NEI 12-06 [Rev 4]

DIVERSE AND FLEXIBLE COPING STRATEGIES (FLEX) IMPLEMENTATION GUIDE

December 2016

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Nuclear Energy Institute

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NOTICE

REVISION TABLE

Revision	Description of Major Changes from Revision 2 to Revision 4[1]	Responsible Person
4	11.5 – Clarifications/revisions to 11.5.4	A.Mauer
4	11.6 – Clarification that guidance for FLEX drills is addressed in NEI 13-06	A.Mauer
4	13.2 – Clarification that the FIP need not be maintained indefinitely provided that the program document and a record of changes is maintained	A.Mauer
4	Tables C-3 and D-3 modified with respect to spent fuel pool spray capability consistent with NRC JLD-ISG-2012 Rev. 1	A.Mauer
4	Appendix H – Section H.4.3 – Clarification that the IPEEE does not need to be maintained	A.Mauer
4	Appendix H – Section H.4.5 – Section added to address seismic mitigation strategy assessments for plants with GMRS > 2X SSE	A.Mauer

[1] Revision 3 was issued on September 22, 2016 and was superseded by Revision 4

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DIVERSE AND FLEXIBLE COPING STRATEGIES (FLEX) IMPLEMENTATION GUIDE

1 INTRODUCTION

One of the primary lessons learned from the accident at Fukushima Dai-ichi was the significance of the challenge presented by a loss of safety-related systems following the occurrence of a beyond-design-basis external event. In the case of Fukushima Dai-ichi, the extended loss of alternating current (ac) power (ELAP) condition caused by the tsunami led to loss of core cooling and a significant challenge to containment. The design basis for U.S. nuclear plants includes bounding analyses with margin for external events expected at each site. Extreme external events (e.g., seismic events, external flooding, etc.) beyond those accounted for in the design basis are highly unlikely but could present challenges to nuclear power plants.

In order to address these challenges, this guide outlines the process to be used by licensees, Construction Permit (CP) holders, and Combined License (COL) holders to define and deploy strategies that will enhance their ability to cope with conditions resulting from beyond-design-basis external events. Although this guidance addresses events caused by a beyond-design-basis external event (BDBEE), the strategies may be applied for the identified set of plant conditions regardless whether they resulted from a BDBEE or other causes.

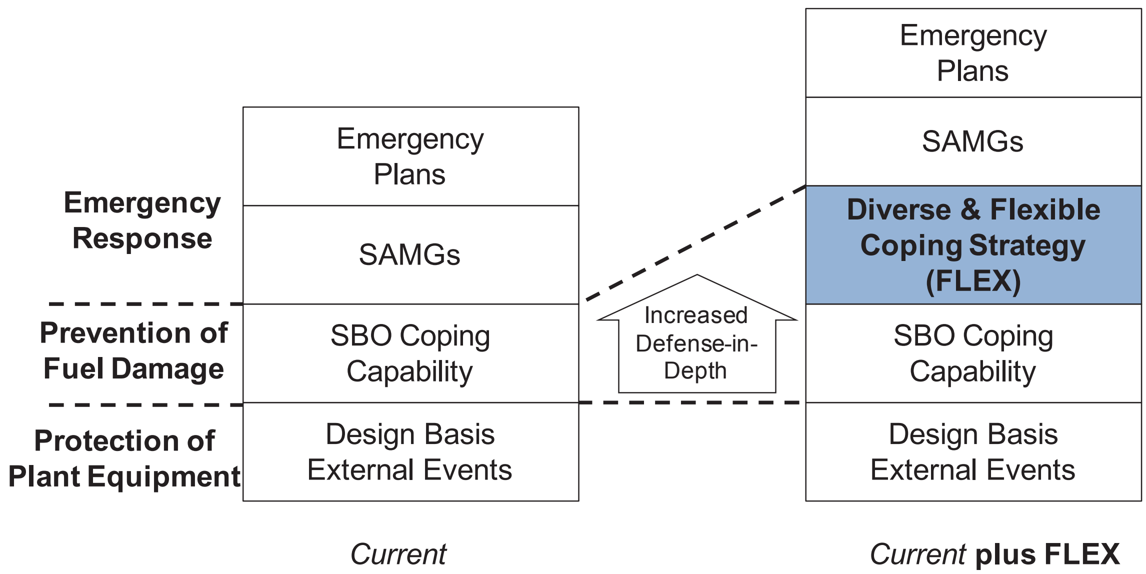
1.1 Background

The Fukushima Dai-ichi accident was the result of a tsunami that exceeded the plant's design basis and flooded the site's emergency power supplies and electrical distribution system. This extended loss of power severely compromised the key safety functions of core cooling and containment and ultimately led to core damage in three reactors. While the loss of power also impaired the spent fuel pool cooling function, sufficient water inventory was maintained in the pools to preclude fuel damage from loss of cooling.

The size of the tsunami that hit Fukushima Dai-ichi was not accounted for in the plant's design basis. Although the ability to predict the magnitude and frequency of BDBEEs) such as earthquakes and floods may be improving, and design bases for plants include some margin, some probability will always remain for a beyond-design-basis external event. As a result, though unlikely, external events could exceed the assumptions used in the design and licensing of a plant, as demonstrated by the events at Fukushima. Additional diverse and flexible strategies that address the potential consequences of these "beyond-design-basis external events" would enhance safety at each site.

The consequences of postulated beyond-design-basis external events that are most impactful to reactor safety are loss of power and loss of the ultimate heat sink. This document outlines an approach for adding diverse and flexible mitigation strategies—or FLEX— that will increase defense-in-depth for beyond-design-basis scenarios to address an ELAP and loss of normal access to the ultimate heat sink (LUHS) occurring simultaneously at all units on a site. (See Figure 1-1).

Figure 1-1
FLEX Enhances Defense-in-Depth



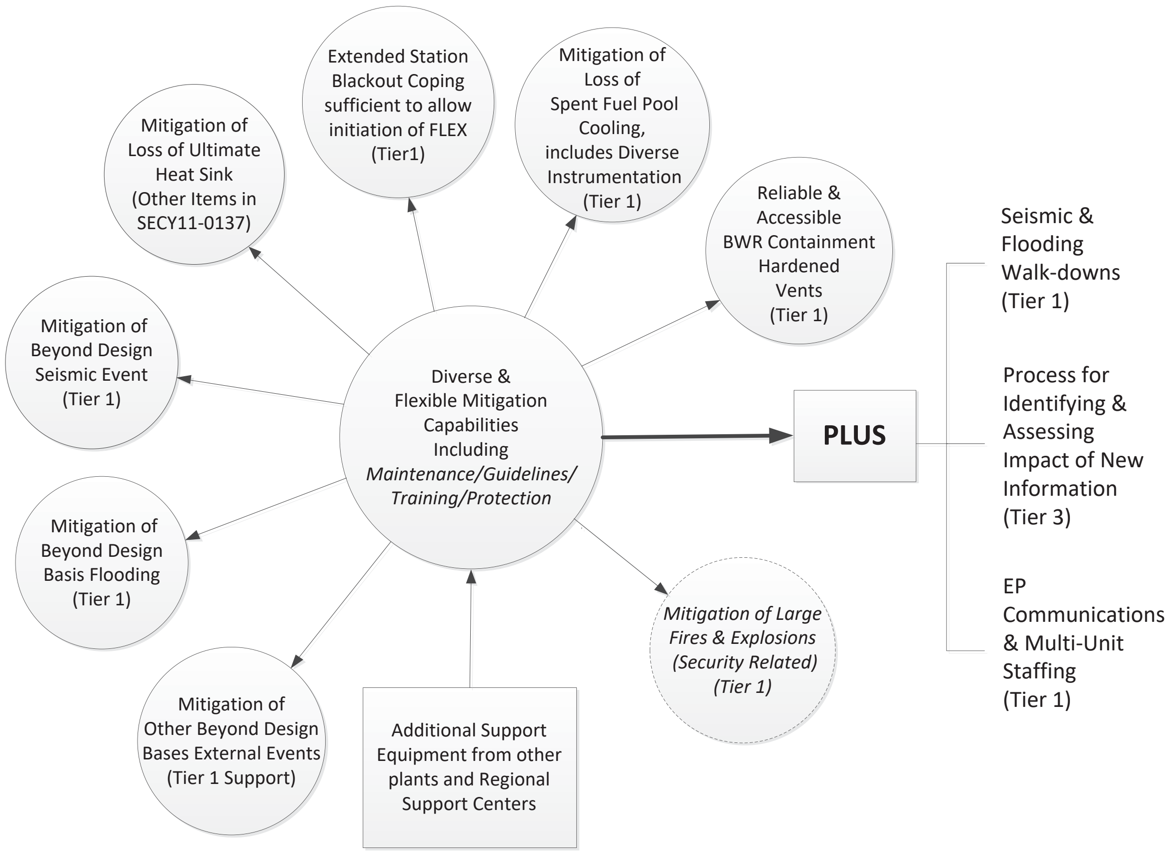
FLEX consists of the following elements:

- **Both plant and FLEX equipment that provides means of obtaining power and water to maintain or restore key safety functions for all reactors at a site.** This could include equipment such as pumps, generators, batteries and battery chargers, compressors, hoses, couplings, tools, debris clearing equipment, temporary flood protection equipment and other supporting equipment or tools.
- **Reasonable staging and protection of FLEX equipment from BDBEEs applicable to a site.** The FLEX equipment would be reasonably protected from applicable site-specific severe external events to provide reasonable assurance that N sets of FLEX equipment will remain deployable following such an event.
- **Procedures and guidance to implement FLEX strategies.** FLEX Support Guidelines (FSG), to the extent possible, will provide pre-planned FLEX strategies for accomplishing specific tasks in support of Emergency Operating Procedures (EOP) and Abnormal Operating Procedures (AOP) functions to improve the capability to cope with beyond-design-basis external events.
- **Programmatic controls that assure the continued viability and reliability of the FLEX strategies.** These controls would establish standards for quality, maintenance, testing of FLEX equipment, configuration management and periodic training of personnel.

The FLEX strategies will consist of both an on-site component using plant equipment as well as FLEX equipment stored at or near the plant site and an off-site component for the provision of additional materials and equipment for longer-term response.

By providing multiple means of power and water supply to support key safety functions, FLEX can mitigate the consequences of beyond-design-basis external events. Figure 1-2 depicts how FLEX can provide a common solution to mitigate multiple risks in an integrated manner. The figure also shows how FLEX comprehensively addresses the majority of the NRC's Tier 1 recommendations.

Figure 1-2
Overview of FLEX Concept



1.2 PURPOSE

The purpose of this guide is to outline the process to be used by individual licensees to define and implement site-specific diverse and flexible mitigation strategies that reduce the risks associated with beyond-design-basis conditions. Revision 0 of this guide was endorsed as an acceptable method to implement the requirements of Order EA-12-049, Order Modifying Licenses With Regard To Requirements For Mitigation Strategies For Beyond-Design-Basis External Events. This revision of the guide also provides an acceptable method to implement the requirements of Order EA-12-049 while also addressing mitigating strategy approaches for addressing reevaluated flooding and seismic hazard information. The revisions to the guide also align it with the Mitigating Beyond-Design-Basis Events rulemaking.

1.3 FLEX OBJECTIVES & GUIDING PRINCIPLES

The objective of FLEX is to establish an indefinite coping capability to prevent damage to the fuel in the reactor and spent fuel pools and to maintain the containment function by using plant equipment and FLEX equipment. This capability will address an ELAP (i.e., loss of off-site power, emergency diesel generators and any alternate ac source[2] but not the loss of ac power from buses fed by station batteries through inverters) concurrent with a LUHS which could arise following external events that are within the existing design basis with additional failures and conditions that could arise from a beyond-design-basis external event. Since the beyond-design-basis regime is essentially unlimited, plant features and insights from beyond-design-basis evaluations are used, where feasible, to inform coping strategies.

The FLEX strategies are focused on maintaining or restoring key plant safety functions and are not tied to any specific damage state or mechanistic assessment of external events. In some cases, additional hazard-specific boundary conditions are applied in order to cause the implementation strategies to be focused on the nature of challenges that are most likely for that hazard. A safety function-based approach is in keeping with the symptom-based approach taken to plant emergency operating procedures (EOPs) and facilitates the utilization of the FLEX strategies in support of the operating and emergency response network of procedures and guidance.

The underlying strategies for coping with these conditions involve a three-phase approach:

1. Initially cope by relying on plant equipment.
2. Augment or transition from plant equipment to on-site FLEX equipment and consumables to maintain or restore key functions.
3. Obtain additional capability and redundancy from off-site FLEX equipment until power, water, and coolant injection systems are restored or commissioned.

Plant-specific analyses will determine the duration of each phase. Recovery of the damaged plant is beyond the scope of FLEX capabilities as the specific actions and capabilities will be a function of the specific condition of the plant and these conditions cannot be known in advance.

To the extent practical, generic thermal hydraulic analyses will be developed to support plant-specific decision-making. Justification for the duration of each phase will address the on-site availability of equipment, the resources necessary to deploy the equipment consistent with the required timeline, anticipated site conditions following the beyond-design-basis external event, and the ability of the local infrastructure to enable delivery of equipment and resources from off-site.

While FLEX strategies are focused on the prevention of fuel damage, they would be available to support accident mitigation efforts following fuel damage. FLEX coordination with Severe Accident Management Guidelines (SAMGs) is addressed in NEI 14-01, Emergency Response Procedures and Guidelines for Beyond-Design-Basis Events and Severe Accidents.

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[2] Alternate AC source as defined in 10 CFR 50.2

1.4 Relationship to Other Tier 1 Requirements

Effective implementation of FLEX requires coordination with the following activities:

- Seismic walkdowns (NRC Request for Information (RFI) dated March 12, 2012 on Recommendation 2.3) – These walkdowns provide the basis for the capability of the plant to successfully respond to design basis seismic events, which is a foundation for the FLEX strategies.
- Flood walkdowns (NRC RFI dated March 12, 2012 on Recommendation 2.3) – These walkdowns provide the basis for the capability of the plant to successfully respond to design basis flooding events, which is a foundation for the FLEX strategies.
- Some BWR MK I and II units may utilize the vent capability installed under separate NRC order EA-13-109 to accomplish anticipatory venting to meet the requirements of mitigating strategies.
- SFP level instrumentation – The enhanced SFP instrumentation will support the implementation of FLEX strategies for maintaining SFP water level to prevent fuel damage.
- EOP/SAMG activities (Recommendation 8) – Implementation of FLEX will require coordination with plant EOPs and supporting procedures and guidance.
- Staffing and communications (NRC RFI dated March 12, 2012 on Recommendation 9.3) – Implementation of FLEX will utilize on-site and off-site communications capabilities, and the on-shift and augmented staff will implement appropriate FLEX strategies in response to a beyond-design-basis external event affecting all units on a site.

The FLEX strategies assumed a beyond-design-basis event caused the ELAP and LUHS but otherwise were based on the existing design bases. A mitigating strategies approach will be employed to address new beyond-design-basis flood and seismic hazard information. This mitigating strategies approach could rely on the FLEX strategies or could develop hazard-specific strategies based on a mitigating strategies assessment (MSA) of the new hazard information. The guidance for performing a MSA for the new flood hazard information is included in Appendix G, Mitigating Strategies Assessment for New Flood Hazard Information. The guidance for performing a MSA for the new seismic hazard information is included in Appendix H, Mitigating Strategies for the New Seismic Hazard Information.

1.5 APPLICABILITY

This guidance document is applicable to operating reactors and Combined License (COL) holders and addresses the development of mitigation strategies for beyond-design-basis external events. This guidance document may be used by Operating License and COL applicants in the development of plans for implementing strategies and guidelines to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities to mitigate a BDBEE.

2 OVERVIEW OF IMPLEMENTATION PROCESS

The accident at Fukushima Dai-ichi highlighted the potential challenges associated with coping with an ELAP. ELAP and LUHS have long been identified as contributors to nuclear power plant risk in plant-specific PRAs.

FLEX strategies will be determined based on two criteria. Each plant will establish the ability to cope with the baseline conditions for a simultaneous ELAP and LUHS event. Each plant would then evaluate the FLEX protection and deployment strategies in consideration of the challenges of the external hazards applicable to the site. Depending on the challenge presented, the approach and specific implementation strategy may vary.

Each plant and site has unique features and for this reason, the implementation of FLEX capabilities will be site-specific. This guideline is organized around the site assessment process shown in Figure 2-1. The guidance is provided to outline the steps, considerations, and ultimate FLEX strategies that are to be provided for each site.

<u>Boundary Conditions</u>

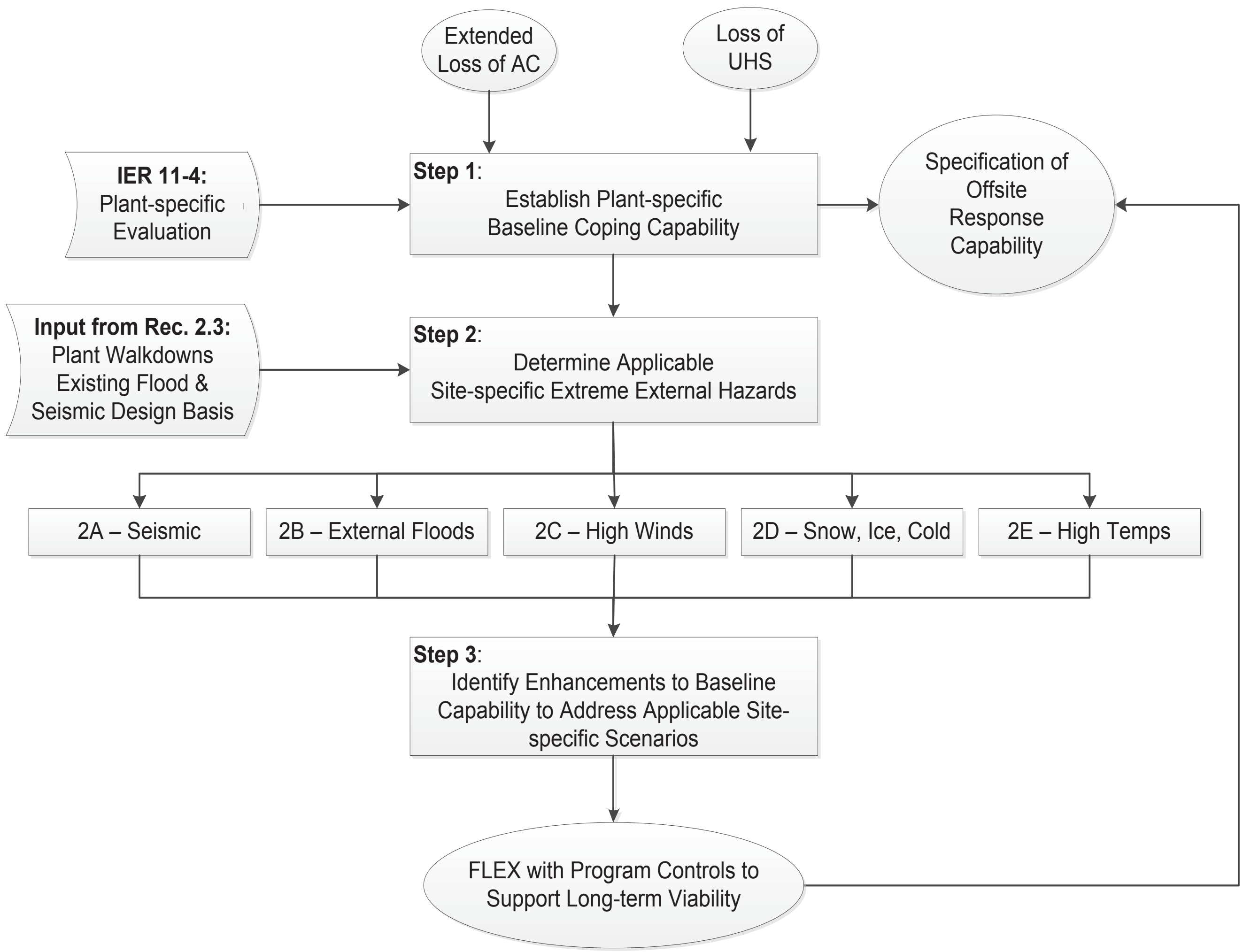
The following general boundary conditions apply to the establishment of FLEX strategies:

- Beyond-design-basis external event occurs impacting all units at site.
- All reactors on-site initially operating at power, unless site has procedural direction to shut down due to the impending event.
- Each reactor is successfully shut down when required (i.e., all rods inserted, no ATWS).
- On-site staff is at site administrative minimum shift staffing levels.
- No independent, concurrent events, e.g., no active security threat.
- All personnel on-site are available to support site response.
- Spent fuel in dry storage is outside the scope of FLEX.

In some cases, additional hazard-specific boundary conditions are defined for various types of external hazards.

The boundary conditions for core cooling and containment strategies assume all reactors on the site are initially at power because this is more challenging in terms of core protection. The FLEX strategies have been designed for this condition. However, the FLEX strategies are also “diverse and flexible” such that they can be implemented in many different conditions as it is not possible to predict the exact site conditions following a beyond-design-basis external event. As such, the strategies can be implemented in all modes by maintaining the FLEX equipment available to be deployed during all modes.

Figure 2-1
Site Assessment Process



The main body of this guidance is written for current generation LWRs. Appendix F provides guidance on the development of mitigation strategies for the AP 1000 design.

2.1 ESTABLISH BASELINE COPING CAPABILITY

The first step of FLEX capability development is the establishment of the baseline coping capability to address a simultaneous ELAP and LUHS event. In general, the baseline coping capability is established based on an assumed set of boundary conditions that arise from a beyond-design-basis external event. Each plant will establish the ability to cope for these baseline conditions utilizing a combination of plant and FLEX equipment. These capabilities will also improve the ability of each plant to respond to other causes of a simultaneous ELAP and LUHS not specifically the result of an external event.

Examples of the types of capabilities identified on a plant-specific basis include:

- Battery load shedding to extend battery life.
- Provision of additional small ac and/or direct current (dc) power sources to recharge batteries or energize key equipment and instrumentation.

In nearly all cases, the deployment of these enhanced coping strategies will require revisions to plant procedures/guidance, as current plant procedures were largely oriented to the conditions defined under 10 CFR 50.63.

The process for establishing a baseline coping capability is described in Section 3.

While initial approaches to FLEX strategies will take no credit for installed ac power supplies, longer term strategies may be developed to prolong Phase 1 coping that will allow greater reliance on permanently installed, bunkered or hardened ac power supplies that are adequately protected from external events.

2.2 DETERMINE APPLICABLE EXTREME EXTERNAL HAZARDS

This step of the site assessment process involves the evaluation of the external hazards that are considered credible to a particular site. For the purposes of this assessment, external hazards have been grouped into five classes to help further focus the effort:

- seismic events
- external flooding
- storms such as hurricanes, high winds, and tornadoes
- extreme snow, ice, and cold
- extreme heat

Each plant will evaluate the applicability of these hazards and, where applicable, address the implementation considerations associated with each. These considerations include:

- protection of FLEX equipment
- deployment of FLEX equipment
- procedural interfaces
- utilization of off-site resources

The process for determining the applicable external hazards and enhancing the baseline FLEX strategies to address these hazards is described in Sections 4 through 9. The aggregation of the FLEX storage and deployment considerations is discussed in Section 10.

2.3 Define Site-Specific FLEX Strategies

This step involves the consideration of the hazards that are applicable to the site, in order to establish the best overall strategy for the deployment of FLEX capabilities for beyond-design-basis conditions.

Considering the external hazards applicable to the site, the on-site FLEX equipment should be stored in a location or locations such that it is reasonably protected such that no one external event can reasonably fail the site FLEX capability. Reasonable protection can be provided for example, through provision of multiple sets of on-site FLEX equipment stored in diverse locations or through storage in structures designed to reasonably protect from applicable external events.

2.4 Programmatic Controls

The programmatic controls for implementation of FLEX include:

- quality attributes
- equipment design
- equipment storage
- procedure guidance
- maintenance and testing
- training
- staffing
- configuration control

Procedures and guidance to support deployment and implementation including interfaces to EOPs, special event procedures, abnormal event procedures, and system operating procedures, will be coordinated within the site procedural framework.

The storage requirements for the on-site FLEX equipment will be based on the results of the analysis performed in Sections 4 through 9.

The programmatic controls for FLEX strategies are described in Section 11.

2.5 Synchronization with Off-Site Resources

The timely provision of effective off-site resources will need to be coordinated by the site and will depend on the plant-specific analysis and strategies for coping with the effects of the beyond-design-basis external event. Arrangements will need to be established by each site for the off-site FLEX equipment and resources that will be required for the off-site phase.

The off-site response interfaces for FLEX capabilities are described in Section 12.

3 STEP 1: ESTABLISH BASELINE COPING CAPABILITY

The primary FLEX objective is to develop a plant-specific capability for coping with a simultaneous ELAP and LUHS event for an indefinite period through a combination of plant equipment and FLEX equipment. Each plant will establish the ability to cope for these baseline conditions based on the appropriate engineering analyses and procedural framework.

3.1 PURPOSE

All U.S. plants have a coping capability for station blackout (SBO) conditions under 10 CFR 50.63. In some cases, plants rely on installed battery capacity to support operation of ac-independent core cooling sources. While in other cases, stations rely on SBO diesel generators, gas turbines, or ac power from other on-site sources to mitigate the blackout condition. The U.S. plants also developed emergency response strategies to mitigate the effects of loss of large areas (LOLA) of the plant due to large fires and explosions.

While existing capabilities for coping with SBO conditions are robust, it is possible to postulate low-probability events and scenarios beyond a plant's design basis that may lead to a simultaneous ELAP and LUHS. The purpose of this step is to identify reasonable strategies and actions to establish an indefinite coping capability during which key safety functions are maintained for the simultaneous ELAP and LUHS conditions.

3.2 PERFORMANCE ATTRIBUTES

This baseline coping capability is built upon strategies that focus on a simultaneous ELAP and LUHS condition caused by unspecified events. The baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, plant equipment that is designed to be robust with respect to design basis external events is assumed to be fully available. Plant equipment that is not robust is assumed to be unavailable. The baseline assumptions are provided in Section 3.2.1.

3.2.1 General Criteria and Baseline Assumptions

The following subsections outline the general criteria and assumptions to be used in establishing the baseline coping capability.

3.2.1.1 General Criteria

Procedures and equipment relied upon should ensure that satisfactory performance of necessary fuel cooling and containment functions are maintained. A simultaneous ELAP and LUHS challenges both core cooling and spent fuel pool cooling due to interruption of normal ac powered system operations.

For a PWR, an additional requirement is to keep the fuel in the reactor covered. For a BWR, reactor core uncovery following RPV depressurization is allowed as long as it can be shown that adequate core cooling is maintained using analytical methods. For BWRs it is understood that containment venting may be required for decay heat removal purposes.

For both PWRs and BWRs, the requirement is to keep fuel in the spent fuel pool covered.

The conditions considered herein are beyond-design-basis. Consequently, it is not possible to bound all essential inputs to these evaluations. This document provides the appropriate rationale and assumptions for developing plant-specific strategies.

3.2.1.2 Initial Plant Conditions

The initial plant conditions are assumed to be the following:

1. Prior to the event the reactor has been operating at 100 percent rated thermal power for at least 100 days or has just been shut down from such a power history as required by plant procedures in advance of the impending event.
2. At the time of the postulated event, the reactor and supporting systems are within normal operating ranges for pressure, temperature, and water level for the appropriate plant condition. All plant equipment is either normally operating or available from the standby state as described in the plant design and licensing basis. The minimum conditions for plant equipment Operability or functionality do not need to be assumed in establishing the capability of that equipment to support FLEX strategies, provided in accordance with Section 11.2 there is an adequate basis for the assumed value (e.g., procedural controls). For example, the minimum Technical Specification value for level or volume of water for Operability of the Condensate Storage Tank does not need to be assumed for the site-specific ELAP analysis if the tank is normally maintained at a greater level or volume.

3.2.1.3 Initial Conditions

The following initial conditions are to be applied:

1. No specific initiating event is used. The initial condition is assumed to be a loss of off-site power (LOOP) at a plant site resulting from an external event that affects the off-site power system either throughout the grid or at the plant with no prospect for recovery of off-site power for an extended period. The LOOP is assumed to affect all units at a plant site.
2. All design basis installed sources of emergency on-site ac power and SBO alternate ac power sources[3] are assumed to be not available and not imminently recoverable. Station batteries and associated dc buses along with ac power from buses fed by station batteries through inverters remain available.

[3]Alternate AC source as defined in 10 CFR 50.2

3. Cooling and makeup water inventories contained in systems or structures with designs that are robust for the applicable hazard(s) [4] are available.
4. Normal access to the ultimate heat sink is lost, but the water inventory in the UHS remains available and robust piping connecting the UHS to plant systems remains intact. The motive force for UHS flow, i.e., service water or circulating water pumps, is assumed to be lost with no prospect for recovery. Fire or other pumps may be available provided they are robust for the applicable hazard(s).
5. Fuel for FLEX equipment stored in structures with designs which are robust for the applicable hazard(s) remains available.
6. Plant equipment that is contained in structures with designs that are robust for the applicable hazard(s) is available.
7. Other equipment, such as portable ac power sources, portable back up dc power supplies, spare batteries, and LOLA equipment, may be used as on-site FLEX equipment provided it is reasonably protected from the applicable external hazards per Sections 5 through 9 and Section 11.3 of this guidance and has predetermined hookup strategies with appropriate procedures/guidance and the equipment is stored in a relative close vicinity of the site.
8. Installed electrical distribution system, including inverters and battery chargers, remain available provided they are protected consistent with current station design.
9. No additional events or failures are assumed to occur immediately prior to or during the event, including security events.
10. The fire protection system ring header as a water source is acceptable only if the header is robust for the applicable hazard(s).

3.2.1.4 Reactor Transient

The following additional boundary conditions are applied for the reactor transient:

1. Following the loss of all ac power, the reactor automatically trips and all rods are inserted.
2. The main steam system valves (such as main steam isolation valves, turbine stops, atmospheric dumps, etc.), necessary to maintain decay heat removal functions operate as designed.
3. Safety/Relief Valves (S/RVs) or Power Operated Relief Valves (PORVs) initially operate in a normal manner if conditions in the RCS so require. Normal valve reseating is also assumed.

[4]Equipment only needs to be robust for the hazards for which it is relied on for mitigation.

4. No independent failures, other than those causing the ELAP/LUHS event, are assumed to occur in the course of the transient.

3.2.1.5 Reactor Coolant Inventory Loss

Sources of expected PWR and BWR reactor coolant inventory loss include:

1. Normal system leakage
2. losses from letdown unless automatically isolated or until isolation is procedurally directed
3. losses due to reactor coolant pump seal leakage (rate is dependent on the RCP seal design)
4. losses due to BWR recirculation pump seal leakage
5. BWR inventory loss due to operation of steam-driven systems, SRV cycling, and RPV depressurization.

Procedurally-directed actions can significantly extend the time to core uncovery in PWRs. However, RCS makeup capability is assumed to be required at some point in the extended loss of ac power condition for inventory and reactivity control.

3.2.1.6 SFP Conditions

The initial SFP conditions are:

1. All boundaries of the SFP are intact, including the liner, gates, transfer canals, etc.
2. Although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool.
3. SFP cooling system is intact, including attached piping.
4. SFP heat load assumes the maximum design basis heat load for the site.

3.2.1.7 Event Response Actions

Event response actions follow the command and control of the existing procedures and guidance based on the underlying symptoms that result from the event. The priority for the plant response is to utilize systems or equipment that provides the highest probability for success. Other site impacts as a result of the event would be addressed according to plant priorities and resource availability. The FLEX strategy relies upon the following principles:

1. Initially cope by relying on plant equipment.
2. Augment or transition from plant equipment to on-site FLEX equipment and consumables to maintain or restore key functions.

3. Obtain additional capability and redundancy from off-site resources until power, water, and coolant injection systems are restored or commissioned.
4. Response actions will be prioritized based on available equipment, resources, and time constraints. The initial coping response actions can be performed by available site personnel post-event.
5. Transition from plant equipment to FLEX equipment may involve on-site, off-site, or recalled personnel as justified by plant-specific evaluation.
6. Strategies that have a time constraint to be successful should be identified and a basis provided that the time can reasonably be met.

3.2.1.8 Effects of Loss of Ventilation

The effects of loss of HVAC in an extended loss of ac power event can be addressed consistent with NUMARC 87-00 [Ref. 8] or by plant-specific thermal hydraulic calculations, e.g., GOTHIC calculations.

3.2.1.9 Personnel Accessibility

Areas requiring personnel access should be evaluated to ensure that conditions will support the actions required by the plant-specific strategy for responding to the event.

3.2.1.10 Instrumentation and Controls

Actions specified in plant procedures/guidance for loss of ac power are predicated on use of instrumentation and controls powered by station batteries. In order to extend battery life, a minimum set of parameters necessary to support strategy implementation should be defined. The parameters selected must be able to demonstrate the success of the strategies at maintaining the key safety functions as well as indicate imminent or actual core damage to facilitate a decision to manage the response to the event within the Emergency Operating Procedures and FLEX Support Guidelines or within the SAMGs. Typically, these parameters would include the following:

PWRs	**BWRs**
• SG Level • SG Pressure • RCS Pressure • RCS Temperature • Containment Pressure • SFP Level	• RPV Level • RPV Pressure • Containment Pressure • Suppression Pool Level • Suppression Pool Temperature • SFP Level

The plant-specific evaluation may identify additional parameters that are needed in order to support key actions identified in the plant procedures/guidance (e.g., isolation condenser (IC) level), or to indicate imminent or actual core damage.

3.2.1.11 Containment Isolation Valves

It is assumed that the containment isolation actions delineated in current station blackout coping capabilities is sufficient.

3.2.1.12 Qualification of Plant Equipment

Plant equipment relied upon to support FLEX implementation does not need to be qualified to all extreme environments that may be posed, but some basis should be provided for the capability of the equipment to continue to function. Appendix G of Reference 8 contains information that may be useful in this regard.

3.2.1.13 FLEX Analyses, Methodologies and Generic Topics

As described above, in order to establish the FLEX capabilities, plant-specific analyses are required. Generally, best-estimate analyses are appropriate for this purpose. For some analyses, methodologies were established through the development of supplemental guidance. Additionally, generic topics were addressed similarly. The references to the supplemental guidance for these topics are as follows:

Topic	Subject	Guidance	NRC Endorsement	Notes Concerning Endorsement
Battery Duty Cycles	Extended battery life calculations for batteries	Nuclear Energy Institute (NEI) August 27, 2013 "Extended Battery Duty Cycles"	ML13241A188	Letter contains limitations
Boron Mixing	PWR Boron mixing	PWROG LTR-FSE-13-46, Rev. 0	ML13276A183	Letter contains limitations
BWR Anticipatory Venting	EOP override limits when only steam driven pump available	BWROG-13059 November 1, 2013	ML13358A206	None
CENTS Thermal-Hydraulic Code	Code handling of 2 phase flow and reflux cooling in PWRs	PWROG LTR-TDA-13-20-P, Rev. 0November 20, 2013	ML13276A555	Letter contains limitations.
Maintenance Guide for FLEX	PM basis from EPRI Template	EPRI 3002000623	ML13276A224	None
MAAP analysis	Use of MAPP analysis for FLEX conditions	EPRI 3002001785	ML13275A318	Letter contains limitations
Shutdown/ Refueling Modes	Provides required guidance for Shutdown/ Refueling Modes	Nuclear Energy Institute (NEI) September 18, 2013, "Position Paper: Shutdown/ Refueling Modes"	ML13267A382	The information for shutdown modes was incorporated into Section 3.2.3
NOTRUMP Thermal-Hydraulic Code	Code handling of 2 phase flow and reflux cooling in PWRs	PWROG-14064-P Revision 0 PWROG-14027-P Revision 3	ML15061A442	Letter contains limitations
SHIELD Reactor Coolant Pump	Seal leakage values	TR-FSE-14-1-P, Revision 1 and TR-	ML14132A128	Letter contains limitations

Seals		FSE-14-1-NP, Revision 1,		
FLOWSERVE Reactor Coolant Pump Seals	Seal leakage values	PWROG LTR-OG-15-313, August 5, 2015	ML15310A094	Letter contains limitations
Original Westinghouse Reactor Coolant Pump Seals	Seal leakage values	PWROG-14008-P, Revision 2 PWROG-14015-P, Revision 2 PWROG-14027-P, Revision 3 PWROG-14074-P, Revision 0		
National SAFER Response Centers	Conformance of the NSRCs to the guidance in Section 12	NEI September 11, 2014, "National SAFER Response Center Operational Status" Letter	ML14265A107	None
Change Processes	Application of regulatory change processes to BDBEEs	NEI August 19, 2014, "Change Process with respect to BDB applications"	ML14147A073	None
Maintenance Rule	Application of the Maintenance Rule to FLEX equipment	NEI June 24, 2015 letter Revision 4B to NUMARC 93-01.	ML15097A034	None
Hoses and cables	Quantity of spare lengths of hoses and cables	NEI May 1, 2015 letter, "Alternative Approach to NEI 12-06 Guidance for Hoses and Cables"	ML15125A442	Letter contains clarification.

3.2.2 Minimum Baseline Capabilities

Each site should establish the minimum coping capabilities consistent with unit-specific evaluation of the potential impacts and responses to an ELAP and LUHS. In general, this coping can be thought of as occurring in three phases:

- Phase 1: Cope relying on plant equipment.
- Phase 2: Augment or transition from plant equipment to on-site FLEX equipment and consumables to maintain or restore key functions.
- Phase 3: Obtain additional capability and redundancy from off-site equipment until power, water, and coolant injection systems are restored or commissioned.

In order to support the objective of an indefinite coping capability, each plant will be expected to establish capabilities consistent with Table 3-1 (BWRs) or Table 3-2 (PWRs). Additional explanation of these functions and capabilities are provided in Appendices C and D.

The overall plant response to an ELAP and LUHS will be accomplished through the use of normal plant command and control procedures and practices. The normal emergency response capabilities will be used as defined in the facility emergency plan, as augmented by NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities. As described in Section 11.4, the plant emergency operating procedures (EOPs) will govern the operational response. This ensures that a symptom-based approach is taken to the response, available capabilities are utilized, and control of the plant is consistent with EOP requirements, e.g., control of key parameters, cooldown rate, etc. The FLEX strategies will be deployed in support of the EOPs using separate FLEX Support Guidelines (FSGs) that govern the use of FLEX equipment in maintaining or restoring key safety functions.

The following guidelines are provided to support the development of guidance to coordinate with the existing set of plant operating procedures/guidance:

1. *Plant procedures/guidance should identify site-specific actions necessary to restore ac power to essential loads. If an Alternate ac (AAC) power source is available it should be started as soon as possible. If not, actions should be taken to secure existing equipment alignments and provide an alternate power source as soon as possible based on relative plant priorities.*

   While initial actions following the event may focus on restoration of ac power to essential loads, procedural guidance needs to assure a timely decision is made on whether or not the BDBEE has resulted in an SBO condition that is an ELAP. This is an important decision to ensure that actions to maintain or restore key safety functions are taken consistent with the timelines required for the successful implementation of the FLEX strategies for the initial response phase.

2. *Plant procedures/guidance should recognize the importance of AFW/HPCI/RCIC/IC during the early stages of the event and direct the operators to invest appropriate attention to assuring its initiation and continued, reliable operation throughout the transient since this ensures decay heat removal.*

   The risk of core damage due to ELAP can be significantly reduced by assuring the availability of AFW/HPCI/RCIC/IC, particularly in the first 30 minutes to one hour of the event. Assuring that one of these systems has been initiated to provide early core heat removal, even if local initiation and control is required is an important initial action. A substantial portion of the decay and sensible reactor heat can be removed during this period. AFW/HPCI/RCIC/IC availability can be improved by providing a reliable supply of water, monitoring turbine conditions (particularly lubricating oil flow and temperature), bypassing automatic trips, and maintaining nuclear boiler/steam generator water levels. These actions help ensure that the core remains adequately covered and cooled during an extended loss of ac power event.

3. *Plant procedures/guidance should specify actions necessary to assure that plant equipment functionality can be maintained (including support systems or alternate method) in an ELAP/LUHS or can perform without ac power or normal access to the UHS.*

   Cooling functions provided by such systems as auxiliary building cooling water, service water, or component cooling water may normally be used in order for plant equipment to perform their function. It may be necessary to provide an alternate means for support systems that require ac power or normal access to the UHS, or provide a technical justification for continued functionality without the support system.

4. *Plant procedures/guidance should identify the sources of potential reactor inventory loss, and specify actions to prevent or limit significant loss.*

   Actions should be linked to clear symptoms of inventory loss (e.g., specific temperature readings provided by sensors in relief valve tail pipes, letdown losses, etc.), associated manual or dc motor driven isolation valves, and their location. Procedures/guidance should establish the priority for manual valve isolation based on estimated inventory loss rates early in the event. If manual valves are used for leak isolation, they should be accessible, sufficiently lighted (portable lighting may be used) for access and use, and equipped with a hand wheel, chain or reach rod. If valves are locked in position, keys or cutters should be available. Procedures/guidance should identify the location of valves, keys and cutters.

5. *Plant procedures/guidance should ensure that a flow path is promptly established for makeup flow to the steam generator/nuclear boiler and identify backup water sources in order of intended use. Additionally, plant procedures/guidance should specify clear criteria for transferring to the next preferred source of water.*

   Under certain beyond-design-basis conditions, the integrity of some water sources may be challenged. Coping with an ELAP/LUHS may require water supplies for multiple days. Guidance should address alternate water sources and water delivery systems to support the extended coping duration. 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 assumed to be available in an ELAP/LUHS at their nominal capacities. Water in robust UHS piping may also be available for use but would need to be evaluated to ensure adequate NPSH can be demonstrated and, for example, that the water does not gravity drain back to the UHS. Alternate water delivery systems can be considered available on a case-by-case basis. In general, all condensate storage tanks should be used first if available. If the normal source of makeup water (e.g., CST) fails or becomes exhausted as a result of the hazard, then robust demineralized, raw, or borated water tanks may be used as appropriate. Heated torus water can be relied upon if sufficient NPSH can be established. Finally, when all other preferred water sources have been depleted, lower water quality sources may be pumped as makeup flow using available plant or FLEX equipment (e.g., a diesel driven fire pump or a pump drawing from a raw water source). Procedures/guidance should clearly specify the conditions when the operator is expected to resort to increasingly impure water sources. A heat transfer analysis is not required when crediting an alternate makeup water source using raw water, provided the procedures/guidance include actions to be taken to transition to a more preferable water source as soon as is practical.

6. *Plant procedures/guidance should identify loads that need to be stripped from the plant dc buses (both Class 1E and non-Class 1E) for the purpose of conserving dc power.*

   DC power is needed in an ELAP for such loads as shutdown system instrumentation, control systems, and dc backed AOVs and MOVs. Emergency lighting may also be powered by safety-related batteries. However, for many plants, this lighting may have been supplemented by Appendix R and security lights, thereby allowing the emergency lighting load to be eliminated. ELAP procedures/guidance should direct operators to conserve dc power during the event by stripping nonessential loads as soon as practical. Early load stripping can significantly extend the availability of the unit's Class 1E batteries. In certain circumstances, AFW/HPCI /RCIC operation may be extended by throttling flow to a constant rate, rather than by stroking valves in open-shut cycles.

