., final safety analysis reports), or (2) calculated to be to more severe than described in licensing basis documents when reevaluated using current-day information and methodologies.

In assessing whether additional regulatory action is warranted, the staff took a holistic approach considering the likelihood of the event, the assumed severity of the event, and the plant's ability to respond to the event. When evaluating the plant's ability to respond, the staff considered both the protection provided by structures, systems and components (SSCs) in pre-Fukushima configurations, and capabilities that have been added as part of post-Fukushima upgrades. The primary post-Fukushima upgrade is the additional capabilities required by Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012 (ADAMS Accession No. ML12054A735). The staff's evaluations were performed using guidance such as Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection," to determine if additional regulatory actions were justified.

The NRC divided the review process into the following four tasks:

1. Define natural hazards other than seismic and flooding to determine those hazards that could potentially pose a threat to nuclear power plants and perform a screening to determine which of those should be reviewed generically. As part of this task, the staff also screened hazards for additional reviews if new information or guidance from the last regulatory review of the hazard for operating plants was issued.

2. Determine and apply screening criteria to remaining hazards from Task 1 and appropriately exclude certain natural hazards from further generic evaluations, or exclude some licensees from considering certain hazards.

3. Perform a technical evaluation to assess the need for additional actions if the hazard or licensee was not screened out generically in Task 2.

4. As discussed in SECY-15-0137, the last task in the process would be for the staff to determine if additional actions are needed, such as performing further analyses of potential plant backfits or issuing a generic communication requesting information from licensees.

The screening process resulted in the assessment and disposition of a variety of external natural hazards with the staff concluding that no additional actions or information are needed.

The Commission approved the resolution plan for this issue in the staff requirements memorandum (SRM) to SECY-15-0137 dated February 8, 2016 (ADAMS Accession No. ML16039A175), and directed the staff to provide the Commission the results of Task 2 by the end of May 2016. This enclosure provides that assessment.

The staff's assessment performed in accordance with Task 1 screened out natural hazards (other than seismic and flooding) with the exception of high winds, extreme ambient temperatures, drought and other low-water conditions, and winter precipitation that results in snow and ice loading on structures. Based on its assessment in accordance with Task 2 of the process, the NRC staff determined that additional regulatory actions are not warranted for extreme ambient temperatures, and drought and other low-water conditions. The hazards proceeding to the third task in the screening process include high winds and snow and ice loads. The staff considers Task 1 and Task 2 activities completed. For the high winds and snow loads evaluation, this document provides initial considerations for the assessment of these hazards. The staff intends to complete the assessment of high winds and snow loads in accordance with Task 3 by the end of 2016.

The staff notes that flooding, seismic and geomagnetic storms are subject to ongoing work. The staff will continue to update the Commission regarding the status of the seismic and flooding reevaluations in accordance with Commission direction. In addition, if the staff determines that regulatory actions are needed to address geomagnetic storms, the staff will inform the Commission through existing processes (e.g., response to the petition for rulemaking (PRM 50-96 associated with geomagnetic storms, which is discussed later in this enclosure).

2.0 Background

As directed by the SRM to SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated August 19, 2011 (ADAMS Accession No. ML112310021), the NRC staff identified additional recommendations related to lessons learned from the Fukushima Dai-ichi event, beyond those identified in the Near-Term Task Force (NTTF) report. Additional recommendations were based on information from U.S. NRC staff and external stakeholders, including the Office of Science and Technology Policy, Congress, international counterparts, other Federal and State agencies, nongovernmental organizations, the public, and the nuclear industry. These issues were raised in a variety of forums, including an August 31, 2011, public meeting and a September 9, 2011, Commission meeting.

In response to comments from the Advisory Committee on Reactor Safeguards (ACRS) and specific language included in the Consolidated Appropriations Act, 2012 (Public Law (Pub. L.) 112-74, signed into law on December 23, 2011), the NRC staff identified an action regarding reevaluation of natural external hazards other than seismic and flooding hazards. In 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 (ADAMS Accession No. ML12039A103), this action was prioritized as a Tier 2 activity both because of the lack of availability of the critical skill sets for both the NRC staff and external stakeholders and because the NRC staff considered the seismic and flooding reevaluations to be of higher priority.

Enclosure 3 to SECY-12-0025 detailed the initial program plan for this recommendation. That plan called for the staff to follow the same process used for the Tier 1 seismic and flooding reevaluations (i.e., issue a request for information pursuant to 10 CFR 50.54(f)).

Section 402 of Division B of Pub. L. 112-74 requires the NRC to have licensees reevaluate external hazards against applicable requirements and guidance. More specifically, this section provides the following:

> The Nuclear Regulatory Commission shall require reactor licensees to re-evaluate the seismic, tsunami, flooding, and other external hazards at their sites against current applicable Commission requirements and guidance for such licensees as expeditiously as possible, and thereafter when appropriate, as determined by the Commission, and require each licensee to respond to the Commission that the design-basis for each reactor meets the requirements of its license, current applicable Commission requirements and guidance for such license. Based upon the evaluations conducted pursuant to this section and other information it deems relevant, the Commission shall require licensees to update the design-basis for each reactor, if necessary.

Subsequently, the NRC's Office of Congressional Affairs, during interactions with House and Senate Appropriations staff, identified that the intent of Pub. L. 112-74 was for the NRC to include natural external hazards in the scope of its review, and exclude man-made hazards. Because man-made hazards do not have a direct nexus to the Fukushima Dai-ichi accident, the NRC staff concluded that they should be treated outside the scope of Fukushima lesson-learned activities. As such, the NRC staff submitted the consideration of man-made hazards to the NRC's Generic Issues (GI) Program by memorandum dated September 9, 2013 (ADAMS Accession No. ML12328A180). By memorandum dated January 17, 2014 (ADAMS Accession No. ML13298A782), the NRC staff concluded that the proposed GI does not satisfy at least three criteria for acceptance as a GI. Therefore, the NRC staff did not undertake possible regulatory requirements or information collection related to man-made hazards and will continue to address issues in that area as they arise on a case-by-case basis, as has been the NRC's historical practice.

SECY-15-0137, Enclosure 1, provided an update to the staff's plan for resolving this issue. This document provides the interim results of the staff's assessment based on the process outlined in SECY-15-0137, Enclosure 1.

3.0 Discussion

Seismic and flooding hazards were given priority as Tier 1 activities during the NRC's review of Fukushima lessons learned because of the nature of the Fukushima disaster and the historically recognized risk these hazards pose to operating plants and due, in part, to significant advancements in the state of knowledge and the state of analysis in these areas since the operating plants were sited and licensed. This paper focuses on Tier 2 activities and assesses natural hazards other than seismic and flooding.

The state of knowledge and the state of analysis have also advanced for other natural hazards, such as snow loads and extreme winds. Regulatory guidance, which was not available at the time early generation operating plants were licensed, has recently been updated on how to

evaluate snow loads. In the case of extreme winds, improved understanding has led the staff to determine that the hazard level previously considered for many sites was more conservative than that defined in present-day guidance. However, improved understanding and enhanced models have also indicated that for some sites, hurricane winds, which are often lower speed than design-basis tornado winds, may produce more intense missiles than tornado winds. In light of those facts, the staff adopted a screening approach that focuses resources on those hazards of higher relative concern.

In addition to the original plant siting parameters, the NRC staff considered how other natural hazards are being addressed within the requirements for mitigating strategies for beyond-design-basis external events. Specifically, as part of compliance with Order EA-12-049 (ADAMS Accession No. ML12054A735), the NRC has required licensees to ensure that mitigating strategies can be implemented under a broad array of external natural hazards, which, in turn, required licensees to evaluate other external natural hazards applicable to their sites against current NRC requirements and guidance. The guidance in NRC-endorsed NEI 12-06 describes a process for licensees to determine which external natural hazards should be addressed within the mitigating strategies developed for each site. Licensees following this guidance evaluate external natural hazards on a site-specific basis. The NRC reviewed the results of those evaluations during precompliance audits. As such, a safety benefit has been achieved in the near-term for the Tier 2 hazards, as well as seismic and flooding, because external natural events associated with these hazards have been considered in the implementation of Order EA-12-049 and are being considered in the proposed rule for mitigation of beyond-design-basis events (MBDBE). Nevertheless, the staff performed an additional review to determine if changes in the hazard warrant other regulatory actions, beyond those associated with Order EA-12-049 and the MBDBE proposed rule, to ensure the protection of public health and safety against external natural hazards other than seismic and flooding. Consistent with the Commission direction in its staff requirements memorandum (SRM) for COMSECY-12-0037, “Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards,” the staff factored the safety benefits achieved through Order EA-12-049 into the evaluations to determine whether additional changes could be justified.

Moreover, in its assessment of the need for additional regulatory actions with respect to natural hazards other than seismic and flooding, the staff was informed by the Commission guidance on performing backfit analyses. The NRC established methods of performing these assessments and used criteria such as those defined in the Commission’s Safety Goal Policy Statement (51 FR 28044; August 4, 1986, as corrected and republished at 51 FR 30028; August 21, 1986). As a general matter, the process includes evaluating the overall plant risk associated with an identified event or condition and ultimately assessing whether the event or condition might be expected to lead to fuel damage and the release of radioactive materials from a site. This is significantly different from the consideration of events or conditions during the design and initial licensing of plants. In the design and licensing process, individual components and structures are assessed to ensure they protect safety-related systems from given events or conditions (i.e., generally deterministically specified rather than probabilistically estimated). This design and licensing approach establishes with a high degree of confidence an initial capability, with margin, of a plant to cope with a defined set of internal and external events.

As described below, the staff assessed the ability of existing plant SSCs to withstand structural loads from snow, tornado and hurricane winds, and wind-generated missiles of a higher

magnitude than was defined in the initial design and licensing process for the current operating reactors. In some cases the higher magnitude events correspond to the use of more recent regulatory guidance developed for the siting and design of new reactors. In many cases, typical engineering practice and design margins result in SSCs being able to remain functional even with a higher magnitude hazard. The purpose of the assessment is to provide reasonable confidence that the higher magnitude event would not lead to more severe consequences than presented in the initial design and licensing documents. This type of deterministic assessment allows the NRC staff to screen out certain external natural events for many plants without needing to address initiating event frequencies or estimating the overall plant risk associated with external natural events of higher magnitudes than assumed in the initial design and licensing process. If there are cases where some events for specific plants are not screened out through the deterministic assessment, the NRC staff used available information and engineering judgment to assess whether the event might be expected to lead to a more severe reactor accident and thereby challenge the NRC's established safety goals.

3.1 Review Process

The NRC staff divided the review process into the following four tasks:

1. Define natural hazards other than seismic and flooding to determine those that could potentially pose a threat to nuclear power plants, and screen them to determine which ones should be reviewed generically. As part of this task, the staff also screened hazards for additional reviews if new information or guidance from the last regulatory review of the hazard for operating plants was issued. For example, improved understanding and enhanced models have indicated that for some sites, hurricane winds, which are often lower speed than the design-basis tornado winds, may produce more intense missiles than tornado winds. The staff issued Regulatory Guide (RG) 1.221, "Design Basis Hurricane and Hurricane Missiles for Nuclear Power Plants" (ADAMS Accession No. ML110940300), in October 2011, after all of the current operating plants, except Watts Bar Unit 2, were licensed.

   Potential external natural hazards to nuclear power plants have been identified in various NRC studies, international reports, standards, and other guidance documents. The documents reviewed for this evaluation included the following:

   - Electric Power Research Institute (EPRI) 1022997, "Identification of External Hazards for Analysis in Probabilistic Risk Assessment," dated December 2011, and EPRI 3002005287, "Identification of External Hazards for Analysis in Probabilistic Risk Assessment: Update of Report 1022997," dated October 2015;

   - American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) RA-Sa-2009 Appendix 6-A, "Addenda to ASME/ANS RA-S–2008 Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," dated February 2009;

   - International Atomic Energy Agency (IAEA) TECDOC-1341, "Extreme External Events in the Design and Assessment of Nuclear Power Plants," dated March 2003;

- Nuclear Energy Agency (NEA), Committee on the Safety of Nuclear Installations (CSNI), NEA/CSNI/R(2009)4, “Probabilistic Safety Analysis (PSA) of Other External Events Than Earthquake,” dated March 2009;

- NUREG/CR-5042, “Evaluation of External Hazards to Nuclear Power Plants in the United States,” dated December 1987;

- NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light Water Reactor] Edition,” dated March 2007; and

- other international and domestic references.

Using previous analyses and engineering judgment, as discussed in Section 3.2 of this enclosure and Enclosure 1 of SECY-15-0137, the staff determined that most hazards from the above reports are screened out and those moving to the second task of the process are: (1) wind and missile loads from tornadoes and hurricanes, (2) snow and ice load for roof design, (3) drought and other low-water conditions that may reduce or limit the available safety-related cooling water supply, and (4) extreme maximum and minimum ambient temperatures.

2. Determine and apply screening criteria to remaining hazards from Task 1 and appropriately exclude certain natural hazards from further generic evaluations, or exclude some licensees from considering certain hazards. Screening criteria included:

   - conservatism of design safety margins;
   - operational limits provided in technical specifications;
   - low frequency of occurrence/low risk; and
   - warning time available to allow measures to be taken to prevent an accident from occurring.

   This process, which is discussed in further detail in Section 3.3 of this enclosure, considered, among other things, whether external natural hazards should be eliminated from consideration, because they are addressed by existing requirements (e.g., temperatures affecting UHSs) or common industry preparations for severe weather, such that it is unlikely the hazard will cause an accident. Wind events, and primarily tornadoes, have been the focus of discussions related to other external natural hazards because of the limited time available for licensees to prepare for such events. However, many plants may have been designed to winds speeds and missiles that are more severe than would be required today.

3. Collect additional information and, where necessary, perform a technical evaluation to assess the need for additional actions if the hazard or licensee was not screened out in Task 2. The staff determined that information collection and possible technical evaluations were warranted for wind and missile loads from tornadoes and hurricanes, as well as for snow loads. The staff’s approach for assessing and dispositioning these hazards can be found in Section 3.4 of this enclosure.

As discussed in SECY-15-0137, the staff considered whether or not actions were warranted as a result of the staff's evaluation of wind and missile loads from tornadoes and hurricanes including the following:

- taking actions to address plant-specific issues associated with the updated external natural hazards (including potential changes to the licensing or design basis of a plant or mitigating strategies in place to address the impact of the hazard); and

- requiring licensees to reevaluate site-specific external natural hazards (e.g., issue a request for information pursuant to 10 CFR 50.54(f) to reevaluate a hazard, as was done for seismic and flooding hazards in March 12, 2012, letters).

The NRC guidance for determining if requests for information from licensees are warranted is provided in NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection."

4. As discussed in SECY-15-0137, the last task in the process would be for the staff to determine if additional actions are needed, such as the following:

   - Evaluate the results from Task 3, including actions taken or planned by the licensee, and determine if additional action is needed. Any further regulatory actions will require a formal and systematic review to ensure that changes are properly justified and suitably defined as required in 10 CFR 50.109.

   - Issue generic communications per Management Directive 8.18, "NRC Generic Communications Program," dated March 5, 2009.

   The NRC guidance for evaluating the possible imposition of additional requirements on licensees for operating nuclear power plants is also provided in NRC Management Directive 8.4. As part of Task 4, the staff would use the information developed to determine if a facility-specific backfit is necessary, based on the guidance in Management Directive 8.4 and the requirements in 10 CFR 50.109. As noted above, the staff would also consider other regulatory options, such as issuance of a generic communication, depending on the results of its assessment.

   The staff has not completed its evaluation in accordance with Task 3 of the process for wind and missile loads from tornadoes and hurricanes, or snow loads; Task 4 will only be exercised if the results from Task 3 indicate the need to do so.

3.2 Identifying Natural Hazards other than Seismic and Flooding To Be Considered for Further Evaluation

Appendix A provides a tabulation of the natural hazards that the staff considered as part of its review. The list of hazards was developed based on the staff's review of the documents referenced in Section 3.1 of this enclosure. The current regulatory framework requires that U.S. nuclear sites be evaluated for these hazards when initially licensed. As required by 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A,

"General Design Criteria for Nuclear Power Plants,"[1] General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," licensees shall demonstrate that their safety-related structures, systems, and components (SSCs) are designed to withstand the effects of natural phenomena without loss of capability to perform their safety functions, giving appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

To complete the Tier 2 activity and satisfy the NRC's obligations under Section 402 of Division B of Pub. L. 112-74, the NRC staff evaluated the external hazards using existing information and processes, and assessed the need for further regulatory actions. This included consideration of such previously submitted licensee information on external hazards as the following:

- information associated with plants licensed in the late 1960s and early 1970s that were reviewed as part of the Systematic Evaluation Program (SEP);

- licensee submittals associated with the review of individual plant examination of external events (IPEEEs);

- information provided in the licensees' integrated plans required by Order EA-12-049;

- licensee information (e.g., updated safety analysis reports (USARs)) on the criteria used for their plants' design and licensing basis; and

- information from recent NRC activities related to atural hazards (e.g., Regulatory Issue Summary (RIS) 15-06, "Tornado Missile Protection," dated June 6, 2015) and recent GI Program reviews.

Appendix A includes Table A-1 that provides the staff's rationale for either including or excluding the hazard for further evaluation. The staff's evaluation is based on the potential for the magnitude of the beyond-design-basis external hazard to challenge a nuclear power plant, such that additional regulatory action beyond what the NRC currently requires is warranted to address the hazard. Part of the staff's assessment of other natural hazards is based on whether new regulatory guidance has been developed for a particular hazard since the currently operating reactors received their operating licenses. In completing its evaluation, the staff considered whether the potential risks from new insights on external natural hazards might warrant imposing additional requirements using the regulations in 10 CFR 50.109, "Backfitting," requirements.

The staff's process used for identifying hazards for review is consistent with the process that licensees used to comply with the order on mitigating strategies. As part of compliance with Order EA-12-049, the NRC required licensees to ensure that mitigating strategies can be implemented under a broad array of external natural hazards, which, in turn, required licensees to evaluate other external natural hazards applicable to their sites using current NRC

[1] The General Design Criteria (GDC) were implemented for plants that had construction permits issued after May 21, 1971. Each plant that was licensed before the GDC were formally adopted was evaluated on a plant specific basis. As discussed later in this paper, these "pre-GDC" plants were reviewed as part of the SEP.

requirements and guidance. This process is outlined in NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625). Interim staff guidance JLD-ISG-12-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML15357A163) endorsed NEI 12-06.

The staff also considered the insights and perspectives developed as a result of IPEEEs. On June 28, 1991, the NRC issued Supplement 4 to Generic Letter (GL) 88-20, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities, 10 CFR 50.54(f)," and NUREG-1407, "Procedure and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities." Supplement 4 to GL 88-20 requested that each licensee identify and report to the NRC all plant-specific vulnerabilities to severe accidents caused by external events. The external events to be considered in the IPEEE were seismic events; internal fires; and high winds, floods, and other external initiating events.

The staff evaluated each plant's IPEEE submittal and also produced NUREG 1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE)," (ADAMS Accession No. ML021270132). The primary purpose of NUREG 1742 was to document the perspectives derived from the technical reviews of the IPEEE submittals. The report describes the overall IPEEE process and findings; discusses the dominant risk contributors for the major areas of evaluation (i.e., seismic events; fires; and high winds, floods and other external initiating events); lists plant improvements made by licensees as a result of the IPEEE program; summarizes the overall strengths and weaknesses in the licensees' implementation of the IPEEE evaluation methodologies; and assesses licensees' overall effectiveness in meeting the IPEEE objectives.

3.2.1 Excluding Hazards from Further Review

Appendix A provides the rationale and primary reasons for excluding some hazards from additional consideration. The staff's evaluation of the hazards found in Appendix A is generally consistent with the results found in NRC-endorsed guidance document NEI 12-06, although the staff's rationale for excluding a hazard from additional review may vary from that found in NEI 12-06. As documented in Section 4.1 of NEI 12-06, the external natural hazards generically identified for additional consideration to address the mitigating strategies order were: (1) seismic, (2) external flooding, (3) storms with high winds, (4) snow, ice, and extreme cold, and (5) extreme high temperatures. NEI 12-06 also provides guidance to licensees to address site-specific hazards as appropriate.

The evaluation found in Appendix A provides the staff's rationale for excluding certain beyond-design-basis events from further consideration. Appendix A also provides a list of those events that the staff further evaluates in Sections 3.3 and 3.4 of this enclosure. The basis for excluding the majority of the hazards from additional evaluation was the staff's deterministic judgment, augmented by risk insights (where available), to determine that additional regulatory action beyond what the NRC currently requires is not warranted at this stage.

For geomagnetic storms the staff's decision that additional evaluation as part of this activity is not needed is based on evaluations that are being, or will be, performed in the context of other regulatory processes. Specifically, Appendix A describes the ongoing efforts within the MBDBE

rulemaking and PRM process to address geomagnetic storms. Because the NRC staff has not identified an immediate safety concern associated with geomagnetic storms and will continue to evaluate this issue using existing processes, the staff considers this issue resolved in the context of this assessment. The staff will inform the Commission if additional actions are warranted as a result of the MBDBE rulemaking effort and in the final disposition of PRM-50-96.[2]

3.2.2 Hazards Proceeding to Second Task of Screening Process

In accordance with Task 1 of the process discussed above, the staff determined that additional evaluations are warranted for a subset of hazards. The hazards needing additional evaluation per Task 2 of the process fall into the following categories: (1) wind and missile loads from tornadoes and hurricanes, (2) snow and ice load for roof design, (3) drought and other low-water conditions that may reduce or limit the available safety-related cooling water supply, and (4) extreme maximum and minimum ambient temperatures. The basis for including these four categories of hazards for additional evaluation is discussed for each hazard below.

Tornado and Hurricane Missile Loads

Many of the currently operating plants were licensed before the 1975 version of the standard review plan (SRP). As a result, the staff determined that it would be appropriate to review the design-basis tornado missile protection for these older plants against the current standard review plan and the March 2007, version of RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants" (ADAMS Accession No. ML100541776). The NRC staff also reviewed current operating plants that were licensed against the 1975 version of the SRP using the current version of the SRP and the March 2007 version of RG 1.76.

The staff determined that additional review of hurricane missiles was warranted because of recently issued guidance in this area. In October 2011 the staff issued RG 1.221 (ADAMS Accession No. ML110940300). RG 1.221 notes that, because the size of the hurricane zone with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field with the same maximum wind speed.

Snow and Ice Loads

On June 23, 2009, the staff issued interim staff guidance (ISG) DC/COL-ISG-007, "Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures" (ADAMS Accession No. ML091490556). This guidance was issued for new reactor reviews since the existing guidance in NUREG-0800 (available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800) did not provide specific approaches to consider snow loads at ground level due to normal and extreme winter precipitation events for the design of seismic Category I structures. The staff determined it was appropriate to advance this external natural event to the next task in the screening process because the recent updated guidance

[2] Appendix A of this document discusses PRM 50-96 related to geomagnetic storms.

provides approaches for considering snow loads that were not available when some of the operating plants were initially licensed.

Drought and Other Low-Water Conditions

The staff's assessment of water level conditions at nuclear power plant sites has been focused on flooding and the associated flooding reevaluations. One of the causes of flooding that the staff is reviewing is flooding due to upstream dam failures. The staff determined that it would be appropriate to review low water conditions caused by failures from seismically-qualified dams downstream of a nuclear power plant.[3] Low water conditions can also be caused by drought. Regardless of the cause of the low water condition, the staff's review is based on the concern that such conditions could reduce or limit the available safety-related cooling water supply. Therefore, the staff determined that additional evaluation of low water conditions was warranted to determine whether additional regulatory actions are needed to address this condition.

