Evaluation of Natural Hazards other than Seismic and Flooding

Contents

1.0. Summary

As described in SECY-15-0137, “Proposed Plans for Resolving Open Fukushima Tier 2 and 3 Recommendations,” dated October 29, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15254A008), and SECY-16-0074, “Assessment of Fukushima Tier 2 Recommendation Related to Evaluation of Natural Hazards other than Seismic and Flooding” (ADAMS Accession No. ML16102A297), the staff undertook a series of screening evaluations to determine if there is a need to take additional regulatory action to address external hazards other than seismic and flooding. The screening-type evaluations for external hazards other than seismic and flooding cover a variety of potential natural events that were either: (1) not addressed within existing licensing basis documents (e.g., final safety analysis reports), or (2) calculated to be more severe than described in licensing basis documents when reevaluated using present-day information and methodologies.

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

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

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

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 plants from considering certain hazards. Examples of screening criteria include conservatism in design, low frequency of occurrence of a given hazard, and available warning time.

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

4. Determine if the agency needs to take additional actions, such as a plant-specific backfit.

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

As directed by the Commission in SRM to SECY-15-0137, in SECY-16-0074 the staff provided the Commission with the results of Task 2 of its evaluation. As discussed in SECY-16-0074, the staff's assessment performed in accordance with Task 1 screened out all natural hazards with the exception of high winds, extreme ambient temperatures, drought and other low-water conditions, and winter precipitation that results in snow and ice loading on structures. The screening analysis did not include seismic and flooding, which are being addressed separately as part of an ongoing activity. As documented in SECY-16-0074, based on its assessment in accordance with Task 2 of the process, the NRC staff determined that additional regulatory actions are not warranted for extreme ambient temperatures and drought and other low-water conditions. The hazards proceeding to the third task in the screening process were high winds and snow and ice loads. The staff documented in SECY-16-0074 that Task 1 and Task 2 activities were complete.

This enclosure provides the staff's assessment for high winds and snow loads, in accordance with Task 3 of the process outlined in SECY-15-0137 and SECY-16-0074. Based on the assessment that follows, the staff concludes that additional regulatory actions for high winds and snow loads are not warranted. The staff notes that, if approved by the Commission, ongoing assessment of these and other natural external hazards would be within the scope of the staff's proposed process to address Near-Term Task Force (NTTF) Recommendation 2.2, as described in Enclosure 2 to this paper.

2.0. Discussion

As discussed in SECY-16-0074, the staff identified high winds and snow loads for evaluation in accordance with Task 3 of the process described above. The staff made this decision, in part, because the NRC had developed new regulatory guidance for high winds and snow loads after the majority of the currently operating reactors received their operating licenses. The purpose of the Task 3 evaluation is to determine if application of the new guidance to currently operating plants would result in identification of the need for additional regulatory action for these plants, such as a plant-specific backfit.

<u>Tornado and Hurricane Missile Loads</u>

Many of the currently operating plants were licensed before the Standard Review Plan (SRP) was issued as NUREG/75-087, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (now NUREG-0800).[1] As such, the staff determined that it would be appropriate to review the design-basis tornado missile protection for these older plants against the current SRP and Regulatory Guide (RG) 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1, dated March 2007 (ADAMS Accession

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[1] Both current and previous versions of the SRP are publicly available in ADAMS and can be accessed at the following Web address: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/

No. ML070360253). The NRC staff also reviewed current operating plants that were licensed against the 1975 version of the SRP using the current version of the SRP and RG 1.76, Revision 1.

The staff determined that additional review of hurricane-driven missiles was warranted because of recently issued guidance in this area. Specifically, in October 2011 the staff issued RG 1.221, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants” (ADAMS Accession No. ML110940300).

Section 2.1 of this enclosure provides the staff’s evaluation of high wind hazards.

Snow and Ice Loads

On June 23, 2009, the staff issued interim staff guidance (ISG) DC/COL-ISG-007, “Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures” (ADAMS Accession No. ML091490556). The agency issued this guidance for new reactor reviews because the existing guidance in NUREG-0800 did not provide specific approaches to consider snow loads at ground and roof levels 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 through the screening process because the recent updated guidance provides approaches for considering snow loads that were not used when some of the operating plants were initially licensed.

Section 2.2 of this document provides the staff’s evaluation of snow and ice loads.

2.1. Evaluation of High Winds

The staff’s evaluation of high wind hazards is broken into five parts:

1. a comparison of current tornado and hurricane guidance to previous guidance used to license the currently operating reactor fleet (Section 2.1.1)

2. a discussion of the licensing basis for the currently operating reactor fleet (Section 2.1.2)

3. insights from recent inspection findings related to tornadoes that led to the generation of a generic communication (Section 2.1.3)

4. an evaluation comparing results from analyses completed by the staff using current guidance against the licensing basis of operating reactors (Section 2.1.4)

5. the NRC staff’s conclusion for its evaluation of tornado and hurricane winds (Section 2.1.5)

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

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

- For tornado missiles, RG 1.76, Revision 1, is based on tornado hazard curves provided in NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," Revision 2, dated February 2007 (ADAMS Accession No. ML070810400).

- For hurricane missiles, 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," dated December 2009 (ADAMS Accession No. ML11335A031) and NUREG/CR-7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants," dated February 2011 (ADAMS Accession No. ML11341A102).

The NRC staff reviewed both RG 1.76 and RG 1.221,[2] because improved understanding and enhanced models indicate that for some sites, hurricane winds (which often have lower speeds than design basis tornado winds) may produce more intense missiles than tornado winds. RG 1.221 notes that because the size of the hurricane zone with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field even if both have the same maximum wind speed. In other words, even though the maximum wind speed in a hurricane may be bounded by the maximum tornado wind speed, the missile generated from a hurricane may reach a higher maximum speed than the tornado missile.

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

- Based on SRP Section 3.5.1.4, "Missiles Generated by Natural Phenomena," Revision 2, dated July 1981 (ADAMS Accession No. ML052340526), one of two missile spectra could be used by licensees. SRP Section 3.5.1.4 previously provided the missile spectrum and velocities to be considered in a plant's design. The missile spectrum and velocity profiles were moved to RG 1.76, Revision 1, during an update to SRP 3.5.1.4. Regardless, many of the currently operating plants were designed following the guidance of an earlier version of the SRP that assumed either Spectrum I or Spectrum II missiles.

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[2] The staff also reviewed RG 1.117, "Protection Against Extreme Wind Events and Missiles for Nuclear Power Plants," Revision 2, dated July 2016 (ADAMS Accession No. ML15356A213). This RG notes that RG 1.76 tornado wind speeds may not bound hurricane wind for certain portions of the Atlantic and Gulf of Mexico coasts and notes for these cases that SSCs should also be designed for hurricane-generated missiles as defined in RG 1.221. Because RG 1.117, Revision 2, does not provide wind or missile speeds design criteria, the staff determined that it did not need to be reviewed further for this evaluation.

Both spectra include consideration of automobile missiles:

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

- o Spectrum II missiles: an 1810-kilogram (3990-pound) automobile would have a velocity of 59 meters per second (132 miles per hour).

- o This regulatory guide contained additional guidance that allowed applicants who designed their facilities to the 1975 version of the SRP at the construction permit stage to have the option at the operating license stage to show conformance to their original commitment. The 1975 version of the SRP included an automobile of 4000 pounds having a velocity of 100 feet per second (68 miles per hour).

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

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

Based on the discussion above, the staff notes that depending on the time a plant was licensed, it could have a range of assumed automobile-type missile speeds:

- Plants that were licensed using the 1981 SRP Spectrum I missile characteristics would have automobile missile speeds for tornadoes of 126 miles per hour, higher than the 93-miles-per-hour value in the current RG 1.76, Revision 1.

- Plants that were licensed using the 1981 SRP Spectrum II missile characteristics would have automobile missile speeds for tornadoes of 132 miles per hour, higher than the 93-miles-per-hour value in the current RG 1.76, Revision 1.

- Plants that demonstrated conformance to commitments made at the construction permit stage would have automobile missile speeds for tornadoes of 68 miles per hour, lower than the 93-miles-per-hour value in the current RG 1.76, Revision 1.

- Plants that were licensed using either set of missile characteristics in the 1981 SRP would have automobile missile speeds for hurricanes of 126 miles per hour (Spectrum I) or 132 miles per hour (Spectrum II), lower than the 156-miles-per-hour value in the current RG 1.221.

Because of the various options provided above and noting that some plants were licensed before the 1975 version of the SRP existed, the staff performed a review of the licensing basis for the current operating fleet and compared the licensing basis automobile missile speed (if applicable) to that found in RG 1.76, Revision 1. Based on this review, the staff found that approximately two-thirds of plants have design-basis automobile missile speeds lower than that suggested by the latest regulatory guidance (i.e., Revision 1 to RG 1.76 or RG 1.221).

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, dated April 1974 (ADAMS Accession No. ML003740273), and SRP 3.5.1.4, Revision 0, dated November 1975, had six different missile characteristics, while the RG 1.76, Revision 1, and RG 1.221 have three. Regardless of the version of the regulatory guidance, the missile characteristics that were chosen included at least one of the following: (1) a massive high kinetic energy missile that deforms on impact (i.e., an automobile), and (2) a rigid missile that tests penetration resistance. Later guidance provided a small rigid missile of a size sufficient to pass through openings in protective barriers. Below is a comparison of the missile characteristics of the various versions of the regulatory guidance. Note that different speeds were assumed for each type of missile, based on the corresponding tornado or hurricane wind speed characteristics.

Table 1: Comparison of Missile Characteristics in Versions of Regulatory Guidance

Missile Type	Tornadoes		Hurricanes
	RG 1.76, Revision 0, and SRP 3.5.1.4, Revision 0	RG 1.76, Revision 1	RG 1.221
Massive high-kinetic energy missile that deforms on impact	Automobile	Automobile	Automobile
A rigid missile that tests penetration resistance	• Wood plank: 4 inches by 12 inches by 12 feet, weighing 200 lbs • Steel pipe: 3 inches in diameter by10 feet, weighing 78 lbs • Steel pipe: 6 inches in diameter by 15 feet, weighing 285 lbs • Steel pipe: 12 inches in diameter by 15 feet, weighing 743 lbs • Utility pole: 13.5 inches in diameter by 35 feet, weighing 1490 lbs	Schedule 40 pipe: 6.625 inches in diameter by 15 ft, weighing 287 lbs	Schedule 40 pipe: 6.625 inches in diameter by 15 ft, weighing 287 lbs
A small rigid missile of a size sufficient to pass through openings and protective barriers	Not applicable	Solid steel sphere: 1 inch in diameter, weighing 0.147 lbs	Solid steel sphere: 1 inch in diameter, weighing 0.147 lbs

Conclusion

For some plants, the licensing basis has a higher automobile missile speed for tornadoes than the current guidance found in RG 1.76, Revision 1; for other plants, the licensing-basis speed is lower than the current guidance would suggest. In addition, for some coastal sites, hurricane-driven automobile missile speeds found in RG 1.221 are higher than those in the current licensing basis.