   Given the beyond-design-basis nature of these conditions, it is acceptable to strip loads down to the minimum plant equipment necessary and one set of instrument channels for required indications. Credit for load-shedding actions should consider the other concurrent actions that may be required in such a condition.

7. *Plant procedures/guidance should specify actions to permit appropriate containment isolation and safe shutdown valve operations while ac power is unavailable*

   Compressed air is used to operate (cycle) some valves used for decay heat removal and in reactor auxiliary systems (e.g., identifying letdown valves or reactor water cleanup system valves that need to be closed). Most containment isolation valves are in the normally closed or failed closed position during power operation. Many other classes of containment isolation valves are not of concern during an extended loss of ac power.

8. *Plant procedures/guidance should identify the lighting (e.g., flashlights or headlamps) and communications systems necessary for ingress and egress to plant areas required for deployment of FLEX strategies.*

   Areas requiring access for instrumentation monitoring or equipment operation may require lighting as necessary to perform essential functions.

   Normal communications may be lost or hampered during an ELAP. Consequently, in some cases, portable communication devices may be required to support interaction between personnel in the plant and those providing overall command and control.

9. *Plant procedures/guidance should consider the effects of ac power loss on area access, as well as the need to gain entry to the Protected Area and internal locked areas where remote equipment operation is necessary.*

   At some plants, the security system may be adversely affected by the loss of the preferred or Class 1E power supplies in an ELAP. In such cases, manual actions specified in ELAP response procedures/guidance may require additional actions to obtain access.

10. *Plant procedures/guidance should consider loss of ventilation effects on specific energized equipment necessary for shutdown (e.g., those containing internal electrical power supplies or other local heat sources that may be energized or present in an ELAP.*

   ELAP procedures/guidance should identify specific actions to be taken to ensure that equipment failure does not occur as a result of a loss of forced ventilation/cooling. Actions should be tied to either the ELAP/LUHS or upon reaching certain temperatures in the plant. Plant areas requiring additional air flow are likely to be locations containing shutdown instrumentation and power supplies, turbine-driven decay heat removal equipment, and in the vicinity of the inverters. These areas include: steam driven AFW pump room, HPCI and RCIC pump rooms, the control room, and logic cabinets. Air flow may be accomplished by opening doors to rooms and electronic and relay cabinets, and/or providing supplemental air flow.

   Air temperatures may be monitored during an ELAP/LUHS event through operator observation, portable instrumentation, or the use of locally mounted thermometers inside cabinets and in plant areas where cooling may be needed. Alternatively, procedures/guidance may direct the operator to take action to provide for alternate air flow in the event normal cooling is lost. Upon loss of these systems, or indication of temperatures outside the maximum normal range of values, the procedures/guidance should direct supplemental air flow be provided to the affected cabinet or area, and/or designate alternate means for monitoring system functions.

   For the limited cooling requirements of a cabinet containing power supplies for instrumentation, simply opening the back doors is effective. For larger cooling loads, such as HPCI, RCIC, and AFW pump rooms, portable engine-driven blowers may be considered during the transient to augment the natural circulation provided by opening doors. The necessary rate of air supply to these rooms may be estimated on the basis of rapidly turning over the room's air volume.

Temperatures in the HPCI pump room and/or steam tunnel for a BWR may reach levels which isolate HPCI or RCIC steam lines. Supplemental air flow or the capability to override the isolation feature may be necessary at some plants. The procedures/guidance should identify the corrective action required, if necessary.

Actuation setpoints for fire protection systems are typically at 165-180°F. It is expected that temperature rises due to loss of ventilation/cooling during an ELAP/LUHS will not be sufficiently high to initiate actuation of fire protection systems. If lower fire protection system setpoints are used or temperatures are expected to exceed these temperatures during an ELAP/LUHS, procedures/guidance should identify actions to avoid such inadvertent actuations or the plant should ensure that actuation does not impact long term operation of the equipment.

11. *Plant procedures/guidance should consider accessibility requirements at locations where operators will be required to perform local manual operations.*

    Due to elevated temperatures and humidity in some locations where local operator actions are required (e.g., manual valve manipulations, equipment connections, etc.), procedures/guidance should identify the protective clothing or other equipment or actions necessary to protect the operator, as appropriate.

    FLEX strategies must be capable of execution under the adverse conditions (unavailability of installed plant lighting, ventilation, etc.) expected following a BDBE resulting in an ELAP/LUHS. Accessibility of equipment, tooling, connection points, and plant components shall be accounted for in the development of the FLEX strategies. The use of appropriate human performance aids (e.g., component marking, connection schematics, installation sketches, photographs, etc.) shall be included in the FLEX guidance implementing the FLEX strategies.

12. *Plant procedures/guidance should consider loss of heat tracing effects for plant equipment required to cope with an ELAP. Alternate steps, if needed, should be identified to supplement planned action.*

    Heat tracing is used at some plants to ensure cold weather conditions do not result in freezing important piping and instrumentation systems with small diameter piping. Procedures/guidance should be reviewed to identify if any heat traced systems are relied upon to cope with an ELAP. For example, additional condensate makeup may be supplied from a system exposed to cold weather where heat tracing is needed to ensure control systems are available. If any such systems are identified, additional backup sources of water not dependent on heat tracing should be identified.

13. *Use of FLEX equipment, e.g., power supplies, pumps, etc., can extend plant coping capability. The procedures/guidance for implementation of the FLEX equipment should address the transitions from plant equipment to the FLEX equipment.*

    The use of FLEX equipment to charge batteries or locally energize plant equipment may be needed under ELAP/LUHS conditions. Appropriate electrical isolations and interactions should be addressed in procedures/guidance.

    Regardless of installed coping capability, all plants will include the ability to use FLEX equipment to provide RPV/RCS/SG makeup as a means to provide a diverse capability beyond plant equipment. The use of FLEX equipment to provide RPV/RCS/SG makeup requires a transition and interaction with installed systems. For example, transitioning from RCIC to FLEX equipment as the source for RPV makeup requires appropriate controls on the depressurization of the RCS and injection rates to avoid extended core uncovery. Similarly, transition to FLEX equipment for SG makeup from the TDAFW pump may require cooldown and depressurization of the SGs in advance of using the portable pump connections.

    Guidance should address both the proactive transition from plant equipment to FLEX equipment and reactive transitions in the event plant equipment degrades or fails. Preparations for reactive use of FLEX equipment should not distract site resources from establishing the primary coping strategy. In some cases, in order to meet the time-sensitive required actions of the site-specific strategies, the FLEX equipment may need to be stored in its deployed position.

    The fuel necessary to operate the FLEX equipment needs to be assessed in the plant-specific analysis to ensure sufficient quantities are available as well as to address delivery capabilities.

14. *Procedures/guidance should address the appropriate monitoring and makeup options to the SFP.*

    Traditionally, SFPs have not been thoroughly addressed in plant EOPs. In the case of an ELAP/LUHS, both the reactor and SFP cooling may be coincidently challenged. Monitoring of SFP level can be used to determine when SFP makeup is required.

    The sizing of FLEX equipment used to cool the SFP should be based on the maximum design basis heat load for the site. For the purposes of determining the response time for the SFP strategies when fuel is in the reactor vessel, the rate of inventory loss of the SFP should be calculated based on the worst case conditions for SFP heat load assuming the plant is at power.

15. *Procedures/guidance for units with BWR Mark III and PWR Ice Condenser containments should address the deployment of FLEX power supplies for providing backup power to the containment hydrogen igniters, including a prioritization approach for deployment.*

Hydrogen igniters support maintenance of containment function following core damage. While the FLEX strategies are focused on prevention of fuel damage, the igniters need to be in-service prior to significant hydrogen generation due to fuel damage in order to be effective. However, in the extreme conditions postulated in this guidance, a prioritization approach should be outlined to support on-site staff decision-making on whether resources should focus on deployment of FLEX capabilities for fuel damage prevention versus for containment protection following fuel damage. For example, if there are indications that plant equipment reliability is compromised by the beyond-design-basis condition, then a priority might be placed on re-powering the hydrogen igniters. Similarly, if the plant staff determines that the plant equipment is functioning well, then priority could be given to deployment of FLEX equipment.

16. *In order to assure reliability and availability, sufficient FLEX equipment should be provided.*

The site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where "N" is the number of units on-site. Thus, a two-unit site would nominally have at least three FLEX pumps, three sets of FLEX ac/dc power supplies, etc. It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the N+1 could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function (e.g., two separate means to repower instrumentation). In this case the FLEX equipment associated with each strategy does not require N+1. The existing LOLA pump and supplies can be counted toward the N+1, provided it meets the functional and storage requirements outlined in this guide. The N+1 capability applies to the FLEX equipment described in Tables 3-1 and 3-2 (i.e., that equipment that directly supports maintenance of the key safety functions). Other FLEX support equipment only requires an N capability.

Each site should have N sets of FLEX hoses and cables. In addition, each site should have spare hose and cable in a quantity that meets either of the two methods described below:

Method 1: Provide additional hose or cable equivalent to 10% of the total length of each type/size of hose or cable necessary for the "N" capability. For each type/size of hose or cable needed for the "N" capability, at least 1 spare of the longest single section/length must be provided.

- Example 1-1: An installation requiring 5,000 ft. of 5 in. diameter fire hose consisting of 100 50 ft. sections would require 500 ft. of 5 in. diameter spare fire hose (i.e., ten 50 ft. sections).
- Example 1-2: A pump requires a single 20 ft. suction hose of 4 in. diameter, its discharge is connected to a flanged hard pipe connection. One spare 4 in. diameter 20 ft. suction hose would be required.
- Example 1-3: An electrical strategy requires 350 ft. cable runs of 4/0 cable to support 480 volt loads. The cable runs are made up of 50 ft. sections coupled together. Eight cable runs (2 cables runs per phase and 2 cable runs for the neutral) totaling 2800 ft. of cable (56 sections) are required. A minimum of 280 ft. spare cable would be required or 6 spare 50 ft. sections.
- Example 1-4: An electrical strategy requires 100 ft. of 4/0 cable (4 cables, 100 ft. each) to support one set of 4 kv loads and 50 ft. of 4/0 (4 cables, 50 ft. each) to support another section of 4 kv loads. The total length of 4/0 cable is 600 ft. (100 ft. x 4 plus 50 ft. x 4). One spare 100 ft. 4/0 cable would be required representing the longest single section/length.

Method 2: Provide spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any single FLEX strategy.

- Example 2-1 – A FLEX strategy for a two unit site requires 8 runs each of 500 ft. of 5 in. diameter hose (4000 ft. per unit). The total length of 5 in. diameter hose required for the site is 8000 ft. with the longest run of 500 ft. Using this method, 500 ft. of 5 in. diameter spare hose would be required.

For either alternative method, both the N sets of hoses or cables and the spare hoses and cables would need to remain deployable following the BDBEE. Note: if a longer spare hose or cable length is substituted for a shorter length the capability of the flow path or circuit must be confirmed.

17. *Diversity and flexibility should be considered in the connection points for the FLEX strategies.*

The intention of this guidance is to have permanent, installed connection points for FLEX fluid and electrical equipment.

The FLEX fluid connections for core and SFP cooling functions are expected to have a primary and an alternate connection or delivery point (e.g., the primary means to put water into the SFP may be to run a hose over the edge of the pool).

Electrical diversity can be accomplished by providing a primary and alternate method to repower key plant equipment and instruments utilized in FLEX strategies. For example, a strategy to have the primary connection on an 'A' Train electrical bus (e.g., 4kV) and the alternate connection to the equivalent bus on the 'B' Train is acceptable.

At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site FLEX equipment. The secondary connection point may require reconfiguration (e.g., removal of valve bonnets or breaker) if it can be shown that adequate time is available and adequate resources are reasonably expected to be available to support the reconfiguration. Both the primary and alternate connection points do not need to be available for all applicable hazards, but the location of the connection points should provide reasonable assurance of at least one connection being available.

If separate strategies are used as delineated in paragraph 16 above, then the two strategies do not each need a primary and alternate connection point provided the connection points for the two strategies are separate.

Appendices C and D provide more details on how this is to be accomplished.

3.2.3 Shutdown Modes

Due to the small fraction of the operating cycle that is spent in an outage condition, generally less than 10%, the probability of a beyond design basis external event occurring during any specific outage configuration is very small. Additionally, due to the large and diverse scope of activities and configurations for any given nuclear plant outage (planned or forced), a systematic approach to shutdown safety risk identification and planning, such as that currently required to meet §50.65(a)(4) along with the availability of the FLEX equipment, is the most effective way of enhancing safety during shutdown.

In order to effectively manage risk and maintain safety during outages, plants maintain contingencies to address the precautions and response actions for loss of cooling. These contingencies direct actions to minimize the likelihood for a loss of cooling but also direct the actions to be taken to respond to such an event.

In order to further reduce shutdown risk, the shutdown risk process and procedures will be enhanced through incorporation of the FLEX equipment. Consideration will be given in the shutdown risk assessment process to:

- Maintaining FLEX equipment necessary to support shutdown risk processes and procedures readily available, and
- Determining how FLEX equipment could be deployed or pre-deployed/pre-staged to support maintaining or restoring the key safety functions in the event of a loss of shutdown cooling.

In cases where FLEX equipment would need to be deployed in locations that would quickly become inaccessible as a result of a loss of decay heat removal from an ELAP event, pre-staging of that equipment may be required.

Though the FLEX strategies are not explicitly designed for outage conditions due to the small fraction of the operating cycle that is spent in an outage condition, the provisions for the shutdown modes should include:

- Primary and alternate connection points for core cooling,
- Core cooling pumps sized to provide core cooling for outage conditions,
- Identify a source of borated water for core cooling (the borated water source does not need to be robust for all external events)[5], and
- A means to remove heat from containment, e.g., venting,

Analyses are only needed to support the sizing of the makeup pump/connections and to ensure sufficient containment heat removal capability exists. Analyses are not needed for the purposes of determining the sequence of events of an ELAP during shutdown conditions.

[5]The key is to have sufficient water sources. If the borated water source is not robust for an external hazard applicable to the site, other water sources robust for that hazard should be identified to back it up. If the backup water source is not borated, then consideration should be given to controlled use to minimize dilution.

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Table 3-1
BWR FLEX Baseline Capability Summary

Safety Function		Method	Baseline Capability
Core Cooling	Reactor Core Cooling	• RCIC/HPCI/IC • Depressurize RPV for Injection with FLEX Injection Source • Sustained Source of Water	• Use of plant equipment for initial coping • Primary and alternate connection points for FLEX pump • Means to depressurize RPV • Use of alternate water supply to support core heat removal makeup
Core Cooling	Key Reactor Parameters	• RPV Level • RPV Pressure	• (Re-)Powered instruments • Other instruments for plant-specific strategies
Containment	Containment Pressure Control /Heat Removal	• Containment Venting or Alternative Containment Heat Removal	• Containment vent or other capability.
Containment	Containment Integrity (BWR Mark III Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a FLEX power supply.
Containment	Key Containment Parameters	• Containment Pressure • Suppression Pool Temperature • Suppression Pool Level	• (Re-)Powered instruments
SFP Cooling	Spent Fuel Cooling	• Makeup with FLEX Injection Source	• Makeup via hoses direct to pool • Makeup via connection to SFP makeup piping or other suitable means
SFP Cooling	SFP Parameters	• SFP Level	• Wide-range spent fuel pool level instruments

Table 3-2
PWR FLEX Baseline Capability Summary

	Safety Function	Method	Baseline Capability
Core Cooling	Reactor Core Cooling & Heat Removal (steam generators available)	• AFW/EFW • Depressurize SG for Makeup with FLEX Injection Source • Sustained Source of Water	• Use of plant equipment for initial coping • Connection for FLEX pump to feed required SGs • Use of alternate water supply to support core heat removal
Core Cooling	RCS Inventory Control	• Low Leak RCP Seals and/or RCS high pressure makeup	• Low-leak RCP seals and/or providing on-site high pressure RCS makeup capability
Core Cooling	Core Heat Removal (shutdown modes with steam generators not available)	• All Plants Provide Means to Provide Borated RCS Makeup	• Diverse makeup connections to RCS for long-term RCS makeup and shutdown mode heat removal • Source of borated water • Letdown path if required
Core Cooling	Key Reactor Parameters	• SG Level • SG Pressure • RCS Pressure • RCS Temperature	• (Re-)Powered instruments
Containment	Containment Pressure Control/Heat Removal	• Containment Spray	• Connection point on containment spray header for use with FLEX pump or alternate capability (e.g., venting) or analysis demonstrating that containment pressure control is not challenged.
Containment	Containment Integrity (Ice Condenser Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a FLEX power supply.
Containment	Key Containment Parameters	• Containment Pressure	• (Re-)Powered instruments
SFP Cooling	Spent Fuel Cooling	• Makeup with FLEX Injection Source	• Makeup via hoses direct to pool • Makeup via connection to SFP makeup piping or other suitable means
SFP Cooling	SFP Parameters	• SFP Level	• Spent fuel pool level instruments

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3.3 CONSIDERATIONS IN UTILIZING OFF-SITE RESOURCES

Once the analysis determines the FLEX equipment requirements for extended coping, the licensee should obtain the required on-site equipment and ensure appropriate arrangements are in place to obtain the necessary off-site equipment including its deployment at the site in the time required by the analysis for the purposes of sustaining functions indefinitely. In planning the coping strategies, water and fuel resources, among other things, needed to cope indefinitely would imply the need for an infinite source of supply. Since site access is considered to be restored to near-normal within 24 hours, by 72 hours from the event initiation, outside resources should be able to be mobilized by that time such that a continuous supply of needed resources will be able to be provided to the site. Within these first 72 hours a site will have deployed its FLEX strategies which should result in a stable plant condition on the FLEX equipment and plans will have been established to maintain the key safety functions for the long term. Therefore, FLEX strategies and/or resources are not required to be explicitly planned in advance for the period beyond 72 hours.

The site will need to identify staging area(s) for receipt of the off-site FLEX equipment and a means to transport the off-site equipment to the deployment location.

It is expected that the licensee will ensure the off-site resource organization will be able to provide the resources that will be necessary to support the extended coping duration.

In addition, the licensee will need to ensure standard connectors for electrical and mechanical FLEX equipment compatible with the site connections are provided

4 STEP 2: DETERMINE APPLICABLE EXTREME EXTERNAL HAZARDS

The design basis of U.S. nuclear power plants provides protection against a broad range of extreme external hazards. However, it is possible to postulate BDB external hazards that exceed the levels of current designs. In Section 3, a baseline coping capability scenario was established for a simultaneous ELAP and LUHS. The nature of the specific BDBEE could, however, contribute to and/or complicate the plant and off-site response.

The potential scope of these beyond-design-basis conditions makes it impossible to bound all possible conditions. However, general risk insights from PRAs that have previously been performed in the industry can inform the important scenarios even without a plant-specific PRA.

To this end, Appendix B provides an assessment of a broad spectrum of possible external hazards as a means to organize and focus the site-specific assessment process on classes of extreme external hazards. The purpose of this section is to identify the potential complicating factors to the deployment of FLEX equipment for the baseline coping scenarios based on site-specific vulnerabilities to BDBEEs. The strategies that result from this assessment are intended to provide greater diversity and flexibility to cope with a wider range of potential damage states. All possible scenarios are not intended to have the same rigorous analytical basis, training, or step by step procedural implementation requirements of the baseline strategies as it is not possible to postulate all of the possible scenarios.

4.1 SITE-SPECIFIC IDENTIFICATION OF APPLICABLE HAZARDS

This step of the process focuses on the identification and characterization of applicable BDBEEs for each site. Identification involves determining whether the type of hazard applies to the site. Characterization focuses on the likely nature of the challenge in terms of timing, severity, and persistence.

As outlined in Appendix B, for the purposes of this effort, hazards have been grouped into five classes to help further focus the assessment:

- seismic events
- external flooding
- storms such as hurricanes, high winds, and tornadoes
- snow and ice storms, and cold
- extreme heat.

Table 4-1 provides a high-level summary of the types of challenges and potential challenges presented by these five classes of hazards.

Table 4-2 provides a description of the general attributes that are used in assessing the applicability of a class of hazards to a particular site. Further detail on these considerations is provided in Sections 5 through 9.

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Table 4-1
Challenges Posed by External Hazards

Hazard Class	Example Potential Site Threats	Potential Considerations
Seismic	• Loss of off-site power • Damage to non-robust electrical equipment • Damage to non-robust flat bottom tanks • Flooding due to damage to on-site water sources that are not seismically robust	• No warning time • Widespread infrastructure damage • Diversion of national/state resources
External flooding	• Loss of off-site power • Inundation of plant structures • Inundation of key equipment • Loss of intake/UHS	• Substantial warning time possible • Possible long duration event • Increased flow in groundwater e.g., streams • Widespread infrastructure impacts • Diversion of national/state resources
Storms with High Winds (Hurricanes, tornadoes, etc.)	• Loss of off-site power • Loss of intake/UHS • Equipment performance issues	• Warning possible for some • Limited duration event • Widespread infrastructure impacts • Diversion of national/state resources
Snow, Ice, Low Temperatures	• Loss of off-site power • Loss of intake/UHS • Equipment performance issues	• Warning likely • Limited duration event • Widespread infrastructure impacts
Extreme High Temperatures	• Loss of off-site power • Loss of intake/UHS • Equipment performance issues	• Warning likely • Limited duration event • Infrastructure impacts

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Table 4-2
Considerations in Assessing Applicability of External Hazards

Hazard Class	Applicability Considerations
Seismic	• All sites will consider seismic events
External flooding	• Variability in design basis considerations • Potential for large source floods at site • Margin in current external flood design basis
Storms with High Winds (Hurricanes, tornadoes, etc.)	• Coastal sites exposed to hurricanes/large storms • Regional history with tornadoes
Snow, Ice, Low Temperatures	• Regional experience with extreme snow, ice, and low temperatures
Extreme High Temperatures	• Regional experience with extreme high temperatures

4.2 SITE-SPECIFIC CHARACTERIZATION OF HAZARD ATTRIBUTES

For those hazards considered applicable to a particular site, the focus is on the proper consideration of the challenge presented. Sites will consider the beyond-design-basis hazard levels for all applicable site hazards in order to evaluate impact of these hazards, as described in Sections 5 through 9, on the deployment of the strategies to meet the baseline coping capability. With the potential impacts characterized, potential enhancements can be identified for each hazard that will increase viability of strategy deployment for these extreme conditions. These enhancements can take the form of changes to the equipment deployment strategy (e.g., relocation or addition of a connection point to address flood conditions) or changes to the procedural implementation of the strategies by incorporation into event response procedures (e.g., addition of FLEX preparatory action to hurricane response procedures for hurricanes in excess of a certain level).

Characterization of a hazard for a site includes the following elements:

- Identification of the realistic response timeline for the applicable hazards, e.g., tornadoes generally have very little warning to enable anticipatory plant response, whereas hurricanes have considerable warning time.
- Characterization of the functional threats caused by the hazard, e.g., equipment that may be inundated by a BDB external flood.
- Development of a plant strategy for responding to events with warning, e.g., procedure changes to support anticipatory actions.
- Development of a plant strategy for responding to events without warning, e.g., response actions that may be required to a particular hazard such as debris removal following a tornado.

5 STEP 2A: ASSESS SEISMIC IMPACT

Beyond-design-basis seismic events have been extensively studied in seismic margin assessments (SMAs) and seismic PRAs (SPRAs). These studies have demonstrated that an ELAP is a dominant contributor to seismic risk. These evaluations provide many insights that can help guide the evaluation and enhancement of the baseline coping capability for BDB seismic events.

5.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

Beyond-design-basis seismic events are known to directly contribute to the risk from a simultaneous ELAP and LUHS, depending on the site. In addition, severe seismic events can present a challenge to both on-site and off-site resources relied upon for plant response.

Beyond-design-basis seismic evaluations (SMAs and SPRAs) consistently identify loss of off-site power as an important contributor. The loss of off-site power is generally attributed to damage to the grid and/or on-site power transmission equipment that is essentially unrecoverable in the near-term. The next most likely failures observed in these evaluations involve failures of non-robust flat bottom tanks, e.g., large storage tanks that are not seismically robust, and failures of electrical equipment [Ref. 9].

Seismic events can also impact the availability of the UHS for sites that rely on a not seismically robust downstream dam to contain water that is used as the source of water for the UHS.

These insights are used to inform the approach to consideration of seismically-induced challenges.

5.2 APPROACH TO SEISMICALLY-INDUCED CHALLENGES

All sites will address BDB seismic considerations in the implementation of FLEX strategies, as described below. The basis for this is that, while some sites are in areas with lower seismic activity, their design basis generally reflects that lower activity. There are large, and unavoidable, uncertainties in the seismic hazard for all U.S. plants. In order to provide an increased level of safety, the FLEX deployment strategy will address seismic hazards at all sites. These considerations will be treated in four primary areas: protection of FLEX equipment, deployment of FLEX equipment, procedural interfaces, and considerations in utilizing off-site resources.

5.3 PROTECTION AND DEPLOYMENT OF FLEX STRATEGIES

5.3.1 Protection of FLEX Equipment

1. FLEX equipment should be stored in one or more of following three configurations such that no one external event can reasonably fail the site FLEX capability (N):
    a. In a structure that meets the plant's design basis for the Safe Shutdown Earthquake (SSE)(e.g., existing safety-related structure).
    b. In a structure designed to or evaluated equivalent to ASCE 7-10, Minimum Design Loads for Buildings and Other Structures.
    c. Outside a structure and evaluated for seismic interactions to ensure equipment is not damaged by non-seismically robust components or structures.
2. Large FLEX equipment such as pumps and power supplies should be secured as appropriate to protect them during a seismic event (i.e., Safe Shutdown Earthquake (SSE) level).
3. Stored equipment and structures should be evaluated and protected from seismic interactions to ensure that unsecured and/or non-seismic components do not damage the equipment.

5.3.2 Deployment of FLEX Equipment

The baseline capability requirements already address loss of non-seismically robust equipment and tanks as well as loss of all AC. So, these seismic considerations are implicitly addressed.

There are five considerations for the deployment of FLEX equipment following a seismic event:

1. If the equipment needs to be moved from a storage location to a different point for deployment, the route to be traveled should be reviewed for potential soil liquefaction that could impede movement following a severe seismic event.
2. At least one connection point of FLEX equipment will only require access through seismically robust structures. This includes both the connection point and any areas that plant operators will have to access to deploy or control the capability.
3. If the plant FLEX strategy relies on a water source that is not seismically robust, e.g., a downstream dam, the deployment of FLEX coping capabilities should address how water will be accessed. Most sites with this configuration have an underwater berm that retains a needed volume of water. However, accessing this water may require new or different equipment.

4. If power is required to move or deploy the equipment (e.g., to open the door from a storage location), then power supplies should be provided as part of the FLEX deployment.
5. A means to move FLEX equipment should be provided that is also reasonably protected from the event.

5.3.3 Procedural Interfaces

There are four procedural interface considerations that should be addressed.

1. Seismic studies have shown that even seismically qualified electrical equipment can be affected by BDB seismic events. In order to address these considerations, each plant should compile a reference source for the plant operators that provides approaches to obtaining necessary instrument readings to support the implementation of the coping strategy (see Section 3.2.1.10). Such a resource could be provided as an attachment to the plant procedures/guidance. Guidance should include critical actions to perform until alternate indications can be connected and on how to control critical equipment without associated control power.

   This reference source should include control room and non-control room readouts and should also provide guidance on how and where to measure key instrument readings using a portable instrument (e.g., a Fluke meter) at a location that does not rely on the functioning of intervening electrical equipment (e.g. I/E convertors, analog to digital converters, relays, etc.) that could be adversely affected by BDB seismic events. An instrument reading should be obtained at the closest accessible termination point to the containment penetration or parameter of measurement, as practical.
2. Consideration should be given to the impacts from large internal flooding sources that are not seismically robust and do not require ac power (e.g., gravity drainage from lake or cooling basins for non-safety-related cooling water systems).
3. For sites that use ac power to mitigate ground water in critical locations, a strategy to remove this water will be required.
4. Additional guidance may be required to address the deployment of FLEX for those plants that could be impacted by failure of a not seismically robust downstream dam.

5.3.4 Considerations in Utilizing Off-site Resources

Severe seismic events can have far-reaching effects on the infrastructure in and around a plant. While nuclear power plants are designed for large seismic events, many parts of the Owner Controlled Area and surrounding infrastructure (e.g., roads, bridges, dams, etc.) may be designed to lesser standards. Obtaining off-site resources may require use of alternative transportation (such as air-lift capability) that can overcome or circumvent damage to the existing local infrastructure.

1. The FLEX strategies will need to assess the best means to obtain resources from off-site following a seismic event.

6 STEP 2B: ASSESS EXTERNAL FLOODING IMPACT

The potential challenge presented by external flooding is very site-specific and is a function of the site layout, plant design, and potential external flooding hazards present. Typically, plant design bases address the following hazards:

- local intense precipitation
- flooding from nearby rivers, lakes, and reservoirs
- high tides
- seiche
- hurricane and storm surge
- tsunami events

There are large uncertainties in predicting the magnitude of beyond-design-basis flooding events. Consequently, it is necessary to evaluate the FLEX deployment strategies for sites where there is potential for such extreme flooding.

6.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

A beyond-design-basis external flooding event can create a significant challenge to plant safety. This could include the following:

- loss of off-site power
- loss of UHS and/or
- impact on safe shutdown equipment.

In addition, severe flooding events can present a challenge to both on-site and off-site resources relied upon for coping.

6.2 APPROACH TO EXTERNAL FLOOD-INDUCED CHALLENGES

The evaluation of external flood-induced challenges has three parts. The first part is determining whether the site is susceptible to external flooding. The second part is the characterization of the applicable external flooding threat. The third part is the application of the flooding characterization to the protection and deployment of FLEX strategies.

6.2.1 Susceptibility to External Flooding

Susceptibility to external flooding is based on whether the site is a “dry” site, i.e., the plant is built above the design basis flood level (DBFL) [Ref. 10]. For sites that are not “dry”, water intrusion is prevented by barriers and there could be a potential for those barriers to be exceeded or compromised. Such sites would include those that are kept “dry” by permanently installed barriers, e.g., seawall, levees, etc., and those that install temporary barriers or rely on watertight doors to keep the design basis flood from impacting safe shutdown equipment.

Plants that are not dry sites will perform the next two steps of the flood-induced challenge evaluation.

6.2.2 Characterization of the Applicable Flood Hazard

Most external flooding hazards differ from seismic and other events in that the event may provide the plant with considerable warning time to take action and the flood condition may exist for a considerable length of time. Table 6-1 summarizes some of these considerations for various flood sources.

Table 6-1
Flood Warning and Persistence Considerations

Flood Source	Warning	Persistence
Regional precipitation (PMF)	Days	Many Hours to Months
Upstream dam failures	Hours to Days	Hours to Months
High tides	Days	Hours
Seiche	None	Short
Hurricane and storm surge	Days	Hours
Tsunami events	Limited	Short

Each site that has identified that external flooding is an applicable hazard should review the current design basis flood analyses to determine which external floods are limiting. In general, a site will have one flood source that has been identified as the limiting condition, with respect to DBFL. However, in some cases, there can be multiple sources that yield similar DBFLs, e.g., various river flood scenarios involving combinations of dam failures and other input conditions. The limiting hazards should be characterized in terms of warning time and persistence following the creation of a flood condition. Such information is generally available in UFSARs and supporting analyses. It is not the intention to define precise time windows, simply to gauge the timing so that plant response actions can be considered. If warning time is credited, the evaluation of the adequacy of warning time includes review of the flooding event and warning time triggers needed to implement any flood protection or mitigating strategies. Multiple triggers or a single trigger can be established for milestones if the response to a flood hazard is done in graduated steps (e.g. stage equipment, assemble equipment, and complete implementation).

6.2.3 Protection and Deployment of FLEX Strategies

In view of the characterization of the applicable flood hazard, the site should consider means to reasonably assure the success of deployment of FLEX strategies such as flood protection of FLEX equipment, relocation of FLEX connection points, etc.

6.2.3.1 Protection of FLEX Equipment

These considerations apply to the protection of FLEX equipment from external flood hazards:

1. The equipment should be stored in one or more of the following configurations such that no one external event can reasonably fail the site FLEX capability (N):
    a. Stored above the flood elevation from the most recent design basis site flood analysis. The evaluation to determine the elevation for storage should be informed by flood analysis applicable to the site from early site permits, combined license applications, and/or contiguous licensed sites.
    b. Stored in a structure designed to protect the equipment from the flood.
    c. FLEX equipment can be stored below flood level if time is available and plant procedures/guidance address the needed actions to relocate the equipment. Based on the timing of the limiting flood scenario(s), the FLEX equipment can be relocated[6] to a position that is protected from the flood, either by barriers or by elevation, prior to the arrival of the potentially damaging flood levels. This should also consider the conditions on-site during the increasing flood levels and whether movement of the FLEX equipment will be possible before potential inundation occurs, not just the ultimate flood height.
2. Storage areas that are potentially impacted by a rapid rise of water should be avoided.

[6]Allowance for relocation is consistent with no concurrent independent events assumption per section 2.0 provided it is of limited duration.

6.2.3.2 Deployment of FLEX Equipment

There are a number of considerations which apply to the deployment of FLEX equipment for external flood hazards:

1. For external floods with warning time, the plant may not be at power. In fact, the plant may have been shut down for a considerable time and the plant configuration could be established to optimize FLEX deployment. For example, the FLEX pump could be connected, tested, and readied for use prior to the arrival of the critical flood level. Further, protective actions can be taken to reduce the potential for flooding impacts, including cooldown, borating the RCS, isolating accumulators, isolating RCP seal leak off, obtaining dewatering pumps, creating temporary flood barriers, etc. These factors can be credited in considering how the baseline capability is deployed.
2. The ability to move equipment and restock supplies may be hampered during a flood, especially a flood with long persistence. Accommodations along these lines may be necessary to support successful long-term FLEX deployment.
3. Depending on plant layout, the ultimate heat sink may be one of the first functions affected by a flooding condition. Consequently, the deployment of the FLEX equipment should address the effects of LUHS, as well as ELAP.
4. FLEX equipment will require fuel that would normally be obtained from fuel oil storage tanks that could be inundated by the flood or above ground tanks that could be damaged by the flood. Steps should be considered to protect or provide alternate sources of fuel oil for flood conditions. Potential flooding impacts on access and egress should also be considered.
5. Connection points for FLEX equipment should be reviewed to ensure that they remain viable for the flooded condition.
6. For plants that are limited by storm-driven flooding, such as Probable Maximum Surge or Probable Maximum Hurricane (PMH), expected storm conditions should be considered in evaluating the adequacy of the baseline deployment strategies.
7. Since installed sump pumps will not be available for dewatering due to the ELAP, plants should consider the need to provide water extraction pumps capable of operating in an ELAP and hoses for rejecting accumulated water for structures required for deployment of FLEX strategies.
8. Plants relying on temporary flood barriers should assure that the storage location for barriers and related material provides reasonable assurance that the barriers could be deployed to provide the required protection.

9. A means to move FLEX equipment should be provided that is also reasonably protected from the event.

6.2.3.3 Procedural Interfaces

The following procedural interface considerations that should be addressed:

1. Many sites have external flooding procedures. The actions necessary to support the deployment considerations identified above should be incorporated into those procedures.
2. Additional guidance may be required to address the deployment of FLEX for flooded conditions (i.e., connection points may be different for flooded vs. non-flooded conditions).
3. FLEX guidance should describe the deployment of temporary flood barriers and extraction pumps necessary to support FLEX deployment.

6.2.3.4 Considerations in Utilizing Off-site Resources

Extreme external floods can have regional impacts that could have a significant impact on the transportation of off-site resources.

1. Sites should review site access routes to determine the best means to obtain resources from off-site following a flood.
2. Sites impacted by persistent floods should consider where equipment delivered from off-site could be staged for use on-site.

7 STEP 2C: ASSESS IMPACT OF SEVERE STORMS WITH HIGH WINDS

The potential challenge presented by severe storm with high winds can be very site-specific and is a function of the site layout, plant design, and potential high wind hazards present. Typically, plant design bases address the following hazards:

- hurricanes
- extreme straight winds
- tornadoes and tornado missiles

While extreme straight winds can present a challenge to off-site power supplies, these conditions are not judged to be significant factors in contributing to a simultaneous ELAP and LUHS and will not be further considered in this guidance.

7.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

A beyond-design-basis high wind event can create a significant challenge to plant safety. This could include the following:

- loss of off-site power
- loss of UHS
- Impact on safe shutdown equipment.

In addition, high wind events can present a challenge to both on-site and off-site resources desired to assist in plant response. However, while the damage from hurricanes can be quite widespread, the damage from tornadoes is generally relatively localized, even for extreme tornadoes.

7.2 APPROACH TO HIGH WIND CHALLENGES

The evaluation of high wind-induced challenges has three parts. The first part is determining whether the site is potentially susceptible to different high wind conditions. The second part is the characterization of the applicable high wind threat. The third part is the application of the high wind threat characterization to the protection and deployment of FLEX strategies.

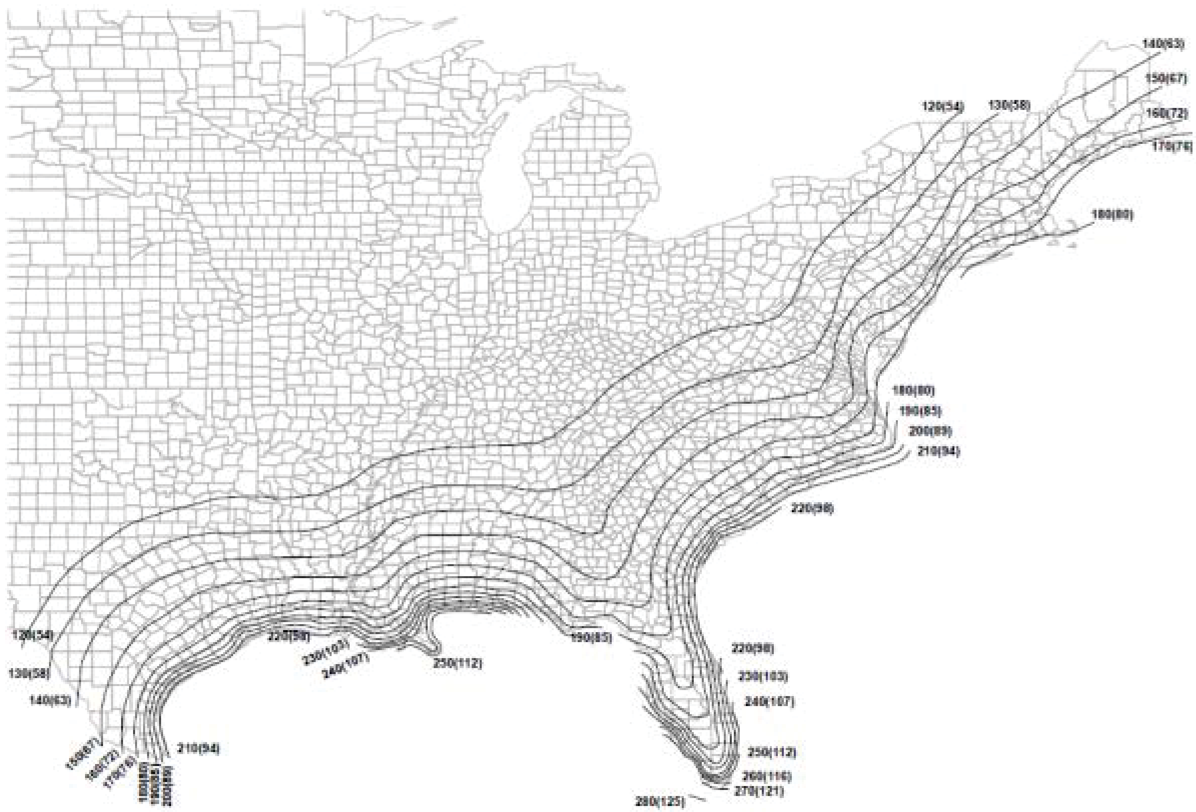
7.2.1 Applicability of High Wind Conditions

A screening process is used to identify whether a site should address high wind hazards as a result of hurricanes and tornadoes.

Hurricanes are extremely uncommon on the West Coast of the U.S. Furthermore, even in regions like the Gulf, Southeast and Northeast where hurricanes do occur, the high winds from hurricanes are generally only within some distance from the coast. Figure 7-1 provides contours for hurricane wind speeds expected to occur at a rate of 1 in 1 million chance of per year. These maps can be used to guide the identification of sites with the potential to experience severe winds from hurricanes based on winds exceeding 130 mph.

Figure 7-1

Contours of Peak-Gust Wind Speeds at 10-m Height in Flat Open Terrain, Annual Exceedance Probability of 10^{-6} [Figure 3-1 of Ref. 13]



For considering the applicability of tornadoes to specific sites, data from the NRC's latest tornado hazard study, NUREG/CR-4461, is used. Tornadoes with the capacity to do significant damage are generally considered to be those with winds above 130 mph. Figure 7-2 provides a map of the U.S. in 2 degree latitude/longitude blocks that shows the tornado wind speed expected to occur at a rate of 1 in 1 million chance of per year. This clearly bounding assumption allows selection of plants that are identified in blocks with tornado wind speeds greater than 130 mph. All other plants need not address tornado hazards impacting FLEX deployment.

Each site should use the information in Figures 7-1 and 7-2 to determine whether the site needs to address storms involving high winds. In general, plants west of the Rockies will be screened out, but most other sites will have to address at least tornadoes.

7.2.2 Characterization of the Applicable High Wind Hazard

The characterization of hurricanes includes the fact that significant notice will be available in the event a severe hurricane will impact a site. This can allow plants to pre-stage FLEX equipment for the most severe storms. Hurricanes can also have a significant impact on local infrastructure, e.g., downed trees and flooding, that should be considered in the interface with off-site resources.

The characterization of tornadoes is such that pre-staging of FLEX equipment in advance is not likely to be effective. However, the impact on the local infrastructure is much more limited than hurricanes and largely limited to debris dispersal.

7.3 PROTECTION AND DEPLOYMENT OF FLEX STRATEGIES

7.3.1 Protection of FLEX Equipment

These considerations apply to the protection of FLEX equipment from high wind hazards:

1. For plants exposed to high wind hazards, FLEX equipment should be stored in one or more of the following configurations such that no one external event can reasonably fail the site FLEX capability (N):
    a. In a structure or structures that meets the plant's design basis for high wind hazards (e.g., existing safety-related structure).
    b. In storage locations designed to or evaluated equivalent to ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* given the limiting tornado wind speeds from Regulatory Guide 1.76, Rev. 1 or design basis hurricane wind speeds for the site
        - Given the FLEX basis limiting tornado or hurricane wind speeds, building loads would be computed in accordance with requirements of ASCE 7-10. Acceptance criteria would be based on building serviceability requirements not

strict compliance with stress or capacity limits. This would allow for some minor plastic deformation, yet assure that the building would remain functional. The load combination for wind speeds for mapped wind speeds contained in ASCE 7-10 should use the load combinations from ASCE 7-10. Since the load combinations in ASCE 7-10 are not applicable to tornado winds, the design wind speeds from Regulatory Guide 1.76, Rev. 1 should use the combinations required consistent with the Standard Review Plan and other safety-related applications (i.e., wind speed by factor of 1.0).

