Qualitative Assessment for Crediting Mitigating Strategies Equipment in Risk-Informed Decision Making

Developed by the NEI FLEX in Risk Informed Decision Making (FRIDM) Task Force

1. PURPOSE

The purpose of this guidance document is to establish the considerations that should be assessed when evaluating the qualitative risk and safety benefit of Mitigating Strategies Equipment in Risk Informed Decision Making (RIDM). The licensee should determine that the use of a qualitative risk assessment is acceptable for the specific RIDM process being evaluated (e.g. Shutdown Risk Assessment, Online Risk Management, Significance Determination Process (SDP), and Notice of Enforcement Discretion (NOED)). This guidance uses FLEX as an example case, however equipment of other mitigating strategies is applicable. This guidance identifies the key elements of a qualitative assessment of the benefits of mitigating strategies and the associated equipment. These strategies and equipment can be used to enhance and/or develop qualitative considerations for use in the risk-informed decision making process. This qualitative risk assessment can supplement or be used in lieu of quantitative risk assessment if applicable.

2. APPLICABILITY OF GUIDANCE

This guidance provides a suitable approach in crediting the use of equipment associated with various plant's mitigating strategies in risk informed decision making. The focus of this guidance is around FLEX and provides examples based on those strategies; however, the approaches can be applicable to similar equipment procured by the plant independent of the strategies they were originally designed to support. In general, mitigating strategies are supported by various types of equipment and the applicability of this guidance varies with their primary function, location, and normal configuration. Equipment used to support mitigating strategies may include the following:

- **Permanently Installed Plant Equipment** – Equipment permanently installed in the plant with a primary function associated with traditional plant operations outside of their role in the mitigating strategies. This guidance document is not directly applicable to this type of equipment.

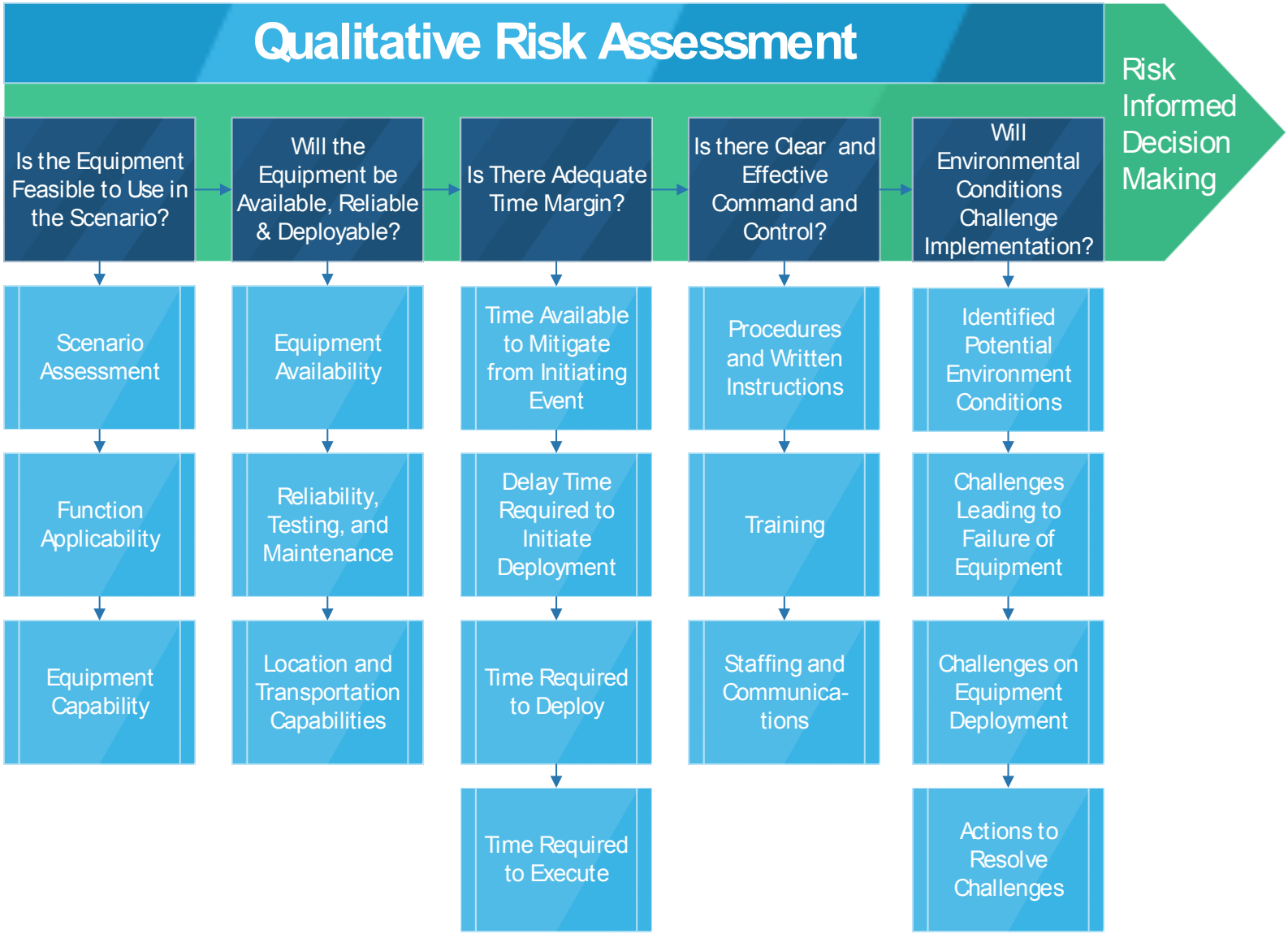
- **On-site Portable Equipment** – Equipment on or near the owner controlled area which may need to be mobilized and hooked up to plant systems where their primary functions are to support the mitigating strategies or other safety functions. This guidance document is directly applicable and focused on this type of equipment.