2.1.2. Licensing Basis for Currently Operating Reactors

Currently operating power plants have been analyzed against tornado missiles. The extent of the evaluation conducted for tornado missiles varies based on when the plant was originally licensed. However, as described above, hurricane-generated missiles were not specifically modeled as they were previously considered to be bounded by tornado events.

In 1977, the NRC initiated the Systematic Evaluation Program (SEP) to review the designs of 51 older, operating nuclear power plants. The SEP was divided into two phases. In Phase I, the staff defined 137 issues for which regulatory requirements had changed enough over time to warrant an evaluation of those plants licensed before the issuance of the 1975 version of SRP. In Phase II, the staff compared the designs 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 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 NRC issued the SRP 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 the staff evaluated under the SEP. NUREG-1742, Table 5.6, "GSI [Generic Safety Issue] 156, Systematic Evaluation Program," provides a listing of plants that the staff evaluated under the SEP.

Plants Included in the Systematic Evaluation Program

The staff used its generic safety issues program to track the resolution of the SEP issues. 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 GSI 156. GSI 156 was composed of various issues the staff identified under the SEP program, including Issue 156.1.5 related to protection against tornadoes. The objective of Issue 156.1.5, "Tornado Missiles," was to ensure that safety-related SSCs can withstand the impact of an appropriate postulated spectrum of tornado-generated missiles. At the time, the NRC's focus was on evaluating plants that received operating licenses before 1976 to ensure they were adequately protected against tornado-generated missiles. The NRC was particularly interested in those reviewed before 1968 (which was the year 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 final safety analysis report (UFSAR) or in the IPEEE evaluation. The criteria used to evaluate these plants vary greatly and in some cases consist of two missiles (e.g., a rigid steel pipe and a telephone pole) and in other cases rely on probabilistic risk assessments (PRA) methodologies. In some cases plants were backfit to provide additional tornado missile protection or took steps as a result of insights gained from their IPEEEs to provide more robust protection from tornado missiles.

Later Generation Plants

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

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

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

The staff notes that some of the plants performed a risk evaluation for tornadoes,[3] which indicated that based on conformance with the 1975 version of the SRP or completion of a PRA, these plants were adequately protected against the effects of tornadoes. The NRC staff considered IPEEE insights when evaluating this issue for later generation plants.

Conclusion

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

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

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

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

As a result of these regulatory programs, a number of licensees took actions to upgrade tornado missile protection, as appropriate.

[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.

2.1.3. Insights from Regulatory Issue Summary 2015-06, “Tornado Missile Protection”

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

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

In designing SSCs for the consequences of design-basis tornadoes, tornado-generated missiles must be considered. The specific tornado missile protection criteria for each nuclear power plant are contained in the individual plant’s licensing basis. 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 probabilistic analysis to demonstrate that the probability of a tornado-generated missile striking a component required to safely maintain the plant is sufficiently low that no additional measures are required.

Most facilities use deterministic methods when evaluating protection from tornado-generated missiles and as a basis for complying with these regulations. However, NUREG-0800, Section 3.5.1.4, Revision 0, includes acceptance criteria that permit the use of an alternative approach if it can be demonstrated that the probability of strike to unprotected essential safety-related features is sufficiently small. Some licensees used this alternative approach by incorporating the NRC-approved, Electric Power Research Institute-developed TORMIS methodology, or another NRC-approved PRA methodology through 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. The staff has documented these noncompliances in NRC inspection reports, and in some cases these noncompliances have resulted in license amendment requests. Some of the nonconforming SSCs included Technical Specification (TS)-required equipment (e.g., emergency diesel generator (EDG) 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.

As a result of identified nonconformances, the NRC issued Regulatory Issue Summary (RIS) 2015-06, “Tornado Missile Protection,” dated June 10, 2015 (ADAMS Accession No. ML15020A419). The intent of the RIS was to reinforce the need to conform to a plant’s current, plant-specific licensing basis for tornado-generated missile protection, and provide examples of recently-identified failures to conform to a plant’s tornado-generated missile licensing basis.

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," dated June 10, 2015 (ADAMS Accession No. ML15111A269), to licensees who are in noncompliance with their plant-specific licensing bases for issues related to tornado missile protection. EGM 15-002 provides a basis for granting enforcement discretion, including that tornado missile scenarios that may lead to core damage are generally low probability events. For a tornado-missile-induced scenario to occur, a tornado would have to hit the site and result in the generation of missiles that would hit and fail vulnerable, unprotected safety-related equipment and/or unprotected safety-related subcomponents in a manner that is nonrepairable and nonrecoverable. In addition, because plants are designed with redundancy and diversity, other trains may be available to achieve safe shutdown if a tornado missile were to impact a single train of a safety system.

EGM 15-002 included a generic risk analysis of potential tornado missile protection noncompliances to examine the risk significance of these scenarios. This assessment (ADAMS Accession No. ML14114A556) uses tornado hazard curves to provide a bounding estimate of the initiating event frequency of a damaging tornado missile and then it uses PRA tools to analyze the failure of SSCs that have typically been found to not meet the licensing basis for tornado missile protection for selected plant facilities. This analysis used tornado hazard curves provided in NUREG/CR-4461 and Regulatory Guide 1.76, Revision 1.

The generic risk analysis performed by the Office of Nuclear Reactor Regulation concluded that the nonconformance with tornado missile protection requirements does not rise to the level of an adequate protection concern or require immediate plant shutdown because the risk is bounded by the initiating event frequency of 4E-4 per year even in the most severe tornado region. This frequency is well below the 1E-3 per year core damage frequency (CDF) threshold for a "high" risk impact provided in Office of Nuclear Reactor Regulation Office Instruction LIC-504, "Integrated Risk-Informed Decision-Making Process for Emergent Issues," Revision 4, dated June 2, 2014 (ADAMS Accession No. ML14035A143). Therefore, the EGM concluded that enforcement discretion of up to 5 years, accounting for differences in initiating event frequency based on the geographical location of the plants, will not impose significant additional risk to public health and safety.

Therefore, regarding the tornado licensing basis for operating plants:

- The staff notes that the tornado missile protection design basis requirements are generally conservative.
- The staff has taken advantage of current licensing processes to ensure that licensees continue to meet their tornado missile protection design basis by alerting licensees to issues the NRC has identified in various inspections as documented in RIS 2015-06.
- EGM 15-002 provides a basis for granting enforcement discretion that notes in general tornado missile scenarios that may lead to core damage are low probability events, because safety-related SSCs are typically designed to withstand the effects of tornadoes. In addition, because plants are designed with redundancy and diversity, other trains may be available to achieve safe shutdown if a tornado missile were to impact a single train of a safety system.

2.1.4 Evaluation of Current Operating Plants' Wind Protection Against Current Tornado and Hurricane 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 based on its review of current tornado and hurricane guidance against the licensing basis for current operating plants. The staff's deterministic review process had three parts:

- assessment of wind loads based on wind speeds from current guidance in RG 1.76, Revision 1, and RG 1.221, as compared to the current licensing basis wind speed loads for operating plants;
- assessment of the ability of tornado or hurricane missiles to damage structures protecting safety-related SSCs based on current guidance in RG 1.76, Revision 1, and RG 1.221, as compared to the current licensing basis missile design spectrum for operating plants; and
- assessment of structural loads from a large missile (i.e., an automobile) based on current guidance in RG 1.76, Revision 1, and RG 1.221, as compared to the margin provided in a plant's current licensing basis structural design basis.
    - For this assessment the NRC staff reviewed the automobile missile structural loads from current guidance as compared to those used to establish the current licensing basis for the plant. In cases where the use of current-day guidance resulted in a potentially more damaging missile than addressed in a plant's licensing basis, the staff then assessed the new information against the structural margin in the operating power plant. The NRC performed a margin assessment of structural loads from an automobile missile impact as one of the steps in determining if additional regulatory action might be warranted to request additional information or require licensees for current operating plants to perform analyses using RG 1.76, Revision 1, and RG 1.221 guidance.

Based on the staff's deterministic assessment, as supplemented by risk insights, the staff concludes that additional regulatory actions are not warranted to address beyond-design-basis tornadoes and hurricanes. The staff's assessment supporting this conclusion is provided below in Sections 2.1.4.1 through 2.1.4.4.

2.1.4.1. High Wind Velocity Pressure Loads

To assess wind velocity pressure loads, the staff reviewed licensees' UFSARs and licensees' integrated plans provided in response to the mitigating strategies Order EA-12-049. Licensees' UFSARs typically provide a discussion of the design-basis tornado wind speed loads assumed in the structural analysis. The licensees' integrated plan response to Order EA-12-049 included a discussion of whether the plant met the criteria for a high wind evaluation.

Figure 2.1.4-1, "Comparison of Current Design Basis Tornado Wind Speeds vs Updated Tornado and Hurricane Wind Speed," located at the end of this enclosure, plots the data that the NRC staff collected. As noted with the shaded plot in Figure 2.1.4-1, the majority of nuclear power plants were designed for a tornado wind speed of 360 miles per hour. Figure 2.1.4-1 shows that for the majority of the sites, the RG 1.76, Revision 1, tornado wind speeds (shown as the dashed line in the plot) are less than those assumed in the design of the plant. Regarding hurricanes, Figure 2.1.4-1 shows that not every plant has an associated hurricane wind speed (shown by the black bars in the plot). 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 2.1.4-1 shows that for the majority of sites, the hurricane wind speed is bounded by the design-basis tornado wind speed provided in the UFSAR.

The staff notes that for one site (Ginna), on the far right of the horizontal axis in Figure 2.1.4.1-1, the design-basis tornado wind speed is less than that found in RG 1.76, Revision 1 (for tornadoes), and RG 1.221 (for hurricanes). One other site's design basis tornado wind speed is not the same for all safety-related SSCs (Oyster Creek). In addition, not every plant was licensed with a design-basis tornado wind speed (Nine Mile Point 1 and Indian Point 2).

The staff reviewed the IPEEEs for the four plants whose tornado design-basis wind speed does not exist or whose tornado design-basis wind speed is lower than the RG 1.76, Revision 1, tornado wind speed or the RG 1.221 hurricane wind speed. The safety evaluations associated with the IPEEEs noted CDFs due to high winds for two of the sites to be less than 5E-6 per year for high winds (Oyster Creek and Nine Mile Point 1). One of the sites had a CDF due to high winds of 3E-5 per year with the dominant contributor being a loss of all alternating current (ac) power resulting in loss of reactor coolant pump (RCP) seal cooling (Indian Point 2). For this site, the staff notes the low CDF contribution and also notes that loss of ac power resulting in loss of RCP seal cooling is a scenario that is addressed as part of the mitigating strategies order. The last site (Ginna) did not calculate a CDF, instead noting that as part of the SEP review it made several modifications to the plant to increase the protection from high winds. Based on walkdowns, coupled with a review of the SEP results, the licensee for Ginna concluded that the CDF was less than 1E-6 per year in accordance with Section 5.2.4, "Determine if the Hazard Frequency is Acceptably Low," of NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," dated June 1991 (ADAMS Accession No. ML063550238).

