UNITED STATES
NUCLEAR REGULATORY COMMISSION
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April 18, 2022

MEMORANDUM TO: Kenneth See, Dam Safety Officer
External Hazards Branch
Division of Engineering and External Hazards
Office of Nuclear Reactor Regulation

FROM: Stacey Rosenberg, Chief **/RA/**
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Office of Nuclear Reactor Regulation

SUBJECT: RECOMMENDATION FOR CHANGING THE INSPECTION FREQUENCY FOR ULTIMATE HEAT SINK DAMS BASED ON PRINCIPLES OF RISK-INFORMED DECISION-MAKING

In your capacity as Nuclear Regulatory Commission (NRC's) Dam Safety Officer, you requested the Probabilistic Risk Assessment (PRA) Licensing Branch C (APLC) in the Office of Nuclear Reactor Regulation's Division of Risk Assessment for support in using the principles of risk-informed decision-making to recommend changes, if any, to the frequency of the UHS dam inspections. This request was based on the inspection data to date.

APLC staff evaluated all five principles of risk-informed decision-making listed in Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Revision 3 (ADAMS Accession No. ML17317A256), to make an integrated recommendation on changing the frequency of UHS dam inspections. The scope of this effort, and the resulting recommendation, is limited to UHS dams at the 7 sites for which NRC has regulatory authority. This evaluation did not consider and is not applicable to large upstream dams because the NRC does not have regulatory authority over those dams. The enclosure to this memorandum documents the APLC staff's approach and resulting recommendation on changes to UHS dam inspection frequency for each of the 7 sites for your consideration. We recognize that you retain the decision-making authority to accept our recommendation.

The enclosure includes data from NRC's plant-specific Standardized Plant Analysis Risk (SPAR) probabilistic risk assessments (PRAs). Some of this data can be considered proprietary. Therefore, we recommend that APLC is consulted prior to making the enclosure publicly available.

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SUBJECT: RECOMMENDATION FOR CHANGING THE INSPECTION FREQUENCY FOR ULTIMATE HEAT SINK DAMS BASED ON PRINCIPLES OF RISK-INFORMED DECISION-MAKING Dated: April 18, 2022

Enclosure:
Recommendation for Changing the Inspection Frequency for Ultimate Heat Sink Dams Based on Principles of Risk- Informed Decision-making

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Recommendation for Changing the Inspection Frequency for Ultimate Heat Sink Dams Based on Principles of Risk-Informed Decision-making

Executive Summary

Under the Federal Dam Safety Program (DSP), the U.S. Nuclear Regulatory Commission (NRC) has regulatory authority over dams that are integral to operation of licensed facilities, or the possession and use of licensed materials, that pose a radiological safety-related hazard should they fail. The ultimate heat sink (UHS) dams at seven (7) operating nuclear power plant (NPP) sites meet the definition of a dam and are integral to operation of licensed facilities, that pose a radiological safety-related hazard should they fail. Therefore, NRC has regulatory authority over the UHS dams at these 7 sites.

SECY 91-193 establishes the NRC DSP and outlines the roles and responsibilities of the Dam Safety Officer (DSO). In an SRM, the Commission approved SECY 91-193 (Reference 1). Since 1992, under a Memorandum of Understanding, the Federal Energy Regulatory Commission (FERC) provides technical assistance to the NRC by inspecting dams under NRC's jurisdiction in lieu of creating an NRC inspector program for that purpose. The frequency of current FERC inspections of UHS dams over which NRC has regulatory authority is 2 years. The inspections ensure compliance with Federal Guidelines for Dam Safety.

Based on the inspection data to date, NRC staff explored potentially changing the frequency of UHS dam safety inspections. The DSO, who is currently in the Office of Nuclear Reactor Regulation's (NRR's) Division of Engineering and External Hazards (DEX), requested support from the Probabilistic Risk Assessment (PRA) Licensing Branch C (APLC) in NRR's Division of Risk Assessment (DRA) in using the principles of risk-informed decision-making to recommend changes, if any, to the frequency of the UHS dam inspections.

