Evaluation of Natural Hazards Other than Seismic and Flooding

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Enclosure 1 – Draft Nuclear Regulatory Commission Staff Updated Assessment of Fukushima Tier 2 Recommendation Related to Evaluation of Natural Hazards other than Flooding and Seismic

1.0 Background

As directed by staff requirements memorandum (SRM) to SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated August 19, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML112310021), the staff sought to identify additional recommendations related to lessons learned from the Fukushima Dai-ichi event, beyond those identified in the Near-Term Task Force report. Additional recommendations were considered 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, non-governmental organizations, the public, and the nuclear industry. These issues were raised in a variety of forums, including the staff's August 31, 2011, public meeting and a September 9, 2011, Commission meeting.

As part of that initiative and 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 reevaluations 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 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 Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.54(f)).

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

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, clarified 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.

In SECY-15-0137, "Proposed Plans for Resolving Open Fukushima Tier 2 and 3 Recommendation," Enclosure 1, "Proposed Resolution Plan on Tier 2 Recommendation on Other Natural Hazards," (ADAMS Accession No. ML15254A006) the staff provided an update to its plan for resolving this issue. The resolution of this issue outlined in SECY-15-0137 Enclosure 1 included a 4 step process for evaluating the other hazards and a timeframe of December 2016 for completing the evaluation. This document provides the interim results of this evaluation.

2.0 Current Status

As described in SECY-15-0137, the staff undertook a series of screening-type evaluations to determine if any external hazard warranted regulatory action. The NRC staff reviewed a variety of domestic and international documents related to external hazards. The list of hazards considered is discussed and provided in Appendix A Table A-1. As described below, these hazards were assessed and a subset of the hazards identified for the next step in the screening process. The subset of natural hazards, beyond seismic and flooding, that proceed to the second stage of the screening process are extreme winds, extreme ambient temperatures, drought and other low-water conditions, and winter precipitation that results in snow and ice loading on structures. These are the hazards the staff has determined should be considered in the Tier 2 activity. The current regulatory framework requires that all 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," General Design Criterion 2[1], "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 Tier 2 external hazards using existing information and processes, and assessed the need for further regulatory actions. This included consideration of previously submitted licensee information on external hazards, such as:

[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 GDCs were formally adopted were evaluated on a plant specific basis. As discussed later in this paper these "pre GDC" plants were reviewed as part of the Systematic Evaluation Program (SEP).

- Information associated with plants licensed in the late 1960s and early 70s that were reviewed as part of the Systematic Evaluation Program

- Licensee submittals associated with the Individual Plant Examination of External Events reviews

- Information provided in the licensee's integrated plans 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)

- Licensee information (e.g., updated safety analysis reports) on the criteria used for their plant's design and licensing basis

- Information from recent NRC activities related to the natural hazards (e.g., Regulatory Issue Summary 15-06, "Tornado Missile Protection," dated June 6, 2015); and recent GI program reviews.

In addition, compliance with Order EA-12-049 required licensees to ensure that mitigating strategies can be implemented under a broad array of external hazards, which, in turn, required licensees to evaluate other external hazards applicable to their sites.

The following sections of this document describe the process the NRC staff used to identify the potential for 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. Where applicable, the NRC staff's process described below used present-day guidance to assess the potential impacts of the natural hazards other than seismic and flooding on the current operating fleet.

Based on the staff's systematic assessment provided below, the staff proposes to close a portion of this recommendation and to continue to review hurricane and tornado winds and missiles generated from these winds and snow loads. The NRC staff notes that its assessment of flooding, seismic, and geomagnetic storms (which are screened out for further consideration) will continue and the staff will inform the Commission if additional regulatory actions are needed as a result of the staff's review of these hazards. The staff will continue to provide the Commission updates regarding the status of the seismic and flooding reevaluations in accordance with Commission directions and if the staff determines additional regulatory actions are needed to address geomagnetic storms, the staff will inform the Commission through existing processes (e.g., response to petition for rulemaking (PRM) 50-96 associated with geomagnetic storms that is discussed later in this enclosure)

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's focus is on Tier 2 activities and provides an assessment of natural hazards other than seismic and flooding.

The state of knowledge and the state of analysis has also advanced for other natural hazards, such as snow loads and extreme winds. In the case of snow loads guidance has recently been updated on how to evaluate snow loads that was not available at the time early generation operating plants were licensed. In the case of extreme winds improved understanding of the hazard has led the staff to determine the hazard level previously considered was more conservative than that required today. For example, many of the current operating plants used guidance that relied on the Fujita scale to relate the degree of damage to maximum tornado wind speed. Current guidance relies on the Enhanced Fujita scale, which results in lower maximum tornado wind speed for a given damage state, meaning many currently operating plants used higher tornado wind speeds to design the plant than would be required today. 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 adopts a screening approach that would focus resources on those hazards that provide the most opportunity to gain safety benefits.

In addition to the original plant siting parameters, the staff has also considered the available defense in depth provided by the newly-developed mitigation strategies. As part of its review, the NRC staff has 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 Nuclear Energy Institute (NEI) 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0 (ADAMS Accession No. ML12242A378) 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 reviews the results of those evaluations during pre-compliance 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. However, the safety benefits achieved through Order EA-12-049 should be factored into an evaluation of potential regulatory requirements to determine whether additional changes could be justified when evaluated against the criteria in 10 CFR 50.109 for the backfitting of operating reactors.

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 backfit. The NRC has established methods of performing these assessments and uses 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 a given (i.e., generally deterministically specified rather than probabilistically estimated) events or conditions. 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 performed an assessment of the ability of existing plant SSCs to withstand structural loads from snow, tornado and hurricane winds, and tornado and hurricane 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 margins result in SSCs being able to deal with a higher magnitude hazard. The staff is not imposing a new requirement on these plants by using the higher magnitude event in this assessment, rather, the assessment provides 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 more severe reactor accident and thereby challenge the NRC's established safety goals.

3.1 Review Process

The NRC staff has 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 step 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, as discussed above, 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 the majority of the current operating fleet was 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," and EPRI 3002005287, "Identification of External Hazards for Analysis in Probabilistic Risk Assessment: Update of Report 1022997"

- 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"

- International Atomic Energy Agency TECDOC-1341, "Extreme External Events in the Design and Assessment of Nuclear Power Plants"

- 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"

- NUREG/CR-5042, "Evaluation of External Hazards to Nuclear Power Plants in the United States"

- NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light Water Reactor] Edition"

- Other international and domestic references

Using previous analysis and engineering judgment, as discussed in Section 3.2 of this enclosure and SECY-15-0137 Enclosure 1, the staff determined that most hazards from the above reports screen out and those moving to the second step 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 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 ultimate heat sink (UHS) design.

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

This process 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 tornados, 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, as discussed above, some plants may have been designed to winds speeds and missiles that are more severe than would be required today.

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. As discussed in Section 3.3 of this enclosure, the staff determined that a technical evaluation was warranted for wind and missile loads from tornadoes and hurricanes, as well as for snow loads. The staff's approach for performing the technical evaluation for 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:

   - 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).

   - 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 step 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.

Considering the staff has not completed its evaluation in accordance with step 3 of the process for wind and missile loads from tornadoes and hurricanes as well as snow loads the step has not yet been exercised and will only be done if the results from step 3 indicate the need to do so.

3.2 Evaluation of 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. 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 beyond-design-basis magnitude of the 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 or not new regulatory guidance has been developed for a particular hazard since the time that the currently operating reactors received their operating licenses. In completing its evaluation, the staff considered whether or not the potential risks from new insights on external natural hazards might warrant imposing additional requirements using the 10 CFR 50.109, “Backfitting,” requirements.