- **Permanently Staged Equipment** – Equipment that is permanently staged to reduce installation time, but its primary function is to support mitigating strategies or other safety functions. The licensee should determine if the nature of the specific equipment

being addressed is closer to permanently installed plant equipment or the portable equipment. If the determination is that the equipment is closer to portable equipment, then the considerations in this guidance are applicable.

- **Off-site Portable Equipment** – Equipment almost identical to the on-site portable equipment but housed remotely at locations such as national response centers or other plant sites. This guidance is directly applicable to this type of equipment but it is recognized that crediting this equipment is likely to only be applicable in scenarios with much longer mission times and may not be readily creditable in most qualitative assessments.

3. CONSIDERATIONS TO BE ASSESSED



4. BACKGROUND FOR FLEX

Under the NRC order EA-12-049, plants have implemented or have planned to implement a series of strategies called FLEX with a goal of establishing an indefinite coping capability to prevent core damage, ensure containment function is not jeopardized and spent fuel pool cooling is retained for events which cause an extended loss of emergency power to the site and a simultaneous loss of the ultimate heat sink (reference EA 12-049). These mitigating strategies utilize on-site permanent equipment, pre or permanently staged equipment, and portable equipment. The strategies provide defense in depth to the offsite and on-site emergency electrical power systems including the safety related on-site diesel generators and SBO generators. Therefore, during events which cause an extended loss of power to the stations emergency bus (assuming no additional failures or events, e.g. LOCA), the strategies can be implemented to prevent core damage. The limitation of the strategies are that the event itself cannot cause the failure of key components in the plant (i.e. station batteries, turbine or diesel driven makeup pumps) for which the mitigating strategies relies upon.

The industry guidance document for the implementation of FLEX is NEI 12-06. Individual site documents which implemented the strategies should be used as a reference for the qualitative assessment. NEI 12-06 focused on developing strategies based on an extended loss of ac power (ELAP) and a loss of normal access to the ultimate heat sink (LUHS) caused by a beyond-design-basis external event (BDBEE). An ELAP assumes a loss of off-site power, emergency diesel generators and any alternate ac source but not the loss of ac power to buses fed by station batteries through inverters. However, it is recognized that plants can use the equipment and similar strategies can be used to increase defense-in-depth for other plant events and conditions. NEI 12-06 identified the following elements in the FLEX concept:

- **Portable 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 portable 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 portable equipment from BDBEEs applicable to a site**. The equipment used for FLEX would be staged and 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, where N is the number of units on site.