APLC staff evaluated all five principles of risk-informed decision-making listed in Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Revision 3 (Reference 2), to make an integrated recommendation on changing the frequency of UHS dam inspections. Risk contribution and risk importance measures from the electronic Plant Risk Information Books (ePRIBs) for the plants under consideration were used for quantitative risk information. These ePRIBs are based on the corresponding Standardized Plant Analysis Risk (SPAR) models, which are NRC's plant-specific PRA models. In addition, the re-evaluated site-specific seismic hazard for each of the 7 NPP sites was also used.

Decision-making logic was developed that used the data to determine the appropriate UHS dam inspection frequency. The logic used criteria that are anchored to established risk significance thresholds. This logic weighted impact on current plant operations higher than a postulated failure. Alternative criteria were also explored. The need to increase UHS dam inspection frequency was also investigated and a strong basis to do so was not identified for any of the 7 NPP sites.

Based on the evaluation, the recommendation for the UHS dam inspection frequency at the 7 NPP sites is ("retain" means no change to the existing frequency):

Site	Inspection Frequency (years)
North Anna	**3 (Extend)**
Catawba	2 (Retain)
McGuire	2 (Retain)
Shearon Harris	2 (Retain)
Summer	**3 (Extend)**
Farley	2 (Retain)
Comanche Peak	2 (Retain)

The recommendation is provided to the DSO for consideration. NRC's DSO will make the decision on any changes to the UHS dam inspection frequency based on these recommendations and any other considerations not included in developing the recommendations. The scope of this effort, and the resulting recommendation, is limited to UHS dams at the 7 sites (listed above) for which NRC has regulatory authority. This evaluation did not consider and is not applicable to large upstream dams because the NRC does not have regulatory authority over those dams.

Background

Under the Federal Dam Safety Program (DSP), the U.S. Nuclear Regulatory Commission (NRC) has regulatory authority over dams that are integral to operation of licensed facilities, or the possession and use of licensed materials, that pose a radiological safety-related hazard should they fail. The ultimate heat sink (UHS) dams at seven (7) operating nuclear power plant (NPP) sites meet the definition of a dam. These UHS dams, which are designed based on the guidance in RG 1.27, "Ultimate Heat Sink for Nuclear Power Plants" (Reference 3), play a critical role in normal operations and for dissipating the residual heat after shutdown and postulated accidents. As a result, they are integral to operation of licensed facilities and pose a radiological safety-related hazard should they fail. Therefore, NRC has regulatory authority over the UHS dams at the following 7 sites:

1. North Anna Nuclear Generating Station (UHS called the Service Water Reservoir)
2. Catawba Nuclear Station (UHS called the Standby Nuclear Service Water Pond [SNSWP])
3. McGuire Nuclear Station (UHS called the SNSWP)
4. Shearon Harris NPP (UHS called the Auxiliary Reservoir)
5. Virgil C. Summer Nuclear Station (UHS called the Service Water Pond [SWP])
6. Joseph M. Farley Nuclear Plant (UHS called the Service Water Pond [SWP])
7. Comanche Peak NPP (UHS called the Safe Shutdown Impoundment [SSI])

SECY 91-193 establishes the NRC DSP and outlines the roles and responsibilities of the Dam Safety Officer (DSO). In an SRM, the Commission approved SECY 91-193. Since 1992, under a Memorandum of Understanding (MoU), the Federal Energy Regulatory Commission (FERC) provides technical assistance to the NRC by inspecting dams under NRC's jurisdiction in lieu of creating an NRC inspector program for that purpose. The frequency of current FERC inspections of UHS dams over which NRC has regulatory authority is 2 years. The inspections ensure compliance with Federal Guidelines for Dam Safety. The licensees at the 7 NPP sites perform walkdowns of their UHS dams on a more frequent basis than the FERC.

To date, FERC's inspections of UHS dams have not identified any noteworthy inspection findings. Based on this data, NRC staff explored potentially changing the frequency of UHS dam safety inspections. The DSO requested support from the Probabilistic Risk Assessment (PRA) Licensing Branch C (APLC) in NRR's Division of Risk Assessment (DRA) (i.e., NRR/DRA/APLC) in using the principles of risk-informed decision-making to recommend changes, if any, to the frequency of the UHS dam inspections. The DSO will make the decision on any changes to the UHS dam inspection frequency based on the recommendations and any other considerations not included in developing the recommendations.