The staff’s process for identifying hazards for review is consistent with the process that licensees used to comply with the Mitigating Strategies order. As discussed above, 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 against current NRC requirements and guidance. The guidance in NRC-endorsed NEI 12-06, “Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,” 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 staff also considered the insights and perspectives developed as a result of Individual Plant Examination of External Events. 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 provided an evaluation to each plant related to the IPEEE submittals 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 Screening 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 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) external flooding, (3) storms with high winds, (4) snow, ice, and extreme cold, and (5) extreme high temperatures.

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 listing of those events that the staff further evaluates in Sections 3.3 and 3.4 of this enclosure.

As discussed in Appendix A, the basis for excluding geomagnetic storms from further evaluation differs from the basis for excluding other natural hazards. The basis for excluding the majority of the hazards from additional evaluation was the staff's deterministic judgement, 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 evaluation that additional evaluation is not needed is based on evaluations that are being, or will be, performed in the context of existing regulatory processes.

Appendix A describes the ongoing efforts within the mitigating strategies rulemaking and petition for rulemaking 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 determined to be warranted as a result of the mitigating strategies rulemaking effort and in the final disposition of PRM-50-96.[2]

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[2] Petition for rulemaking (PRM) 50-96 related to geomagnetic storms is discussed in more detail in Appendix A of this document.

3.2.2 Hazards Proceeding to Second Step of Screening Process

Per step 1 of the process discussed above, the staff determined that additional evaluations using step 2 of the process are warranted for a subset of hazards. The staff's basis for identifying issues for additional evaluation was the potential for additional regulatory action being needed to address these beyond design-basis events. Appendix A includes a listing of the beyond-design-basis events that warrant additional evaluation. The hazards needing additional evaluation per step 2 of the process outlined above 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, (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 UHS design. 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 prior to the 1975 version of the standard review plan (SRP). As a result, the staff determined that it would be prudent 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 standard review plan using the current version of the SRP and the March 2007 version of RG 1.76.

The staff determined that it would be prudent to review hurricane missiles because of recently issued guidance in this area. In October of 2011 the staff issued RG 1.221, "Design Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," (ADAMS Accession No. ML110940300). Guide 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 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. The staff determined it was appropriate to advance this external natural event to the next step 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.

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 the possibility of flooding due to upstream dam failures. The staff determined that it would be prudent to review low water conditions caused by failures from seismically qualified 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 evaluation of low water conditions was prudent to determine whether additional regulatory actions are warranted 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 step 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 prudent to determine whether additional regulatory actions are warranted to address this condition.

3.3 Evaluation of Natural Hazards that Screen in for Further Evaluation

This portion of the document provides the staff's determination of the external natural hazards per step 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 some licensees from considering certain hazards. Screening criteria determined by the staff to be applicable to this part of the evaluation include:

- 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.
- 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 tornados and hurricanes and based on the screening criteria identified above, determined that additional evaluation of these loads were warranted. As part of step 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 screen many sites out for 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 screen the hazards out for additional evaluation. Therefore, the staff determined that a more detailed evaluation in accordance with step 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 were warranted. As part of step 2 of the process, the staff recognized the conservatism in 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 screen the hazards out of additional regulatory actions, but further examination of available site-specific information against the staff's initial evaluation assumptions and conclusions is warranted. Therefore, the staff determined that further evaluation in accordance with step 3 of the process above is appropriate. 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

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

- Conservatism of design safety margins.
- Operational limits provided in technical specifications.
- Warning time available to allow measures to be taken to prevent an accident from occurring.

<u>Drought Conditions</u>

Regarding drought conditions the staff notes that power plants have safety-related heat sinks that rely on sufficient water to safely shutdown the plant and keep the plant in a safe shutdown condition for several days. If a drought occurred such that it would affect the safety-related water supply, licensees would be obligated, in accordance with their technical specification, 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 with them that would allow licensee to take measure 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 spent fuel pool, and removal of decay heat from the reactor through long-term means)

<u>Low Water Conditions</u>

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 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 time, 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 reactor vessel for boiling-water reactors (BWRs) in the near term, and providing onsite makeup to the spent fuel pool (an action that is not needed for a relatively long time).

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 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 Office (RES) 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 this was that actions taken in response to Order EA-12-049 on mitigating strategies already address the failure of non-seismic dams. The industry 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 non-seismic 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, non-seismically robust downstream dam failure has been evaluated separately. However, if a downstream dam or downstream impoundment was 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-categorized 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 issue program, with the possible exception of H. B. Robinson. The panel recommended that NRR conduct further evaluation of Robinson to evaluate sources of water than were not credited by the panel.

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 to provide a mechanism for decay heat removal, 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, the emergency diesel generators, or FLEX 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 and the water inventory available in the refueling water storage tank.

- 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).

Summary

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 non-seismically qualified downstream dam failures in response to the mitigating strategies Order EA-12-049.

- The March 11, 2016, memorandum 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. 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

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 was closed to this SECY paper.

The March 18, 2015, letter discusses plants that are possibly impacted 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 USH water supply. However, 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 impact normal offsite power to cause an ELAP. 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.

As discussed in Appendix B of this document, the staff concludes that additional regulatory action is not warranted to address low water level conditions due to a seiche because:

- The majority of the sites that could be impacted by such a phenomena 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. The NRC staff notes that after 24 hours the water supply needed to remove decay heat is reduced to approximately 1/3 of that needed immediately after a reactor shutdown.

- For the units that do not have this 24 hours water supply, the units 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 alternate water supplies (e.g., natural draft cooling tower basin) that could be accessed using FLEX equipment.

<u>Conclusion</u>

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

Appendix A Table A-1 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. The staff determined that an evaluation was warranted to determine if additional regulatory action beyond what is currently required is appropriate because of the effects temperature extremes could have on the normal 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.

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 the 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 shutdown 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 plants' 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 include (General Electric BWR, Combustion Engineering PWR, and Babcock and Wilcox PWR STS have similar requirements):

- STS 3.7.9, "Ultimate Heat Sink," provides the surveillance requirements and actions that operators must take to verify 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 a diesel generator 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 89-30, Supplement 1: High Temperature Environments at Nuclear Power Plants) 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, will continue to monitor the licensee performance. The inspectors use inspection procedure 71111.01 "Adverse Weather Protection" (ADAMS Accession No. ML14343A684) to guide their assessments of whether plants are ready for extreme temperatures.

For high temperatures, inspection procedure 71111.01 notes that prior to high grid loading season inspectors should conduct a review of summer readiness of offsite and alternate ac power systems. The procedures also directs inspectors to evaluate licensee' adverse weather procedure 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

In NEI 12-06 step 9 directs licensees to assess impact of high temperatures and notes that extreme temperatures can present a challenge to off-site power (e.g., grid issues) and on-site capabilities (e.g., inadequate diesel generator cooling). Guidance document NEI 12-06 provides guidance that the equipment should be procured to function in a high temperature environment and that the storage of the equipment should consider the potential impacts of high temperature (e.g., expansion of sheet metal, swollen door seals, etc.).

Extreme High Temperatures Conclusion

Based on the NRC requirements and inspection in place to address high air and water temperature conditions and the additional requirement 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

Inspection Procedure 7111.01 directs inspectors to verify cold weather protection features, such as heat tracing, space heaters, and weatherized enclosures are monitored sufficiently to ensure they support operability of the SSC 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 in January 1998 issued an Information Notice on "Nuclear Power Plant Cold Weather Problems and Protective Measures." 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 Jan. 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 the Information Notice 96-06, "Degradation of Cooling Water Systems due to Icing," 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 mm) 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 due to frazil ice blocking of the intake trash racks, and the second train was degraded. The root cause of the Wolf Creek event was deficiencies in the essential service water system (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.

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 obligated to review the issue and take appropriate action, which includes declaring equipment inoperable and entering the appropriate action statements as directed by the plants 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 (e.g., issuance of IN 96-06) reinforces these regulatory requirements if needed.