Extreme Maximum and Minimum Ambient Temperatures

Extreme maximum and minimum ambient temperatures were identified by the staff for additional evaluation under Task 2 of the process above because of the potential for these events to cause operational issues for normal plant heat sink and containment heat removal systems (post-accident), and meteorological conditions related to the maximum evaporation and drift loss and minimum water cooling for the UHS design. Although the NRC evaluates extreme temperature conditions during licensing, and specifically for license amendments to increase allowable UHS maximum temperatures, not all plants have made such requests; and even for plants that have, minimum temperature would not have been reviewed as part of such an amendment request. Therefore, the staff determined that additional evaluation of extreme temperature conditions was warranted to determine whether additional regulatory actions are needed to address this condition.

3.3 Evaluation of Natural Hazards that Meet the Criteria for Further Evaluation

This portion of the document provides the staff's determination of the external natural hazards per Task 2 of the screening process outlined above. In this part of the evaluation process, the staff determined and applied screening criteria to appropriately exclude certain natural hazards from further generic evaluations, or exclude consideration of certain hazards for some licensees. Screening criteria determined by the staff to be applicable to this part of the evaluation include the following:

- conservatism of design safety margins (in terms of ability to address new information or events exceeding design basis values);
- operational limits provided in technical specifications;
- low frequency of occurrence/low risk; and

[3] Non-seismically qualified dams are assumed to fail in accordance with the guidance associated with Order EA-12-049. Because these dams are evaluated as part of compliance with Order EA-12-049 they are outside the scope of this paper.

- warning time available to allow measures to be taken to prevent an accident from occurring.

This process considered, among other things, whether external natural hazards should be eliminated from consideration because they are addressed by existing requirements (e.g., temperatures affecting UHSs) or common industry preparations for severe weather, such that it is unlikely the hazard will cause an accident.

3.3.1 Wind and Missile Loads for Tornadoes and Hurricanes

The staff assessed the wind and missile loads for tornadoes and hurricanes and based on the screening criteria identified above, determined that additional evaluation of these loads were warranted. As part of Task 2 of the process, the staff recognized the conservatism in design of nuclear power plants associated with tornado missile protection, and the warning time available for hurricanes. Application of these criteria could exclude many sites from further evaluation. A few sites may require further review of available site-specific information to assess the need for additional regulatory actions. Nevertheless, the staff determined that the application of these criteria alone did not eliminate the hazards from additional evaluation because:

1. Many of the currently operating plants were licensed prior to the 1975 version of the standard review plan and the staff determined that it would be appropriate to review the design basis tornado missile protection for these plants, and

2. The staff determined that it would be appropriate to review hurricane missiles because of recently-issued guidance in this area.

Therefore, the staff determined that a more detailed evaluation in accordance with Task 3 of the process above is appropriate. The approach to the staff's review of this hazard is discussed in Section 3.4.1 of this enclosure.

3.3.2 Snow and Ice Loads

The staff assessed snow and ice loads and based on the screening criteria identified above, determined that additional evaluation of these loads was warranted. As part of Task 2 of the process, the staff recognized the conservatism in the design of nuclear power plants associated with snow and ice loads, and the warning time available for large snow events. The staff determined that the application of these criteria could ultimately exclude the hazards from additional regulatory actions. The staff determined it was appropriate to advance this external natural event to Task 3 because the recent updated guidance provides approaches for considering snow loads which were not available when some of the operating plants were initially licensed. The approach to the staff's review of this hazard is discussed in Section 3.4.2 of this enclosure.

3.3.3 Drought and Other Low Water Conditions

In evaluating drought and other low water conditions, the staff considered the following criteria from Task 2:

- conservatism of design safety margins;
- operational limits provided in technical specifications; and

- warning time available to allow measures to be taken to prevent an accident from occurring.

Drought Conditions

Regarding drought conditions the staff notes that power plants have safety-related heat sinks that rely on sufficient water to safely shut down the plant and keep the plant in a safe shut down condition for several days. If a drought occurred such that it would affect the safety-related water supply, licensees would be required, in accordance with their technical specifications, to take actions to place the plant in a safe condition. Drought conditions that would affect the operability of the safety-related heat sink would have associated warning times available that would allow licensees to take measures to prevent an accident from occurring: licensees would be expected to provide additional water sources to remove decay heat either through the safety-related ultimate heat sink or through other means (e.g., replenishing of water in the spent fuel pool, and removal of decay heat from the reactor through long-term means).

Low Water Conditions

Low water conditions (other than caused by drought) could be due to failure of downstream dams or impoundments associated with the safety-related heat sink or a seiche or a tsunami leading to a rapid drawdown of water away from safety-related pumps in service water structures. Although such events could occur with little or no warning, they are not expected to affect a licensee's capability to remove decay heat from the reactors or spent fuel pools by other means. That is, the low water conditions are not expected to prevent a licensee from providing onsite makeup capability to the steam generators for pressurized-water reactors (PWRs) or to the reactor vessel for boiling-water reactors (BWRs) in the near term, and providing onsite makeup to the spent fuel pool.

Low Water Conditions Due to Downstream Dam Failure

Low water conditions due to the failure of a downstream dam was evaluated in two steps. In the first step, the NRC's Generic Issue Program evaluated all operating reactors and concluded that all plants screened out (no further regulatory actions are needed) with the exception of H. B. Robinson. Robinson was not resolved in the first step because the Generic Issue Program stipulates that decisions can only rely on readily-available information. The generic issue review panel that was formed to evaluate the issue did not have sufficient information on the backup water sources at Robinson. In the second step (documented herein), the NRC staff evaluated the Robinson plant and determined that no further regulatory actions are needed. These steps are described below.

Generic Issue Review

The NRC staff submitted a proposed generic issue on the effects of downstream dam failures on nuclear power plants. The issue was designated Pre-Generic Issue 11, "Effects of Downstream Dam Failures on Nuclear Power Plants." A generic issue review panel was formed to evaluate the issue following the processes outlined in Management Directive (MD) 6.4, "Generic Issues Program," and the Office of Nuclear Regulatory Research's (RES) Office Instruction (TEC) 002, "Procedure for Processing Generic Issues." The staff assessment of this issue can be found in a memorandum from John Monninger to Michael Weber, titled "Recommendation for Dispositioning Proposed Generic Issue on the Effects of Downstream

Dam Failures on Nuclear Power Plants," dated March 11, 2016 (ADAMS Accession No. ML15253A365). To summarize, the review panel established to address the issue determined that downstream dam failures did not meet the criteria for becoming a generic issue. As noted in that memorandum, the scope of the staff's assessment was limited to the failure of seismically-qualified downstream dams.

The staff's rationale for focusing on seismically-qualified dams was that actions taken in response to Order EA-12-049 on mitigating strategies already address the failure of nonseismic dams. The NRC-endorsed guidance document for this order, NEI 12-06, directs licensees to develop strategies to cope without reliance on any equipment that is not considered "robust." Per the guidance, a nonseismic dam would not be considered "robust" and, therefore, licensees would develop strategies to use other sources of water. The scenario evaluated under the order is an extended loss of alternating current (ac) power (ELAP) and a loss of normal access to the UHS, coupled with a beyond-design-basis external event. This scenario bounds all single scenarios that would result in a dam failure, including a random (sunny day) dam failure. Thus, the failure of downstream dams not shown to be seismically robust have been evaluated separately. However, if a downstream dam or downstream impoundment were categorized as seismically-qualified, the NRC staff would consider the structure to be "robust" and would not evaluate its failure under the order. Therefore the panel reviewed the random (sunny day) failure of seismically-qualified downstream dams or impoundment reservoirs.

The panel's process and conclusions are discussed in detail in the March 11, 2016, letter and are outlined in Appendix B of this document. In summary, the staff found that none of the plants met the risk criteria for continued evaluation in the Generic Issues Program, with the possible exception of H. B. Robinson. The panel recommended that the Office of Nuclear Reactor Regulation conduct further evaluation of Robinson to evaluate sources of water that were not credited by the panel. In order to timely address the panel's recommendations and comprehensively disposition this external hazard, the NRC staff performed a Task 3-like, site-specific technical evaluation to address this hazard for Robinson, as documented below.

Review of Robinson

The staff's review of Robinson downstream dam failure is presented in detail in Appendix B to this enclosure. The plant relies on Lake Robinson for its ultimate heat sink. Lake Robinson is formed in part by Lake Robinson dam, which is seismically qualified. The plant has several water sources available to provide cooling water in the event of a random failure of Lake Robinson dam. The staff concludes that further regulatory actions are not needed to address a random failure of this dam because:

- Over 20 hours of water supply is provided to remove decay heat using the condensate storage tank and auxiliary feedwater tanks. Alternate sources of water should be able to be acquired in this time period to feed the steam generators. The NRC staff notes that the 20 hours is based on the instantaneous loss of the UHS due to the downstream dam failure and no credit is taken for the time it would take to drain the lake from such a failure. The NRC staff also notes that the amount of decay heat produced after 20 hours is approximately 1/3 of the decay heat created immediately after a plant shutdown.

- Water from the "D" deepwell pump can provide cooling to the emergency diesel generators, or can be used as a source of water to the steam generators. In addition, non-safety related deepwell pumps A, B, and C, can provide an alternate source of water to the steam

generators. These non-safety-related systems should be available in the event of a "sunny day" dam failure and can be powered by offsite power, or FLEX generators. In addition, the "D" deepwell pump can be powered from the onsite emergency diesel generator. RCS inventory makeup water supplies are sufficient in the event of a sunny day dam failure based on the use of reactor coolant pump (RCP) low leakage seals, the water inventory available in the refueling water storage tank, and the availability of a portable high-pressure FLEX pump.

- The deepwell pumps may not be available following a seismic event; however, the need for regulatory action due to risks associated with seismic failure of the downstream dam and concurrent failure of other onsite water sources will be addressed through NTTF Recommendation 2.1 activities. Therefore, the NRC staff concludes that additional regulatory actions are not warranted for Robinson (outside any that may arise through the NTTF Recommendation 2.1 activities).

Conclusion

The staff concludes that additional regulatory actions are not warranted for low water conditions from a downstream dam failure for the following reasons:

- Licensees are addressing issues associated with nonseismically-qualified downstream dam failures in response to the mitigating strategies Order EA-12-049.

- The March 11, 2016, memorandum regarding Pre-Generic Issue 11 provides a risk assessment for failure of seismically-qualified downstream dams. The conclusion is that no plants meet the risk screening criteria (due to the availability of additional water sources at the plant) with the possible exception of H. B. Robinson Steam Electric Plant, Unit No. 2 (Robinson). This means that additional regulatory actions are not warranted for sites with seismic downstream dams (with the possible exception of Robinson).

- The NRC staff reviewed the capabilities of Robinson to cope with the loss of the ultimate heat sink due to the "sunny day" failure of its downstream dam to timely address the panel's recommendation and supplement the March 11, 2016, Generic Issues Program assessment. The staff determined that the plant would maintain the ability to use the onsite storage tanks and deep well pumps for this condition. The staff notes that the deep well pumps may not be available following a seismic event; however, the need for regulatory action due to risks associated with seismic failure of the downstream dam and concurrent failure of other onsite water sources will be addressed through NTTF Recommendation 2.1 activities. Therefore, the NRC staff concludes that additional regulatory actions are not warranted for Robinson (outside any that may arise through the NTTF Recommendation 2.1 activities).

Low Water Conditions Due to Seiche or Tsunami

As part of the review of other natural hazards, the NRC staff considered the potential vulnerability of nuclear power plants from low water conditions caused by severe storm-wave or seiche conditions. Storm surges can cause short-term fluctuations in lake-levels. When combined with dramatic changes in atmospheric pressure or a sudden drop in the wind speed, storm surges can produce a seiche, which is a standing wave that oscillates in a lake as a result of seismic or atmospheric disturbances creating fluctuations in the water level (see

http://oceanservice.noaa.gov/facts/seiche.html). For example, on April 10, 2013, the forebay levels at Palisades and Donald C. Cook Nuclear Plant, Units 1 and 2 (DC Cook) were decreased by a maximum of 1.7 feet and were disrupted by oscillatory wave motion for a period of about 20 minutes, evidence of a seiche.

The review of seiche in this evaluation is limited to low level conditions because potential flooding from high water levels due to a seiche are part of the flooding reevaluations being performed in accordance with the March 12, 2012, request for information. The concern associated with low-water level conditions from a seiche is the impact on the safety-related UHS. The mechanism of concern is safety-related UHS pump damage from air ingestion via vortex formation or cavitation via inadequate net positive suction head.

By letter dated March 18, 2015 (ADAMS Accession No. ML15078A284), NRC regional staff submitted a possible generic issue concerning loss of the UHS due to storm-wave interaction or seiche with low Great Lake water levels. The March 18, 2015, letter states that there is not an immediate safety concern based on the low likelihood of the event occurring and creating a condition that would damage the safety-related UHS pump such that it cannot be returned to service in a short amount of time. This issue was being addressed through the generic issue program; however, because the generic issue program and this SECY paper were reviewing the same technical issue, the pre-generic issue will leverage the work in this SECY paper to document dispositioning the issue as part of the Generic Issues Program process.

The March 18, 2015, letter discusses plants that are possibly affected by the issue, which include nuclear power plants along the Great Lakes, and possibly plants along the Gulf of Mexico, which may also experience a similar low-water level condition due to seiche. The staff has reviewed plants near the Gulf of Mexico and confirmed that no nuclear power plant relies on the Gulf of Mexico for its safety-related UHS water supply. The NRC staff also reviewed coastal plants to determine if their safety related ultimate heat sinks were susceptible to low water level conditions due to a seiche. The review of coastal plants was performed because of the possibility of large bays connecting to the ocean being potentially susceptible to seiches. Based on this review, the staff could not eliminate the possibility of this event occurring in other nearly closed bodies of water, such as the Chesapeake Bay. Therefore, the staff's assessment considers plants along the Great Lakes and the Chesapeake Bay.

The NRC staff notes that while loss of the safety-related UHS could lead to a problem with the safety-related systems at a nuclear power plant due to lack of cooling, a seiche would also have to affect normal offsite power to cause an ELAP. The ability to maintain offsite power, if a seiche were to occur, would provide licensees additional capabilities to mitigate the loss of the UHS. In addition, if such a scenario were to occur, the turbine-driven auxiliary feedwater pumps in a PWR or reactor core isolation cooling systems in BWRs would have to fail in order to lead to a core damage scenario. The NRC staff's detailed assessment of this issue can be found in Appendix B of this document. Appendix B contains detailed, site-specific technical evaluations to address this hazard for a number of sites in order to timely disposition this hazard and avoid duplicative efforts in the Generic Issues Program. As a result of ACRS comments, the NRC staff supplemented the assessment found in Appendix B to address low water level conditions caused by a tsunami.

Conclusion

The staff concludes that additional regulatory action is not warranted to address low water level conditions due to a seiche or a tsunami because of the following:

- The majority of the sites that could be affected by a seiche have at least 24 hours of water supply to provide decay heat removal capabilities using FLEX equipment. The staff expects water levels in the UHS to recover sufficiently in 24 hours, such that FLEX equipment can access the water by that time. Also, additional equipment and consumables should be available from the National SAFER [Strategic Alliance of FLEX Emergency Response] Response Centers (NSRC) and other nearby unaffected nuclear power plants within this time frame.

- Units that do not have this 24 hour water supply are either considered not to be as susceptible to low water conditions from a seiche due to the design of their safety-related intake structure, or because they have nearby alternative water supplies (e.g., natural draft cooling tower basin) that could be accessed using FLEX equipment.

- Coastal plants were reviewed for susceptibility to low water level conditions due to a seiche or tsunami. The staff determined that a coastal plant was either not susceptible to this phenomena or the design of the plant had sufficient margin such that adequate suction head for the safety-related service water pumps would be met.

Based on the above, the staff has determined that additional regulatory actions to address low water conditions of the UHS are not warranted.

3.3.4 Extreme Ambient Temperatures

Table A-1 of Appendix A identifies the following hazards for additional evaluation by the staff related to temperature extremes: high air temperature, high water temperature, low air temperature, and low water temperature. Temperature extremes can affect the normal heat sink and containment heat removal systems (post-accident). Very high temperatures might also exceed those used in design calculations to estimate maximum evaporation and drift loss and minimum water cooling needed for some UHS designs. The staff determined that an additional evaluation was warranted to determine if additional regulatory actions should be considered.

The staff also considered climate change as it relates to extreme ambient temperatures. The staff determined that climate change does not warrant further evaluation in this enclosure because it is a long-term phenomenon that does not manifest itself on a time scale that could have an adverse impact on the safe operation of a facility without recognition and opportunity to mitigate. The staff considers current regulatory controls adequate to mitigate adverse impacts on the safe operation of a facility. Therefore, the impacts of climate change are not addressed further in this enclosure.

Extreme High Temperatures

The staff determined that additional regulatory action is not required based on nuclear power plants being designed to withstand and having procedures to address extreme temperatures. The programs in place to ensure that extreme temperatures are appropriately addressed

include technical specifications and operability evaluations. The NRC verifies implementation of these programs through the inspection process.

Plant technical specifications have requirements associated with the operability of the safety-related heat sink that require the plant to shut down if ultimate heat sink temperature limits or containment average air temperature limits are exceeded because operability of containment or the ultimate heat sink is not assured. Although each plant's technical specifications are unique, many plants follow the standard technical specifications (STS) which are available at: http://www.nrc.gov/reactors/operating/licensing/techspecs/current-approved-sts.html.

The Westinghouse STS requirements (General Electric BWR, Combustion Engineering PWR, and Babcock and Wilcox PWR STS have similar requirements) include:

- STS 3.7.9, "Ultimate Heat Sink," provides the surveillance requirements and actions that operators must take to verify that the water temperature of the UHS is less than the design basis once per hour.

- STS 3.6.5, "Containment Air Temperature," provides the surveillance requirements and actions for containment average air temperature to ensure it remains less than the design basis for the plant.

- STS 3.7.11, "Control Room Emergency Air Temperature Control Systems (CREATCS)," provides the surveillance requirements and actions to ensure this system remains within its design basis. This technical specification includes a surveillance requirement to verify each CREATCS train has the capability to remove the assumed heat load by performing an analysis in accordance with the surveillance frequency control program every 18 months.

If ambient air temperatures are anticipated to be outside the design temperatures for plant equipment for which air temperature is considered to be a critical parameter, licensees would need to assess the possible effects of extreme temperatures on the operability of safety-related equipment and functionality of other equipment important to safety. For example, safety-related components, such as diesel generators may not only rely on the capability of the safety-related water cooling system to remove heat, but may also be sensitive to high air temperatures inside the plant (see for example Information Notice (IN) 89-30, Supplement 1: "High Temperature Environments at Nuclear Power Plants," dated November 1, 1990) and high external air temperatures. The NRC staff concludes that the regulatory requirements related to design and configuration control, corrective action programs, and operability and functionality of plant equipment adequately address extreme high temperature conditions.

The staff notes that NRC resident inspectors, who are assigned to specific sites, routinely monitor the licensee performance with respect to preparations for adverse weather. The inspectors use Inspection Procedure (IP) 71111.01 "Adverse Weather Protection" (ADAMS Accession No. ML14343A684), to guide their assessments of whether plants are ready for extreme temperatures.

For high temperatures, IP 71111.01 notes that before the high grid loading season, inspectors should conduct a review of summer readiness of offsite and alternate ac power systems. The procedure also directs inspectors to evaluate licensees' adverse weather procedures written for extreme high temperatures.

In addition high air or ultimate heat sink water temperatures have warning times associated with them. Therefore, based on operational limits provided in technical specifications and the warning time available to allow measures to be taken, the staff has determined that additional regulatory action for high temperature extreme conditions is not warranted.

NEI 12-06 Treatment of Extreme High Temperatures

As discussed in Section 3.0 of this enclosure and consistent with the Commission direction in its staff requirements memorandum (SRM) for COMSECY-12-0037, the staff factored the safety benefits achieved through the implementation of Order EA-12-049 into the evaluations to determine whether additional regulatory actions could be justified. The staff notes that NRC-endorsed guidance document NEI 12-06 directs licensees to assess the impact of high temperatures on the storage, deployment and operation of FLEX equipment and notes that extreme temperatures can present a challenge to offsite power (e.g., grid issues) and on-site capabilities (e.g., inadequate diesel generator cooling). NEI 12-06 provides guidance that the equipment should be procured to function in a high temperature environment and that the storage of mitigating strategies equipment should consider the potential impacts of high temperature (e.g., expansion of sheet metal, swollen door seals, etc.). The staff concludes that measures taken in response to Order EA-12-049 provide additional defense-in-depth to those capabilities that existed prior to issuance of the order such that operating power plants have enhanced capabilites when faced with extreme high temperature conditions.

Extreme High Temperatures Conclusion

Based on the NRC requirements and inspections in place to address high air and water temperature conditions and the additional requirements imposed on licensees through the mitigating strategies order, the staff has determined that beyond-design-basis high temperature conditions do not warrant additional regulatory action beyond what the NRC currently requires.

Extreme Cold Temperatures

Similar logic exists for extreme cold temperatures. The staff notes that if a licensee identifies a cold weather issue that calls into question the operability of safety related SSCs the licensee is required to review the issue and take appropriate action, which includes declaring equipment inoperable and entering the appropriate action statements as directed by the plant's technical specifications. Therefore the staff concludes that existing regulatory requirements address cold weather conditions and that the staff's continuing process to review operating experience and take appropriate action reinforces these regulatory requirements if needed.

Inspection Procedure 71111.01 directs inspectors to verify that cold weather protection features, such as heat tracing, space heaters, and weatherized enclosures are monitored sufficiently to ensure they support operability of the SSCs they protect. The procedure also instructs inspectors to perform walkdowns to verify the physical condition of weather-protection features. The inspection procedure was developed because the NRC has recognized the need for nuclear plant owners to be on guard for extreme cold-related issues.

Along those lines, the agency issued Information Notice 98-02 "Nuclear Power Plant Cold Weather Problems and Protective Measures," dated January 21, 1998. Although such notices

do not require a specific action or written response, they do serve to make plant owners aware of possible concerns. For example, the Information Notice discussed an ice plug that formed on January 8, 1996, at the Millstone Unit 2 nuclear power plant in a service water strainer backwash drain line. Service water refers to water taken from a nearby source of water—be it the ocean, a lake or river—used for cooling purposes in the plant and then returned. To prevent a recurrence of the problem, the plant owner changed an operating procedure to ensure closer monitoring when service water intake structure temperatures drop below 40 degrees Fahrenheit and to make use of portable heaters or go to manual operation of the strainers.

Similarly, Information Notice 96-06, “Degradation of Cooling Water Systems due to Icing,” dated January 25, 1996, provided information regarding problems experienced at Wolf Creek, Fitzpatrick, and Fermi because of icing and the steps that licensees took to correct the problem. The information notice documents the problem at Wolf Creek associated with frazil ice. The accumulation of frazil ice on intake trash racks can completely block the flow of water into an intake structure. The process starts when the water flowing into the intake is supercooled (a condition where the water is below the freezing point). The supercooling occurs with a loss of heat from a large surface area such as a lake with open water and clear nights. High winds contribute to the problem by providing mixing of the supercooled water to depths as great as 20 to 30 feet. The frazil ice, which is composed of very small crystals (1-15 millimeters) with little buoyancy because of their size, is carried along in the water and mixed all through the supercooled water.