The scope of this effort, and the resulting recommendation, is limited to UHS dams at the 7 sites (listed above) for which NRC has regulatory authority. This evaluation did not consider and is not applicable to large upstream dams because the NRC does not have regulatory authority over those dams.

Approach

As the first step, information was collected on the design and function of the UHS dams at the 7 NPP sites of interest. RG 1.27 and the plant-specific Updated Final Safety Analysis Report (UFSAR) were consulted for this purpose. Next, all five principles of risk-informed decision-making listed and discussed in RG 1.174, Revision 3, were evaluated. These principles are:

Principle 1: Meet regulations or request an exemption
Principle 2: Consistent with defense-in-depth philosophy
Principle 3: Maintains safety margins
Principle 4: Any increase in risk is consistent with the Commission's policy statement
Principle 5: Performance monitoring strategies are implemented

Although RG 1.174 provides guidance of risk-informed changes to the licensing basis, the five principles listed above are applicable to a broader set of risk-informed decision-making. This is supported by Appendix A to NUREG/KM-0016, "Be riskSMART: Guidance for Integrating Risk Insights into NRC Decisions (Reference 4) .

The existing licensing basis for each NPP was reviewed and relied upon to meet Principles 1 through 3. Principle 1 is met for the 7 NPP sites because each site, at the time of this effort, was in compliance with its current licensing basis and had not requested an exemption related that impacted its UHS.

RG 1.174, Revision 3, provides guidance on seven considerations for defense-in-depth in the context of risk-informed decision making. The seven considerations are: (1) a reasonable balance among the layers of defense (i.e., minimizing challenges to the plant, preventing any events from progressing to core damage, containing the radioactive source term, and emergency preparedness) is preserved, (2) adequate capability of design features is preserved without an overreliance on programmatic activities as compensatory measures, (3) system redundancy, independence, and diversity is preserved commensurate with the expected frequency and consequences of challenges to the system, including consideration of uncertainty, (4) adequate defense against potential common-cause failures is preserved, (5) multiple fission product barriers are maintained, (6) Sufficient defense against human errors is preserved, and (7) the intent of the plant's design criteria continues to be met. An evaluation did not identify any challenges to the seven considerations for defense-in-depth in RG 1.174 because this effort does not change the existing component- and plant-level defense-in-depth of any of the 7 NPPs. Consequently, none of the seven considerations are significantly impacted from their status at the time of this effort. Therefore, Principle 2 is met.

The safety margins currently existing at a component- and plant-level were also maintained and left unchanged by this effort. This effort does not change or recommend any changes to the regulatory guidance for the design of UHS dams in RG 1.27. Consequently, the safety margins therein are unaffected by this effort. Therefore, Principle 3 is met.

Performance monitoring of the UHS dams occurs through FERC inspections and licensee walkdowns. While this effort can result in a recommendation to decrease the frequency, the inspections will not be eliminated. As noted previously, the inspections ensure compliance with Federal Guidelines for Dam Safety. Further, this effort does not impact the walkdown of the UHS performed by the licensee. Therefore, Principle 5 is met.

The evaluation of Principle 4 uses risk contribution and risk importance measures from the electronic Plant Risk Information Books (ePRIBs) for the 7 NPPs. These ePRIBs are based on the corresponding Standardized Plant Analysis Risk (SPAR) models, which are NRC's plant-specific PRA models. Investigation of the SPAR models determined that the UHS is not explicitly modeled. Based on the UFSARs for each the 7 NPPs, service water (SW) and component cooling water (CCW) are systems that have a direct nexus and close dependency on the UHS. Therefore, any issues with the UHS impact the SW and CCW functions. Consequently, the SW and CCW systems were chosen as surrogates for the UHS for the evaluation of Principle 4.

The ePRIBs were used to obtain the following data:

1. The relative contribution of initiating events resulting from SW and CCW failures to the total internal events risk,
2. The Fussell-Vesely (FV[1]) importance measure for SW and CCW components, and
3. The Risk Achievement Worth (RAW[2]) importance measure for SW and CCW components.

In case of FV and RAW, the maximum value among all the basic events modeling the SW and CCW components was chosen for use in the evaluation.