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

In NEI 12-06 Section 2D, "Assess Impact of Snow, Ice and Extreme Cold," provides guidance to licensees for addressing these events as it relates to FLEX equipment. 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 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 the procured equipment can function 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.
Extreme Cold Temperatures Conclusion

Based on the NRC requirements and inspection 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.

<u>Extreme Ambient Temperatures Conclusion</u>

Based on the NRC requirements and inspection 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, and Tornado and Hurricanes

3.4.1 Tornado and Hurricane Winds and Associated Missile Protection

As described in Section 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 standard review plan and the March 2007, version of Regulatory Guide (RG) 1.76, "Design-Basis Tornado and Tornado Missile for Nuclear Power Plants," (ADAMS Accession No. ML100541776), and RG 1.221, "Design Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," (ADAMS Accession No ML110940300).

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

- Conservatism of design safety margins.
- Low frequency of occurrence/low risk.
- Warning time available to allow measures to be taken to prevent an accident from occurring.

The staff also considered changes being implemented at nuclear power plants as a result of the mitigating strategies Order EA-12-049 and 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 that there was sufficient concern to warrant issuing a request for information to licensee(s) 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 6 parts: 1) comparison of current tornado and hurricane guidance to previous guidance used to license the current operating reactor fleet, 2) a discussion of the licensing basis for the current operating reactor fleet, 3) insights from recent inspection finding 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 on 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 Tornado and Hurricane Missile Protection Current Guidance to Previous Guidance

In order 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
    - Regulatory Guide (RG) 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1, March 2007 (ADAMS Accession No. ML070360253).
    - RG 1.76 Rev 1 is based on tornado hazard curves provided in NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," (ADAMS Accession No. ML 070810400)
- Hurricane Missiles
    - Regulatory Guide 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)

The NRC staff reviewed both RG 1.76 Rev 1 and RG 1.221 because improved understanding and enhanced models have 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. 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 missiles 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, Rev 1, during an update to SRP 3.5.1.4. Regardless, many of the current operating plants were designed to the earlier version of the RG that assumed either Spectrum I or Spectrum II missiles. Characteristics of these missiles are:

  - Spectrum I missiles - a 1810 kg (3990 pound) automobile in the region of the United States capable of generating the highest wind speed would have a velocity of 59 meters per second or 132 miles per hour.

  - Spectrum II missiles – a 4000 pound automobile would have a velocity of 100 feet per second or 69 miles per hour.

- Based on RG 1.76, Rev 1, a 4000 pound automobile in the region of the United States capable of generating a maximum wind speed of 230 miles per hour would have a characteristic velocity of 135 feet per second or 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 generated missile speed went down from 132 miles per hour to 93 miles per hour based on comparing the old SRP missile characteristic to the current RG 1.76 Rev 1 characteristics. However, the automobile speed increased from 132 miles per hour to 156 miles per hour based on comparing the old SRP missile characteristics to the current RG 1.221 characteristics.

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 1974 version of SRP 3.5.1.4 had six different missile characteristics while the RG 1.76 Rev 1 and RG 1.221 have three. Regardless of the version of the regulatory guide, 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), 2) a rigid missile that test penetration resistance, and 3) 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 for each missile, different missile speeds were assumed based on the corresponding tornado or hurricane wind speed characteristics.

Missile Type	RG 1.76 Rev 0 and SRP 3.5.1.4 1974 version	RG 1.76 Rev 1	RG 1.221
Massive high-kinetic energy missile that deforms on impact	Automobile	Automobile	Automobile
A rigid missile that tests penetration resistance	5 different missiles meet this criteria: • 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	Steel rod, 1 inch diameter x 3 ft long, weighing 8 lbs.	Solid steel sphere 1 inch in diameter weighing 0.147 lbs	Solid steel sphere 1 inch in diameter weighing 0.147 lbs

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 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 2 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 156 (GSI): Systematic Evaluation Program.” GSI 156.1.5: “Tornado Missiles” objective 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 updated safety analysis report (USAR) or in the IPEEE evaluation. The criteria used to evaluate these plants varies greatly and in some cases consists of two missiles (e.g., a rigid steel pipe and a telephone pole) and in other cases relies 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 found in general that:

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

- however, for automobiles, missile speeds based on RG 1.76 Rev 1 increased by around 50% for many sites (even though tornado velocities generally decreased) from those found in the 1975 version of the SRP, and automobile missile speeds for coastal sites based on RG 1.221 criteria are generally not bounded by the automobile missile speeds found in the

1975 version of the SRP.

The staff notes that some of the plants performed PRA of tornadoes,[3] which indicated that based on conformance with the 1975 version of the SRP or completion of a PRA that 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

The operating power plants' tornado missile protection has been reviewed twice to determine 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

- later generation plants tornado missile protection 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 as a result of the backfit process or as a result of insights gained from the IPEEE process to upgrade tornado missile protections for operating plants. However, as mentioned above, the increase in hurricane-borne automobile missile velocities in accordance with present-day guidance represents an increase in missile protection requirements for some plants.

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

To further assess the risk posed to the safety of operating plants by tornadoes, the NRC staff considered the risk insights developed in support of the agency's recent guidance on the enforcement of licensees' compliance with their licensing basis for 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 structures, systems, and components 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)

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[3] 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.

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.

The specific criteria for each nuclear power plant are contained in the individual plant's specific licensing basis. In designing SSCs for the consequences of design-basis tornados, tornado-generated missiles must be considered. There are several design 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 the probability of a tornado-generated missile striking a component required to safely maintain the plant is sufficiently low such 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 includes acceptance criteria permitting 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 utilized this alternative approach by incorporating the NRC-approved, Electric Power Research Institute-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 non-compliances have been documented in NRC inspection reports and have resulted in license amendment requests. Some of the non-complying 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 LCO was met.

As a result of non-conformances, 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. The EGM 15-002 provides a basis for granting enforcement discretion that noted 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 tornados. 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 non-repairable and non-recoverable. 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 non-compliances 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. ML 070810400) 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 which 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 non-compliances 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 NRR 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 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, the staff notes the following regarding the tornado licensing basis for operating plants:

- The tornado missile protection design basis requirements are 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 tornados.

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 might provide insights on the risk from hurricanes. The staff's deterministic review process was done in three parts:

- Assessment of wind loads based on wind speeds from current guidance in RG 1.76 Rev 1 and RG 1.221 against the current licensing basis wind speed loads for operating plants

- Assessment of the ability of tornado or hurricane missiles to damage concrete protecting safety-related SSCs based on current guidance in RG 1.76 Rev 1 and RG 1.221 against the current licensing basis missile design spectrum for operating plants.

- Assessment of structural loads from a large missile (i.e., automobile) based on current guidance in RG 1.76 Rev 1 and RG 1.221 against the margin provided in current licensing basis structural design-basis

    - For this assessment the NRC staff reviewed the delta from the automobile missile structural loads from current guidance against the current licensing basis for the plant. In the cases where a delta existed 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 prudent before determining if additional regulatory action is warranted to require current operating plants to meet RG 1.76 Rev 1 and RG 1.221 guidance.

Wind Loads

To assess wind loads the staff relied on licensees' updated final safety analysis report (UFSAR) and in licensees' integrated plans provided in response to the Mitigating Strategies 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 or not the plant screened in 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 Rev 1 tornado wind speeds are less than those assumed in the design of the plant. Regarding hurricanes, the Figure 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 in the UFSAR.