The staff concludes that for the majority of sites, the design basis tornado wind speed bounds updated wind speed guidance provided in RG 1.76, Revision 1, and RG 1.221. Therefore, for these sites the staff has determined that additional regulatory action is not warranted in this area. For the four sites whose design basis tornado wind speed does not bound wind speed guidance provided in RG 1.76, Revision 1, and RG 1.221, the staff performed a review of the IPEEEs to determine if additional regulatory action is needed. Based on the insights from the IPEEEs for these sites, the staff determined that additional regulatory actions would likely not be justified when assessed against the agency's backfitting criteria. As described in Section 2.1.4.4 of this report the staff considered additional safety insights to determine if additional regulatory action are warranted to address high wind velocity pressure loads.

2.1.4.2. Tornado and Hurricane Penetrating Missile Evaluation

In evaluating a wind-borne missile's capability to penetrate structures that are designed to protect safety-related SSCs, the staff compared design-basis missile characteristics for the current operating fleet to the design-basis missile characteristics from RG 1.76. Revision 1, and

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

The staff used a formula to convert a missile's mass, velocity, and contact area into a concrete penetration depth based on guidance found in SRP Section 3.5.3, "Barrier Design Procedures," March 2007 (ADAMS Accession No. ML070570004). SRP 3.5.3 notes that several empirical equations, such as the modified National Defense Research Council equation, proposed in "A Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects," by R.P. Kennedy, Nuclear Engineering and Design (the Kennedy paper), are available to estimate missile penetration into concrete.

Figure 2.1.4-2 is an NRC staff-developed plot using the Kennedy paper formula to develop minimum concrete thickness to prevent perforation based on design-basis tornado missile characteristics found in a plant's UFSAR as compared to the minimum concrete thickness to prevent perforation when struck by a schedule 40 pipe based on guidance in Revision 1 to RG 1.76 or RG 1.221 guidance (whichever results in the higher velocity missile). Figure 2.1.4-2 presents concrete thicknesses as calculated values at various sites based on tornado missile characteristics found in the UFSAR and does not represent actual value of concrete thickness of safety-related structures at a given site. The staff performed this calculation to use as one of the screening tools to aid it in determining whether additional regulatory action is warranted related to tornado and hurricane missile protection.

Based on this assessment, the staff found that the majority of the current operating plants have design-basis missile characteristics that bound the missile characteristic of the rigid pipe found in RG 1.76, Revision 1, or RG 1.221. There are six sites (Brunswick, D.C. Cook, Saint Lucie, Robinson, Turkey Point, and Ginna) for which this is not the case. For four of these six sites, the calculated penetration depth using the RG 1.76, Revision 1, or RG 1.221 missile characteristic is within a factor of 1.5 or less of the UFSAR design basis value. Based on structural margins that are known to be incorporated into the design and construction of safety-related structures, the staff's engineering judgment is that it is unlikely that safety-related SSCs will fail at the higher velocities assumed for the schedule 40 pipe in RG 1.76, Revision 1, or RG 1.221.

For two of the six sites (Turkey Point and Ginna), the calculated penetration depth using the RG 1.76, Revision 1, or RG 1.221 missile characteristic is more than 1.5 times the UFSAR design basis value. The staff reviewed the IPEEEs for these two sites to obtain insights into the risk of wind-driven missiles. For Turkey Point, the licensee used the guidance in NUREG-1407 and determined that the total CDF from high winds, which includes the risk contribution from both the wind itself and from wind-driven missiles, is less than 1E-6 per year for each unit. The staff notes that wind-driven missiles make up a fraction of this total risk, such that the risk from missiles is even lower. The staff also notes that one of the dominant contributors to this CDF estimate is failure of a fossil-fired smoke stack falling on one of the units' EDGs, and that this failure mechanism is no longer a concern because the smoke stack is no longer needed and is being removed from the site. The other site (Ginna) is discussed in Section 2.1.4.1 of this report. The licensee for Ginna did not calculate a CDF, instead noting that as part of the SEP review, it made several modifications to the plant to increase the protection from high winds. Based on walkdowns coupled with a review of the SEP results, the licensee concluded that the CDF could reasonably be assumed to be less than 1E-6 per year in accordance with Section 5.2.4 of NUREG-1407.

In addition to the six sites whose missile penetration resistance is not bounded by the FSAR design basis value, two sites do not have a design basis tornado and associated missile spectrum (Indian Point 2 and Nine Mile Point 1). The results of the staff's review of the IPEEE for these two sites are discussed in the previous section.

In summary, the staff reviewed the IPEEEs for the eight sites whose calculated missile penetration resistance is not bounded by the value calculated by the staff using the UFSAR tornado missile characteristics to determine if a basis for additional regulatory action to address missile penetration protection exists. Highlights from the staff's review of the IPEEEs include:

- Five of the eight sites had a calculated CDF due to high winds of less than 3E-5 per year.

- Three of the eight sites performed a bounding CDF analysis based on compliance with the 1975 version of the SRP and concluded that their CDFs due to high winds was less than 1E-6 per year.

The staff compared these CDF values to the NRC's backfit criteria, which are found in NUREG/BR-0058, Revision 4, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission" (available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0058/br0058r4.pdf). Section 3.3.1 of NUREG/BR-0058 provides a process for evaluating whether a proposed regulatory action to prevent or reduce the likelihood of sequences that can lead to core damage should be pursued. If a calculated change in CDF is less than 1E-5 per year, then it is recommended that no action be pursued. The staff compared this delta CDF to the high winds CDF for the eight sites discussed above. The eight sites that calculated a tornado-induced CDF fall in this range; as such, it is unlikely that the imposition of a requirement to reduce the already low high winds CDF would represent a change that meets the criteria for change in CDF found in NUREG/BR-0058. The staff also notes that the IPEEE analyses, which were performed in the 1990s, do not credit mitigating strategies equipment required by Order EA-12-049 or equipment required to comply with requirements for mitigation of loss of large areas of the plant due to fire or explosion in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), paragraph 50.54(hh)(2), since these requirements were imposed after the IPEEEs were performed. The staff notes that if this equipment is credited, the IPEEE calculated values would be even lower.

Therefore, the staff concludes that, for the majority of sites, the design-basis tornado missile characteristic associated with missile penetration depth bounds the missile characteristic for a schedule 40 pipe provided in Revision 1 to RG 1.76 and RG 1.221. For these sites, the staff has determined that additional regulatory action is not warranted in this area. For the eight sites whose tornado or hurricane-borne rigid missile design basis speed does not bound rigid missile speed guidance provided in Revision 1 to RG 1.76 and RG 1.221, the staff performed a review of the IPEEEs to determine if additional regulatory action is needed. Based on the insights from the IPEEEs and the additional mitigation capabilities established thereafter, the staff determined that additional regulatory actions are likely not justified. As described in Section 2.1.4.4 of this report, the staff considered additional safety insights to determine if additional regulatory actions are warranted to address a tornado or hurricane-borne missile's ability to penetrate structures designed to protect safety-related SSCs.

2.1.4.3. Tornado and Hurricane Automobile Missile Evaluation

The staff assessed the automobile missile loads from a tornado or a hurricane. As indicated above, hurricanes and, in some instances, tornadoes have the potential to produce more intense automobile missiles than those assumed in previous guidance. The staff notes that the automobile missile can be considered a surrogate for a spectrum of missiles that can be found at a site, including objects like heating, ventilation, and air conditioning units on roof tops.

Figure 2.1.4-3 provides a plot of the tornado and hurricane missile speeds for events with a frequency of approximately 1E-7 per year (referred to as the 1E-7 tornado or hurricane) based on RG 1.76, Revision 1, and RG 1.221 guidance, respectively. For many sites, automobile missile speeds for a 1E-7 tornado are in the 90 miles per hour range; for some coastal sites, the RG 1.221 automobile missile speeds for a 1E-7 hurricane are above 120 miles per hour. Figure 2.1.4-3 also provides a plot of automobile missile speeds for hurricanes with a frequency of approximately 5.9E-4 per year (referred to as the 5.9E-4 hurricane) based on wind speed data from American Society of Civil Engineers (ASCE) 7-10, "Minimum Design Loads for Buildings and Other Structures," and the corresponding automobile missile speed for the given hurricane wind speed from RG 1.221. The staff chose the 5.9E-4 automobile missile speed data because this information was readily available and it is at the frequency that provides useful insights to the staff's consideration of whether additional regulatory actions are warranted based on guidance provided in NUREG/BR-0058 (i.e., while wind speeds from less frequent events may result in higher missile speeds, they would be less likely to result in the need for a plant-specific backfit based solely on event frequency).

The staff used a conservative approach to assess the impact of the increased automobile missile speed as compared to the plant's current missile protection requirements. The staff used a systematic screening method to assess the potential impact that the updated automobile missile speeds could have on the operating fleet. Current guidance uses the automobile as the most limiting missile for a high-wind scenario. However, some plants were licensed using relatively lower velocities for their automobile missiles (as low as 33 miles per hour). At some sites, the utility pole missile was considered the most limiting impact load in the current licensing basis due to its relatively high weight, large diameter, and high speed. Thus, the automobile missile was not always the most limiting case in the staff's reanalysis.

The first step in the staff's screening evaluation was to compare the peak force calculated using a plant's UFSAR missile data to the calculated peak force from missiles using current guidance. The staff determined the highest-impact load for each site based on the licensing basis (e.g., tornado-driven automobile or tornado-driven telephone pole). This load was then compared to the load calculated using automobile characteristics from RG 1.76 traveling at either NUREG-4461 tornado missile speeds or NUREG-7005 hurricane missile speeds, whichever was greater.

The initial insights from the comparison indicated that the automobile missile speeds estimated using present-day guidance are higher than similar missiles within the licensing basis for many plants. For 1E-7 tornado and hurricane events, the velocity of the automobile in recent guidance is about twice that found in the current operating plants' licensing bases. Thus, the kinetic energy of the automobile was about four times that previously estimated, based on the kinetic energy of an object being equivalent to half the mass of an object times the velocity squared. Some UFSARs described automobile-type missiles with higher velocities, but many UFSARs discussed estimated speeds between 50 and 75 miles per hour.

To provide additional context to the missile-resistance capacity of reinforced concrete walls, the staff performed a calculation for representative concrete walls of varying thicknesses to determine the speed at which automobile missile impact loads could be expected to exceed the structural capacity. The staff chose representative reinforced concrete walls that are 12 inches, 18 inches, and 24 inches thick. The staff chose this range of thicknesses because safety-related structures have a range of concrete thicknesses. For example, service water intake structures and auxiliary buildings typically have concrete thicknesses in the 12- to 18-inch range, while containments typically have greater than 24-inch thick concrete protecting systems and components.

