



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION**  
WASHINGTON, D.C. 20555-0001

March 11, 2016

MEMORANDUM TO: Michael F. Weber  
Director of Nuclear Regulatory Research

FROM: John D. Monninger, Chair **/RA KWebber for/**  
Review Panel for Pre-Generic Issue 11, "Effects of Downstream  
Dam Failures on Nuclear Power Plants"

SUBJECT: RECOMMENDATION FOR DISPOSITIONING PROPOSED  
GENERIC ISSUE ON THE EFFECTS OF DOWNSTREAM DAM  
FAILURES ON NUCLEAR POWER PLANTS

This memorandum documents the findings and recommendations of the Generic Issues Review Panel (the Panel) for Pre-Generic Issue 11, "Effects of Downstream Dam Failures on Nuclear Power Plants." A description of the proposed generic issue and the Panel's evaluation, conclusions, and recommendations are provided below. Enclosure 1 contains a summary of the Panel's assessment of the proposed generic issue against the seven screening criteria, and Enclosure 2 contains the Screening Analysis Report, which provide the basis the Panel used to make its conclusions. These documents can be found in Agencywide Documents Access and Management System (ADAMS) package ML15253A365.

Description of the Proposed Generic Issue

After reviewing data on dam failure frequencies<sup>1</sup> and new seismic hazard estimates<sup>2</sup>, the Nuclear Regulatory Commission (NRC) staff enhanced their understanding of the hazards affecting dam safety. Subsequently, on November 18, 2011, the staff proposed a generic issue (ML11308B373) regarding the effect of downstream dam failures on the availability of cooling and service water at operating commercial nuclear power plant (NPP) sites. A generic issue review panel was later appointed on November 2, 2012 (ML 12283A339) to evaluate the issue. If the proposed generic issue was approved, it would result in the evaluation of the ultimate heat sink (UHS) analyses previously conducted for the initial licensing of NPPs in light of the enhanced understanding of hazards affecting dam safety. This evaluation, along with consideration of the frequency and consequences of the events, would be used to determine whether the risk associated with downstream dam failure impacting the UHS remains acceptable.

The cooling water for normal and/or emergency operations at NPPs can be provided by reservoirs (e.g., lake, pond) formed by dams blocking a river or stream. These reservoirs are

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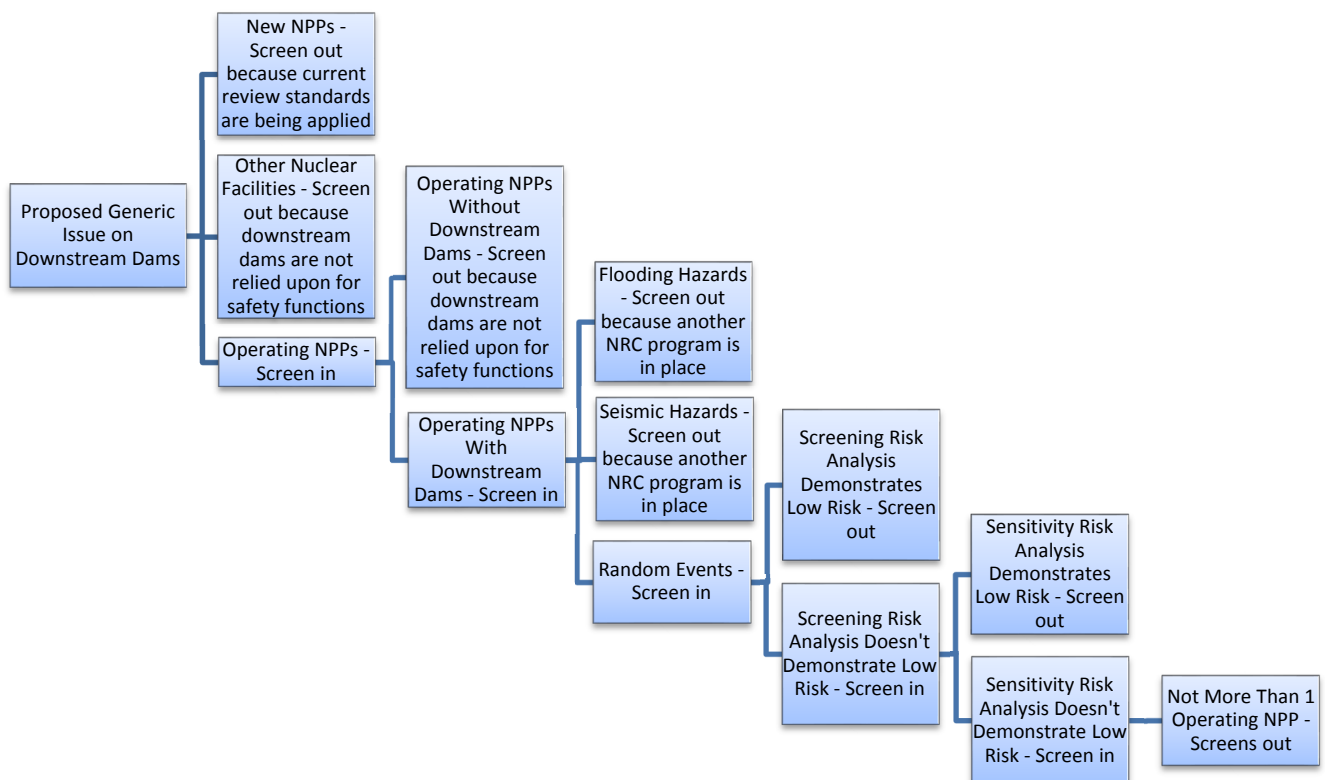
<sup>1</sup> F. Ferrante, S. Sancaktar, J. Mitman, J. Wood. "An Assessment of Large Dam Failure Frequencies based on US Historical Data," *Proceedings of ANS PSA 2011 International Topical Meeting on Probabilistic Safety Assessment and Analysis*, Wilmington, NC: American Nuclear Society, 2011.