The staff concludes 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 Rev 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 Concrete

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 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 Rev 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 Rev 1 and RG 1.221. Converting a missile's energy and contact area to a concrete penetration depth and then a concrete thickness is an easily digestible and meaningful way to compare the existing missile protection requirements for operating plants against current 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 Rev 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 tornado and hurricanes produce more intense automobile missiles. The staff used a simplified, conservative approach to assess the impact of the increased automobile missile speed related to current plant's missile protection requirements. In order 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 needed to select a 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. In order to determine equivalent static load the staff had to determine 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 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 due to its relatively high weight, large diameter, and high speeds could be considered the bounding impact load. 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 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 in order to produce a method of comparison. The initial insights from the simplified comparison indicated that the new automobile missile speeds represent an increase in missile protection requirements for many plants. The difference in requirements 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 UFSAR's had described their automobiles with higher velocities originally, but many were between 50-75mph.

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 wind 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 plant existing missile protection requirements. In order to examine these assumptions and assess the need for additional regulator 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 NRC staff plans to continue its evaluation and to update this assessment prior to December 31, 2016.

3.4.1.5 Evaluation of Whether Additional Regulatory Action is Needed to Address Beyond Design-Basis Hurricanes and Tornadoes

The staff's evaluation in this section is common to both tornadoes and hurricanes in the beginning of this section to reflect common insights that apply to both events. There is an extra analysis for hurricanes to reflect difference in warning time (which is a screening criteria) between these two events.

The NRC staff notes that early insights from recent PRAs done to date do not identify extreme tornadoes and hurricanes as dominant risk contributors to a plant's core damage frequency. Rather it is the more common tornado and hurricanes that fail offsite power, and damage important non-safety related equipment, which have been identified as needing further study. An example of such a presentation can be found in a May 28, 2015, summary of a meeting to discuss technical aspects of high winds probabilistic risk methodologies (ADAMS Accession No. ML15187A266). The summary includes the following insights:

- Challenges exist in the characterization of a hazard curve with respect to straight winds, hurricanes, and tornadoes. Peak wind gusts between 115 mph to 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 identified: (1) consideration of directional wind analysis for vulnerable structures to reduce the level of conservativism 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 in order 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 going 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:

- Issues identified 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 to tools to make external event analysis more risk informed.

- A Commission approved full-scope level 3 probabilistic risk assessment discussed in SECY-11-0089, “Options for Proceeding with the Future Level 3 Probabilistic Risk Assessment Activities” (ADAMS Accession No. ML11090A041). In a September 21, 2011, SRM (ADAMS Accession No. ML112640419) directed the staff to conduct a full-scope comprehensive site level 3 PRA. This work includes assessments of external hazards and involves the development of high wind PRA.

While the NRC staff believes this work is important and can provide additional insights to inform its regulatory processes, the NRC staff does not believe that this work needs to be completed before providing its final assessment for tornadoes and hurricanes.

For the majority of operating plants, the staff does not consider 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 document in RIS 2015-06 and EGM 15-002 the NRC staff has developed a basis for granting enforcement discretion that notes in general tornado missile scenarios that may lead to core damage are very low probability events, and low risk events, because safety-related SSCs are typically designed to withstand the effects of tornados. 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 non-repairable and non-recoverable. 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.

- Guidance document NEI 12-06, Rev 0 provides implementation guidance for the mitigation strategies order EA-12-049 that includes additional capabilities related to beyond design-basis hurricanes and tornadoes. In NEI 12-06 step 2C “Assess Impact of Severe Storms with High Winds” 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. In NEI 12-06 Section 7.3 includes provisions for 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 three criteria above for supporting a preliminary conclusion that additional regulatory actions are not warranted apply to both beyond-design-basis hurricanes and beyond-design-basis tornadoes. The staff applied an additional criteria 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 Tornado and Hurricane Missile Protection Evaluation Conclusion

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 3.4.1.3 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. As described above the staff performed the evaluation to assess the impact of present-day guidance and methods for snow loads on the safety of operating plants. The staff applied the following three criteria from step 2 of the process as part of its evaluation:

- Conservatism of design safety margins.
- Low frequency of occurrence/low risk.
- 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 current 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 step 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, negative pressure due to tornado suction and checked for 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 Section 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 NRC staff notes that DC/COL ISG-007 does not include a concurrent loads from an ice storm. Rather it assumes the 48 hour PMP is in the form of water that is combined with the 100 year snow load under an “extreme snow load” condition that is discussed later in this section. 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 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 is broken into two part: plants that were licensed prior to 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 broken 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 than plants licensed before the 1975 version of the standard review plan existed.

Plants Included in the Systematic Evaluation Program

As wans 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 156 (GSI): Systematic Evaluation Program." The objective of GSI 156.2.1: "Severe Weather Effects on Structures," was to identify those meteorological conditions which 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 utilized 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 1975 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:

- Review of 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. Figure 7-1 from ASCE 7-05 is provided at the end of this enclosure and provides a map showing snow loads for various portions of the country as CS or case study sites. 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 bounds the snow loads. The staff did perform an additional assessment of sites were 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 both before and during the event, the NRC staff expects licensees will take prudent actions to protect their investment in the nuclear power plant. Therefore, the NRC staff would expect that licensees will take actions for both non-safety and safety-related structures to minimize the snow load (e.g., removing other live loads prior to the event and during the event by shoveling the snow). Nevertheless, the staff will interact with industry to gain further insights into licensee’s anticipatory actions in preparation for an approaching severe snow storm.

- ISG DC/COL 7 notes that an “extreme snow load” is a combination of the 100 year snow load and the weight of the 48 hour PMPs. The staff notes that such an extreme snow load event would include warning times such that licensees would be expected to take appropriate action to protect their investments.

  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 were extreme snow loads are significant and the seismic loads are low, the ratio was 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 leading 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 potential for large roof deformations, in the event the snow loads significantly exceeding 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 and did not identify risk significance associated with 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 prudent actions to protect their investment in the nuclear power plant. Therefore, the NRC staff would expect that licensees will take actions for both non-safety and safety-related structures to minimize the snow load (e.g., removing other live loads prior to the event and during the event by shoveling the snow). Moreover, the above discussion on 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 load are warranted for these plants.

Additional Considerations

In addition, 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. In 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,

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 experience difficulties with equipment as a result of 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.