- Tornado missiles and hurricane missiles will be accounted for in that the FLEX equipment will be stored in diverse locations to provide reasonable assurance that N sets of FLEX equipment will remain deployable following the high wind event. This will consider locations adjacent to existing robust structures or in lower sections of buildings that minimizes the probability that missiles will damage all mitigation equipment required from a single event by protection from adjacent buildings and limiting pathways for missiles to damage equipment. The axis of separation of the structure locations should consider the predominant path of tornados in the geographical location. In general, tornadoes travel from the West or West Southwesterly direction, diverse locations should be aligned in the North-South arrangement, where possible. Additionally, in selecting diverse FLEX storage locations, consideration should be given to the location of the diesel generators and switchyard such that the path of a single tornado would not impact all locations.
- Stored mitigation equipment exposed to the wind should be adequately tied down. Loose equipment should be in protective boxes that are adequately tied down to foundations or slabs to prevent protected equipment from being damaged or becoming airborne. (During a tornado, high winds may blow away metal siding and metal deck roof, subjecting the equipment to high wind forces.)

c. In evaluated storage locations separated by a sufficient distance that minimizes the probability that a single event would damage all FLEX equipment such that at least N sets of FLEX equipment would remain deployable following the high wind event. Separation is not an acceptable reasonable protection method for hurricane conditions. However, if two buildings, built to withstand hurricane winds are used, then separation of the buildings can be credited for tornado events. Tornado widths from NOAA's Storm

Prediction Center for 1950 – 2011should be considered as the minimum separation distance for which further analysis is not required to justify diversity

- Consistent with configuration b., the axis of separation of the storage locations should consider the predominant path of tornados in the geographical location.
- Consistent with configuration b., stored FLEX equipment should be adequately tied down.

NOTE: For plant equipment that is not robust for tornado winds and/or missiles, the separation guidance of Sections 7.3.1.1.b and 7.3.1.1.c may be used to demonstrate the robustness of one piece of that plant equipment for tornado winds and missiles. For example, if the site has two condensate storage tanks that are robust except for tornado missile protection, the separation of these tanks may be used to demonstrate robustness for one of the tanks following a tornado event.

2. Examples of Adequate wind protection:

- Example: For a 2-unit site, 3 sets (N+1) of on-site FLEX equipment are required. The plant screens in per Sections 5 through 9 for seismic, flooding, wind (both tornado and hurricane), snow, ice and extreme cold, and high temperatures.

a. To meet Section 7.3.1.1.a, either of the following are acceptable:

- All three sets (N+1) in a structure(s) that meets the plant's design basis for high wind hazards, or
- Two sets (N) in a structure(s) that meets the plant's design basis for high wind hazards and one set (+1) stored in a location not protected for a high wind hazard.

b. To meet Section 7.3.1.1.b, either of the following is acceptable:

- Two buildings built to ASCE 7-10 using Regulatory Guide 1.76, Rev. 1 for tornado wind speeds or hurricane wind speeds whichever is bounding. Tornado missiles are accounted for in this option by the diversity of the storage locations. Each building needs to contain N sets of on-site FLEX equipment. Axis of separation and equipment tie down should be considered.
- Three buildings built to ASCE 7-10 using Regulatory Guide 1.76, Rev. 1 for tornado wind speeds or hurricane wind speeds whichever is bounding. Tornado missiles are accounted for in this option by the diversity of the storage locations. Each building needs to contain one set of on-site FLEX equipment. Axis of separation and equipment tie down should be considered.

c. To meet Section 7.3.1.1.c for sites with both hurricane and tornado events, any of the following is acceptable:

- Two buildings built to ASCE 7-10 for hurricane wind speeds (Section 7.3.1.1.c allows reasonable protection by separation for tornadoes only so the buildings need to be hurricane protected). Tornadoes and wind-generated missiles are accounted for in this option by the separation distance of the buildings. Each building needs to contain N sets of on-site FLEX equipment. Axis of separation and equipment tie down should be considered.
- Three buildings built to ASCE 7-10 for hurricane wind speeds. Tornadoes and wind-generated missiles are accounted for in this option by separation of the buildings. Each building needs to contain one set of on-site FLEX equipment. Axis of separation and equipment tie down should be considered.
- Two separated buildings not designed for tornado winds or missiles, one built for hurricane winds and missiles and one commercial building. Each building needs to contain N sets of on-site FLEX equipment. Axis of separation and equipment tie down should be considered

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Figure 7-2
Recommended Tornado Design Wind Speeds
for the 10^{-6} /yr Probability Level [Ref. 14]

	124	122	120	118	116	114	112	110	108	106	104	102	100	98	96	94	92	90	88	86	84	82	80	78	76	74	72	70	68	66
47	0	100	83	116	98	0	0	117	127	124	160	141	164	150	150	146	179	160	131										155	
45	0	92	72	127	109	0	71	0	104	111	137	157	165	170	171	178	184	180	177	172	146	175						0	127	142
43	0	0	0	0	104	0	129	114	118	120	148	160	166	178	183	188	191	189	188	182	179	182		147	169	138	141	131	134	133
41	84	0	0	0	0	80	110	83	68	125	142	161	173	186	192	192	196	198	191	194	193	188	188	189	168	161	166	165		
39	109	108	81	104	0	103	0	118	0	0	149	154	176	191	197	198	193	196	195	194	192	182	168	168	165	166	135			
37		121	97	0	0	0	78	0	71	129	115	155	181	193	200	197	188	187	192	190	185	170	152	158	166	158				
35		118	86	94	0	92	108	87	0	101	122	157	183	196	203	195	194	195	194	197	186	166	172	171	161	160				
33			0	118	110	96	95	136	0	120	122	161	178	189	194	195	195	194	196	196	186	179	172	178	154					
31					89	93	98	104	102	108	119	148	165	173	181	189	189	190	193	186	182	177	160	160						
29		Region 1 -- 200 mph									72	143	146	166	174	178	178	170	178	171	169	164	165							
27		Region 2 -- 170 mph											168	150	161	133						179	164							
25		Region 3 --130 mph												144	157							196	157							

7.3.2 Deployment of FLEX Equipment

There are a number of considerations which apply to the deployment of FLEX equipment for high wind hazards:

1. For hurricane plants, the plant may not be at power prior to the simultaneous ELAP and LUHS condition. In fact, the plant may have been shut down and the plant configuration could be established to optimize FLEX deployment. For example, the FLEX pumps could be connected, tested, and readied for use prior to the arrival of the hurricane. Further, protective actions can be taken to reduce the potential for wind impacts. These factors can be credited in considering how the baseline capability is deployed.
2. The ultimate heat sink may be one of the first functions affected by a hurricane due to debris and storm surge considerations. Consequently, the evaluation should address the effects of ELAP/LUHS, along with any other equipment that would be damaged by the postulated storm.
3. Deployment of FLEX following a hurricane or tornado may involve the need to remove debris. Consequently, the capability to remove debris caused by these extreme wind storms should be included.
4. A means to move FLEX equipment should be provided that is also reasonably protected from the event.
5. The ability to move equipment and restock supplies may be hampered during a hurricane and should be considered in plans for deployment of FLEX equipment.

7.3.3 Procedural Interfaces

The overall plant response strategy should be enveloped by the baseline capabilities, but procedural interfaces may need to be considered. For example, many sites have hurricane procedures. The actions necessary to support the deployment considerations identified above should be incorporated into those procedures.

7.3.4 Considerations in Utilizing Off-site Resources

Extreme storms with high winds can have regional impacts that could have a significant impact on the transportation of off-site resources.

1. Sites should review site access routes to determine the best means to obtain resources from off-site following a hurricane.
2. Sites impacted by storms with high winds should consider where equipment delivered from off-site could be staged for use on-site.

8 STEP 2D: ASSESS IMPACT OF SNOW, ICE AND EXTREME COLD

The potential challenge presented by snow, ice and extreme cold can be very site-specific and is a function of the site layout, plant design, and regional weather hazards present. Typically, plant design bases address snow from the perspective of building roof loadings and ice and extreme cold temperatures from the perspective of potential impacts on the intake structure and safety-related equipment.

This general category of snow, ice and extreme low temperatures includes the following hazards:

- avalanche
- frost
- ice cover
- frazil ice
- snow
- extreme low temperatures

Extreme low temperatures may also present challenges and could follow a significant snow/ice storm such that a combination of significant snowfall, ice, and extreme cold cannot be ruled out.

This set of hazards presents more of a challenge to the deployment of the FLEX equipment than the other aspects of the evaluation.

8.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

Snow and ice storms and extreme low temperatures can present a challenge to both off-site power and on-site capabilities, e.g., intake structures. Depending on the plant design, these may be contributors to a simultaneous ELAP and LUHS, e.g., loss of off-site power with loss of cooling water due to extreme cold and frazil ice formation. In addition, if applicable, such storms could impact deployment of both on-site and off-site coping resources.

8.2 APPROACH TO SNOW, ICE, AND EXTREME COLD CHALLENGES

Snow, ice, and extreme cold can, in principle, occur at any site. However, for the purposes of this guideline, we are interested in extreme events that could impede or prevent the deployment of the baseline FLEX capability.

8.2.1 Applicability of Snow, Ice, and Extreme Cold

All sites should consider the temperature ranges and weather conditions for their site in storing and deploying their FLEX equipment. That is, the equipment procured should be suitable for use in the anticipated range of conditions for the site, consistent with normal design practices.

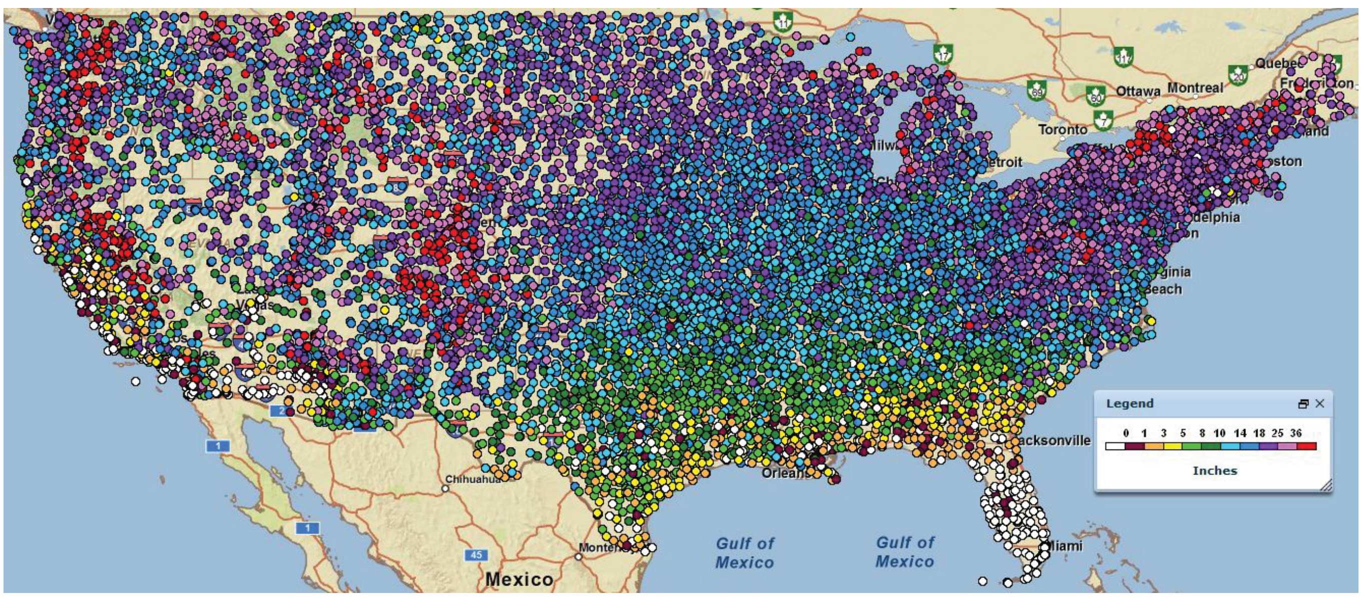
In general, the southern parts of the U.S. do not experience snow, ice, and extreme cold. However, it is possible at most sites, except sites in Southern

California, Arizona, the Gulf Coast, and Florida, to experience such conditions. Consequently, all other sites are expected to address FLEX deployment for these conditions.

The map in Figure 8-1 provides a visual representation of the maximum three day snowfall records across the U.S, with Red being max, Blue, Purple, and Pink being significant, and Green, Yellow, and White being low accumulations. The Green dots represent a record that is approximately 6 inches accumulation over three days. Such snowfalls are unlikely to present a significant problem for deployment of FLEX. This region is generally below the 35th parallel. Thus, excluding plants in Arizona and Southern California, plants above the 35th parallel should provide the capability to address the impedances caused by extreme snowfall with snow removal equipment.

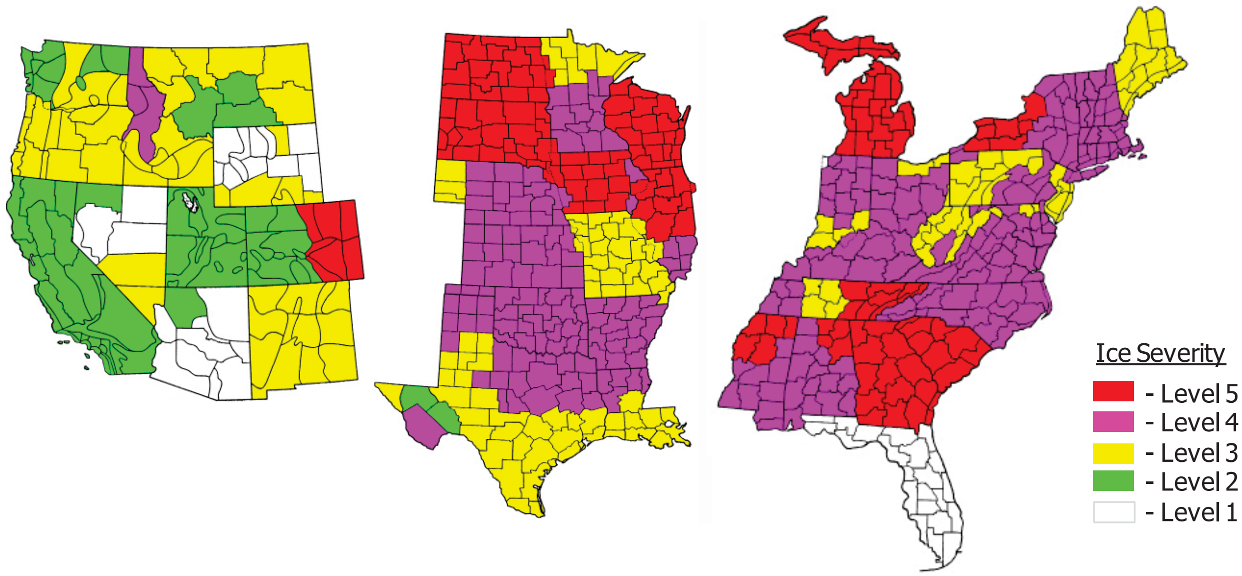
It will be assumed that this same basic trend applies to extreme low temperatures.

Figure 8-1
Record 3 Day Snowfalls [Ref. 15]



Applicability of ice storms is based on a database developed by EPRI for the United States [Ref. 16]. The database summarized ice storms that occurred in any area of the United States from 1959 to April 1995. Regional ice severity, ice event, and maximum level maps were generated based on the information in the ice storm database. Specifically, one set of maps developed by EPRI characterizes the expected maximum severity of ice storms across the U.S. Figure 8-2 collects the EPRI data. The white and green regions (Levels 1 and 2) identify regions that are not susceptible to severe ice storms that may impact the availability of off-site power. Sites in all other regions (i.e., yellow, purple and red) should consider ice storm impacts on their FLEX strategies, as outlined in Sections 8.3.1 through 8.3.4.

Figure 8-2
Maximum Ice Storm Severity Maps [Ref. 16]



Level 5 -	Catastrophic destruction to power lines and/or existence of extreme amount of ice
Level 4 -	Severe damage to power lines and/or existence of large amount of ice
Level 3 -	Low to medium damage to power lines and/or existence of considerable amount of ice
Level 2 -	Existence of small amount of ice
Level 1 -	No ice

8.2.2 Characterization of the Applicable Snow, Ice, and Low Temperature Hazard

In this case, sites that should address snow, ice and low temperatures should consider the impacts of these conditions on the storage and deployment of the FLEX equipment.

8.3 PROTECTION AND DEPLOYMENT OF FLEX EQUIPMENT

8.3.1 Protection of FLEX Equipment

These considerations apply to the protection of FLEX equipment from snow, ice, and extreme cold hazards:

1. For sites subject to significant snowfall and ice storms, FLEX equipment should be stored in one or more of the following configurations:
    a. In a structure that meets the plant's design basis for the snow, ice and cold conditions (e.g., existing safety-related structure).

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

c. Provided the N FLEX equipment is located as described in a. or b. above, the N+1 set of equipment may be stored in an evaluated storage location capable of withstanding historical extreme weather conditions and the equipment is deployable.

2. Storage of FLEX equipment should account for the fact that the equipment will need to function in a timely manner. The equipment should be maintained at a temperature within a range to ensure its likely function when called upon. For example, by storage in a heated enclosure or by direct heating (e.g., jacket water, battery, engine block heater, etc.).

8.3.2 Deployment of FLEX Equipment

There are a number of considerations that apply to the deployment of FLEX equipment for snow, ice, and extreme cold hazards:

1. The FLEX equipment should be procured to function in the extreme conditions applicable to the site. Normal safety-related design limits for outside conditions may be used, but consideration should also be made for any manual operations required by plant personnel in such conditions.
2. For sites exposed to extreme snowfall and ice storms, provision should be made for snow/ice removal, as needed to obtain and transport FLEX equipment from storage to its location for deployment.
3. For some sites, the ultimate heat sink and flow path may be affected by extreme low temperatures due to ice blockage or formation of frazil ice. Consequently, the evaluation should address the effects of such a loss of UHS on the deployment of FLEX equipment. For example, if UHS water is to be used as a makeup source, some additional measures may need to be taken to assure that the FLEX equipment can utilize the water.

8.3.3 Procedural Interfaces

The only procedural enhancements that would be expected to apply involve addressing the effects of snow and ice on transport of the FLEX equipment. This includes both access to the transport path, e.g., snow removal, and appropriately equipped vehicles for moving the equipment.

8.3.4 Considerations in Utilizing Off-site Resources

Severe snow and ice storms can affect site access and can impact staging areas for receipt of off-site materials and equipment.

9 STEP 2E: ASSESS IMPACT OF HIGH TEMPERATURES

The potential challenge presented by extreme high temperatures can be very site-specific and is a function of the site layout, plant design, and regional weather hazards present. Extreme temperatures can present a challenge to both off-site power (e.g., grid issues) and on-site capabilities (e.g., inadequate DG cooling). However, such conditions would not be expected to impact deployment of on-site and off-site coping resources.

9.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

Extreme high temperatures can present a challenge to both off-site power and on-site capabilities by stressing the grid and making cooling systems, such as the UHS, less effective due to high water temperatures.

9.2 APPROACH TO EXTREME HIGH TEMPERATURE CHALLENGES

Virtually every state in the lower 48 contiguous United States has experienced temperatures in excess of 110˚F. Many states have experienced temperatures in excess of 120˚F. Therefore, all sites will address the impact of high temperatures on the storage, deployment and operation of the FLEX equipment.

9.3 PROTECTION AND DEPLOYMENT OF FLEX EQUIPMENT

9.3.1 Protection of FLEX Equipment

The equipment should be maintained at a temperature within a range to ensure its likely function when called upon.

9.3.2 Deployment of FLEX Equipment

The FLEX equipment should be procured to function, including the need to move the equipment, in the extreme conditions applicable to the site. The potential impact of high temperatures on the storage of equipment should also be considered, e.g., expansion of sheet metal, swollen door seals, etc. Normal safety-related design limits for outside conditions may be used, but consideration should also be made for any manual operations required by plant personnel in such conditions.

9.3.3 Procedural Interfaces

The only procedural enhancements that would be expected to apply involve addressing the effects of high temperatures on the FLEX equipment.

9.3.4 Considerations in Utilizing Off-site Resources

Extreme high temperatures are not expected to impact the utilization of off-site resources.

10 STEP 3: DEFINE SITE-SPECIFIC FLEX CAPABILITIES

10.1 AGGREGATION OF FLEX STRATEGIES

This step involves the consideration of the aggregate set of on-site and off-site resource considerations for the hazards that are applicable to the site. That is, the site should aggregate all of the considerations related to:

- protection of FLEX equipment
- deployment of FLEX equipment
- procedural interfaces
- utilization of off-site resources

In order to establish the best overall strategy for the storage and deployment of FLEX capabilities over a broad set of beyond-design-basis conditions an aggregated assessment is needed of the site-specific considerations identified for the applicable hazards.

FLEX equipment should be stored in a location or locations[7] informed by evaluations performed per Sections 5 through 9 such that no one external event can reasonably fail the site FLEX capability (N). Procedures and guidance to support deployment and implementation including interfaces to EOPs, special event procedures, abnormal event procedures, and system operating procedures, will be coordinated within the site procedural framework.

[7] Location or locations may include areas outside the owner controlled area provided equipment can be relocated in time to meet FLEX strategy requirements.

11 PROGRAMMATIC CONTROLS

This section summarizes the programmatic controls that are to be considered in the implementation of the plant-specific FLEX strategies.

11.1 QUALITY ATTRIBUTES

FLEX equipment associated with these strategies will be procured as commercial equipment with design, storage, maintenance, testing, and configuration control as outlined in this section. If the equipment is credited for other functions (e.g., fire protection), then the quality attributes of the other functions apply.

11.2 EQUIPMENT DESIGN

1. Design requirements and supporting analysis should be developed for FLEX equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented[8] analysis that the mitigation strategy and support equipment will perform as intended. When specifying FLEX equipment, the capacities should ensure that the strategy can be effective over a range of plant and environmental conditions. This documentation should be auditable, consistent with generally accepted engineering principles and practices, and controlled within the configuration document control system.
    a. The basis for designed flow requirements should consider the following factors:
        i. Pump design output performance (flow/pressure) characteristics.
        ii. Line losses due to hose size, coupling size, hose length, and existing piping systems.
        iii. Head losses due to elevation changes.
        iv. Back pressure when injecting into closed/pressurized spaces (e.g., containment, steam generators).
        v. Capacity, temperature, and availability of the suction sources needs to be considered given the specific external initiating events (condensate storage tank (CST)/refueling water storage tank (RWST)/circulating water basin/fire main/city water supply/lake/river, etc.) to provide an adequate supply for the pumps (fire engines, FLEX pumps, fire protection system pumps, etc.).
        vi. Potential detrimental impact on water supply source or output pressure when using the same source or permanently installed pump(s) for makeup for multiple simultaneous strategies.

[8] FLEX documentation should be auditable but does not require Appendix B qualification. Manufacturer's information may be used in establishing the basis for the equipment use.

vii. Availability of sufficient supply of fuel on-site to operate diesel powered pumps for the required period of time.

viii. Availability of an adequate and reliable source of electrical power to operate electric powered pumps for the required period of time.

ix. Potential clogging of strainers, pumps, valves or hoses from debris or ice when using rivers, lakes, ocean or cooling tower basins as a water supply.

2. Portable towable equipment that is designed for over the road transport typically used in construction/remote sites are deemed sufficiently rugged to function following a BDB seismic event.
3. Note that the functionality of the equipment may be outside the manufacturer's specifications if justified in a documented engineering evaluation.
4. It is desirable for diverse mitigation equipment to be commonly available (e.g., commercial equipment) such that parts and replacements can be readily obtained.

11.3 Equipment Storage

1. Detailed guidance for selecting suitable storage locations that provide reasonable protection during specific external events is provided in Sections 5 through 9.
2. A technical basis should be developed for equipment storage for FLEX equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented[9] basis that the mitigation strategy and support equipment will be reasonably protected from applicable external events such that the equipment could be operated in place, if applicable, or moved to its deployment locations. This basis should be auditable, consistent with generally accepted engineering principles, and controlled within the configuration document control system.
3. FLEX equipment should be stored in a location or locations[10] informed by evaluations performed per Sections 5 through 9 such that no one external event can reasonably fail the site FLEX capability (N).
4. Different FLEX equipment can be credited for independent events.
5. Consideration should be given to the transport from the storage area following the external event recognizing that external events can result in obstacles restricting normal pathways for movement.
6. If FLEX equipment is installed or pre-staged such that it minimizes the time delay and burden of hook-up following an external event, then the equipment should be evaluated to not have an adverse effect on existing SSCs. The primary and

[9] FLEX documentation should be auditable but does not require Appendix B qualification. Manufacturer's information may be used in establishing the basis for the equipment use.

[10] Location or locations may include areas outside the owner controlled area provided equipment can be relocated in time to meet FLEX strategy requirements.

alternate connection criteria and N+1 criteria of Section 3.2.2 still apply. The FLEX equipment must be reasonably protected in accordance with Section 11.3.3 above. The primary connection point should be as close to the intended point of supply as possible, e.g., a staged power supply to recharge batteries should be connected as close to the battery charger as practicable to maintain diversity and minimize the reliance on other plant equipment.

7. FLEX equipment should be stored and maintained in a manner that is consistent with assuring that it does not degrade over long periods of storage and that it is accessible for periodic maintenance and testing.
8. If LOLA equipment is credited in the FLEX mitigating strategies, it should meet the above storage requirements in addition to the LOLA requirements.
9. If debris removal equipment is needed, it should be reasonably protected from the applicable external events such that it is likely to remain functional and deployable to clear obstructions from the pathway between the FLEX equipment's storage location and its deployment location(s).
10. Deployment of the FLEX equipment or debris removal equipment from storage locations should not depend on off-site power or on-site emergency ac power (e.g., to operate roll up doors, lifts, elevators, etc.).

11.4 PROCEDURE GUIDANCE

11.4.1 Objectives

The purpose of this section is to describe the procedural approach for the implementation of diverse and flexible (FLEX) strategies. This approach includes appropriate interfaces between the various accident mitigation procedures so that overall strategies are coherent and comprehensive.[11] This approach is intended to provide guidance for responding to BDBEE events while minimizing the need for invoking 50.54 (x).

1. FLEX Support Guidelines (FSG) will provide available, pre-planned FLEX strategies for accomplishing specific tasks. FSG will support EOP, EDMG, and SAMG strategies.
2. Clear criteria for entry into FSG will ensure that FLEX strategies are used only as directed, and are not used inappropriately in lieu of existing procedures.
3. FLEX strategies in the FSG will be evaluated for integration with the appropriate existing procedures. As such, FLEX strategies will be implemented in such a way as to not violate the basis of existing procedures.
4. When FLEX equipment is needed to supplement EOP/AOP strategies, the EOP/AOP will direct the entry into and exit from the appropriate FSG procedure.

[11] Additional industry guidance concerning emergency response procedure coordination is provided in NEI 14-01.

5. FSG will be used to supplement (not replace) the existing procedure structure that establish command and control for the event (e.g., AOP, EOP, EDMG, and SAMG).
6. The existing command and control procedure structure will be used to transition to SAMGs if FLEX mitigation strategies are not successful.
7. If plant systems are restored, exiting the FSGs and returning to the normal plant operating procedures will be addressed by the plant's emergency response organization and operating staff dependent on the actual plant conditions at the time.

11.4.2 Operating Procedure Hierarchy

1. The existing hierarchy for operating plant procedures remains relatively unchanged with the following exceptions:
    a. A new group of FSG for implementation of FLEX strategies will be created.
    b. Existing AOP and EOPs will be revised to the extent necessary to include appropriate portions or reference to FSG.
2. Where FLEX strategies rely on plant equipment, changes may be required to AOPs and EOPs.
3. Transition from the current procedure structure to the modified procedure structure that incorporates the FLEX strategies is illustrated in Figure 11-1.

11.4.3 Development Guidance for FSGs

The inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, the FSG will provide guidance that can be employed for a variety of conditions.

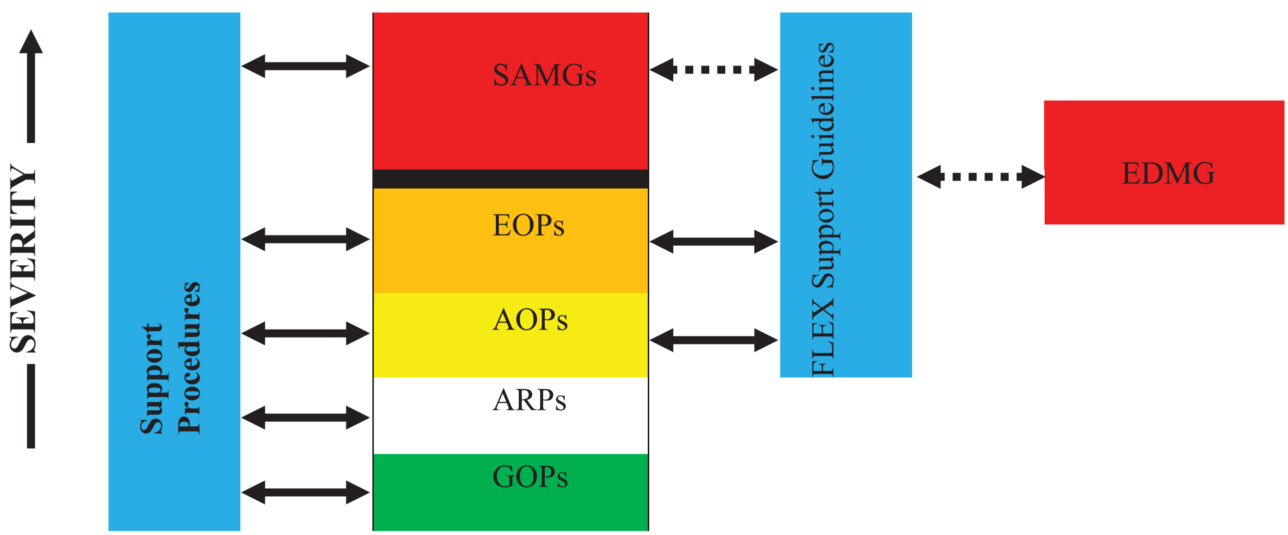
1. FSG should be reviewed and validated by the involved groups to the extent necessary to ensure the strategy is feasible in accordance with Appendix E. Validation may be accomplished via walk-throughs or drills of the guidelines.
2. FSGs will be controlled under the site procedure control program.

11.4.4 Regulatory Screening/Evaluation

NEI 96-07, revision 1, and NEI 97-04, revision 1 should be used to evaluate the changes to existing procedures as well as to the FSG to determine the need for prior NRC approval. Changes to procedures (EOPs or FSGs) that perform actions in response to events that exceed a site's design basis should screen out per the guidance and examples provided in NEI 96-07, Rev. 1. Therefore, procedure steps which recognize the beyond-design-basis ELAP/LUHS has occurred and which direct actions to ensure core cooling, SFP cooling, or containment function should not need to be evaluated in accordance with the regulatory processes associated with the UFSAR (i.e., 10 CFR 50.59 and 50.71). The same is true for other key licensing basis documents such as the security plan and emergency plan, and their related change control and reporting requirements, provided the changes being evaluated impact only mitigating strategies for BDBEEs and do not affect the content of the other licensing basis documents.

Figure 11-1
(a) Existing View of Typical Operating Procedure Hierarchy

(b) Future View of Typical Operating Procedure Hierarchy



Notes:

- The central column represents the procedure set that is in "command and control" of plant functions dependent upon plant conditions, shown in sequence of severity (e.g., risk to protection of the core). EDMG currently establish a separate command and control that is not recognized by the EOPs and SAMGs.
- Clear entry conditions and transitions exist between procedure sets as severity increases exist. Note that there may be some overlap on an Owner's Group specific basis where some AOPs, Alarm response and Normal plant procedures may be used to support each other or support the EOPs. However, there will be a clear controlling procedure in effect.
- Support procedures and FSGs are used to support the execution of plant strategies as shown, without exiting the controlling procedure. The double arrows mean that you may pull a specific strategy from the support procedure set without leaving the procedure in

effect. Note, not all sites have AOPs that would refer to FSGs. Interface with SAMGs and EDMGs (dotted arrows) is addressed in NEI 14-01.

- FSGs would be similar in intent as the current EDMGs. The future EDMG may rely upon FSGs.
- The heavy line between EOPs and SAMGs represents the procedure transition due to imminent core damage or damage to SFP fuel.

11.5 MAINTENANCE AND TESTING

1. FLEX equipment should be initially tested or other reasonable means used to verify performance conforms to the limiting FLEX requirements. Validation of source manufacturer quality is not required.
2. FLEX equipment that directly performs a FLEX mitigation strategy for the core, containment, or SFP should be subject to maintenance and testing [12] guidance provided in INPO AP 913, Equipment Reliability Process, to verify proper function. The maintenance program should ensure that the FLEX equipment reliability is being achieved. Standard industry templates (e.g., EPRI) and associated bases (i.e., site-specific) will be developed to define specific maintenance and testing including the following:
    a. Periodic testing and frequency should be determined based on equipment type and expected use. Testing should be done to verify design requirements and/or basis. The basis should be documented and deviations from vendor recommendations and applicable standards should be justified.
    b. Preventive maintenance should be determined based on equipment type and expected use. The basis should be documented and deviations from vendor recommendations and applicable standards should be justified.
    c. Existing work control processes may be used to control maintenance and testing. (e.g., PM Program, Surveillance Program, Vendor Contracts, and work orders).
3. Maintenance and testing for plant equipment is conducted in accordance with existing plant processes.
4. The functionality (i.e., the ability to perform its intended function) and protection of FLEX equipment and connections that directly perform a FLEX mitigation strategy for core, containment, and SFP should be managed.
    a. The controls for plant equipment that performs a FLEX function are provided by existing plant processes such as the Technical Specifications. When plant equipment which supports FLEX strategies is not able to perform its FLEX function, then the affected FLEX strategy(ies) does not need to be functional.

[12] Testing includes surveillances, inspections, etc.

b. FLEX equipment may be non-functional for 90 days provided that the FLEX capability (N) is met.[13]

   i. If equipment, which relies on separation from redundant or alternate equipment for reasonable protection (e.g., for tornado winds and/or missiles), is not functional, the non-functionality does not constitute a loss of reasonable protection for the redundant or alternate equipment.

c. Either the primary or alternate connection to plant equipment may be out of service for 90 days provided the remaining connection is functional.

d. If FLEX equipment or connections become non-functional such that the site FLEX capability (N) is not met, initiate actions (e.g., enter the condition into a corrective action or work management program) within 24 hours to restore the site FLEX capability (N) and implement compensatory measures (e.g., use of alternate suitable equipment or supplemental personnel) within 7 days or in advance of a forecast external event.

e. If the FLEX capability (N) is met but the equipment being relied on to meet the FLEX capability (N) is not all in its specified (i.e., per the Final Integrated Plan or Program Document) reasonable protection configuration for the N equipment, restore protection or implement compensatory actions (e.g., review hazard applicability under current conditions, achieve alternate protection or equipment separation, etc.) to justify a temporary reasonable protection configuration within 14 days or in advance of a forecast external event. Restore the specified reasonable protection configuration within 90 days.

f. FLEX equipment may be pre-staged for up to 45 days to reduce the risk of maintenance or outage activities. For this pre-staged equipment, condition e above does not apply.

11.6 TRAINING

1. Training should be provided to key personnel relied upon to implement the procedures and guidelines for responding to a beyond design basis event (see NEI 13-06, Enhancements to Emergency Response Capabilities for Beyond Design Basis Events and Severe Accidents). Training materials, delivery methods and frequencies, and evaluation techniques should be developed using established processes that address the “Systems approach to training” (SAT) elements listed in 10 CFR 55.4.

2. Periodic training should be provided to site emergency response leaders[14] on beyond-design-basis emergency response strategies and implementing guidelines.

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[13] The spare FLEX equipment is not required for the FLEX capability to be met. The allowance of 90-day non-functionality is based on a normal plant work cycle of 12 weeks. Aligning the out of service allowance to the site work management program is important to keep maintenance of spare FLEX equipment from inappropriately superseding other more risk-significant work activities. Equipment being unprotected does not make it non-functional.

[14] Emergency response leaders are those site and corporate emergency response personnel assigned leadership roles, as defined by the Emergency Plan, for managing emergency response to design basis and beyond-design-basis plant emergencies.

Operator training for beyond-design-basis event accident mitigation should not be given undue weight in comparison with other training requirements. The testing/evaluation of Operator knowledge and skills in this area should be similarly weighted.

3. Personnel assigned to direct the execution of mitigation strategies for beyond-design-basis events will receive necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints.
4. "ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training" certification of simulator fidelity (if used) is considered to be sufficient for the initial stages of the beyond-design-basis external event scenario until the current capability of the simulator model is exceeded. Full scope simulator models will not be upgraded to accommodate FLEX training or drills.
5. Industry guidance for conducting FLEX drills is provided in NEI 13-06.

11.7 STAFFING

1. On-site staff are at site administrative minimum shift staffing levels, (minimum staffing may include additional staffing that is procedurally brought on-site in advance of a predicted external event, e.g., hurricane).
2. No independent, concurrent events, e.g., no active security threat, and
3. All personnel on-site are available to support site response.

11.8 CONFIGURATION CONTROL

1. The FLEX strategies and basis will be maintained in an overall program document. This program document will contain a historical record of previous strategies and the basis for changes. The document will also contain the basis for the ongoing maintenance and testing programs chosen for the FLEX equipment.
2. Existing plant configuration control procedures will be modified to ensure that changes to the plant design, physical plant layout, roads, buildings, and miscellaneous structures will not adversely impact the approved FLEX strategies.
3. Changes to FLEX strategies may be made without prior NRC approval provided:
    a. The revised FLEX strategy meets
        i. the provisions of this guideline, or
        ii. the change to the strategies and guidance implement an alternative or exception approved by the NRC, provided that the bases of the NRC approval are applicable to the licensee's facility, or
        iii. an evaluation demonstrates that the provisions of Order EA-12-049 continue to be met.

        AND

b. An engineering basis is documented that ensures that the change in FLEX strategy continues to ensure the key safety functions (core and SFP cooling, containment function) are met.

4. If the change is determined to require prior NRC approval, a written request shall be submitted for prior NRC approval.
5. Documentation of all changes, including the evaluations required by paragraph 3 above shall be maintained for as long as the plant is required to have FLEX strategies

12 OFF-SITE RESOURCES

12.1 SYNCHRONIZATION WITH OFF-SITE RESOURCES

The timely provision of effective off-site resources will need to be coordinated by the site and will depend on the plant-specific analysis and strategies for coping with the effects of the beyond-design-basis external event. Arrangements will need to be established by each site addressing the scope of equipment that will be required for the off-site phase, as well as the maintenance and delivery provisions for such equipment.

As previously noted, the underlying strategies for coping with these events involve a three phase approach:

1. Initially cope by relying on plant equipment.
2. Augment plant equipment with sufficient on-site FLEX equipment and consumables to maintain or restore key functions.
3. Obtain additional capability and redundancy from off-site equipment until power, water, and coolant injection systems are restored or commissioned.

The plant-specific analyses previously described in this document will determine the duration of each phase. Justification for the duration of each phase should address the on-site availability of FLEX equipment, the resources necessary to deploy the equipment consistent with the required timeline, anticipated site conditions following the beyond-design-basis external event, and the ability of the off-site supplier and local infrastructure to enable delivery of equipment and resources from off-site.

On-site resources will be used to cope with the first two phases of the casualty for a minimum of the first 24 hours of the event. The site-specific ELAP analysis will dictate the deployment schedule for off-site equipment. The delivery schedule for the off-site equipment must allow for sufficient margin to meet the deployment times of the off-site equipment. The schedule for initial delivery of off-site equipment (equipment needed to back up on-site equipment and extend the coping duration) needs to be contractually arranged with the off-site facility.

Site procedures for Phase 3 implementation should address early notification to mobilize the off-site response, establishment of a point of delivery for the off-site equipment, arrangements for delivery and deployment at the site, and sufficient supplies of commodities to support the equipment and site personnel.

12.2 MINIMUM CAPABILITIES OF OFF-SITE RESOURCES

Each site will establish a means to ensure the necessary resources will be available from off-site. Considerations that should be included in establishing this capability include:

1. A capability to obtain equipment and commodities to sustain and backup the site's coping strategies.

2. Off-site equipment procurement, maintenance, testing, calibration, storage, and control.
3. A provision to inspect and audit the contractual agreements to reasonably assure the capabilities to deploy the FLEX strategies including unannounced random inspections by the Nuclear Regulatory Commission.
4. Provisions to ensure that no single external event will preclude the capability to supply the needed resources to the plant site.
5. Provisions to ensure that the off-site capability can be maintained for the life of the plant.
6. Provisions to revise the required supplied equipment due to changes in the FLEX strategies or plant equipment or equipment obsolescence.
7. The appropriate standard mechanical and electrical connections need to be specified.
8. Provisions to ensure that the periodic maintenance, periodic maintenance schedule, testing, and calibration of off-site equipment are comparable/consistent with that of similar on-site FLEX equipment.
9. Provisions to ensure that equipment determined to be unavailable/non-operational during maintenance or testing is either restored to operational status or replaced with appropriate alternative equipment within 90 days.
10. Provision to ensure that reasonable supplies of spare parts for the off-site equipment are readily available if needed. The intent of this provision is to reduce the likelihood of extended equipment maintenance (requiring in excess of 90 days for returning the equipment to operational status).

13 DOCUMENTATION

13.1 OVERALL INTEGRATED PLAN SUBMITTAL

New applicants should submit an Overall Integrated Plan describing how compliance with this guidance will be achieved. The Overall Integrated Plan should include a complete description of the FLEX strategies, including important operational characteristics. The level of detail generally considered adequate is consistent to the level of detail contained in the Licensee's Final Safety Analysis Report (FSAR). The plan should provide the following information:

1. Extent to which this guidance is being followed including a description of any alternatives to the guidance, and provide a milestone schedule of planned actions.

2. Description of the strategies and guidance to be developed.

3. Description of plant and FLEX equipment used in the strategies, the applicable reasonable protection for the FLEX equipment, and the applicable maintenance requirements for the FLEX equipment.

4. Description of the steps for the development of the necessary procedures, guidance, and training for the strategies; FLEX equipment acquisition, staging or installation, including necessary modifications.

5. Conceptual sketches, as necessary to indicate plant equipment or FLEX equipment hookups necessary for the strategies. (As-built piping and instrumentation diagrams (P&ID) will be available upon completion of plant modifications.)