- **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

5. INITIAL FEASIBILITY ASSESSMENT

The initial step is to perform an overall feasibility assessment to determine if a detailed evaluation is warranted. This feasibility assessment performs a high level evaluation of the specific scenarios that credit mitigating strategies equipment, whether the equipment can be used to mitigate a loss of function given the conditions of the scenario, and whether the specific equipment has the capability to perform the function. The considerations in this section are not intended to be all-inclusive.

5.1 Scenario Assessment

The first step in a feasibility assessment is to identify the accident scenarios the equipment can be used for (e.g. station blackout, loss of heat sink, loss of inventory). The intent of the scenario assessment is to determine whether the use of the equipment is feasible for the given scenario. This determination should include the following:

- Whether the overall timeline of the scenario supports the deployment and installation of the equipment to meet the success criteria
- Identify all equipment needed to meet the success criteria of the scenario
- Whether operators would know to use the equipment for the given scenario
- Whether there are written instructions that would drive the use and ensure the effective implementation of the equipment
- Whether the process of deploying and installing the equipment has been demonstrated and/or validated

5.2 Function Applicability

Determine which functions are desired to be credited in the qualitative assessment. For example, scenarios with the following functions may be mitigated using FLEX equipment:

- Restoration/maintenance of dc or vital ac systems to restore instrumentation and dc functions
- Restoration/maintenance of core cooling
- Restoration of RCS inventory and reactivity control

- Maintenance of containment function

- Restoration of Spent Fuel Pool cooling

For scenarios associated with mitigation of the above functions, the qualitative assessment can reference details of the FLEX program appropriately to credit the mitigating strategy equipment in RIDM. Other functions may need further evaluation to determine if use is appropriate.

5.3 Equipment Capability Evaluation

Once the equipment is determined to be able to support the function, the capabilities of that equipment should be evaluated against the success criteria of the scenario. This first step includes an evaluation of the equipment and system interaction needed to support mitigation:

- Evaluate the conditions of the system being supported to determine whether they are within the capabilities of the equipment being used.
    - Are the conditions within the design capabilities of any support components such as hoses, piping, or valve connections?
    - If conditions are outside of design parameters, is there any evidence to support the use for these conditions?

- Determine and evaluate the connection points and routing paths to connect the equipment into the system being supported.

- Evaluate system considerations (e.g. valve alignments, backpressure)

- Evaluate the suction sources (e.g. tank levels/capacity, water quality, need for strainers)

- Evaluate the level of instrumentation and control needed to ensure the functionality of the equipment.

The next step is to determine if the equipment has the capability to meet the success criteria of the scenario. To do this, an understanding of the specific equipment that has been procured and its relevant performance specifications is needed. The following is a list of considerations:

- Pump performance and capability (e.g. flow/pressure)

- Flow path capability and compatibility (e.g. hose/pipe capacity and rating, adequate lengths, connections, valves, environmental rating)

- Generator performance capability (e.g. voltage)
- Generator cable capability (e.g. rating, adequate lengths, connections, grounding, environmental rating)
- Electrical breaker capability
- Air compressor performance capability
- Equipment fuel and re-fueling capability

Plants developed the FLEX equipment and documented performance capability in accordance with NEI 12-06 Sections 11-2 and 11-3. For this qualitative assessment, the specific capability should be documented or referenced from the site's program documents. Other equipment may need further evaluation to determine if use is appropriate.

6. AVAILABILITY AND RELIABILITY OF EQUIPMENT

The availability and reliability of equipment should be considered to determine if credit can be taken for the scenario being evaluated in the applicable RIDM process. In addition, capability to deploy the equipment should be accounted for as a part of the qualitative assessment.