The suction of the supercooled water and the suspended frazil ice crystals through an intake structure brings the frazil ice crystals in contact with the trash rack bars. Frazil ice crystals easily adhere to any object with which they collide. The ice collects first on the upstream side of the trash racks, then steadily grows until the space between the trash racks is bridged. This bridging rapidly blocks the trash racks. The accumulation of ice can withstand high differential pressures; effectively damming the intake suction. One train of the essential service water systems (ESWS) was inoperable because frazil ice blocked the intake trash racks, and the second train was degraded. The root cause of the Wolf Creek event was deficiencies in the ESWS warming line design. Corrective action at Wolf Creek included changing the hydraulics of the ESWS discharge to the ultimate heat sink, and the warming line to the ESWS pumphouse, to establish and distribute the proper amount of flow to the ESWS warming line.

NEI 12-06 Treatment of Snow, Ice and Extreme Cold Challenges

The staff factored the safety benefits achieved through the implementation of Order EA-12-049 into the evaluations to determine whether additional regulatory actions could be justified. Step 2D, “Assess Impact of Snow, Ice and Extreme Cold,” within NRC-endorsed guidance document NEI 12-06 provides guidance on the use of FLEX equipment in addressing these events. The approach outlined in NEI 12-06 considers how these events could impede or prevent the deployment of the baseline FLEX equipment. The guidance includes consideration of equipment storage and notes that the “N” set of equipment (where N represents the number of units on-site) must be stored in a structure that meets the plant’s design basis for the snow, ice, and cold conditions, or in a structure designed to or equivalent to the American Society of Civil Engineers (ACSE) 7-10, “Minimum Design Loads for Buildings and Other Structures.”

NEI 12-06 also provides guidance that addresses the deployment of FLEX equipment for snow, ice, and extreme cold. This guidance includes considerations that of equipment functionality in

these conditions, transportation of the equipment, and an evaluation of the potential for the ultimate heat sink to be affected by ice blockage or the formation of frazil ice. The staff concludes that measures taken in response to Order EA-12-049 provide additional defense-in-depth to those capabilities that existed prior to issuance of the order such that operating power plants have enhanced capabilities when faced with extreme cold temperature conditions.

Extreme Cold Temperatures Conclusion

Based on the NRC requirements and inspections in place to address extreme cold challenges, and the additional requirement imposed on licensees through the mitigating strategies order, the staff has determined that the beyond-design-basis extreme cold conditions do not warrant additional regulatory action beyond what the NRC currently requires. This conclusion does not consider the snow and ice loads on SSCs, which are discussed separately in this paper.

Extreme Ambient Temperatures Conclusion

Based on the NRC requirements and inspections in place to address extreme ambient temperatures, and the additional requirement imposed on licensees through the mitigating strategies order, the staff has determined that the potential for beyond-design-basis extreme ambient temperature conditions do not warrant additional regulatory action beyond what the NRC currently requires.

3.4 Detailed Technical Evaluation of Snow Loads, Tornadoes, and Hurricanes

3.4.1 Tornado and Hurricane Winds and Associated Missile Protection

As described in Sections 3.2.2 and 3.3.1 of this enclosure, the staff performed an additional evaluation of wind and missile loads for tornadoes and hurricanes because of recent guidance updates in this area; specifically, the current SRP and the March 2007, version of RG 1.76 (ADAMS Accession No. ML100541776), and RG 1.221 dated October 2011 (ADAMS Accession No ML110940300).

The staff applied the following three criteria from Task 2 of the process as part of its evaluation:

- conservatism of design safety margins;
- low frequency of occurrence/low risk; and
- warning time available to allow measures to be taken to prevent an accident from occurring.

Consistent with the Commission's SRM on COMSECY-14-0037, the staff also considered changes being implemented at nuclear power plants as a result of the mitigating strategies in Order EA-12-049 and the pending rulemaking. The NRC staff evaluation assessed whether or not additional regulatory action is needed to initiate the backfit process consistent with the criteria in 10 CFR 50.109 or whether there was sufficient concern to warrant issuing a request for information to licensees in accordance with 10 CFR 50.54(f). The NRC guidance for determining if requests for information from licensees are warranted is provided in NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection."

The staff's evaluation that follows is broken into six parts: 1) comparison of current tornado and hurricane guidance to previous guidance used to license the currently operating reactor fleet, 2) a discussion of the licensing basis for the currently operating reactor fleet, 3) insights from recent inspection findings related to tornadoes that led to the generation of a generic communication, 4) a deterministic evaluation comparing current guidance to the licensing basis of operating reactors, 5) a preliminary assessment of whether additional regulatory action is warranted, and 6) the NRC staff's preliminary conclusion for its evaluation of tornado and hurricane winds.

3.4.1.1 Comparison of Current Guidance to Previous Guidance for Tornado and Hurricane Missile Protection

To characterize the change in missile protection requirements for nuclear power plants, the NRC staff compared the current guidance to the guidance in place during the licensing of operating plants. The existing regulatory guidance documents that the staff used are:

- Tornado Missiles
    - RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1, March 2007 (ADAMS Accession No. ML070360253)
    - RG 1.76, Revision 1, is based on tornado hazard curves provided in NUREG/CR-4461, "Tornado Climatology of the Contiguous United States" (ADAMS Accession No. ML070810400).
- Hurricane Missiles
    - RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plant," October 2011 (ADAMS Accession No. ML110940300)
    - RG 1.221 is based on data provided in NUREG/CR 7005, "Technical Basis for Regulatory Guidance on Design Basis Hurricane Wind Speeds for Nuclear Power Plants," December 2009 (ADAMS Accession No. ML11335A031) and NUREG/CR 7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants,' February 2011 (ADAMS Accession No. ML11341A102).

The NRC staff reviewed both RG 1.76, Revision 1, and RG 1.221, because improved understanding and enhanced models have indicated that for some sites, hurricane winds, which often have lower speeds than design basis tornado winds, may produce more intense missiles than tornado winds. RG 1.221 notes that because the size of the hurricane zone with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field with the same maximum wind speed. Thus, even though the maximum wind speed in a hurricane may be bound by the maximum tornado wind speed, the generated missile from a hurricane may reach a higher maximum speed than the tornado missile.

The following example illustrates the changes in the missile spectrum characteristics over time:

- Based on Standard Review Plan Section 3.5.1.4, Revision 2, dated July 1981, one of two missile spectrums could be used by licensees. SRP Section 3.5.1.4 previously provided the missile spectrum and velocities to be considered in a plant's design. The missile spectrum and velocity profiles were moved to RG 1.76, Revision 1, during an update to SRP 3.5.1.4. Regardless, many of the currently operating plants were designed to the earlier version of the Standard Review Plan that assumed either Spectrum I or Spectrum II missiles. Characteristics of one type of missile are:

    - Spectrum I missiles – a 1800 kg (3970 pound) automobile in the region of the United States susceptible to tornadoes that are capable of generating the highest wind speed would have a velocity of 56 meters per second (126 miles per hour).

    - Spectrum II missiles – a 1810 kg (3990 pound) automobile would have a velocity of 59 meters per second (69 miles per hour).

- Based on RG 1.76, Revision 1, a 4000 pound automobile in the region of the United States susceptible to hurricanes that are capable of generating a maximum wind speed of 230 miles per hour would have a characteristic velocity of 135 feet per second (93 miles per hour).

- Based on RG 1.221, a 4000 pound automobile in a 235 mile per hour hurricane would have a characteristic velocity of 156 miles per hour.

Based on the example above, the staff notes, the automobile-type missile speed went down from 126 miles per hour to 93 miles per hour based on comparing the 1981 SRP Spectrum I missile characteristic to the current RG 1.76, Revision 1, characteristics for tornadoes. However, the automobile-type missile speed went up from 69 miles per hour to 93 miles per hour based on comparing 1981 SRP Spectrum II missile characteristics to current RG 1.76, Revision 1 guidance. Likewise, the automobile speed increased from 126 miles (Spectrum I missile characteristics) or 69 miles per hour (Spectrum II missile characteristics) to 156 miles per hour based on comparing the 1981 SRP characteristics to the current RG 1.221 characteristics for hurricanes.

In addition to the automobile missile described above, other missiles were identified in RG 1.76 and RG 1.221. RG 1.76, Revision 0, and the 1975 version of SRP 3.5.1.4 had six different missile characteristics, while the RG 1.76, Revision 1, and RG 1.221 have three. Regardless of the version of the regulatory guidance, the missile characteristics that were chosen included at least one of the following: 1) a massive high-kinetic-energy missile that deforms on impact (i.e., an automobile), and 2) a rigid missile that tests penetration resistance. Later guidance provided a small rigid missile of a size sufficient to pass through any openings in protective barriers. Below is a comparison of the missile characteristics of the various versions of the regulatory guidance. Note that different speeds were assumed for each type of missile, based on the corresponding tornado or hurricane wind speed characteristics.

Missile Type	RG 1.76, Revision 0, and SRP 3.5.1.4 1975 version	RG 1.76, Revision 1	RG 1.221
Massive high-kinetic energy missile that deforms on impact	Automobile	Automobile	Automobile
A rigid missile that tests penetration resistance	• Wood plank, 4 inches x 12 inches x 12 feet long weighing 200 lbs • Steel pipe, 3 in diameter, 10 feet long weighing 78 lbs • Steel pipe, 6 inches in diameter 15 feet long weighing 285 lbs • Steel pipe, 12 inches diameter, 15 feet long, weighing 743 lbs • Utility pole, 13.5 inches diameter, 35 feet long, weighing 1490 lbs	Schedule 40 pipe 6.625 inches in diameter x 15 ft long weighing 287 lbs	Schedule 40 pipe 6.625 inches in diameter x 15 ft long weighing 287 lbs
A small rigid missile of a size sufficient to pass through any openings and protective barriers	Not applicable	Solid steel sphere 1 inch in diameter weighing 0.147 lbs	Solid steel sphere 1 inch in diameter weighing 0.147 lbs

Conclusion

For some plants, although the speed of the tornado may have decreased based on a comparison of the licensing basis to current guidance found in RG 1.76, Rev 1, the speed of the automobile missile may have increased. In addition, for some coastal sites, automobile missile speeds increased from that found in the current licensing basis to that found in RG 1.221 due to hurricanes.

3.4.1.2 Licensing Basis for Currently Operating Reactors

Currently operating power plants have been analyzed against tornado missiles but not hurricane-generated missiles. The extent of the evaluation conducted for tornado missiles varies and is based on when the plant was originally licensed.

In 1977, the NRC initiated the Systematic Evaluation Program (SEP) to review the designs of 51 older, operating nuclear power plants. The SEP was divided into two phases. In Phase I, the staff defined 137 issues for which regulatory requirements had changed enough over time to warrant an evaluation of those plants licensed before the issuance of the 1975 version of NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear

Power Plants," (SRP). In Phase II, the staff compared the design of 10 of the 51 older plants to the SRP issued in 1975. Based on these reviews, the staff identified 27 of the original 137 issues that required some corrective action at one or more of the 10 plants that were reviewed. The staff referred to the issues on this smaller list as the SEP lessons-learned issues and concluded that they would generally apply to operating plants that received operating licenses before the SRP was issued in 1975. The staff used NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE)," available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1742/ as an aid in identifying the current fleet of operating units that were evaluated under the SEP. NUREG 1742, Table 5.6, "GSI 156, Systematic Evaluation Program," provides a listing of plants that were evaluated under the SEP.

Plants Included in the Systematic Evaluation Program

The staff used its generic safety program to track the resolution of the SEP issue. As documented in NUREG-0933, "Resolution of Generic Safety Issues (available at: http://nureg.nrc.gov/sr0933/)," the staff identified the resolution of this issue as Generic Safety Issue (GSI) 156: Systematic Evaluation Program." GSI 156 was comprised of various issues identified under the SEP program, including Issue 156.1.5 related to protection against tornadoes. The objective of GSI 156.1.5: "Tornado Missiles," was to ensure that safety-related structures, systems, and components can withstand the impact of an appropriate postulated spectrum of tornado-generated missiles. The concern existed for plants that received operating licenses before 1976 and may not be adequately protected against tornado-generated missiles; in particular, those reviewed before 1968 when criteria on tornado protection were first developed.

As a result of the SEP review all current operating plants have been analyzed for tornado-generated missiles to some degree as reflected in the current version of the plant's USAR or in the IPEEE evaluation. The criteria used to evaluate these plants vary greatly and in some cases consist of two missiles (e.g., a rigid steel pipe and a telephone pole) and in other cases rely on probabilistic risk assessments (PRA) methodologies. In some cases plants were backfit to provide additional tornado missile protection or took steps as a result of insights gained from their IPEEEs to provide more robust protection from tornado missiles.

Later Generation Plants

The staff reviewed the tornado-missile spectrum and velocities assumed for plants that were licensed in accordance with the 1975 version of the SRP and, in general, found the following:

- For rigid missiles that test penetration resistance, these plants have robust tornado missile protection design basis requirements for their safety-related SSCs when compared to the newer criteria found in RG 1.76, Revision 1, and RG 1.221.

- However, speeds for tornado-generated automobile-type missiles increased by around 50 percent for many sites based on RG 1.76, Revision 1, as compared to the 1975 version of the SRP, and automobile missile speeds for coastal sites based on RG 1.221 criteria for hurricanes are generally not bounded by the tornado-generated automobile missile speeds found in the 1975 version of the SRP.

The staff notes that some of the plants performed a PRA of tornadoes,[4] which indicated that based on conformance with the 1975 version of the SRP or completion of a PRA, these plants were adequately protected against the effects of tornadoes. The NRC staff plans to consider IPEEE insights when evaluating this issue for later generation plants.

Conclusion

Tornado missile protection for operating power plants has been reviewed under previous NRC initiatives to determine the appropriate design basis for the plant:

- Plants licensed before the 1975 version of the SRP was available were evaluated in accordance with the SEP process.

- Tornado missile protection for later generation plants' was reviewed in accordance with the guidance found in the 1975 version of the SRP.

- During the IPEEE process, licensees' evaluated high winds, including tornado missile protection, and verified through reviews and walkdowns that their plant met the guidance found in the 1975 version of the SRP or alternatively performed a probabilistic risk assessment.

As a result of these regulatory programs, licensees took actions to upgrade tornado missile protections, as appropriate. However, as mentioned above, the increase in hurricane-borne automobile missile velocities in present-day guidance represents a potential increase in missile protection guidance for some plants.

3.4.1.3 Insights from Regulatory Issue Summary 2015-06, "Tornado Missile Protection"

To further assess the risk posed by tornadoes, the NRC staff considered insights from the agency's recent assessments and enforcement discretion related to tornado missile protection. The background and the risk insights related to this issue are summarized below.

The SSCs of nuclear power plants are designed to withstand natural phenomena, such as earthquakes, tornadoes, hurricanes, and floods without the loss of capability to safely maintain the plant. In general, the design bases for these SSCs reflect: (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated; (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and (3) the importance of the safety functions to be performed.

In designing SSCs for the consequences of design-basis tornadoes, tornado-generated missiles must be considered. The specific tornado missile protection criteria for each nuclear power plant are contained in the individual plant's specific licensing basis. There are several design

[4] The majority of plants that were reviewed against the 1975 version of the SRP did not perform a high-winds PRA. The IPEEE process allowed licensees to forgo a high-winds PRA if the plant was reviewed against this version of the SRP and plant walkdowns confirmed the licensing basis assumptions associated with this regulatory guidance.

methods typically used for protecting SSCs from tornado-generated missiles. These include placing the SSC within a structure designed to withstand tornado missiles, designing the SSC to withstand the tornado missile, or installing a barrier designed to withstand tornado missiles around the SSC. In addition to physical design methods, the NRC allows the use of probability analysis to demonstrate that the probability of a tornado-generated missile striking a component required to safely maintain the plant is sufficiently low that no additional measures are required.

Most facilities use deterministic methods when evaluating protection from tornado-generated missiles and as a basis for complying with these regulations. However, NUREG-0800, Section 3.5.1.4, Revision 0, includes acceptance criteria that permit the use of an alternative approach if it can be demonstrated that the probability of damage to unprotected essential safety-related features is sufficiently small. Some licensees used this alternative approach by incorporating the NRC-approved, EPRI-developed TORMIS methodology, or other NRC-approved probabilistic risk assessment methodology via the license amendment process. Over the past several years, licensees and the NRC have identified facilities that have not conformed to their licensing basis for tornado-generated missile protection and are therefore not in compliance with applicable regulations. These noncompliances have been documented in NRC inspection reports and have resulted in license amendment requests. Some of the nonconforming SSCs included TS-required equipment (e.g., emergency diesel generator exhaust header/ductwork, pipe risers, fan motors, etc.), which required an operability determination. In cases where the licensee concluded that the TS-required SSC was inoperable, the licensee was required to complete any actions specified by the TS until the limiting condition for operation was met.

As a result of nonconformances, the NRC issued Regulatory Issue Summary (RIS) 2015-06, “Tornado Missile Protection,” (ADAMS Accession No. ML15020A419). The intent of the RIS was to remind licensees of the need to conform to a plant’s current, site-specific licensing basis for tornado-generated missile protection, and provide examples of failure to conform to a plant’s tornado-generated missile licensing basis.

The RIS 2015-06 notes that the NRC may grant enforcement discretion in accordance with Enforcement Guidance Memorandum (EGM) 15-002, “Enforcement Discretion for Tornado Missile Protection Noncompliance” (ADAMS Accession No. ML15111A269), to licensees who are in non-compliance with their plant-specific licensing bases for issues related to tornado missile protection. EGM 15-002 provides a basis for granting enforcement discretion, including that tornado missile scenarios that may lead to core damage are generally very low probability events. For a tornado missile induced scenario to occur, a tornado would have to hit the site and result in the generation of missiles that would hit and fail vulnerable, unprotected safety-related equipment and/or unprotected safety-related subcomponents in a manner that is nonrepairable and nonrecoverable. For example, the emergency diesel generator exhaust stack would have to be crimped in a manner that would prevent the exhaust of combustion products; if it were sheared off completely, the emergency diesel generator (EDG) would likely remain operable. In addition, because plants are designed with redundancy and diversity, the tornado missiles would have to affect multiple trains of safety systems and/or means of achieving safe shutdown.

The EGM 15-002 included a generic risk analysis of potential tornado missile protection noncompliances to examine the risk significance of these scenarios. This assessment (ADAMS Accession No. ML14114A556) documents a conservative, bounding-type analysis of the risk

significance for plant facilities that may not be in compliance with their tornado missile protection licensing basis. This analysis used tornado hazard curves provided in NUREG/CR-4461, "Tornado Climatology of the Contiguous United States" (ADAMS Accession No. ML070810400), and Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missile for Nuclear Power Plants" (ADAMS Accession No. ML100541776). The generic nature of this analysis did not afford the staff the capability to assess plant-specific tornado missile protections that likely exist at some reactors in accordance with their current licensing basis, and that would result in even lower risk determinations. It also did not consider the plant-specific nature of the noncompliances or the redundancies of SSCs. The generic analysis assumed that core damage would occur if a tornado hit a plant located in the most active tornado region in the country and that it caused a tornado-generated missile to fail all emergency core cooling equipment at the plant with no ability to recover. Given this conservative assumption, the core-damage frequency (CDF) was calculated to be 4E-5 per year.

The EGM notes that the generic bounding risk analysis performed by the Office of Nuclear Reactor Regulation, Division of Risk Assessment, concluded that this issue is of low risk significance. Therefore, enforcement discretion of up to 5 years, accounting for differences in initiating event frequency based on the geographical location of the plants, will not impose significant additional risk to public health and safety. The EGM notes that the enforcement discretion will expire 3 years after the issuance date of RIS 2015-06 for plants of a higher tornado missile risk (Group A plants) and 5 years after RIS issuance for plants of a lower tornado missile risk (Group B plants).

Therefore, regarding the tornado licensing basis for operating plants:

- The staff notes that the tornado missile protection design basis requirements are generally conservative.
- The staff has taken advantage of current licensing processes to ensure that licensees continue to meet their tornado missile protection design basis by alerting licensees to issues the NRC has identified in various inspections as documented in RIS 2015-06.
- EGM 15-002 provides a basis for granting enforcement discretion that notes in general tornado missile scenarios that may lead to core damage are very low probability events, because safety-related SSCs are typically designed to withstand the effects of tornadoes.

3.4.1.4 Deterministic Evaluation of Current Operating Plants' Tornado Wind Protection Against Current Guidance

The risk study discussed above indicates that the risk from tornadoes is low. Nevertheless, the NRC staff performed a deterministic evaluation to identify insights that on the risk from hurricanes. The staff's deterministic review process had three parts:

- assessment of wind loads based on wind speeds from current guidance in RG 1.76, Revision 1, and RG 1.221 as compared to the current licensing basis wind speed loads for operating plants;
- assessment of the ability of tornado or hurricane missiles to damage structures protecting safety-related SSCs based on current guidance in RG 1.76, Revision 1, and RG 1.221 as compared to the current licensing basis missile design spectrum for operating plants; and

- assessment of structural loads from a large missile (i.e., automobile) based on current guidance in RG 1.76, Revision 1, and RG 1.221 as compared to the margin provided in current licensing basis structural design-basis.
    - For this assessment the NRC staff reviewed the automobile missile structural loads from current guidance as compared to the current licensing basis for the plant. In the cases where the use of current day guidance resulted in a potentially more damaging missile than addressed in a plant's licensing basis, the staff then assessed the new information against the structural margin in the operating power plant. The NRC staff believes that the use of such a structural margin assessment of structural loads from an automobile missile is a logical first step in determining if additional regulatory action might be warranted to request additional information or require licensees for current operating plants to perform analyses using RG 1.76, Revision 1, and RG 1.221 guidance.

<u>Wind Loads</u>

To assess wind loads, the staff relied on licensees' updated final safety analysis reports (UFSAR) and on licensees' integrated plans provided in response to the mitigating strategies orders, Order EA-12-049. Licensees' UFSARs typically provide a discussion of the design-basis wind speed loads assumed in the structural analysis. The UFSAR design-basis wind speed is typically based on wind loads from a tornado. The licensee's integrated plan response to Order EA-12-049 included a discussion of whether the plant met the criteria for a high wind evaluation.

Figure 3.4-1, "Comparison of Current Design Basis Wind Speeds vs Updated Tornado and Hurricane Wind Speed," plots the data that the NRC staff collected. As noted in the plot the majority of nuclear power plants were designed for a wind speed of 360 miles per hour. Figure 3.4-1 shows that for the majority of the sites, the RG 1.76, Revision 1, tornado wind speeds are less than those assumed in the design of the plant. Regarding hurricanes, Figure 3.4-1 shows that not every plant has an associated hurricane wind speed. This is consistent with the guidance found in RG 1.221 that does not provide hurricane wind speeds for plants that are far inland because of the assumption that the tornado wind speed will bound a hurricane wind speed for these sites. Regardless, Figure 3.4-1 shows that for the majority of sites, the hurricane wind speed is bounded by the design-basis wind speed provided in the UFSAR.