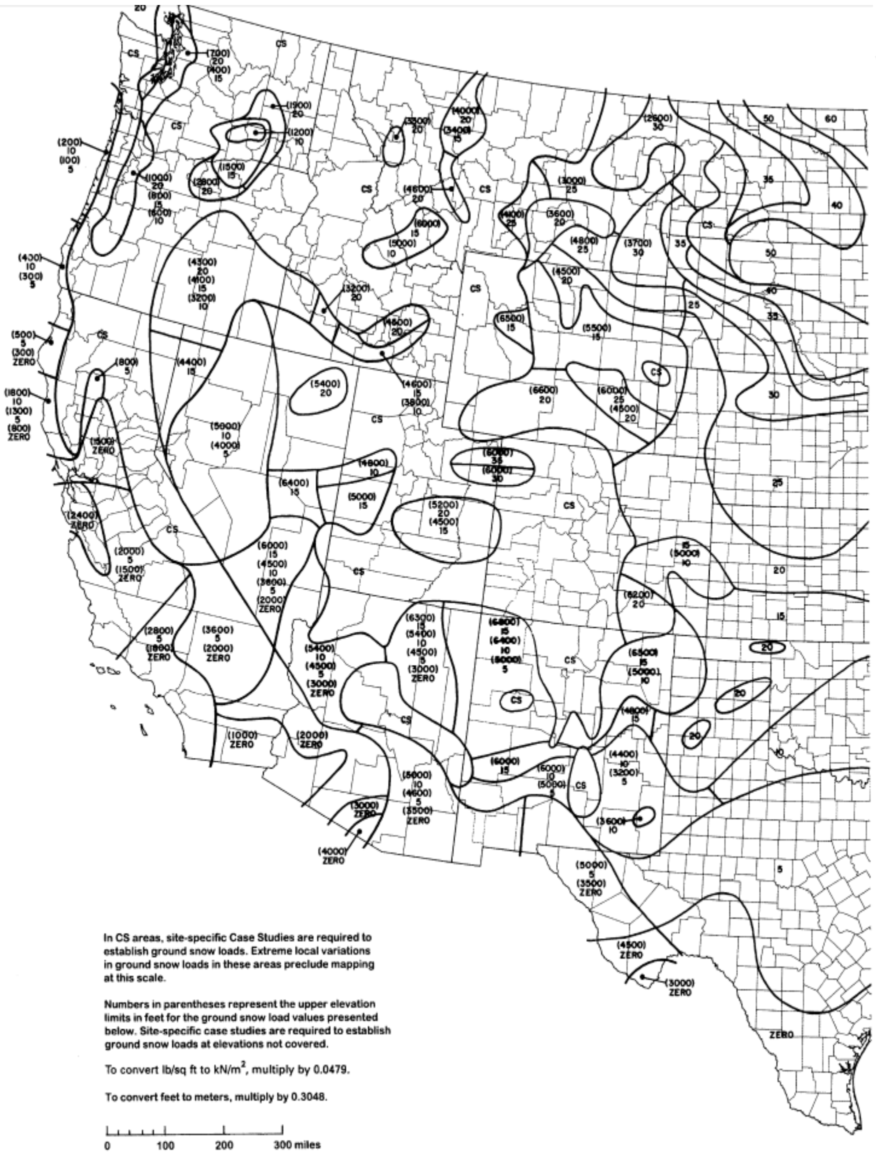
4.0 Stakeholder Interactions

The staff supported several meetings associated with the process outlined for reviewing evaluating this issue as documented in SECY 15-0137. These meetings included a meeting held on October 6, 2015, in which the NRC staff provided the Fukushima subcommittee of the ACRS 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 plans to hold a Category 3 public meeting in early April 2016 and brief the ACRS Fukushima Subcommittee and Full Committee prior to providing this assessment to the Commission.

5.0 Conclusion

Based on the staff's assessment provided in Sections 3.1 through 3.3 of this enclosure, the staff has closed 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. In the case of high winds and snow loads, the staff provides initial considerations for the assessment of these hazards in Section 3.4 of this enclosure and intends to finalize its assessment in these areas by the end of 2016. The process the NRC staff is using to assess high winds and snow loads is consistent with the process described as part of Task 3 in SECY-15-0137.



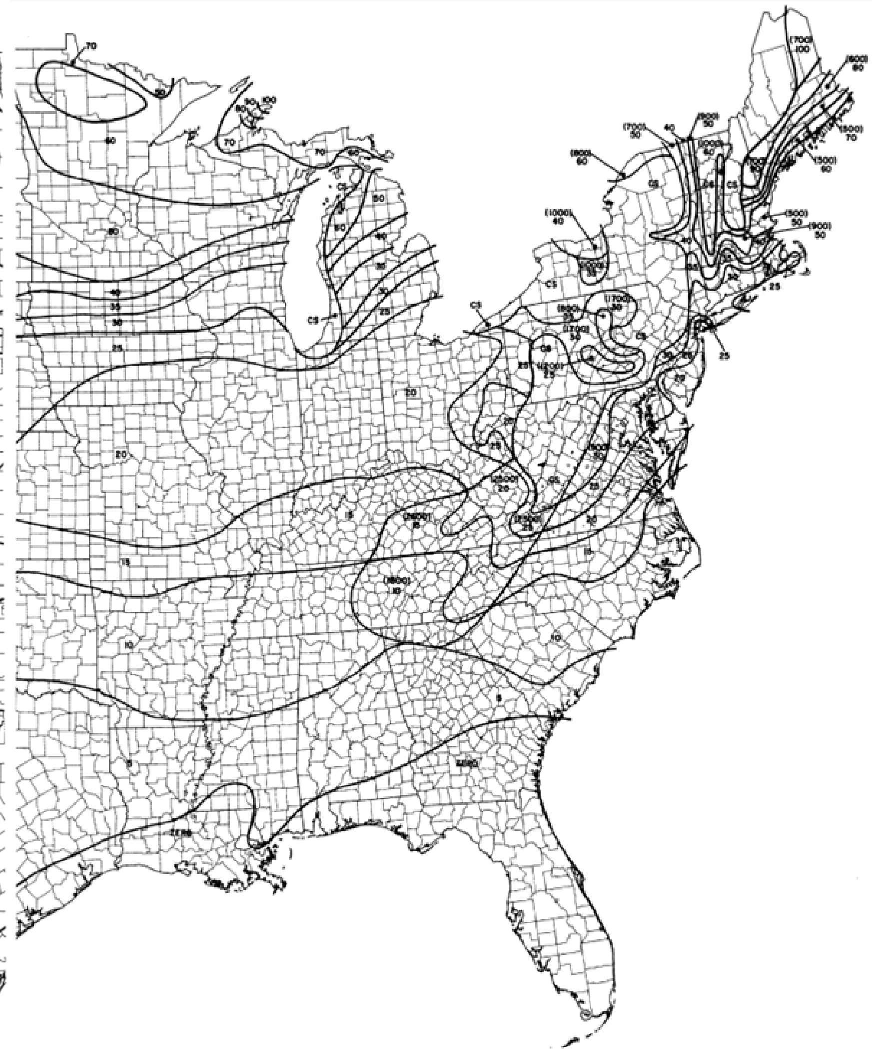
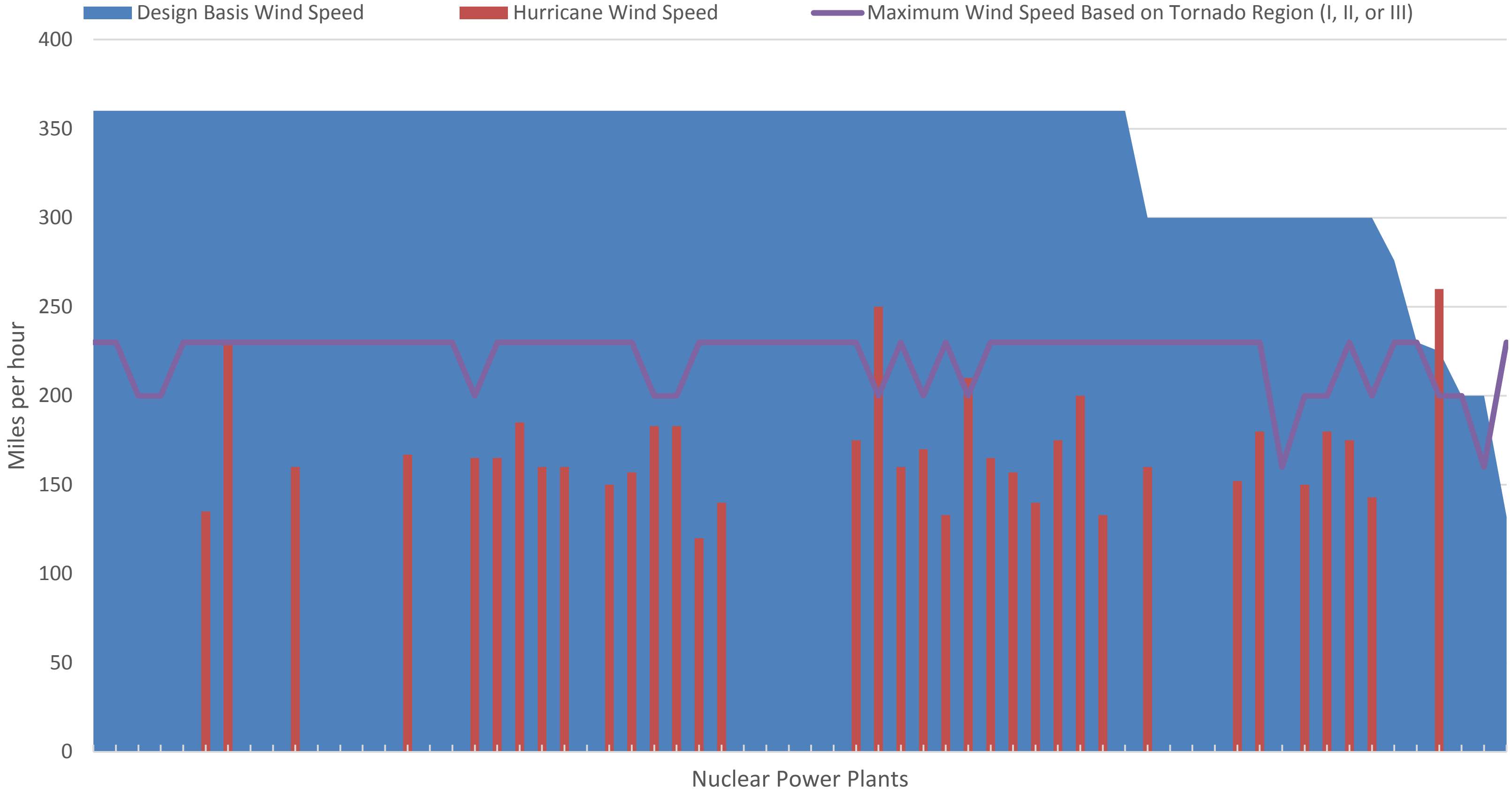