6.1 Equipment Availability

The qualitative discussion should consider the availability of the equipment for the function and scenario needed. Competing functions should be considered. As an example, the use of a piece of equipment for one function may preclude its use for another function.

NEI 12-06 requires that FLEX equipment be administratively tracked when unavailable, and compensatory measures should be taken for equipment unavailability that does not meet certain requirements (NEI 12-06 Section 11.5). As an example, the program requires that the site have N+1 sets of equipment, where N is the number of units on site. If the additional (+1) set is unavailable for 90 days, the equipment must be returned to service or other compensatory actions are required. The qualitative assessment can credit the existing controls, or, if necessary, additional controls can be established if appropriate for the needed function. Equipment pre-staging can be used to ensure availability.

The installed FLEX connections provide a level of flexibility and diversity by requiring that each function have a primary connection/capability and an alternate connection/capability (reference NEI 12-06). The qualitative assessment can include this diversity as appropriate when discussing the additional defense in depth being provided by the FLEX equipment. The qualitative assessment should demonstrate that equipment and connections are available when needed. The existing requirements of the FLEX program should be referenced for FLEX equipment being credited. Other equipment and connections may need further evaluation to determine an acceptable level of availability.

6.2 Reliability, Testing and Maintenance

A discussion of the relevant reliability information of the equipment should be evaluated and discussed in the qualitative assessment. The following should be evaluated for relevant information or it should be determined if additional/supplemental performance testing is warranted:

- Manufacturer testing and reliability information
- Generic industry information and operating experience

- Plant specific operating experience and/or testing and maintenance programs

NEI 12-06 requires key FLEX equipment to be subject to maintenance and testing guidance provided in INPO AP 913, "Equipment Reliability Process," and EPRI 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment – Project Overview Report," to verify proper function. The FLEX program established for each site can be used as a reference for reliability of the equipment. Other equipment may need further evaluation to determine an acceptable level of reliability.

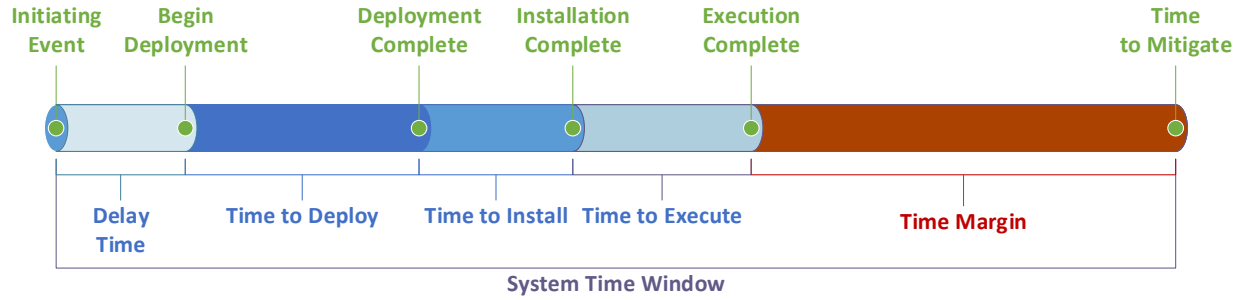
6.3 Location and Transportation Capability

The location and storage of equipment must be considered including the deployment capabilities. Support equipment (e.g. for hauling or debris removal) should be available after the event, if required. Pre-deployment or pre-staging may be credited to ensure equipment is at the proper location to meet the time line established for the scenario.

The FLEX program considered deployment of equipment for the applicable evaluated external hazards (seismic, flooding, wind, cold and hot temperatures) which can be used as a reference to justify the use in a given scenario. Other equipment may need further evaluation to determine deployment requirements.

7. TIME AVAILABILITY AND MARGIN

The availability of time margin to complete necessary actions is an important consideration in the qualitative risk assessment of the mitigating strategies equipment. To support this effort, a timeline of the necessary actions should be constructed, and adequate time margin should be demonstrated to provide confidence in meeting the success criteria.