<sup>2</sup> U.S. Nuclear Regulatory Commission. "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants: Safety/Risk Assessment," 2010a, ADAMS Accession No. ML100270639.

designated as the UHS if they are used for emergency operations. The failure of a downstream dam supporting the reservoir could affect the availability of cooling water for safety functions, such as: reactor decay heat removal, containment cooling, emergency diesel generator cooling, and reactor coolant pump seal cooling. The failure of downstream dams differs from other events impacting the UHS (e.g., clogging of intake screens or failure of individual components) due primarily to the capability of site personnel to recover from the event in a timely manner. Site personnel may be able to remove obstructions temporarily blocking the UHS intake structure or promptly repair broken equipment; however, it is not possible to immediately resolve a dam failure. The loss of the UHS does not necessarily mean an immediate safety issue by itself. NPPs typically have sufficient cooling water stored on-site (e.g., condensate storage tanks, refueling water storage tanks, suppression pools) to remove heat in the short term until the water inventory can be replenished. Depending on the plant characteristics (e.g., sources of cooling water, configuration of water intake systems, external conditions), a loss of the UHS that is not readily recoverable may result in an inability to provide sufficient cooling water for long term emergency operations.

### Panel's Evaluation

To evaluate the proposed generic issue, the Panel followed the agency's guidance as outlined in Management Directive (MD) 6.4, "Generic Issues Program," and the Office of Nuclear Regulatory Research's Office (RES) Instruction (TEC) 002, "Procedure for Processing Generic Issues." In accordance with this guidance, a proposed generic issue must meet seven screening criteria (see Enclosure 1) in order to be considered further as a Generic Issue. The Panel considered various issues to determine the scope of the proposed generic issue and whether it should proceed in the Generic Issues Program. The following figure illustrates these considerations, and they are discussed in more detail below.



To determine the scope of potentially impacted nuclear facilities, the Panel engaged the Office of Nuclear Material Safety and Safeguards (NMSS) and the Office of Nuclear Reactor Regulation (NRR). These offices provided the Panel with an assessment stating that no research reactors, test reactors, material licensees, or fuel cycle facilities rely on an impoundment reservoir to provide cooling water for emergency operations. Therefore, the Panel determined that the scope of the proposed generic issue is limited to NPPs. The NRC categorizes NPPs as “operating reactors” or “new reactors.” Over the years, the NRC has updated the review guidance and standards used in the licensing of NPPs. The purpose of the proposed generic issue is to evaluate downstream dams in light of NRC’s current guidance and standards to determine whether any safety issues arise. The NRC is already applying the current guidance and standards in the licensing of new reactors. As a result, the Panel determined that the scope of the proposed generic issue does not apply to new reactors, and that the scope of potentially impacted nuclear facilities is limited to operating NPPs.