FIGURE 7-1. *(Continued)*

Figure 7-1 Ground Snow Loads, P_g, for the United States (lbs/ft^2)
From Snow Loads: Guide to the Snow Load of American Society of Civil Engineers (ASCE) 7-10

Figure 3.4-1 Comparison of Curent Design Basis Wind Speeds vs Updated Tornado and Hurricane Wind Speeds[4]



4 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 below 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 ASME/ANS RA-Sa-2009, 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 judgement, augmented by risk insights (where available), to determine whether or not additional regulatory action beyond what the NRC currently requires are warranted. Part of the staff's assessment of other natural hazards is based on whether or not 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 step 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, (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 a screening reason(s) for the staff either including or excluding 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 and guidance associated with this order. Guidance associated with the mitigating strategies Order EA-12-049 can be found in Revision 0 of NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guidance," (ADAMS Accession No. ML12242A378). The NRC endorsed NEI

[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 of 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.

12-06, Revision 0 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. ML12229A174). 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. As discussed in the enclosure of this document, the staff reviewed the NEI 12-06 results and the staff 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.

This following discussion relates to those hazards that have been excluded from additional evaluation. Hazards that have been identified as result of the staff’s screening process for additional evaluation are discussed in Sections 3.2.2, 3.3, and 3.4 of the enclosure to this document.

External Hazards Excluded from Additional Evaluation

Table A-1 does not include man-made hazards because they do not have a direct nexus to the Fukushima Dai-ichi accident. Therefore, 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 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.

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. The man-made hazards excluded from Table A-1 are: aircraft impacts, chemical releases into water, eddy currents into the ground, electromagnetic interference/disturbance, excavation work, external fires from transportation and pipeline accidents, chemical ground contamination, ground vibration from nearby explosions, high air pollution, impurities in the water from ship releases, industrial or facility accidents, internal fire spreading from adjacent unit, internally generated missiles, pipeline accident, release of chemicals from on-site storage, toxic gas release, transportation accidents, turbine-generated missile, vehicle impact, and vehicle/ship explosion.

Based on the reasons provided in the notes found in Table A-1, the staff has determined that the following beyond-design-basis hazards do not warrant additional regulatory action beyond what the NRC currently requires to address the hazard: animals, avalanche, biological events, coastal erosion, corrosion, dust storm, erosion, extreme air pressure, fog/mist, frost, groundwater, hail, ice barriers, ice cover, ice storm, lake or river-borne material plugging water intakes, land rise, landslide, meteorite, salt storm, sink holes, soil shrink/swell, underwater erosion and impact on soil from an underwater landslide.

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.

The staff's evaluation of volcanic activity and geomagnetic storms is complex and only a short-hand version of the basis for excluding the hazard from further evaluation is provided in Table A-1. The more detailed evaluation of these hazards is provided below.

Volcanic Activity

Guidance document NEI 12-06 notes that volcanic activity should not challenge the structures and internal plant equipment such that additional actions are needed. While the staff generally agrees with this statement the staff's basis for its determination that no additional regulatory actions are needed to address volcanic activity also considered additional evaluations performed by the staff to address a Yellowstone caldera 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). The staff's evaluation considered the following operating sites: Columbia Generating Station (Columbia), Wolf Creek Generating Station (Wolf Creek), Fort Calhoun Station (Fort Calhoun), Cooper Nuclear Station (Cooper), Diablo Canyon Power Plant, Unit Nos. 1 and 2 (Diablo Canyon), and Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde). Volcanic activity was addressed in detail only by the Columbia licensee. The licensee concluded that ash fall is the only hazard from future eruptions of 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. Based on the staff's evaluation documented in the September 11, 2009, letter, and the protection of the mitigating strategies phase 2 equipment, the staff concluded that additional regulatory actions to address volcanic activity at Columbia are not warranted.

The staff notes that the September 11, 2009, letter discusses that the licensees for Palo Verde, Diablo Canyon, Cooper, Fort Calhoun and Wolf Creek eliminated volcanic activity for review in the IPEEEs for those plants using the screening methodology outlined in NUREG 1407. The NRC staff review of the IPEEEs for these plants concluded that the licensees' processes were capable of identifying the most likely severe accident vulnerabilities for the plants and that the IPEEEs met the intent of GL 88-20, supplement 4.

Geomagnetic Storms

Guidance document NEI 12-06 notes that solar-geomagnetic disturbances could lead to extended loss of off-site power due to geomagnetically-induced currents in electrical power transmission systems and that such disturbances are not expected to impact the on-site safety-related equipment due to the equipment being housed in reinforced concrete structures. 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 the staff's basis for its determination that no additional regulatory actions related with 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 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 impacts 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 assure 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 the NRC's 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 impact 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 and in the final disposition of PRM-50-96.

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, 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 NEI 12-06)
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, lightening, sandstorms, salt storm	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 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

Hazard	Reason
	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.
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. See additional discussion above.
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.
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. A more detailed discussion of the hazard can be found in the text above.

Hazard	Reason
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 prudent to review the design basis tornado missile protection for these older plant, and 2. The staff determined that it would be prudent 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 prudent to determine whether additional regulatory actions are warranted to address this condition.
Drought, Low lake or river level, River diversion	The staff determined that it would be prudent 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 evaluation of low water conditions was prudent to determine whether additional regulatory actions are warranted to address this condition.
Snow and Ice Loads	The staff determined it was appropriate to advance this external natural event to the next step 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,

Hazard	Reason
	"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 NRC staff's evaluation of low water conditions found in Section 3.3.3, "Drought and Other Lower Water Conditions," of the enclosure of this report. Section 3.3.3 provides an assessment of low water conditions due to downstream dam failure and low water conditions due to a seiche. This appendix provides additional information regarding these assessments.