The scenario first needs to be evaluated to determine the following:

- Time of the Initiating Event – This is when the initiating event occurs to begin the scenario. (e.g. Reactor Trip, LOOP, Turbine Trip, Loss of Feedwater)

- Time to Mitigate – This is the point in the timeline where mitigation must begin to restore or maintain the function in order to meet the success criteria.

- System Time Window – The time available between the Time of Initiating Event and the Time to Mitigate. This is the overall time window where actions to implement a mitigating strategy will be evaluated.

Next, the following elements of the timeline need to be identified:

- Delay Time – This is the duration of time it takes to begin the deployment of the mitigating strategies equipment. This includes the time for operators to receive enough indication, evaluate the written instructions, and take any necessary preparatory actions to begin the deployment actions.

- Time to Deploy – This is the duration of time needed to fully deploy the equipment so it is ready to be installed. This includes the time associated with getting the equipment out of the storage location, clearing any debris from the route, and transporting the equipment to the appropriate location. Actions for pre-deployment may be considered to adjust the timeline.

- Time to Install – This is the duration of time to complete necessary steps in aligning connections such as hoses and power cables.

- Time to Execute – This is the duration of time necessary to complete the steps to start equipment and begin restoration or continuation of the function provided by the equipment.

Finally, the Time Margin should be assessed:

- Time Margin – This is the difference between the Time to Mitigate and the execution completion time.

During the FLEX Implementation, validation of time sensitive actions was required in accordance with NEI guidance which was later added to NEI 12-06 Rev 1a as Appendix E. The purpose of this guide is to outline a process that may be used by licensees to reasonably ensure required tasks, manual actions and decisions for FLEX strategies are feasible and may be executed within the time constraints. The validation process included a qualitative assessment of performance shaping factors (cues and indications, special fitness issues, environmental factors and accessibility, communications, procedures, training, stress, staffing, and human-system interfaces). The site specific validation documentation should be used as a reference for time considerations if applicable for crediting FLEX equipment. Other mitigating strategies or new scenarios not previously assessed may need further evaluation to determine adequate time margin.

8. COMMAND AND CONTROL

The credit for use of mitigating strategies equipment is dependent on the quality of knowledge of when and how to use the equipment in a given scenario. Therefore, associated procedures, written instructions, and training of the implementation staff are very important to provide confidence that the appropriate mitigation or prevention activities will be successful.

8.1 Procedures and Written Instructions

Relevant procedures should be reviewed to confirm that operators will have clear directions and cues to implement the equipment successfully. It should be noted that there could be different procedures for different types of scenarios for the same equipment. For portable equipment it is recognized that not all instructions will be contained within plant procedures, however other written instructions may be implemented to deliver the same level of clarity. Though not explicitly called procedures, these instructions should be reviewed, evaluated and credited based on their clarity and effectiveness.

FSGs were developed during implementation of the FLEX program. In general, the command and control was retained within the EOPs. The EOPs direct the implementation of the FSGs to complete steps required for the mitigating function associated with the specific conditions that necessitated entry into the FSGs. The site specific development and procedural structure can be referenced and reviewed to ensure the operating staff has sufficient information to implement the strategy being credited. Additionally, operation placards developed for FLEX equipment and standardized in the industry were installed to ensure adequate instruction is available for operation of the portable equipment and can be referenced in the assessment. Written instructions for other equipment or mitigating strategies may need further evaluation to determine adequacy.

8.1 Training

Training programs should be evaluated to determine how well operators are aware of equipment capabilities, the location of the equipment, actions necessary to deploy them, and how they are aligned and operated. The quality, effectiveness, and frequency of training programs and operator exercises should be evaluated to understand the knowledge base of the personnel required to perform the necessary actions to implement the credited mitigating strategies.

For example, NEI 12-06 required FLEX training to 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). Utility Training Programs have been revised to ensure personnel proficiency in utilizing FSGs and associated Beyond Design Basis (BDB) equipment for the mitigation of BDB external events is adequate and maintained. These programs and controls have been developed and implemented in accordance with the Systems Approach to Training (SAT) Process (Reference 10 CFR 55.4).