The staff notes that for a limited number of sites that are on the far right of the horizontal axis in Figure 3.4-1, the licensing basis tornado wind speed is less than that found in RG 1.76, Revision 1, tornado guidance or RG 1.221, hurricane guidance. The staff intends to take advantage of the work performed as part of the IPEEE when performing its assessment for the sites whose current licensing basis does not bound guidance found in RG 1.76, Revision 1, or RG 1.221.

The staff concludes that, from a deterministic prospective, the design-basis wind speeds for the majority of operating power plants bound the wind speeds for the site found in RG 1.76, Revision 1, and RG 1.221. As part of Task 3, the staff is continuing its deterministic review for the small number of sites for which this is not the case.

Tornado and Hurricane Missile's Ability To Penetrate Structures

In evaluating missile hazards, the staff relied on a comparison of tornado or hurricane-borne missiles to penetrate concrete protecting safety related SSCs. The staff relied on calculations to determine the minimum concrete thickness to prevent perforation of the structure by the bounding tornado missile in the current licensing basis for operating plants as described in the UFSAR against the bounding missile's minimum concrete thickness to prevent perforation for either tornadoes or hurricanes based on RG 1.76, Revision 1, or RG 1.221. The staff used this method of comparison because the tornado missiles described in the operating plant UFSARs differ from the missiles described in RG 1.76, Revision 1, and RG 1.221. Converting a missile's energy and contact area to a concrete penetration depth allows for ready comparison of the existing missile protection requirements for operating plants against current-day regulatory guidance.

Based on the NRC staff's assessment, the staff found that the majority of the current operating plants have design-basis missile characteristics that bound the missile characteristic of the rigid pipe found in RG 1.76, Revision 1, or RG 1.221. In Task 3, the staff is continuing its deterministic review for the small number of sites for which this is not the case.

Tornado and Hurricane Automobile Missile Evaluation

The staff is continuing its assessment of automobile missile loads from a tornado or hurricane. As indicated above, based on current guidance, both tornadoes and hurricanes have the potential to produce more intense automobile missiles. The staff used a simplified, conservative approach to assess the impact of the increased automobile missile speed related to the current plant's missile protection requirements. To begin the comparison of the impact loads developed using the current tornado and hurricane generated missiles in a plant's UFSAR versus missiles described by current guidance, the staff selected a screening criterion that could give an estimate for how the updated missiles would compare to the design-basis missiles. The staff determined that finding an equivalent static load would provide the necessary comparison to determine what, if any, further evaluation should be performed for each site. To determine equivalent static load, the staff determined which missile was bounding out of the original missiles in terms of impact loading. Current guidance uses the automobile as the missile for this scenario, but because in the past, plants used relatively low velocities for their automobile missiles (as low as 33 mph), this was not always the bounding case. At some sites the utility pole missile could be considered the bounding impact load due to its relatively high weight, large diameter, and high speeds.

The staff determined the bounding load for each site and then compared it to the load generated from the RG 1.76 defined automobile traveling at the higher velocity between the missile-speed generated by the NUREG-4461 tornado speeds and the missile speed generated by the NUREG-7005 hurricane speeds. These loads were then converted to their equivalent static loads on the assumed target slab to produce a method of comparison. The initial insights from the simplified comparison indicated that the automobile missile speeds estimated using present-day guidance are higher than similar missiles within the licensing basis for many plants. The difference in estimated missile speeds is mainly driven by the fact that for 10E-7 tornado and hurricane events, the velocity of the automobile was increased by a median factor of 2. Thus the kinetic energy of the automobile was increased by a median factor of 4. Some UFSARs had

described automobile-type missiles with higher velocities, but many UFSARs discussed estimated speeds between 50-75 mph.

In Task 3, the NRC staff will continue its evaluation of this issue and will consider insights from past IPEEEs and current high wind studies by licensees as part of its assessment. The NRC staff's preliminary assessment is that the risk associated with high winds is generally low and is dominated by the lower wind speeds (75-85 mph). These wind speeds would generate automobile missile speeds that are likely to be bound by plants' existing missile protection requirements. To examine these assumptions and assess the need for additional regulatory actions, the staff will interact with the industry and other stakeholders to gain additional insights into the early observations from ongoing wind PRAs and to further understand licensees' anticipatory actions in preparation for an approaching hurricane. The staff notes that the automobile missile is a surrogate for a spectrum of missiles that can be found at a site, including buildings that are not designed for hurricane loads. Such buildings could suffer damage during a hurricane and the debris could become windborne missiles. The NRC staff plans to continue its evaluation under Task 3 and to update this assessment prior to December 31, 2016.

3.4.1.5 Evaluation of the Need for Additional Regulatory Action To Address Beyond-Design-Basis Tornadoes and Hurricanes

The NRC staff notes that early insights from recent PRAs do not identify extreme tornadoes and hurricanes as dominant risk contributors to a plant's core damage frequency. Rather, the more common tornado and hurricanes that fail offsite power and damage important non-safety related equipment, have been identified as needing further study. This was described in meeting summary dated May 28, 2015, which discusses technical aspects of high wind probabilistic risk methodologies (ADAMS Accession No. ML15187A266). The summary includes the insights described below.

Challenges exist in the characterization of a hazard curve with respect to straight winds, hurricanes, and tornadoes. Peak wind gusts between 115 mph and 150 mph would typically represent the range where potential damage to buildings due to debris and structural impacts could be observed. There is a need for stochastic modeling in hazard characterization, given the potentially large uncertainties involved. Two important aspects not typically considered were: (1) consideration of directional wind analysis for vulnerable structures to reduce the level of conservatism in straight winds analysis, and (2) assessment of the impact of rain on plant equipment, as this phenomenon often accompanies high wind events.

The National Institute of Standards and Technology (NIST) plans to update current guidance on tornado wind risk, aimed at leveraging new data that became available over the past decade to derive tornado risk maps for the United States. As part of this work, factors affecting hazard modeling, such as the inconsistent reporting of tornadoes across different time periods, path area uncertainties, and the windspeed relationship across commonly used scales (e.g., Fujita and Enhanced Fujita Scale) will be taken into account to better reflect the extremely large epistemic uncertainties associated with tornado hazard modeling.

Based on the early insights from ongoing high wind PRAs and insights gained from the IPEEEs, the NRC staff believes that long term activities are better focused on updating its PRA tools for high wind events. Examples of this work include the following:

- The NRC identified issues in an August 10, 2015, letter, "User Need Request for Support in the Development and Enhancement of NRC Risk Analysis Tools" (ADAMS Accession No. ML15110A210, non-public). The user need request includes a request for enhancements of tools to make external event analysis more risk informed.

- A September 21, 2011, SRM (ADAMS Accession No. ML112640419) directed the staff to conduct a full-scope comprehensive site Level 3 PRA as described in SECY-11-0089, "Options for Proceeding with the Future Level 3 Probabilistic Risk Assessment Activities" (ADAMS Accession No. ML11090A041). Southern Nuclear Company volunteered to cooperate with the staff and offered Vogtle Units 1 and 2 to be the subject of this study. This work includes assessments of external hazards and involves the development of high wind PRA.

While the NRC staff believes this work can improve the understanding of the risk profiles for plants and provide insights for future licensing and oversight decisions, it does not believe these activities need to be completed to support the Task 3 assessment for tornadoes and hurricanes. The consideration of deterministic and risk-informed approaches within the Task 3 assessment is sufficient to determine if NRC-imposed actions on licensees might be warranted.

For the majority of operating plants, the staff does not consider that additional regulatory actions are warranted to address tornadoes and hurricanes for the following reasons that are based on low risk, conservatism in design, and additional capabilities to address these events based on compliance with the mitigation strategies Order EA-12-049:

- As documented in RIS 2015-06 and EGM 15-002, the NRC staff has developed a basis for granting enforcement discretion that notes, in general, that tornado missile scenarios that may lead to core damage are very low probability and low risk events, because safety-related SSCs are typically designed to withstand the effects of tornadoes. For a tornado missile induced scenario to occur, a tornado would have to hit the site and result in the generation of missiles that would hit and fail vulnerable, unprotected safety-related equipment and/or unprotected safety-related subcomponents in a manner that is nonrepairable and nonrecoverable. For example, the EDG exhaust stack would have to be crimped in a manner that would prevent the exhaust of combustion products; if it were sheared off completely, the EDG would likely remain operable. In addition, because plants are designed with redundancy and diversity, the tornado missiles would have to affect multiple trains of safety systems and/or means of achieving safe shutdown.

- NRC-endorsed guidance document NEI 12-06 provides implementation guidance for the mitigation strategies Order EA-12-049 that includes additional capabilities beyond the protection of safety-related equipment for plants dealing with the possible effects of hurricanes and tornadoes. Step 2C, "Assess Impact of Severe Storms with High Winds," in NEI 12-06 notes that severe storms with high winds can create a significant challenge to plant safety, simultaneous extended loss of ac power and loss of the ultimate heat sink. NEI 12-06 Section 7.3 includes provisions for the protection and deployment of FLEX equipment that include guidance for the configuration of the storage of this equipment.

- The NRC staff has continually assessed regulatory requirements related to tornadoes and hurricanes as part of the operating experience lessons learned process. As an example, GI-178, "Effect of Hurricane Andrew on Turkey Point," documents the steps the NRC took to compile lessons that might benefit other nuclear facilities. These efforts are summarized in NUREG-1474, "Effect of Hurricane Andrew on the Turkey Point Nuclear Generating Station

from August 20 through 30, 1992," which was distributed to all power reactor licensees. In addition, similar lessons learned activities were associated with the effects of Hurricane Katrina and Hurricane Sandy.

Additional Considerations for Hurricanes

The staff applied an additional criterion associated with warning time when considering hurricanes. Based on hurricane weather forecasts and the warning time associated with these forecasts, licensees take preplanned actions to prepare for the onset of high winds on the site, including shutting down the plant if winds greater than a certain speed are expected on the site.

3.4.1.6 Conclusion of Evaluation of Tornado and Hurricane Missile Protection

For the majority of operating plants, the NRC staff's preliminary conclusion is that additional regulatory actions are not warranted to address beyond-design-basis tornadoes and hurricanes based on: low risk; conservatism in design; additional capabilities to address these events based on compliance with the mitigation strategies Order EA-12-049; lessons learned from past events being incorporated into licensees' and NRC actions; and for hurricanes, the additional warning time associated with these events. As described in Section 3.4.1.4 of this enclosure, the NRC staff is continuing its evaluation to assess the remaining sites using additional available site-specific information and risk insights. The results of these assessments will be provided in a future update to this assessment.

3.4.2 Snow Loads

Extreme cold conditions are evaluated in Section 3.3.4 of this enclosure. The evaluation of snow and ice loads is focused on the potential for the loads from this beyond-design-basis event to challenge seismic Category I structures at a nuclear power plant, such that additional regulatory action beyond what the NRC currently requires is warranted to address the hazard. The staff performed the evaluation to assess the differences in snow load estimates using assumptions described in present-day guidance and methods as compared to operating plants' licensing bases information. The staff applied the following three criteria from Task 2 of the process as part of its evaluation:

- conservatism of design safety margins;
- low frequency of occurrence/low risk; and
- warning time available to allow measures to be taken to prevent an accident from occurring supported by operating history.

On June 23, 2009, the staff issued interim staff guidance (ISG) DC/COL-ISG-007, "Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures" (ADAMS Accession No. ML091490556). This guidance was issued for new reactor reviews because at the time of the issuance of the ISG NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800), did not provide specific approaches for considering snow loads at ground level due to normal and extreme winter precipitation events for the design of seismic Category I structures. The currently operating reactor fleet was designed to guidance that predates this DC/COL ISG-007. Consequently, the

staff determined that it was appropriate to advance this external natural event to the next task in the screening process given the recent updated guidance for snow loads.

DC/COL-ISG-007 guidance notes the following:

> Seismic Category I structures are required to be designed to withstand the effects of natural phenomena to meet the requirements of GDC 2 in Appendix A to 10 CFR Part 50. Therefore, Seismic Category I structures must be designed to withstand the effects of winter precipitation events.
>
> Roofs of Seismic Category I structures not protected by a shield building will be subject to loading due to accumulation of winter precipitation. In SRP Section 2.3.1 identifies winter precipitation event site characteristics/site parameters at ground level. Therefore, these site characteristics/site parameters must be converted to corresponding roof loads.
>
> Currently, no guidance is included in any of the SRP sections regarding how snow loads at ground level should be converted to snow loads on the roofs of Seismic Category I structures. Further, SRP sections pertaining to design of Seismic Category I structures do not provide any guidance as to how roof loads due to normal and extreme winter precipitation events should be included in loading combinations for design of Seismic Category I structures. This ISG includes guidance for NRC staff members for acceptable methods for (a) converting winter precipitation site characteristics/site parameters (as ground snow loads) to roof loads, and (b) including roof loads due to normal and extreme winter precipitation events into loading combinations for the design of Seismic Category I structures.

The DC/COL ISG-007 is consistent with the guidance for the plants that were reviewed against the 1975 version of the SRP. In accordance with the 1975 version of the SRP, roofs were designed and evaluated for snow, and negative pressure due to tornado suction and were checked for the effects of probable maximum precipitation. Live loads were considered in combination with other loads (e.g., dead loads like those from the weight of structures and equipment and accident loads like those associated with earthquakes) and evaluated using guidance found in SRP Sections 3.8.1, “Concrete Containments,” and 3.8.4, “Other Seismic Category I Structures.” In addition, as discussed in a March 24, 1975, branch technical position, “Site Analysis Branch Position – Winter Precipitation Loads” (ADAMS Accession No. ML050630277), 48 hour probable maximum precipitations (PMPs) were to be considered in addition to the 100 year snow load event. Additional background regarding DC/COL ISG-007 guidance can be found in Appendix C of this document.

The winter precipitation events to be included in the combination of extreme winter precipitation live roof loads are based on the weight of the antecedent snowpack resulting from the normal winter precipitation event plus the larger resultant weight from either (1) the extreme frozen winter precipitation event or (2) the extreme liquid winter precipitation event. The NRC staff recognizes that an ice storm can lead to loss of offsite power; however, because the additional weight of the ice is evaluated as part of the 48 hour PMP, the staff considers its evaluation of the 48 hour PMP under “extreme snow loads” to bound ice storm structural loads.

Plants licensed before the 1975 version of the standard review plan did not consider the additional weight of the 48-hour probable maximum winter precipitation at ground level for the month corresponding to the selected snowpack. The purpose of the staff's assessment of this issue is to determine if the treatment of snow loads in accordance with DC/COL ISG-007 leads to a determination that additional regulatory action is needed. As discussed above the staff identified several screening criteria in evaluating a hazard for additional evaluation, including comparing new hazard information against the design safety structural margins inherent in the design of nuclear power plants.

In assessing the conservatism of design safety margins relative to snow loads, the staff evaluation has two parts: plants that were licensed before the 1975 version of the standard review plan, and plants reviewed against the 1975 version of the standard review plan. The staff's evaluation is divided into these two parts because, based on the application of review guidance at the time, plants that were licensed against the 1975 version of the standard review plan, in general, are expected to have additional design safety margins associated with load combinations compared to plants licensed before the 1975 version of the standard review plan existed.

Plants Included in the Systematic Evaluation Program

As was discussed under the tornado evaluation, the staff used its generic safety program to track the resolution of the SEP issue. As documented in NUREG-0933, "Resolution of Generic Safety Issues" (available at: http://nureg.nrc.gov/sr0933/), the staff identified the resolution of this issue as Generic Safety Issue (GSI) 156: Systematic Evaluation Program." The objective of GSI 156.2.1, "Severe Weather Effects on Structures," was to identify those meteorological conditions that should be considered in structural reviews to determine the ability of structures to withstand these conditions. The staff's resolution of this issue noted that snow and ice loads, when accompanied by strong winds, caused several complete and partial losses of offsite power and the potential of causing severe accidents would be evaluated under the individual plant evaluation (IPE) program. The evaluation also states that snow and ice loads alone, are judged based on limited PRA experience to be unlikely to cause significant structural failure that might lead to severe accidents at nuclear power plants.

NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," Section 4.1.3.2, "Guidance for Conduction IPEEE HFO [High Winds Floods and Other External Events] Analyses," provides a screening approach that includes a determination of whether the plant conforms to the guidance in the 1975 standard review plan, and a performance of a plant walkdown. The majority of the plants licensed before the 1975 SRP was available used this method for dispositioning snow loads as documented in NUREG-1742, Table 4.1, "Methodologies and results for the HFO [High Winds Floods and Other External Events] external events." Only Haddam Neck (which has ceased operations) performed a snow and ice PRA and reported a core damage frequency contribution of 7E-6 from snow and ice. It is not clear whether or not the assessment of these plants against the 1975 version of the SRP also considered the March 24, 1975, branch technical position. Regardless, snow loads were considered as part of the IPEEEs that were performed for plants included in the systematic evaluation program and it was determined that additional regulatory action was not needed to address snow loads.

The staff performed an additional review of plants that were evaluated under the SEP. The staff performed this review to assess the magnitude of current estimates against the margin inherent in the design. The staff's process involved the following steps:

- The NRC staff reviewed the 100 year snow load in accordance with American Society of Civil Engineers (ASCE) 7-05, "Minimum Design Loads for Buildings and Other Structures." ASCE 7 is listed as an acceptable method for determining 100 year snow loads in ISG DC/COL-7. In some cases ASCE 7 lists an area of the country as CS or a case study site. For the majority of these sites the staff obtained snow load information from State officials for the area in which the nuclear power plant is located.

- The NRC staff then reviewed information in licensee UFSARs related to the design of safety-related structures. In general the staff found that the design of the safety-related SSCs was either bound by the snow load design basis in the UFSAR or the structural margin from the staff's review of seismic loading conditions for a site that bounds the snow loads. The staff performed an additional assessment of sites where the snow load may not be bounding for the 100 year snow event as part of its assessment of extreme snow loads discussed in the bullet below.

- The staff also notes that 100 year snow load events should have warning time associated with them and the accumulation is not expected to occur over a short period of time. Because of the warning time and the relatively long duration of event, the NRC staff expects licensees will take appropriate actions to protect the nuclear power plant. Therefore, the NRC staff would expect that licensees would monitor the snow loads on both non-safety and safety-related structures and take appropriate corrective actions in accordance with their severe weather procedures. Nevertheless, the staff will interact with industry to gain further insights into licensees' anticipatory actions in preparation for an approaching severe snow storm.

- The staff assessed the magnitude of the current estimates of the extreme snow loads, which includes the 100 year snow event, as compared to the design-basis seismic loads. In the bounding cases where extreme snow loads are significant and the seismic loads are low, the snow load could exceed the seismic load by a factor of nearly 2.0. The staff's initial assessment is that a beyond-design-basis snow load twice as large as the design-basis earthquake is not likely to cause a catastrophic failure of a seismic Category I structure roof, which in turn would damage plant equipment and lead to core damage. This is in part based on the margin inherent in the design due to the use of linear analysis approaches, lower-bound material properties, and conservative estimates of structural capacities. Other considerations include roof load path redundancy such that the loads are distributed from structural members approaching its design capacity to other parts with available design margin. Finally, the staff considered the potential for large roof deformations, in the event the snow loads significantly exceed the design margin, so as to alert the operators to take appropriate actions.

In Task 3, the NRC staff will continue to apply the screening criteria of conservatism of design, warning time, and low frequency of the event (in the case of extreme snow loads), to determine if additional regulatory actions for extreme snow load are warranted. As part of this task, the staff will further examine available site-specific information against its assumptions and conclusions to ensure their applicability.

Plants Evaluated Using the 1975 Version of the Standard Review Plan

Plants that were evaluated using the 1975 version of the SRP include snow loading (if applicable) as part of the load combinations for structural analysis associated with Category I structures.

The NRC staff reviewed the IPEEEs for these plants, in which the licensees had not identified snow-load related vulnerabilities for safety-related structures for plants in this category. The staff also notes that because of the warning time both before and during the extreme snow events the NRC staff expects licensees will take appropriate actions to protect their investment in the nuclear power plant. Therefore, NRC staff would expect that licensees would monitor the snow loads on both non-safety and safety-related structures and take appropriate corrective actions in accordance with their severe weather procedures. Moreover, the discussion on the design margin for SEP plants applies equally to plants evaluated to the 1975 version of the SRP.

As part of Task 3, the staff will assess structural margins inherent in the designs of seismic Category I roof designs for nuclear power plants evaluated in accordance with the 1975 version of the SRP, and the warning time associated with the extreme snow events, to determine if additional regulatory actions for extreme snow loads are warranted for these plants.

Additional Considerations

In addition, NRC-endorsed guidance document NEI 12-06 step 2D, "Assess Impact of Snow, Ice and Extreme Cold," notes that snow and ice storms and extreme cold can be contributors to simultaneous extended loss of ac power and loss of the ultimate heat sink. NEI 12-06, Section 8.3, includes provisions for protection and deployment of FLEX equipment and notes that for sites subject to significant snowfall and ice storms, portable FLEX equipment should be stored in one of two configurations:

a. in a structure that meets the plant's design basis for the snow, ice, and cold conditions; or

b. in a structure designed to or evaluated equivalent to ASCE 7-10, "Minimum Design Load for Buildings and Other Structures," for snow, ice, and cold conditions from the site's design basis

Accordingly, mitigating strategies developed by licensees in response to Order EA-12-049 provide defense in depth should a site be adversely affected by snow and ice.

Conclusion

As part of Task 3, the staff will assess design conservatism, warning time, and low frequency of the 100 year snow loads combined with a 48 hour PMP, to determine if additional regulatory actions are warranted to address structural issues due to extreme snow loads. The staff will further examine available site-specific information against its assumptions and conclusions to

ensure their applicability. Any new insights of this further examination will be provided in a future update to this assessment.

4.0 Stakeholder Interactions

As documented in SECY-15-0137, the staff supported several public meetings during the development of the processes described in this paper. These meetings included a meeting held on October 6, 2015, in which the NRC staff provided the ACRS Fukushima Subcommittee an overview of the staff's plans to resolve the open Tier 2 and 3 recommendations. A similar meeting occurred with the ACRS Full Committee on November 5, 2015. In addition, the staff provided an overview of its proposed resolution plans for all the open Tier 2 and 3 recommendations during a Category 2 public meeting held on October 20, 2015. The staff also briefed the Commission on status of Tier 2 and 3 activities in a public meeting on November 17, 2015.

In addition to the meetings to support SECY-15-0137, the staff held a number of public meetings to solicit input on its evaluation of natural hazards other than seismic and flooding. The NRC staff provided a draft white paper to stakeholders for their review and comment prior to the public meetings (ADAMS Accession No. ML16039A054), which contained much of the staff's assessment found in this document. The staff held a Category 3 public meeting on April 5, 2016. In addition, the NRC staff provided an email address and accepted comments on the draft white paper through April 12, 2016. A summary of the April 5, 2016, public meeting is available in ADAMS at Accession No. ML16106A234.

The NRC staff briefed the ACRS Fukushima Subcommittee on April 21, 2016, and ACRS Full Committee on May 5, 2016. The ACRS issued a letter on May 17, 2016 (ADAMS Accession No. ML16130A254), providing its conclusions and recommendations associated with the staff's assessment. The NRC staff intends to engage the ACRS again as it completes its assessment for high winds and snow loads and during these interactions will brief the ACRS on changes that were made to the assessment based on the ACRS May 17, 2016, letter.