The staff performed these calculations using targeted ductility factors of both 10 and 30. Ductility is a measure of the ability of structures/structural elements to deform prior to ultimate failure, once the structure has surpassed its yield strength (i.e., in the inelastic range). The staff calculated a ratio comparing the deformation caused by the impact loading and the representative walls' ultimate deformation capability, and compared it against the targeted ductility factors. Once the deformation ratio exceeded the targeted ductility factor (10 or 30), the staff assumed the wall had failed. A flexural ductility factor of 10 was chosen because code design requirements for impactive and impulsive loads from the American Concrete Institute limits the allowable ductility to 10. However, topical report BC-TOP-9A, "Design of Structures for Missile Impact," Revision 2, dated September 1974 (ADAMS Accession No. ML14093A217), suggests that higher maximum ductility ratios in flexure of up to 30 may be justified. The staff, therefore, used that value as a sensitivity case to provide further context to the magnitude of missile speeds expected to be required to cause a structural failure of a reinforced concrete wall. The results of this calculation are shown in the following table.

Table 2: Staff Calculated Automobile Missile Speed to Exceed Ductility Factor for Various Concrete Wall Dimensions

Thickness of Representative Concrete Wall (inches)	Automobile Impact Speed to Exceed Ductility Factor of 10 (miles per hour)	Automobile Impact Speed to Exceed Ductility Factor of 30 (miles per hour)
12	110	200
18	180	275
24	240	360

The staff notes that based on the above simplified calculation and assuming a ductility factor of 10, a 12-inch representative concrete wall would have sufficient structural capacity to withstand the following:

- all of the 1E-7 tornado automobile missile speeds associated with RG 1.76, Revision 1
- the majority of the 1E-7 automobile missile speeds associated with RG 1.221, noting that the 18-inch wall would have capacity to withstand all 1E-7 hurricane automobile missile speeds
- all of the 5.9E-4 automobile missile speeds

Assuming a ductility factor of 30 for the conservatively thin 12-inch wall would bound all 1E-7 tornado and hurricane automobile missile speeds from RG 1.76, Revision 1, and RG 1.221.

Based on the results of the deterministic screening approach, and recognizing that each plant's licensing basis is unique, the staff also considered insights from high wind risk studies.

2.1.4.4. Additional Safety Insights

The NRC staff notes that early insights from recent PRAs do not identify extreme tornadoes and hurricanes as dominant risk contributors to a plant's CDF. Rather, the more common tornadoes and hurricanes that fail offsite power and damage important nonsafety-related equipment have been identified as needing further study. This effect was described in a meeting summary dated May 28, 2015 (ADAMS Accession No. ML15187A266), for a meeting between the NRC Office of Nuclear Regulatory Research and Applied Research Associates. The meeting summary discusses technical aspects of high wind probabilistic risk methodologies and 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 and 150 miles per hour would typically represent the range where potential damage to buildings due to debris and structural impacts could be observed. There is a need for stochastic modeling in hazard characterization, given the potentially large uncertainties involved. Two important aspects not typically considered were: (1) consideration of directional wind analysis for vulnerable structures to reduce the level of conservatism in straight winds analysis, and (2) assessment of the impact of rain on plant equipment, as this phenomenon often accompanies high wind events.
- The National Institute of Standards and Technology plans to update current guidance on tornado wind risk, aimed at leveraging new data that became available over the past decade to derive tornado risk maps for the United States. As part of this work, factors affecting hazard modeling, such as the inconsistent reporting of tornadoes across different time periods, path area uncertainties, and the wind speed relationship across commonly used scales (e.g., Fujita and Enhanced Fujita Scale) will be taken into account to better reflect the extremely large epistemic uncertainties associated with tornado hazard modeling.

Based on the early insights from ongoing high wind PRAs and insights gained from the IPEEEs, the NRC staff believes that further pursuit of current research activities to assess high winds risk are appropriately suited to address these safety insights, rather than imposing new requirements at this time. Examples of this research include the following:

- The NRC's Office of Nuclear Regulatory Research, in response to needs identified by the regulatory offices regarding the NRC's risk analysis tools, is enhancing existing tools to make external event analysis more risk informed.

- A September 21, 2011, SRM (ADAMS Accession No. ML112640419) directed the staff to conduct a full-scope comprehensive site Level 3 PRA, as described in SECY-11-0089, "Options for Proceeding with the Future Level 3 Probabilistic Risk Assessment Activities" (ADAMS Accession No. ML11090A041), dated July 7, 2011. Vogtle 1 and 2 are the subject of this study, which includes assessments of external hazards and involves the development of a high wind PRA.

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

As discussed above, the staff considered the following factors in assessing the need for additional regulatory actions for high winds:

- While tornadoes and tornado-generated missiles impacting a nuclear power plant are low frequency events, hurricane force winds impacting a nuclear power plants are not low frequency events for nuclear power plants along the Atlantic Coast and the Gulf of Mexico Coast. The staff notes that, based on preliminary recent PRA insights and past IPEEE insights, CDF for high winds from hurricanes is typically driven by wind-induced failure of offsite power and wind-induced damage to risk-significant nonsafety-related equipment. For example, for one site, the IPEEE risk insights note that the dominant high wind core damage sequences are station blackout sequences, responsible for 87 percent of the high wind CDF. Following the station blackout, RCP seal cooling is lost, resulting in loss of coolant accident through the RCP seals with no RCS make up capability.[4]

- Given the warning time associated with hurricane forecasts, licensees take preplanned actions to prepare for the onset of high winds, including shutting down the plant if winds greater than a certain speed are forecast. Based on these insights, the staff reviewed the severe weather procedures for four coastal plants related to hurricanes (i.e., Saint Lucie, Turkey Point, Brunswick, and Waterford). The staff chose these sites for additional review because, as discussed in Section 2.1.4.3 of this enclosure, these sites exceed a ductility factor of 10 for a 12 inch thick representative concrete wall. The severe weather procedures for these plants direct the operators to shut down the plant prior to hurricane force winds arriving onsite. In addition, procedures direct staff

[4] As noted above since the IPEEEs were performed additional capabilities have been provided in response to the mitigation strategies orders that should reduce the risk from this sequence.

personnel to perform walkdowns to look for and address potential hurricane-induced missiles and to ensure EDGs have adequate fuel supplies and have been recently tested to ensure high reliability if a loss of offsite power should occur. Licensee actions prior to a hurricane impacting a site can reduce the risk of core damage.

- NRC-endorsed guidance document Nuclear Energy Institute (NEI) 12-06 Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guidance" (ADAMS Accession No. ML16005A625), provides implementation guidance for the mitigation strategies described in Order EA-12-049. For plants dealing with the possible effects of hurricanes and tornadoes, NEI 12-06, Revision 2, includes additional capabilities beyond the protection of safety-related equipment. Step 2C, "Assess Impact of Severe Storms with High Winds," in NEI 12-06 notes that severe storms with high winds can create a significant challenge to plant safety, namely through the simultaneous extended loss of ac power and loss of the ultimate heat sink. NEI 12-06 Section 7.3 includes provisions for the protection and deployment of FLEX equipment that include guidance for the configuration of the storage of this equipment and deployment of the equipment. Therefore, the staff concludes that implementation of FLEX strategies reduces risk from high wind events leading to loss of core cooling or spent fuel pool cooling.

- As described in previous sections of this enclosure, the staff's high wind evaluation considered insights from the IPEEEs and/or the review of hurricane procedures for the following plants: Brunswick 1 and 2, D.C. Cook 1 and 2, Ginna, Indian Point 2, Nine Mile Point 1, Oyster Creek, Robinson, Saint Lucie 1 and 2, Turkey Point 3 and 4, and Waterford 3. The staff reviewed these plants' plans for complying with the mitigation strategies order EA-12-049 from a high winds perspective as a check to determine if additional regulatory actions are needed. Table 2.1.4.4-1 provides a summary of the high winds mitigation strategies for these nuclear power plants. The staff notes that it has not yet completed its evaluation of the final integrated plan associated with Order EA-12-049 for all of these sites. The staff also notes that licensees may change their plans, either prior to their compliance date, or after their compliance date under the configuration control provision of NEI 12-06. The staff will take appropriate action if it identifies a concern with a licensee's compliance with Order EA-12-049. Nevertheless, based on the staff's review of the licensee's plans for complying with Order EA-12-049, the staff reaffirms its conclusion for these plants that the actions taken in response to the Order reduce risk from high wind events leading to the loss of core cooling or spent fuel pool cooling and additional regulatory action, beyond those being taken to comply with the Order are not warranted.

- The NRC staff has continually assessed regulatory requirements related to tornadoes and hurricanes as part of the operating experience process. As an example, GSI-178, "Effect of Hurricane Andrew on Turkey Point," in NUREG-0933 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 20-30, 1992," dated March 1993 (available at https://www.osti.gov/scitech/biblio/10158520), which the NRC distributed to all power reactor licensees. In addition, the NRC conducted similar lessons-learned activities associated with the effects of Hurricane Katrina and Hurricane Sandy.

2.1.5. Conclusion of Evaluation of Tornado and Hurricane Missile Protection

The NRC staff concludes that additional regulatory actions are not warranted to address beyond-design-basis tornadoes and hurricanes based on: the low risk when compared to the backfit guidance found in NUREG/BR-0058; conservatism in design; additional capabilities to address these events based on compliance with 10 CFR 50.54(hh)(2) and Order EA-12-049; lessons learned from past events being incorporated into licensee and NRC actions; and for hurricanes, the additional warning time associated with these events.

2.2. Evaluation of Snow Loads

The evaluation of snow and ice loads is focused on the potential challenge to seismic Category I structures at a nuclear power plant, to assess whether additional regulatory action (beyond what the NRC currently requires) is warranted to address the hazard. The staff performed the evaluation to assess the differences in snow load estimates using assumptions described in present-day guidance and methods, compared to operating plants' licensing bases information. The staff applied the following three criteria as part of its evaluation:

1. conservatism of design safety margins
2. low likelihood that the event will lead to a loss of reactor core cooling or spent fuel pool cooling
3. warning time available to allow licensees to take measures to prevent an accident from occurring

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). The staff issued this guidance for new reactor reviews because, at the time of the issuance of the ISG, the SRP 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 operating reactor fleet was designed to guidance that predates DC/COL-ISG-007. Given the recently updated guidance for snow loads, the staff determined that it was appropriate to further assess this external natural event as part of Task 3 in the staff's evaluation process.

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 [General Design Criterion] 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, as well as negative pressure due to tornado suction, and were checked for the effects of probable maximum precipitation. Live loads were considered in combination with other loads (e.g., dead loads, like those from the weight of structures and equipment, and accident loads, like those associated with earthquakes) and were evaluated using guidance found in SRP Section 3.8.1, “Concrete Containments,” and Section 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), a 48-hour probable maximum precipitation (PMP) event was to be considered in addition to the 100-year snow load event.