6. Description of how the FLEX equipment will be available to be deployed in all modes.

13.2 FINAL REPORT

As stated in Section 11.8, the FLEX strategies and basis will be maintained in an overall program document. Changes to the FLEX strategies may be made in accordance with the guidance in Section 11.8. [15] These strategies and bases were originally submitted to the NRC for review and approval in the Overall Integrated Plan described above. Following implementation, the final strategies and bases will be submitted to the NRC in the Final Integrated Plan (FIP).

[15] See NRC memorandum "Regulatory Treatment of Mitigation Strategies" dated September 12, 2014 (ML14254A467)

14 REFERENCES

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APPENDIX A
GLOSSARY OF TERMS

This glossary provides definitions of key terms used in this guidance document. These definitions have been made consistent with other external definitions, to the degree possible, but the definitions herein represent the expressed intent of the terms as used in this guideline.

Alternate Mitigating Strategies (AMS): an event-specific functional approach taken to maintain or restore core cooling, containment, and SFP cooling capabilities in which an ELAP and LUHS are not assumed unless they are caused by the specified event.

Applicable external hazard: an external hazard that meets the screening criteria of the applicable section for a particular site. Not all sites will find the same hazards to be applicable.

Associated Effects: Factors, in addition to the maximum stillwater surface elevation, that are related to the flooding event. Associated Effects include:

- wind waves and run-up effects
- hydrodynamic loading, including debris
- effects due to sediment deposition and erosion
- concurrent site conditions, including adverse weather conditions
- groundwater ingress
- other pertinent factors

Baseline Coping Capability: a basic set of strategies for providing essentially indefinite coping capability for extended loss of ac power and loss of the ultimate heat sink scenarios through the use of plant equipment and FLEX equipment.

*Beyond-design-basis external event*s: for the purpose of this document are considered events initiated by natural phenomena that either exceed the protections provided by design basis features or involve natural phenomena within the design basis in combination with beyond-design-basis failures leading to an extended loss of ac power concurrent with a loss of ultimate heat sink. Appendix B provides an assessment of the potentially applicable natural phenomena and the basis for the grouping of hazard classes used in this guideline.

Essentially indefinitely: See *Sustaining functions indefinitely*.

Extreme external event: an external event that exceeds the plant design basis.

Final Integrated Plan (FIP) – The final document that contains the basis for the beyond-design-basis (BDB) strategies including the ongoing maintenance, training and testing programs.

FLEX Capability: a site-specific set of equipment strategies implemented through plant-specific procedures/guidance that provides essentially indefinite coping capability through the use of plant equipment and FLEX equipment.

FLEX Equipment: Equipment stored on-site or off-site whose primary function is to support FLEX strategies. The on-site equipment may be installed, pre-staged, or portable equipment based on the site-specific sequence of events for the ELAP with LUHS event and may be stored within the owner controlled area or in close proximity to the site.

FLEX Strategies: the plant-specific functional approaches taken to maintain or restore core cooling, containment, and SFP cooling capabilities

Flooding Event Duration: The length of time in which the flood event affects the site, beginning with conditions being met for entry into a flood protection procedure or notification of an impending flood (e.g., a flood forecast or notification of dam failure), including preparation for the flood and the period of inundation, and ending when water has receded from the site and the plant has reached a stable state that can be maintained indefinitely.

Flood Protection Features: Flood protection features include incorporated, exterior and temporary structures, systems, and components that are credited to protect against external floods (including flood height and associated effects) or mitigate the effects of external floods. These features can have either an active or passive flood protection function.

Loss of normal access to the ultimate heat sink: Loss of ability to provide a forced flow of water to key plant systems (i.e., the pumps are unavailable and not restorable as part of the coping strategy).

Mitigating strategies assessment: The process of establishing a plant's mitigating strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in response to the mitigating strategies flood hazard information.

Mitigating Strategies Flood Hazard Information: Flood scenario parameters (i.e., flood height, associated effects, and flooding event duration) that are determined by the flood hazard evaluation.

N+1 capability: provision of a spare capability to support the safety functional requirements beyond the minimum necessary to support the "N" units on-site.

Off-site equipment: equipment that is located away from the plant site and has to be transported from its storage location to the plant site for use.

Overall Integrated Plan (OIP) – The initially submitted OIP (i.e., February 2013 for the current operating fleet) , including any supplements, Responses to Requests for Additional Information, Six-Month Status Updates, and Responses to Open Items and Confirmatory Items from the Interim Staff Evaluation formally submitted to the NRC.

Program Document – Contains the FLEX basis and strategies as well as a historical record of changes. It also contains the basis for ongoing maintenance and testing programs for FLEX equipment.

Reasonable protection- Storing on-site FLEX equipment in configurations such that no one external event can reasonably fail the site FLEX capability (N) when the required FLEX equipment is available. When required FLEX equipment is not functional one external event could potentially fail the site FLEX capability (N) and, therefore, the duration of this non-functionality is limited.

Robust (designs): the design of an SSC either meets the current plant design basis for the applicable external hazard(s) or the current NRC design guidance for the applicable hazard (e.g., Regulatory Guide 1.76, Revision 1); or has been shown by analysis or test to meet or exceed the current design basis.

Sustaining functions indefinitely: Establishing strategies and resources to maintain a stable plant condition until recovery actions are implemented.

Targeted Hazard Mitigating Strategy (THMS): is an *alternate mitigating strategy* except that there is a need to open containment as a preemptive element of the strategy such that only core and spent fuel pool cooling capabilities are maintained.

Warning Time – The time from when the event is known to present a threat to the plant and the time when conditions could exceed permanently installed protections.

APPENDIX B
IDENTIFICATION OF BEYOND-DESIGN-BASIS EXTERNAL EVENTS TO BE CONSIDERED

B.1 Purpose

The purpose of this paper is to provide an evaluation of potential beyond-design-basis external hazards that could significantly challenge a U.S. nuclear power plant by causing a simultaneous ELAP and LUHS. The identified hazards will be addressed in the industry process developing site-specific FLEX capabilities.

B.2 Approach

Utilize the list of beyond-design-basis external hazards considered in the current ASME/ANS PRA Standard [Ref. B-1]. The PRA Standard explicitly addresses requirements for PRAs of seismic, high wind, and external flood hazards and provides a non-mandatory appendix (Appendix 6-A) that provides a comprehensive list of hazards that may be applicable to a specific site. Each of the hazards from Appendix 6-A is reviewed. Any that cannot be screened out as clearly irrelevant to a simultaneous ELAP and LUHS are retained for consideration as part of the site assessment process.

B.3 Results

The results of the review of the ASME/ANS list of external hazards are provided in Table B-1. A summary of where/how each applicable hazard will be addressed is provided below.

Some hazards could contribute to the potential for a simultaneous ELAP and LUHS, but do not significantly challenge the structures and internal plant equipment[16]. These hazards are therefore considered to be enveloped by baseline ELAP in Step 1:

- forest fire
- grass Fire
- lightning
- sandstorm
- volcanic activity

[16]NOTE: Solar-Geomagnetic disturbances could also lead to extended loss of off-site power due to geomagnetically-induced currents in electrical power transmission systems. However, this hazard was not included in Reference B-1 so it is not explicitly listed here. Nevertheless, while such disturbances could cause an extended loss of off-site power, they are not expected to impact the on-site safety-related equipment (e.g., diesel generators and internal distribution equipment) due to their being housed in reinforced concrete structures and would not change the approach to devising FLEX strategies.

Some hazards could contribute to the potential for a Loss of UHS in Step 1:

- biological events
- coastal erosion
- ice cover
- low lake or river water level
- river diversion

Seismic activity is explicitly considered as part of Step 2A.

Some hazards contribute to External Flooding and will be addressed in Step 2B:

- external flooding
- high tide
- precipitation
- seiche
- storm surge
- tsunami events
- waves
- hurricane

Some hazards involve High Winds and will be addressed in Step 2C:

- hurricane
- extreme winds and tornadoes

Some hazards involve Snow/Ice/Extreme Cold that may impede response actions. These will be addressed in Step 2D:

- avalanche
- ice cover
- snow
- low winter temperature

Some hazards involve Extreme High Temperatures and will be addressed in Step 2E:

- high summer temperature

The following hazards are either already covered by other regulations or were judged to be not applicable or insignificant contributors to a simultaneous ELAP and LUHS and were screened from further consideration:

- accidental aircraft impacts
- drought
- fog
- frost
- hail
- industrial or military facility accident
- landslide
- meteorite/satellite strikes
- pipeline accident
- release of chemicals from on-site storage
- ship impact
- sink holes
- soil shrink-swell
- toxic gas
- transportation accidents w
- turbine-generated missiles
- vehicle impact
- vehicle/ship explosion

B.4 References

American Society of Mechanical Engineers and American Nuclear Society, Addenda to ASME/ANS RA-S-2008 Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications, ASME/ANS RA-Sa-2009, New York (NY), February 2009.

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Table B-1
Evaluation of External Hazards Identified in the ASME/ANS PRA Standard [Ref. B-1]

External Hazard	Potentially Applicable for ELAP/LUHS?	Disposition
Accidental aircraft impacts	Y	Screened. Already enveloped by LOLA.
Avalanche	Y	Consider as part of treatment of Snow/Ice Effects
Biological events	Y	Consider as part of LUHS
Coastal erosion	Y	Consider as part of LUHS
Drought	N	Slow developing event not a short-term challenge to LUHS
External flooding	Y	Consider as part of External Flooding
Extreme winds and tornadoes	Y	Consider as part of High Winds
Fog	N	Screened
Forest fire	Y	Consider as enveloped by baseline treatment of ELAP
Frost	N	Consider as enveloped by treatment of Snow/Ice Effects
Grass Fire	Y	Consider as enveloped by baseline treatment of ELAP
Hail	N	Screened
High summer temperature	Y	Consider as part of treatment of Extreme Temperatures
High tide	Y	Consider as part of External Flooding
Hurricane	Y	Consider as part of External Flooding & High Winds
Ice cover	Y	Consider as part of LUHS and treatment of Snow/Ice Effects
Industrial or military facility accident	N	Screened
Landslide	N	Screened
Lightning	Y	Consider as enveloped by baseline treatment of ELAP
Low lake or river water level	Y	Consider as part of LUHS
Low winter temperature	Y	Consider as part of treatment of Snow/Ice Effects
Meteorite/satellite strikes	N	Screened
Pipeline accident	N	Screened
Precipitation	Y	Consider as part of External Flooding
Release of chemicals from on-site storage	N	Screened

Table B-1
Evaluation of External Hazards Identified in the ASME/ANS PRA Standard [Ref. B-1]

External Hazard	Potentially Applicable for ELAP/LUHS?	Disposition
River diversion	Y	Consider as part of LUHS
Sandstorm	Y	Consider as enveloped by baseline treatment of ELAP
Seiche	Y	Consider as part of External Flooding
Seismic activity	Y	Consider as part of Seismic
Ship impact	N	Screened
Sink holes	N	Screened
Snow	Y	Consider as part of treatment of Snow/Ice Effects
Soil shrink-swell	N	Screened
Storm surge	Y	Consider as part of External Flooding
Toxic gas	N	Screened
Transportation accidents	N	Screened
Tsunami events	Y	Consider as part of External Flooding
Turbine-generated missiles	N	Screened
Vehicle impact	N	Screened
Vehicle/Ship explosion	N	Screened
Volcanic activity	Y	Consider as enveloped by baseline treatment of ELAP
Waves	Y	Consider as part of External Flooding

APPENDIX C
APPROACH TO BWR FUNCTIONS

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling	• Reactor Core Cooling	• RCIC/HPCI/IC	• Use of plant equipment for initial coping	Provide initial makeup sufficient to maintain or restore RPV level with plant equipment and power supplies to the greatest extent possible to provide core cooling	• Extend installed coping capability through procedural enhancements (e.g., load shedding), provision of FLEX battery chargers and other power supplies. • Objective is to provide extended baseline coping capability with plant equipment. • Procedures/guidance to include local manual initiation of RCIC/IC, consistent with NEI 06-12. • If HPCI is relied upon as part of the Phase 1 coping strategy, provide means to manually initiate locally.

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling		• Depressurize RPV for Injection with FLEX Injection Source	• Diverse connection points for FLEX pump	Provide RPV makeup sufficient to maintain or restore RPV level with diverse and flexible capability.	• Diverse injection points are required to establish capability to inject through separate divisions/trains, i.e., should not have both connections in one division/train. • RPV makeup rate should be capable of removing the decay heat levels at the time of deployment in order to support restoring RPV water level, e.g., 300* gpm

*Note: Items are subject to generic or plant-specific analysis

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling			• Multiple means to depressurize RPV	Multiple means improves the reliability of the depressurization function. .	• Capability to manually depressurize the RPV to allow low head injection. • Procedure should address transition from the plant makeup/cooling source to FLEX equipment. This includes the appropriate approaches to initiating the transition to avoid prolonged core uncovery. • Multiple means established to assure reliability. • Analysis should demonstrate that guidance and equipment for combined RPV depressurization and makeup capability supports continued core cooling

*Note: Items are subject to generic or plant-specific analysis

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling		• Sustained Source of Water	• Use of alternate water supply up to support core and SFP heat removal	Water is a critical resource in sustaining coping capability.	• Water source sufficient to supply water indefinitely
	• Key Reactor Parameters	• RPV Level	• (Re-)Powered instruments	Instrumentation is vital to implementation of the coping procedures/guidance.	• Identify instruments to be relied upon, including control room and field instruments
		• RPV Pressure	• Other instruments for EOP-driven strategies		• Depending on strategy employed, some additional instrumentation may be required

*Note: Items are subject to generic or plant-specific analysis

Table C-2
Summary of Performance Attributes for BWR Containment Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Containment	• Containment Function	• Containment Venting or Alternative	• For Mk I and II a venting capability and, if desired, an alternative capability • For others, a vent or other capability.	Containment heat removal will be required for long-term coping	• Reliable means to assure containment heat removal.
	• Containment Integrity (BWR Mark III Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a FLEX power supply.	Maintain containment function post-core damage	• Diverse power connection points are required to establish capability through separate divisions/trains, i.e., should not have both connections in one division/train. • Procedures/guidance to prioritize deployment strategies.

*Note: Items are subject to generic or plant-specific analysis

Table C-2
Summary of Performance Attributes for BWR Containment Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Containment	• Key Containment Parameters	• Containment Pressure	• (Re-)Powered instruments	Required for containment venting and other coping actions.	• Identify instruments to be relied upon, including control room and field instruments
		• Suppression Pool Temperature		Required to determine HCTL to guide other actions	• Depending on strategy employed, additional parameters may be required.
		• Suppression Pool Level		Required for venting decisions	• Depending on strategy employed, additional parameters may be required.

*Note: Items are subject to generic or plant-specific analysis

Table C-3
Summary of Performance Attributes for BWR SFP Cooling Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
SFP Cooling	• Spent Fuel Cooling	• Makeup with FLEX Injection Source	• Makeup via hoses on refuel deck	Exceed SFP boil-off to support long-term cooling of spent fuel with sufficient makeup	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Makeup via connection to SFP cooling piping or other alternate location	Exceed SFP boil-off and provide a means to supply SFP makeup without accessing the refueling floor.	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Vent pathway for steam & condensate from SFP	Steam from boiling pool can condense and cause access and equipment problems in other parts of plant.	• Plant-specific strategy should be considered as needed
			• Spray capability via portable monitor nozzles from refueling floor using portable pump	Provide spent fuel cooling when makeup rate is not sufficient.	• Minimum of 200 [gallons per minute] gpm per unit to the pool or 250 gpm per unit if overspray occurs • This capability is not required for plants that have SFPs that are below ground and cannot be drained as determined during the implementation of

Table C-3
Summary of Performance Attributes for BWR SFP Cooling Function

Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
				B.5.b/10 CFR 50.54(hh)(2) • This capability is not required for plants that demonstrate spent fuel pool integrity by performing a seismic spent fuel pool integrity evaluation for their mitigating strategies seismic hazard using EPRI 3002007148, Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation, or other NRC endorsed guidance.
SFP Parameters	SFP Level	• Reliable means to determine SFP water level to prevent undue distraction of operators and identify conditions when makeup is required	Confirm SFP level is adequate to provide cooling	• Wide-range spent fuel pool level instruments

APPENDIX D
APPROACH TO PWR FUNCTIONS

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling	• Reactor Core Cooling & Heat Removal (steam generators available)	• AFW/EFW	• Use of plant equipment for initial coping	Provide SG makeup sufficient to maintain or restore SG level with plant equipment and power supplies to the greatest extent possible to provide core cooling	• Extend installed coping capability through procedural enhancements (e.g., load shedding), provision of FLEX battery chargers and other power supplies. • Objective is to provide extended baseline coping capability with plant equipment. • Procedures/guidance to include local manual initiation of ac-independent AFW/EFW pumps consistent with NEI 06-12.

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling		• Depressurize SG for Makeup with FLEX Injection Source	• Connection for FLEX pump	Provide SG makeup sufficient to maintain or restore SG level with diverse and flexible capability	• Primary and alternate injection points are required to establish capability to inject through separate divisions/trains, i.e., should not have both connections in one division/train. • Makeup paths supply required SGs • SG makeup rate should exceed decay heat levels at time of planned deployment in order to support restoring SG water level, e.g., 200* gpm. • Analysis should demonstrate that the guidance and equipment for combined SG depressurization and makeup capability supports continued core cooling.

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

C o	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
		• Sustained Source of Water	• Use of alternate water supply up to support core and SFP heat removal	Water is a critical resource in sustaining coping capability.	Water source sufficient to supply water indefinitely.

*Note: Items are subject to generic or plant-specific analysis

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling	• RCS Inventory Control/Long-Term Subcriticality	• Low Leak RCP Seals and/or borated high pressure RCS makeup required	• Site analysis required to determine RCS makeup requirements • Boration and/or letdown path may be required	Extended coping without RCS makeup is not possible without minimal RCS leakage. Plants must evaluate use of low leak RCP seals and/or providing a high pressure RCS makeup pump.	• Makeup capability to maintain core cooling*. • Sufficient letdown to support required makeup and ensure subcriticality*. • In order to address the requirement for diversity, if re-powering of installed charging pumps is used for this function, then either (a) multiple power connection points should be provided to the charging pump, or (b) provide a single power supply connection point for the charging pump and a single connection

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

Co	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
					point for a FLEX makeup pump

*Note: Items are subject to generic or plant-specific analysis

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling	• Core Cooling and Heat Removal (Modes 5 and 6 with steam generators not available)	• All Plants Provide Means to Provide Borated RCS Makeup **	• Diverse makeup connections to RCS for long-term RCS makeup and residual heat removal to vented RCS	Long-term sustained coping will require RCS makeup and boration	• Diverse injection points or methods are required to establish capability to inject through separate divisions/trains, i.e., should not have both connections in one division/train. • Connection to RCS for makeup should be capable of flow rates sufficient for simultaneous core heat removal and boron flushing (combined makeup flow exceeding 300* gpm). • On-site FLEX pump for RCS makeup. This can be the SG makeup pump since both will not be required at same time.
			• Source of borated water required	A source of borated water will be required to support RCS makeup.	• Could be an on-site tank, or could be provided by off-site resources.

*Note: Items are subject to generic or plant-specific analysis
**Note: There may be short periods of time during Modes 5 & 6 where plant configuration may preclude use of this strategy.

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling	• Key Reactor Parameters)	• SG Level	• (Re-)Powered instruments	Necessary to control heat removal.	• Identify instruments to be relied upon, including control room and field instruments • Depending on strategy employed, additional parameters may be required.
		• SG Pressure		Necessary to transition to FLEX pump.	
		• RCS Pressure		Necessary to assure depressurization to gain access to inventory for RCS makeup in safety injection accumulators.	
		• RCS Temperature		Necessary to monitor subcooling	

Table D-2
Summary of Performance Attributes for PWR Containment Function

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
Containment	• Containment Function	• Containment Spray	• Connection to containment spray header or alternate capability or analysis	In the long-term containment pressure may rise due to leakage from RCS adding heat to containment. Containment spray can help manage containment pressure.	• Due to the long-term nature of this function, the connection does not need to be a permanent modification. However, if a temporary connection, e.g., via valve bonnet, then this should be pre-identified.
	• Containment Integrity (Ice Condenser Containments Only)	• Hydrogen Igniters	• Re-powering of hydrogen igniters with a FLEX power supply.	Maintain containment function post-core damage	• Diverse power connection points are required to establish capability through separate divisions/trains, i.e., should not have both connections in one division/train. • Procedures/guidance to prioritize deployment strategies.

Table D-2
Summary of Performance Attributes for PWR Containment Function

Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
• Key Containment Parameters	• Containment Pressure	• (Re-)Powered instruments	Monitor long-term pressure buildup in containment	• Identify instruments to be relied upon, including control room and field instruments

Table D-3
Summary of Performance Attributes for SFP Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
SFP Cooling	• Spent Fuel Cooling	• Makeup with FLEX Injection Source	• Makeup via hoses on refuel floor	Exceed SFP boil-off to support long-term cooling of spent fuel with sufficient makeup.	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Makeup via connection to SFP cooling piping or other alternate location	Exceed SFP boil-off and provide a means to supply SFP makeup without accessing the refueling floor.	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Vent pathway for steam & condensate from SFP	Steam from boiling pool can condense and cause access and equipment problems in other parts of plant.	• Plant-specific strategy should be considered as needed
			• Spray capability via portable monitor nozzles from refueling floor using portable pump	Provide spent fuel cooling when makeup rate is not sufficient.	• Minimum of 200 [gallons per minute] gpm per unit to the pool or 250 gpm per unit if overspray occurs • This capability is not required for plants that have SFPs that are below ground and cannot be drained as determined

Table D-3
Summary of Performance Attributes for SFP Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
					during the implementation of B.5.b/10 CFR 50.54(hh)(2) • This capability is not required for plants that demonstrate spent fuel pool integrity by performing a seismic spent fuel pool integrity evaluation for their mitigating strategies seismic hazard using EPRI 3002007148, Seismic Evaluation Guidance: Spent Fuel Pool Integrity Evaluation, or other NRC endorsed guidance.

Table D-3
Summary of Performance Attributes for PWR SFP Cooling Functions

	Safety Function	Method	Baseline Capability	Purpose	Performance Attributes
SFP Cooling	• SFP Parameters	• SFP Level	• Reliable means to determine SFP water level to prevent undue distraction of operators and identify conditions when makeup is required	Confirm SFP level is adequate to provide cooling.	• Wide-range spent fuel pool level instruments

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APPENDIX E
VALIDATION GUIDANCE

E.1 PURPOSE

The purpose of this guide is to outline a process that may be used by licensees to reasonably assure required tasks, manual actions and decisions for FLEX strategies are feasible and may be executed within the time constraints identified in the Overall Integrated Plan (OIP) / Final Integrated Plan (FIP) or the sequence of events associated with the Mitigating Strategies Flood Hazard Information (MSFHI).

The process defined in this appendix is sufficient for a licensee to demonstrate the ability to execute the strategies developed per this guidance.

E.2 SCOPE

Validation Process – Validation of FLEX strategies consists of validation of the feasibility of individual strategies identified in the OIP/FIP using the graded approach as described in this document and an integrated review of the FLEX strategies. The purpose of the integrated review is to ensure that adequate resources (personnel, equipment, materials) are available to implement the individual strategies to achieve the intended results. Any appropriate methodology (schedule, spreadsheet, etc.) may be used to perform the integrated review. Validation also includes actions that are time constraints required to mitigate the MSFHI.

Verification Process – Prior to the validation process, verification of equipment capability and performance, equipment connections, tooling, plant modifications, and procedures/guidelines will have been accomplished as part of the existing licensee processes such as the design change process, procurement process or procedure/guideline development process. Therefore, additional verification is not within the scope of this validation process.

E.3 TERMS AND DEFINITIONS

Anticipatory Actions – Actions completed in preparation for the occurrence of an event based upon the receipt of notification of the event due to the availability of warning time.

Reactive Actions- Actions completed after the event starts or after warning time ends.

Scaling – Method of determining the duration of a task/sub-task (repetitive task such as rolling out hose or cable) by timing a portion of the activity to determine the total time of the activity through a simple ratio analysis.

Time Constraint – The maximum time period associated with a strategy for which an action(s) can be completed and still be successful.

Time Sensitive Actions (TSAs) – Tasks, manual actions or decisions that are identified as having Time Constraints in Attachment 1A of the OIP/FIP, "Sequence of Events Timeline" or the sequence of events associated with the MSFHI.

E.4 ASSUMPTIONS AND CONSIDERATIONS

A. The validation plan for the selected TSA must be consistent with the resources assumed available for the event (e.g., Phase 2 Staffing Study, if complete).

B. The validation process will be conducted consistent with ensuring plant and personnel safety consistent with site safety policies and practices. It is not the intent to connect to or operate plant equipment during validation.

C. To minimize the risk to personnel and plant equipment, the validation may be conducted out of sequence, under simulated conditions, using reasonable scaling and under normal working conditions.

D. The time required to place the system in service to implement the given strategy, such as fill and vent and sequencing of loads for electrical systems, should be included in the validation process.

E. Validation is not required for damage assessment (post event plant assessment) or debris removal. Debris removal capability was included as part of debris removal equipment and deployment route(s) selection.

F. For FLEX implementation, anticipatory actions taken for external events that have warning time (e.g., plant shutdown, pre-staging FLEX equipment, extra personnel and/or staffing of TSC/OSC, etc.) are excluded from the validation process. Any actions taken in advance provide additional margin for timed actions post event and are considered bounding. Additionally, since the external events for which FLEX was validated were design basis external events, the validation did not include actions taken in advance of the event during any applicable warning time because these actions would have been validated as part of the design basis event response (e.g., external hazards preparation abnormal operating procedures).

G. Validation should be performed for new or modified anticipatory actions as well as existing anticipatory actions from the design basis response that may be performed under different environmental conditions. This validation should include an assessment of the triggering event notification that starts the warning time period and the conditions that could exist when the anticipatory action is planned to be performed to ensure that the action is viable (e.g., assess that site flood levels at the time of deployment of FLEX equipment would not prevent the deployment).

H. An essential part of the validation is a qualitative assessment of the available margin (the time difference between when a TSA can be completed under ideal conditions and when the TSA is required to be complete for successful implementation of the strategy.) This assessment balances the nature (e.g. amount of work, degree of difficulty and coordination, length of deployment paths, etc.) and timing (i.e., how soon does the task need to be started following the event) of the tasks against the margin available and supports a conclusion on whether or not the margin is adequate to accommodate the unknown using reasonable judgment. This qualitative assessment is documented in the conclusions of the validation plan.

I. The focus of the validation process is on assuring that confidence can be established in the feasibility of the actions required. The implementation of FLEX included features that can enhance the feasibility of these actions (e.g. standard connections, color coding, enhanced labeling, procedural cues, use of diagrams/pictorial reference, etc.). These attributes are addressed in the straightforward nature of the required actions and validation of the key tasks/subtasks.

J. Since shutdown mode strategies under Section 3.2.3 do not require an analysis defining a timeline for response, any identified tasks that require validation only require a Level C validation. This does not include anticipatory actions.

K. Personnel will be available to implement the individual FLEX strategies as documented in the staffing study.

L. Any deficiencies noted during the validation process will be entered in the station corrective action program. Deficiencies that affect compliance will be resolved prior to implementation.

E.5 OVERVIEW

E.5.1 OVERALL VALIDATION PROCESS

A graded approach for validation is used in order to apply a higher level of detail and rigor to validations for TSAs that have limited available margin and would be necessary when personnel resources may be at minimum administrative staffing levels. Resources to accomplish the TSA are considered in the application of validation methods.

The overall validation process will consist of the following steps:

- Identify the tasks, manual actions and/or decisions that require validation
- Select the appropriate graded approach (Level A, B or C as discussed below) for the applicable decisions and/or actions
- Conduct the validation
- Document the results

The validation process will be conducted consistent with ensuring plant and personnel safety.

E.5.1.1 Identification

TSAs in the OIP/FIP, Attachment 1A, "Sequence of Events Timeline" or in the sequence of events associated with the MSFHI will be considered for validation. In addition, any other actions that are labor intensive or require significant coordination should be considered for validation.

E.5.1.2 Graded Approach Selection

Note: Phase 3 activities, tasks performed greater than 24 hours after the event, and tasks performed for events that occur while units are in an outage (per Section 3.2.3), will not be time validated. In each case additional personnel and equipment are assumed to be available either from off-site response, or in the case of an outage, additional on-site personnel.

For reactive actions, a graded approach is used to identify the level of validation for TSAs as follows:

- Level A: Used for TSAs started within the first 6 hours
- Level B: Used for TSAs started between 6 and 24 hours after the event
- Level C: Used for other tasks or manual actions in the OIP/FIP that are not TSAs but are labor intensive or require significant coordination

For anticipatory actions, a graded approach is used to identify the level of validation for TSAs as follows:

- Level A: TSAs for events where warning time is 6 hours or less.
- Level B: TSAs for events where warning time is greater than 6 hours.

E.5.1.3 Conduct of Validation

Create a validation plan commensurate with the validation level selected for each identified TSA.

Conduct the validation on each identified TSA using one or more of the methods specified in Section E.6.3.

A TSA may be divided into subtasks. To minimize the risk to personnel and plant equipment, the validation may be conducted out of sequence, under simulated conditions, using scaling and under normal working conditions.

A validation may be conducted in a segmented manner.

Draw conclusions based upon results of the validation process, including qualitative assessment of environmental impacts (Refer to Assumptions and Considerations in Section 4 and examples in Attachment 3).

E.5.1.4 Documentation

Validation documentation will include the validation plan for the TSA, which will consist of the validation level selected, the elements of the TSA to be measured or demonstrated, the success criteria, results, and conclusion.

Validation will be included or incorporated by reference in the Program Document.

E.6 VALIDATION PROCESS

E.6.1 IDENTIFICATION OF ITEMS TO BE VALIDATED

Reactive TSAs within the first 24 hours will be included in the validation process.

Anticipatory TSAs will be included in the validation process.

Other tasks or manual actions in the OIP/FIP may be identified for inclusion in the validation process, such as those which are labor intensive or require significant coordination.

E.6.2 SELECTION OF VALIDATION METHODS

- Select Level A based on Section E.5.1.2, Graded Approach Selection.
- Select Level B based on Section E.5.1.2, Graded Approach Selection.
- Select Level C based on Section E.5.1.2, Graded Approach Selection.

E.6.3 CONDUCT OF VALIDATION

Create a validation plan commensurate with the validation level selected for each identified TSA, task, manual action or decision using the template in Attachment 2. Clarifying guidance for the validation plan instructions below is provided via the validation examples included in this document (Attachment 3).

A successful validation plan will be included or incorporated by reference in the Program Document.

A validation plan header shall be included with a unique validation plan number for ease of reference.

Table A. Validated Item Results

Document the following:

- Action. This will normally be a TSA that supports the strategies, but can be any task, manual action or decision that needs a validation to ensure that it can be successfully performed to support the strategies.

- Level. This is the validation level based on the criteria from Section E.6.2.
- Time Constraint. This is the time at which the validated item must be completed to successfully implement the strategy. Note that time constraints are normally measured from the time of the event or 0 hours.
- Action Item # from OIP Attachment 1A or the sequence of events from the MSFHI. The number for the Action Item from Attachment 1A that is being validated.
- Task. Short description of the action.
- Start Time. The earliest time that the validated item can start. Some examples of start times are the time of the event (0 hours), declaration of the ELAP (1 hour), arrival of augmented staff (6 hours).
- Success Criteria. The time available to complete the validated item, which is the time constraint minus the start time.
- Results. The actual time it took to complete the validated item during the performance of the validation. It will be the sum of the times for each subtask for those items that were divided into subtasks. (Note: For Level C validations the times will be N/A.)
- Margin. The time difference between the success criteria and results is the margin available for that item.

Table B. Validation Team Members:

- Document the names of all personnel that took part in the validation and their title/position.

Table C. Validation Performance

- Action Item #. The number for the Action Item from OIP Attachment 1A or the sequence of events from the MSFHI that is being validated.
- Task. Short description of the action.
- Controlling Procedure. FSG or site-specific procedure used to validate the task.
- Subtask No. Sequential order for ease of reference.
- Subtasks to complete task from Table A. Short description of subtasks.
- Method. The method(s) chosen from Section E.6.3, based on the validation level, used to validate the subtask.
- Resources. Reference Section E.4.0.A.

- Results. The actual time it took to complete the validated item during the performance of the validation. It will be the sum of the times for each subtask for those items that were divided into subtasks. (Note: For Level C validations the times will be N/A).
- Aggregate. The sum of the controlling results (see Note below).

Note: Certain subtasks may be performed in parallel with other subtasks. In the case of parallel subtasks, only those subtasks that take the longest time are considered the controlling results and counted in the aggregate. Parallel subtasks that are not included in the sum should be shaded.

Table D. Other Considerations:

- Document any other considerations that are important to understanding the validation. Items documented should include: predecessor activity, definition of time constraint/success criteria, specific assumptions, use of multiple crews/validation performances, exceptions and justifications to the process, special or unique situations and circumstances, etc.

Table E. Performance Attributes

Attachment 4, "Guidance on the Consideration of Performance Attributes", provides general instructions on filling out Table E. Site specifics will need to be considered for each attribute.

- Document the appropriate attributes for the Action Item being validated. A brief summary (a paragraph will suffice) to explain the factors taken into consideration for the specific performance attribute.

Attachment 5, "Inherent FLEX Attributes that Enhance Human Reliability in the Event of a Beyond-Design-Basis Event," addresses how FLEX considers the performance attributes listed in Table E.

Table F. Conclusions

- Document the conclusion(s) regarding the results of the validation.
- Document the qualitative assessment of adequate margin.

Table G. References and Supporting Documentation

- Document relevant references used in the validation.

E.6.3.1 Validation for Level A TSAs

Validation for Level A TSAs shall be performed by one or a combination of the following methods:

- Simulated Scenario – A timed validation method using a simulator or mock-up to validate a decision or action in a procedure/guideline.

- In-plant Timed Walkthroughs and/or Timed Demonstrations – A timed validation method where procedure/guideline performance is simulated by walking through the procedure/guideline steps at the locations specified in the procedure/guideline and/or by demonstrating the action through the physical deployment of equipment, if appropriate. No manipulation of plant equipment is required.
- Level A Reasonable Judgment – A validation method only used to estimate the time required to accomplish a portion of the TSA, where Simulator and In-plant Timed Walkthrough methods are not practicable for the task to be performed due to safety of plant/personnel concerns. If used, Level A reasonable judgment should be based on prior performance of similar tasks or evaluations. A brief justification should be provided to support non-performance of a task and to provide confidence of feasibility of the task performance during a BDBEE. A TSA cannot be validated solely with Level A Reasonable Judgment.
- Level A Records – A validation method where documentation of previous performance (timed) are used as a basis for the time required for performing a TSA, using training or other validation records such as simulator scenarios, validation results for similar activities, Job Performance Measures (JPM), On the Job Training (OJT), or Task Performance Evaluations (TPEs).

E.6.3.1.1 Resources

Validation for Level A TSAs shall be performed with resource(s) intended for implementation of TSA(s) / task(s) / sub-task(s). For Level A Validation, resources include on-site resources such as tools, equipment, and the available personnel expected to be assigned to the TSA.

E.6.3.1.2 Validation Confidence

Additional performances using different personnel and/or multiple teams will be conducted to ensure confidence in the initial validation based on the aggregate of the following:

- Complexity of the task.
- Margin available for the task (difference between the time required to perform the task and the time available)
- Consequences of suboptimal performance (e.g., would partial performance of load shedding result in an extension of battery life less

than that planned for and reduce the time available for completing the strategy to maintain key safety functions).

- Consequences of task failure that would result in a failure of the strategy to maintain key safety functions.

E.6.3.2 Validation for Level B TSAs

Validation for Level B TSAs shall be performed by one or a combination of the following methods:

- In-plant Walkthroughs and/or Demonstrations – A validation method where procedure/guideline performance is simulated by walking through the procedure/guideline steps at the locations specified in the procedure/guideline and/or by demonstrating the physical deployment of equipment, if appropriate. It is acceptable to estimate time rather than timing the walkthrough or demonstration. The intent is to confirm the feasibility of the TSA. No manipulation of plant equipment will occur.
- Level B Reasonable Judgment – A validation method used to estimate the time required to accomplish tasks. Level B Reasonable Judgment may be used in conjunction with other methods in this section.
- Tabletop – A validation method where TSAs are reviewed to determine feasibility and estimated time through procedure/guideline reviews and reasonable judgment using knowledgeable members representative of personnel intended to perform the TSA.
- Level B Records – A validation method used to document the timed validation of TSAs using training or other validation records such as simulator scenarios, validation results for similar activities, Job Performance Measures (JPM), On the Job Training (OJT), or Task Performance Evaluations (TPEs). NOTE: If the Level B records do not provide a timed duration, Level B reasonable judgment can be used, where appropriate, to estimate task duration.
- Any of the Level A methods described above may be used, but are not required.

E.6.3.2.1 Resources

Validation for Level B TSAs shall be performed with resource(s) intended for implementation of TSA(s) / task(s) / sub-task(s). Resources include on-site and augmented personnel expected to be assigned to the TSA, tools, equipment, etc.

E.6.3.2.2 Validation Confidence

In order to ensure confidence of the validation of Level B TSAs, licensees should consider:

- Use of multiple performances with multiple crews in instances where validation indicates limited margin.
- Use of additional rigor by employing different personnel during the initial validation to ensure confidence.
- Use of any of the Level A methods described above.

E.6.3.3 Validation for Level C Tasks or Manual Actions

Validation for Level C tasks or manual actions shall be performed by one or a combination of the following methods:

- Level C Reasonable Judgment - A validation method used to assess the capability to successfully accomplish tasks or manual actions.
- Any of the Level A or Level B methods described above may be used, but are not required.

E.6.3.3.1 Resources

Validation for Level C tasks or manual actions shall be performed with resource(s) intended for implementation of task(s) / sub-task(s). Resources include on-site and augmented personnel (including consideration of the National SAFER Response Centers personnel) expected to be assigned to the task(s), tools, equipment, etc.

E.6.3.3.2 Validation Confidence

Additional validation confidence of Level C tasks or manual actions is not required since these actions are not time sensitive and therefore, no defined margin exists that requires the application of additional rigor.

E.6.4 DOCUMENTATION

Validation documentation, as shown in Attachment 2, shall contain the following:

- Items to be Validated
- Validated Item Results
  - Item
  - Level

- Time Constraint
- Action Item # from OIP Attachment 1A
- Task
- Start Time
- Success Criteria
- Results
- Margin

- Validation Team Members
  - Name
  - Title / Position
- Validation Performance
  - Action Item #
  - Task
  - Controlling Procedure
  - Subtask No.
  - Subtasks to Complete Task from Table A
  - Method
  - Resources
  - Results
  - Aggregate
- Other Considerations (if needed)
  - Performance Attributes
  - Special Equipment
  - Complexity
  - Cues and Indications
  - Special Fitness Issues
  - Environmental Factors and Accessibility
  - Communications
  - Special Considerations

- Conclusions
- References and Supporting Documentation

E.6.5 VALIDATIONS AND INTEGRATED REVIEW

When the Validation Plan has been completed, there should be reasonable confidence in both the ability to execute each validated item in the plan individually and the margin to account for the unknown associated with Level A & B validated items. Any exceptions should be documented in the corrective action program and the proper adjustments made and validated prior to proceeding with the integrated review.

Up until this point the validation process has considered only a subset of the actions required to implement a specific FLEX strategy and only as individual actions. Additionally, each separate validation plan assumes that all of the resources necessary to execute the item being validated are available without regard to any other actions that may be taking place at the same time.

An integrated review must be performed as the final step of the validation process to ensure adequate resources are available to accomplish a FLEX strategy as a whole. The specifics on how to perform this integrated review can be in the form of a resource loaded schedule, spread sheet or any other appropriate methodology that will readily show that the resources are adequate and not credited more than once for any given time.

The following should be considered for the integrated review:

- The integrated review applies to baseline coping strategy. Even though there are contingencies in FLEX (e.g. deploying a FLEX pump to back up the Turbine Driven Auxiliary Feedwater pump), these contingency actions should not be included in the integrated review (i.e., the assumptions in Section 3 all hold true for the integrated review).
- Even though an item or action was not included for independent validation in the validation plan, the integrated review must account for any additional resources that are required for these items or actions.
- Staffing assumptions are based on NEI 12-01.
- Use of margin is still appropriate to account for any unknown (inclement weather, darkness, etc.) that only uses more time. (i.e., no additional personnel or equipment resources are assumed or required.) One possible method of showing margin is through the use of float time in scheduling software.
- Some consideration must be given to unknowns (debris removal, damage assessment, etc.) that require the use of personnel or equipment. Margin can still account for this type of unknown. The difference is that the resource must also be tracked and margin adjusted appropriately when the resources are needed for other than just addressing the unknown.

- Where appropriate, the integrated review must also account for the logical progression of activities. There may be cases where an activity cannot start until another activity is completed.

Document the results of the integrated review in the same manner as the validation plans.

E.7 ATTACHMENTS

[Throughout the Attachments, both instructions and fields for licensee specific information are presented in brackets.]

- Green brackets designate utility specific information for licensees to fill in
- Blue brackets designate instructions
- All bracketed text should be removed from the final forms.

Attachment 1, Items to be Validated

Attachment 2, Validation Plan

Attachment 3, Examples

Attachment 4, Guidance on the Consideration of Performance Attributes

Attachment 5, Inherent FLEX Attributes that Enhance Human Reliability in the Event of a Beyond-Design-Basis Event

ATTACHMENT 1
ITEMS TO BE VALIDATED

[The following table, based on an Overall Integrated Plan/Final Integrated Plan, Table 1A, or the sequence of events associated with the MSFHI, provides the reviewer with a rapid reference for determining validation levels with respect to the event timeline.]

Annotated Sequence of Events Timeline, Attachment 1A

From [Site Overall Integrated Plan/Final Integrated Plan or MSFHI]

Action Item	**Elapsed Time**	**Action**	**Time constraint Y/N Level of Validation (A,B,C,N/A)**	**Remarks/Applicability**
	0	Event Starts	NA	Plant @ 100% power
1	xxx	xxxxxxxxxxx	x	xxxxxxxx
x	xxx	Declare ELAP	x	xxxxxxxx

ATTACHMENT 2
VALIDATION PLAN

Validation Plan No.: [x] [*Plant specific unique identifier*]

<table>
<tr><td colspan="6">Table A - Validated Item Results</td></tr>
<tr><td colspan="2">Item: [Title of Item to be Validated] [From Attachment 1, Items to be Validated]</td><td colspan="3">Level:
☐A☐B☐C
[From Attachment 1, Items to be Validated]</td><td>Time Constraint:
[time constraint]</td></tr>
<tr><td>Action Item # from OIP Attachment 1A</td><td>Task</td><td>Start Time</td><td>Time Constraint</td><td>Success Criterion
(Time Constraint minus Start Time)</td><td>Results
(sum of times measured during validation process)</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Margin = [Success Criteria] – [Results] hrs</td></tr>
</table>

Validation Plan No.: [x] *[Plant specific unique identifier]*

Table B - Validation Team Members	
Name	**Title / Position**

Validation Plan No.: [x] *[Plant specific unique identifier]*

Table C - Validation Performance				
Action Item #: [X] *[From Attachment 1, Items to be Validated]* **Task: [X]** *[From Table A, Validated Item Results Table above]*			**Controlling Procedure** *[enter FSG or site-specific procedure used]*	
NOTE: Non-controlling parallel results have been shaded				
Subtask No.	**Subtasks to Complete Task from Table A**	**Method**	**Resources**	**Results**
a.				
b.				
c.				
Aggregate:				

<u>Validation Plan No.</u>: <u>[x]</u> *[Plant specific unique identifier]*

Table D - Other Considerations (if needed)
[Unique considerations] *[Document any other considerations that are important to understanding the validation. Items documented should include: predecessor activity, definition of time constraint/success criteria, specific assumptions, use of multiple crews/validation performances, exceptions and justifications to the process, special or unique situations and circumstances, etc.]*

NOTE: Refer to Attachment 4 for Performance Attributes that are applicable for the task/subtask being validated.

