

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
OFFICE OF FEDERAL AND STATE MATERIALS AND
ENVIRONMENTAL MANAGEMENT PROGRAMS
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

March 5, 2012

NRC INFORMATION NOTICE 2012-02: POTENTIALLY NONCONSERVATIVE
SCREENING VALUE FOR DAM FAILURE
FREQUENCY IN PROBABILISTIC RISK
ASSESSMENTS

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities."

All holders of or applicants for an early site permit, standard design certification, standard design approval, manufacturing license, or combined license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

All holders of and applicants for a fuel cycle facility license under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material."

All holders of and applicants for an independent spent fuel storage installation license under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste."

All holders of and applicants for a gaseous diffusion plant certificate of compliance or an approved compliance plan under 10 CFR Part 76, "Certification of Gaseous Diffusion Plants."

All holders of and applicants for a specific source material license under 10 CFR Part 40, "Domestic Licensing of Source Material."

All Agreement State Radiation Control Program Directors and State Liaison Officers.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to alert addressees of a potentially nonconservative screening value for dam failure frequency that originated in 1980's reference documents which may have been referenced by licensees in their probabilistic risk assessment (PRA) for external events. Using a nonconservative screening value for dam failure frequency to evaluate the need for an additional detailed analysis may

ML090510269

result in underestimating the risks to the plant associated with external flooding or loss of heat sink from the failure of upstream and downstream dams or levees. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

BACKGROUND

The NRC staff has identified a potentially nonconservative screening value for dam failure frequency contained in Nuclear Safety Analysis Center (NSAC) report NSAC-60, "A Probabilistic Risk Assessment of Oconee Unit 3," issued June 1984. NSAC-60 calculated a value for the dam failure frequency of the Jocassee Dam, a value referenced by other licensees in their flooding analyses. The NSAC-60 PRA study determined the failure frequency for the Jocassee Dam by compiling data for dams with similar attributes. NSAC-60 then performed a Bayesian analysis using historical dam failures to estimate the annual failure frequency at the time the analysis was performed (1981) and an associated uncertainty range for dams built within different time periods: 1900–1981, 1940–1981, and 1960–1981. For these time periods, the NSAC-60 PRA analysis determined that the median annual failure frequencies for the Jocassee Dam based on each of these data ranges were 2.3×10^{-5} /year, 1.6×10^{-5} /year, and 1.4×10^{-5} /year, respectively, from causes other than earthquakes and overtopping (which NSAC-60 treated separately).

The NSAC-60 approach estimated the failure frequency for the Jocassee Dam by screening the available historical data for United States (U.S.) dams at the time of the analysis (1981) and using only the data deemed applicable to the Jocassee Dam, based on characteristics such as (1) dam composition, (2) construction completion date, and (3) failure modes. NSAC-60 acknowledged the challenge in collecting sufficient historical information based on the scarcity of the data applicable to the specific dam characteristics considered, as well as the complexity of the actual phenomena controlling dam failures and their potential impacts on a nuclear power plant site.

The NRC subsequently included the NSAC-60 dam failure frequency results in NUREG/CR-5042, "Evaluation of External Hazards to Nuclear Power Plants in the United States," which was initially published in 1987. NUREG/CR-5042 reported bounding calculations with results of " 10^{-6} /year or even smaller" for modern well-engineered dams and a range of values between " 10^{-4} /year and 10^{-5} /year," referring to NSAC-60 in both cases (NUREG/CR-5042, page 5-8, Agencywide Documents Access and Management System (ADAMS) Accession No. [ML111950285](#)). Some licensees referred directly to NSAC-60 as part of their Individual Plant Examination of External Events submittal in response to Supplement 4 to Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities," dated November 23, 1988. In other cases, licensees may have indirectly used NSAC-60 via references such as NUREG/CR-5042.

Bounding values for dam failure frequency, such as those mentioned in NUREG/CR-5042 were not the result of a dam-specific analysis but instead utilized a generic dam failure database to determine a bounding generic estimate of dam failure frequency. The information used to determine the generic estimate can be a starting point to estimate bounding values of dam failure frequency for another dam by adjusting for dam-specific differences involving design, operation, and potential failure mechanisms. For example, including historical dam failure events that failed in a manner that could not occur at the dam being analyzed would increase the estimated dam failure frequency. Also, consideration of site-specific characteristics such as

meteorology and hydrology may either increase or decrease the likelihood of a dam failure with respect to a generic estimate.

DESCRIPTION OF CIRCUMSTANCES

After reviewing the dam failure frequency estimates in NSAC-60, the NRC staff noted that many assumptions in the dam failure rate estimation approach used in NSAC-60 are strongly dependent on the completeness and accuracy of the dam data used and on the criteria for including or excluding certain failure events and operational years deemed to be applicable to characteristics specific to the dam considered in NSAC-60 (i.e., type, height, construction year, and years of operation). The NRC staff also noted that NSAC-60 did not consider hazards in an integrated manner and instead considered several hazard categories separately, leading to certain hazard categories being completely excluded from the calculation of dam failure frequency. In particular, the dam failure frequency derived in NSAC-60 was representative of failure modes resulting from causes other than hydrologic (e.g., severe precipitation) and seismic events, which NSAC-60 considered in separate analyses. The NSAC-60 method considered severe precipitation events to be negligible contributors to downstream impacts and screened them out from further consideration, although these types of events are responsible for the majority of the dam failures recorded in historical data. Additionally, failure modes associated with nonhydrologic, nonseismic phenomena (e.g., internal erosion/degradation) were screened out because they were deemed not applicable based on site-specific design considerations made in NSAC-60. Based on the NRC staff's assessment, screening failure modes from the historical data and special treatment of failure modes may require additional detailed analyses beyond the consideration of the specific dam design features in order to establish sufficient technical bases. Additionally, the NRC staff believes that excluding credible hazard categories such as hydrologic events without an integrated assessment could lead to an underestimation of the true dam failure frequency.