The winter precipitation events to be included in the combination of extreme winter precipitation roof loads are based on the weight of the antecedent snowpack resulting from the normal winter precipitation event plus the larger resultant weight from either (1) the extreme frozen winter precipitation event or (2) the extreme liquid winter precipitation event. 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 SRP did not consider the additional weight of the 48-hour probable maximum winter precipitation at ground level for the month corresponding to the selected snowpack. The purpose of the staff’s assessment of this issue is to determine if the treatment of snow loads in accordance with DC/COL ISG-007 leads to a determination that additional regulatory action is needed. As discussed above, the staff identified several screening criteria in evaluating a hazard, including comparing new hazard information against the 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 evaluated both plants that were licensed before the 1975 version of the SRP and plants reviewed against the 1975 version of the SRP. Plants that were licensed against the 1975 version of the SRP, in general, are expected to have additional design safety margins associated with load combinations compared to plants licensed before the 1975 version of the SRP existed.

Plants Included in the Systematic Evaluation Program

As was discussed under the tornado evaluation, the staff used its generic issues program to track the resolution of the SEP issues. As documented in NUREG-0933, the staff identified the resolution of this issue as GSI-156. The objective of GSI 156.2.1, "Severe Weather Effects on Structures," was to identify those meteorological conditions that should be considered in structural reviews to determine the ability of structures to withstand these conditions. The staff's resolution of this issue noted that snow and ice loads, when accompanied by strong winds, caused several complete and partial losses of offsite power and had the potential of causing severe accidents and would be evaluated under the Individual Plant Examination program. The staff's evaluation at that time also stated 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, Section 4.1.3.2, "Guidance for Conducting 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 SRP plan, and performance of a plant walkdown. The majority of the plants licensed before the 1975 SRP was available used this method for dispositioning snow loads, as documented in NUREG-1742, Table 4.1, "Methodologies and results for the HFO external events." Only the Haddam Neck nuclear plant (which ceased operations in 1996) performed a snow and ice PRA and reported a CDF contribution of 7E-6 from snow and ice. It is not clear whether or not the assessment of these plants against the 1975 version of the SRP also considered the March 24, 1975, branch technical position. Regardless, snow loads were considered as part of the IPEEEs that were performed for plants included in the SEP and the agency determined that additional regulatory action was not needed to address snow loads.

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 seismic Category I structures. The NRC staff reviewed the IPEEEs for these plants, and notes that these licensees did not identify snow-load related vulnerabilities for safety-related structures.

2.2.1. Snow Load Deterministic Evaluation

The NRC staff calculated the 100-year snow load and extreme snow load for the current operating fleet based on guidance provided in DC/COL-ISG-7. Figure 2.2-1 provides a plot of the staff-calculated 100-year snow load and extreme snow loads for current operating nuclear power plants (ten sites whose 100-year snow load is zero based on ASCE-7 information are not plotted on this figure). The staff performed additional structural assessments for these sites by developing equivalent roof loading for a representative reinforced concrete roof. The staff's evaluation included developing the dead load for this representative roof. Figure 2.2-1 plots double the dead load of a representative concrete roof that equates to a 225 pounds per square foot roof loading. Doubling the representative roof dead load is within the structural design margin of the representative roof.

The extreme snow loads are within the structural margins for a representative concrete roof slab, providing confidence that such roofs will not fail due to extreme roof snow load conditions. This is based, in part, 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.

The staff recognizes that roof structures that protect safety-related equipment vary across the fleet of U.S. operating reactors. For example, pressurized water reactor (PWR) concrete containment domes are sloped in such a manner that they prevent the accumulation of snow and they are also typically very thick. PWR auxiliary building roofs and roofs protecting safety-related PWR and boiling water reactor (BWR) intake structures are typically flat reinforced concrete structures. BWR Mark I and II reactor building roofs are not typically reinforced concrete structures. However, for Mark I and Mark II containments and other structures that may not have reinforced concrete roofs, the staff also notes that such structures would typically have significant capacity due to other design requirements (e.g., requirements associated with seismic design and missile protection) and due to additional design margin beyond elastic limits.

In addition to the structural assessment discussed above, the staff reviewed the UFSARs for the operating fleet to determine if the design-basis roof loading for a power plant may warrant additional regulatory actions when compared to an extreme roof snow loading calculated in accordance with DC/COL-ISG-7. Based on the UFSAR review and insights from the structural assessments, the staff identified five northern sites for additional assessment (Point Beach, Prairie Island, Nine Mile Point 1, Fitzpatrick, and Susquehanna).

For these five sites, the staff applied the screening criteria of warning time associated with extreme snow events. In addition to the warning time provided by the weather forecasting, the roof loading associated with an anticipated extreme snow event would take days to develop. The staff reviewed the severe weather procedures for these five sites and confirmed that these procedures direct licensees to take precautionary actions prior to winter events and to monitor potential adverse effects at these sites.

2.2.2. Qualitative Considerations

Actions taken to comply with Order EA-12-049 provide additional protection again extreme snow and ice. Step 2D, “Assess Impact of Snow, Ice and Extreme Cold,” of NEI 12-06 notes that snow, ice storms, and extreme cold can contribute to simultaneous extended loss of ac power and loss of normal access to the ultimate heat sink. NEI 12-06, Section 8.3, includes provisions for protection and deployment of FLEX equipment and notes that for sites subject to significant snowfall and ice storms, portable FLEX equipment should be stored in one of two configurations:

1. in a structure that meets the plant’s design basis for the snow, ice, and cold conditions

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

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

The staff also notes that a structural failure of a roof due to extreme snow loads does not necessarily lead to loss of core cooling or spent fuel pool cooling. It is also unlikely that a roof collapse would disable multiple trains (at different physical locations) of safety-related systems.

Furthermore, the extreme snow load calculation in present-day regulatory guidance is based on water being retained by a snow pack. Some licensees made changes to their roof drain designs to provide additional paths to prevent roof ponding in response to Generic Letter 89-22, “Potential for Increased Roof Loads and Plant Area Flood Runoff Depth at Licensed Nuclear Power Plants Due to Recent Change in Probable Maximum Precipitation Criteria Developed by the National Weather Service,” dated October 19, 1989 (available at https://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1989/gl89022.html).

In the staff guidance for performing IPEEEs (NUREG-1407), the staff stated:

> … for existing plants, the NRC recommended that licensees review the information contained in Generic Letter 89-22 and determine if they need to take additional action. For the IPEEE, the severe accident risk from PMP should be assessed. The licensees should assess the effects of applying this new PMP criterion to their plants in terms of onsite flooding and roof ponding to determine whether that would lead to severe accidents.

Roof drains were also within the scope of the flooding walkdowns performed in accordance with NTTF Recommendation 2.3 of the NRC’s March 12, 2012, request for information issued pursuant to 10 CFR 50.54(f). As appropriate, actions were taken as a result of Generic Letter 89-22 and in response to the March 12, 2012, request for information that should reduce the likelihood of gross amounts of water being trapped on roofs that are assumed under extreme snow load conditions.

2.2.3. Snow Load Conclusion

The NRC staff concludes that additional regulatory actions are not warranted to address beyond-design-basis snow loads. This conclusion is based on conservatism in design, warning time associated with the event, additional capabilities to address these events based on compliance with the Order EA-12-049, and the fact that roof failures from such an events would not necessarily lead to loss of core cooling or spent fuel pool cooling.

3.0. Stakeholder Interactions

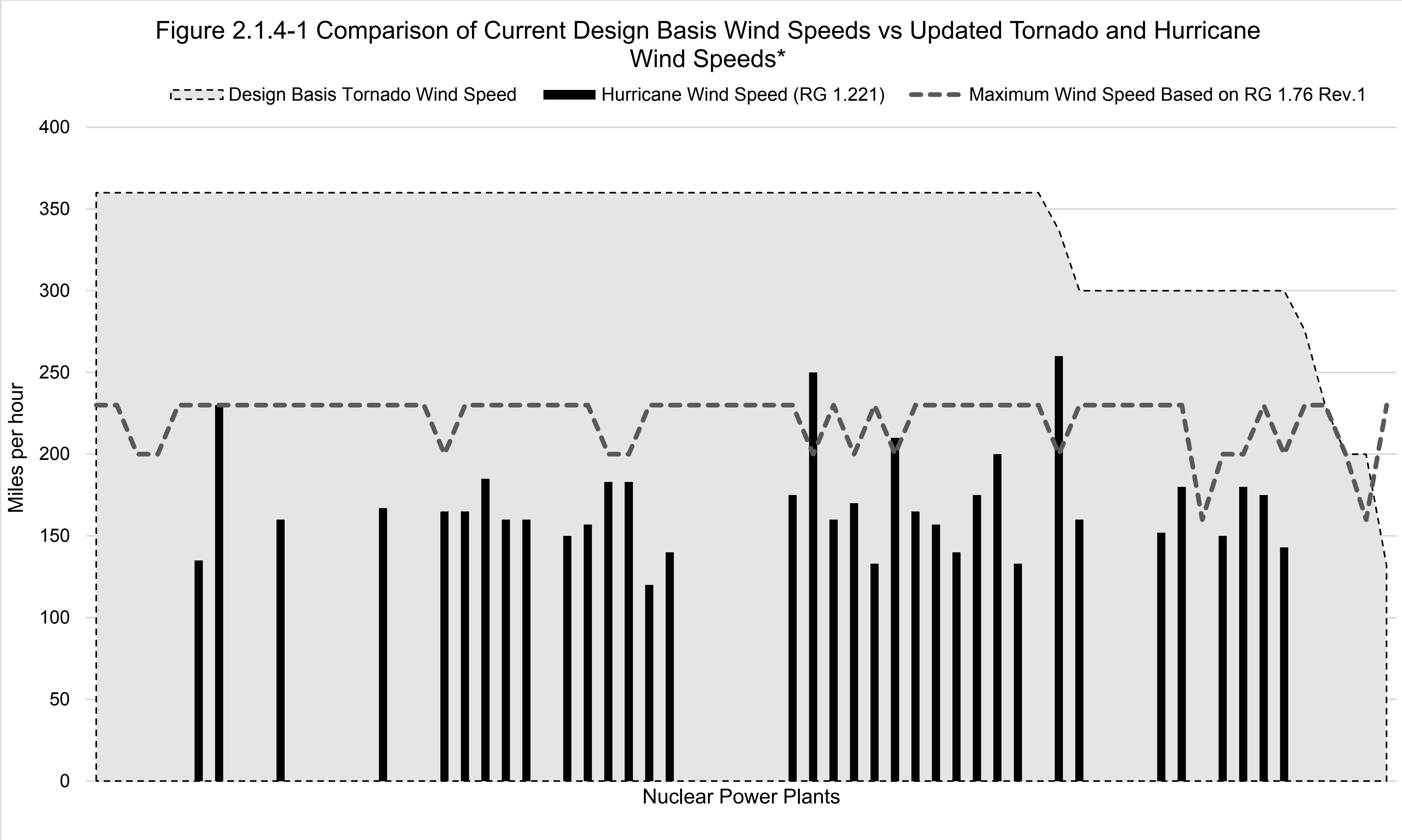
As documented in SECY-15-0137, the staff supported several public meetings during the development of the processes described in this paper. On October 6, 2015, the staff provided the Advisory Committee on Reactor Safeguards (ACRS) Fukushima Subcommittee an overview of the staff's plans to resolve the open Tier 2 and 3 recommendations. The staff also discussed these plans 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 the status of Tier 2 and 3 activities in public meetings held on November 17, 2015, and May 17, 2016.