The UHS dams at the 7 NPP sites are designed to withstand the corresponding safe shutdown earthquake per the guidance in RG 1.27. Therefore, in addition to the risk information listed above, data on the re-evaluated seismic hazard, in the form of the ground motion response spectrum (GMRS), at each of the 7 NPP sites was used. This data provided information on whether a site's safe shutdown earthquake (SSE) was exceeded by the re-evaluated GMRS and the magnitude of the exceedance.

Decision-making logic was developed to determine the appropriate UHS dam inspection frequency. Changes to the frequency were evaluated by considering a 3- and 4-year inspection frequency compared to the current 2-year frequency (i.e., 50% and 100% increase from the current frequency). The potential to increase the inspection frequency was also explored. In addition, the decision-making logic used criteria that are anchored to established risk significance thresholds. The consensus PRA Standard endorsed by the NRC staff in RG

[1] A cut set represents the necessary and sufficient combination of failures that results in an undesirable outcome (e.g., core damage). FV importance measure is the contribution of cut sets containing a basic event of interest to the total risk. A higher FV value means larger contribution. FV values can range from 0 (no contribution) to 1.
[2] RAW importance measure is the ratio of the increase in the risk from a postulated guaranteed failure of the failure mode represented by a basic event to the risk with the nominal failure probability of that basic event. A higher value means a larger increase in risk due to the postulated guaranteed failure.

1.200 (Reference 5) as well as established risk-informed applications (e.g., Reference 6 as endorsed in Reference 7) use the following thresholds for risk significance:

- ≥ 5% cumulative contribution to risk from a particular hazard
- FV importance ≥ 0.5%
- RAW importance ≥ 2.0

These thresholds are consistent with Principle 4 of risk-informed decision making.

The base case, also termed Option 1, decision-making logic is shown in Figure 1. The logic weights the impact on current plant operations more than a postulated failure. This is achieved using the relative contribution of initiating events resulting from SW and CCW failures to the total internal events risk and the FV importance. To distinguish between retaining the current inspection frequency and extending the frequency to 3 years, a FV importance of 5% was used in the decision-making logic. This represents a factor of 10 increase above the base threshold for FV importance and can identify a major impact on risk.