Table E - Performance Attributes	
CONSIDERATION OF PERFORMANCE ATTRIBUTES ***(Task Title Here)***	
Special Equipment	**Describe special equipment required for successful completion of the task.**
Complexity	**Describe any complexity issues or coordination requirements related to this task.**
Cues and Indications	**Describe specific cues or indications needed for the successful completion of the task.**
Special Fitness Issues	**Describe how special fitness issues have been addressed.**
Environmental Factors and Accessibility	**Describe how environmental issues have been addressed. (Include any specific assessments that may have been performed.)**
Communications	**Describe the communication requirements needed for the performance of the task.**
Special Considerations	**Describe any other special considerations identified for the task.**

<u>Validation Plan No.</u>: **<u>[x]</u>** *[Plant specific unique identifier]*

Table F - Conclusions
[Provide input here for additional relevant items including plant response time, donning and doffing of personnel protective equipment (PPE)]

Table G - References and Supporting Documentation

ATTACHMENT 3
EXAMPLES

EXAMPLE SECTION

This section contains examples of Attachment 1 and

Attachment 2 Level A, B, and C type validations

Annotated Sequence of Events Timeline, Attachment 1A
From XYZ Power Plant Overall Integrated Plan

Action Item	**Elapsed Time**	**Action**	**Time constraint Y/N** **Level of Validation**	**Remarks/Applicability**
	0	Event Starts	NA	Plant @ 100% power
1	15 sec	TDAFW pump starts. Verify AFW flow to "A" SG.	N	Original design basis for SBO event. 50 min to "A" SG dryout.
2	15 sec	Loss of All Power Procedure is entered	N	SBO event required response
3	15 min	Verify RCS Isolation	N	Establishes long term inventory in the RCS.
4	**50 min**	**Re-Align AFW to all SGs**	**Y** **Level A**	**50 min to "B" and "C" SGs dryout. 1 hr. to "A" SG overfill.**
5	50 min	Control SG PORVs and AFW flow	N	On-going action for cooldown and decay heat removal – operations personnel remain stationed locally.
6	**60 min**	**ELAP Declared**	**Y** **Level A**	**Predecessor activity for entry into FSGs**
7	**90 min**	**DC load stripping completed**	**Y** **Level A**	**Starts at 60 min and completed in 30 min. to provide an 8 hr. battery life for each unit.**
8	**4.2 hrs**	**Provide backup AFW supply**	**Y** **Level A**	**Minimum ECST level is reached (4.2 hrs).**
9	6 hrs	Augmented Staff Arrive on Site	N/A	Reference NEI 12-01
10	**8 hrs**	**Repower battery chargers**	**Y** **Level A**	**Batteries depleted in 8 hours. (start activity within 6 hours)**

Action Item	Elapsed Time	Action	Time constraint Y/N Level of Validation	Remarks/Applicability
11	12 to 24 hrs	Deploy BDB AFW pumps	N	BDB AFW pumps are deployed in standby as a backup to the TDAFW pump. This is not a time critical action since the TDAFW pump will continue to function.
12	**17.2 hrs**	**Initiate RCS injection for RCS inventory make-up /reactivity control using the BDB RCS Injection pump**	**Y** **Level B**	**17.2 hrs (Ensure adequate boron mixing) / Reactivity control: 37 hrs**
13	**20 hrs**	**Add inventory to SFP**	**Y** **Level B**	**9 hours to boiling / 20 hours to water level at 10 ft. above fuel. This is an ongoing activity.**
14	**3-4 days**	**Deploy BDB High Capacity pump**	**N** **Level C**	**This pump may be used to replenish the ECST, for mixing with boric acid, or to refill the SFP. It is not required at this time but will be deployed for future use if needed.**
15	**4-5 days**	**Reduce pressure and temperature in Containment**	**N** **Level C**	**Prior to affecting the function of key** **parameter monitoring instrumentation.**
16	**>5 days**	**Establish Back-up Water Source to Condensate Storage Tank**	**N** **Level C**	**This is an alternate SG feed source after CST and RMWT are depleted.**

Table A - Validated Item Results					
Item: ***Repowering Battery Chargers***		**Level:** ☒*A*☐*B*☐*C*		**Time Constraint:** ***8 hrs***	
Action Item # from OIP Attachment 1A	**Task**	**Start Time**	**Time Constraint**	**Success Criterion** ***(Time Constraint minus Start Time)***	**Results** ***(sum of times measured during validation process)***
10	Energize 480V loads and battery chargers	1 hr	8 hrs	7 hrs	5.75 hrs
Margin = 1.25 hrs					

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Level A Example

Validation Plan No.: 12345

Table B - Validation Team Members	
Name	**Title / Position**
John J. Smith	Auxiliary Operator
Paul Russell	Auxiliary Operator
Mindy Jones	Reactor Operator
George Hunnicutt	Operations Supervisor
Jane Bachman	Security Officer
Wayne First	Security Officer
Jesse Good	Security Officer

Level A Example

Validation Plan No.: 12345

Table C - Validation Performance

Action Item #: 10 **Task:** ***Energize 480V Loads and Battery Chargers***	**Controlling Procedure:** **FSG-4,** ELAP DC Bus Load Shed / Management

NOTE: Non-controlling parallel results have been shaded

Subtask No.	Subtasks to Complete Task from Table A	Method	Resources	Results
a.	Conduct pre-job brief and transport generator from storage to sally port	Timed Demonstration	1 Auxiliary Operator, 1 Security Officer, Tow vehicle#1	0.75 hrs
b.	Transport generator through sally port	Level A Reasonable Judgment	1 Auxiliary Operator, 2 Security Officers, Tow vehicle #1, 1 Fork lift	0.5 hrs
c.	Transport generator from sally port to staging area A	Timed Demonstration	1 Auxiliary Operator, 1 Security Officer, Tow vehicle #1	0.5 hrs

Table C - Validation Performance				
Action Item #: 10 **Task:** ***Energize 480V Loads and Battery Chargers***			**Controlling Procedure:** **FSG-4,** ELAP DC Bus Load Shed / Management	
NOTE: Non-controlling parallel results have been shaded				
Subtask No.	**Subtasks to Complete Task from Table A**	**Method**	**Resources**	**Results**
d.	Conduct pre-job brief and transport cable from storage building (inside PA) and deploy (in parallel with actions a, b, and c above)	Timed Demonstration / Scaling	1 Electrician, 1 Chemist, Tow vehicle #2	2 hrs (in parallel)
e.	Termination of cable connections from generator to ELAP connection points	Timed Walkthrough	1 Electrician, tooling	1.25 hrs
f.	Breaker alignments (simulated)	Timed Walkthrough	1 Auxiliary Operator	1.25 hrs
g.	Generator start and loading (simulated)	Timed Walkthrough	1 Auxiliary Operator	1.25 hrs
Aggregate:				5.75 hrs

Validation Plan No.: 12345

Table D - Other Considerations (if needed)
• Declaration of an ELAP is the predecessor to Action Item #10. • The Time Constraint for this TSA is 8 hours, which includes the start time of 1 hour for declaration of an ELAP and the success criterion of 7 hours to energize the 480 VAC loads to repower the battery chargers.
• An adjustment of 0.25 hrs was allotted for manual operation of the sally port based on……..(need to include the rationale for using judgment for this task and address feasibility for the task being able to be performed in a BDBEE.)

NOTE: Refer to Attachment 4 for Performance Attributes that are applicable for the task/subtask being validated.

Table E - Performance Attributes	
CONSIDERATION OF PERFORMANCE ATTRIBUTES ***Energize 480V Loads and Battery Chargers***	
Special Equipment	**Describe special equipment required for successful completion of the task.** There is no special equipment required to complete validation of this task. FLEX equipment required for this task includes the FLEX 480 VAC DG and associated cabling, tow vehicles, fork lift, and tooling that are maintained on site. The DG and tow vehicles are in a PM program and are demonstrated to operate periodically providing confidence in their ability to be deployed and operated properly.
Complexity	**Describe any complexity issues or coordination requirements related to this task.** Coordination is required to move cable from storage and deploy in parallel with the generator being transported via face-to-face or hand held radio communication. The pre-job briefing will outline the coordination of these activities.
Cues and Indications	**Describe special cues or indications needed for the successful completion of the task.** Appropriate indications are available on the 480 VAC DG. Ensure breaker position indicators are identified, and breakers in the correct configuration. Verify DG is staged in the correct location based on markings or drawings in the procedure. Upon starting did the DG exhibit any abnormal sounds? When running unloaded? Loaded? Need to validate charger output voltage and current which are available locally.
Special Fitness Issues	**Describe how special fitness issues have been addressed.** A review of the cable sections was performed and based on

Table E - Performance Attributes	
	the length, weight and number of sections required, no special fitness issues were identified.
Environmental Factors and Accessibility	**Describe how environmental issues have been addressed. (Include any specific assessments that may have been performed.)** The site deployment route path from the outside PA storage location to the sally port has been evaluated for the effects of the applicable BDBEEs for the site (list each one and how it was assessed). Due to loss of security features from the ELAP, Sally Port operation will be done manually. In addition operators will have access to keys that will allow access to locked security doors. Flashlights and headlamps will be available for personnel.
Communications	**Describe the communication requirements needed for the performance of the task.** Face-to-face pre-job brief (included in time validation for the task/subtask being validated). Use of handheld radios in the talk-around mode and sound powered phones.
Special Considerations	**Describe any other special considerations identified for the task:** None

Table F - Conclusions
• Repowering Battery Chargers in accordance with FSG-4 has been validated to be less than the required 7 hours criterion with the available resources. Two independent crews successfully performed this strategy with the limiting time being 5.75 hours.
• Performance attributes have been reviewed per Table E and no significant challenges were identified.
• The validation efforts resulted in margin judged sufficient to account for potential challenges or impacts.

Table G - References and Supporting Documentation
• FSG-4, Revision 0

Level B Example

Validation Plan No.: 678910

Table A - Validated Item Results					
Item: ***Make-up to the Spent Fuel Pool***		**Level:** ☐*A* ☒*B* ☐*C*		**Time Constraint:** ***20 hrs***	
Action Item # from OIP Attachment 1A	**Task**	**Start Time**	**Time Constraint**	**Success Criterion** ***(Time Constraint minus Start Time)***	**Results** ***(sum of times measured during validation process)***
13	Commence make-up to the Spent Fuel Pool	6 hrs	20 hrs	14 hrs	9.75 hrs
Margin = 4.25 hrs					

Table B - Validation Team Members

Name	Title / Position
John E. Smith	Equipment Operator
Paul Russell	Equipment Operator
Mindy Jones	Reactor Operator
George Hunnicutt	Operations Supervisor
Jane Bachman	Security Officer
Tim Reed	Augmented Staff
Spencer Bowman	Augmented Staff

Level B Example

Validation Plan No.: 678910

Table C - Validation Performance				
Action Item #: 13 **Task:** ***Commence Make-up to the SFP***			**Controlling procedure:** **FSG-11:** Alternate SFP Make-up and Cooling	
NOTE: **Non-controlling parallel results have been shaded**				
Subtask No.	**Subtasks to Complete Task from Table A**	**Method**	**Resources**	**Results**
a.	Conduct pre-job brief and transport pump from storage building to sally port	Records	2 Augmented Staff, Tow vehicle #1	1.0 hrs
b.	Transport pump through sally port	Level A Reasonable Judgment	2 Augmented Staff, 1 Security Officer, Tow vehicle #1	0.50 hrs
c.	Transport pump from sally port to staging area A	Records	2 Augmented Staff, Tow vehicle #1	0.5 hrs
d.	Establish Fuel Building vents and access (in parallel with actions a, b, c, e, f, g, and h)	Level B Reasonable Judgment / Tabletop	1 Security Officer	0.75 hrs

Table C - Validation Performance

Action Item #: 13

Task: ***Commence Make-up to the SFP***

Controlling procedure:

FSG-11: Alternate SFP Make-up and Cooling

NOTE: **Non-controlling parallel results have been shaded**

Subtask No.	Subtasks to Complete Task from Table A	Method	Resources	Results
e.	Conduct pre-job brief and transport hose from Protected Area (PA) storage building and deploy (in parallel with actions a, b, c, and d above)	Demonstration / Scaling	2 Augmented Staff, Tow vehicle #2	4 hrs (in parallel)
f.	Hose connections from the source to the pump suction and from pump to connection points (simulated)	Walkthrough	1 Operator, tooling	4 hrs
g.	Valve alignments (simulated)	Walkthrough	1 Operator	1.25 hrs
h.	Pump start and establishment of flow (simulated)	Walkthrough	1 Operator	0.5 hrs
Aggregate:				9.75 hrs

Level B Example

Validation Plan No.: 678910

Table D - Other Considerations (if needed)
• The validation assumed that the task would be performed with the augmented staff that does not begin to arrive on site until 6 hours after the event in accordance with NEI-12-01. The arrival of augmented staff is considered a precursor to Action Item #13. • The Time Constraint for this TSA is 20 hours, which includes the 6 hours for augmented staff to arrive on site and the time constraint of 14 hours necessary to complete the subtasks required to commence makeup to the spent fuel pool. (Success Criterion)
• Action Item #13, Subtasks a and c used records as the validation method to provide estimated times. The validation time was based on similar deployment of the FLEX generator alignment to provide time estimates. The same tow vehicle was utilized for the generator that would be used for the pump (both trailers have the same hitch size).
• Action Item #13, Subtask b used Level A reasonable judgment as the validation method to provide estimated times.
• Action Item #13, Subtask "d" used Level B Reasonable Judgment based on normal time to reach the fuel building from the Main Access Facility and open the building doors. Additional time of 0.25 hrs added to provide margin. Subtask d is independent of subtasks a, b, c, e, f, g and h.
• Action Item #13, Subtask "e" used Scaling. A 2000 foot run of hose was needed to makeup to the SFP. Scaling was based on 18 minutes required for deploying four (4) 50-foot sections of hose multiplied by 10. An additional hour has been added to account for transport time.
• An adjustment of 0.25 hrs was allotted for manual operation of the sally port. This did not impact the task; it was not the controlling activity.

NOTE: Refer to Attachment 4 for Performance Attributes that are applicable for the task/subtask being validated.

Table E - Performance Attributes	
CONSIDERATION OF PERFORMANCE ATTRIBUTES ***Commence Make-Up to Spent Fuel Pool***	
Special Equipment	**Describe special equipment required for successful completion of the task.** There is no special equipment required to complete validation of this task. FLEX equipment required for this task includes the FLEX engine driven make-up pump and associated hoses, and tow vehicle that are stored on-site. Both the tow vehicle and the pump are in a PM program and are demonstrated to operate periodically, providing confidence in the ability to be deployed and operated properly.
Complexity	**Describe any complexity issues or coordination requirements related to this task.** Two activities in unrelated areas must be performed concurrently. The hose, which is staged inside the protected area, must be moved and deployed in parallel with moving the FLEX SFP make-up pump from outside the PA storage location through the sally port. The pre-job briefing will outline the coordination of these activities.
Cues and Indications	**Describe special cues or indications needed for the successful completion of the task.** Indication of SFP level is available to Control Room personnel via direct visual or remote means. Hose connections can be validated via visual and audible cues. The operator initiating makeup to the SFP will use the local indications available on the pump skid which will provide adequate indication of flow and discharge pressure. SFP makeup pump should run at approximately 1200RPM. Hose expansion should be noticeable upon pump start.
Special Fitness Issues	**Describe how special fitness issues have been addressed.** Although the deployment length is long, the sections of hose have been divided such that the 50 ft. sections did not identify any special fitness requirements.

Table E - Performance Attributes	
Environmental Factors and Accessibility	**Describe how environmental issues have been addressed. (Include any specific assessments that may have been performed.)** The site deployment route path from the outside PA storage location to the sally port has been evaluated for the effects of the applicable BDBEEs for the site (list each one and how it was assessed).s. Due to loss of security features from the ELAP, Sally Port operation will be done manually. During the damage assessment walkdown, the Fuel Building door was opened, which will aid in ventilation and accessibility. Consider current and anticipated weather conditions.
Communications	**Describe the communication requirements needed for the performance of the task.** Face-to-face pre-job brief (included in time validation for the task/subtask being validated). Use of handheld radios in the talk-around mode and the use of runners.
Special Considerations	**Describe any other special considerations identified for the task:** **None**

Table F - Conclusions
• Make-up to SFP per FSG-11 has been validated to be less than the required success criterion of 14 hours with the expected available resources.
• Performance attributes have been reviewed per Table E and no significant challenges were identified.
• The validation efforts resulted in margin judged sufficient to account for potential challenges or impacts.

Table G - References and Supporting Documentation
• FSG-11, Revision 0

Level C Example

Validation Plan No.: 111213

Table A - Validated Item Results					
Item: ***Establish Back-up Water Source to Condensate Storage Tank***		**Level:** ☐*A*☐*B*☒*C*		**Time Constraint:** *N/A*	
Action Item # from OIP Attachment 1A	**Task**	**Start Time**	**Time Constraint**	**Success Criterion** ***(Time Constraint minus Start Time)***	**Results** ***(sum of times measured during validation process)***
16	Commence make-up to the CST	N/A	N/A	N/A	N/A
Margin = N/A					

Table B - Validation Team Members	
Name	**Title / Position**
John G. Smith	Vendor Staff
Judy Almond	Operations Staff
George Hunnicutt	ERO Staff
John Fisher	Augmented Staff

Level C Example

Validation Plan No.: 111213

Table C - Validation Performance				
Action Item #: 16 **Task:** ***Commence Make-up to the CST***			**Controlling Procedure:** **Per site-specific FSG**	
NOTE: **Non-controlling parallel results have been shaded**				
Subtask No.	**Subtasks to Complete Task from Table A**	**Method**	**Resources**	**Results**
a.	Mobilize vendor per contract	Tabletop	1 ERO Staff	Satisfactory
b.	Stage pipe from storage location	Tabletop	Vendor Staff	Satisfactory
c.	Assemble pipeline	Level C Reasonable Judgment	Vendor Staff	Satisfactory
d.	Deploy and connect portable pump at reservoir to pipeline (in parallel)	Tabletop	2 Augmented Staff, 1 Tow vehicle	Satisfactory
e.	Connect pipeline to CST(s)	Tabletop	9 Augmented Staff	Satisfactory
f.	Simulate valve alignments	Tabletop	3 Operations Staff	Satisfactory

Table C - Validation Performance				
Action Item #: 16 **Task:** ***Commence Make-up to the CST***				**Controlling Procedure:** **Per site-specific FSG**
NOTE: **Non-controlling parallel results have been shaded**				
g.	Simulate pump start and establishment of flow	Tabletop	1 Augmented Staff	Satisfactory
<u>Additional adjustments</u> N/A				N/A
Aggregate:				Satisfactory

Level C Example

Validation Plan No.: 111213

Table D - Other Considerations (if needed)
• Validation was completed because this is a task that is labor intensive.
• Tabletop was used and included contract review with knowledgeable vendor personnel.
• In Subtask c, Reasonable Judgment was used based upon vendor staff routinely performing similar activities.

NOTE: Refer to Attachment 4 for Performance Attributes that are applicable for the task/subtask being validated.

Table E - Performance Attributes	
CONSIDERATION OF PERFORMANCE ATTRIBUTES ***Establish Back Up Water Source for the Condensate Storage Tank***	
Special Equipment	**Describe special equipment required for successful completion of the task.** Special equipment includes the pumps, 12-inch HDPE piping, fusion machine and connectors. Vendor personnel are familiar with the equipment's operation and spare commercial grade equipment is available.
Complexity	**Describe any complexity issues or coordination requirements related to this task.** This is not a complex task nor are there significant coordination requirements related to this task.
Cues and Indications	**Describe special cues or indications needed for the successful completion of the task.** Once piping is assembled and the vendor has demonstrated system operation, a local gauge panel at the reservoir will provide for pump flow and discharge pressure. Control room personnel will monitor Condensate Storage Tank level via control room indications.
Special Fitness Issues	**Describe how special fitness issues have been addressed.** The vendor has committed via the contract that there will be adequate personnel available for pipeline construction and that no undue physical burden will be experienced.

Table E - Performance Attributes	
Environmental Factors and Accessibility	**Describe how environmental issues have been addressed. (Include any specific assessments that may have been performed.)** The site deployment route path through the sally port is impacted due to the loss of power for the security features. The site deployment path including the path to the reservoir has been evaluated and is anticipated to be accessible via on-site debris removal capability without impacting task completion. Extreme cold or wind will require use of appropriate PPE to compensate for environmental impacts. This is only anticipated for activities conducted outside plant buildings.
Communications	**Describe the communication requirements needed for the performance of the task.** A pre-job brief will be held with the participants. Due to the distance at the reservoir, there will be limited direct communication capability. It is planned to use runners if needed, and the job foreman will have a face-to-face brief with a site contact twice per shift. Cell phones and handheld radios will be used, if available.
Special Considerations	**Describe any other special considerations identified for the task:** None

Table F - Conclusions
• Establish Back-up Water Source to Condensate Storage Tank has been validated to be feasible to meet the site-specific FSG.

Table G - References and Supporting Documentation
• Vendor contract XXX
• Site-specific FSG-XXX, Revision 0

ATTACHMENT 4
GUIDANCE ON THE CONSIDERATION OF PERFORMANCE ATTRIBUTES

(Use for Evaluation of Attributes in Table E)

Special Equipment - Some tasks may require special equipment for completion. As outlined in Attachment 5, the FLEX implementation guidance already addresses the availability and ease of use of portable FLEX equipment.

The focus of this attribute should be on any special or unfamiliar equipment required for the tasks being validated.

If special or unfamiliar equipment is required, then the measures taken to validate the availability of this equipment should be documented in Table E.

Complexity - EOPs/AOPs provide the overall framework for plant response. The specific tasks required for implementation of FLEX are generally simple, straightforward, and well within the skill of the craft. In addition, as described in Attachment 5, FLEX implementation has involved a number of important features that facilitate the implementation of these tasks in a beyond design basis condition, e.g., labeling, color-coding, etc. Demonstration of margin also provides additional confidence in task

The focus of this performance attribute is on tasks that require significant coordination of concurrent sub-tasks or tasks occurring in different locations. Examples of such tasks may include:

- Local manual control of TDAFW pump which depressurizing the SGs
- Control of RCS boration using a portable pump

If coordination is required for concurrent sub-tasks or tasks occurring in different locations, then the measures taken to accomplish this coordination should be documented in Table E.

Cues and Indications - The focus of this performance attribute is on the cues and indications that are unique to the tasks being addressed and are used to confirm the success of the action. NEI 12-06 outlines the high-level key parameters required for FLEX. Some examples include:

- Output current on the battery charger following re-powering by a portable generator
- Flow indication on a portable pump being used for makeup

Individual actions that rely upon specific cues and/or indications should be documented in Table E.

Special Fitness Issues - In general, the tasks involved in FLEX implementation have been established to avoid the need for special fitness requirements. However, some physically demanding tasks may require performance of tasks for extended time periods.

The focus of this performance attribute is on tasks that require physical tasks for an extended period of time. Examples of such tasks may include deployment of large quantities of hose, pipe, or cable.

If site-specific FLEX strategies require physical tasks for an extended period of time, then the approach taken to validate that these physical actions can be accomplished should be documented in Table E.

Environmental Factors and Accessibility - All FLEX actions have been designed to avoid the need for heroic actions. Sections 5 through 9 include many requirements that define the requirements for addressing the environmental factors caused by the beyond design basis external events applicable to each site. However, some sites have identified different strategies, requiring slightly different tasks/sub-tasks, for different hazards.

Any site specific analysis for environmental impacts that would impact a transit route, or analysis for specific external events that result in contingency strategies should be included. For example if a non-seismic building could block a transit route, is there an alternate route?

Additionally, any site specific analysis for environmental impacts that would impact operation of the equipment (accessibility) that result in contingency strategies should also be included.

The focus of this performance attribute is on activities that require different sub-tasks or tasks based on a particular hazard. Examples of such tasks may include:

- Reliance on a specific strategy/task for addressing a seismic event
- Reliance on a specific strategy/task for addressing an external flooding event

Beyond design basis ELAP conditions may result in accessibility considerations. As described in Appendix B, NEI 12-06 identified the need to address accessibility for specific tasks.

The focus of the accessibility performance attribute contains factors that may impede human access under the ELAP condition. Examples of such factors may include:

- Loss of power to plant security features requiring workarounds
- Effects of loss of normal ventilation for actions requiring extended exposure to elevated temperatures

If tasks/subtasks require unique environmental factors or accessibility considerations, then the approach to address these should be documented in Table E.

Communications - Beyond design basis ELAP conditions may result in a degradation of normal communications systems. As described in Attachment 5, sites have taken a number of steps to enhance communications for ELAP conditions. Cases where traditional communication approaches are relied upon, e.g., face-to-face, handheld radios, sound-powered phones, etc., in locations with nominal conditions do not require additional consideration in the validation. Likewise, many times, the communication can occur during or at the completion of a task in a face-to-face manner and do not require additional consideration in the validation.

However, in some cases, plant conditions or action locations may impede even these enhanced communication capabilities during the course of an action.

The focus of this performance attribute is on tasks that require unique communication approaches during the course of the action. Examples of such tasks may include:

- Communication from locations where traditional communication devices do not reach
- Communication from locations where background noise may preclude clear communication, e.g., near open SG PORVs.

If site-specific FLEX strategies require different unique communication approaches, e.g., runners, then these approaches should be documented in Table E. If only traditional communication approaches are relied upon, then this section of Table E can be completed with an "N/A".

Procedures - The implementation of FLEX is predicated on clear procedures and guidance, integrated with the existing EOP/AOP framework and augmented, as needed, with additional guidance such as FLEX Support Guidelines (FSGs). For this reason, additional documentation of this performance attribute is not included Table E. If the same procedure framework is not used for an AMS/THMS, then this attribute would need to be addressed in Table E.

Training - The training requirements for FLEX are addressed separately via the Systems Approach to Training (SAT) process and are, therefore, outside the scope of the validation process. For this reason, additional documentation of this performance attribute is not included in Table E. If the SAT process is not used for an AMS/THMS, then this attribute would need to be addressed in Table E.

Stress - Clearly, beyond design basis conditions have increased levels of stress. As outlined in Attachment 5, many features have been incorporated in this guide to minimize the impact of stress. For this reason, additional documentation of this performance attribute is not included Table E. If the features of this guide described in Attachment 5 are not implemented for an AMS/THMS, then this attribute would need to be addressed in Table E.

Staffing - The staffing requirements for FLEX are addressed separately via the staffing study per NTTF Rec 9.3 and are, therefore, outside the scope of the validation process. For this reason, additional documentation of this performance attribute is not included Table E. If the staffing study is not updated for an AMS/THMS, then this attribute would need to be addressed in Table E.

Human-System Interfaces - The implementation of FLEX is predicated on a clear Human-System Interface (HSI). As described in Attachment 5, the FLEX implementation guidance addresses clear consistent labeling, color coding, and other human-system interface features. Provide documentation that these attributes are as expected in Table E.

<u>Special Considerations</u>

Use this field to document any information that would be helpful to a reviewer in understanding the validation performed

ATTACHMENT 5
INHERENT FLEX ATTRIBUTES THAT ENHANCE HUMAN RELIABILITY IN THE EVENT OF A BEYOND DESIGN BASIS EVENT

Issue

FLEX strategies are unique in that they are adaptable for an undefined external initiating event that is beyond the plants design basis. Personnel will be implementing mitigating strategies, in off – normal conditions including, but not limited to, reduced instrumentation, loss of normal lighting, lack of normal ventilation and hampered communications. Although these conditions are considerably beyond what would be considered "normal" post trip conditions, it is expected that FLEX strategies will be able to be implemented without personnel error.

This is due to the manner in which the FLEX guidance was initially structured, considerations in equipment selection, specific beyond-design-basis external event (BDBEE) procedures, and training.

Background

Many of the features included in this guide build off of the foundation established for Station Blackout response as described in NUMARC 87-00. In addition, it was recognized that all strategies would need to consider environmental impacts, stress, and what attributes could be incorporated into the process, procedures, modifications, training and equipment to provide an increased level of confidence that the personnel called upon to respond in the event of a BDBEE event will be successful.

Factors Optimizing/Enhancing Human Performance - Performance Attributes

For the purposes of assuring FLEX feasibility, attributes that could shape performance have been identified. These performance attributes (PA) are defined as: Potential influences on performance during unusual plant conditions. It includes such items as level of training, quality and availability of procedural or FLEX Support Guideline (FSG) guidance, and time available to perform an action. Factors may include the influences of environmental impact such as visibility and extreme weather. Many of these PA's are addressed in this guide and other coordinated industry actions, as well as in the validation process.

Special Equipment – The number and type of specialized equipment is minimal. For example both the 480 VAC and 4.16 KV generators have similar control panels and operating procedures. This standardization is also applicable for the portable pumps, which have clearly labeled gauges, components, and control panels, with similar ergonomics, regardless of the pump sizing. An individual need not "master" each specific pump or generator to be successful. Additionally, connections on the FLEX equipment use standardized color coded connections (electrical) and standardized couplings (mechanical). Equipment operating instructions, prepared per the industry writer's guide, are printed on colored paper with a standardized font determined to be the optimal combination for readability. This standardized operating aid format is applied throughout the industry, and allows equipment to be supplied from one utility to another without requiring extensive familiarization.

Complexity – While the performance of FLEX strategies would be in an extraordinary situation, the tasks themselves are simple, straightforward; do not entail new techniques or analysis. To the contrary, the skill-set needed to implement FLEX strategies reside in each journeyman level employee. Equipment to be used is also straightforward with standardized connections, color coding, placards and labeling to further assist in ease of deployment. Tasks may require coordination between individuals or teams for completion of a task or subtask. The method of communication for coordination of an action via redundant means (radio, face-to-face, use of messengers, satellite phones) should provide increased confidence that coordination efforts will be successful.

Indications – Normal installed indications should be available throughout the implementation, and indications that will be unavailable will have been addressed in the validation process, with appropriate feedback to enhance procedural guidance. FLEX equipment indications are clearly labeled, easy to read, and consistent for each type of device. For example – each pump will have a similar gauge panel.

Human-System-Interface – The actions needed to be taken inside the plants are verified to be accessible, functional and have been evaluated for use in the anticipated conditions. Additional enhancements for human performance include clear labeling, color coded connections, standardized font, text and colored paper used for portable FLEX equipment, procedures, guidelines, drawings for each FLEX strategy as appropriate, training, and communication capability.

Procedures – Procedures and or guidelines exist for each FLEX strategy, the procedures and/or guidelines include what to monitor, specific cues or indications will be identified and will be readily available to the user, contain drawings or pictures where appropriate. The procedures and/or guidelines are written at a sufficient level of detail for the user and will be easily understood in the circumstances it is expected to be used. The procedures and guidelines are validated as part of a plants normal procedure process. For portable FLEX equipment operating procedures have been developed using guidance from "Tips for Making Print More Readable."[17]

Training – Training will be developed and provided via the systematic approach to training (SAT) process. Typically training will be in the licensed and non-licensed operator training requalification process. Maintenance personnel will receive training on the specific plant changes and equipment. No new skill set will be required for maintenance personnel. Emergency response personnel will receive training as part of their ongoing emergency plan training.

The training will provide specific focus on new procedures and guidelines, relevant indications, special equipment, and will include use of job performance measures (JPM's) as appropriate. Many of the tasks are presently performed as job performance measures (JPM's) and will not require additional training. Plant simulators will be used to the extent practical to train Operations crews in diagnosing an event and subsequent use of the FLEX support guidelines (FSG).

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[17] Vision Aware Resources for Independent Living with Vision Loss; American Foundation for the Blind. Web. 10 July 2013.

Stress – During a BDBEE condition there will be an undeniable impact due to the pressure and stress of the event. The provisions built into the overall preparation of the response in NEI 12-06, considerations in the design inputs of the modification processes, equipment selection, audit process, training, standardized connections, labeling and placards provide a sound foundation for limiting any additional stress on the individual's performance.

Special Fitness Issues – There are no extraordinary tasks/subtasks which would require special fitness capabilities. On site staff response with minimal administrative staff will validate ample resources are accounted for without extraordinary burden on individuals. Additional personnel resources (augmented staff) will begin to arrive within 6 hours of the event, with full access to the site at 24 hours. While there should be no undue physical burdens on station staff that would adversely affect performance, this will be confirmed as part of the validation process.

Environmental Factors and Accessibility – It is not possible to address all beyond-design-basis environmental conditions. However, environmental factors and conditions such as inclement weather, darkness, etc. cannot be ignored for the deployment and operation of FLEX equipment. The environmental impact of darkness, wind, and rain is addressed by personal protective equipment, flashlights and lighting on the deployment equipment and the FLEX portable equipment. Appendix R lights, where needed, will remain functional. In addition, human factor aids (labeling, color coding, placarding, etc.) limit the impact of darkness. Where environmental conditions can be more specifically determined from the mechanistic evaluation of the event performed in support of an AMS/THMS, this information should be taken into account in this assessment.

Sections 3.2.1.9 and 3.2.2 Items 8, 9, 10 and 11 require that accessibility be considered in operator actions including impacts due to environmental factors. Sites provide and evaluate alternate routes for deploying FLEX equipment. Debris removal equipment is provided at each site and training to operate the debris removal equipment is provided where appropriate. In instances where deployment could be delayed or would be uncertain, sites have elected to pre-stage the FLEX equipment. In circumstances where there is warning of an adverse environmental event (e.g. hurricane, flooding), FLEX equipment will be pre-deployed to ensure accessibility is not impacted.

Staffing – Staffing is being addressed via a separate staffing study (Phase 2 staffing study). The site minimum administrative staff will be validated to be able to successfully perform the needed actions in the event of an ELAP. Furthermore additional personnel resources (augmented staff) will be available within 6 hours of the event, with full access to additional resources at the 24 hour point.

Communications – Communication capability is expected to be impacted by an ELAP condition and contingencies are provided via use of satellite phones, battery back up for in-plant communications, procedures and guidelines which are designed to provide complete and unambiguous directions, reliance on messengers if needed and the straightforward nature of the tasks to be performed. All tasks and actions would be briefed prior to personnel being dispatched – the method of communication would be established as appropriate for the task and situation.

Validation Plan

Per Section 1.3, "The FLEX strategies are not tied to any specific damage state or mechanistic assessment of external events." However, environmental factors and conditions such as inclement weather, darkness, etc. cannot be ignored. Therefore, an essential part of the validation is a qualitative assessment of the margin (the time difference between when a time sensitive action (TSA) can be completed under ideal conditions and when the TSA is required to be complete for successful implementation of the strategy.) This assessment balances the nature (i.e., amount of work, degree of difficulty and coordination, length of deployment paths, etc.) and timing (i.e., how soon does the task need to be started following the event) of the tasks against the margin available and supports a conclusion on whether or not the margin is adequate to accommodate the unknown event using reasonable judgment. This qualitative assessment is documented in the conclusions of the validation plan.

Summation

With respect to the feasibility of individuals successfully performing the required tasks in response to the adverse conditions in a BDBEE it is anticipated that personnel will be able to respond and perform without error. This is due to the numerous performance attributes carefully considered, the structure of this guidance, the validation of the tasks, and the audit process conducted at each site. Confidence in the success is further bolstered by the pre-emptive evaluations of the environmental factors (seismic, flooding, extreme heat, extreme cold and wind). Validation of the tasks using multiple and diverse personnel and the NRC audit process provides additional confirmation of human action feasibility.

Providing additional confidence includes the use of standardized mechanical connections, standardized and color coded electrical connections, use of placards, enhanced labeling, and specific procedures or guidelines which will as appropriate, include diagrams/pictorial references.

The straightforward nature of the tasks will require no new skills to be acquired and would be considered normal journeyman knowledge. Plant personnel typically use PPE on a daily basis and there would be no introduction of a new variable in carrying out these tasks.

Emergency Operating Procedures/Abnormal Operating Procedures (EOP/AOP) will provide the decision making guidance for initiation into the FLEX guidelines. Operations personnel are well versed in maneuvering through EOP/AOP procedure steps. Indications for the diagnosis are readily available in the control room.

APPENDIX F
GUIDANCE FOR AP1000 DESIGN

F.1 INTRODUCTION

The purpose of this Appendix is to outline, using the framework defined in Sections 1.0 to 13.0 and adapting to the AP1000 design features as necessary, the process to be used by AP1000 COL Holders and Applicants to define and implement site-specific diverse and flexible mitigation strategies that reduce the impact associated with beyond-design-basis conditions resulting from an extended loss of ac power.

By nature of the passive safety approach and its licensing basis, AP1000 is designed to provide a significant coping period for a station blackout. Hence, the focus on this guidance is to define the required review of the AP1000 design relative to the transition from passive systems operation and their initial coping capabilities (i.e., 72 hr.), to indefinite, long term operation of the passive cooling systems with support using off-site equipment and resources.

The principles identified in this appendix thus discuss the extension of the passive systems operation indefinitely during an extended loss of ac power (ELAP) and the loss of ultimate heat sink makeup (LUHS). These principals have been applied during the design and development of the AP1000 and thus, the extended coping strategies are accomplished with existing passive safety and coping systems within the standard design utilizing existing connection points for FLEX equipment. Specifically, coping with extended loss of ac power in the AP1000 is covered by design and by post-72 hour procedures described in Section 1.9.5.4 of the AP1000 Design Control Document (DCD), Revision 19.

The use of passive systems with their extended coping times is an important difference because whereas active plants are expected to show primary and diverse connection points for maintaining core cooling, AP1000 core cooling is maintained by the passive safety systems without reliance on ac power. The passive safety systems, however, should have the ability to have their operation extended indefinitely. The standard design licensing basis demonstrates safety-related means of providing core cooling, containment cooling, and SFP cooling for at least 72 hours. The standard design also demonstrates primary and alternate means of extending passive safety system cooling indefinitely as part of the baseline capability assessment as described in Section 1.9.5.4 of the Design Control Document (DCD), Revision 19.

The assessment of the AP1000 design is expected to be the same as for the site specific evaluation and is documented by this process:

- Step 1: Establish standard design baseline coping capability considering design basis hazards.
- Step 2: Apply beyond-design-basis (BDB) external hazards and perform margin assessment, and confirm the capability to extend core, containment and spent fuel pool cooling also under beyond-design-basis conditions.
- Step 3: Identify any enhancements to baseline capability to address BDB scenarios, if applicable.

Whereas a site-specific evaluation can screen out and screen in applicable extreme hazards, the assessment defined in this Appendix evaluates beyond-design-basis seismic and flooding hazards as part of margin assessments, to evaluate the strength of the design basis against a threshold effect. For the flooding margin assessment, the approach considers two site-specific outcomes based on the amount of margin between the site-specific maximum probable flooding level and the standard AP1000 design basis flooding level; Section F.6 describes this approach.

F.2 Overview and Implementation Process

This appendix (F) incorporates the entirety of Section 2.0 of this document. Specifically, the process outlined in Figure 2-1 also provides the framework for the assessment of the AP1000.

F.3 Step 1: Establishing Baseline Coping Capability

For the AP1000, the underlying strategies for coping with extended loss of ac power events involve a three phase approach:

a. Initial coping is through installed plant equipment, without any ac power or makeup to the UHS. For the AP1000 this phase is already covered by the existing licensing basis and is not discussed further herein. This covers the 0 to 72-hours basis for passive systems performance for core, containment and spent fuel pool cooling.

b. Following the 72-hour passive system coping time, support is required to continue passive system cooling. This support can be provided by installed plant ancillary equipment or by off-site equipment installed to connections provided in the AP1000 design. The installed ancillary equipment is capable of supporting passive system cooling from 3 to 7 days.

c. In order to extend the passive system cooling time to beyond 7 days (to an indefinite time) some off-site assistance is required. As a minimum, this would include delivery of diesel fuel oil. The rest of this guidance focuses on the off-site FLEX equipment and its definition, protection and deployment. General Criteria and Baseline assumptions consistent with Section 3.2.1 will be used for the AP1000 assessment.

For AP1000, it is recognized that strategies for dealing with ELAP, LOOP, SBO, and LUHS are significantly different due to the passive nature of the plant design. As discussed in previous sections, the fundamental difference is in the significantly longer coping period available before FLEX equipment may be required (i.e. at least 72 hours) and in the reduced size and number of this equipment. Thus, many of the strategies detailed in Section 3.2 are not required for the AP1000. The AP1000 will demonstrate the capability to meet the functional requirements of Section 3.2, even though the employed strategies will generally be different.

F.3.1 PERFORMANCE ATTRIBUTES

This baseline coping capability is built upon strategies that focus on an ELAP condition caused by beyond design basis hazard events. The baseline assumptions have been established on the presumption that other than the loss of the ac power sources, equipment that is protected and designed to withstand design basis natural phenomena is assumed to be fully available. The baseline assumptions are provided in Section 3.2.1, and will be used for the assessment of indefinite extension of passive systems cooling.

F.3.2 QUALIFICATION OF INSTALLED EQUIPMENT

Equipment relied upon to support FLEX implementation does not need to be qualified to all extreme environments that may be posed, but some basis should be provided for the capability of that equipment to remain functional or to be easily repaired. Appendix G of Reference 8 contains information that may be useful in this regard.

Equipment that is stored far enough from the site such that it would not be subjected to the hazard that affected the site need not be designed or qualified for any of the assumed hazards. In addition, the storage arrangements (building, etc.) would not be required to have any hazard capability. Since AP1000 has a 72-hour passive system coping time, there is significant time to transport equipment from off-site. Use of more than one storage location is not necessary as long as the storage site is far enough away from the site(s) such that the same extreme hazard could not affect both the plant(s) and the storage location. In this way, the storage location would not be required to be built to nuclear safety standards for hazard protection. This approach is reasonable considering the small number and size of the equipment needed for AP1000 long term passive system cooling, and the significant coping period provided by the AP1000 before the equipment would be needed.

Table F.3.2-1 summarizes the AP1000 baseline coping capability and a list of FLEX equipment that should be provided.

