APPENDIX H TO NEI 12-06

DRAFT TO SUPPORT PUBLIC MEETING ON SEPTEMBER 8, 2016

NOTE: A SUBSEQUENT VERSION OF THIS DOCUMENT WILL BE PROVIDED TO NRC FOR REVIEW AND ENDORSEMENT

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 approaches that can be used.

The deterministic approach is consistent with that used for Path 4 (H.4.4) to demonstrate reasonable protection of mitigating strategies SSCs. As part of this approach, the results and insights from the plant SPRA may optionally be used to inform the evaluation of the mitigating strategies SSCs to determine which equipment or other plant modifications, if any, will improve the plant's seismic safety.

The risk-informed approach uses the SPRA, to demonstrate that the likelihood of maintaining key safety functions given the MSSHI is high, and therefore the mitigating strategies SSCs are reasonably protected.

The overall process is illustrated in Figure H.4. The deterministic approach is described in Section H.4.5.2, the application of risk insights within the deterministic approach is described in Section H.4.5.3, and the risk-informed approach is described in Section H.4.5.4.

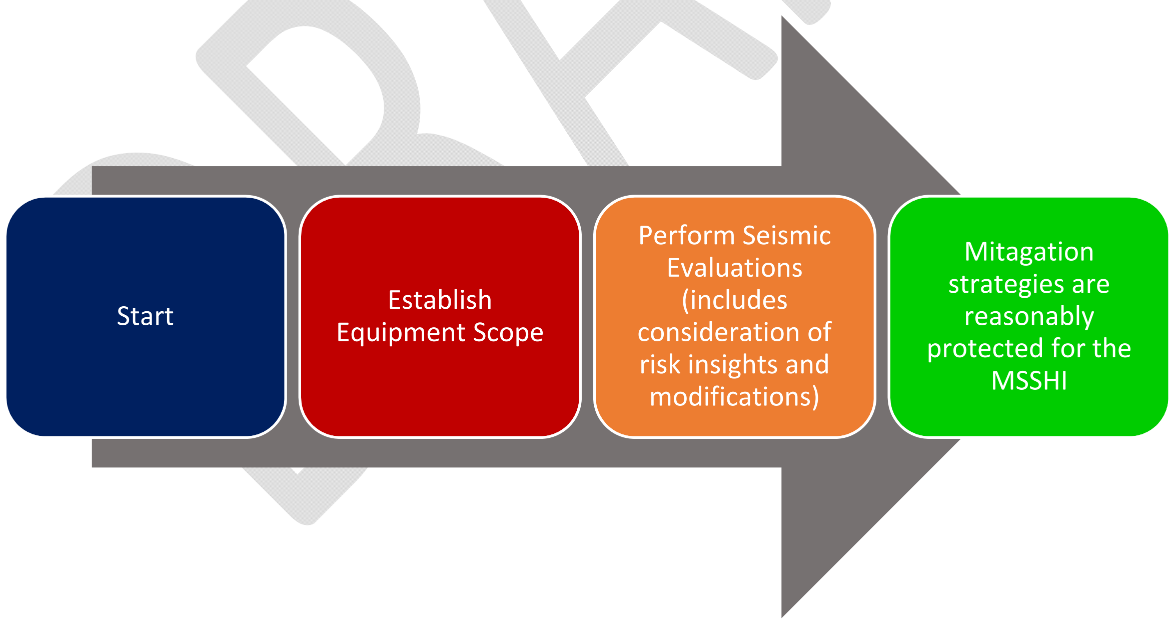

Figure H.4: General Path 5 Process Overview

H.4.5.2 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, determined by NRC as sufficient upon which to base an MSA, and the results, with or without credit for FLEX, are less than $1x10^{-5}$/yr SCDF and $1x10^{-6}$/yr SLERF, an evaluation under H.4.5.3, H.4.5.4, or H.4.5.5 is unnecessary, because the delta risk values that are used in the risk-informed evaluations will also be small. Therefore, modifying mitigating strategies SSCs to have $C_{10\%}$ capacity ≥ GMRS does not significantly improve protection, and the process described in H.4.5.4 is reduced to the documentation of the process. Plants that satisfy this criterion properly address the MSSHI and demonstrate based upon the base SPRA results that the likelihood of maintaining the key safety functions is high; therefore mitigating strategies SSCs are reasonably protected consistent with the NRC rulemaking for mitigation of beyond-design-basis events.

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.4.5.3 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. *<u>Step 1: Determine Scope of Plant Equipment for the MSA</u>* – 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[1] 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

[1] Cable trays which use smooth retainer nuts with support struts should be reviewed to verify adequate seismic capacity

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 $C_{1\%}$ HCLPF and the $C_{10\%}$ value, which for the 0.8g HCLPF 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 EPRI 3002004396 [Ref. 5], HF in-structure response spectrum (ISRS) above 20 Hz are considered non-damaging. Therefore, high frequency 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 appropriately 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 high frequency 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 in-structure response spectra 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:
    - o demonstrating that a $C_{10\%}$ capacity of the haul path exceeds the GMRS, or
    - o justifying that a particular failure mode (such as liquefaction induced failures at a hard rock site) would not be credible, or
    - o 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.

Completion of the above process demonstrates that mitigating strategies SSCs are reasonably protected consistent with the NRC rulemaking for mitigation of beyond-design-basis events.

H.4.5.4 Application of Risk Insights into the Deterministic Assessment

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 seismic core damage frequency (SCDF) and seismic large early release frequency (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.

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.4.5.3.