Summary of Stakeholder Comments

Appendix D of the Enclosure provides a description and the staff's proposed resolution of stakeholder comments. Changes to the staff's white paper evaluation to address stakeholder comments include the following:

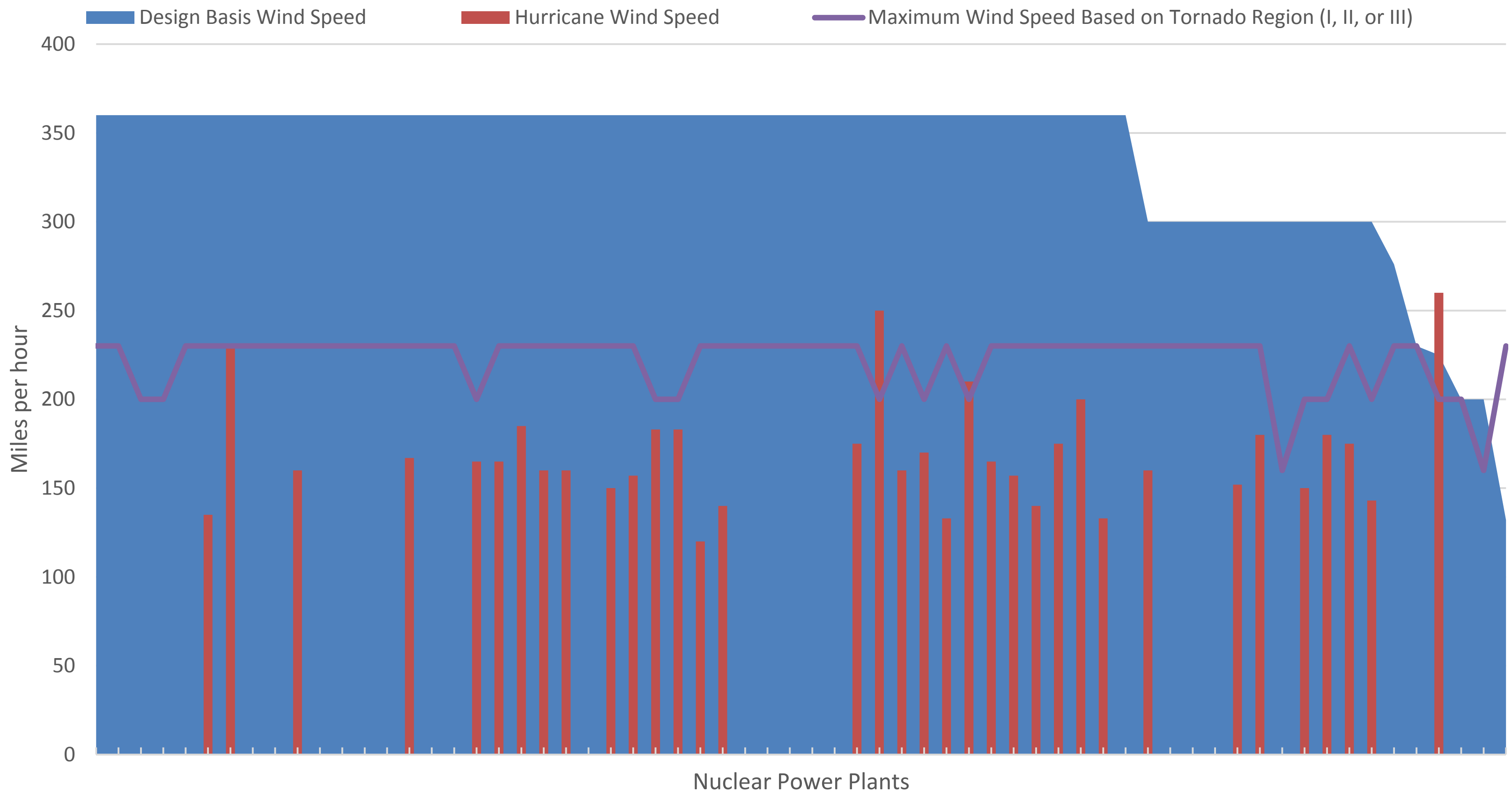
- The staff's evaluation of low water levels due to a downstream dam failure or a seiche was updated to include additional discussion of a plant's capability to maintain reactor coolant system inventory control in the event there is a loss of the safety related ultimate heat sink.

- The staff's assessment of Task 1 activities found in Appendix A of the enclosure was updated to address ACRS comments from the April 21, 2016, Fukushima Subcommittee meeting and the May 5, 2016, Full Committee meeting as well as recommendations found in the May 17, 2016, ACRS letter.

5.0 Conclusion

Based on its assessment provided in Sections 3.1 through 3.3 of this enclosure, the staff has completed Tasks 1 and 2 of the process described in SECY-15-0137. The staff concludes that of the natural hazards other than seismic and flooding, only those associated with high winds and snow loads warranted further assessments and stakeholder interactions on possible regulatory action.

Figure 3.4-1 Comparison of Curent Design Basis Wind Speeds vs Updated Tornado and Hurricane Wind Speeds[5]



5 Note that not every plant has a hurricane wind speed associated with it. For example, plants that are located away from the coast do not have a hurricane wind speed value in Regulatory Guide 1.221, "Design-Basis Hurricane And Hurricane Missiles for Nuclear Power Plants."

Appendix A – Natural Hazards other than Seismic and Flooding Considered for Further Evaluation

The list of hazards found in Table A-1 was derived from Electric Power Research Institute (EPRI) 1022997, "Identification of External Hazards for Analysis in Probabilistic Risk Assessment[1]", which uses the list of external hazards provided in Appendix 6-A of American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) RA-Sa-2009, International Atomic Energy Agency (IAEA) TECDOC-1341, NUREG/CR-5042, NUREG-0800, and other international and domestic sources. The staff's basis for including or excluding the hazard for additional evaluation is found in the table's "reason" column and the associated accompanying notes. The staff evaluation is based on deterministic judgment, augmented by risk insights (where available), to determine whether additional regulatory action is warranted, beyond what the U.S. Nuclear Regulatory (NRC) currently requires. Part of the staff's assessment of other natural hazards is based on whether new regulatory guidance has been developed for a particular hazard since the majority of the currently operating reactors received their operating licenses. Based on the list below, the staff identified the following natural hazards other than seismic and flooding for additional evaluation in the second task of the screening process:

• Drought	• Hurricane/typhoon - wind and missile loading	• River diversion
• Externally generated missiles	• Low air temperature	• Snow
• Extreme winds and tornadoes	• Low lake or river level	• High water temperature
• High air temperature	• Low water temperature	

These hazards generally fall into the following categories: (1) wind and missile loads from tornadoes and hurricanes; (2) snow and ice load for roof design; (3) drought and other low-water conditions that may reduce or limit the available safety-related cooling water supply; and (4) extreme maximum and minimum ambient temperatures for normal plant heat sink and containment heat removal systems (post-accident), and meteorological conditions related to the maximum evaporation and drift loss and minimum water cooling for the ultimate heat sink design.

Table A-1 provides screening reasons for the staff to either include or exclude the hazard for additional consideration. In addition to the reason and notes provided in Table A-1, the staff considered actions taken as a result of the mitigating strategies Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012, and guidance associated with

[1] The Electric Power Research Institute provided an update to this EPRI report. EPRI 3002005287, "Identification of External Hazards for Analysis in Probabilistic Risk Assessment: Update of Report 1022997," was issued in October 2015 to include incorporation of additional implementation processes, clarification of examples, expanded quantitative criteria and extended treatment of combined events. The NRC staff has reviewed this updated EPRI report and determined that the updates do not affect the staff's conclusions found in this SECY paper.

this order. Guidance associated with the mitigating strategies Order EA-12-049 can be found in Revision 2 of NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guidance" (ADAMS Accession No. ML16005A625). The NRC endorsed NEI 12-06, Revision 2 in JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML15357A163). Appendix B of NEI 12-06 provides a process for identifying beyond-design-basis external events to be considered in implementing the mitigating strategies order. The staff reviewed the NEI 12-06 results and notes that the results of its evaluation provided in Table A-1 and summarized above is generally consistent with the results found in NEI 12-06, although the staff's rationale for excluding a hazard from additional review may vary from that found in NEI 12-06. As documented in NEI 12-06, Section 4.1, the external natural hazards identified for additional consideration to address the mitigating strategies order were identified as: (1) seismic, (2) flooding, (3) severe storms with high winds, (4) snow, ice, and extreme cold, and (5) high temperatures. Licensees are also instructed to consider the list of beyond-design-basis external hazards considered in the current ASME/ANS PRA Standard to determine if any should be included in the site assessment process.

This following discussion provides additional details on select hazards that have been excluded from additional evaluation. Hazards that have been identified as the result of the staff's screening process for additional evaluation are discussed in Sections 3.2.2, 3.3, and 3.4 of this SECY paper.

Man-Made Hazards

Table A-1 does not include man-made hazards because they do not have a direct nexus to the Fukushima Dai-ichi accident. The NRC staff concluded that they should be treated outside the scope of Fukushima lesson-learned activities. As such, the NRC staff submitted the consideration of man-made hazards to the NRC's GI Program by memorandum dated September 9, 2013 (ADAMS Accession No. ML12328A180). By a memorandum dated January 17, 2014 (ADAMS Accession No. ML13298A782), the NRC staff concluded that the proposed GI does not satisfy at least three criteria for acceptance as a GI. The three criteria that were not met (as documented in the memorandum) are:

- Appendix A, "Generic Issues Criteria," of RES TEC-002, "Procedures for Processing Generic Issues," states that in "cases where probabilistic tools and methods are not useful, the decision to accept the issue in the Generic Issues Program is generally based on more qualitative elements linked to NRC's strategic plan and expert judgment. In general, only those issues that represent credible threats to NRC's strategic and performance goals and measures, unless current regulatory programs are changed, meet this criterion."

  The assessment of the Generic Issue Program's staff was that the information provided in the submittal does not raise an issue that represents a credible threat to the NRC's strategic and performance goals and measures.

- Current regulatory programs, processes, and guidance provide mechanisms to address the man-made hazards. Therefore, the criteria for acceptance into the Generic Issues Program that the issue cannot be readily addressed through other regulatory programs and

processes; existing regulations, policies, or guidance; or voluntary industry initiatives is not met.

- Because the issues associated with man-made hazards is site-specific and not readily available, the criterion that such information is available to determine the safety significance is not met. The staff determined that the likely risk significance of changes in man-made hazards near nuclear power plants did not warrant a request for information to address the lack of readily available up-to-date information.

Flooding and Seismic Events

Because beyond design-basis external floods and seismic events are being addressed from the respective reevaluations of these hazards, the staff excluded the following hazards found in Table A-1 from evaluation in this document: external flooding, extreme rain, high tide, hurricane (potential to cause flooding), other extraordinary waves, precipitation, seismic activity, storm surge, and tsunamis.

Volcanic Activity

For the currently operating fleet, volcanic activity is considered a design-basis event only at the Columbia Generating Station in Washington. At Columbia, the licensee concluded that ash fall is the only hazard from future eruptions of potentially active volcanoes that would affect the plant. Considering the maximum expected ash-fall rate concurrent with a 2-hour loss of offsite power, the licensee concluded that the procedures and equipment available will provide adequate assurance of safe plant operation and shutdown. The staff notes that since this evaluation, the Columbia licensee has committed to designing the structure housing the Phase 2 mitigating strategies equipment to withstand the loads placed on the structure from volcanic ash. If new information is developed that questions the ability of SSCs to perform their intended function during a volcanic ash-fall event at the Columbia Generating Station, NRC's existing regulatory processes will be used to evaluate this information and ensure the continued safe operation of the plant.

The staff notes that several additional studies have determined that volcanic hazards are not credible events for other operating plants in the western U.S. The IPEEE analyses (NUREG 1407) confirmed that, with the exception of the Columbia Generating Station, other plants are located too far from potentially active volcanoes to have a credible hazard from volcanic eruptions. The NRC staff also addressed the potential ash-fall from a Yellowstone caldera super-eruption in response to 10 CFR Section 2.206, "Request for action under this subpart." The staff's evaluation can be found in a letter dated September 11, 2009 (ADAMS Accession No. ML091470689), which concludes available information demonstrates that a potential Yellowstone eruption is not a credible event.

Based on a stakeholder comment (see Appendix D of this enclosure under comment number 7), the staff updated this assessment to include additional information regarding Columbia's design basis and mitigation strategies ability to cope with a volcanic eruption. The IPEEE for Columbia,

which the staff evaluated in a February 26, 2001, letter (ADAMS Accession No. ML010570035 (non-public)), notes the following regarding volcanic activity:

> Although major processes and secondary effects of an erupted volcano can be numerous, world-wide data regarding volcanic eruptions and processes show that, except for ash fall, the major volcanic processes (hazards) generally occur within about 40 kms of an explosive volcano (FSAR,Section 2.5.1.2.6.1). Because WNP-2 [Columbia] is 165 kms east of the closest Cascade composite volcano (Mount Adams), and since the site is not downstream on a drainage emanating from a Cascade composite volcano, only ash fall poses a hazard to the WNP-2 site.

Based on the proximity of volcanos to the Columbia site, the staff agrees with the licensee's assessment that ashfall in the only volcanic hazard to the Columbia site. Regarding ashfall, a recent inspection report dated May 7, 2014 (ADAMS Accession No. ML14127A419), provides a description of the licensing basis for Columbia and the protective features that the site has to ensure safety-related SSCs continue to function. The inspection resulted in a violation associated with the diesel generator air intake pre-filters that help to protect the diesel generators air intakes against clogging from volcanic ash. The inspection report notes that licensee procedure ABN-ASH, "Ash Fall," Revision 19, directs licensee staff to replace and monitor pre-filters to ensure that the emergency diesel generators are operable during the design-basis ashfall event. The decision-basis ashfall is a 20-hour event which includes two hours when offsite power is lost. During those two hours, the emergency diesel generators are required to provide electrical power for safety-related systems. Calculation ME-02-87-95, FSAR Sections 2.3 and 2.5, and procedure ABN-ASH all indicate that the diesel generator air intake pre-filters are components used to ensure diesel generator operability during dust storms or volcanic ashfall events.

In addition to its design basis protection, the FLEX portable emergency diesel generators also have filters designed to remove volcanic ash before air enters the engine intakes. The FLEX equipment provides additional defense-in-depth to the licensee's design basis protection. Based on the design features of the plant and the FLEX equipment relative to protection against volcanic ash, the staff concludes that additional regulatory action at Columbia Generating Station related to volcanic hazards are not warranted beyond those already being considered as part of the response to the mitigation strategies order.

<u>Geomagnetic Storms</u>

NRC-endorsed guidance document NEI 12-06 notes that solar-geomagnetic disturbances could lead to extended loss of offsite power due to geomagnetically-induced currents in electrical power transmission systems and that such disturbances are not expected to affect the onsite safety-related equipment. Guidance document NEI 12-06 concludes that the response to such a disturbance would not change the approach to devising FLEX strategies. While the staff generally agrees with this assessment, its determination that no additional regulatory actions related to Fukushima lessons learned are needed to address geomagnetic storms is also based on an evaluation documented in a September 29, 2011, letter to Congressman Roscoe Bartlett regarding concerns about the potential threat to U.S. nuclear reactors from an electromagnetic pulse (EMP) incident (ADAMS Accession No. ML11237A060), as well as ongoing NRC activities in this area, including staff review of a petition for rulemaking (PRM-50-96). The staff's basis for

considering the issue closed for the purposes of this document is that ongoing rulemaking activities and activities associated with PRM-50-96 will document the staff's conclusions in this area, including identifying what, if any, additional regulatory actions are warranted to address this hazard.

The following information can be found in the enclosure to the September 29, 2011, letter:

> The NRC is aware of the potential significance of EMP to the Nation's critical infrastructure and has reviewed the "Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack," issued in 2004. In the late 1970s, concerns with EMP induced large currents and voltages in electrical systems led the NRC to undertake a research program to study the effects of EMP on nuclear power plant safe-shutdown systems. The NRC conducted this study and documented the results in NUREG/CR-3069, "Interaction of Electromagnetic Pulse with Commercial Nuclear Power Plant Systems," issued in February 1983. That report concluded that the safe-shutdown capability of nuclear power plants would, in general, survive the postulated manmade EMP event. In 2007, the NRC revisited this earlier study in light of the modernization of nuclear plants with digital systems, which potentially could be more susceptible to EMP. The new study, completed in 2009, also concluded that nuclear power plants can achieve safe shutdown following a manmade EMP event. In addition, a supplemental study, completed in 2010, which analyzed and compared the potential effects on nuclear power plants from solar or geomagnetically-induced current events to those of the EMP events previously analyzed, led to the same conclusion.
>
> The NRC is also aware of the potential damage to the electric grid that can occur from geomagnetically-induced currents resulting from a significant solar storm. In response to the strong geomagnetic storm on March 13, 1989, which caused major damage to electrical power equipment in Canada, Scandinavia, and the United States, the NRC issued Information Notice 90-42, "Failure of Electrical Power Equipment Due to Solar Magnetic Disturbances," dated June 19, 1990, to inform nuclear power plant licensees of the potential for damage to transmission systems and other components of the power grid from severe solar activity events.
>
> The NRC does not have direct regulatory authority over the electric transmission systems, except with regard to nuclear power plants. The Federal Energy Regulatory Commission (FERC) has direct regulatory authority over these systems and the North American Electric Reliability Corporation (NERC) has the authority to develop and enforce reliability standards for these systems. The NRC collaborates closely with FERC and NERC on electric grid reliability and cyber security issues. The NRC has entered into separate Memorandum of Agreements with FERC and with NERC that commits each agency to share information, and coordinate on matters of mutual interest pertaining to the Nation's electric grid reliability and nuclear power plants.

On March 15, 2011, the NRC docketed a petition for rulemaking (PRM-50-96). In this petition, the petitioner requested that the NRC amend its regulations to require facilities licensed by the NRC to ensure long-term cooling and unattended water makeup of spent fuel pools in the event of geomagnetic storms caused by solar storms resulting in long-term losses of power. The petition and other documents related to the review of PRM-50-96 are available at

http://www.regulations.gov/ under Docket ID NRC-2011-0069. The NRC determined that the issues raised in this PRM should be considered in its rulemaking process and the NRC published a document in the *Federal Register (*FR*)* with this determination on December 18, 2012 (77 FR 74788). In that FR document, the NRC also closed the docket for this petition. Specifically, the NRC indicated that it would monitor the progress of the mitigation strategies rulemaking to determine whether the requirements established would address, in whole or in part, the issues raised in the PRM.

In this context, in a FR Notice dated November 13, 2015 (80 FR 70609), the NRC issued a proposed rule to establish requirements for nuclear power reactor applicants and licensees to mitigate beyond-design-basis events. The proposed requirements in § 50.155(b)(1) and (c) and the associated draft regulatory guidance should address, in part, the issues raised because these actions would establish offsite assistance to support maintenance of the key functions (including both reactor and spent fuel pool cooling) following an extended loss of ac power that has been postulated for geomagnetic events. Additional consideration of these issues will result from NRC's participation in the interagency task force developing a National Space Weather Strategy and the associated action plan. When the National plans are completed, the NRC will reevaluate the need for additional actions to address the effects of geomagnetic storms on nuclear power plants within the overall context of the National Space Weather Strategy and action plan.

Because the NRC has not identified an immediate safety concern and will continue to evaluate whether additional regulatory actions are needed to address geomagnetic storms using existing processes, the staff considers this issue resolved in the context of this paper. The staff notes that the Commission will be informed if additional actions are determined to be warranted as a result of the mitigating strategies rulemaking effort, the final disposition of PRM-50-96, and the staff's ongoing engagement in the interagency task force.

Table A-1: List of Beyond Design Basis Hazards Evaluated by the Staff to Determine if Additional Regulatory Actions are Warranted

Hazard	Reason
Natural Hazards Excluded from Additional Review	
Animals	Hazard highly unlikely to cause coincident loss of all trains of safety related SSCs and extended loss of ac power
Avalanche	Hazard highly unlikely to cause coincident loss of all trains of safety related SSCs and extended loss of ac power. In addition, NRC-endorsed guidance document NEI 12-06 notes that hazard may impede response actions and is addressed as part of step 2D of that process.
Biological Events, Coastal Erosion, ice barrier, ice cover, Lake- or river-borne material plugging water intakes / organic material in water	Hazards can contribute to the loss of ultimate heat sink. Loss of all trains of safety related ultimate heat sink considered unlikely. If this were to occur NEI 12-06 assumes as part of the baseline coping capability evaluation that normal access to the UHS is lost and that the motive force for the UHS flow is assumed to be lost with no prospect for recovery. (See Section 3.2.1.3 of NRC-endorsed NEI 12-06). Based on a stakeholder comment (see Appendix D of this evaluation comment number 6 and 14), the staff also evaluated scenarios involving the hypothetical total loss of the heat sink (e.g. inundated with debris or biomass) versus the mitigating strategies assumption of a loss of access (e.g., the loss of a pump or installed flow path) to the body of water serving as the ultimate heat sink. Mitigating strategies generally rely on installed steam-driven systems and stored water sources (e.g., condensate storage tank) for the first phase of the response and then the use of portable equipment and reestablishing access to the ultimate heat sink during the second phase of the response. There have been examples of degraded performance of cooling water systems due to biofouling, screen blockage, or other conditions that adversely affected the water quality or temporarily interfered with using water from ultimate heat sinks (see for example Generic Letter 89-13, "Service Water System Problems Affecting Safety-Related Equipment," available at http://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1989/gl89013.html). The discussions of low water conditions in Appendix B of this evaluation partially address this question for some plants by describing the availability of water in a variety of systems and storage tanks (e.g., condensate storage tank, condenser, refueling water storage tank, etc.) and licensees' ability to align installed or portable equipment to support key safety functions. The capabilities for these plants is not unusual and so it is reasonable to assume that all plants have sufficient sources of water to provide cooling for some period of time without relying on the ultimate heat sink. Licensees could use the available time to

Hazard	Reason
	identify ways of obtaining water from the ultimate heat sink or secure alternate sources of water, including delivery from offsite sources. Scenarios that do not include a loss of electrical power coincident with a loss of the ultimate heat sink would provide additional flexibility given the increased ability to move water within the plant. In the absence of reestablishing cooling water from the ultimate heat sink or an alternative source, the licensee would, if they had not already done so, enter into severe accident management guidelines and initiate appropriate emergency response measures. Based on licensee's obligations to maintain the ability to reject decay heat to the safety related ultimate heat sink as described in Generic Letter 89-13 and the additional capability provided by the mitigation strategies FLEX equipment, the staff concludes that additional regulatory action to address the hazards that these hazard that could potentially lead to loss of access to the ultimate heat sink do not warrant additional regulatory action. In addition, the staff notes potential changes to regulatory requirement to address the loss of essential service water was evaluated in the generic safety program. As documented in NUREG-0933, "Resolution of Generic Safety Issues (available at: http://nureg.nrc.gov/sr0933/)," the staff identified this issue as Generic Safety Issue (GSI) 153: "Loss of Essential Service Water in [light water reactors] LWRs." The issue was resolved and no new requirements were established.
Corrosion (e.g., from salt water), Erosion, Strong currents (under-water erosion)	The event is slow in developing such that it can be demonstrated that there is sufficient time to eliminate the source of the threat or provide an adequate response such as instituting a program to manage the corrosion or replace affected systems, structures, or components.
External flooding, Extreme Rain, Groundwater (too much), High tide, Hurricane or typhoon - (potential to create flooding), Precipitation, Other extraordinary waves, Seiche, Storm Surge, Tsunami, Waves	Included as part of the flooding reevaluation that is being conducted separately from this document.
Extreme air pressure (high/low/gradient)	Extreme air pressure is a design value when defining the design basis tornado. The values for pressure drop and rate of pressure drop decreased in revision 1 of RG 1.76 and are therefore bound by existing analysis.
Fog / Mist, Frost, Hail, Landslide,	Based on review of operational experience databases and engineering judgement these events were determined to be insignificant contributor to simultaneous extended loss of ac power and safety related ultimate heat sink.
Dust storms, forest fire, grass fire, Ice storm/freezing rain/sleet,	Can contribute to the potential for a simultaneous extended loss of ac power and loss of the ultimate heat sink, but does not challenge the structures and internal components of a

Hazard	Reason
lightening, sandstorms, salt storm	nuclear power plant such that additional regulatory action is needed. In making this determination the staff notes that although the events could lead to an extended loss of AC power the plant itself should be able to achieve safe stable shutdown conditions using safety related equipment. In addition, the mitigating strategies developed in response to Order EA-12-0049 provide an additional level of protection such that additional regulatory actions are not warranted. As a result of stakeholder comments (See Appendix D of this enclosure comment number 12 and 14) the staff performed additional searches of operational experience databases to determine if operational experience provided a basis for additional regulatory action. Although the staff found multiple examples of component failures (mostly breakers) caused by dirt/grime/dust buildup on contact surfaces the buildup was attributed to ineffective maintenance. No cases were found where the malfunction of the component was caused by extreme environmental conditions.
Land rise, sink holes, soil shrink-swell, underwater landslides (impact on soil, i.e., not tsunami)	From International Atomic Energy Agency TECDOC 1341, "Extreme External Events in the Design and Assessment of Nuclear Power Plants": Site related characteristics, such as subsidence due to subsurface pumping, mining, sink holes, or alteration of groundwater regions; active surface faulting, liquefaction potential, chemically active soils and rocks or volcanic activity which have expansive, heave, shrinkage characteristics, flood plain level are natural phenomena which are considered and evaluated during the site suitability evaluation process. Such characteristics either result in (1) the site being considered unsuitable, or (2) appropriate design consideration and construction techniques are employed to mitigate or prevent the hazard.
Meteorite / satellite strikes	Low probability event that does not meet the threshold for regulatory action. NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," (ADAMS Accession No. ML063550238) Section 2.10 states the following: Extraterrestrial activity is considered to be natural satellites such as meteors or artificial satellites that enter the earth's atmosphere from space. Because the probability of a meteorite strike is very small (less than 10^{-9}) (NUREG/CR-5042, Suppl. 2), it can be dismissed on the basis of its low initiating event frequency.
Seismic activity	Included as part of the seismic reevaluation that is being conducted separately from this document.
Solar storms / Geomagnetic disturbances	As described in the text that precedes this table the staff has not identified an immediate safety concern and will continue to evaluate whether additional regulatory actions are needed to address geomagnetic storms using existing processes, the staff considers this issue resolved in the context of this paper.