Table F.3.2-1

AP1000 Preliminary FLEX Capability Summary				
Safety Function		**Method**	**Baseline Capability**	**FLEX Equipment**
Core Cooling	Core cooling	- PRHR HX	- PRHR HX provides long-term cooling	- None
			- ADS and IRWST actuation provides long-term passive cooling alternate	- None
	RCS inventory / boration	- CMT water / boron makeup - Canned RCPs	- CMTs provide long-term water / boron makeup	- None
			- ADS and IRWST actuation provides long-term passive makeup alternate	- None
	RCS instruments	-Class 1E PAMS[4]	- 72 hr. batteries with on- or off-site DGs afterwards	- Shared equipment, see Support - Electrical Power
Containment	Pressure / temp control	- PCS	- Provides cooling for 72 hr.	- None
			- Use Ancillary Tank for next 4 days or off-site equipment as alternate	- Off-site self-powered pump & alt. water supply[1]
	Cont. instruments	- Class 1E PAMS [4]	- 72 hr. batteries with on- or off-site DGs afterwards	- Shared equipment, see Support – Electrical Power
SF Cooling	SF cooling	- Initial inventory & Ancillary makeup.	- Initial inventory provides 72 hr.	- None
			- Use Ancillary Tank for next 4 days or off-site equipment as alternate	- Shared equipment, see Containment
	SFP instruments	- Class 1E PAMS [4,5]	- 3 S/R level transmitters each powered by 72 hr. batteries	- None
			- After 72 hr. power from on- or off-site DGs	- Shared equipment, see Support – Electrical Power
Support	Electrical power	- 1E batteries	- Provides 72 hr. indication	- None
			- After 72 hr. power from on- or off-site DGs	- Off-site electrical generator[2]
	Other support	- Communications	- as needed after 72 hr.	- None
		- Hoses, couplings, tools	- as needed after 72 hr.	- Off-site hoses, couplings
		- Delivery of fuel oil - Makeup water[3]	- Needed after 7 days for on- or off-site DGs - Needed for makeup to passive systems[3]	- Fuel oil - Makeup water[3]

Notes:

1. FLEX self-powered pump – one pump is required to provide makeup to the PCS and SFP. A capability of 135 gpm and 273 ft. head is sufficient.
2. FLEX electrical generator – one generator is required to provide post-accident monitoring and emergency lighting. A capacity of 15 kW and 480 volts is sufficient assuming that the FLEX pump is self-powered. Note that multiple connection points (see Section F.12) are provided such that portable instrumentation is not necessary.

3. Off-site makeup water is only required if on-site makeup water is not available.
4. The post-accident monitoring system (PAMS) class 1E instrumentation provides the monitoring of these functions. This instrumentation is powered for the first 72 hours by the safety-related batteries and is powered thereafter by on-site or off-site (i.e., FLEX) diesels for indefinite coping. Note that there are multiple connection points (see Section F.12) for the FLEX electrical generator such that portable instrumentation is not necessary. This instrumentation includes the following:

Instrumentation	Function
Neutron flux	Reactivity control
RCS wide range pressure	RCS integrity, core cooling
RCS wide range Thot	RCS integrity, core cooling
Containment water level	RCS integrity
Containment pressure	RCS integrity, containment
Pressurizer level	RCS inventory
Hot Leg level	RCS inventory
Core exit temperature	Core cooling
PRHR flow	Heat sink
PRHR outlet temperature	Heat sink
PCS water storage tank level	Heat sink
PCS water flow rate	Heat sink
Spent fuel pool level (see note 5)	Spent fuel cooling

5. Refer to NEI 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, "To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation", Appendix A-4 for AP1000 guidance

F.4 Step 2: Determine Applicable Extreme External Hazards

In Step 2 for AP1000, the approach is to perform a generic assessment of the capability of a standard plant design licensed under 10 CFR 52. This appendix details an alternative approach from that indicated in Sections 4.1 and 4.2, which is based on the concept of evaluating the design to a specified beyond design basis, review level hazard to verify the robustness of the design against threshold effects. This approach allows for a one time standard assessment, review, and approval of mitigating strategies for all AP1000 plants

F.5 Step 2A: Standard Design Seismic Impact Assessment

For the AP1000 standard design, the Seismic Margin Assessment (SMA) demonstrates the robustness of the passive safety systems and the associated structures to beyond-design-basis conditions and is already included in the AP1000 licensing basis for design certification.

For the survivability and deployment of the FLEX equipment, if the equipment is stored sufficient distance from the site such that it would not reasonably be subject to the same seismic hazard, it would not need to be stored in a nuclear seismic building and would be expected to be operational following the 72-hour coping period for AP1000 as described in Section F.3.2.

F.6 Step 2B: Standard Design External Flooding Margin Assessment

The AP1000 design basis (see Table 2-1, Site Parameters, of the AP1000 site-specific [Final Safety Analysis Report] FSAR) demonstrates the wide range of extreme environmental conditions covered by the design. Because of the conservatisms that are incorporated into the selection of these site environmental conditions, they are expected to bound extreme site-specific values.

For the indefinite extension of the passive system coping time, the environmental condition should be assessed, consistent with the plant licensing basis, to verify the capability of the FLEX equipment to perform its mission to extend the coping time indefinitely under this range of conditions. In general, FLEX equipment, as described in Section F.3.2, may be stored at a sufficient distance from the site such that it would not reasonably be subject to the same external hazard and would therefore be expected to be available following the 72-hour coping period for AP1000. However, appropriate conditions will need to be defined to ensure the FLEX equipment, once deployed, will maintain its operability over the appropriate range of external conditions considering the site conditions that may exist 72 hours after the initial event.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment, Sections 6.2.3.2 – 6.2.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of external flooding.

F.7 Step 2C: Assess Impact of Severe Storms with High Winds

See considerations provided for Section F.6.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment, Sections 7.3.2 – 7.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of severe storms with high winds.

F.8 Step 2D: Assess Impact of Snow, Ice, and Extreme Cold

See considerations provided for Section F.6.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment, Sections 8.3.2 – 8.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of snow, ice, and extreme cold.

F.9 Step 2E: Assess Impact of High Temperatures

See considerations provided for Section F.6.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment, Sections 9.3.2 – 9.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of high temperatures.

F.10 Step 3: Define Site-Specific FLEX Capabilities

This Appendix (F) replaces the entirety of Section 10.0 of this document. Note that considering the extended AP1000 coping capabilities and the limited amount of equipment required, the AP1000 FLEX equipment shall be stored at a sufficient distance from the site such that it would not reasonably be subject to the same external hazard and would therefore be expected to be available following the 72-hour coping period for AP1000.

F.11 Programmatic Controls

The AP1000 design has a graded QA approach; the QA applied to non-safety-related equipment with short-term availability controls (DCD Table 17-1) will be applied to the AP1000 FLEX equipment. Because of the differences in the AP1000 design vs. operating plants, the use of installed ancillary equipment and off-site equipment is utilized in the plant design basis and operation of this equipment has been integrated into the plant procedures. AP1000 has a graded approach to availability and testing as shown in DCD Section 16.3. This graded approach will be applied to the FLEX equipment. The FLEX equipment will be maintained in accordance with Section 11.5 of this document.

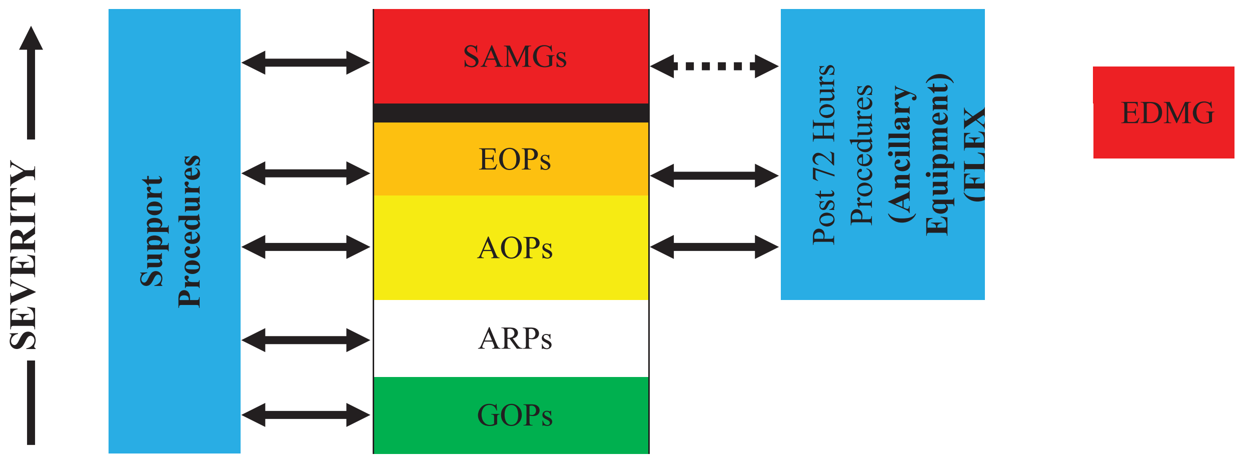
F. 11.1 Post-72 Hours Procedures

The AP1000 design and licensing basis as described in AP1000 DCD Section 1.9.5.4 already provides a set of procedures (referred to as "Post-72 Hour Procedures") which address the actions that would be necessary 72 hours subsequent to an extended loss of all ac power (extended SBO) to maintain core, containment, and SFP cooling for an indefinite period of time.

The post-72 hour procedures and their relationship to other procedures and guidelines should be reviewed to confirm integration with the FLEX guidance provided in the previous sections, including consideration of capability for beyond-design-basis external events as discussed in previous sections. Figure F.11.1 depicts the relationship of the Post-72 Hour Procedures to other plant procedures.

Figure F.11-1

View of AP1000 Operating Procedure Hierarchy



F.12 Off-site Response

This Appendix (F) incorporates the entirety of Section 12.0 of this document. Note that the AP1000 only requires a few, small pieces of FLEX equipment. Table F.3.2-1 defines the AP1000 FLEX equipment. In addition, it is not required for at least 72 hours because of the large passive system coping time.

The off-site response entity will provide the equipment with the specified standard mechanical and electrical connections as follows (It is noted that these are safety-related, seismically qualified connections for FLEX equipment. Other non-safety-related means for makeup and power are also available. Single point vulnerabilities in the connection of FLEX equipment will be considered and evaluated):

a. The safety-related flange located in the yard connected to the Passive Containment Cooling System, which allows makeup to the SFP and to the Passive Containment Cooling Water Storage tank, is fitted with a 4" standard fire nozzle fitting per local fire regulations.

b. The IDS voltage-regulating transformers B & C provide a safety-related 480V connection point for power for post-accident monitoring, MCR lighting, MCR and I&C rooms B & C ventilation from the FLEX diesel generator.

F.13 Submittal Guidance

This Appendix (F) incorporates the entirety of Section 13.0 of this document.

F.14 References

This Appendix (F) incorporates the entirety of Section 14.0 of this document.

APPENDIX G
MITIGATING STRATEGIES ASSESSMENT FOR NEW FLOOD HAZARD INFORMATION

G.1 INTRODUCTION

The purpose of this appendix is to provide guidance for a Mitigating Strategies Assessment (MSA) of the impact of reevaluated flood hazard information developed in response to the NRC's 50.54(f) letter and the modification of existing or the development of new mitigating strategies if necessary to mitigate the effects of the reevaluated flood hazard information. The guidance for performing a MSA for the reevaluated flood hazard information is being included as an appendix in NEI 12-06 because the mitigating strategy approach to addressing this information makes use of the work done for the FLEX strategies.

In this appendix the reevaluated flood hazard information will be referred to as the Mitigating Strategies Flood Hazard Information (MSFHI). The MSA process is illustrated in Figure 1.

The FLEX strategies assumed an ELAP with a LUHS from an unspecified event. Sections 2 and 3 establish the boundary conditions and initial assumptions used for developing these strategies. In addition, Section 3 provides key considerations in the development of the strategies. Sections 4 through 11 establish the reasonable protection requirements for on-site FLEX equipment.

The MSA determines whether FLEX strategies can be implemented given the impact of the MSFHI. If it is determined that FLEX strategies cannot be implemented, the MSA considers other options such as modifications to FLEX strategies or different mitigation strategies that address the specific parameters of the MSFHI. If a strategy other than FLEX is chosen, a basis for choosing the selected strategy as the most effective option should be provided. In addition, the Targeted Hazard Mitigating Strategy (THMS) will deviate from the previous guidance in this document in that it will not maintain or restore the containment capability but will use the opening of containment as an element of the strategy. As such, a justification should be developed for defeating the containment capability in order to maintain core and spent fuel cooling and this strategy should be chosen only if other strategies are not reasonable.

A brief description of this process and the associated sections in this Appendix follows:

- Section G.2 - this section guides the characterization of the MSFHI.
- Section G.3 - this section guides the comparison of the flood hazard used to develop the FLEX strategies with the MSFHI to determine if the MSFHI is bounded.
- Section G.4.1- if the MSFHI is NOT bounded in all aspects as described in Section G.3 (i.e., flood height, associated effects, and flood event duration), this section provides guidance for evaluating the existing FLEX strategies

against the impacts of the MSFHI to determine if the FLEX strategies can still be implemented without change.

- Section G.4.2- if the FLEX strategies cannot be implemented without change, this section provides guidance to determine if the FLEX strategies can be modified to address the identified impacts from the MSFHI.

- Section G.4.3- as an alternative to modifying the FLEX strategies, this section provides guidance for the development of an alternate mitigating strategy (AMS). Unlike the FLEX strategies which assume specific event consequences (i.e., ELAP and LUHS) from an undefined external event, the AMS would be based specifically upon the MSFHI as the defined external event. As such, the AMS would not assume an ELAP and LUHS unless the flood event caused such consequences. The AMS would use any configuration of equipment (e.g., protective features, plant equipment, and/or FLEX equipment) to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities.

- Section G.4.4- as an alternative to modifying the FLEX strategies or developing an AMS, this section provides guidance for the development of a THMS that would consider other mitigative measures. The difference between an AMS and THMS is that for the THMS there will be a need to open containment as an element of the strategy to perform the core cooling function and, as such, only the core cooling and spent fuel pool cooling capabilities would be maintained or restored. A THMS should be used only if it is not reasonable to develop an AMS.

- Section G.5- this section provides guidance for demonstrating that flood protection features are robust for the MSFHI.
- Section G.6- this section provides guidance for documenting the results of the MSA.

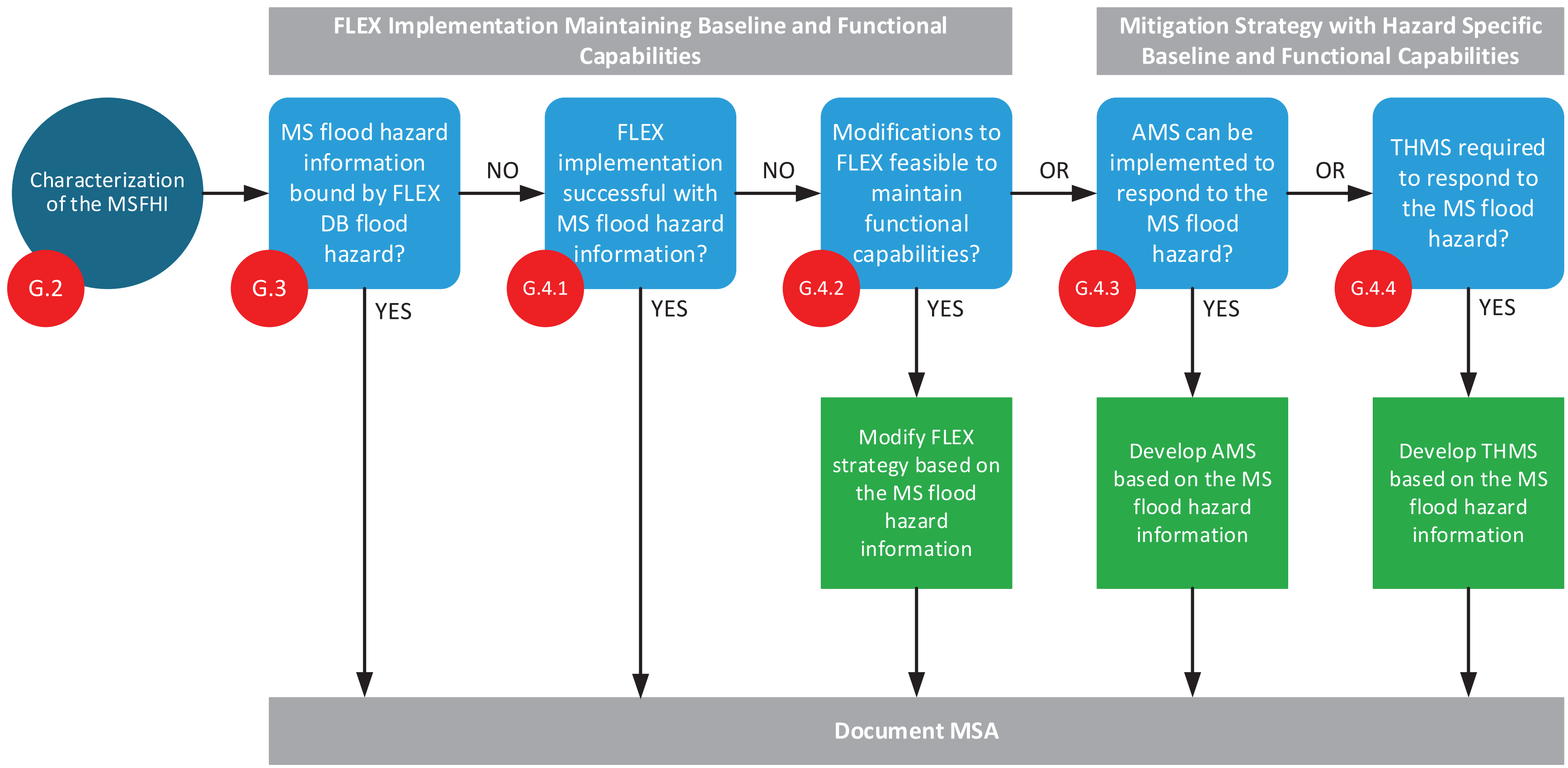


Figure 1 –Mitigating Strategies Assessment Flow Chart

G.2 CHARACTERIZATION OF THE MSFHI

IDENTIFICATION OF CONTROLLING FLOOD PARAMETERS

The following controlling flood parameters should be identified from the MSFHI. This information will be used as input to the following steps of the MSA.

- flood height
- flood event duration
- relevant associated effects (e.g., wind driven waves and run-up effects, hydrodynamic loading including debris, sedimentation and erosion, etc.)
- warning time and flood event transient water surface elevations. Identify intermediate water surface elevations that trigger actions by plant personnel necessary to implement mitigation strategies[18]

In some cases, only one controlling flood hazard may exist for a site. In this case, sites should define the flood scenario parameters based on this controlling flood hazard. However, sites that have a diversity of flood hazards to which the site may be exposed should define multiple sets of flood scenario parameters to capture the different plant effects from the diverse flood parameters associated with applicable hazards. In addition, sites may use different flood protection systems to protect against or mitigate different flood hazards. In such instances, the MSA should define multiple sets of flood scenario parameters.

If appropriate, the site may combine these flood parameters to generate a single bounding set of flood scenario parameters for use in the assessment. This bounding scenario (e.g., the maximum water surface elevation from one hazard combined with maximum inundation duration, minimum warning time, and maximum impact of associated effects from other hazards) can then be used in the assessment instead of considering multiple sets of flood scenario parameters.

[18] Information on the approach that may be utilized to evaluate appropriate warning time for the local intense precipitation flooding hazard is presented in NEI 15-05 "*Warning Time for Maximum Precipitation Events*". In addition, the National Weather Service and the National Hurricane Center offer additional tools that can be helpful when establishing warning time. Warning time for other hazards such as dam failures and river forecasts should be defined based on the site's communication plans with dam operators or other organizations responsible for providing this information.

G.3 BASIS FOR MITIGATING STRATEGY ASSESSMENT

This section provides guidance on:

- Describing what flood mechanisms or associated effects of the MSFHI need to be considered, and
- Comparing the MSFHI to the flood hazard used for developing the FLEX strategies.

Note that throughout this appendix, the term FLEX DB will refer to the flood hazard for which FLEX was designed and the term MSFHI will refer to reevaluated flood hazard information.

All parameters of the flood hazard must be given consideration when determining if the MSFHI is bounded by the FLEX DB and when determining the scope of the evaluation that is required. These parameters include applicable flood mechanisms (including the identification of new flood mechanisms that were not addressed in the FLEX DB flood analysis) and for each mechanism identifying: flood height, associated effects, and flood event duration. The following considerations apply:

- The FLEX DB to MSFHI comparison is to be done on a flood mechanism to flood mechanism basis, comparing the flood height, associated effects, and flooding event duration.
- If the MSFHI overall flood height exceeds the FLEX DB flood height for a given flood mechanism, the FLEX DB flood does not bound and an assessment of the effects of the applicable flood mechanism is required.
    - Only those MSFHI flood mechanisms whose effects exceed the FLEX DB need to be included in the assessment (e.g., if a site’s FLEX DB includes river flooding and storm surge, and the MSFHI shows that the FLEX DB flood bounds the river flood results, but not the storm surge results, only the storm surge needs to be evaluated in MSA.)
- If the MSFHI introduces a new flood mechanism, (e.g., local intense precipitation) or a new associated effect (e.g., debris) that was not included in the FLEX DB, then the FLEX DB does not bound the MSFHI for this condition and the assessment must be performed on the new mechanism or associated effect.
- If any associated effect evaluated in the MSFHI is greater than the effect in the FLEX DB or was not considered in the FLEX DB, then those effect(s) would be treated as being not bounded and an assessment of all associated flooding mechanisms is required with the following exception:
    - If only a single associated effect of a flooding mechanism is not bounded by the FLEX DB, the assessment needs to initially consider only the changes introduced by the new or more severe associated effect. It is only necessary to consider all the aspects of the flood hazard when there is reason to believe that the single unbounded

associated effect influences other aspects of the evaluation, or when more than one associated effect differs from the FLEX DB. For example: If the FLEX DB flood did not explicitly consider debris loads whereas the MSFHI does and all other aspects of the MSFHI are bounded by the FLEX DB, it is only necessary to evaluate the effects of the debris loads. It is reasonable to assume that the effects of the other MSFHI parameters are bounded. However, the combined load effects of hydrostatic loads, wave loads, and debris act upon a structure in aggregate. Therefore, it would not be appropriate to consider the effects of debris loads without considering the superposition of all relevant loads concurrently.

- If the period of inundation of the MSFHI flood event is greater than the period of inundation of the event in the FLEX DB for a given flood mechanism, the FLEX DB does not bound and an assessment of the associated flood mechanism is required. Note that the design basis flooding evaluation for some licensees does not contain specific information on period of inundation. In these cases, it is not necessary to conclude that the FLEX DB does not bound the MSFHI for the associated mechanism as long as there is no reason to believe that the period of inundation has increased. An effort should be made to determine whether the period of inundation was considered in the design in order to be confident that the protection features remain adequate to perform their credited function.
- If the warning time available for the MSFHI flood event is less than the warning time for the same event in the FLEX DB, the FLEX DB does not bound and an assessment of the associated flood mechanism is necessary.

If the FLEX DB bounds the MSFHI for a given flood mechanism, then this information is documented in accordance with Section G.6 and, since FLEX would still work for that flood mechanism, no further action is required.

If the FLEX DB does not bound the MSFHI, the guidance in sections G.4.1 through G.4.4 below (as applicable) should be followed for all unbounded flood mechanisms and associated effects as described in the bullets above.

G.4 EVALUATION OF MITIGATING STRATEGIES FOR THE MSFHI

If one or more parameters of the MSFHI (i.e., flood height, associated effects, flood event duration) are not bounded by the FLEX DB, an evaluation of the impacts is required. The focus of the evaluation is to determine the appropriate mitigating strategy given the impact of the MSFHI. This determination includes considering use of, or modification of the existing FLEX strategies or development of new mitigating strategies using the flood event as the initiating event.

As changes to existing strategies or new strategies are considered, the required baseline capabilities of FLEX to cope with an ELAP and LUHS must continue to be maintained for all other screened-in hazards in accordance with Section 4 (e.g., seismic hazards, high winds, etc.).

The following sections provide guidance for performing the assessments of G.4.1 through G.4.4 as shown in Figure 1.

G.4.1 ASSESSMENT OF THE CURRENT FLEX STRATEGIES

This section provides guidance for evaluating the existing FLEX strategies to determine if they can be implemented as designed given the impacts of the MSFHI.

The following process should be applied to determine whether the FLEX strategies will be sufficient as currently developed given the impacts of the MSFHI:

- In the sequence of events for the FLEX strategies, if the reevaluated flood hazard does not cause the ELAP/LUHS, then the time when the ELAP/LUHS is assumed to occur should be specified and a basis provided (e.g., the ELAP/LUHS occurs at the peak of the flood).
- The impacts of the MSFHI should be used in place of the FLEX DB flood to perform the screening and evaluation per Section 6.
- The equipment storage guidance of Section 11.3 should be reassessed based on the impacts of the MSFHI.
- The impacts of the MSFHI should be used in place of the FLEX DB flood in the consideration of robustness of plant equipment as defined in Appendix A. For determining robustness only the MSFHI should be used as the applicable hazard.
- The impacts of the MSFHI should be used to evaluate the location of connection points in accordance with Section 3.2.2.17.
- Any flood protection features credited in the FLEX strategies meet the performance criteria in Section G.5.

This evaluation should confirm the following:

- The boundary conditions and assumptions of the initial FLEX design are maintained.
- The sequence of events for the FLEX strategies is not affected by the impacts of the MSFHI (including impacts due to the environmental conditions created by the MSFHI) in such a way that the FLEX strategies cannot be implemented as currently developed.
- The validation performed for the deployment of the FLEX strategies is not affected by the impacts of the MSFHI.

If the evaluation demonstrates that the existing FLEX strategies can be deployed as designed, then the MSA is considered complete and should be documented per Section G.6.

If the evaluation demonstrates that the existing FLEX strategies cannot be implemented as designed, those aspects of the FLEX strategies that could not be implemented are documented. The outcome of this evaluation will be used to identify the most effective strategy for mitigating the flood hazard. The results of this evaluation should be documented in accordance with G.6 and provide the basis of the selected strategy.

G.4.2 Assessment for modifying FLEX Strategies

If FLEX strategies cannot be implemented as designed due to the impact of the MSFHI, this section provides guidance for modifying the FLEX strategies to address the impacts of the MSFHI.

The process to modify the FLEX strategies should be the same as that used to develop the original FLEX strategies but will use the modified sequence of events developed under the evaluation performed in G.4.1. The impacts of the MSFHI to the original sequence of events may be addressed through alternatives such as early deployment, modifications to the flood protection features or equipment deployment locations, procedures or operator actions.

Documentation of the changes to the FLEX strategies should be performed in accordance with Section 11.8 Configuration Control to ensure the required baseline capabilities of FLEX to cope with an ELAP and LUHS continue to be maintained for all other screened-in hazards.

In addition to meeting the original FLEX guidance, the modification of the FLEX strategies should also address the following:

- If deployment locations of FLEX equipment are changed as a result of the evaluation per Section 6, the design considerations for the strategy should be reevaluated per Section 11.2.1.

- New or modified actions required for the strategy or existing actions that are impacted by the environmental conditions created by the MSFHI should be validated in accordance with Appendix E.
- The flood protection features that support the modified FLEX strategies should meet the performance criteria provided in Section G.5.

Document the MSA per Section G.6.

G.4.3 ASSESSMENT OF ALTERNATE MITIGATING STRATEGIES

If FLEX strategies cannot be implemented as designed given the impact of the MSFHI, this section provides guidance for developing an AMS to mitigate the impacts of the MSFHI. An AMS utilizes any configuration of FLEX equipment and/or plant equipment (including flood protection features) to maintain or restore core cooling, spent fuel pool cooling, and containment capabilities for the duration of the event.

For some scenarios it may be more effective (e.g., require less resources, simpler to implement, more reliable, result in overall improvement in flood protection, etc.) to address the impacts of the MSFHI through the development of an AMS as opposed to modifying the FLEX strategies.

The AMS would be based on a sequence of events determined from using the flood as the initiating event. The AMS would not assume an ELAP and LUHS unless or until such time as the flood event caused such consequences.

Equipment stored on-site or off-site whose primary function is to support an AMS will be considered to be FLEX equipment in accordance with the definition in Appendix A. Such equipment should be designed and implemented to the same standards (e.g., programmatic controls) to which the FLEX strategies were designed and implemented.

The MSA should address the following:

- The sequence of events should be established based on the flood as the initiating event.
    - If warning time is available, the sequence of events should include the basis for the warning time allowance.
- The MSA should use the General Criteria and Baseline Assumptions in Section 3.2.1 with the exception that the only losses that need to be considered (e.g., ELAP, LOOP, LUHS) are those that would be caused by the flood hazard.
- The impacts of the MSFHI should be used in place of the FLEX DB flood to perform the screening and evaluation per Section 6. Reasonable protection from the MSFHI should be provided for the FLEX equipment which is being used.
- In order to provide additional potential mitigation capability, portable FLEX equipment not being used should be preserved for use as follows:
    - Take action to preserve N sets of onsite FLEX equipment from the MSFHI in accordance with Section 11.3.3.

    - This action applies only if there is sufficient warning time to allow this action to be taken and does not distract from the deployment of the strategy.
    - No strategies need to be preplanned for the preserved equipment.
    - Extraordinary measures do not need to be taken to preserve the unused equipment.
    - Examples of equipment preservation could include storage in the current storage location, relocation to an area not impacted by the MSFHI, etc.
  - Maintain the capability to obtain additional portable FLEX equipment from offsite sources.
    - No strategies need to be preplanned for the use of the offsite equipment.

- If deployment locations of FLEX equipment are changed as a result of the evaluation per Section 6, the design considerations for the strategy should be reevaluated per Section 11.2.1.
- The equipment storage guidance of Section 11.3 should be reassessed based on the impacts of the MSFHI.
- The impacts of the MSFHI should be used in place of the FLEX DB flood in the consideration of robustness of plant equipment as defined in Appendix A. For determining robustness only the MSFHI should be used as the applicable hazard.
- The impacts of the MSFHI should be used to evaluate the applicability of the Minimum Baseline Capabilities of Section 3.2.2 with the only losses (e.g., ELAP, LOOP, LUHS) needing to be considered being those that would be caused by the flood hazard. Additionally, the strategy may use plant equipment, FLEX equipment, or any combination of the two (including flood protection features).
- The flood protection features relied upon should meet the performance criteria provided in Section G.5.
- New or modified actions required for the strategy or existing actions that are impacted by the environmental conditions created by the MSFHI should be validated in accordance with Appendix E.

Document the MSA in accordance with Section G.6.

G.4.4 ASSESSMENT OF TARGETED HAZARD MITIGATING STRATEGIES

If FLEX strategies cannot be implemented as designed due to the impact of the MSFHI, this section provides guidance on developing a Targeted Hazard Mitigating Strategy (THMS) to mitigate the impacts of the MSFHI. For some scenarios it may be necessary to address the MSFHI through the development of a THMS because of the impracticality to develop another effective strategy. As in the case of the AMS, the THMS utilizes any configuration of FLEX equipment and/or installed plant equipment (including protective barriers). Similar to the AMS, the THMS is based upon the flood as the initiating event with the sequence of events and plant impacts determining the necessary strategies for mitigating the event (e.g., the THMS would not assume an ELAP and LUHS unless or until such time as the flood event caused such consequences). Therefore, the THMS is developed using the same guidance as an AMS with the exception that there will be a need to open containment as an element of the strategy and, as such, only the core cooling and spent fuel pool cooling capabilities would be maintained. The THMS should demonstrate the ability to maintain or restore core cooling and spent fuel pool cooling capabilities for the entire event duration of the event.

The MSA should follow the guidance for an AMS with the following additional consideration:

- A justification for not maintaining the containment capabilities should be provided. The additional options that this allowed in the development of the strategies should be addressed.

Document the MSA in accordance with Section G.6.

G.5 PERFORMANCE CRITERIA FOR FLOOD PROTECTION FEATURES

This section provides guidance for demonstrating that flood protection features are robust for the MSFHI. Throughout Section G.4 above, it is necessary to evaluate flood protection features if they are relied on in the strategy. This evaluation is required to demonstrate that the flood protection features can accommodate the flood scenario parameters from the MSFHI defined in Section G.2.

Flood protection evaluations should consider the following for any flood protection feature relied on to protect equipment or actions in a mitigating strategy:

- The equipment quality attributes and design guidance in Sections 11.1 and 11.2 (as applicable) are met for flood protection features used as FLEX equipment.
- The individual flood protection features will perform the intended function under any new loads (i.e., flood height, associated effects, and flood event duration including warning time and period of inundation) due to the revised flood scenario parameters.
- The assessment of plant flood protection features is performed using the appropriate codes and standards (current flooding design basis if it exists or others as applicable) and accepted engineering practices.
- The capacity of pumping or drainage systems is sufficient to handle any inflow through flood protection features for the entire flood event duration.
- Necessary support systems and consumables are available.

The following flood protection features, both installed and temporary, should be considered in the evaluation:

Passive Features

Passive flood protection features may be incorporated, exterior, or temporary and do not require a change in a component's state in order for it to perform as intended. Passive features would include:

- earthen embankments (e.g., earth dams, levees and dikes)
- floodwalls
- seawalls
- concrete barriers
- plugs and penetration seals[19]
- storm drainage systems

[19] For the purposes of evaluating the adequacy of plugs and penetration seals, it is sufficient to use the guidance prepared for the flooding design basis walkdowns performed in response to Near Term Task Force (NTTF) Recommendation 2.3. This guidance is described in NEI 12-07, Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features. Consideration of recent operating experience should be used when applying this guidance.

Active Features

Note: Flood protection features that are normally considered active (e.g. valves, flood gates, doors and hatches) that are administratively controlled to remain closed could be evaluated as passive flood features.

Active flood protection features may be incorporated, exterior or temporary features that requires the change in a component's state in order for it to perform as intended. Active features would include:

- Rotating equipment (e.g. pumps, generators)
- Valves
- Flood Gates
- Doors
- Hatches

G.6 DOCUMENTATION

Document the characterization of the MSFHI for the site. Identify if a controlling flood hazard or bounding parameters are utilized.

Document whether the MSFHI is bounded or not bounded by the FLEX DB and describe the nature of any element not bounded.

Document the results of the process in G.4 and the basis for selecting FLEX, AMS, or THMS.

G.6.1 FLEX: Document the evaluation that demonstrates existing FLEX strategies are acceptable without modification for the MSFHI.

G.6.2 Modified FLEX: Document the evaluation that demonstrates that modifications enable FLEX strategies to be implemented based on the impacts of the MSFHI. The following items should be included:

- identification of the impacts to the FLEX strategies,
- a revised sequence of events demonstrating the necessity of revised FLEX actions
- description and justification of the modifications (equipment, procedures, etc.) to address the revised FLEX actions, and
- validation documents in accordance with Appendix E

G.6.3 AMS or THMS: Document the evaluation that concludes that the selected strategy will mitigate the MSFHI. The following items should be included:

- the sequence of events for the flood hazard(s)
- a detailed description of the mitigating strategies
- a detailed list of equipment necessary for the mitigating strategies
- a description of how the provisions in Sections 3, 6, and 11 have been addressed
- validation documentation in accordance with Appendix E
- for a THMS, document the justification for not maintaining the containment capability

The documentation identified above should be included in and be of the same level of detail as that included in the Program Document.

APPENDIX H
MITIGATING STRATEGIES ASSESSMENT FOR NEW SEISMIC HAZARD INFORMATION

H.1 INTRODUCTION

The purpose of this appendix is to provide guidance for a Mitigating Strategies Assessment (MSA) of the impact of reevaluated seismic hazard information developed in response to the U.S. Nuclear Regulatory Commission's (NRC) "*Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident"* [Ref.1] and the modification of existing or the development of new mitigating strategies, if necessary, to mitigate the effects of a seismic event at the level of the reevaluated seismic hazard information. The guidance for performing an MSA for the reevaluated seismic hazard information is being included as an appendix in NEI 12-06 because the mitigating strategy approach to addressing this information makes use of the work done for the FLEX strategies.

In this appendix the reevaluated seismic hazard information will be referred to as the Mitigating Strategies Seismic Hazard Information (MSSHI). The MSA process is illustrated in Figure H.2.

The FLEX strategies initially developed under Order EA-12-049 [Ref.2] assumed an extended loss of alternating current (AC) power (ELAP) with a loss of normal access to the ultimate heat sink (LUHS) from an unspecified event. Sections 2 and 3 establish the boundary conditions and initial assumptions used for developing these strategies. In addition, Section 3 provides key considerations in the development of the strategies. Sections 4 through 11 establish the reasonable protection requirements for on-site FLEX equipment.

The MSA determines whether the FLEX strategies developed can be implemented for the MSSHI. If it is determined that FLEX strategies cannot be implemented for the MSSHI, the MSA considers other options such as performing additional evaluations, modifying existing FLEX strategies, or developing of alternate mitigating strategies (AMS) that addresses the MSSHI.

Licensees will use the guidance for performing an MSA in this Appendix to do the following:

- Confirm FLEX strategies can be implemented considering the impacts of the MSSHI; or
- Develop and implement modifications necessary to ensure the FLEX strategies are able to address the MSSHI; or
- Develop and implement AMS that are able to address the MSSHI.

A brief description of the associated sections in this appendix is as follows:

- Section H.2 – this section guides the characterization of the MSSHI
- Section H.3 – this section guides the comparison of the seismic hazard used to develop the FLEX strategies with the MSSHI to determine if the MSSHI is bounded
- Section H.4 – this section provides guidance for the evaluation of FLEX strategies with respect to the MSSHI
- Section H.5 – this section provides performance criteria used to establish adequate seismic ruggedness requirements for structures, systems, and components (SSCs) that support the FLEX strategies
- Section H.6 – this section provides requirements for documentation of the results

H.2 CHARACTERIZATION OF THE MSSHI

The MSSHI is the licensee's reevaluated seismic hazard information at the plant's site, developed using probabilistic seismic hazard analysis (PSHA). It includes a performance-based ground motion response spectrum (GMRS), uniform hazard response spectra (UHRS) at various annual probabilities of exceedance, and a family of seismic hazard curves at various frequencies and fractiles developed at the plant's control point elevation. Licensees typically submitted their responses to the NRC 50.54(f) letter dated March 12, 2012 [Ref.1] including the UHRS, GMRS and the hazard curves at their plants to the NRC between March 2014 and July 2015. The seismic hazard information that the NRC staff found acceptable should be used as the MSSHI in the development of the MSA. Figure 1 below describes the use of GMRS, UHRS and/or seismic hazard curves for the various MSA paths described in Section H.4.

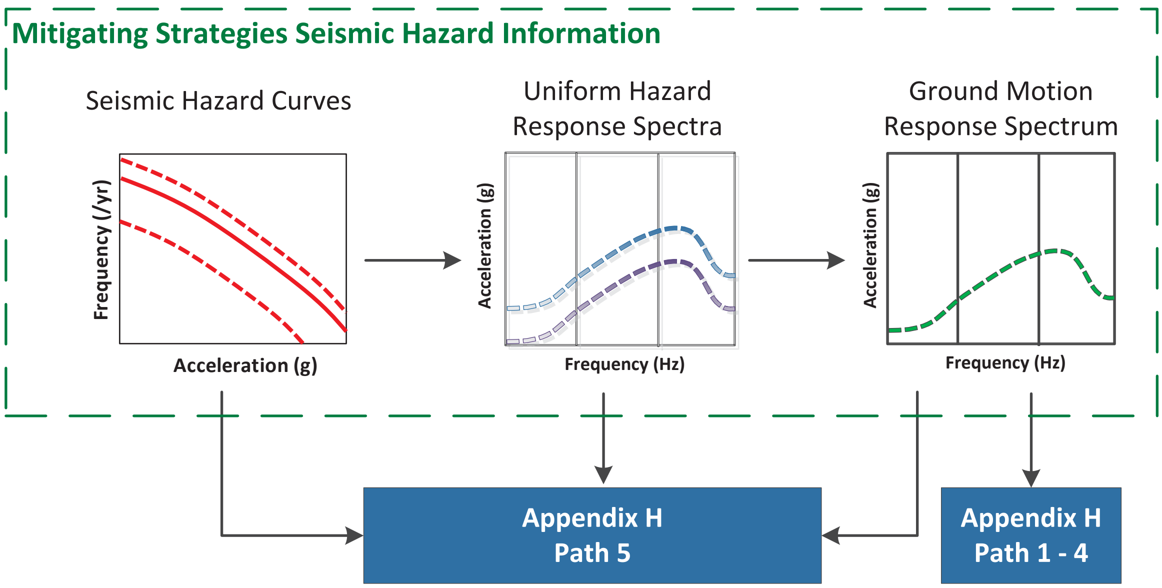


Figure H.1: MSSHI Use for Appendix H Paths

As shown in Figure H.1, the GMRS is used in Paths 1 through 4. The seismic hazard curves and the UHRS are used in addition to the GMRS in Path 5, when the MSA is based on a probabilistic evaluation such as a seismic probabilistic risk assessment (SPRA). Descriptions of the use of MSSHI for each of the five paths are discussed in the sections below.

H.3 APPROACH FOR COMPARISON OF EXISTING SEISMIC DESIGN BASIS/PLANT CAPACITY TO MSSHI

This section provides the approach for comparing the GMRS (consistent with the screening criteria in Electric Power Research Institute (EPRI) 1025287 [Ref.3]) to the seismic design basis spectrum used for developing the FLEX strategies. The term safe shutdown earthquake (SSE) is defined in Appendix A to 10 CFR Part 100 and the site-specific SSE[20] response spectrum is described within the safety analysis reports of plants. For Path 3, the GMRS is compared to a plant capacity spectrum derived from the individual plant examination of external events (IPEEE) program using the plant's high-confidence-of-low-probability-of-failure (HCLPF) capacity. The IPEEE HCLPF spectrum or IHS is described in Section 3.3 of EPRI 1025287 [Ref.3].

The GMRS at frequencies 1 Hz and higher is compared to the SSE (and IHS for Path 3) to determine whether the SSE (or IHS for Path 3) bounds the GMRS, or identify any areas of exceedance of the SSE (or IHS for Path 3). The results of the comparison are used as input to the evaluation of FLEX strategies in Section H.4. The process for determining the appropriate MSA is illustrated in Figure H.2 and described below.