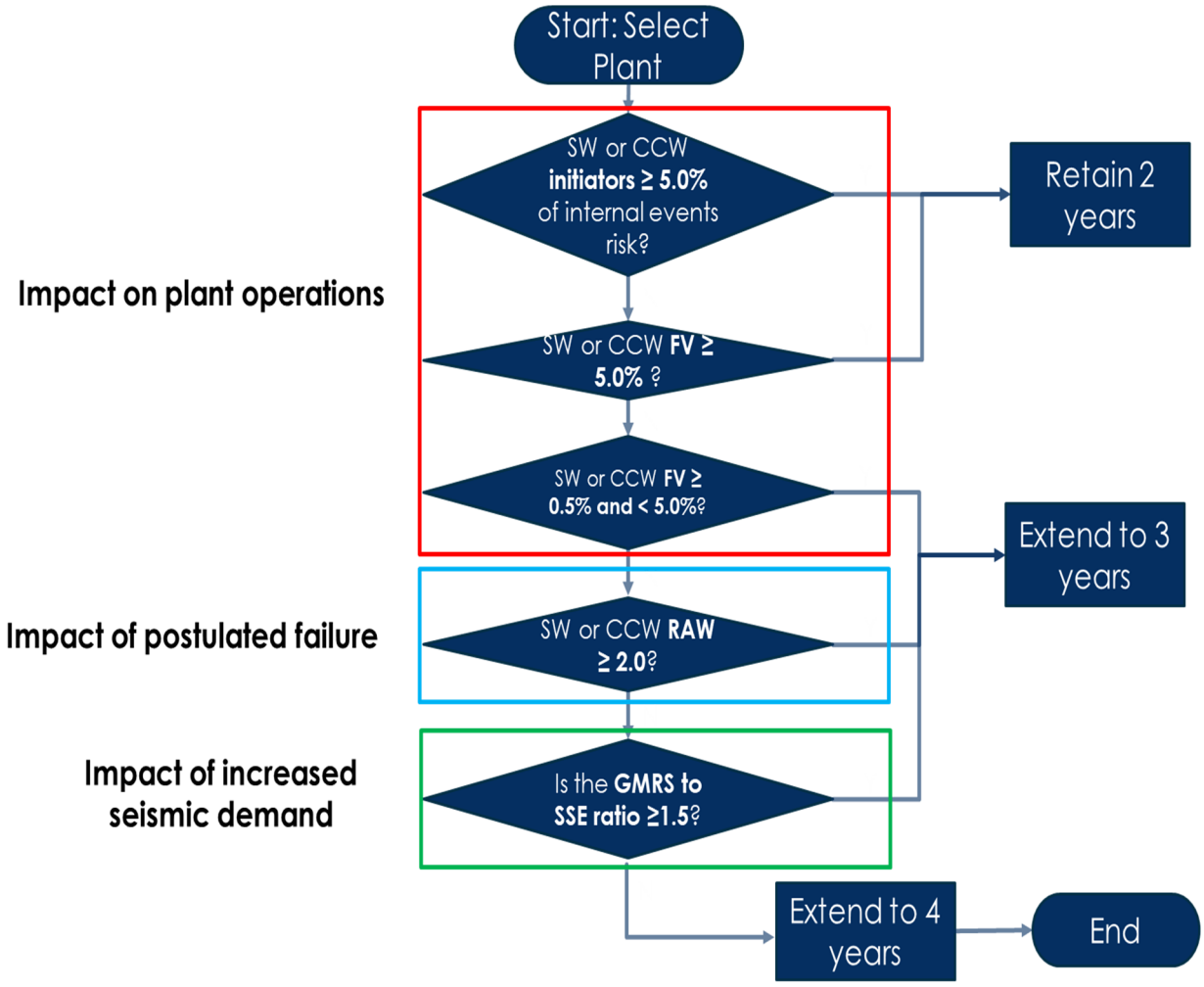

Figure 1: Base case (termed Option 1) decision-making logic

Per the logic in Figure 1, if the relative contribution of initiating events resulting from SW and CCW failures to the total internal events risk is ≥ 5% or if the FV importance for SW and CCW components ≥ 5.0%, the current inspection frequency is retained because of the heightened impact on plant risk. If the FV importance for SW and CCW components is ≥ 0.5% and < 5% or if the RAW importance for SW and CCW components is ≥ 2, the inspection frequency can be extended to 3 years due to the lesser association with plant risk. In addition, if the re-evaluated GMRS for the site is greater than 1.5 times the SSE (i.e., the re-evaluated seismic demand is 50% higher than the design basis demand), the inspection frequency can be extended to 3 years. Increased seismic demand was considered to warrant limiting extension of the inspection frequency but not prevent the extension because it represented a postulated failure resulting from a low frequency (approximately 1E-5/year and higher) event. Not meeting any of the above criteria would result in recommendation for a 4-year inspection frequency because there are no significant impacts of the UHS on plant risk. A review of the Diverse and Flexible Coping Strategies (FLEX) for the 7 plants did not identify any differentiating features in the strategies regarding the use of the UHS as a water source. Therefore, reliance of FLEX strategies on the UHS was not included in the decision-making logic.

Sensitivities were performed to evaluate the impact of alternative decision-making logic. One of the sensitivities, termed Option 2, used a RAW importance of 10 (i.e., a factor of 5 increase above the base threshold for RAW importance) to identify a major impact on risk and consequently, to retain the current 2-year inspection frequency. This is illustrated in Figure 2. Another sensitivity, termed Option 3 and illustrated in Figure 3, investigated the outcome of retaining the current inspection frequency in case of an increased seismic demand on the UHS represented by the GMRS to SSE ratio of 1.5 or more. The results from the decision-making logic for the base and sensitivity cases, and the recommendation for UHS dam inspection frequency based on them, are presented in the next section.