Hazard	Reason
Waterspout	Based on review of operational experience databases and engineering judgement these hazards are considered highly unlikely to cause coincident loss of all trains of safety related SSCs and extended loss of ac power. Once a waterspout moves from water onto land the staff considers the hazard to be a tornado. The tornado evaluation is evaluated as a hazard as needing additional review (see discussion of extreme winds below).
Volcanic activity	As described in the text that precedes this table this hazard should not challenge the structures and internal plant equipment such that additional regulatory actions are needed.
Natural Hazards Identified for Additional Review	
Externally generated missiles, Extreme winds, and tornadoes, hurricane/typhoon – wind and missile loading, Strong winds (other than hurricane or tornado), Tornado/Extreme Winds	Staff determined a need for additional review because: 1. Many of the currently operating plants were licensed prior to 1975 version of the standard review plan and the staff determined that it would be appropriate to review the design basis tornado missile protection for these older plant, and 2. The staff determined that it would be appropriate to review hurricane missiles because of recently issued guidance in this area. In October of 2011 the staff issued Regulatory Guide (RG) 1.221, “Design Basis Hurricane and Hurricane Missiles for Nuclear Power Plants,” (ADAMS Accession No ML110940300). See section 3.2.2 and of the enclosure to this document for more information regarding the basis for the additional review.
Frazil ice, High air temperature, High water temperature, Low air temperature, Low water temperature	Extreme maximum and minimum ambient temperatures. These issues were identified by the staff for additional evaluation because of the potential for these events to cause operational issues for normal plant heat sink and containment heat removal systems (post-accident), and meteorological conditions related to the maximum evaporation and drift loss and minimum water cooling for the ultimate heat sink design. In recent years the staff has processed license amendment requests to allow an increase in the safety-related ultimate heat sink temperature. Therefore, the staff determined that additional evaluation of extreme temperature conditions was warranted to determine whether additional regulatory actions are needed to address this condition.
Drought, Low lake or river level, River diversion	The staff determined that it would be appropriate to review low water conditions caused by failures from dams downstream of a nuclear power plant. Low water conditions can also be caused by drought. Regardless of the cause of the low water condition the staff’s review is based on the concern that such conditions could reduce or limit the available safety-related cooling water supply. Therefore, the staff determined that additional

Hazard	Reason
	evaluation of low water conditions was warranted to determine whether additional regulatory actions are needed to address this condition.
Snow and Ice Loads	The staff determined it was appropriate to advance this external natural event to the next task in the screening process because the recent updated guidance provides approaches for considering snow loads which were not available when some of the operating plants were initially licensed. On June 23, 2009, the staff issued interim staff guidance DC/COL-ISG-007, "Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures," (ADAMS Accession No. ML091490556). This guidance was issued for new reactor reviews since the existing guidance in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," (available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800) did not provide specific approaches to consider snow loads at ground level due to normal and extreme winter precipitation events for the design of Seismic Category I structures.

Appendix B – Additional Background Information Regarding Low Water Conditions

This appendix provides additional background information related to the U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of low water conditions found in Section 3.3.3, "Drought and Other Lower Water Conditions," of the enclosure to this SECY paper. Section 3.3.3 provides an assessment of low water conditions due to downstream dam failure and low water conditions due to a seiche or tsunami. The NRC staff conducted and is documenting these Task 3-like, site-specific evaluations in order to timely address these two issues and avoid duplicative efforts in the Generic Issues Program.

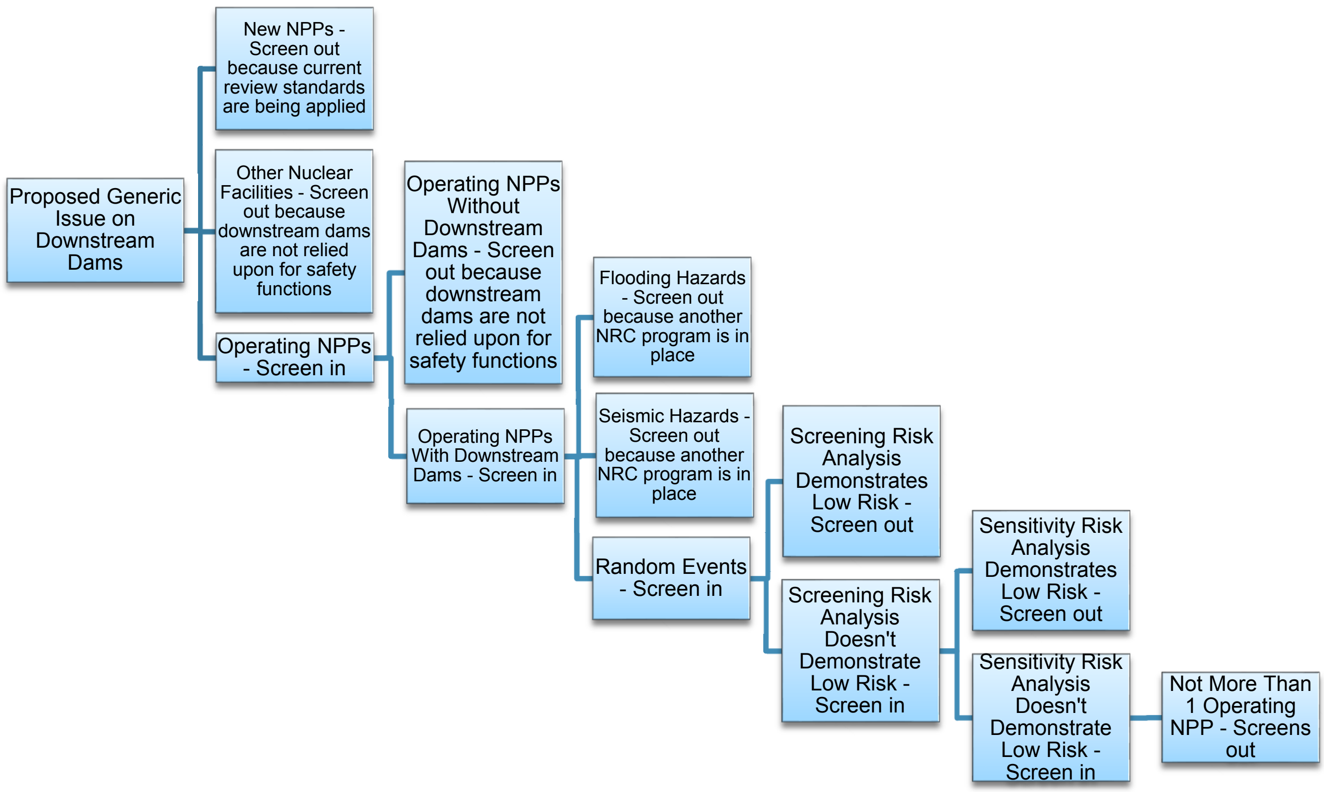
Low Water Conditions Due to Downstream Dam Failure

Low water conditions due to the failure of a downstream dam was evaluated in two steps. In the first step, the NRC's generic issue program evaluated all operating reactors and concluded that all plants screened out (no further regulatory actions are needed) with the exception of H. B. Robinson. Robinson was not resolved in the first step because the generic issue program stipulates that decisions can only rely on readily-available information. The generic issue review panel did not have sufficient information on the backup water sources at Robinson. In the second step (documented herein), the NRC staff evaluated the Robinson plant and determined that no further regulatory actions are needed. These steps are described below.

Generic Issue Review

As discussed in Section 3.3.3 of the SECY enclosure, a generic issue review panel reviewed downstream dam failures that fell outside the scope of the NRC staff's review of compliance with the mitigation strategies Order EA-12-049 "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events." The NRC staff's assessment of this issued can be found in a memorandum from John Monninger to Michael Weber, titled "Recommendation for Dispositioning Proposed Generic Issue on the Effects of Downstream Dam Failures on Nuclear Power Plants," dated March 11, 2016 (ADAMS Accession No. ML15253A365). This appendix summarizes the evaluation found in the March 11, 2016, letter and its enclosures.

The March 11, 2016, staff assessment includes a process figure that shows the steps the NRC staff used for determining the generic applicability of downstream dam failures. The process figure from the March 11, 2016, letter is repeated below.



The staff's assessment was limited to the potential loss of the ultimate heat sink at operating nuclear power plants from a random (sunny day) failure of seismically qualified downstream dams or impoundment reservoirs. The rationale for this is that licensees are already modifying plants to accommodate the failure of nonseismic downstream dams as part of Order EA-12-049. The order does not apply directly to the failure of dams, but requires licensees to develop strategies to mitigate beyond design basis external events. The guidance documents direct licensees to assume that only "robust" assets are available. Nonseismic dams or impoundments are assumed to be unavailable, so licensees have developed the means to access other water sources to maintain key safety functions. In this way, the industry and NRC staff are addressing the consequences and any remedial actions from a random failure of a nonseismic downstream dam.

The staff identified 13 nuclear power plant (NPP) sites that rely on seismically-qualified downstream dams or impoundment reservoirs as their ultimate heat sink for normal cooling water or emergency cooling water. The staff determined that all of these sites except Robinson screened out on low risk due to the availability of alternate water sources; therefore, the conditions were not met for consideration under the Generic Issues program.

The March 11, 2016, memorandum on the staff's assessment states the following regarding Robinson (bracketed information summarizes additional context from other parts of the memorandum):

> With regards to Robinson, the sensitivity risk analysis indicated that the risk met the threshold for issues that should be considered for further evaluation in the Generic Issues program. The Robinson results were unique and driven by uncertainty as to whether two separate UHS water sources exist at the site to mitigate the event. Given the uncertainty [in the availability of Robinson's installed backup water sources], no credit was given for a second UHS water source in the sensitivity risk analysis. Robinson was identified as the only NPP with just once source of water for the UHS in NUREG-0965, "NRC Inventory of Dams." The staff confirmed this through a review of the NRC's Interim Staff Evaluation (ISE) prepared in response to the Mitigating Strategies Order that the NRC issued in response to the Fukushima Dai-ichi accident. The Panel notes that the Robinson Updated Final Safety Analysis Report (UFSAR) states that there are on-site deep water wells that can be connected to the heat exchangers for the emergency diesel generators and backfed to the service water system. There is also some information discussing the potential use of alternative sources of water to the service water system. NRC's risk analysis tools mention these water sources; however, sufficient information on these sources was not available [to support crediting these sources in preliminary screening evaluations]. Therefore, they were not credited in the sensitivity risk analysis as a redundant source of emergency cooling water. Also, these water sources were not credited in the Robinson mitigating strategies because they are not assumed to be available following a beyond-design-basis external event [even though they are expected to be available for most events]. With no credit taken for these alternative water sources, the potential Generic Issue at the Robinson site meets the threshold in TEC-002 for further consideration. If sufficient credit is given for the alternative UHS water sources, the calculated risk would be lower and the potential Generic Issue at the Robinson site would not meet the threshold for further consideration.
>
> As a final check, the staff reassessed all plants using information in NUREG-0965, the NRC's ISE reports, and the UFSARs to confirm that two separate (i.e., redundant) UHS water sources existed. Redundancy significantly mitigates the impact of a random failure of a downstream dam. The reassessment confirmed that all the plants with downstream dams have two UHS water sources, except for the Robinson plant [assuming no credit for the wells]. As Robinson is the only plant potentially adversely affected by a random failure of a downstream dam, the proposed generic issue does not meet criterion 2, "The issue applies to two or more facilities and/or licensees/certificate holders, or holders of other regulatory approvals."

The purpose of the Panel was to determine whether an issue should proceed to the next step in the Generic Issues Program; not to evaluate the unique aspects of one particular site. As a result, the Panel did not conduct any further evaluation of Robinson. The panel recommended that the Office of Nuclear Reactor Regulation conduct further evaluation of Robinson to evaluate sources of water that were not credited by the panel. In order to timely address the panel's recommendations and comprehensively disposition this external hazard, the NRC staff

performed a Task 3-like, site-specific technical evaluation to address this hazard for Robinson, as documented below.

Robinson Review

The JLD staff conducted a further evaluation of the Robinson site to determine if additional regulatory action may be warranted. The JLD staff considered additional information on the capabilities of on-site backup water sources (in particular, the deep wells), the additional plant capabilities that would not be lost during a random "sunny day" dam failure, and regulatory actions already being taken under other NTTF activities that address dam failures due to flooding and seismic events. The assessment is based on a qualitative analysis of the capabilities of the plant to supply cooling water using FLEX equipment and other equipment without relying on Lake Robinson (ultimate heat sink). The assessment considered the following information:

- By letter dated August 19, 2015 (ADAMS Accession No. ML15232A007), Duke Energy Progress, Inc. (Duke, the licensee) submitted a compliance letter and Final Integrated Plan (FIP) in response to the mitigation strategies Order EA-12-049 for Robinson. The NRC staff's safety evaluation regarding Robinson's implementation of mitigating strategies, which includes an assessment of the FIP, is documented in a letter dated March 31, 2016 (ADAMS Accession No. ML16075A377). As part of its mitigating strategies review, the staff verified that the Lake Robinson dam is considered robust, therefore, the water supply is available for use in accordance with the guidance in NRC-endorsed guidance document NEI 12-06, Section 3.2. Lake Robinson is credited as a makeup water source for most events. Robinson's mitigating strategies credit makeup to the condensate storage tanks (CSTs)/ Auxiliary feedwater (AFW) tanks provided by a FLEX pump that takes suction from Lake Robinson, the discharge canal, or the circulating water inlet bay (the inlet bay will remain filled from the lake as long as lake level is above 217' (normal level is 221') after the CSTs and AFW tanks are empty. This capability would be unavailable in the event of a failure of Lake Robinson dam.

- Robinson's water sources for steam generator (SG) makeup include the condensate storage tanks (CSTs) and AFW tanks. These tanks are seismically qualified but are not protected from high winds. In the event of a random or "sunny day" failure of the Lake Robinson dam, the CSTs and AFW tanks would provide 7 hours and 13.5 hours of makeup, respectively (approximately 20 hours total).

- As discussed in the FIP, Westinghouse performed an evaluation of the Robinson alternate water sources (and duration of use) as makeup to the SGs. The evaluation addressed the UHS (seismic event) and deep wells (nonseismic event) providing SG makeup using FLEX pumps. The licensee performed hydraulic analyses to demonstrate that the FLEX pumps can draw from these sources. The licensee concluded that the UHS and deep wells can provide makeup for 283 hours and 700 hours, respectively, before water fouling becomes a factor for the SGs. This provides enough time for delivery and deployment of the Phase 3 NSRC reverse osmosis / ion exchange equipment.

- The Robinson UFSAR describes four deep wells on site. It further states that an engineering modification installed the "D" deepwell pump to provide an alternate source of

cooling water to the service water system. Piping from this pump is connected to the heat exchangers for the “A” and “B” EDGs and can backfeed the service water (SW) system in the event of a loss of SW. Loss of SW is considered to be outside the design basis of the plant. Operation of the “D” deepwell pump, and the associated valves, requires manual operator actions.

- Power to the deep well D pump can be supplied by motor control center (MCC)-16, MCC-18, or MCC-11 via manual transfer switches. MCC-16, and MCC-18 are fed from the 480 Vac safety related busses that have emergency diesel generator backup. The MCC-11 is provided by a non-safety related bus. Switching is arranged so that either diesel generator can power this deepwell pump and such that electrical separation is maintained. Maintaining cooling water power to a diesel generator will allow for decay heat removal via “feed and bleed” of the primary system.

- The deep wells are expected to be available following a random, “sunny day” failure of the Lake Robinson dam.

- The August 19, 2015, FIP provides additional information regarding the capabilities of the “D” Deepwell pump as it relates to Robinson’s mitigation strategies. The “D” Deepwell pump can provide 1320 gallons per minute (gpm) of water to either the service water system through a hard-pipe connection, or to replenish the AFW tanks through the use of FLEX hoses. The staff notes that based on NRC guidance found in its Response Technical Manual a 3000 megawatt thermal (MW(t)) plant needs approximately 300 gpm of injection of water into the reactor vessel for a BWR or into a steam generator for a PWR to remove decay heat by boiling immediately after a plant shutdown. The amount of water needed at 24 hours is approximately 100 gpm. The 1320 gpm capability of the “D” deepwell pump is more than sufficient to provide the makeup needed to supply the water necessary to the steam generators to remove decay heat. A FLEX diesel generator can be used to power the D deepwell pump and to supply containment cooling.

- Deepwell pumps A, B, and C are a source of water to the auxiliary feedwater pumps in the event of a failure of the water source from Lake Robinson (as described in the UFSAR and FIP). As a backup to the condensate storage tank, a discharge line from these three deepwell pumps is connected to the suction from the condensate storage tank to the motor-driven auxiliary feedwater pumps. The power supply for the A, B, and C deepwell pumps are non-safety related 480 volt busses. In the event of a sunny day dam failure these pumps should retain power (from offsite power) and be capable of supplying water to the steam generators. A FLEX portable diesel generator can also be used to provide power to these deepwell pumps.

- Section 2.2.8 of the FIP notes that Robinson is a Westinghouse 3-Loop plant with Westinghouse SHIELD low leakage reactor coolant pump passive seals. These seals actuate passively upon a loss of seal cooling (such as would be caused by failure of the Robinson dam). Upon activation, the seals are designed to allow less than 1 gallon per minute of leakage per pump seal. As noted in the FIP, the operators have more than 16 hours to initiate makeup to the reactor coolant system (RCS) and still maintain natural circulation cooling of the core. If the D Deepwell is available, the plant has the capability to use normal plant equipment for RCS injection. Alternately, a FLEX portable pump can provide makeup taking suction from multiple sources, including the 353,000 gallon refueling water storage tank, which should be unaffected by a Robinson downstream dam failure.

The NRC staff concludes that in the event of a sunny day dam failure, there are sufficient alternate water supplies that can be used in a timely fashion to provide RCS inventory control.

- NTTF 2.1 activities will determine whether additional regulatory action is needed for failure of the Lake Robinson dam that is caused by flooding or a seismic event. The staff issued a request for information on these events by letter dated March 12, 2012.

    - Regarding seismic failure of the Lake Robinson dam, the licensee's March 31, 2014 (ADAMS Accession No. ML14099A204) response to the request for information provided the licensee's seismic hazard and screening report. By letter dated July 17, 2015 (ADAMS Accession No. ML15201A006), the licensee provided a revision to its Seismic Hazard Evaluation, which included a revised ground motion response spectrum (GRMS) using new geotechnical data and shear-wave velocity testing for the Robinson site. The licensee's revised seismic hazard and screening report indicates that the site GMRS exceeds the safe shutdown earthquake for Robinson over the frequency range of 1 to 10 Hertz. As such, Robinson screens-in to perform a seismic risk evaluation and spent fuel pool evaluation.

      By letter dated October 27, 2015 (ADAMS Accession No. ML15194A015), the NRC staff provided its final determination of licensee seismic probabilistic risk assessments (SPRAs) under the NTTF Recommendation 2.1 March 12, 2012, request for information. The letter provides the SPRA submittal dates for all applicable sites, which includes a March 31, 2019, target date for Duke providing an SPRA for Robinson. By letter dated May 23, 2016 (ADAMS Accession No. ML16144A433), Duke clarified that the SPRA to be submitted in response to Recommendation 2.1 will include an evaluation of the overall plant response to the new seismic information, including an evaluation of the downstream dam at Robinson.

    - Regarding flooding-induced failure of the Lake Robinson dam, the licensee provided a flood hazard reevaluation report (FHRR) dated March 12, 2014 (ADAMS Accession No. ML14086A384) and a revised FHRR to address staff requests for additional information dated August 29, 2015, (ADAMS Accession No. ML15243A077). The FHRR reviewed the downstream dam's ability to handle a probable maximum flood (PMF) and determined that based on the spillways being incapable of passing a PMF the downstream dam would overtop and fail. The FHRR provides an interim action for such an event that relies on the plant being shutdown well ahead of the dam failure, which minimizes the decay heat load and significantly extends the time that the condensate storage tank water supply can remove decay heat. The staff finds the interim actions proposed by the licensee to be reasonable.