In addition to determining the scope of impacted facilities (i.e., operating NPPs), the Panel also needed to determine the scope of hazards (e.g., floods, seismic events, random events) potentially impacting downstream dams. Dams are robust engineered structures; however, there are events that can lead to their failure. These events are commonly categorized as flooding-related failures (e.g., dam overtopping), seismic-related failures, or random (sunny day) failures. The NRC has programs underway relating to some of these failure modes, and the Panel needed to determine how these programs impact the proposed generic issue. For example, in response to the accident at the Fukushima Dai-ichi site in Japan, the NRC is evaluating a range of issues impacting operating NPPs. These issues are discussed in the NRC’s report from the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-ichi Accident entitled “Recommendations for Enhancing Reactor Safety in the 21<sup>st</sup> Century.” Several of these issues (i.e., seismic hazards, flooding hazards, and mitigating strategies) impact the evaluation of downstream dam failures and any potential effects on operating NPPs. To understand and consider these impacts, the Panel met with staff from the former NRR Japan Lessons-Learned Project Directorate (now Japan Lessons-Learned Division) (JLD) and the Office of New Reactors (NRO) to discuss the issues and actions being taken. The goal was to determine how the issues and actions affect consideration of the proposed generic issue. This was necessary because one of the Generic Issue screening criteria (Criterion 3) excludes matters from consideration as a Generic Issue if the NRC is addressing that matter through a separate program or process.

Under NTTF Recommendations 2.1 and 2.3, the NRC has programs in place to re-evaluate flooding hazards and seismic hazards, to perform walk downs to confirm the licensing basis has been maintained, and to require the modification of protection features as necessary. The NRC also has a program in place to require licensees to implement mitigation strategies (NTTF Recommendations 4.1 and 4.2) for beyond-design-basis external events. The Panel discussed how those programs encompass the concerns pertaining to this proposed generic issue.

Regarding flooding hazards, the JLD informed the Panel that the scope of the flooding hazard integrated assessment includes relevant systems, structures, and components important to safety and the UHS. As appropriate, this includes flood-induced loss of the UHS due to failure of a downstream dam. As a result, the Panel concluded that flooding hazards to downstream dams impacting the UHS were out of scope because they are being addressed through an ongoing NRC program.

Regarding seismic hazards, the JLD informed the Panel that potential impacts on the UHS due to failure of downstream dams were being addressed through the mitigation strategies program and the seismic hazard integrated assessments. For downstream dams that are not

seismically robust, the NRC's mitigation strategies program is requiring licenses to address sources and access to water supplies in instances where the primary source of water (e.g. downstream dam) is not available. For seismic qualified downstream dams, the scope of the seismic integrated assessments includes these dams. As a result, the Panel concluded that seismic hazards to downstream dams impacting the UHS were out of scope because they are being addressed through ongoing NRC programs.

Therefore, the JLD efforts to address flooding and seismic hazards reduced the scope of the hazards potentially impacting a downstream dam to random (sunny day) failures. The risk significance of a random failure of a downstream dam is influenced by whether alternative means are available to provide cooling water for emergency operations. As mentioned above for downstream dams that are not seismically robust, the NRC required licensees to address sources and access to water supplies in instances where the primary source of water (e.g. downstream dam) is not available. As such, the need for an alternative source of water for the UHS is being addressed for operating NPPs with non-seismic downstream dams through NRC's mitigation strategies program. This alternative source of water could also be relied upon in the event of a random failure of the downstream dam. That is to say, the need for the alternative source of water is not dependent upon whether the downstream dam failed as a result of a seismic event or whether it failed due to a random event. As a result, the Panel concluded that measures to mitigate a random failure of non-seismic downstream dams impacting the UHS were being adequately addressed through an ongoing NRC program. These efforts further reduced the scope of the proposed generic issue to random failure of seismically qualified downstream dams impacting the UHS at operating NPPs.

The staff identified 13 NPP sites with 21 units that rely on downstream dams or impoundment reservoirs as their UHS for emergency cooling water. The Panel conducted a more detailed evaluation of these NPPs to determine whether the proposed generic issue should continue in the Generic Issues program.

To assist with the Panel's evaluation, the staff provided the Panel with a quantitative screening risk analysis of these NPPs to assess the effect from a random failure of their downstream dam [ML15253A402]. Note that this analysis contains sensitive information and is non-public. The results of the analysis showed that the resulting change in core damage frequency (CDF) for the majority of the NPPs fell within the region of "Exclude from Further Consideration" per Figure A2 of the TEC-002. However, the results for two plants (Farley and North Anna) indicated that the change in CDF was slightly greater than the threshold in Figure A2 for determining whether an issue should continue in the Generic Issues program.