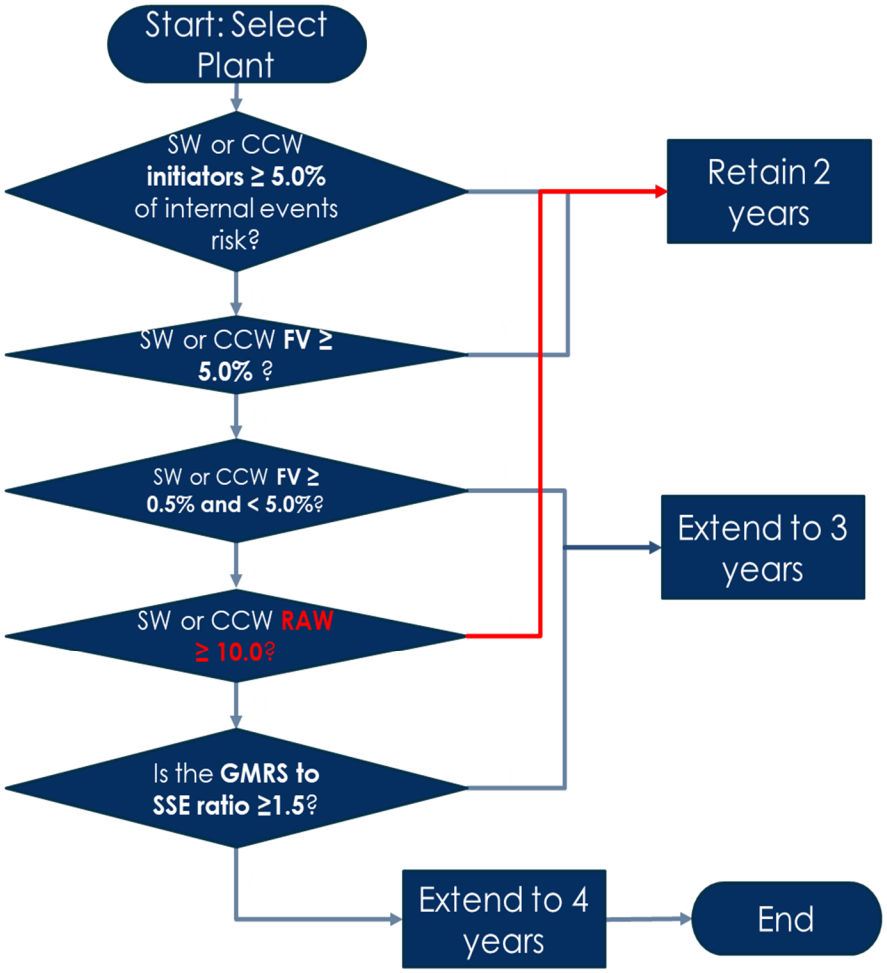

Figure 2: Sensitivity to RAW importance measure threshold (termed Option 2)