      The staff's detailed assessment of the licensees interim action can be found in an internal memorandum dated October 30, 2015, "Staff Documentation of the Interim Actions Review Process Associated with the Flooding Hazard Revaluations – Recommendation 2.1 of the Near-Term Task Force for H.B. Robinson Steam Electric Plant, Unit 2," (ADAMS Accession No. ML15272A1590). As documented in the October 30, 2015 memorandum the staff determined that the interim actions provided reasonable, short-term means to address the reevaluated hazard and these actions can be reasonably expected to be within the capability of plant personnel. In addition regional inspectors verified that the proposed interim actions were acceptable through:

1) visual inspection of a representative sample of the flood protection features, 2) reasonable simulations of flood mitigation actions, to verify they could be executed as specified and 3) flood protection functionality. The results of the inspection can be found in inspection report 0500261/2014005 (ADAMS Accession No. ML15028A121).

- Furthermore, according to the proposed MBDBE rule, the licensee will need to demonstrate that the mitigation strategies are reasonably protected and could be deployed under the reevaluated hazard. As such, the robustness of the downstream dam will be appropriately assessed as part of the mitigation strategies assessment or alternative methods will be identified to support mitigation strategies.

The NRC staff concludes that additional regulatory actions are not needed to address a random dam failure and corresponding loss of the ultimate heat sink at Robinson because:

- Over 20 hours of water supply is provided to remove decay heat using the CST and AFW tanks. Alternate sources of water should be able to be acquired in this time period to feed the steam generators. The NRC staff notes that the 20 hours is based on the instantaneous loss of the UHS due to the downstream dam failure and no credit is taken for the time it would take to drain the lake from such a failure. The NRC staff also notes that the amount of decay heat produced after 20 hours is approximately 1/3 of the decay heat created immediately after a plant shutdown.

- Water from the “D” deepwell pump can provide cooling to the emergency diesel generators, or can be used as a source of water to the steam generators. In addition, non-safety related deepwell pumps A, B, and C, can provide an alternate source of water to the steam generators. These non-safety-related systems should be available in the event of a “sunny day” dam failure and can be powered by offsite power, or FLEX generators. In addition, the “D” deepwell pump can be powered from the onsite emergency diesel generators. RCS inventory makeup water supplies are sufficient in the event of a sunny day dam failure based on the use of RCP low leakage seals, water inventory available in the refueling water storage tank, and the availability of a portable high-pressure FLEX pump.

- The deepwell pumps may not be available following a seismic event; however, the need for regulatory action due to risks associated with seismic failure of the downstream dam and concurrent failure of other onsite water sources will be addressed through NTTF Recommendation 2.1 activities. Therefore, the NRC staff concludes that additional regulatory actions are not warranted for Robinson (outside any that may arise through the NTTF Recommendation 2.1 activities).

Low Water Conditions Due to a Seiche

Section 3.3.3 of the enclosure of this report discusses the staff’s evaluation of low water conditions due to a seiche or tsunami. As discussed in the enclosure the NRC staff’s assessment is limited to areas of the country where this phenomena could create concerns (i.e., plants located on the Great Lakes, and Chesapeake Bay) because of its ability to affect the safety related ultimate heat sink. The plants that are within the scope of this assessment include as part of Task 2:

- DC Cook, Units 1 and 2	- Palisades	- Point Beach, Units 1 and 2
- Davis Besse	- Perry	- Calvert Cliffs, Units 1 and 2
- Ginna	- Fitzpatrick	- Nine Mile Point, Units 1 and 2

Plants such as Fermi 2 and Fermi 3 (which received a combined construction permit and operating license) do not rely on the Great Lake as the safety-related heat sink and therefore are not listed because their safety-related heat sink is not susceptible to low water conditions from a seiche. The staff also performed a review of the following bodies of water to determine if a low water level condition due to a seiche are a concern:

- Plants on the Gulf of Mexico were reviewed, but these plants do not rely on the Gulf of Mexico for their safety-related cooling water

- The staff also performed a review of Atlantic and Pacific coastal plants to determine if their safety related ultimate heat sinks relied on Bays or inlets connected to the Ocean that maybe susceptible to low water level conditions due to a seiche or other mechanism such as tsunami or storm surge drawdown. The table below provides the results of the staff's evaluation for these coastal plants. Based on this assessment the staff concludes that for the coastal plants, low water levels due to seiches or tsunamis do not warrant additional regulatory action.

Site	**Coastal Plant Seiche and Tsunami Low-Water Level Evaluation**
Seabrook	The USAR and FHRR report note that the natural period of Hampton Harbor during peak surge conditions is far different from the significant period of incident waves, so resonance from a seiche is not an issue for this site. In addition, the plant has a safety related ultimate heat sink mechanical draft cooling tower in the event access to ocean cooling is lost. Section 4.13 and 5.13 of the FHRR evaluates low water level conditions due to a tsunami drawdown and a probable maximum storm surge. The FHRR concludes that the limiting low water level was due to a low tide combined with a very strong offshore wind. This led to a -20.65 ft -plant datum water level. The FHRR concludes that because the bottoms of the pump bells for the safety-related service water pumps are below -39 ft-plant datum that the minimum water level to provide adequate suction head for the service water pumps will be met.
Pilgrim	The FHRR notes that Cape Cod bay was evaluated as an open-ended/semi-enclosed basin in the north-south direction, and as an enclosed basin in the east-west direction. The FHRR also notes that although meteorological forcing has a broad energy spectrum, it typically does not have sufficient energy to drive a seiche in Cape Cod Bay at the estimated seiche modes. The FHRR also notes that tsunami would not be a significant contributor to flooding potential at Pilgrim considering: 1) the site's location relative to Cape Cod Bay; 2) the relatively low level of exposure to the open ocean; and 3) the complex geography and bathymetry of the region (i.e., Cape Cod and Georges Bank).

Millstone	The FHRR evaluated two surface water bodies at Millstone as requiring evaluation, including: 1) the Long Island Sound and 2) the discharge basin (former quarry). Licensee concluded that seiche poses no flood risk based on the screening analysis performed to determine if the resonance frequency of the bodies of water was such that they are susceptible to seiches and a literature review. The FHRR indicates that a tsunami is possible. Low water levels due to tsunami drawdown are not discussed. Millstone Unit 2 USAR notes that the safety-related service water pumps are designed for a low-low water of minus 7 feet (mean sea level). The Millstone Unit 3 USAR notes that the suction bell of each of the pumps is located at elevation minus 13 feet mean sea level, 5 feet below their design low water level. Given the low likelihood of a tsunami impacting the site and the design of the service water system the staff concludes that additional regulatory actions to address the possibility of a tsunami drawdown are not warranted.
Oyster Creek	The FHRR states that tides most storm surges and wind-generated waves are not likely to cause seiche standing wave amplitude resonance within Barnegat Bay, which is the safety related UHS for the plant. FHRR notes that the low water tsunami did not result in water levels significantly below the low water antecedent water level.
Hope Creek and Salem	The USAR and FHRR note that due to the lack of resonance with identified forcing functions in the Delaware Estuary, as well as observational evidence of the relatively small magnitude of seiche motions, seiche is not an issue for these plants. In addition, energy dissipation of any water level oscillation occurs by frictional damping and reflection along the banks of the estuary. The FHRR notes that a probable maximum tsunami event is strongly filtered by physical processes in Delaware Bay, and are not critical to the final runup or drawdown estimates at the site.
Brunswick	The FHRR evaluation does not separate the seiche contribution in the storm surge evaluation for the lower portion of the Cape Fear River. Nevertheless, the staff reviewed the geometry of the safety-related UHS canals, the connection of the canals to the Cape Fear River and the Atlantic Ocean and determined that the site is not susceptible to a seiche of a magnitude that would be of concern to the NRC staff. The FHRR indicates that there is no indication of tsunami waves impacting the site based on the shore topography. The FHRR concludes that tsunami waves do not have the ability to reach the site
Saint Lucie	USAR notes that seiche was not considered because of the open, shallow characteristics of the ocean and the Indian River. The FHRR evaluates the possibility of a seiche at Saint Lucie and concludes that the weather conditions needed to establish a seiche due not coincide with the resonance frequency periods needed to establish a seiche and therefore a seiche in the Indian River Lagoon is unlikely to occur. The FHRR evaluates low water level conditions due to a storm surge drawdown, hurricane wind driven drawdown, and tsunami drawdown. The

	storm surge drawdown is based on assumption that hurricane winds blowing out to sea (based on counterclockwise location) could result in a drawdown of the ultimate heat sink. Section 5.12 of the FHRR concludes that the safety-related intake cooling water (ICW) pumps minimum water level elevation is -14.5 feet mean sea level. The FHRR concludes that for the bounding case for low water level conditions for probable maximum storm surge drawdown, hurricane wind driven drawdown, and tsunami drawdown, that the minimum water level elevation for the ICW pumps is met with margin.
Turkey Point	Safety related ultimate heat sink is a series of cooling canals not susceptible to low level conditions from a seiche wave or tsunami drawdown.
Diablo Canyon	The FHRR notes in the storm surge evaluation that the maximum estimated wave height outside the breakwaters for the plant due to a storm surge was 44.6 ft. (1 0.3 m). The maximum crest wave level inside the breakwaters was 12.8 ft. NAVD88 (9.9 ft. MSL). The FHRR notes that while seiche effects were noted in the intake cove, the wave heights were found to be less than 3.2 ft. of the maximum estimated wave height, and are therefore, not a concern. The FHRR also evaluated a seismic event generating a seiche in the two raw water storage reservoirs (RWSRs) located onsite. The RWSRs each contain 2.5 million gallons of water and are an additional source of water to cool the plant by removing heat through the steams generators. The FHRR notes that reevaluation determined that the water sloshing height is approximately 2 ft and concludes that the maximum expected water volume loss from each of the RWSRs is 14,684 gallons of water from the 2.5 million gallons of water stored in each reservoir. The FHRR evaluated drawdown from the reevaluated probable maximum tsunami and provides a reevaluated drawdown level of -18.6 ft mean sea level. The FHRR concludes that because the safety-related auxiliary salt water (ASW) pumps operation minimum water level is -20 ft mean sea level that the ASW pumps are capable of performing their safety function for this temporary condition.

The staff analyzed how the above non-coastal plants along the Great Lakes and Chesapeake Bay would be affected by a hypothetical seiche. In general the NRC considered a plant's response to a hypothetical seiche to be acceptable if either (a) the inlet design was such that a hypothetical seiche would not result in damage to the safety-related heat sink pumps, or (b) the plant had at least 24 hours of cooling water on-site. The staff did not credit the use of a Great Lake or Chesapeake Bay as a source of water for mitigation strategies during the extreme low water condition because the FLEX equipment in general was not analyzed for extremely-low water levels. Extremely low water conditions could temporarily prevent operation of the FLEX support pumps due to limitations on suction lift, net positive suction head, or inability to reach the water. For example, no suction pump can lift water more than 30 feet. Some licensees use a submersible pump, but the depth of the submersible pump is limited by the length of the hoses. The NRC staff considers this to be a conservative assumption because it assumes that the extremely-low water condition still exists at the time the FLEX equipment is deployed (typically 6 hours or more into the event).

This assessment includes the following assumptions:

- The event is initiated by a seiche causing extremely low water levels at the plants. These extremely low water levels would be caused by high winds of sufficient duration and specific direction, and often coupled with low initial water level (as was the case in the Region III March 18, 2015 (ADAMS Accession No. ML15078A284) discussed in section 3.3.3 of the enclosure). These events are expected to be very rare.
  - For the Great Lakes, the staff analyzed a hypothetical seiche that assumes 100 mph winds sustained for 12 hours in the limiting direction, coupled with the 100-year low water level on the lake. (The record sustained winds on Lake Michigan were 62 mph and on Lake Erie were 90 mph.)
- The extremely low water condition damages all of the safety-related heat sink pumps (e.g., due to vortices being created) such that pump repair is not viable in the short-term. Assuming catastrophic damage to all of the safety-related pump is conservative because it assumes the plant operators take no action to protect the operating pumps and it assumes the failure of any pumps that are in standby.
- The extremely low water level would need to persist beyond the plant's capacity to provide cooling water from onsite sources. For the purpose of this evaluation, the staff assumed a 24 hour coping time is based on the following rationale:
  - In approximately 24 hours, licensees would have access to equipment from the NSRCs. This equipment includes pumps designed to draw water from large bodies of water. This extra equipment would give licensee's additional flexibility in reaching low water levels. Providing 24 hours of coping time without having to rely on water from the UHS should allow licensees sufficient time to align the offsite resources if needed.
  - For PWRs that have 24 hours of on-site water supply, at the 24 hour point the mitigating strategies would have resulted in a relatively full RCS in single or two phase natural circulation with high water levels in the SG secondaries. If access to the UHS was still unavailable at that time, there would be a significant time remaining before core damage (e.g., if the onsite sources were depleted before the UHS could be accessed). PWR containments would be at a relatively low pressure and temperature with no makeup or other actions needed (typically nothing is needed until beyond 72 hours). The SFPs, even with a recent full core offload, typically take well over 24 hours before makeup water is needed to prevent fuel damage.
  - For BWRs that have 24 hours of onsite water storage, at the 24 hour point the mitigating strategies would have established a high water level in the reactor vessel. If access to the UHS was still unavailable at that time, operators may be able to maintain RCS injection by re-aligning the RCS injection to take water from the suppression chamber (the safety-related source), or if that failed it would take several more hours before core damage would occur. As discussed in the staff paper titled, "White Paper: Closure of Fukushima Tier 3 Recommendations Related to Containment Vents, Hydrogen Control, and Enhanced Instrumentation," dated February 2, 2016 (ADAMS Accession No. ML16020A245), if containment vents for Mark I and Mark II containments and hydrogen

igniters for Mark III containments are credited, containment cooling is not needed prior to 24 hours. The vents and hydrogen recombiners (which can be powered by FLEX generators) are expected to be available during a seiche.

- The amount of water needed to be provided to remove decay heat from a reactor is substantially less after 24 hours. Based on NRC guidance found in its Response Technical Manual a 3000 MW(t) plant needs approximately 300 gpm of injection of water into the reactor vessel for a BWR or into a steam generator for a PWR to remove decay heat by boiling immediately after a plant shutdown. The amount of water needed at 24 hours is approximately 100 gpm.

- The onsite cooling water sources are not expected to be damaged by the seiche or the winds that result in a seiche.

The following table provides a description of a plant's capabilities to remove decay heat without reliance on a Great Lake, or Chesapeake Bay for a water supply.

Plant Name	**Safety Related Heat Sink**	**Contain-ment Type**	**Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake**
DC Cook Units 1 and 2	Lake Michigan	Ice Condenser	Plant can cope for 24 hours using water stored in onsite tanks to support their FLEX strategy. Credited tanks are protected against all hazards. SG makeup is from the CST for at least 12 hours, taking credit for only the bottom half of the tank because the top half is not protected from tornado missiles. The CST provides over 24 hours if it is not damaged. Also, there are two fire water tanks either of which can provide over 24 hours of water, and the plant can draw water from the municipal water system. These sources are not considered robust for all events, but are expected to survive the winds that generate a seiche and collectively provide reasonable assurance that greater than 24 hours of water is available in a seiche condition. RCS inventory control is based on low leakage reactor coolant pump (RCP) seals. RCS injection is from 3 BASTs and/or 2 RWSTs that are shared between the units. The addition of SHIELD seals allows for injection to be delayed until 16 hours if necessary. The amount of borated water in the BASTs and RWSTs allows for RCS injection well beyond 24 hours.
Palisades	Lake Michigan	Large Dry	The Palisades intake structure is designed such that the safety-related cooling water pumps are not adversely impacted by the hypothetical seiche. In the storm event on April 10, 2013, the plant

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			experienced seiche level setdown of up to 1.7 feet for approximately 20 minutes, while the lake was at historic low water levels. While the lowest water level approached the unusual event criterion of 572 feet in the licensee's emergency response plan, this water level would need to remain below 568.25 feet for some duration to threaten the cooling water inlet (the cooling water pumps can operate down to 557.25 feet but the forebay has a weir at 568.25 feet). In the staff's evaluation, the hypothetical seiche (which would require wind direction opposite the prevailing wind direction) would not result in water levels dropping to 568.25 feet. FLEX strategy for RCS makeup uses the boric acid storage tank to provide makeup water. The BASTs allow for 29 hours of borated water. The SIRWT (safety injection and refueling water storage tank) is not missile protected but would have borated water that is available to be injected into the RCS as well. Palisades has low leakage seals installed. The CST and tank T-81 provide a minimum of 8 hours of cooling water to the SGs. After this the licensee could access the contents of the safety injection refueling water tank, the primary makeup water tank, the utility water storage tank, and/or the demineralized water storage tank (DWST) if they are available, but none are robust for all events. Either the SIRWT or the DWST would provide water beyond 24 hours, and they are on opposite sides of large intervening structures so the staff expects at least one of them to survive the winds that cause the hypothetical seiche.
Point Beach Units 1 and 2	Lake Michigan	Large Dry	The Point Beach FHRR (ADAMS Accession No. ML15071A413) evaluated the plant's susceptibility to low water level conditions due to a seiche. Section 5.10 of the FHRR provides an analysis of historical low levels of the lake combined with a seiche producing an additional setdown, even though the licensee notes that an appreciable seiche is highly unlikely to occur at the site. The analysis concludes that with lowest historic lake level combined with a seiche setdown, there remains sufficient margin to assure operability of

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			the safety related service water pumps. The licensee has procedures to monitor forebay level and secure circulating water pumps as needed to ensure the forebay remains at acceptable levels. The staff also performed a review of the FLEX strategies for the site. The FLEX strategy identifies sources of water to cope for greater than 24 hours. Credited tanks (CSTs) provide approximately 3-6 hours. This time frame is based on TS minimum values, not the typical tank level (which is generally much higher). After the CSTs are depleted, the plant would switch to service water. The licensee analyzed a scenario if normal UHS supply is lost that would rely on water in the pump bay. Use of the pump bay would provide sufficient water available to support decay heat removal capabilities for greater than 24 hours. Manual actions would be taken to establish an alternate connection to the UHS. Therefore, this plant would need to rely on use of the Great Lakes as a water supply to the steam generators before 24 hours (see additional discussion below). RCS inventory control based on the use of low leakage RCP seals. The BASTs and RWST provide 160,000 gallons of protected borated water. This amount of water would allow for the plant to inject into the RCS for well beyond 24 hours.
Davis Besse	Lake Erie	Large Dry	Condensate Storage tank provides 14 hours of decay heat removal by supplying water to the steam generator(s) through the turbine driven auxiliary feedwater pump, assuming that the CST is not damaged by the seiche conditions. Alternately (or additionally), 24 hours of decay heat removal can be provided by a newly installed, automatically started diesel-driven emergency feedwater pump, taking suction from a newly installed 300,000 gallon emergency water storage tank that is seismically qualified and missile protected. Reactor coolant system makeup is provided by the clean water receiver tank (protected) and/or the borated water storage tank (550,000 gallons, not tornado missile protected), either of which can

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			provide least 24 hours of cooling water. RCS inventory control based on the use of low leakage N-9000 RCP seals.
Perry	Lake Erie	Mark III	The emergency service water system was analyzed for low water level conditions from a seiche. USAR Section 2.4.11.2 notes that the emergency service water system was analyzed for the maximum setdown from a seiche combined with the historic low water level conditions. As discussed in USAR section 2.4.11.5, the corresponding minimum level in the emergency service water pump chamber for these conditions is 562.09 ft. The staff's analysis shows slightly lower water level during the hypothetical seiche, and the staff notes that the intake is designed such that it dampens the wave action in the lake (as described in the USAR). The licensee also reevaluated low water level as part of the FHRR. With the invert of the chamber for the essential service water pump at Elevation 537 ft, the 10-foot minimum depth requirement for the essential service water pumps is met with significant margin in all cases. Mitigation strategies credit water from Lake Erie within 6-7 hours in order to minimize challenges to RCIC operation, assuming the RCIC suction is aligned to the Suppression Pool. However, if either the condensate storage tank, mixed bed storage tank, or the two bed storage tank on the west side of the plant are available, Perry has sufficient water sources such that Lake Erie water is not needed for 24 hours. It is unlikely that these tanks would be affected by a conditions that create a seiche. The NRC staff notes that the ELAP/LUHS mitigating strategy at Perry utilizes a modified suppression pool cooling system using the ultimate heat sink prior to 24 hours. This system is employed to eliminate the need for containment venting as part of the strategy to maintain containment integrity. However as noted above, cooling water is not expected to be challenged by a seiche. If cooling water was lost, and power to hydrogen igniters is credited through use of the FLEX support

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			equipment, onset of containment failure is delayed past 24 hours.
Fitzpatrick	Lake Ontario	Mark I	The staff did not perform a detailed review of Fitzpatrick. The licensee has informed the Commission of its intent to shut the facility[1] and has suspended its implementation of mitigating strategies. Available volume in the suppression chamber and condensate storage tank is considered robust and can supply water to RCIC such that Lake Ontario water is not needed until approximately 24 hours into the event. The licensee can then use fire trucks or other equipment to provide injection into the core, and the containment vent can be used to prevent overpressure; however, the licensee may not completely implement other mitigating strategies so availability of electrical busses may depend on the availability of offsite power.
Ginna	Lake Ontario	Large Dry	Decay heat removal is initially from the turbine-driven auxiliary feedwater (TDAFW) pump, taking suction from the condensate storage tank (CST). However, this equipment is not considered to be robust for all events. If the TDAFW pump or CST is not available, the licensee will use the two existing standby auxiliary feedwater (SAFW) pumps with suction from a new SAFW CST, which is protected from all events. The SAFW pumps are electric and can be powered by offsite power or a FLEX DG. This system was designed to provide water to the SGs for core decay heat removal for about 24 hours without needing any additional water. The FLEX DG can power a RCS injection pump taking suction from the refueling water storage tank (RWST), which is fully protected from all hazards, and commence injecting water to the RCS using the safety injection header. The RWST has enough water for 60 hours of injection at the nominal RCS flow rate of 75 gpm at 1500 psig.

[1] This assumes compliance with the mitigation strategies Order EA-12-049. By letter dated November 18, 2015 (ADAMS Accession No. ML15322A273), the licensee informed the Commission of its intention to permanently cease operations of this facility. Therefore, the licensee may not achieve full compliance with Order EA-12-049 before the facility no longer operates and is defueled.