The staff also held a number of public meetings to solicit input on its evaluation of natural hazards other than seismic and flooding that is found in SECY-16-0074. The NRC staff provided a draft white paper to stakeholders for their review and comment prior to the public meetings (ADAMS Accession No. ML16039A054), which contained much of the staff's assessment found in SECY-16-0074. The staff held a Category 3 public meeting on April 5, 2016 (ADAMS Accession No. ML16106A234). In addition, the NRC staff provided an email address and accepted comments on the draft white paper through April 12, 2016. The NRC staff also briefed the ACRS Fukushima Subcommittee on April 21, 2016, and ACRS Full Committee on May 5, 2016, on the staff's assessment of natural hazards other than seismic and flooding found in SECY-16-0074. The ACRS issued a letter on May 17, 2016 (ADAMS Accession No. ML16130A254), providing its conclusions and recommendations associated with the staff's assessment.

The staff held a public meeting on July 21, 2016, to solicit stakeholder comments specifically on its approach to addressing high winds and snow (ADAMS Accession No. ML16207A436). In addition, the staff issued a white paper on September 22, 2016 (ADAMS Accession No. ML16230A384), which provides much of the staff's assessment found in this enclosure. The staff briefed the ACRS Fukushima Subcommittee on October 19, 2016, and the ACRS Full Committee on November 30, 2016. The ACRS issued a letter on December 13, 2016 (ADAMS Accession No. ML16341B333) providing its conclusions and recommendations associated with the staff's assessment, including a conclusion that additional regulatory actions related to high winds and snow loads cannot be justified. The staff considered the ACRS recommendations in finalizing the proposals in this paper and intends to respond formally in January 2017.

4.0. Conclusion

Based on its assessments using the Task 3 process described in SECY-16-0074, the staff concludes that external events related to high winds and snow loads do not warrant additional regulatory action, and that the staff's evaluation of external hazards other than seismic and flooding is complete.



*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.

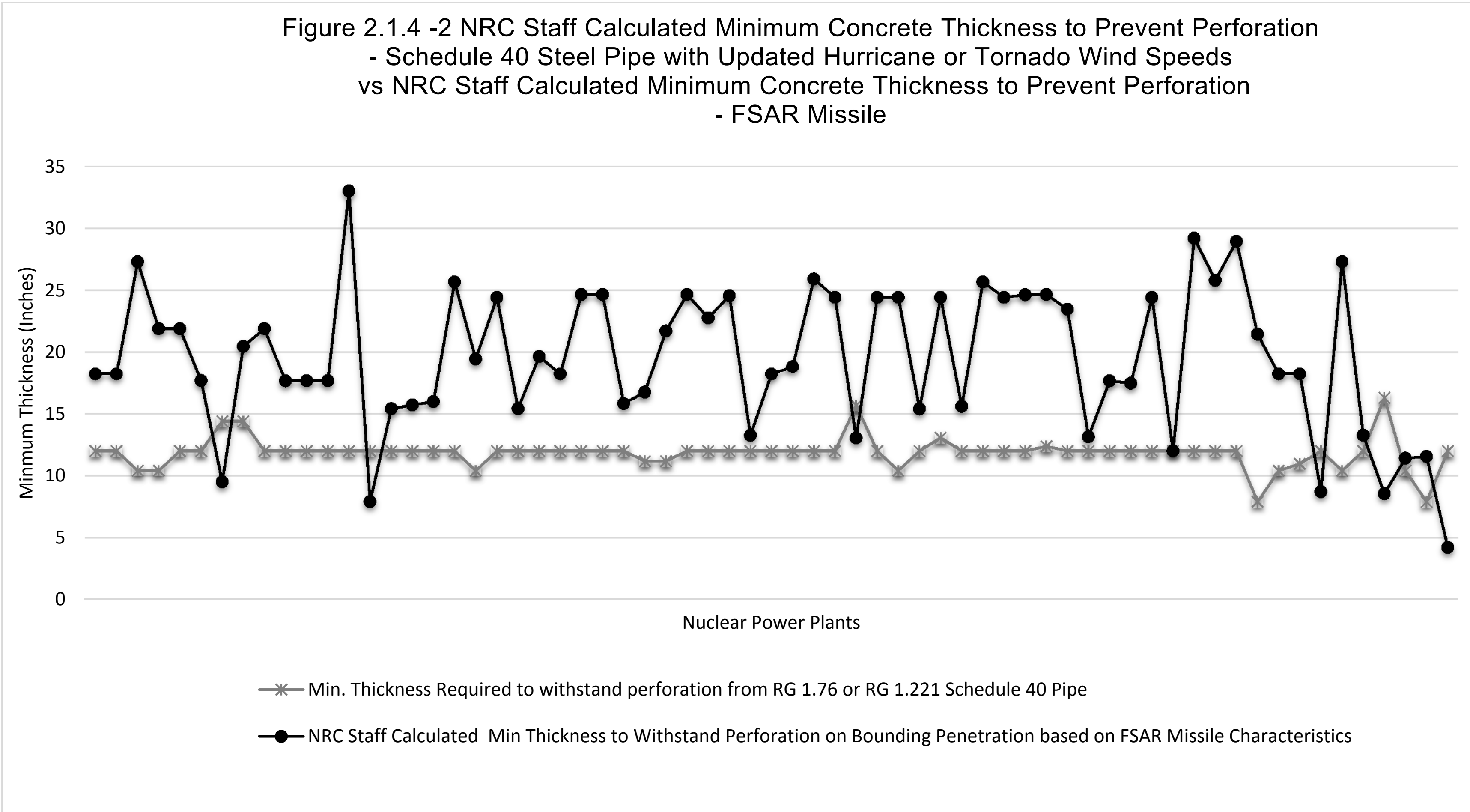
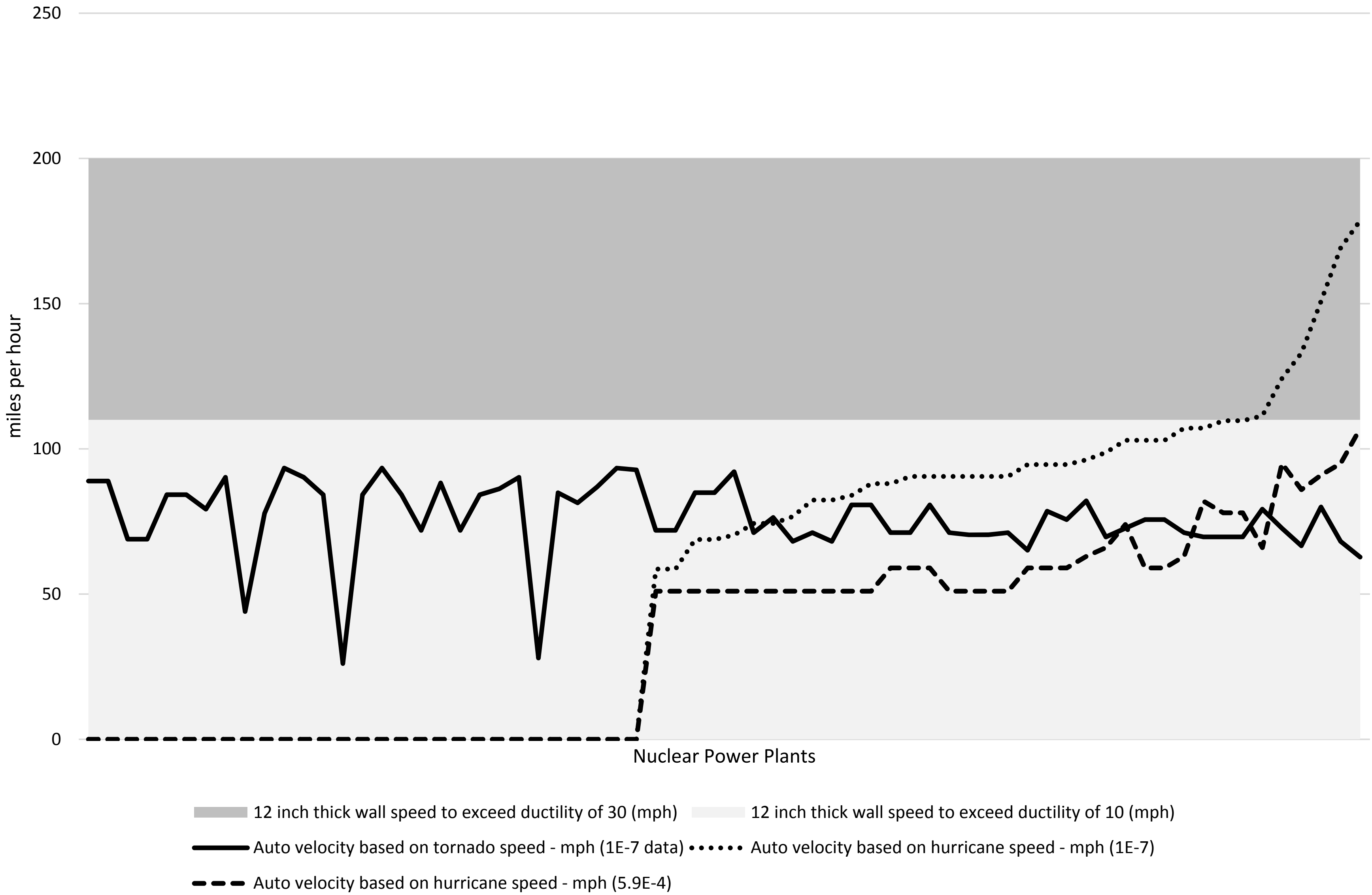


Figure 2.1.4 -2 NRC Staff Calculated Minimum Concrete Thickness to Prevent Perforation
- Schedule 40 Steel Pipe with Updated Hurricane or Tornado Wind Speeds
vs NRC Staff Calculated Minimum Concrete Thickness to Prevent Perforation
- FSAR Missile
35
30
25
20
15
10
5
0
Minmum Thickness (Inches)
Nuclear Power Plants
Min. Thickness Required to withstand perforation from RG 1.76 or RG 1.221 Schedule 40 Pipe
NRC Staff Calculated Min Thickness to Withstand Perforation on Bounding Penetration based on FSAR Missile Characteristics