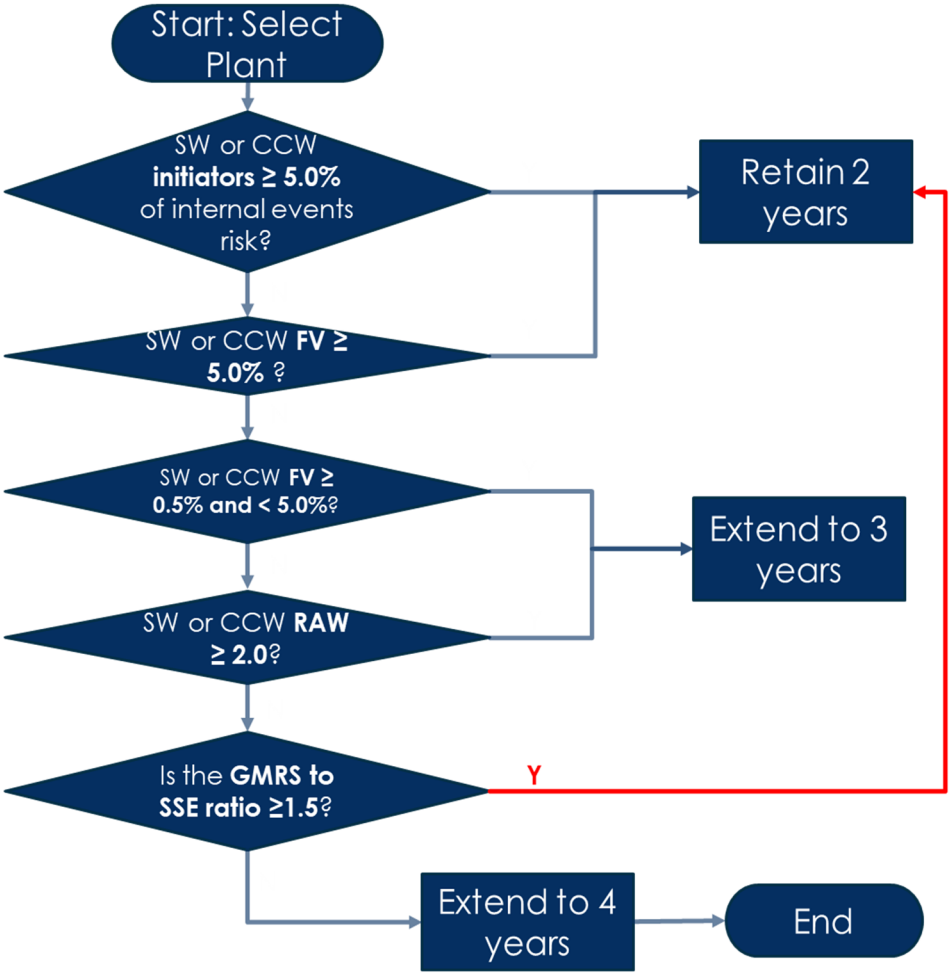

Figure 3: Sensitivity to GMRS to SSE ratio (termed Option 3)

Results and Recommendation

Table 1 provides the results of the decision-making logic discussed in the previous section.

Table 1:

Plant	Inspection Frequency (years)		
	Option 1	Option 2	Option 3
North Anna	**3 (Extend)**	3 (Extend)	**2 (Retain)**
Catawba	2 (Retain)	2 (Retain)	2 (Retain)
McGuire	2 (Retain)	2 (Retain)	2 (Retain)
Shearon Harris	2 (Retain)	2 (Retain)	2 (Retain)
Summer	**3 (Extend)**	3 (Extend)	**2 (Retain)**
Farley	2 (Retain)	2 (Retain)	2 (Retain)
Comanche Peak	2 (Retain)	2 (Retain)	2 (Retain)

The results of the risk-informed approach using the base case decision-making logic (Option 1 in Table 1), identify that the UHS dam inspection frequency can be extended to 3 years for 2 of the 7 plants. The results for Option 2 (i.e., the sensitivity to identify a major impact on risk using a RAW importance of 10) are the same as that for Option 1. This is because the plants with RAW importance greater than or equal to also meet the criteria for contribution to internal events and FV, resulting in the same outcome for the UHS inspection frequency evaluation. Placing higher importance on the increased seismic demand on the UHS (i.e., Option 3) results in the current inspection frequency being retained for all plants. This is because the plants for which Option 1 identified changes to the inspection frequency have GMRS to SSE ratios of 1.5 or higher.

Option 1 emphasizes the impact on plant operations compared to postulated failure of the UHS (via the surrogates used for this evaluation). The operational experience to date indicates that the likelihood of a postulated failure of the UHS will not increase substantially due to reduced inspection frequency. Further, the GMRS corresponds to an occurrence frequency of approximately 1E-5/year and therefore, the frequency of a postulated failure due to the increased seismic demand is relatively low.

Based on the evaluation, the results from the base case (Option 1) are recommended for further consideration by NRC's DSO in conjunction with monitoring and trending of inspection findings, if any, for degraded performance.

References

1. Memorandum from Chilk, S. J., to Taylor, J. M., "SECY-91-193 – Dam Safety Program," July 30, 1991 (ADAMS Accession No. ML010050030).
2. United States Nuclear Regulatory Commission, Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Revision 3, January 2018 (ADAMS Accession No. ML17317A256).
3. United States Nuclear Regulatory Commission, Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants," Revision 3, November 2015 (ADAMS Accession No. ML14107A411).
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5. United States Nuclear Regulatory Commission, Regulatory Guide 1.200, "Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities," December 2020, Revision 3 (ADAMS Accession No. ML20238B871).
6. Nuclear Energy Institute, "10 CFR 50.69 SSC Categorization Guideline," NEI 00-04, Revision 0, July 2005 (ADAMS Accession No. ML052910035).
7. United States Nuclear Regulatory Commission, Regulatory Guide 1.201, "Guidelines for Categorizing Structures, Systems, And Components in Nuclear Power Plants According to their Safety Significance," Revision 1 (for Trial Use), May 2006 (ADAMS Accession No. ML061090627).