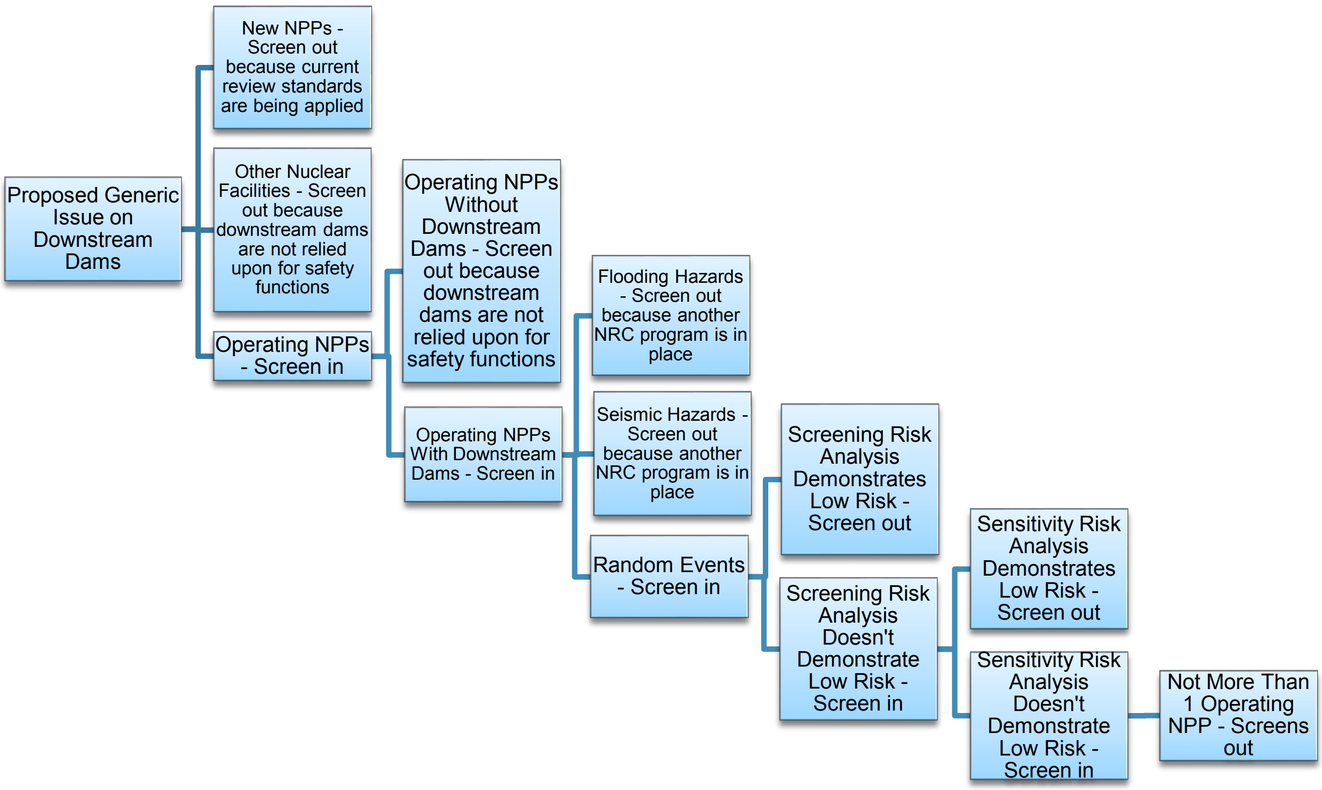
Low Water Conditions Due to Downstream Dam Failure

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 Review

As discussed in Section 3.3.3 of this 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. 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.



As described in Section 3.3.3 of the enclosure of this report, 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 non-seismic 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. Non-seismic 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 non-seismic 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, but turned the question over to NRR (memo cite).

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 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 (non-seismic 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 drywell 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 houses. 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. A FLEX portable pump provides an alternative mechanism for providing makeup to the reactor coolant system, taking suction from multiple sources of water. The water sources for RCS makeup using FLEX include the 353,000 gallon refueling water storage tank, which should be unaffected by a Robinson downstream dam failure. In the event of a random dam failure, other installed plant system could also be used. 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 April xx, 2016, Duke clarified that the SPRA to be submitted in response to Recommendation 2.1 will include 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, the proposed rulemaking 50.1[55] requires that licensee evaluate the mitigation strategies to the reevaluated hazard. 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 to provide a mechanism for decay heat removal, 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, the emergency diesel generators, or FLEX 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 and the water inventory available in the refueling water storage tank.

- 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. As discussed in the enclosure the NRC staff's assessment is limited to areas of the country were this phenomena could create concerns (i.e., plants located on the Great Lakes and the 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:

- 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 has 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 NRC staff's analysis below 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. The staff's assumption is based on FLEX equipment in general not being analyzed for extremely-low UHS (Great Lake or Chesapeake Bay) water levels. Extremely low water conditions could temporarily prevent operation of the FLEX support pumps in the short-term 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 conditions that created the low water condition still exist at the time the FLEX support 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.

- The extremely low water condition damages 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 as a result of the event 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. 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 if makeup water from the UHS was delayed (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 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. RCS inventory control based on low leakage reactor coolant pump (RCP) seals.
Palisades	Lake Michigan	Large Dry	FLEX strategy identifies the boric acid storage tank as providing primary coolant system makeup water for at least 24 hours. The condensate storage tank and tank T-81 provide a minimum of 8 hours of cooling water to the steam generator (SG) after which the FLEX strategies utilize portable pumps on Lake Michigan as an indefinite source of cooling water. Should seiche conditions render Lake Michigan unavailable as a water source, the demineralized water storage tank (DWST) could provide an additional 300,000 gallons of SG cooling water. The DWST is not seismically qualified, or

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			protected from tornado missiles and is not credited in the FLEX strategies. However, the 300,000 gallons of DWST inventory could provide an additional 16 hours (total of 24 hours) of SG cooling water assuming that the tank is not damaged by the seiche conditions. RCS inventory control based on low leakage RCP seals.
Point Beach Units 1 and 2	Lake Michigan	Large Dry	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.
Davis Besse	Lake Erie	Large Dry	Condensate Storage tanks provide 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. An additional 16 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 and the borated water storage tank for at least 24 hours assuming that the tanks are not damaged by the seiche conditions. RCS inventory control based on the use of low leakage RCP seals.

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
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. 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 margin. Mitigation strategies to minimize challenges to RCIC operation due to high suction temperatures credit water supplied from Lake Erie being provided to the suction of RCIC within 6 to 7 hours. This time frame assumes that the RCIC suction is aligned to the Suppression Pool. This assumption is made because, in part, the condensate storage tank, mixed bed storage tank, or the two bed storage tank on the west side of the plant are not considered “robust” and are therefore unavailable per the mitigation strategies guidance. It is unlikely that these tanks would be affected by a conditions that create a seiche. When these tanks are credited Perry has sufficient water sources such that the Lake Erie water supply is not needed for over 24 hours. 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 if power to hydrogen igniters is credited through use of the FLEX support equipment, onset of containment failure is delayed past 24 hours.
Fitzpatrick	Lake Ontario	Mark I	Available volume in the condensate storage tanks is considered robust and can supply water to RCIC

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			such that Lake Ontario water is not needed until 24 hours into the event.[1]
Ginna	Lake Ontario	Large Dry	Decay heat removal mechanism via the steam generators. The water could initially be added by the turbine-driven auxiliary feedwater (TDAFW) pump, taking suction from the condensate storage tank (CST). However, this equipment is not robust considering the potential external natural events. Therefore, if the TDAFW pump or CST is not available, the licensee's primary strategy is to utilize the two existing standby auxiliary feedwater (SAFW) pumps, with suction from a new SAFW CST, which has been constructed to meet the definition of robust equipment given in NEI 12-06. The SAFW pumps are powered by electric motors, and if offsite power is lost the power is supplied from the plant's emergency diesel generators (EDGs). However, under the conditions of Order EA-12-049, the EDGs may not be available. Therefore, the licensee installed a FLEX SAFW DG with a capacity of about 1 MW, which was designed to meet the definition of robust equipment given in NEI 12-06, and it can be used to power an SAFW pump. The licensee has the ability to recognize the ELAP event, start the SAFW DG, start an SAFW pump, and start feeding the SGs before the lowering water level in the SGs cause adverse consequences for the reactor coolant system (RCS). 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 SAFW DG can power a RCS injection pump taking suction from the refueling water storage tank (RWST), 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.
Nine Mile Point 1	Lake Ontario	Mark I	The licensee will initially remove the core decay heat and cool down the reactor by using the