Figure 2.1.4-3 Automobile Missile Speeds



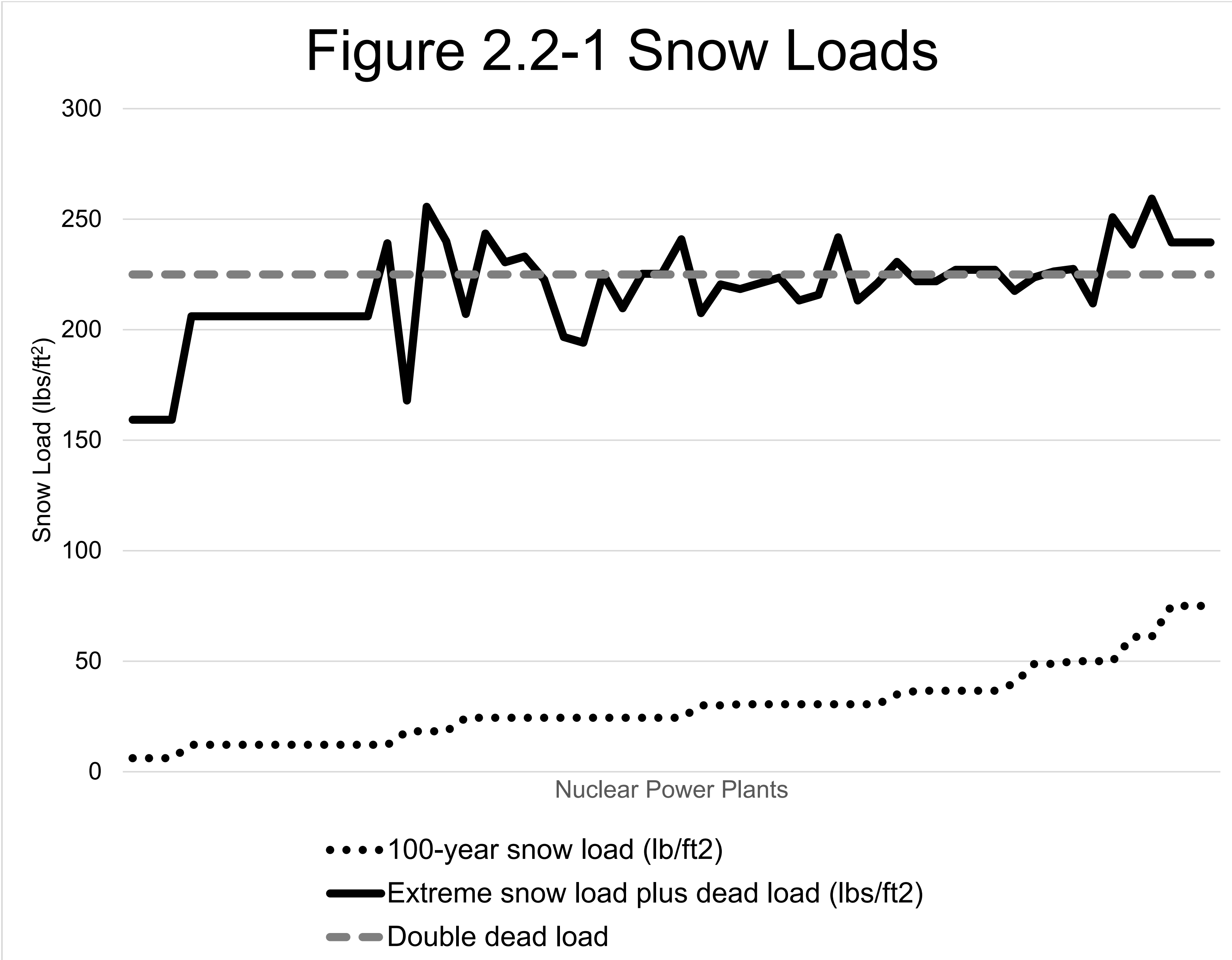


Figure 2.2-1 Snow Loads
300
250
200
150
100
50
0
Snow Load (lbs/ft²)
Nuclear Power Plants
100-year snow load (lb/ft2)
Extreme snow load plus dead load (lbs/ft2)
Double dead load

Table 2.1.4.4 – 1 Summary of High Winds Mitigation Strategies for Select Nuclear Power Plants

<table>
<tr><th>Site</th><th>Summary of High Winds Mitigation Strategy</th></tr>
<tr><td>Brunswick</td><td>As described in the final integrated plan for the Brunswick site dated May 19, 2016 (ADAMS Accession No. ML16146A604), the FLEX storage building (FSB) was designed to withstand tornado loading based on RG 1.76, Revision 1, wind speeds and tornado missile speeds. The FLEX diesel generators (DGs) are pre-staged in the FLEX DG enclosure that meets the requirements of ASCE 7-10 for hurricane and tornado wind loading and the range of tornado missiles specified in Section 3.5.1.4 of the Brunswick updated UFSAR, which has the following tornado missile characteristics:

• Corrugated siding 4 feet (ft) x 8 ft, weighing 100 pounds (lb), traveling at 225 miles per hour (mph)
• Bolted wood decking 12 ft x 4 ft, weighing 450 lb, traveling at 200 mph
• A vehicle with a frontal area of 25 ft^2, weighing 4000 lb, traveling on the ground at 50 mph
• Cedar fence post, 33 lb, 6 inches (in) x 6 in, traveling end-on at 150 mph.

Core cooling during an extended loss of alternating current power (ELAP) is via safety-relief valve (SRV) discharge to the suppression pool. The steam from the reactor pressure vessel (RPV) drives the reactor core isolation cooling (RCIC) turbine, removing heat that would otherwise go directly to the suppression pool via the SRVs. The steam exhaust from the RCIC pump is discharged to the suppression pool to be quenched. The CST will initially provide suction to the RCIC pump until the licensee transfers suction to the suppression pool. RCIC pump suction will be transferred back to the CST when the suppression pool temperature reaches 190°F. Using this approach, the CST inventory is expected to support coping for approximately 52 hours following an event.

Although the CST for Unit 2 is located within the fall zone of the plant stack, the licensee’s analyses have determined that the stack would not fail under tornado wind loading or two times the safe shutdown earthquake (SSE). Additionally, missile barriers are positioned around the CSTs to provide protection from tornado missiles. Therefore, the CST for each unit is protected from applicable hazards and will be available following a beyond design basis external event.

Using electric power from the station batteries and pneumatic supplies from the nitrogen backup systems, the SRVs will remain functional following an ELAP. In addition to powering the SRVs, the station 125/250 volts direct current (DC) Division II batteries will also power the RCIC system and vital instrumentation. The licensee has permanently pre-staged FLEX DGs that can provide power within 1 hour of event initiation. If these FLEX DGs are not immediately available, the licensee can perform battery load shedding, which will extend availability of DC power from the batteries to two hours and ten minutes.</td></tr>
</table>

Site	Summary of High Winds Mitigation Strategy
D.C. Cook	As noted in the staff's November 9, 2015, safety evaluation for the licensee's implementation of Order EA-12-049 (ADAMS Accession No. ML15264A851), the FSB was designed for tornado wind loads resulting from a maximum tornado wind velocity of 360 mph (a tornado with a forward progression of 60 mph with rotational wind speed of 300 mph) and a coincidental pressure drop of 3 psi applied within three seconds, which is consistent with the D.C. Cook UFSAR. The building was designed for protection against the following tornado-generated missiles per UFSAR Table 5.1-1: • Bolted wood decking of 12 ft x 12 ft x 4 in, 450 lbs traveling at 200 mph. • Corrugated sheet siding of 4 ft x 4 ft 100 lbs traveling at 225 mph. • Passenger car of 4000 lbs. traveling along the ground at 50 mph. The licensee stated that the two front-end loaders stored outdoors are sufficiently separated such that there is assurance that at least one of the front-end loaders would survive the applicable site hazards, such as a tornado. During the audit, the licensee stated that the front-end loaders are stored approximately 1500 feet apart and roughly perpendicular to the predominant tornado path. In addition, one diesel fuel transport trailer is stored near the independent spent fuel storage installation area, another one is stored near the switchyards, and the third is stored inside the FSB. The auxiliary building and the portion of the turbine building supporting the mitigation strategies are designed to withstand high winds and tornado-borne missiles. The staff's safety evaluation also notes that each unit has one CST, which provides a qualified source of water for the turbine-driven auxiliary feedwater (TDAFW) pumps to provide water to the steam generators (SGs) for heat removal from the RCS. During an audit of the calculations that support the FLEX strategies, the NRC staff noted that the licensee performed evaluations (calculation No. 32-9222624-004 and calculation No. 32-9222496-002) that determined the CSTs will survive impact from the design-basis missiles up to a tank height of 16 ft-7 in. The licensee indicated that the survival of the CSTs up to a height of 16 ft-7 in ensures that there is sufficient water available for suction to the Units 1 and 2 TDAFW pumps for at least 12 hours, which allows time for portable Phase 2 FLEX equipment to be deployed.

Site	Summary of High Winds Mitigation Strategy
Ginna	As discussed in the staff's July 14, 2016, safety evaluation for the licensee's implementation of Order EA-12-049 (ADAMS Accession No. ML16124A038), at the onset of an ELAP, decay heat is removed by steaming from the SGs through the SG atmospheric relief valves or SG safety valves, and makeup to the SGs is initially provided by the TDAFW pump, if available, taking suction from the CST. Since the non-robust TDAFW pump may not be credited for certain beyond design basis external events, operators can be sent to the standby auxiliary feedwater (SAFW) building to make up to the SGs using one of two installed SAFW pumps powered from the new SAFW DG, taking suction from the new 160,000 gallon (usable capacity), robustly designed SAFW deionized water storage tank. Subsequently, the operators would begin a controlled cooldown and depressurization of the RCS by manually operating the SG atmospheric relief valves. Section 3.6.1.3 of the staff's safety evaluation notes that in its final integrated plan associated with the mitigation strategies order, the licensee stated that, consistent with NEI 12-06, Section 7.3.1.1.a., the structural walls and roof of the new "robust structure" housing the "N" set of FLEX mitigation equipment were designed to the Regulatory Guide 1.76 tornado wind speed and suite of tornado missiles. However, the building's entranceway and openings (e.g., as needed for ventilation) are designed to withstand the plant's design basis tornado (i.e., 132 mph wind speed) and tornado missile spectrum.
Indian Point 2	The Indian Point 2 final integrated plan, dated August 12, 2016 (ADAMS Accession No. ML16235A292), notes that Indian Point 2's licensing basis does not include tornado protections for the design of the buildings, structures, and components. Nevertheless, to provide additional protection over and above the current design and licensing basis, all tanks credited for the Indian Point 2 strategies have been designed to or have been evaluated to survive a 360 mph wind loading. In addition, two water sources are available to support each required strategy to provide defense in depth; this ensures that no single tornado missile occurring at the Indian Point site will prevent the fulfillment of the strategy. Since the credited tanks have been evaluated to exceed the current licensing basis, they are considered robust sources of water.