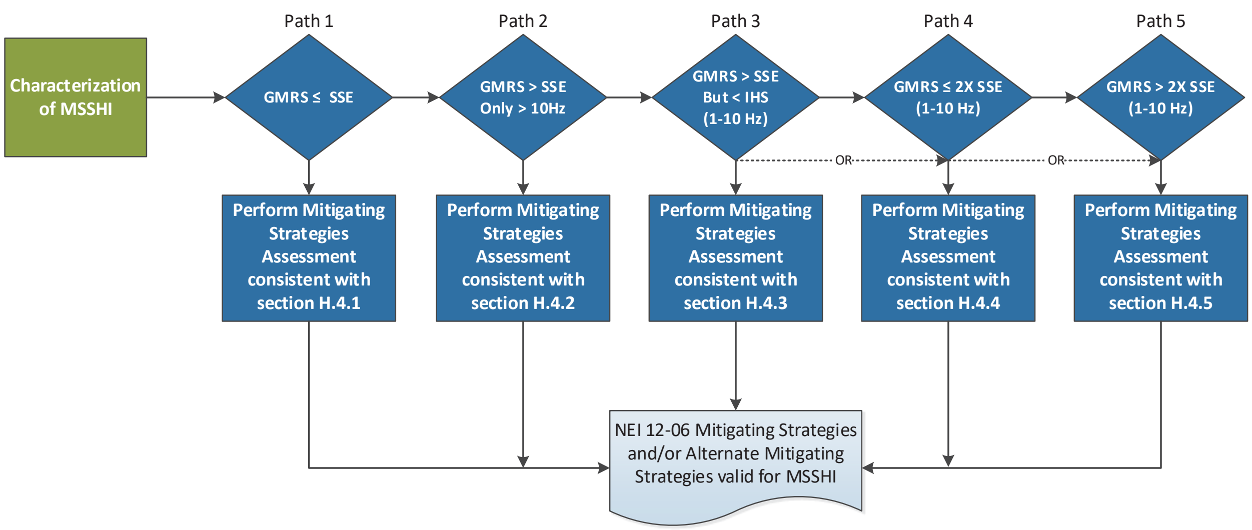


Figure H.2: Mitigating Strategies Assessment Process for the MSSHI

[20] Some plants have used the term "Design Basis Earthquake" or DBE, which is synonymous to SSE.

H.4 EVALUATION OF MITIGATING STRATEGIES FOR THE MSSHI

The MSA is performed in order to determine if the FLEX strategies developed and implemented per this guidance can be implemented considering the impacts of the MSSHI.

If the SSE spectrum bounds the GMRS at frequencies 1 Hz and greater, licensees should follow the process described in Section H.4.1 (Path 1 in Figure H.2) to demonstrate that the FLEX strategies will function as designed since the impacts of the MSSHI are bounded by the hazard for which the mitigating strategies were designed. As described in H.4.1, this process also includes licensees with certain GMRS exceedances above SSE as discussed in the next section.

In the event that the GMRS is not bounded by the SSE, an additional purpose of the MSA is to determine if the FLEX strategies can be implemented as designed in view of the impacts of the MSSHI, or if the FLEX strategies can be modified to address the identified impacts from the MSSHI. For some scenarios it may be more effective (i.e., require less resources, be simpler to implement, more reliable, result in overall improvement in protection) to address the impacts of the MSSHI through the development of an AMS as opposed to modifying the FLEX strategies. Sections H.4.2 through H.4.5 of this appendix provide different approaches for performance of the MSA in order to make this determination.

The MSA evaluates the plant equipment, FLEX equipment, operator actions, plant and site conditions, and procedures required to successfully implement the FLEX strategies so that a site may cope indefinitely with the effects of the MSSHI. Only a single success path is required for the safety functions identified in Tables 3-1 and 3-2. Equipment required to support an alternative means to accomplish a function is not required to be included in the MSA.

1. Section 3.2.2.17 requires primary and alternate connection points for portable equipment. Only one connection point needs to be included, provided the required function can still be accomplished. Justification should be provided for any cases where the primary connection point is not selected.
2. Limiting instrumentation to one indication per key parameter is acceptable, provided the required function can still be accomplished.
3. Plants may have identified additional resources that may be beneficial, but are not required (e.g. multiple water sources available for CST makeup). Only the minimum set of sources to perform the required function needs to be considered.

For each of the paths identified in H.4.1 through H.4.5, the MSA should be documented per Section H.6 of this appendix.

H.4.1 PATH 1: GMRS ≤ SSE

If the GMRS described in Section H.2 is bounded by the SSE spectrum at frequencies 1 Hz and greater, then additional evaluation is unnecessary. For the purposes of determining if the GMRS is bounded by the SSE spectrum, both narrow band exceedances in 1 to 10 Hz range and certain GMRS exceedances in any frequency range above SSE accepted in the site-specific NTTF 2.1 final determination letter [Ref. 4], can be considered to meet the Path 1 screening assessment criteria. The narrow band exceedances in 1 to 10 Hz range are acceptable provided they meet the criteria of Section 3.2.1 of EPRI 1025287 [Ref. 3]. The narrow band exceedances are similar to exceedances found to be acceptable in industry standards such as IEEE Std. 344-1987. The exceedances were accepted by the NRC because SSCs, as designed per a plant's licensing bases, are known to have conservatisms and margins. For plants meeting these criteria, the FLEX strategies can be implemented as designed and no further seismic evaluations are necessary.

H.4.2 PATH 2: GMRS < SSE WITH HIGH FREQUENCY EXCEEDANCES

Introduction:

For plants where the GMRS spectrum above 10 Hz exceeds the SSE spectrum, licensees can demonstrate adequacy of the FLEX strategies with respect to the MSSHI by performing an MSA that consists of an evaluation of high frequency (HF) sensitive plant equipment required for strategy implementation.

If the GMRS described in Section H.2 is less than the SSE in the 1 to 10 Hz range consistent with Section 3.2 of EPRI 1025287 [Ref.3], but is not bounded at frequencies greater than 10 Hz, an MSA should be performed as described in this section. For the purposes of determining if the GMRS is bounded by the SSE spectrum in the 1 to 10 Hz range, certain GMRS exceedances above SSE accepted in the site-specific NTTF 2.1 final determination letter [Ref. 4] can be considered to meet the Path 2 screening assessment.

Basis:

SSE exceedances in the high frequency range (i.e., >10 Hz) can be evaluated by performing an MSA to show that equipment potentially sensitive to high frequency vibration will not prevent successful implementation of the FLEX strategies. The methods for performing the high frequency evaluation are described in Sections 3 and 4 of EPRI 3002004396 [Ref.5]. The acceptance criteria defined below in Section H.5 should be used in these evaluations. The minimal high frequency exceedances defined in Sections 3.1.1 and 3.1.2 of EPRI 3002004396 are considered inconsequential; they do not cause a high frequency concern and do not require additional evaluations.

Background and Discussion:

Section 4 of EPRI 3002004396 [Ref.5] describes an HF evaluation process focusing on contact control devices subject to intermittent states (e.g., relays and contactors that could chatter) in seal-in and lockout circuits. This evaluation process is based on the results of the high frequency testing program described in section 2 of EPRI 3002004396 [Ref. 5]. For the MSA HF evaluation, the acceptance criteria from Section H.5 can be used and the scope of circuits to be reviewed include plant equipment credited for the Phase 1 response as well as permanently installed Phase 2 SSCs that have the capability to begin operation without operator manual actions.

The MSA HF evaluation scope is focused on seal-in and lockout circuits in the following systems and equipment.

- Relays and contactors whose chatter could cause malfunction of a reactor SCRAM.[21]
- Relays and contactors in seal-in or lockout circuits whose chatter could cause a reactor coolant system (RCS) leakage pathway that was not considered in the FLEX strategies. Examples include the automatic depressurization system (ADS) actuation relays in boiling-water reactors (BWRs) and relays that could actuate pressurizer power-operated relief valves (PORVs).
- Relays and contactors that may lead to circuit seal-ins or lockouts that could impede the Phase 1 FLEX capabilities, including buses fed by station batteries through inverters.
- Relays and contactors that may lead to circuit seal-ins or lockouts that could impede FLEX capabilities for mitigation of seismic events in permanently installed Phase 2 SSCs that have the capability to begin operation without operator manual actions.

H.4.3 PATH 3: GMRS > SSE BUT < IHS

Introduction:

If the IHS envelops the GMRS between 1 and 10 Hz or was accepted by the NRC with small narrow band exceedances that meet the criteria of Section 3.2.1.2 of EPRI 1025287 [Ref.3], an MSA may be used based upon the IPEEE evaluation of the IPEEE safe shutdown paths to demonstrate robustness to the MSSHI of SSCs relied upon for the AMS. Alternatively, licensees may elect to perform an MSA of the impacts of MSSHI on FLEX strategies using H.4.4 for Path 4 (if the GMRS ≤ 2XSSE) or perform an MSA for Path 5 using H.4.5. Licensees electing to perform an MSA using Path 4 described in section H.4.4 would not need to perform an ESEP review as an entry condition for that process, but instead may rely on a demonstration of robustness of SSCs using the screening methodology of Path 4, Step 2 and the evaluation methodology of Path 4, Step 3.

An IPEEE-based MSA relies on the seismic evaluation of plant equipment to demonstrate robustness of SSCs to the MSSHI. Licensees that are eligible to use this path rely on the previous seismic evaluations that were conducted under the IPEEE effort and accepted by the NRC per Enclosure 2 of their May 9, 2014 letter [Ref.6] or in a subsequent screening determination that was issued through the letter dated October 27, 2015 [Ref.4]. For those eligible plants, the MSA may be based upon the IPEEE.

IPEEEs relied on the results of an SPRA, an EPRI seismic margins assessment (SMA) methodology, or an NRC SMA methodology to demonstrate the capability to bring the plant to a safe shutdown condition following a review level earthquake (RLE) as described in NUREG-1407 [Ref.7]. These seismic evaluation approaches evaluated two safe shutdown success paths. The safe shutdown success paths provide independent means of

[21] A SCRAM is a manually-triggered or automatically-triggered rapid insertion of all control rods into the reactor, causing emergency shutdown.

achieving a safe shutdown condition following a severe seismic event (e.g., core cooling by heat removal from the steam generators and core cooling by RCS 'feed and bleed').

To provide a complete MSA seismic evaluation, the IPEEE evaluation is supplemented by reviews of spent fuel pool cooling functions and high frequency exceedances (as applicable).

It is not necessary to maintain the IPEEE used for the MSA provided the seismic capacity of any mitigating strategy SSC is not reduced below the IHS level via replacement and/or plant modification.

Basis:

Seismic evaluations performed under IPEEE included SSCs in at least two safe shutdown success paths. Therefore, based on the results of the IPEEE, safe shutdown of the plant following a seismic event can be accomplished, and consequences can be mitigated, for a seismic event up to the plant capacity level (i.e., the IHS) for which the SSCs in the IPEEE were evaluated.

Background and Discussion:

IPEEE Evaluations

The IPEEEs were completed by plants in the 1990s under NRC Generic Letter (GL) 88-20 Supplements 4 [Ref.8] and 5 [Ref.9] in accordance with the guidance of NUREG-1407 [Ref.7]. Acceptable approaches to perform IPEEE included the NRC SMA method, the EPRI SMA method, or an SPRA. For each approach, a seismic equipment list (SEL) was developed that included safe shutdown success paths and/or accident sequences. The evaluation of robustness to the MSSHI of the SSCs in the two safe shutdown success paths demonstrates the capability to maintain or restore core cooling and containment capabilities for a beyond-design-basis seismic event up to the level of the IHS, which envelopes the GMRS in the 1 to 10 Hz range.

The IPEEEs were generally performed using input motions based on the following:

a. Median-centered response spectrum using the NUREG/CR-0098 [Ref.10] shape, anchored to 0.3g peak ground acceleration (PGA).
b. For SPRAs, plants generally used the mean Uniform Hazard Response Spectra and hazard curves developed by Lawrence Livermore National Laboratory (LLNL) in NUREG-1488 [Ref.11] and/or EPRI in EPRI NP-6395-D [Ref.12].
c. In some cases, past SPRAs were submitted for IPEEE closure that used input motions and hazard curves that preceded the LLNL and EPRI hazard curves of NUREG-1488 [Ref.11] and EPRI NP-6395-D [Ref.12] respectively.

Indefinite Coping

For those plants for which the IHS has been already determined to be acceptable and used the EPRI SMA approach based on EPRI NP-6041-SL Rev. 1 [15], the SEL for evaluation of safe shutdown success paths was comprised of those SSCs required to bring the plant to a stable condition (either hot or cold shutdown) and maintain that condition for at least 72 hours. Therefore, for those plants with an IPEEE based on the SMA described in EPRI 1025287 [6] approach, the IPEEE results must be evaluated for limitations that are based on the 72 hour coping duration. Plants that performed a seismic PRA or the NRC margin method for IPEEE may have limitations based on coping durations of less than 72 hours that also need to be further evaluated for meeting the intent of mitigating strategies to cope indefinitely. Generally, the conclusions of the SMAs and SPRAs are not sensitive to coping duration. However, certain consumable items, such as water and fuel oil inventories, may have been evaluated based on a limited onsite supply. The ability to continue coping would require re-supply of consumables. This issue is addressed in Sections 3.3 and 12. A plant-specific evaluation should be performed to conclude that SSCs that limit the SMA-based IPEEE coping duration to 72 hours are available for an indefinite period following a beyond design-basis seismic event at the reevaluated seismic hazard to support continued maintenance of the safe shutdown condition.

IPEEE Upgrade to Full Scope

As noted above, these plants have an IHS that completely envelops the GMRS between the frequency range of 1 and 10 Hz, with the exception of small narrow band exceedances that meet EPRI 1025287 [Ref.3] criteria. To apply this approach, licensees conducted a full scope IPEEE or, if a licensee conducted a plant focused- scope IPEEE, the licensee brought the focused-scope IPEEE assessment to be consistent with a full-scope IPEEE assessment as defined in GL 88-20 Supplements 4 [Ref.8] and 5 [Ref.9] and NUREG-1407 [Ref.7], in accordance with the guidance in EPRI 1025287 [Ref.3]. Licensees that used a screening process based on IHS typically submitted their IPEEE assessments to the NRC in their March 2014 letters on NTTF 2.1. If additional evaluations (e.g., full-scope relay review) were identified to bring the IPEEE to full scope, but are not yet completed, then the successful demonstration must be completed to use this path.

Spent Fuel Pool Cooling Evaluation

Licensees following this path need to ensure the credited SFP cooling capability is maintained. SFP makeup capability equipment needed to accomplish the SFP cooling function should be evaluated using the criteria in H.5 to demonstrate robustness to the MSSHI. For developing in-structure response spectrum (ISRS) corresponding to the GMRS, the SSE-based ISRS are developed by scaling the highest ratio of GMRS/SSE in the 1 to 10 Hz range for these evaluations. This process is typically conservative because it applies the highest GMRS-to-SSE ratio over the entire 1 Hz to 10 Hz frequency range. A high frequency evaluation of the SFP cooling key safety functions is not warranted since operators would have a significant amount of time to restore SFP cooling, as documented in the times for initiation of SFP makeup contained within the FLEX strategies.

High Frequency Evaluation:

Licensees following this path that also have high frequency exceedances (GMRS > IHS above 10 Hz) should perform a high frequency evaluation of potentially sensitive devices in the IPEEE scope consistent with the criteria in Sections 3 and 4 of EPRI 3002004396 [Ref.5], using the acceptance criteria in H.5. This evaluation process is based on the results of the high frequency testing program described in section 2 of EPRI 3002004396 [Ref. 5].

Availability of FLEX Equipment:

With the exception of SFP cooling, the AMS described in H.4.3 does not rely upon availability of FLEX equipment.

On-site FLEX equipment may be available for deployment to support the maintenance of core cooling, containment, and spent fuel cooling functions. In order to provide additional potential mitigating capability, portable FLEX equipment not being used for the AMS should be stored in accordance with Section 5.3.1. No strategies need to be preplanned for the use of this equipment.

Additionally, the licensee will maintain the capability to obtain additional portable FLEX equipment from offsite sources. No strategies need to be preplanned for the use of the offsite equipment.

H.4.4 PATH 4: GMRS ≤ 2X SSE

Licensees who determine that a plant GMRS described in Section H.2 has spectral ordinates greater than the SSE but no more than 2 times the SSE anywhere in the 1 to 10 Hz frequency range may use Path 4, as described below to perform an MSA of the impacts of the MSSHI on FLEX strategies. These licensees may also elect to follow Path 5 of Section H.4.5 of this Appendix.

Introduction:

For licensees with GMRS up to 2 times the SSE in the 1 to 10 Hz frequency range, selected plant equipment relied upon in the FLEX strategies was previously evaluated up to 2 times the SSE under the Expedited Seismic Evaluation Process (ESEP), as described in EPRI 3002000704 [Ref.15]. The scope of SSCs necessary to be evaluated under the MSA needs to be identified, and methods are provided to demonstrate adequate seismic ruggedness. These methods include use of qualitative criteria based on previous experience to show adequate seismic ruggedness as well as a more quantitative approach based on the criteria described in Section H.5 to demonstrate SSCs are seismically robust up to the GMRS earthquake level.

Basis:

Equipment used in support of the FLEX strategies has been evaluated to demonstrate adequacy following the guidance in Section 5. Previous seismic evaluations should be credited to the extent that they apply. This includes the design basis evaluations for the plant, and the ESEP evaluations for the FLEX strategies in accordance with EPRI 3002000704 [Ref.15]. The ESEP evaluations remain applicable for this MSA since these evaluations directly addressed the most critical 1 Hz to 10 Hz part of the new seismic hazard using seismic responses from the scaling of the design basis analyses. In addition, separate evaluations should be performed to address high frequency exceedances under the HF assessment process defined in EPRI 3002004396 [Ref.5]. These high frequency evaluations should be performed as applicable for the equipment supporting the FLEX strategies. The new evaluations should use the MSA seismic performance goal defined in Section H.5. Licensees following this path may also have HF GMRS exceedances above the SSE at frequencies above 10 Hz. The specific assessment of the high frequency exceedance for the Path 4 plants is identical to the procedure described in Section H.4.2 and should be used here also.

Background and Discussion:

Plant equipment relied on for FLEX strategies have previously been evaluated as seismically robust to the SSE levels. The MSA of Path 4 SSCs is conducted as described below and illustrated in Figure H.3:

1. *Step 1: Determine Scope of Plant Equipment for the MSA* – The scope of SSCs is determined following the guidance in the ESEP [Ref.15], and adding the SSCs excluded from the ESEP. The SSCs excluded from the ESEP that need to be added and evaluated are the following:
    - Structures (e.g., containment, reactor building, control building, auxiliary building).
    - Piping, cabling, conduit, and their supports
    - Manual valves, check valves, and rupture disks
    - Power operated valves not required to change state
    - Nuclear Steam Supply System (NSSS) components
    - FLEX storage buildings FLEX haul paths and operator pathways

    In addition, SSC failure modes not addressed under the ESEP need to be added and evaluated. These failure modes are the seismic interactions that could potentially affect the FLEX strategies (note that block walls near plant equipment credited for FLEX strategies and differential displacement of piping attached to tanks were evaluated under the ESEP).

2. *Step 2: ESEP Review –* The ESEP provided an evaluation that demonstrated seismic adequacy for a single success path for core cooling, RCS makeup, and containment function strategies for a scaled SSE spectrum that bounded the GMRS from the re-evaluated seismic hazard (1 to 10 Hz) or the GMRS was directly used. The ESEP was an interim evaluation and included a review for all potential failure modes with the exception of the full review of all potential seismic interactions. The ESEP included the reviews of seismic interactions associated with block walls in the vicinity of the ESEP equipment and differential displacement type interactions for tanks (including buried tanks). Therefore, the ESEP can be used to demonstrate robustness to withstand the reevaluated seismic hazard for those SSCs that were evaluated.

3. *Step 3: Qualitative Assessment Based on Seismic Experience* – The qualitative assessment of SSCs not included in the ESEP is accomplished using (1) a qualitative screening of "inherently rugged" SSCs and (2) evaluation of SSCs to determine if they are "sufficiently rugged." This assessment should be documented in the MSA based on the discussion below.

   Certain SSCs are inherently rugged and the long-standing practice has been to not include the seismic failure of such SSCs into SPRA logic models. By definition, these inherently rugged components have demonstrated high seismic capacity to withstand the seismic hazard and do not need further evaluation or analysis to demonstrate robustness. EPRI 1025287 [Ref. 3], which was endorsed by the NRC in February 2013, discusses seismically inherently rugged SSCs which can be excluded from PRA logic models; for example based on the guidance in EPRI NP-6041 SL Rev. 1 [Ref. 13]. The recent EPRI SPRA Implementation Guide (SPRAIG) [Ref.16] identifies several such inherently rugged components, including:

   - Strainers and small line mounted tanks
   - Welded and bolted piping
   - Manual valves, check valves, and rupture disks
   - Power operated valves (MOVs and AOVs) not required to change state

   In addition to the inherently rugged SSCs, there are classes of SSCs that have sufficiently high seismic capacities and can withstand the GMRS levels for Path 4, which are less than twice the SSE levels in the critical 1 to 10 Hz range. These high capacity components have demonstrated seismic adequacy on an equipment class basis to withstand the seismic hazard for all Path 4 plants. This group of equipment is determined to be "sufficiently rugged" for purposes of Path 4. The EPRI NP-6041 [Ref.13] seismic margin report serves as a good reference to demonstrate robustness for several SSCs. The 5% damped peak spectral acceleration values for all Path 4 plants are below 0.8 g. As such, the first column of Table 2-3 of EPRI NP-6041SL Rev. 1 [Ref. 13] establishes a HCLPF capacity level for nuclear structures.

The following structures have established sufficient seismic capacity to withstand the GMRS for Path 4 plants based on the EPRI NP-6041 screening criteria and do not require additional evaluations to demonstrate robustness:

- Concrete containment and containment internal structures
- Shear walls, footings and containment shield walls
- Diaphragms (floors)
- Category 1 concrete frame structures
- Category 1 steel frame structures

In addition, two classes of high capacity equipment and systems have also been established in EPRI NP-6041 [Ref.13] to have sufficient seismic capacities relative to the GMRS for Path 4 plants and do not require additional evaluations to demonstrate robustness:

- Raceways (Cable Trays and Conduit)
- NSSS components (piping and vessels)

Cable trays and conduits do not have any caveats and restrictions associated with the use of the 0.8g spectral acceleration column of Table 2-4. In addition, since raceway earthquake experience data exists at elevations higher than 40 feet above grade, the caution on use of Table 2-4 from EPRI NP-6041 does not apply to both cable trays and conduit. This use of the 0.8g seismic capacity for raceways at all elevations in the plant is also consistent with Section 8.0 of the SQUG GIP Revision 3A [Ref. 17] which was used in the resolution of USI A-46 [Ref. 18].

The NSSS piping and vessel shave been shown to have high seismic capacities in past SPRAs. In light of the fact that the EPRI NP-6041 Table 2-4 0.8g peak spectral acceleration represents a HCLPF threshold and that the MSA seismic robustness criteria in H.5 is a $C_{10\%}$ level of adequacy, the NSSS piping and vessels do not to require any further effort to demonstrate robustness. This conclusion is supported by the NRC study on transition break size. The NRC reviewed the seismic risks associated with both direct NSSS piping seismic failures and also indirect seismic failures (due to NSSS vessel and component seismic failures) and concluded that the probability of seismically induced failure to be less than 10^{-5} per year.

4. *Step 4: Assessment Based on the Criteria Defined in Section H.5* – SSCs and seismic interactions that were not included within the ESEP review (Step 1) and cannot be justified to be inherently rugged or sufficiently rugged with respect to the GMRS (Step 2) should be evaluated to demonstrate adequate seismic ruggedness. Section H.5 describes the methodology for demonstrating the robustness of equipment used in the FLEX strategies. The equipment and interactions to be considered are:

- FLEX Equipment Storage Building and Non-Seismic Category 1 Structures that could impact FLEX implementation
- Operator Pathways – interaction pathway review, use Section H.5 methods if calculation is required
- Tie down of FLEX portable equipment that are required to be restrained during the earthquake
- Seismic interactions that could potentially affect the FLEX strategies and were not previously reviewed as part of the ESEP program should also be addressed (e.g. flooding from non-seismically robust tanks and interactions to distributed systems associated with the ESEP equipment list). This assessment may be conducted based on a sampling walkdown review to verify that credible seismic interactions are not present.
- Haul Path, including liquefaction, slope stability, and seismic interactions. Options for demonstrating an acceptably low probability of haul path failure include:
    - demonstrating that a $C_{10\%}$ capacity of the haul path exceeds the GMRS, or
    - justifying that a particular failure mode (such as liquefaction induced failures at a hard rock site) would not be credible, or
    - crediting on-site capabilities for debris removal to reestablish a haul path following a beyond-design-basis earthquake.

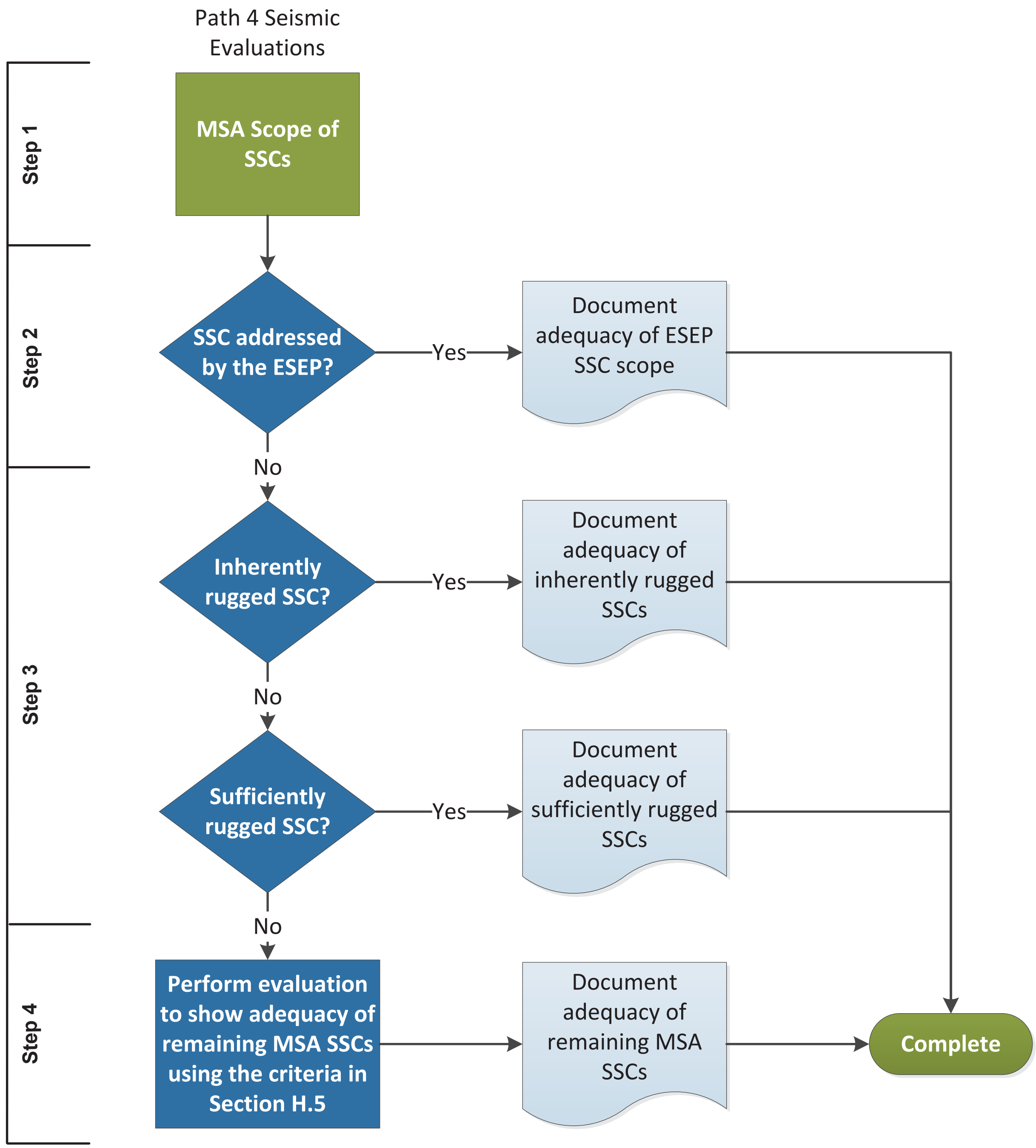


Figure H.3: Evaluation of Path 4 SSCs with the MSA

Restrictions:

The restrictions and caveats that apply in using this path are as follows.

- GMRS must be less than or equal to 2 times the SSE at all frequencies in the 1 to 10 Hz range.

Other Considerations:

High Frequency

Licensees with GMRS exceedances of the SSE above 10 Hz need to perform an HF evaluation of relays in accordance with the methodology described in Section H.4.2.

Spent Fuel Pool Cooling

Licensees following this path need to ensure the SFP cooling FLEX strategies are maintained. SFP makeup capability equipment needed to accomplish the SFP cooling strategies should be evaluated for seismic adequacy to the GMRS. A high frequency evaluation of the SFP cooling function is not warranted since operators would have a significant amount of time to restore SFP cooling, as documented in the FLEX strategies.

H.4.5 PATH 5: GMRS > 2X SSE

H.4.5.1 Introduction

Path 5 applies to plants for which the GMRS as described in Section H.2 has spectral ordinates more than 2 times the SSE anywhere in the 1 to 10 Hz frequency range. Path 5 may also be used for plants meeting the criteria in H.4.4, if a seismic probabilistic risk assessment (SPRA) is performed pursuant to the NRC NTTF 2.1 Information Request under 50.54(f) and submitted to the NRC for review.

For the reevaluated seismic hazards, there are deterministic and risk-informed assessments that can be used.

- The deterministic assessment described in H.4.5.2 is consistent with that used for Path 4 (H.4.4) to determine if the FLEX strategies can be implemented as designed in view of the impacts of the MSSHI, or if the FLEX strategies can be modified to address to impacts of the MSSHI. As part of this assessment and as described in H.4.5.4, the results and insights from the plant SPRA may optionally be used to inform the evaluation of the mitigating strategies SSCs to determine which FLEX equipment or other plant modifications (as an AMS), if any, will improve the plant’s seismic safety.

- The risk-informed assessments described in H.4.5.3 and H.4.5.5 use the SPRA to address the impacts of the MSSHI on that AMS, or to determine if the FLEX strategies can be implemented as designed or modified to address the impacts of the MSSHI in cases where the SPRA incorporates the FLEX strategies.

The overall process is illustrated in Figure H.4.

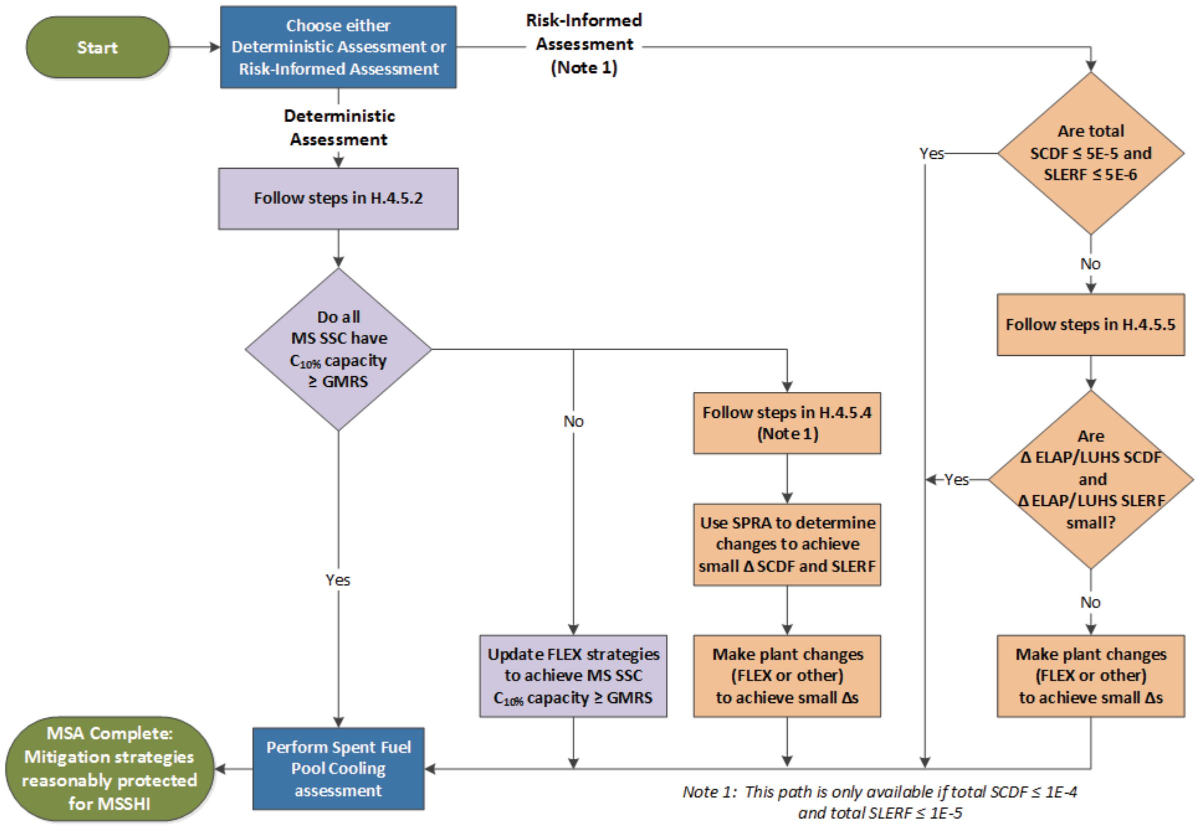


Figure H.4: General Path 5 Process Overview

H.4.5.2 Deterministic Assessment

Background and Discussion

Equipment used in support of the mitigating strategies has been evaluated to demonstrate seismic adequacy following the guidance in Section 5. Subsequent evaluations were performed under the ESEP in accordance with EPRI 3002000704 [Ref.15].

In the Path 5 deterministic assessment, the scope of SSCs identified below is evaluated for the impacts of the MSSHI. SPRA evaluations performed by the licensee provide updated ground motion and in-structure response spectra (ISRS) to be used in the MSA. In some cases, seismic fragility evaluations performed for the SPRA provide the data necessary to estimate the $C_{10\%}$ capacity for the equipment.

The steps for the deterministic MSA of mitigating strategies SSCs are as described below.

1. *Step 1: Determine Scope of Plant Equipment for the MSA* – The scope of SSCs is determined following the guidance for the ESEP [Ref.15] for the mitigating strategies, with the addition of SSCs excluded from the ESEP. The SSCs excluded from the ESEP that need to be considered are the following:

    - Structures (e.g., containment, reactor building, control building, auxiliary building).
    - Piping, cabling, conduit, and their supports
    - Manual valves, check valves, and rupture disks
    - Power operated valves not required to change state
    - Nuclear Steam Supply System (NSSS) components
    - FLEX storage buildings
    - FLEX haul paths and operator pathways

    In addition, SSC failure modes not addressed under the ESEP need to be added and evaluated. These failure modes are the seismic interactions that could potentially affect the FLEX strategies (note that block walls near plant equipment credited for FLEX strategies and differential displacement of piping attached to tanks were evaluated under the ESEP).

2. *Step 2: ESEP Review* and Update – The ESEP provided an evaluation that demonstrated seismic adequacy for a single success path for core cooling, RCS makeup, and containment function strategies for a scaled SSE spectrum that bounded the GMRS from the reevaluated seismic hazard (1 to 10 Hz) or the GMRS (or ISRS based on the GMRS) was directly used. The ESEP was an interim evaluation and included a review for all potential failure modes for the ESEL SSCs with the exception of the full review of all potential seismic interactions. The ESEP included the reviews of seismic interactions associated with block walls in the vicinity of the ESEP equipment and differential displacement type interactions for tanks (including buried tanks). However, the ESEP evaluations that were based on 2xSSE need to be updated to address the MSSHI. Plants using this path will use the ISRS from structural dynamic analyses based on the MSSHI based on a reference earthquake (typically the 1E-4 UHRS, the GMRS or the 1E-5 UHRS).

    The updated ESEP can therefore be used to demonstrate robustness to withstand the MSSHI for those SSCs that are evaluated as discussed above.

3. *Step 3: Qualitative Assessment for Inherently Rugged Items* – Certain SSCs are inherently rugged and long-standing practice has been to not include seismic failure of such SSCs in SPRA logic models. By definition, these inherently rugged components have demonstrated high seismic capacity to withstand the seismic hazard and do not need further evaluation or analysis to demonstrate robustness. The SPID [Ref. 3], which was endorsed by the NRC in February 2013, discusses seismically inherently rugged SSCs that can be excluded from PRA logic models, for example,

based on the guidance in EPRI NP-6041-SL, Rev. 1 [Ref. 13]. The recent EPRI SPRA Implementation Guide (SPRAIG) [Ref.16] identifies several such inherently rugged components, including:

- Strainers and small line mounted tanks
- Welded and bolted piping
- Manual valves, check valves, and rupture disks
- Power operated valves (MOVs and AOVs) not required to change state

Cable Trays and Conduit – In addition to the four sets of rugged components identified above, cable trays and conduits should also be considered sufficiently rugged[22] and do not require specific evaluation. They do not have any caveats and restrictions associated with the use of the 0.8g ground spectral acceleration column of Table 2-4 of EPRI NP-6041-SL, Rev. 1 [Ref. 13]. In addition, since raceway earthquake experience data exists at elevations higher than 40 feet above grade, the caution on use of Table 2-4 from EPRI NP-6041-SL, Rev. 1 [Ref. 13] does not apply to both cable trays and conduit. This use of the 0.8g ground seismic capacity for raceways at all elevations in the plant is also consistent with Section 8.0 of the SQUG GIP Revision 3A [Ref. 17] which was used in the resolution of USI A-46 [Ref. 18]. In order to calculate a $C_{10\%}$ ground spectral acceleration associated with the 0.8g value, the composite variability ($ß_C$) is required. Cable tray fragilities typically have larger uncertainties in past SPRAs. The EPRI Seismic PRA Guide [Ref. 16] shows a range of $ß_C$ values from 0.39 to 0.61 for cable trays and conduit from past SPRAs due to the wide range of locations throughout the plant and the range of anchorage and support configurations required to address unique installation configurations. A reasonably conservative $ß_C$ value for cable trays from Table H.1 would be the last row titled "Other SSCs" with the $ß_C$ value of 0.4, representing the larger group of SSCs that are not either the major passive components or the active components mounted high in the structures. This 0.4 $ß_C$ translates to a factor of 1.52 between the $C_{1\%}$ and the $C_{10\%}$ value, which for the 0.8g $C_{1\%}$ value associated with cable trays would translate to the $C_{10\%}$ of 1.2g. Therefore, only Path 5 plants with GMRS spectral peaks above about 1.2g would need to satisfy the cable tray caveats associated with the second column of Table 2-4 of EPRI NP-6041-SL, Rev.1 [Ref. 13].

4. *Step 4: Other Assessments Based on the Criteria Defined in Section H.5* – SSCs and seismic interactions identified in Step 1 that cannot be justified to be inherently rugged or sufficiently rugged with respect to the GMRS (Step 2) should be evaluated to demonstrate adequate seismic ruggedness. Section H.5 methodology for demonstrating the robustness of equipment used in the FLEX strategies can be used. Licensees in Path 5 may have calculated component-specific fragility parameters (median capacities and variabilities) using the MSSHI that can be used in the MSA evaluation rather than the generic variabilities provided in Table H.1. In addition, with the exception of potentially high frequency (HF) sensitive SSCs identified in

[22] Cable trays which use smooth retainer nuts with support struts should be reviewed to verify adequate seismic capacity

EPRI 3002004396 [Ref. 5], HF in-structure response spectrum (ISRS) above 20 Hz are considered non-damaging. These higher frequency motions produce small displacements and as described in previous guidance [Ref. 3, 5 and 26] are considered non-damaging to components and structures that have strain- or stress-based potential failures modes. Therefore, HF ISRS peaks do not need to be included in capacity calculations using section H.5 criteria. The ISRS amplitudes calculated from detailed dynamic analyses can be reduced up to the 20 Hz cut-off frequency based on plant-specific or generic studies with sound engineering bases, to account for phenomena such as coupled structure-equipment response, averaging over equipment footprint, peak-clipping and peak-averaging, etc. In addition, energy absorption factors based on limited HF displacements and equipment ductile behavior can increase equipment capacity.

The equipment and interactions to be considered are:

- SSCs identified in Step 1 but not deemed inherently rugged or sufficiently rugged in Step 2. Component capacity evaluations from the ESEP can be used in conjunction with the calculated ISRS from the SPRA in these evaluations.
- FLEX Equipment Storage Buildings and Non-Seismic Category 1 Structures that could impact FLEX strategies
- Operator Pathways – interaction pathway review, use Section H.5 methods if calculation is required
- Tie down of FLEX portable equipment required to be restrained during the earthquake
- Seismic interactions that could potentially affect the mitigating strategies and were not previously reviewed as part of the ESEP program (e.g. flooding from large internal flooding sources and interactions to distributed systems associated with the ESEP equipment list). This assessment may be conducted based on a sampling walkdown review to verify that credible seismic interactions are not present.
- Haul path, including liquefaction, slope stability, and seismic interactions. Options for demonstrating an acceptably low probability of haul path failure include:
    - demonstrating that a $C_{10\%}$ capacity of the haul path exceeds the GMRS, or
    - justifying that a particular failure mode (such as liquefaction induced failures at a hard rock site) would not be credible, or
    - crediting on-site capabilities for debris removal to reestablish a haul path following a beyond-design-basis earthquake.

5. *Step 5: High Frequency Evaluation* – Licensees with GMRS exceedances of the SSE above 10 Hz need to perform a high frequency evaluation. The following criteria should be used:

- The high frequency evaluation scope is focused on seal-in and lockout circuits in the same systems and equipment as identified in Section H.4.2
- The evaluation criteria from Section 5 of EPRI 3002004396 [Ref. 5] should be used to calculate the component fragility using ISRS and in-cabinet response spectra computed for the SPRA.
- If for some reason, updated ISRS are not available at the component location, then the HCLPF calculation criteria in Section 4 of EPRI 3002004396 [Ref. 5] can be used.
- The $C_{10\%}$ acceptance threshold from Section H.5 can be used. Component-specific beta values from the fragility calculations can be used rather than the generic values in Table H.1.

Those SSCs in steps 2, 4 and 5 for which the $C_{10\%}$ capacity is less than the GMRS may need to be modified or replaced such that their capacity meets the $C_{10\%}$ acceptance threshold. However, if options for doing so are impractical for some SSCs (e.g., would require substantial changes to the design of the plant), an alternate justification is acceptable using insights from the plant's SPRA. This would involve determining if increasing the $C_{10\%}$ capacity of SSCs modeled in the SPRA to the GMRS provides a significant safety benefit. A process for applying SPRA insights is described in Section H.4.5.4.

H.4.5.3 Overall Seismic Risk

For plants where the base SPRA has been peer reviewed in accordance with expectations in the Screening, Prioritization, and Implementation Details (SPID, Ref. 3), submitted to NRC for the NTTF 2.1 seismic 50.54(f) information request and the results, with or without credit for FLEX, are less than $5x10^{-5}$/yr. seismic core damage frequency (SCDF) and $5x10^{-6}$/yr. seismic large early release frequency (SLERF), an evaluation under H.4.5.2, H.4.5.4, or H.4.5.5 is unnecessary, as the base SPRA results demonstrate a high likelihood that mitigation strategies are reasonably protected for the MSSHI.

As part of the initial documentation, the bases for accepting the seismic capacities should be documented. In addition, the licensee may elect to maintain the SPRA. However, it is not necessary to maintain the SPRA model used for the MSA as long as the seismic capacity of any mitigating strategies SSCs is not reduced via replacement and/or plant modification.

H.4.5.4 Application of Risk Insights into the Deterministic Assessment

Note: Plants meeting the criteria in H.4.4 that elect to follow section H.4.5.4 of Path 5 may use the evaluation process described in H.4.4 in lieu of H.4.5.2.