To assess the impact of the NSAC-60 screening assumptions, the NRC staff reviewed currently available databases for U.S. dams. In order to determine generic dam failure frequencies, the NRC staff used the databases to find (1) the number of historical failures of dams of a particular characteristic, such as dam type, and (2) the total number of years of operation for dams of the same characteristic. The NRC staff reviewed databases of historical dam failure events, primarily the National Performance of Dams Program by Stanford University, <http://npdp.stanford.edu>, and a database of the existing U.S. dam population, the National Inventory of Dams maintained by the U.S. Army Corps of Engineers (USACE), <http://nid.usace.army.mil>¹. While these databases contain valuable information and are more complete and accurate than information available when NSAC-60 was prepared, the NRC staff still found challenges in using the databases to justify with sufficient technical basis a very low value of dam failure frequency using only historical data. The databases were not created for the specific purpose of performing dam failure frequency calculations and were not designed to be fully consistent with each other. Notwithstanding, these databases are still the primary source of information on existing dams and events. The discussion contained in this IN does not intend to express judgment on the quality of the efforts to develop these databases; instead, it highlights the challenges in the input and categorization of data for such a wide population that potential users also need to take into account when deriving estimates for low-probability events. For example, the NRC staff found that, for historical dam failure events, there is, as

¹ Although the USACE Web site states, "Non-government users are no longer able to directly download any data from this site," nongovernment users can request access to the data by contacting the USACE staff member specified on this Web site.

indicated by NSAC-60, an inherent challenge in the completeness of failure event accounts (e.g., construction year of failed dam and failure mode) and the consistency of definitions used on both failed and operating dams (e.g., dam types). In particular, eliminating selected failure modes from consideration without sufficient technical basis while retaining the population contribution for total number of years can produce an artificially low dam failure frequency.

To understand the impact of these data challenges, the NRC staff analyzed the ranges of generic dam failure frequency estimates that can be derived from these databases. The NRC staff also reviewed (1) the literature on previously published dam failure rates based on historical evidence for the U.S. and the international population of dams, and (2) available information on the latest dam risk assessment methodologies, including the following publications, which can be obtained from the U.S. Department of the Interior's Bureau of Reclamation (USBR) (<http://www.usbr.gov>): "Comparison of Failure Modes from Risk Assessment and Historical Data from Bureau of Reclamation Dams," revised in 1998; and "Dam Safety Risk Analysis Best Practices Training Manual," Version 2.1, issued in 2010.

Although historical dam failure information can provide useful qualitative insights on the general performance and failure modes for certain dam types, its applicability to site-specific dams has to be assessed to establish sufficient technical bases. This is due to the variability in site-specific characteristics (i.e., hydrologic, geologic, and operational) and the potential contributions of site-specific failure modes not covered by databases. The range of estimates presented in NSAC-60 (i.e., between 2.3×10^{-5} /year and 1.4×10^{-5} /year) is below the range of estimates found in the available literature for generic dam failure rate estimates. Additionally, frequency extrapolations of severe weather phenomena with insufficient basis may not be fully justified depending on the quality and quantity of the supporting information beyond certain values (e.g., see DSO-04-08, "Hydrologic Hazard Curve Estimating Procedures," issued June 2004 by USBR).

DISCUSSION

Both NSAC-60 and NUREG/CR-5042 reference dam failure rate estimates in the context of external flooding analyses incorporating a dam failure. However, recent NRC reviews determined that the generic failure frequency estimate used in NSAC-60 combined generic information with site-specific screening criteria that produced median values lower than those available in published literature on latest dam risk assessment methodologies and NRC staff's assessments. Consideration of data sources currently available also indicates that (1) such significantly lower values may not be justified by historical data alone, and (2) applying the NSAC-60 estimate to other dams with different characteristics may be inappropriate. Reasons for this include the fact that generic failure frequency values may not account for site-specific features and can be highly dependent on the completeness and applicability of available information to site-specific dams, which may counteract conservative assumptions in the use of data. Hence, both NSAC-60 and NUREG/CR-5042 provide an insufficient basis for estimating site-specific dam failure frequency. NRC staff intends to evaluate the need to modify NUREG/CR-5042 based on the items discussed in this generic communication.

These considerations indicate that data available in these databases are useful in identifying failure mechanisms and performance insights as well as approximate generic dam failure rate estimates, but may not provide sufficient basis for site-specific estimates or to screen out the contribution of external flooding sources or loss of ultimate heat sink to the overall plant risk. Generic failure rate estimates encompass all documented dam failures, irrespective of their potential impacts on a downstream site. By including a large population of dams with a wide

variety of features, the resulting failure frequency may or may not be appropriate for any one specific dam or nuclear power plant site. Although there is no specific regulatory requirement to do so, addressees may evaluate their current or planned site-specific estimate of dam failure frequency in light of the information contained in the IN and address any resulting implications on their external event PRA. Based on the information discussed above, NRC staff has initiated an internal review under the Generic Issues Program, managed by the NRC Office of Nuclear Regulatory Research, to consider this issue in a generic sense (ADAMS Accession No. [ML102210339](#)).

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below.

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Note: NRC generic communications may be found on the NRC public Web site, <http://www.nrc.gov>, under NRC Library.