Site	Summary of High Winds Mitigation Strategy
Nine Mile Point 1	The unit is an early generation boiling water reactor with two emergency cooling loops that includes two condensers consisting of a tube bundle in a tank located above the reactor vessel. During operation of the emergency cooling loops, steam rises from the reactor vessel to the condenser tubes where it is condensed by boiling the condenser shell water. As the water condenses, it returns by gravity flow to the reactor vessel. As stated in the Nine Mile Point 1 final integrated plan, dated June 8, 2015 (ADAMS Accession No. ML15163A097), although the reactor water level will remain above the top of active fuel for at least 5.7 hours, upon recognition of an ELAP, plant personnel will proceed immediately with deployment of a portable FLEX diesel driven pump that will take suction from Lake Ontario at one of two pre-staged locations in the screen house and discharge to the installed control rod drive return header. This capability will be achieved within four hours from the onset of the ELAP. Alternate injection capability for core cooling from a portable FLEX diesel driven pump through the feedwater system can also be deployed in approximately 4 hours. The portable FLEX pump will be installed to take suction with non-collapsible hose from the screen house intake/Lake Ontario. Nine Mile Point has constructed a single hardened FLEX storage structure of approximately 8,400 square feet that will meet the requirements for the external events identified in NEI 12-06, such as earthquakes, external floods, storms (high winds and tornadoes), extreme snow, ice, extreme heat, and cold temperature conditions. The building design is based on SDC-1, “Structural Design Criteria,” Revision 7 (Nine Mile Point 2’s current licensing basis design for SSC for external hazards), which envelopes Nine Mile Point 1 requirements. Cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles are available. Permanent plant equipment that is contained in structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles, are available. The portion of the fire protection system that is robust with respect to seismic events, floods, and high winds and associated missiles is available as a water source.

Site	Summary of High Winds Mitigation Strategy
Oyster Creek	In an August 26, 2016, status report update to the mitigation strategies order (ADAMS Accession No. ML16239A034), the licensee provided a status of the open and confirmation items from the interim staff evaluation issued on February 19, 2014 (ADAMS Accession No. ML14030A513). In a letter dated December 6, 2016 (ADAMS Accession No. ML16342C392; not yet publicly available), the licensee reported that it was in full compliance with Order EA-12-049 and provided its final integrated plan. The interim staff evaluation notes that a simplified description of the Oyster Creek integrated plan to mitigate the postulated ELAP event is that the licensee will initially remove core decay heat by using the isolation condenser (IC) system. This system passively transfers heat from the reactor to the atmosphere. The system functions to remove decay heat as long as the proper valve lineup is maintained and the shell side of the IC is replenished with sufficient cooling water. The use of this system also helps to minimize the heat input into containment. Makeup to the shell side of the IC is provided by a diesel engine-driven FLEX pump taking suction from the ultimate heat sink (UHS). For Oyster Creek, the UHS supply is from the intake or discharge canal, which is connected to Barnegat Bay and ultimately the Atlantic Ocean. Reactor makeup is provided by a FLEX pump, supplied from the UHS, flowing through one train of the core spray system. A portable generator will be used to provide power to essential motor control centers to operate valves and other essential loads. This portable generator will also provide power to the installed battery chargers. The staff will review the licensee's final integrated plan and response to open items from the interim staff evaluation and issue a safety evaluation documenting the results of the review. Although the staff has not completed its review, the staff notes that the licensee's plans for addressing tornado protection relies on two sets of equipment being stored on site with an orientation and sufficient separation distance between them such that it is unlikely that a tornado will impact both sets of equipment. Regarding hurricanes, the August 26, 2016, letter notes that the licensee plans to address the staff's open items by revising their procedures to relocate the FLEX equipment for protection.

Site	Summary of High Winds Mitigation Strategy
Robinson	As discussed in the staff's March 31, 2016, safety evaluation for the licensee's implementation of Order EA-12-049 (ADAMS Accession No. ML16075A377), the permanent FSB is designed in accordance with ASCE 7-10 for high winds. The CST is not protected against wind-generated missiles. In order to provide protection from wind-generated missiles, the licensee modified the circulating water (CW) inlet bay at the main condenser with a FLEX connection in the bay to access the UHS from within the turbine building. Two portable low-pressure diesel pumpers are staged in the turbine building, are protected by the turbine pedestal structure, and are easily deployable at the CW inlet bay. The Phase 2 wind/missile strategy for AFW supply connects a pre-staged pumper to the CW inlet bay FLEX connection and discharges directly to the suction of the steam-driven auxiliary feedwater pump. This strategy can be accomplished in less than one hour with margin for debris removal. The inlet bay FLEX connection and low pressure pumpers can also be used to refill the AFW tanks. There are no installed means to provide borated water makeup following an ELAP. The primary method of boration and inventory control is to use a portable high pressure, low volume pump connected directly to the charging lines or safety injection headers from the refueling water storage tank (RWST) or a portable tanker containing borated water. The RWST is seismically qualified, but is not protected from wind or missiles. Portable high pressure pumping and portable tanker capability will be stored in the permanent FLEX storage building to support this function. The licensee added a FLEX connection at the base of the RWST to access this borated water, if it is available.

Site	Summary of High Winds Mitigation Strategy
Turkey Point	As described in the final integrated plan for the Turkey Point site, dated June 20, 2016 (ADAMS Accession No. ML16181A189), the FLEX equipment storage building meets the plant's design basis for tornado-driven missiles. The licensee's strategy for events that begin with the plant initially at 100 percent power removes the core decay heat by maintaining feedwater flow to the SGs and releasing steam from the SGs through the main steam safety valves (MSSVs) or the steam-dump-to-atmosphere valves, if available. The flow will initially be added by one of three redundant TDAFW pumps taking suction from a CST. A portable diesel-driven pump, FLEX well pump, is used to refill the CST from an artesian well, designated as the FLEX well, for the duration of the TDAFW pump operation. When the TDAFW pumps can no longer be operated reliably due to low steam pressure after plant shutdown, the FLEX well pump supplied from the FLEX well will be used to add water directly to the SGs. When CST makeup is available from the FLEX well or alternate sources, the RCS will be cooled down and depressurized utilizing the SGs. Upon RCS depressurization, the safety injection accumulators will partially inject into the RCS, thereby assisting with inventory and reactivity control. Both CSTs are designed to withstand wind events; however, the tanks are not designed to withstand design-basis missiles. Nevertheless, the current licensing basis considers one tank to be lost due to impact by a tornado missile with the other surviving, since they are at opposite ends on the east side of the turbine building and are separated by several hundred feet. Per UFSAR, Chapter 5, Appendix SE, redundancy and spacing of the CSTs provide the required system capability in the event of damage to one component by a tornado missile. Therefore, if the CST of one unit was impacted by a tornado missile, the CST from the opposite unit would be available to provided water to the TDAFW pump until the FLEX well pump can be used to refill the surviving CST or for use in feeding the SGs.

Site	Summary of High Winds Mitigation Strategy
Saint Lucie	As discussed in the staff's July 5, 2016, safety evaluation for the licensee's implementation of Order EA-12-049 (ADAMS Accession No. ML16167A473), all FLEX equipment is stored in a building capable of withstanding the site design-basis high wind conditions (including tornado missiles). In the event of an ELAP, the RCPs would coast down and flow in the RCS would transition to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by isolating potential RCS letdown paths. Decay heat is removed by steaming from the SGs through the atmospheric dump valves (ADVs) or MSSVs, and make-up to the SGs is initially provided by the TDAFW pump taking suction from the CST. Subsequently, the operators would begin a controlled cooldown and depressurization of the RCS by operating the SG ADVs. The RCS cooldown would commence at a rate of 75 degrees Fahrenheit per hour within 2 hours of the initiation of the ELAP event. At this cooldown rate, the intended RCS cooldown could be completed within an additional 2.5 to 3 hours. According to the licensee's revised FIP, the SGs are depressurized in a controlled manner to about 120 pounds per square inch atmosphere (psia). This SG depressurization will also reduce RCS temperature and pressure. Therefore, during the depressurization, operators would monitor RCS pressure and ensure that it is maintained above 170 psia during Phase 1 to avoid injection of the nitrogen cover gas from the safety injection tanks (SITs) into the RCS. The reduction in RCS temperature will further result in inventory contraction in the RCS, with the result that the pressurizer level is expected to indicate empty for some time. Some leakage from the RCP seals is also expected. However, passive injection of SIT inventory will maintain natural circulation in the RCS throughout Phase 1, without reliance upon FLEX RCS injection. The water supply for the TDAFW pump is initially from the CST. The fully protected (including from tornado missiles) inventory of both CSTs can be shared between Unit 1 and Unit 2 and will provide 17 hours of residual heat removal per unit. Before the CST empties, the operators will deploy a FLEX CST pump to restore CST inventory. The FLEX CST pump will draw water from the most preferable, available water supply that is available and discharge it to the CST.

Site	Summary of High Winds Mitigation Strategy
Waterford	As described in the final integrated plan for the Waterford site, dated July 21, 2016 (ADAMS Accession No. ML16203A321; not yet publicly available), the “N” set of FLEX equipment is stored within the nuclear plant island structure (which is designed to withstand tornado winds and tornado-borne missiles), a FLEX DG enclosure built on the reactor building roof (also designed to withstand tornado winds and tornado-borne missiles). The N+1 set of equipment described in NEI 12-06 is stored within the N+1 storage building that is designed to meet ASCE 7-10 guidance, which includes protection for high winds. Phase 1 core cooling and heat removal strategy relies upon natural circulation in the RCS through the steam generators. The existing turbine driven emergency feedwater pump (TDEFW) pump will provide feedwater from the condensate storage pool to the SGs. The condensate storage pool is protected against tornado winds and tornado-driven missiles. Steam generated within the SGs is exhausted directly to the atmosphere via the ADVs. During Phase 1, an initial plant cooldown and depressurization is performed to protect the RCP seals and thereby minimize RCS leakage. This cooldown and depressurization will also enable SIT injection for reactivity control and to maintain natural circulation within the RCS. DC bus load shedding ensures station Class 1E battery life is extended beyond 12 hours. Prior to depletion of the selected train of station Class 1E batteries, a FLEX DG is placed in service on the associated Class 1E ac bus to repower the credited FLEX Phase 2 equipment. At Phase 2, suction to the TDEFW pump is transferred to the wet cooling tower basin. After the FLEX DG is placed in service, SITs are isolated to preclude nitrogen cover gas injection into the RCS, and a charging pump is placed into service to maintain RCS inventory during the second plant cooldown. The charging pump also provides boron addition to ensure adequate shutdown margin is maintained. The Phase 2 strategy utilizes a permanently staged, electrically-driven FLEX core cooling pump to back up the TDEFW pump to maintain steam generator water levels. The FLEX core cooling pump is capable of operation after the FLEX DG is placed into service, the SITs are isolated, and the second plant cooldown is completed.