SPRAs provide a rigorous evaluation of plant safety in response to a severe seismic event. The SPRA consists of analytical evaluations of the plant structures and equipment response to the reevaluated seismic hazard developed as documented in the plant's Seismic

Hazard and Screening Report submittal, PRA logic model development to include plant seismic response, and quantification of seismic risk in terms of SCDF and SLERF. The evaluations utilize current day methodologies to develop the hazard, analyze response of plant structures to determine seismic demands on equipment, and calculate critical equipment seismic capacities. The SPRA risk quantification is based on plant-specific UHRS (or GMRS). The result of the SPRA is a realistic assessment of the plant's ability to maintain core integrity and public safety in the event of a severe, beyond-design-basis earthquake.

For plants that have performed an SPRA, the results provide detailed plant-specific insights that can assist in understanding the specific capabilities and safety benefits of the mitigating strategies. Thus, plants can utilize the results and insights from the peer-reviewed plant SPRA to further assess mitigating strategies SSCs identified in section H.4.5.2 that are not demonstrated to meet the GMRS at $C_{10\%}$ capacity using the method in this section. Specifically, the SPRA can be used to determine if keeping such mitigating strategies SSCs as currently designed has a significant impact on safety. The approach is to determine the potential risk reduction that would be obtained by modifying mitigating strategies SSCs so that their capacity meets the $C_{10\%}$ performance criteria in Section H.5. The SPRA evaluates the risk from a broader range of seismically-induced challenges than targeted when first developing the mitigating strategies. However, for the evaluation defined here, it is necessary for the SPRA results to reflect the mitigating strategies SSCs to ensure that the SPRA results fully reflect an MSSHI evaluation pertinent to FLEX.

- If this risk reduction is small, then the mitigating strategies are effective for MSSHI without changes, as they would not provide a meaningful improvement in protection against the MSSHI.
- A $1x10^{-5}$/yr delta-SCDF represents a sufficiently small residual risk. This is consistent with the guidance for small changes in CDF in Regulatory Guide 1.174 [Ref. 24].
- Regulatory Guide 1.174 suggests a goal for small LERF that is a factor of 10 lower than the small CDF guidance, which would be $1x10^{-6}$/yr. delta-SLERF for this evaluation. Plants for which a $1x10^{-6}$/yr. delta- SLERF residual goal is not achievable will need to apply insights from the SPRA to justify the acceptability of the results. Further, the noted delta risk values are not intended to be absolute thresholds. They represent goals or desired outcomes.
- An entry condition to application of the H.4.5.4 guidance is that the SPRA must have been submitted to NRC for the NTTF 2.1 seismic 50.54(f) information request and reflect a total SCDF $\leq 1x10^{-4}$/yr. and total SLERF $\leq 1x10^{-5}$/yr. This total seismic risk evaluation addresses the impacts of earthquake-induced consequential events (e.g., internal flooding), and ensures that the mitigating strategies and plant features are sufficient to limit risk from the spectrum of seismic impacts to an acceptable level.
- If the potential risk reduction is not small, then the SPRA can be used to identify the most effective means to enhance plant safety and provide reasonable

protection of the integrated plant mitigation capability. The enhancements would be modifications to mitigating strategies SSCs or other plant equipment or operational practices that will provide a risk reduction similar to having all mitigating strategies SSCs meet the $C_{10\%}$ acceptance criterion.

The application of SPRA risk insights credits the defense-in-depth attributes of the plant design, including redundancy, diversity, and radiological release barriers. Defense in depth and diversity are addressed implicitly in the SPRA by considering the capacities of the relevant redundant systems and features that protect the reactor. Barrier redundancy is addressed by consideration of both the core damage and the large early release insights.

Since ELAP/LUHS scenarios are the focus of the mitigating strategies and are significant contributors to seismic risk, improvements to mitigating strategies SSCs targeted to address ELAP/LUHS scenarios will be most effective in reducing seismic risk. Where other scenarios are more significant, enhancements to mitigating strategies SSCs will be less effective in reducing seismic risk. However, there may be other plant improvement options that may reduce risk, and these can be identified through the SPRA.

The safety significance of potential plant enhancements is performed on an aggregate basis (i.e., considering the potential enhancement of multiple components at a time) in order to assess the benefit of broad sets of enhancements.

For plants using this approach, it is necessary to determine the technical adequacy of the SPRA. This is established through the conduct of SPRA peer reviews, in accordance with the Screening, Prioritization and Implementation Details (SPID) expectations [Ref. 3], including disposition of peer review findings. Through this process, the impacts of modeling limitations or important sources of model uncertainty are known and can be accounted for in the evaluation. An important consideration is that the SPRA scenarios need to account for long term supply of consumables for mitigating strategies, e.g., replenishment of inventories of water for injection into the reactor coolant system, or of fuel for emergency power supplies. If not already addressed in the SPRA, this longer term impact will need to be accounted for in the MSA. Finally, as previously noted, the SPRA results should reflect the impact of the mitigating strategies SSCs.

Evaluation Process

The evaluation process is focused on delta risk reduction. The objective is to define a set of SSC capacity improvements that provide a sufficient seismic risk reduction to offset the impact of mitigating strategies SSCs for which the current design does not provide $C_{10\%}$ GMRS capacity. The steps are as follows, and the process is illustrated in Figure H.5.

a) Identify the set of mitigating strategies SSCs having a seismic capacity less than the GMRS at $C_{10\%}$.

b) Calculate a “Reference SCDF” and “Reference SLERF” using the SPRA model by assigning a seismic capacity equal to the GMRS at $C_{10\%}$ for all the mitigating strategies SSCs that have a $C_{10\%}$ capacity less than the GMRS; the actual seismic capacities are used for all other SSCs. This Reference value is represented by the lower line in Figure H.5.

c) Calculate the "Delta SCDF" (and "Delta SLERF") as the difference between the Base SPRA SCDF (i.e., with the as-analyzed seismic capacities of mitigating strategies SSCs) and the Reference SCDF (and same for SLERF); this is the risk reduction possible if the mitigating strategies SSCs all met the GMRS at $C_{10\%}$.

d) If the risk reduction from the above step is less than or equal to the small residual SCDF and SLERF values defined in the Background and Discussion section above, no action is needed. Plants for which the delta-SLERF residual goal (i.e., $1x10^{-6}$/yr) is not achievable will need to apply insights from the SPRA to justify acceptability of the results.

e) If the (Base SPRA SCDF – Reference SCDF) delta from the above step is greater than $1x10^{-5}$/yr. (or Base SPRA SLERF – Reference SLERF is greater than $1x10^{-6}$/yr.), identify a set of improvements to either mitigating strategies SSCs or plant SSCs that can be reflected in the Base SPRA to produce a Modified Base SCDF and Modified Base SLERF (represented by the dashed line in Figure H.5).

   - This process can be repeated to the point where the delta risk, i.e., the difference between the Modified Base SCDF and the Reference SCDF, meets the $1x10^{-5}$/yr SCDF criterion noted above. (Similarly, the difference between the Modified Base SLERF and Reference SLERF is compared to the $1x10^{-6}$/yr SLERF criterion.) This may be an iterative process, involving identifying additional plant changes until the desired delta risk is achieved. Note that in this process, the Reference SCDF and Reference SLERF are not adjusted.

   - If the SPRA model contains conservatisms or uncertainties that could be impacting the delta risk such that remaining options to achieve the desired risk reduction are impractical (e.g., would require substantial changes to the design of the plant), sensitivities may be performed to show that the residual risk is acceptable in light of these issues. For example, seismic fragility calculations supporting the SPRA may conservatively assume that failure of a particular structural member fails an entire structure when in reality such a consequence is highly unlikely; or the fragility calculations for the SPRA may assume correlated impacts for certain component types that result in pessimistic Base SPRA results. It is acceptable to perform sensitivity evaluations to show that if it were feasible to fully address such issues, the delta risk results would be small. Note that the in performing such sensitivities, the impact on both the Base SCDF (and therefore the Modified Base SCDF) and Reference SCDF (and Base/Modified Base SLERF and Reference SLERF) should be considered.

f) Make the improvements identified above to achieve the target risk reduction.

g) Document the process and outcome.

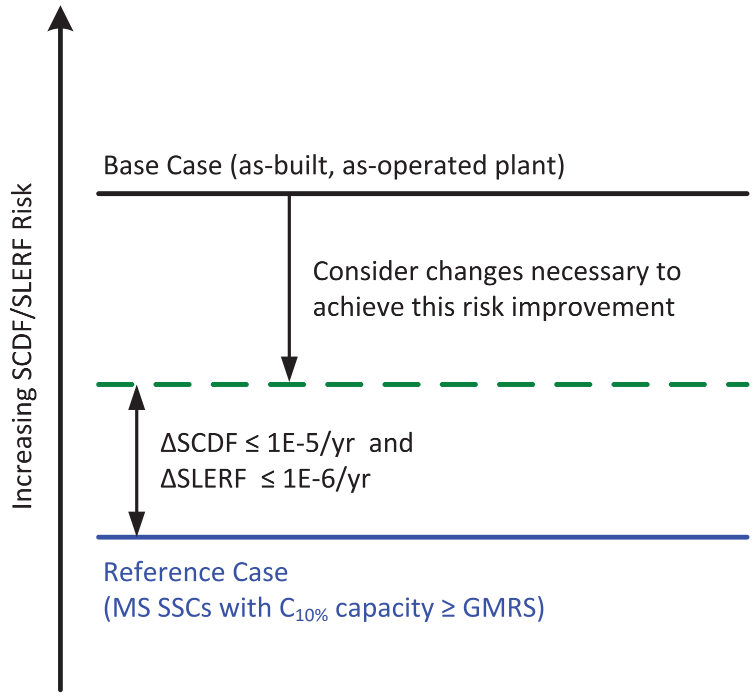


Figure H.5: Illustration of the Application of Risk Insights into the Deterministic Assessment

Once the appropriate set of mitigating strategies or other plant enhancements has been identified, then it is necessary to implement any corresponding modifications in the plant to achieve the calculated risk reduction.

Finally, it is necessary to document the process and outcome. As part of the initial documentation, the bases for accepting the seismic capacities of mitigating strategies SSCs, including those SSCs that may have lower than $C_{10\%}$ capacities should be documented. If a licensee maintains the SPRA, the same process as above can be used and the basis of accepting lower than $C_{10\%}$ capacities, if any, should be documented. However, it is not necessary to maintain the SPRA model used for the MSA as long as the seismic capacity of any mitigating strategies SSCs from Steps 2, 4 and 5 of Section H.4.5.2 is not reduced via replacement and/or plant modification.

H.4.5.5 Delta-Risk Process

Background and Discussion:

As noted earlier, the SPRA results provide detailed plant-specific insights into the seismically-induced scenarios that can impact plant safety. Therefore, these insights can be used to help understand specific susceptibilities to ELAP/LUHS scenarios for which the mitigating strategies are targeted. Thus, plants can directly utilize the results and insights from a peer-reviewed SPRA to identify the degree to which the mitigating strategies are effective for MSSHI or determine if the mitigating strategies need to be enhanced, since the SPRA considers the MSSHI. In this risk-informed approach, the objective is to apply SPRA risk insights to evaluate the need for modifications to the plant SSCs intended to provide mitigation of the ELAP/LUHS scenarios. The SPRA can be used to target the most effective means to enhance plant safety and provides insights to help determine which, if any, modifications to mitigating strategies contribute sufficiently to reducing the risk from ELAP/LUHS scenarios.

The SPRA evaluates the risk from a broader range of seismically-induced challenges than the ELAP/LUHS scenarios relevant to the mitigating strategies SSCs. However, for the MSSHI evaluation pertinent to FLEX, the focus is on ELAP/LUHS scenarios that the mitigating strategies (i.e., FLEX) are intended to address. An entry condition to application of the H.4.5.5 guidance is that the SPRA must have been submitted to NRC for the NTTF 2.1 seismic 50.54(f) information request and reflect a total SCDF $\leq 1x10^{-4}$/yr and total SLERF $\leq 1x10^{-5}$/yr. This total seismic risk evaluation addresses the impacts of earthquake-induced consequential events (e.g., internal flooding), and ensures that the mitigating strategies and plant features are sufficient to limit risk from the spectrum of seismic impacts to an acceptable level. If the SCDF is greater than $1x10^{-4}$/yr. (or SLERF is greater than $1x10^{-5}$/yr.), a justification for proceeding with the MSA using the results of the SPRA must be submitted to and approved by NRC.

The process defined here is similar in some aspects to the approach to applying risk insights to mitigating strategies SSCs that do not meet the $C_{10\%}$ criterion as described in Section H.4.5.4. The primary difference is that this process is focused on the safety benefit in terms of delta SCDF and delta SLERF considering all sequences in which MS SSCs contribute. The similarities are that both credit the defense-in-depth attributes of the plant design, including redundancy, diversity, and radiological release barriers; in both, defense in depth and diversity are addressed implicitly in the SPRA by considering the capacities of the relevant redundant systems and features that protect the reactor; and in both barrier redundancy is addressed by consideration of both the core damage and the large early release insights. Further, both judge the significance of safety enhancements based on delta risk metrics, looking at the safety benefit of various potential sets of enhancements, and both use the same small delta risk metrics. The same goals for small delta risk are used here as in Section H.4.5.4, and the same bases apply.

In this evaluation, if it can be shown that the goals for seismic core damage frequency reduction (ELAP/LUHS delta SCDF) and seismic large early release frequency reduction (ELAP/LUHS delta SLERF) are met, no further action is needed. If not, then further evaluation of ELAP/LUHS mitigation capability is performed. The process provides options for reduction in SLERF which should be evaluated to addresses the seismic defense-in-depth for containment.

Some plant-specific SPRAs may include credit for FLEX equipment utilized in mitigating strategies as part of their base SPRA. However, this process is not dependent on whether or not FLEX has been included in the SPRA.

Where ELAP/LUHS scenarios are large contributors to seismic risk, mitigating strategies that are targeted to address ELAP/LUHS scenarios will be more effective in risk reduction. Where other scenarios are more significant, enhancements to mitigating strategies SSCs will be less effective in reducing seismic risk.

For plants using the SPRA, it is necessary to demonstrate the technical adequacy of the SPRA. This is established through the conduct of SPRA peer reviews, in accordance with the SPID [Ref, 3] expectations, including resolution of peer review findings pertinent to the ELAP/LUHS modeling and results. Through this process, the impacts of modeling limitations or important sources of model uncertainty are known and can be accounted for in the evaluation. An important consideration is that the SPRA scenarios need to account for long term supply of consumables for mitigating strategies, e.g., replenishment of inventories of water for injection into the reactor coolant system, or of fuel for emergency power supplies. This long term impact will need to be accounted for in the MSA, if not already addressed in the SPRA.

In this approach, the SPRA model identifies success paths for installed equipment such that it can be relied upon during the ELAP/LUHS as demonstrated by the reduction in ELAP/LUHS risk achievable with the mitigating strategies. Plants for which the ELAP/LUHS risk is sufficiently low will have demonstrated that the plant is capable of addressing the MSSHI. Plants that are not able to initially demonstrate that the potential for further ELAP/LUHS risk reduction is low will need to enhance their mitigation capability to achieve a sufficient reduction in risk.

Process:

A sequential process is used to determine the safety benefit of increasing the capacity of ELAP/LUHS SSCs to respond to the MSSHI and demonstrate that the likelihood of maintaining key safety functions is high.

The process is illustrated in Figure H.6. Within this process, the ELAP/LUHS results of the baseline SPRA are referred to as the ELAP/LUHS base case for SCDF and SLERF. Note that Figure H.6 illustrates the same process as Figure H.5 except that the focus here is on ELAP/LUHS only.

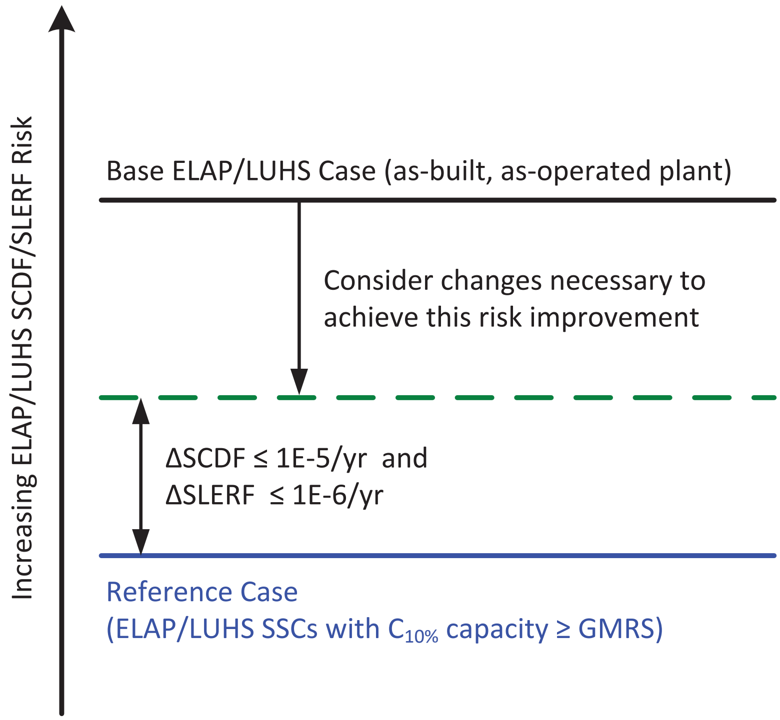


Figure H.6: Delta-Risk Process Illustration

The ELAP/LUHS Base Case (as-built, as-operated plant) risk (SCDF and SLERF) is compared to a hypothetical ELAP/LUHS Reference SCDF (and ELAP/LUHS Reference SLERF) case. There are two approaches to determining the ELAP/LUHS Reference case, depending on the SPRA model.

- Where the plant SPRA model includes FLEX, the ELAP/LUHS Reference case assumes that the seismic $C_{10\%}$ capacities of the mitigating strategies SSCs can be made at least equal to the GMRS. That is, the fragilities used in the SPRA are adjusted to be based on a seismic $C_{10\%}$ capacity equal to the GMRS for the mitigating strategies SSCs for which the capacity is not already greater than or equal to the GMRS.
- Where the plant SPRA model does not include FLEX, the ELAP/LUHS Reference case assumes that the seismic $C_{10\%}$ capacities of SSCs that are contributors to ELAP/LUHS SCDF or SLERF scenarios can be made at least equal to the GMRS. That is, the fragilities used in the SPRA are adjusted to be based on a seismic $C_{10\%}$ capacity equal to the GMRS for the SSCs that are significant contributors to ELAP/LUHS SCDF or SLERF and for which the capacities are not already greater than or equal to the GMRS.

The ELAP/LUHS reference case is represented by the bottom line in Figure H.6. The same goals for small delta risk are used here as in Section H.4.5.4, and the same bases apply. The Reference values used in the delta-risk evaluations reflect a set of changes from the Base values that would result if the set of changes listed above were to be made, and these changes are associated with the ELAP/LUHS contributors. Thus, the reduction from the Base value will be the same regardless of where the Base value is set as long as the SSCs that mitigate ELAP/LUHS sequences are not also important to mitigation of non-ELAP/LUHS sequences. As long as this is the case, the reduction from the Base value will be the same regardless of where the Base value is set. Therefore, it is important to check that the delta risk evaluation is not affected significantly due to important impacts on the Reference case from non-ELAP/LUHS sequences involving the same mitigating equipment.

The process is as follows:

1. Identify the ELAP/LUHS sequences modeled in the SPRA.
2. Identify the set of mitigating SSCs that appear in these sequences, along with the subset of mitigating SSCs for which seismic capacity does not meet or exceed the GMRS at $C_{10\%}$.
3. Review this list of SSCs to identify any that also contribute to mitigation of non-ELAP/non-LUHS sequences.
4. Include the additional sequences to which these SSCs contribute in the set of sequences covered by the BASE case and the Reference case.
5. Calculate the Reference SCDF/SLERF using fragility values corresponding to seismic capacity ≥ GMRS $C_{10\%}$ for the set of SSCs identified in step 2, and re-solving the expanded set of sequences defined in step 4.
6. Calculate the delta SCDF/SLERF (Base case – Reference case).

The ELAP/LUHS base case in Figure H.6 represents the risk (SCDF or SLERF) from the expanded set of sequences, i.e., the ELAP/LUHS sequences and sequences in which the ELAP/LUHS SSCs contribute to mitigation, resulting from the SPRA based on the as-built, as-operated plant, including the as-designed and installed capacities for FLEX equipment if it is included in the SPRA.

The difference in SCDF or SLERF between the expanded ELAP/LUHS sequence Base SPRA case and the expanded ELAP/LUHS sequence Reference case is the risk reduction (ELAP/LUHS delta risk) of interest. If the expanded ELAP/LUHS sequence delta risk without any additional changes is small, then no further improvements need to be considered, because the small delta risk demonstrates that the mitigating strategies are capable of addressing the MSSHI.

If the expanded ELAP/LUHS sequence delta risk (SCDF or SLERF) is not sufficiently small, then enhancements to either the SPRA modeling or capability of modeled equipment need to be considered. If enhancements to the SPRA modeling are made, both the expanded ELAP/LUHS sequence Base case and the expanded ELAP/LUHS sequence Reference case results need to be recalculated. Enhancements to the capability of the significant contributors to these SCDF or SLERF scenarios will result in a new, Modified Base case, represented by the dashed line in Figure H.6, such that the upper line in the figure moves toward the lower expanded ELAP/LUHS sequence reference line. This evaluation may be iterative, with each iteration involving selection of additional plant changes (e.g., additional equipment for which $C_{10\%}$ capacity ≥ GMRS would need to be demonstrated, or procedure enhancements), and checking to see whether the Modified Base case is sufficiently close to the Reference case so that the remaining risk reduction potential is small. In this process, it is possible that the delta risk may be demonstrated to be small by improving the capacities of a number of SSCs (not limited to ELAP/LUHS) to a level less than GMRS at $C_{10\%}$, or through some combination of SSC and procedural improvements. This is an acceptable approach within this process.

Within the expanded ELAP/LUHS sequence delta SCDF and delta SLERF process defined here, risk reduction options include but are not limited to:

- including credit for FLEX capabilities in the SPRA if not already included,
- evaluating enhancements to the seismic capacity of some modeled mitigating strategies SSCs to increase their $C_{10\%}$ capacity to ≥ GMRS,
- demonstrating $C_{10\%}$ capacity ≥ GMRS for specific aspects of FLEX equipment/capabilities that contribute significantly to reducing ELAP/LUHS risk, or
- evaluating enhancements to other plant SSCs or procedures to achieve the desired small delta risk.

The evaluation is complete when making additional changes beyond the selected set would not significantly improve protection (would not provide a significant further ELAP/LUHS risk reduction). In this case, where the delta risk is low, there is high likelihood that key safety functions are maintained for ELAP/LUHS. FLEX adds defense-in-depth and safety margin, but the existing plant design provides the high likelihood of maintaining safety functions.

If the small risk targets are not met at the point where remaining options to reduce the expanded ELAP/LUHS sequence delta SCDF and expanded ELAP/LUHS sequence delta SLERF are impractical (e.g., would require substantial changes to the design of the plant), it is necessary to provide an alternate justification for the selected improvements. This may include performing additional sensitivity studies, documenting conservatism and uncertainties in methods, evaluating whether there are SSCs that are not credited in the SPRA that, if credited, would mitigate functional failures, etc. The examples provided in Section H.4.5.4 apply here as well. It is acceptable to perform sensitivity evaluations to show that if it were feasible to fully address such issues, the delta risk results would be small. Note that the in performing such sensitivities, the impact on both the Base SCDF and Reference SCDF (and Base SLERF and Reference SLERF) should be considered.

Note: In performing the delta risk calculation, care should be taken to avoid understating the delta risk. To avoid understatement of delta risks, the same models and assumptions must be used in the Base case and the Reference case. The comparison to $C_{10\%}$ seismic capacities versus computed capacities ensures that the input changes driving the delta risk calculation are comparable. No other changes to the models and assumptions should be required.

Once the appropriate set of mitigating strategies or other plant enhancements has been identified, then it is necessary to implement any corresponding modifications in the plant to achieve the calculated risk reduction. Any such modifications, including the bases for any credit for FLEX as part of the MSSHI capability, would become part of the mitigating strategies.

Finally, it is necessary to document the process. As part of the initial documentation, the bases for accepting the seismic capacities of mitigating strategies SSCs, including those SSCs that may have lower than $C_{10\%}$ capacities should be documented. If a licensee maintains the SPRA, the same process as above can be used and the basis of accepting lower than $C_{10\%}$ capacities, if any, should be documented. However, it is not necessary to maintain the SPRA model used for the MSA as long as the seismic capacity of any mitigating strategies SSCs is not reduced via replacement and/or plant modification.

H.4.5.6 Additional Considerations

Spent Fuel Pool Cooling

Licensees following this path need to ensure the SFP cooling mitigating strategies are maintained. Licensees will ensure that SFP makeup capability needed to accomplish the SFP cooling strategies is evaluated for seismic adequacy for the MSSHI. A high frequency evaluation of the SFP cooling function is not warranted since operators would have a significant amount of time to restore SFP cooling, as documented in the mitigating strategies.

H.5 SEISMIC EVALUATION CRITERIA ($C_{10\%}$)

The definition for robustness for SSCs relied upon in the FLEX strategies consists of demonstrating that these SSCs have adequate capacity to withstand the GMRS level of seismic hazard at the site. The FLEX strategies serve as a defense in depth to the existing safety systems and, as such, a 90% probability of success criteria is judged sufficient to verify adequate capacity for this beyond seismic design basis review. Precedence for establishing this 90% probability of success criteria exists within a national standard for nuclear SSCs and within a seismic guideline for commercial structures as described below.

The use of a 90% probability of success is equivalent to a 10% probability of unacceptable performance. This use of the 10% probability of unacceptable performance has been used in the past as a criteria for demonstrating seismic adequacy for beyond design basis seismic performance reviews in standards such as ASCE 43-05 [Ref.19] and in commercial criteria such as ATC-63 [Ref. 20].

ASCE/SEI 43-05 [Ref.19] defines a 10% probability of unacceptable performance ($C_{10\%}$) which is reviewed against the beyond design-basis seismic event (150% of the DBE ground motion for the ASCE/SEI 43-05 case). ASCE 43-05 takes advantage of known seismic margin in the seismic designs (e.g. ductility, negligible effects of small displacements, conservative damping, etc.) to justify that the overall risks of unacceptable performance are acceptably low when using the $C_{10\%}$ evaluation criteria.

This same 10% probability of unacceptable performance was used in a recent Applied Technology Council (ATC) project, ATC-63 [Ref. 20], which defined the acceptable low probability of collapse levels for structural evaluations to be the $C_{10\%}$ value. The ATC-63 project stated "*acceptably low probability of collapse is interpreted to be less than a 10% probability of collapse under the [maximum credible earthquake] MCE ground motions*" as shown in Structural Engineers Association of California (SEAOC) 2007 Convention Proceedings [Ref.19]. The MCE is the equivalent of the beyond design-basis seismic event for normal building code applications such as the ATC-63 [Ref. 20]. The existing plant safety systems provide the primary seismic response strategy for the plant and the FLEX strategies perform a defense-in-depth role in the case of an extreme seismic event. The demonstration of seismic adequacy to the $C_{10\%}$ performance criteria for the FLEX strategies represents additional plant seismic safety and is judged to be an adequate performance level of seismic ruggedness.

Performance Target for Mitigating Strategy

As stated above, the FLEX strategies represent a defense-in-depth for the normal plant safety systems in the event of a beyond design basis seismic event. The associated performance target for the FLEX strategies should not be set at the same level as that of the primary safety systems, which have generally been aligned with a 1E-5 performance target. In order to investigate the impact of the use of the $C_{10\%}$ capacity criteria described above for FLEX strategies, a fleet risk assessment was conducted. To perform this assessment, point estimates of the Annual Frequency of Unacceptable Performance (AFUP) were developed using an approach similar to that developed by the NRC to address the plant seismic risk associated with the new seismic hazards developed in 2010 as part of the GI 199 program [Ref. 22]. The FLEX strategies AFUP estimates were developed based on:

- the most recent seismic hazards for the US nuclear plants submitted to the NRC,
- an assumption that the plant level $C_{10\%}$ capacity can be estimated to be equivalent to the minimum SSC $C_{10\%}$ capacity (by definition each SSC $C_{10\%}$ capacity will be greater than or equal to the GMRS),
- a plant fragility function using this $C_{10\%}$ capacity and a generic Beta value using the Hybrid fragility approach, and
- a convolution of the seismic hazard with the plant level fragility to calculate an estimated AFUP.

In order to ensure that the full range of potential AFUP values is reviewed, the following sensitivity studies were conducted:

- Composited Beta (β_C) values were varied between 0.35 and 0.45 in conformance to the values documented in the EPRI SPID
- The AFUP were computed seismic hazard estimates from six different structural frequencies (1, 2.5, 5, 10, 25 and 100 Hz)

The results from these risk studies are plotted in Figure H.7. Each curve represents the cumulative AFUP distribution for all US plants using one of the sensitivity parameters (β_C and structural frequency). In all cases, the highest results are lower than 5E-5 AFUP. Given these moderate AFUP estimates, the $C_{10\%}$ capacity is judged to be an acceptable seismic performance goal for demonstrating robustness for the FLEX strategies. The defense-in-depth provided by the FLEX strategies reduces the existing seismic risk associated with the plant normal safety systems.

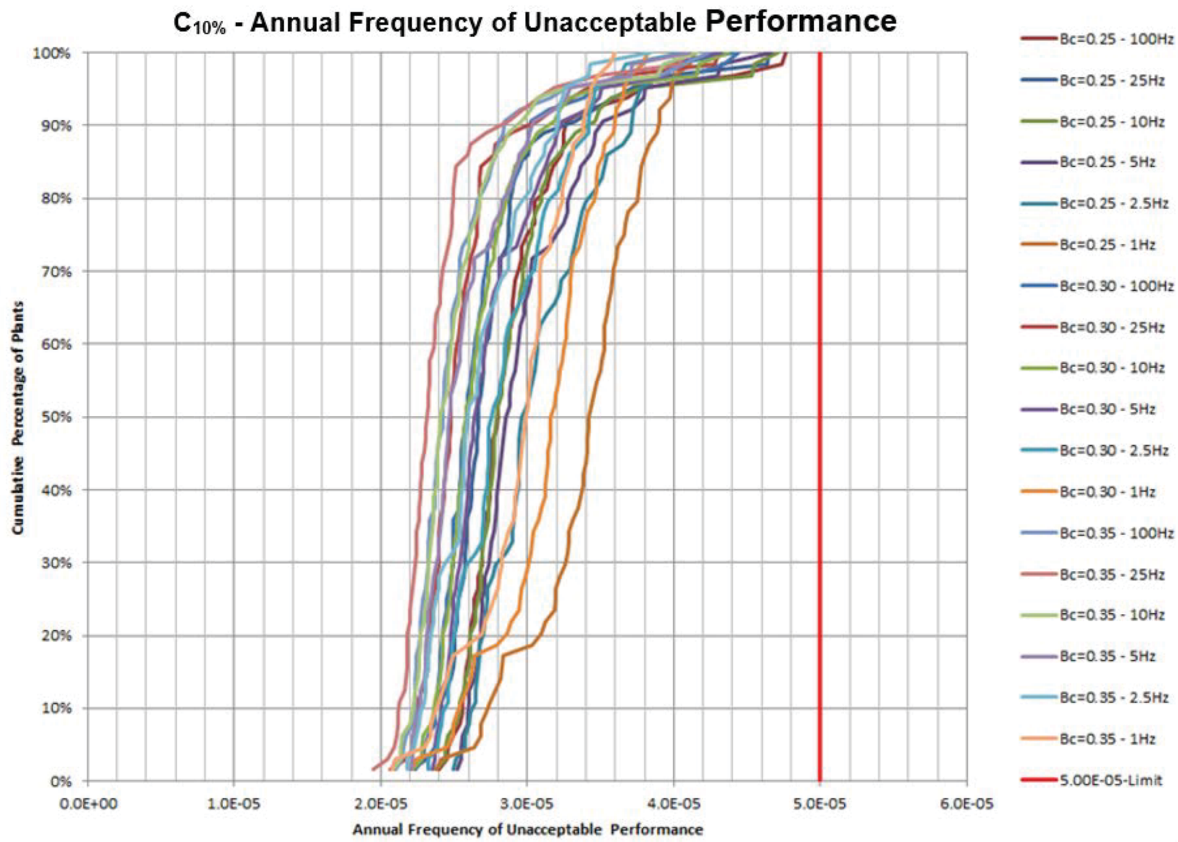


Figure H.7: US Nuclear Plant Fleet Mitigating Strategy Risk Cumulative Distribution

Discussion on $C_{10\%}$ calculations

The process for calculating the $C_{10\%}$ values are defined in this section. Table H.1 provides recommended values for β_C, β_R, β_U, and the ratio of the median capacity $C_{50\%}$ to the $C_{1\%}$[23] capacity taken from EPRI 1025287 [6]. The recommended β_C values are based on Dr. Robert Kennedy's recommendations [Ref. 23] and on average are biased slightly conservative (i.e., slightly low β_C on average). Because random variability β_R is primarily due to ground motion variability, a constant β_R value of 0.24 is recommended regardless of the SSC being considered. In addition to the values provided in EPRI 1025287, values are also included associated with a β_C of 0.3. This lower bound β_C value could represent the variability associated with failure modes with the least difference between the median and HCLPF values. Past fragility and HCLPF assessments have shown that some brittle failure modes and some block wall failure modes could have values that might approach this 0.3 β_C level. The recommended uncertainty β_U values are estimated from the recommended composite β_C and β_R values. The β values for Table H.1 apply to fragilities tied to ground motion parameters (e.g., PGA or Peak Spectral Acceleration at 5 Hz). The ratios of the 10% failure probability capacity ($C_{10\%}$ to the $C_{1\%}$ capacity) were calculated and are shown in the last column of Table H.1. The methodology for demonstrating the

[23] The $C_{1\%}$ capacity is a mean confidence of a 1% probability of failure. This value is equivalent to a HCLPF, which is a high confidence (95%) of a low probability (5%) of failure. For evaluations performed in accordance with this criteria, the HCLPF value is used as the $C_{1\%}$ value.

adequate seismic ruggedness for the FLEX strategies would follow the approach for an SMA in accordance with EPRI NP-6041 SL Rev. 1 [Ref. 13]. In the case of an SMA, the demand for the assessment is referred to as the Review Level Earthquake (RLE). The following steps would be used for SSCs relied upon in the FLEX strategies for the $C_{10\%}$ review:

- The GMRS will be the RLE for the reevaluated seismic hazard review of the FLEX strategies

- The seismic capacity for demonstrating robustness will be the $C_{10\%}$ value. The $C_{10\%}$ can be calculated by:
    - Calculate the $C_{1\%}$ capacity using the methods documented in past SPRA and seismic margin documentation and as summarized in EPRI 1025287 [3].
    - Multiply the $C_{1\%}$ capacity by the $C_{10\%}/C_{1\%}$ ratio from Table 1 based on the type of SSC being evaluated

- Verify that the $C_{10\%}$ capacity exceeds the RLE demand

Table H.1: Recommended β_C, β_R, β_U, and $C_{50\%}/C_{1\%}$ Values to Use in Hybrid Method for Various Types of SSCs[24]

Type SSC	Composite β_C	Random β_R	Uncertainty β_U	$C_{50\%}/C_{1\%}$	$C_{10\%}/C_{1\%}$
Structures & Major Passive Mechanical Components Mounted on Ground or at Low Elevation Within Structures	0.35	0.24	0.26	2.26	1.44
Active Components Mounted at High Elevation in Structures	0.45	0.24	0.38	2.85	1.60
Realistic Lower Bound Case[25]	0.30	0.24	0.18	2.00	1.36
Other SSCs	0.40	0.24	0.32	2.54	1.52

In addition, a sensitivity study was conducted to assess an even lower composite uncertainty case, with a β_C of 0.25. For this sensitivity study case, the $\mathbf{C_{50\%}}/C_{1\%}$ ratio equates to a 1.22 value. The purpose of this sensitivity study was to verify that the conclusions associates with achieving a 5E-5 AFUP were not sensitive to the lower bound β_C value of 0.3. As shown in Figure H.7 the AFUP for the β_C of 0.25 case is still lower than 5E-5 per year.

[24] Table H.1 defines generically the type of SSCs to which the β values specified in the table are applicable. While the use of generic β values is appropriate for this application, the approaches appropriate for the development of β values in an SPRA under NTTF Recommendation 2.1 are documented in EPRI 1025287 [Ref. 3].
[25] These lower bound values can be used for relays, block walls, and SSCs with brittle failure modes if more realistic beta values cannot be estimated.

H.6 DOCUMENTATION

Document the characterization of the MSSHI for the site.

Document whether the GMRS is bounded or not bounded by the SSE and describe the nature of any element not bounded.

Document the results of the process in Section H.4 and the basis for selecting the mitigating strategy.

6.1 Path 1: Document the evaluation that demonstrates existing FLEX strategies are acceptable without modification for the MSSHI Path 1.

- Document that the FLEX strategies can be implemented for the MSSHI
- Description of comparison of GMRS to SSE

6.2 Paths 2 and 4: Document the evaluation that demonstrates that FLEX strategies or FLEX strategies with modifications, address the effects of the MSSHI on mitigation strategies. The following items should be included:

- Description of comparison of GMRS to SSE
- Identification of any MSSHI impacts to the FLEX strategies
- A revised sequence of events demonstrating the necessity of revised FLEX actions, as appropriate
- Description and justification of any resulting modifications (equipment, procedures, etc.) to address the revised FLEX actions, as appropriate
- Description of approach, implementation and results to address additional considerations for Path 4 (e.g. high frequency, spent fuel cooling)
- Validation documents in accordance with Appendix E, as appropriate

6.3 Path 3: Document the evaluation that concludes that the selected strategy will address the effects of the MSSHI. The following items should be included:

- Description of comparison of GMRS to IHS
- Description of plant-specific IPEEE and adequacy from March 2014 submittal
- Description of and need for the AMS and how it provides evaluation of paths to plant safety
- Description of approach, implementation and results to address items (including any modifications) outside scope of IPEEE (e.g. spent fuel pool cooling)
- Description of any limitations and how they were accommodated

- Description of evaluation of IPEEE to full scope
- Description of availability of FLEX equipment
- Validation documents in accordance with Appendix E, as appropriate

6.4 Path 5 (H.4.5.2 and H.4.5.4): Document the evaluation that demonstrates that FLEX strategies or FLEX strategies with modifications, address the effects of the MSSHI on mitigation strategies. The following items should be included:

- Description of comparison of GMRS to SSE
- Identification of the MSSHI impacts to the FLEX strategies, as appropriate
- A revised sequence of events demonstrating the necessity of revised FLEX actions, as appropriate
- Description and justification of any resulting modifications (equipment, procedures, etc.) to address the revised FLEX actions, as appropriate
- Discussion of the bases for accepting the seismic capacities of mitigating strategies SSCs, including those SSCs that may have lower than $C_{10\%}$ capacities should be documented.
- Description of approach, implementation and results to address additional considerations (e.g. high frequency, spent fuel cooling)
- Validation documents in accordance with Appendix E, as appropriate

6.5 Path 5 (H.4.5.3 and H.4.5.5): Document the evaluation that concludes that the selected strategy will address the effects of the MSSHI on mitigation strategies. The following items should be included:

- Description of comparison of GMRS to SSE
- Description of the mitigating strategies approach selected (i.e. H.4.5.3 or H.4.5.5) and how it demonstrates reasonable protection to the MSSHI
    - Discussion of the bases for accepting the seismic capacities of mitigating strategies SSCs, including those SSCs that may have lower than $C_{10\%}$ capacities.
- Description of approach, implementation and results to address spent fuel pool cooling
- Description of any limitations and how they were accommodated
- Validation documents in accordance with Appendix E, as appropriate

The documentation identified above should be included in and be of the same level of detail as that included in the Program Document.

H.7 REFERENCES

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H.8 ACRONYM/TERM LIST

AC	Alternating Current
ADS	Automatic Depressurization System
AFUP	Annual Frequency of Unacceptable Performance
AFW	Auxiliary Feedwater
AMS	Alternate Mitigating Strategy
ASCE	American Society of Civil Engineers
ATC	Applied Technology Council
BWRs	Boiling Water Reactors
β	Logarithmic Standard Deviation in the Seismic Fragility
β_C	Composite Logarithmic Standard Deviation in the Seismic Fragility
β_R	Logarithmic Standard Deviation Representing the Aleatory (Randomness) Uncertainties in the Seismic Fragility
β_U	Logarithmic Standard Deviation Representing the Epistemic Uncertainties in the Seismic Fragility
$C_{X\%}$	The x^{th}-Percentile Conditional Probability of Unacceptable Performance
CP	Construction Permit
CDF	Core Damage Frequency
CRDMs	Control Rod Drive Mechanisms
DB	Design-Basis
DBE	Design Basis Earthquake
DC	Direct Current
EDG	Emergency Diesel Generator
ELAP	Extended Loss of AC Power

EPRI	Electric Power Research Institute
ESEP	Expedited Seismic Evaluation Process
FLEX	Diverse and Flexible Coping Strategies
GL	Generic Letter
GMRS	Ground Motion Response Spectrum
HCLPF	High Confidence of Low Probability of Failure
HF	High Frequency
IHS	IPEEE HCLPF Spectra
IPEEE	Individual Plant Examination of External Events
ISRS	In-Structure Response Spectrum
LERF	Large Early Release Frequency
LLNL	Lawrence Livermore National Laboratory
LUHS	Loss of Normal Access to the Ultimate Heat Sink
MBDBE	Mitigation of Beyond Design-Basis Events
MCE	Maximum Credible Earthquake
MS	Mitigating Strategies
MSA	Mitigating Strategies Assessment
MSSHI	Mitigating Strategies Seismic Hazard Information
NEA	Nuclear Energy Agency
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NTTF	Near-Term Task Force

OECD	Organization for the Economic Co-operation and Development
OIP	Overall Integrated Plan
PGA	Peak Ground Acceleration
PORVs	Power-Operated Relief Valves
PSHA	Probabilistic Seismic Hazard Analysis
RCIC	Reactor Core Isolation Cooling
RCPs	Reactor Coolant Pumps
RCS	Reactor Coolant System
RLE	Review Level Earthquake
RLGM	Review Level Ground Motion
RPV	Reactor Pressure Vessel
SCDF	Seismic Core Damage Frequency
SEAOC	Structural Engineers Association of California
SERs	Staff Evaluation Reports
SFP	Spent Fuel Pool
SLERF	Seismic Large Early Release Frequency
SMA	Seismic Margin Assessment
SPRA	Seismic Probabilistic Risk Assessment
SSCs	Structures, Systems and Components
SSE	Safe Shutdown Earthquake (synonymous with the term "Design Basis Earthquake" or DBE used by some plants)
SMA	Seismic Margin Assessment
SEL	Seismic Equipment List
UHRS	Uniform Hazard Response Spectra