[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
			Emergency Condensers (ECs). This strategy will provide 8 hours of cooling 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	The licensee will initially remove the core decay heat by using the Reactor Core Isolation Cooling (RCIC) system. The steam-driven RCIC pump will initially supply water to the reactor from the condensate storage tanks (CSTs), if available, or the suppression pool. Steam from the reactor will be vented through the safety relief valves (SRVs) to the suppression pool to depressurize and cool down the reactor pressure vessel (RPV). A portable FLEX pump will be connected to a dry hydrant, taking suction 15 feet 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 (see additional discussion below). The Hardened Containment Vent System (HCVS) will be used to limit suppression chamber pressure and suppression pool temperature to support continued RCIC operation.
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 FLEX strategies utilize portable pumps to use brackish water from the Chesapeake Bay. As discussed in the Calvert Cliffs mitigation strategies documents the licensee preferred makeup to the

Plant Name	Safety Related Heat Sink	Contain-ment Type	Plant Capabilities for Removing Decay Heat without Reliance on a Great Lake
			steam generators are non-brackish water supplies. Should these non-brackish water supplies be available the licensee will use these supplies before using Chesapeake Bay water. The non-brackish water supplies include a 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. The DWST, PWSTs, and RWTs should be available as water supplies in the event of a seiche and they have enough capacity to provide decay heat removal capabilities beyond 24 hours. RCS inventory control based on the use of low leakage RCP seals.

Based on the staff's assessment of each plants coping capabilities the only plants that need to consider using a Great Lake or Chesapeake Bay as a water supply prior to 24 hours are Point Beach and Nine Mile Point 2. The NRC staff reviewed the arrangement of the safety-related ultimate heat sink to determine whether or not the design of the system creates a condition making these plants susceptible to low water conditions from a seiche.

Point Beach

Accrording to UFSAR Section 2.5, the water intake is located 1750 feet offshore in a water depth of 18 feet (measured from the lowest recorded level of -4.8 feet plant elevation). This design of the intake structure makes loss of water to the forebay due to a seiche unlikely. Therefore, the staff concludes that additional regulatory action is not warranted to address low water conditions from a seiche for Point Beach.

Nine Mile Point, Unit 2

In the event that Lake Ontario is unavailable due to low water level from a seiche other large basins of water exist on site such as the Unit 2 cooling tower. Based on alternate sources of water (which are not credited as part of mitigation strategies), the NRC staff concludes that additional regulatory action is not warranted to address low water conditions from a seiche at Nine Mile Point, Unit 2.

Conclusion

The resolution of the issues identified in the March 18, 2015, letter is continuing in accordance with established NRC processes. If the NRC staff identifies additional regulatory actions as a result of the resolution of this issue, the NRC staff will follow the appropriate process (e.g., issuance of a regulatory issues summary, generic letter, bulletin, 10 CFR 50.54(f) letter, or Order). Nevertheless, 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 for the following reasons:

- There is conservatism in the design of the nuclear power plants such that the conditions for a seiche to create a low water condition that could damage the safety-related ultimate heat sink pumps is low.

In the event that safety-related UHS pumps are damaged from low water conditions due to a seiche there are independent means to remove decay heat that should provide sufficient time for licensees to make arrangements for alternate sources of water to remove decay heat.

Appendix C – Additional Background Information Regarding Snow Loads

This appendix provides additional background information related to the 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 snowpack depth using two different correlations (i.e., a Tobiasson and Greatorex correlation, and a snowfall event depth using a 0.15 snow density correlation). The correlations are used to reflect 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 snow loads 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 NEI 12-06, Revision 0, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guidance," (ADAMS Accession No. ML12242A378) useful. The NRC endorsed NEI 12-06, Revision 0 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. ML12229A174). 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 that structural loads from snowfall are of interest.

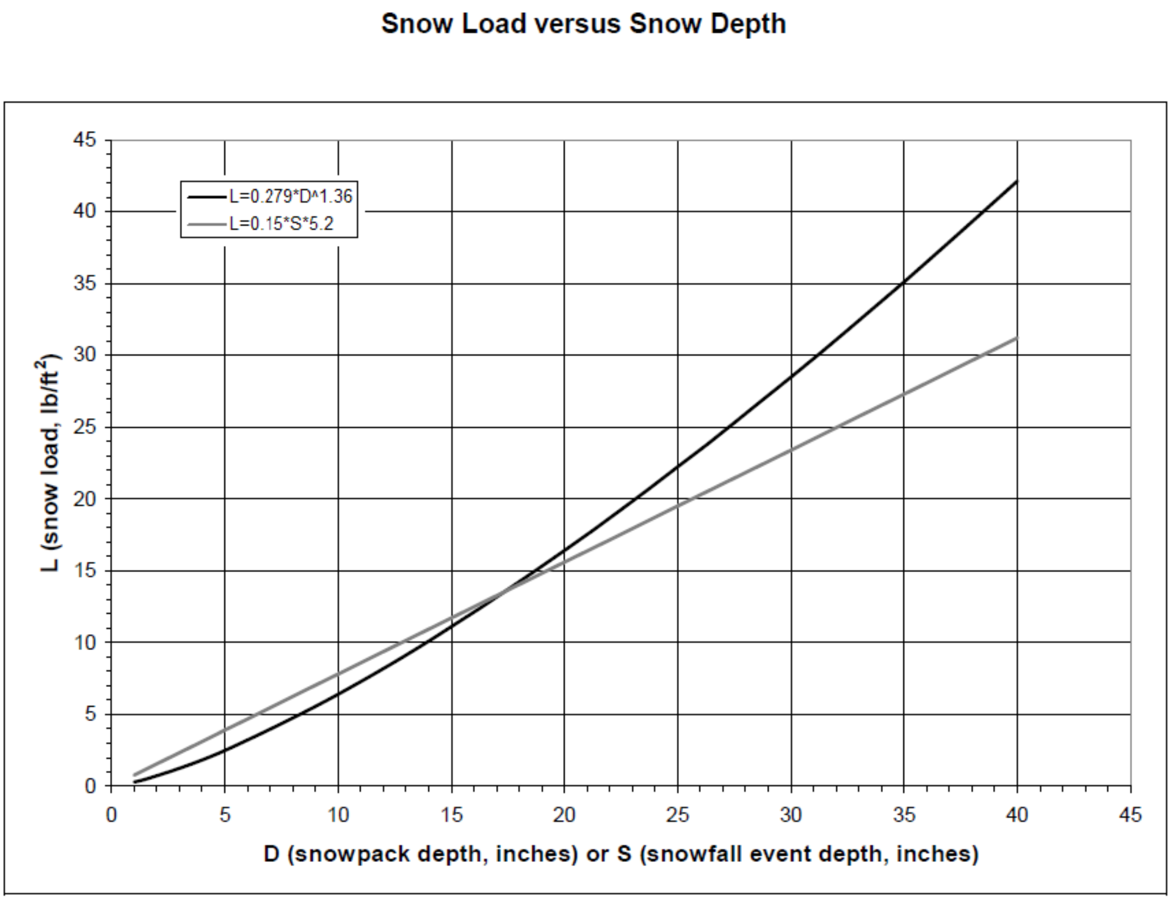


Figure 1 from DC/COL ISG-007 Showing Snow Load versus Snow Depth

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