- 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 $1\text{x}10^{-5}$/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 $1\text{x}10^{-6}$/yr delta-SLERF for this evaluation. Plants for which a $1\text{x}10^{-6}$/yr delta- SLERF residual goal is not achievable will need to apply insights from the SPRA to establish an alternate criterion.
- Further, the noted delta risk values are not intended to be absolute thresholds. They represent goals or desired outcomes. Plants for which the delta-risk residual goals for SCDF or SLERF are not achievable will need to apply insights from the SPRA to define alternate criteria. In this case, the total SCDF should be $\leq 1\text{x}10^{-4}$/yr. with total SLERF reflecting an acceptable containment seismic performance, based on an SPRA which has been peer reviewed and submitted to NRC for the NTTF 2.1 seismic 50.54(f) information request and determined by NRC as sufficient upon which to base an MSA.
- 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 any 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 define an alternate criterion.

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 delta 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.

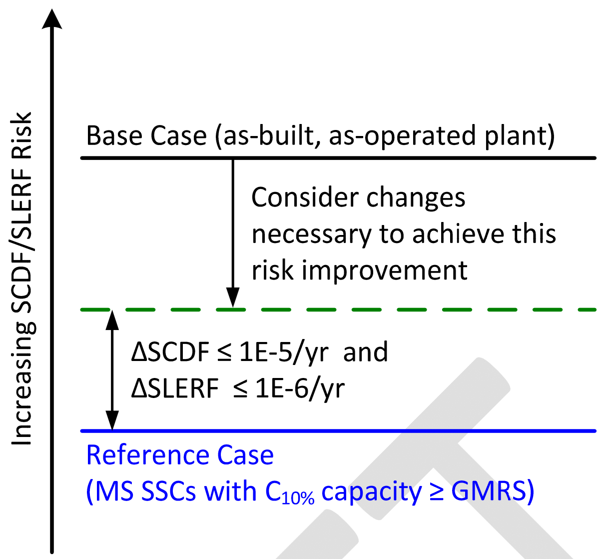

Figure H.5: Illustration of the Application of Risk Insights into the Deterministic Assessment

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. Any such modifications 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 from Steps 2, 4 and 5 of Section H.4.5.3 is not reduced via replacement and/or plant modification.

Completion of the above process properly addresses the MSSHI and demonstrates that the likelihood of maintaining the key safety functions is high; therefore mitigating strategies SSCs are reasonably protected consistent with the NRC rulemaking for mitigation of beyond-design-basis events.

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, determined by NRC as sufficient upon which to base an MSA, and reflect a total SCDF ≤ $1x10^{-4}$/yr. and total SLERF reflecting an acceptable containment seismic performance. If the SCDF is greater than $1x10^{-4}$/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.4.5.3. The primary difference is that this process is focused on the safety benefit in terms of ELAP/LUHS delta SCDF and delta SLERF rather than overall SCDF and SLERF. 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 any 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.

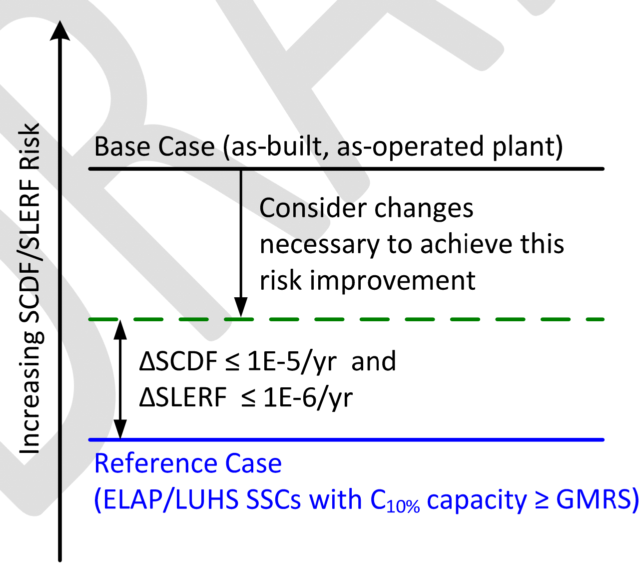

Figure H.6: Delta-Risk Process Illustration

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 significant 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. This is because 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 is the same regardless of where the Base value is set.

The ELAP/LUHS base case in Figure H.6 represents the ELAP/LUHS risk (SCDF or SLERF) 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 ELAP/LUHS base SPRA case and the ELAP/LUHS reference case is the risk reduction (ELAP/LUHS delta risk) of interest. If the ELAP/LUHS 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 ELAP/LUHS 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 ELAP/LUHS Base case and the Reference case results need to be recalculated. Enhancements to the capability of the significant contributors to ELAP/LUHS 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 ELAP/LUHS 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 $\geq$ GMRS would need to be demonstrated, or procedure enhancements), and checking to see whether the Modified ELAP/LUHS Base case is sufficiently close to the ELAP/LUHS 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 ELAP/LUHS 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 ELAP/LUHS delta SCDF and ELAP/LUHS 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.

Completion of the above process, with or without the optional evaluation of FLEX when FLEX is not explicitly included in the model, demonstrates that there is high likelihood that key safety functions are maintained for ELAP/LUHS and that the mitigating strategies are effective for the MSSHI.

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.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.4.5.3 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

6.4 Path 5 (H.4.5.2 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.4.5.2 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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15. EPRI, "*Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*", Report Number 3002000704, Palo Alto, CA, April, 2013.
16. EPRI, "*Seismic Probabilistic Risk Assessment Implementation Guide*", Report Number 3002000709, Palo Alto, CA, December, 2013.
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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
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