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
Nine Mile Point 1	Lake Ontario	Mark I	The Nine Mile Point Units 1 and 2 FHRR (ADAMS Accession No. ML130740943) evaluated the plant's susceptibility to low water level conditions due to a seiche. Section 2.5.3 of the FHRR notes that the amplitude of a seiche wave is expected to be less than the probable maximum storm surge of 4.8 ft. Section 2.6.2.2.2 of the FHRR evaluates the impact on the safety related ultimate heat sink due to drawdown of 9 feet and concludes that there is sufficient margin to protect safety related cooling water. The staff also reviewed the FLEX strategies for the site. The licensee will initially remove the core decay heat and cool down the reactor by using the Emergency Condensers (ECs). This strategy will provide 8 hours of cooling water. If the extremely low water level persists at this time, the licensee could access the condensate water tank or the water volume in the Nine Mile Point 2 cooling tower, either of which provides more than 24 hours of cooling water, before top of active fuel is reached due to assumed leakage through the recirculation pump seals and other small sources of leakage. To provide makeup to the ECs shells and RPV, a FLEX pump will be deployed taking suction from Lake Ontario via the circulating water intake tunnel for an indefinite supply of water. Although not part of the NMP1 mitigating strategy, NMP1 has the capability to utilize the condensate storage tank, which provides 20 hours of water supply to the reactor through the control rod drive pumps. Therefore, the plant has 24 hour coping capability without relying on Lake Ontario water.
Nine Mile Point 2	Lake Ontario	Mark II	In addition to the conclusion that Nine Point 2 has sufficient margin to protect safety related SSCs from a low level condition due to a seiche (see Nine Mile Point Unit 1 evaluation above), the staff performed an evaluation of the licensees FLEX strategies. Decay heat is initially removed by RCIC taking suction from the CSTs, if available, or the suppression pool. A portable FLEX pump will be connected to a dry hydrant, taking suction 15 feet

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			below the minimum lake level from the UHS, Lake Ontario, will be connected to one division of the Residual Heat Removal System, which will allow water to be supplied to the suppression pool or directly injected into the RPV. The time frame for such a connection is 16 hours. Therefore, this plant does not have a 24 hour water supply before switching to the Great Lake as a means of providing water to the RPV. The Hardened Containment Vent System (HCVS) will be used to limit suppression chamber pressure and suppression pool temperature to support continued RCIC operation. The Unit 2 circulation water system (CWS) contains 12,000,000 gallons of water. Of that volume 6,900,000 gallons is contained within the cooling tower basin. Although not specifically mentioned as part of the FLEX strategy, the FLEX pumps for both Unit 1 and Unit 2 can be aligned to the Unit 2 CWS cooling tower basin using the FLEX pumps, hoses and connection points such that reliance on Lake Ontario is not necessary. The water supply in the cooling tower basin can provide decay heat removal capabilities for both unit for several days.
Calvert Cliffs 1 and 2	Chesapeake Bay	Large Dry	The condensate storage tanks provide 10 hours of cooling water to the steam generators, after which the 350,000 gallon demineralized water storage tank (DWST), two Pretreated Water Storage Tanks (PWST) each having a capacity of 500,000 gallons, and two Refueling Water Tanks (RWTs) each having a capacity of 420,000 gallons could be accessed. Any tank will provide the additional water to last beyond 24 hours. The tanks are distributed around the site, with three of the tanks in a tank farm such that they would provide shielding for each other in a seiche event. Therefore, the staff expects at least 24 hours of water to be available during a seiche. . RCS inventory control based on the use of N-9000 low leakage RCP seals. The BASTs provide 6,000 gallons of borated water each, which is sufficient to provide RCS injection for 24 hours. The RWTs should be available for RCS injection through the charging pumps as well.

Conclusion

The staff analyzed plants along the Great Lakes, Chesapeake Bay, and the Atlantic and Pacific coasts for a hypothetical low water level condition caused by a seiche. The staff assessment is that additional regulatory actions beyond those associated with the mitigating strategies order are not warranted for low water conditions from a seiche because: (a) the location and or design of the plant is such that a hypothetical seiche would not result in damage to the safety-related heat sink pumps, or (b) the plant had at least 24 hours of cooling water stored on-site, which leaves the plant in a stable condition and able to re-establish cooling when water level recovers.

Appendix C – Additional Background Information Regarding Snow Loads

This appendix provides additional background information related to the U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of snow loads found in Section 3.3.2, "Snow and Ice Loads," of the enclosure of this document. Section 3.3.2 discusses interims staff guidance DC/COL ISG-007, "Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Catergory I Structures," (ADAMS Accession No. ML0914900556).

In DC/COL ISG-007 Figure 1 (repeated below) presents a comparison of snow load as a function of snow depth using two different correlations. One correlation is for freshly fallen snow which is based on a 0.15 snow density correlation. The second correlation from Tobiasson and Greatorex correlation reflects that the density of fallen snow will increase over time due to snow settlement. The Tobiasson and Greatorex correlation is represented by the equation $L=0.279D^{1.36}$, where D is the snowpack depth in inches and L is the resulting snow load in lbs/ft^2. In DC/COL ISG-007 Figure 1 shows that for snowpacks greater than 17 inches the Tobiasson and Greatorex correlation is more conservative. The NRC staff notes that a 40 inch snowfall event leads to a snow load of approximately 42 lbs/ft^2 using the Tobiasson and Greatorex correlation. As discussed in Section 3.3.2 of the enclosure, the staff found that the majority of sites that are subject to snow fall considerations are designed for a snow load of 50 lbs/ft^2. The staff notes that based on using the Tobiasson and Greatorex correlation a 50 lbs/ft^2 snow load is equivalent to a snow depth of approximately 45 inches.

When considering snow loads, the NRC staff found Figure 8-1 from NRC-endorsed guidance document NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guidance," (ADAMS Accession No. ML16005A625) useful. The NRC endorsed NEI 12-06, Revision 2 in interim staff guidance (ISG) JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (ADAMS Accession No. ML15357A163). In NEI 12-06, Figure 8 1, which appears below, provides a visual representation of the maximum 3 day snowfall based on an EPRI report TR-106762 that was published in 1996. The staff found the figure useful from the perspective that it provides a visual representation of those areas of the country where structural loads from snowfall are of interest.

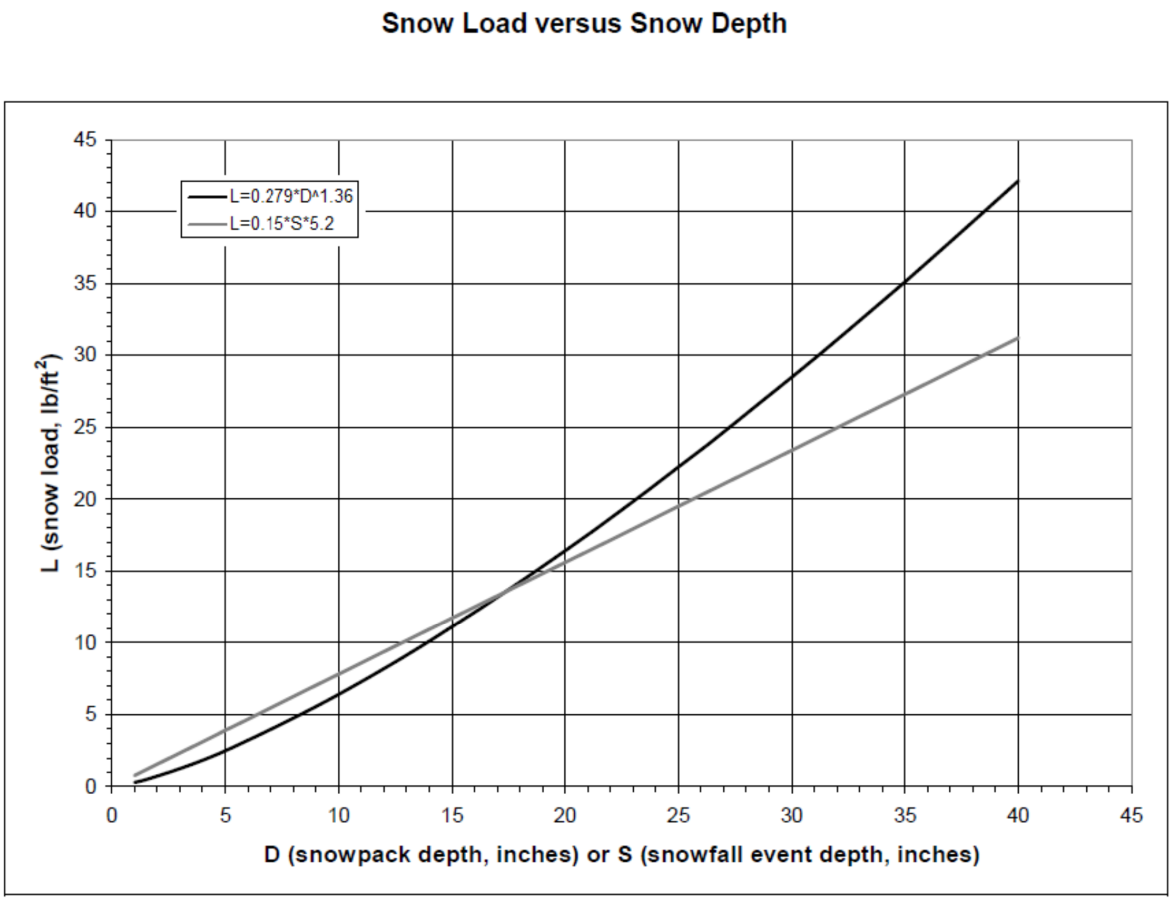
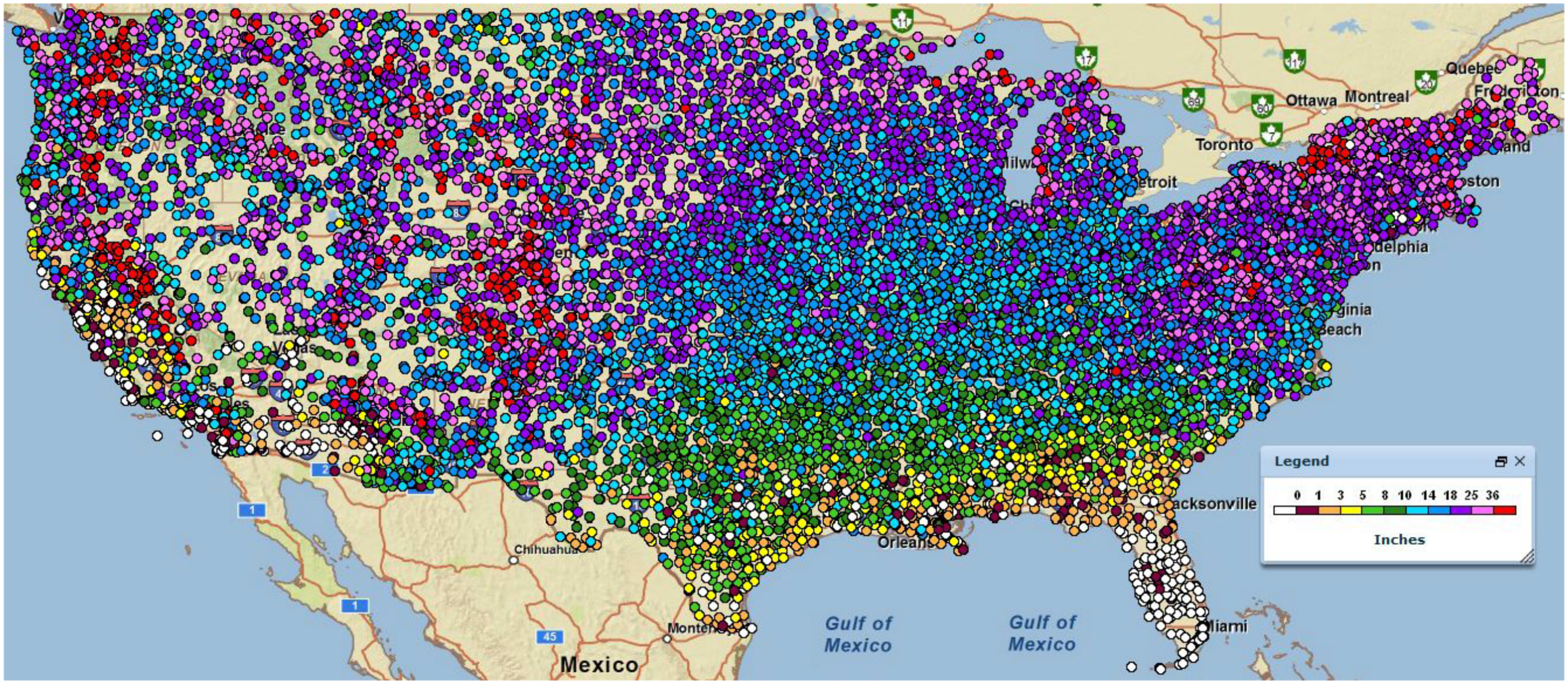


Figure 1 from DC/COL ISG-007 Showing Snow Load versus Snow Depth

Figure 8-1 from NEI 12-06 - Record 3 Day Snowfall



Appendix D – Discussion of Stakeholder Comments Received on Staff's Draft Assessment of Natural Hazards other than Seismic and Flooding

The staff provided an outline of the process used to evaluate natural hazards other than seismic and flooding in SECY-15-0137, "Proposed Plans for Resolving Open Fukushima Tier 2 and 3 Recommendations," dated October 29, 2015 (ADAMS Accession No. ML15254A008). To facilitate stakeholder interactions the staff updated the assessment found in Enclosure 1 of SECY-15-0137 and on March 24, 2016, the NRC staff issued the following document: "White Paper Regarding Nuclear Regulatory Commission Staff Updated Assessment of Fukushima Tier 2 Recommendation Related to Evaluation of Natural Hazards other than Flooding and Seismic," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16039A054). The March 24, 2016, "white paper," was the subject of an April 5, 2016, Category 3 public meeting and was also used to brief the Advisory Committee on Reactor Safeguards (ACRS) Fukushima Subcommittee on April 21, 2016, and the ACRS Full Committee on May 5, 2016.

During the April 21, 2016, ACRS Fukushima Subcommittee meeting the NRC staff briefed ACRS members on the changes the staff was making to the evaluation of natural hazards other than seismic and flooding. The major changes to the staff evaluation at the time of the ACRS Subcommittee briefing were changes that the NRC staff was considering to address stakeholder comments related to the evaluation the white paper, "Additional Background Information Regarding Low Water Condition." Appendix B provided the staff's draft assessment of low water level conditions due to downstream dam failure or a seiche. In response to an ACRS Fukushima Subcommittee request the NRC staff provided the ACRS Full Committee with an updated draft assessment, including a description of the changes that the NRC staff was considering based on stakeholder comments. The NRC staff transmitted this updated draft assessment to the ACRS in a memorandum dated April 26, 2016 (ADAMS Accession No. ML16117A041).

A summary of the April 5, 2016, Category 3 public meeting is available in ADAMS at Accession No. ML16106A234. The ACRS issued a letter on May 17, 2016 (ADAMS Accession No. ML16130A254), providing its conclusions and recommendations associated with the staff's assessment. The NRC staff intends to engage the ACRS again as it completes its assessment for high winds and snow loads and during these interactions will brief the ACRS on changes that were made to the assessment based on the ACRS May 17, 2016, letter.

The major stakeholder comments that the staff received at the April 5, 2016, public meeting as well as other stakeholder comments, including those received during the ACRS Fukushima Subcommittee meeting, the Full Committee meeting, and the May 17, 2016, ACRS letter can be found in the Table below. The Table provides a description of the comment and the staff's response to the comment including identification of changes that the staff made to the evaluation as a result of the comment.

Table 1 – Stakeholder Comments Regarding Staff's Draft Evaluation of Natural Hazards other than Seismic and Flooding

Item #	Issue	Disposition
1	Regarding the NRC staff's hurricane assessment the staff should consider the warning time and the preparations that licensees take based on this warning time to minimize the chance of hurricane-generated missiles. The staff should also consider that hurricane winds are straight line winds that do not have a lifting component like a tornado. Consequently, there is a less likelihood of an automobile to be lifted into the air during a hurricane.	The staff intends to discuss licensee anticipatory actions as part of Task 3 of its hurricane evaluation, including steps licensees may take prior to a hurricane's arrival on site to minimize the chance of an automobile missile. However, Section 3.4.1.4 of the enclosure was updated to include a discussion that the automobile missile is a surrogate for other crushable missiles such as those that might be created by a non-safety related building breaking apart. The staff intends to discuss these surrogate missiles as part of the automobile missile discussions under Task 3 of the process.
2	A member of the public noted that a figure providing a comparison of wind speeds at sites did not include the name of the site. There was also a similar question received relative to the snow load evaluation in that the staff did not identify in the paper the plants that necessitate further assessment. The staff stated during the meeting that because its assessment was preliminary and additional analysis would be performed for both high winds and snow loads it did not consider it appropriate to provide detailed information regarding the sites. For the snow load evaluation the staff did note that the plants that it would review in more detail included plants along the Great Lakes that are subject to lake-effect snow and plants in the Northeast that are subject to heavy snow falls.	No changes were made to the staff evaluation as a result of this comment. The staff intends to engage industry and other stakeholders relative to snow loads and high wind loads as part of Task 3 of the process. As appropriate the staff will include site-specific evaluations in the update to this assessment schedule to be completed by the end of calendar year 2016.
3	An industry member commented that the Electric Power Research Institute (EPRI) has provided an update to one of the documents that the staff referenced and that the staff should consider the information in this new report. The EPRI report is dated October 2015, its EPRI ID number is 3002005287, and the title of the report is "Identification of External Hazards for Analysis in Probabilistic Risk Assessment: Update of Report 1022997." The report is publicly available from EPRI's website.	The staff has reviewed this update and determined that the updated information did not affect the conclusions found in the staff's evaluation of natural hazards other than seismic and flooding. The staff did add a reference to this updated report in the enclosure to this document and to Appendix A of the enclosure.
4	Low water evaluation associated with Robinson downstream dam failure (comment received prior to April 21, 2016, ACRS	Robinson evaluation in the enclosure to the document and in Appendix B expanded to include an

Item #	Issue	Disposition
	Fukushima Subcommittee meeting). The Robinson evaluation does not address actions necessary to maintain reactor coolant system (RCS) inventory control in the event of the short term unavailability of the safety-related ultimate heat sink.	evaluation of the FLEX strategies used to maintain RCS inventory control.
5	Low water evaluation associated with seiche (comment received prior to April 21, 2016, ACRS Fukushima Subcommittee meeting). The evaluation does not address Pressurized Water Reactor RCS inventory control in the event of the short term unavailability of the safety-related ultimate heat sink.	Low water level due to a seiche evaluation expanded to include an evaluation of the FLEX strategies used to maintain RCS inventory control.
6	The screening process performed as Task 1 of the process focused on the possibility of a natural hazard to create both a loss of offsite power and the loss of the ultimate heat sink. The staff should also consider the possibility of the natural hazard creating a loss of ultimate heat sink alone.	Additional language provided in Appendix A of the enclosure to clarify the staff's assessment included an evaluation of loss of the ultimate heat sink without concurrent loss of offsite power.
7	The volcanic assessment of Columbia should assess the plant's capability to respond to byproducts of a volcano such as the ash and toxic gasses (e.g., volcanic ash clogging air filtration units for diesel generators or toxic gasses affecting operator's ability to operate the plant or use the mitigation strategies equipment).	Columbia evaluation in Appendix B of the enclosure expanded to include additional discussion of design features for safety-related SSCs and FLEX equipment and strategies to cope with the effects of a volcano.
8	The waterspout evaluation considers operational experience and engineering judgement to conclude further regulatory action is not needed. The staff should consider addressing the nexus between the waterspout evaluation and the tornado evaluation. In one case waterspouts are screened out in Task 1 of the process while in the other case the staff is performing additional assessment in accordance with Task 3 of the process	Waterspout evaluation in Appendix A of the enclosure expanded to note that once a waterspout is on land it is considered a tornado and the evaluation of tornadoes is being performed in accordance with Task 3 of the process. The staff's conclusion that waterspouts are screened out in Task 1 of the process and additional regulatory action to address the hazard are not warranted.
9	The staff should consider whether the mitigation strategies guidance addresses the possibility of a seismically qualified dam overtopping and failing. Scenarios other than this scenario appear to be addressed in the guidance document. For example, nonseismically robust dams are assumed to fail from a sunny day failure, overtopping, and seismic events. Seismically robust dams are not assumed to fail due to a seismic event but are assumed to fail due to a sunny day failure mechanism. The overtopping failure mechanism of seismically qualified dams does not appear to be addressed.	Because this concern is evaluated as part of Tier 1 activities, the staff considers this comments outside the scope of this paper. The staff notes that interim staff guidance (ISG) JLD-ISG-2013-01, "Guidance for Assessment of Flooding Hazards due to Dam Failure," (ADAMS Accession No. ML13151A153) discusses the steps that the staff expects for the evaluation of dams in the reevaluated hazard. The ISG provides guidance for licensee to evaluate each dam for 3 main causes of failures (1) seismic, (2) hydrologic (including overtopping), (3) other

Item #	Issue	Disposition
		causes/man-made/sunny-day. If the evaluations show that the dam can withstand seismic and hydrologic failure, then it is assumed to fail by sunny-day dam failure. Dams are evaluated for each failure method per the guidance.
10	The staff should consider whether the mitigation strategies addresses the possibility of seismic failure of an upstream dam coincident with the seismic event affecting the power plant. The concern is that FLEX strategies may allow the use of one set of equipment/strategies to mitigate a seismic event and another set of equipment/strategies to address a flooding event. Has the staff considered the possibility the FLEX equipment/strategies may need to address a seismic event affecting the plant and the same seismic event flooding the plant due to it causing failure of an upstream dam?	Because this concern is evaluated as part of Tier 1 activities, the staff considers this comments outside the scope of this paper. The staff is considering this comment as it develops the guidance for the mitigation of beyond-design-basis event rulemaking.
11	The staff should consider for its low water seiche assessment whether coastal plants are susceptible to this condition because of the arrangement of their ultimate heat sink. For example if a plant uses a large bay as part of its ultimate heat sink, the large bay (connected to the ocean) may be susceptible to wind-driven seiches event though the ocean itself is not susceptible to this phenomena.	Staff added an evaluation to Appendix B of the enclosure evaluating coastal plants for the possibility of low water level conditions due to a seiche.
12	The staff should consider whether the dust storm evaluation should consider the potential of the plant being affected by small particles that could interfere with the operation of the plant. For example, dust particles could interfere with electrical component operations by interrupting a connection or creating a short circuit.	The staff added clarifying text to Appendix A of the Enclosure to the assessment noting that based on results of operating experience evaluation of U.S. and international plants, the staff did not identify an event that would cause it to revisit its conclusion that additional regulatory action is warranted to address the effects of dust particles on the safe operation of a nuclear power plant.
13	The staff should consider whether the low water level condition assessment should address low water levels due to a tsunami causing a drawdown of sea water, such that safety-related sea water cooling pumps could be affected.	The staff added an analysis of low water conditions due to a tsunami drawdown to Appendix B of the enclosure for coastal plants.
14	ACRS letter dated May 17, 2016 (ADAMS Accession No. ML16130A254) provided the following conclusions and recommendations:	The disposition of the four ACRS recommendations is as follows:

Item #	Issue	Disposition
	1. The ACRS agrees with the staff's conclusion that further evaluation of the effects from high winds and snow loads is warranted. 2. The ACRS plans to review the analyses which support the staff's conclusions that no further effort is needed to examine the effects from downstream dam failures and intake water seiche conditions at selected sites. 3. The staff has provided adequate justification for excluding most other natural hazards from further evaluation. The following items merit additional attention: • Hazards that may disable the ultimate heat sink as a source of water with adequate quality to support long-term heat removal • Hazards that may prevent reliable operation of plant equipment and alternative mitigation equipment which rely on adequate air quality for combustion or ventilation 4. The staff should remain involved in the multi-agency investigation of severe geomagnetic storms. They need to distill from this effort expeditiously those factors important for the NRC's regulatory process.	1. The staff will update its assessment of high winds and snow loads and will brief the ACRS in a future meeting. 2. The staff did not make changes to the assessment based on this comment but will support additional discussions with the ACRS in a future meeting. 3. Changes made to Appendix A assessment for volcanoes, dust storms, and ultimate heat sink evaluation based on this comment. (See related comments 6, 7, and 12, above). 4. No changes were made to the staff's assessment of geomagnetic storms. As discussed in Appendix A of this assessment geomagnetic storms are being evaluated as part of the MBDBE rulemaking and as the staff develops its response to PRM-50-96.