Since the calculated risk for Farley and North Anna were just above the threshold, the staff performed a more detailed sensitivity risk analysis of these NPP sites. In addition, the staff analyzed two additional NPP sites (Catawba and Robinson) that had unique system configurations [ML15253A407]. Note that this analysis contains sensitive information and is non-public. The results of the analyses for Farley, North Anna, and Catawba revealed that these sites have two separate UHS reservoirs. One of the two reservoirs is a safety-related, seismic service water reservoir, and the other is a lake or river associated with heat removal from normal plant operations. Either reservoir can be utilized by the plant as the UHS in the event that the other UHS is lost. The additional water source at each NPP provides redundancy, which significantly mitigates the impact of random failure of the other water source. The results of the sensitivity risk analysis for Farley, North Anna, and Catawba indicated that the threshold for continuing to evaluate the proposed generic issue in the Generic Issues program was not met.

With regards to Robinson, the sensitivity risk analysis indicated that the risk met the threshold for issues that should be considered for further evaluation in the Generic Issues program. The Robinson results were unique and driven by uncertainty as to whether two separate UHS water sources exist at the site to mitigate the event. Given the uncertainty, no credit was given for a second UHS water source in the sensitivity risk analysis. Robinson was identified as the only NPP with just once source of water for the UHS in NUREG-0965, "NRC Inventory of Dams." The staff confirmed this through a review of the NRC's Interim Staff Evaluation (ISE) prepared in response to the Mitigating Strategies Order that the NRC issued in response to the Fukushima Dai-ichi accident. The Panel notes that the Robinson Updated Final Safety Analysis Report (UFSAR) states that there are on-site deep water wells that can be connected to the heat exchangers for the emergency diesel generators and backfed to the service water system. There is also some information discussing the potential use of alternative sources of water to the service water system. NRC's risk analysis tools mention these water sources; however, sufficient information on these sources was not available. Therefore, they were not credited in the sensitivity risk analysis as a redundant source of emergency cooling water. Also, these water sources were not credited in the Robinson mitigating strategies because they are not assumed to be available following a beyond-design-basis external event. With no credit taken for these alternative water sources, the potential Generic Issue at the Robinson site meets the threshold in TEC-002 for further consideration. If sufficient credit is given for the alternative UHS water sources, the calculated risk would be lower and the potential Generic Issue at the Robinson site would not meet the threshold for further consideration.

As a final check, the staff reassessed all plants using information in NUREG-0965, the NRC's ISE reports, and the UFSARs to confirm that two separate (i.e., redundant) UHS water sources existed. Redundancy significantly mitigates the impact of a random failure of a downstream dam. The reassessment confirmed that all the plants with downstream dams have two UHS water sources, except for the Robinson plant. As Robinson is the only plant potentially adversely affected by a random failure of a downstream dam, the proposed generic issue does not meet criterion 2, "The issue applies to two or more facilities and/or licensees/certificate holders, or holders of other regulatory approvals."

Regarding Robinson, the purpose of the Panel was to determine whether an issue should proceed to the next step in the Generic Issues Program; it is not to evaluate the unique aspects of one particular site. As a result, the Panel did not conduct any further evaluation of the Robinson site to determine whether credit could be taken for the deep water wells or alternate sources of water for the UHS.

#### Panel's Conclusions and Recommendation

The Panel concluded that the proposed generic issue does not meet all seven screening criteria necessary to proceed forward in the Generic Issues program. Specifically, the Panel concluded that the issue does not meet Criterion 2 "The issue applies to two or more facilities and/or licensees/certificate holders, or holders of other regulatory approvals." Therefore, the

Panel recommends that RES process the proposed generic issue for closure. Additionally, the Panel recommends that RES provide the results of the Panel's evaluation to NRR so that they can determine whether any additional analysis, modeling, or action is needed regarding the configuration of the UHS at the Robinson site.

Enclosures:

1. Seven Screening Criteria
2. Screening Analysis Report

Panel recommends that RES process the proposed generic issue for closure. Additionally, the Panel recommends that RES provide the results of the Panel's evaluation to NRR so that they can determine whether any additional analysis, modeling, or action is needed regarding the configuration of the UHS at the Robinson site.

Enclosures:

1. Seven Screening Criteria
2. Screening Analysis Report

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OFFICE	RES/RGGIB	NRO/DSRA	RES/DRA	RES	NRO/DSRA
NAME	S. Gardocki	M. Pohida	R. Correia	L. Cupidon	J. Monninger (KWebber for)
DATE	03/07/16	03/08/16	03/02/16	03/07/16	03/11/16

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