Initial training has been provided and continued training has been established for appropriate site personnel on BDB response strategies and implementing guidelines. Personnel assigned to direct the execution of the FLEX strategies have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints. Training for other mitigating strategies may need further evaluation for adequacy. Just-in-time training may be required for emergent conditions or infrequent or complex evolutions.

8.2 Staffing and Communications

The availability of the staffing required to implement the mitigating strategies equipment needs to be evaluated given the specific scenario being assessed. Sites with multiple units should consider whether the scenario affects all units. Pre-deployment of equipment or additional staffing (e.g. staffing during an outage) should be considered. Communication required to implement the strategies needs to be considered including the availability of necessary communications equipment.

Staffing studies in accordance with NEI 12-01 were performed and referenced in the site specific FLEX program. Minimum administrative staffing was verified to be sufficient to execute FLEX strategies for all units on site. FLEX strategies required consideration for communications (reference NEI 12-06, NEI 12-01). Staffing and communication for other mitigating strategies may need further evaluation for adequacy.

9. ENVIRONMENTAL CHALLENGES

This assessment should evaluate whether the environmental conditions hinder the deployment, timing, or implementation of the equipment being assessed. This consideration also identifies any actions to address these conditions. In general, these conditions are driven by the initiating event of the scenario and are specific to that event. For this evaluation the potential environmental conditions given the event should be identified. These conditions could include failure of buildings, structures, debris, or limiting access to areas. The location of equipment and the building that houses it should be assessed to determine if these conditions could impact the availability of the equipment. The route necessary to deploy the equipment to the required location should also be evaluated for impacts. Potential methods of recovery should be evaluated such as alternate paths, pre-deployment, or removal of debris. The following are examples of events and how they could potentially challenge the implementation of mitigating strategies equipment:

Event	**Potential Challenges**
Internal Fire	• Direct failure of equipment • Fire areas could block equipment routing and limit or delay access to areas
Internal Flooding	• Direct failure of equipment • Flooded areas could block equipment routing and limit or delay access to areas
Seismic	• Direct failure of equipment • Failure of buildings and structures that house equipment • Debris could block equipment routing and limit or delay access to areas

Event	Potential Challenges
External Flooding	• Direct failure of equipment • Failure of buildings and structures that house equipment • Flood level could prevent access to equipment • Debris could block equipment routing and limit or delay access to areas
High Winds and associated missiles	• Direct failure of equipment • Failure of buildings and structures could prevent access to equipment • Debris could block equipment routing and limit or delay access to areas
Extreme Temperatures	• Direct failure of equipment

Once potential challenges are identified, actions that can be taken to resolve challenges should be evaluated. This evaluation should demonstrate adequate likelihood of successful implementation in the scenario such that it can be credited in the assessment. These environmental conditions and associated actions should be taken into consideration for impact on other elements of this assessment such as the time margin evaluation, command and control, and transportation capabilities.

In accordance with NEI 12-06 section 4, the housing, deployment and installation of FLEX equipment was required to be evaluated against a number of external events. The evaluations identified actions and requirements that ensured a higher likelihood of successful implementation of FLEX equipment and strategies. These elements should be considered and referenced in the assessment as applicable. Housing, deployment and installation for other mitigating strategies equipment may need further evaluation.

10. SUMMARY

The nuclear industry has added additional equipment in support of regulations and orders following events on September 11, 2001 and Fukushima accident in March 2011. Equipment was procured and strategies were developed as an additional layer of defense in depth to add flexibility and diversity to permanent station equipment. Considerations of availability and reliability, adequate time margin to implement, clear/effective command and control, and environmental factors were taken into account when these strategies were developed for specific scenarios. These same considerations can be credited or further established for additional scenarios and applications. A qualitative risk assessment that properly evaluates these considerations can demonstrate that these mitigating strategies and associated equipment can be used to further improve safety margin in a variety of scenarios.