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

CHAIRMAN

June 30, 2016

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SPECIAL COUNSEL
WASHINGTON, D.C.

Carolyn N. Lerner
Special Counsel
U.S. Office of Special Counsel
1730 M Street, N.W., Suite 218
Washington, D.C. 20036-4505

Re: OSC File No. DI-15-5254

Dear Ms. Lerner:

By letter dated April 12, 2016, you referred a whistleblower disclosure to me. Pursuant to 5 U.S.C. § 12.13(c)(1), the U.S. Office of Special Counsel (OSC) requested that I, as the Chairman of the U.S. Nuclear Regulatory Commission (NRC), investigate the whistleblower's allegations and submit a written report setting forth my findings to OSC. OSC requested an investigation of the whistleblower's allegations that the NRC has failed to:

- require Oconee Nuclear Station in South Carolina to take corrective measures to safeguard the plant from potential flooding should the Lake Jocassee Dam fail; and
- require 18 other nuclear power stations to take appropriate measures to protect against the risk of flooding in the event of upstream dam failures.

OSC also requested that the investigation address five additional questions related to NRC actions with respect to flooding hazards at nuclear power plants. As discussed below, the referred allegations were not substantiated.

The NRC's organic statute, the Atomic Energy Act of 1954, as amended (AEA), "requires the NRC to provide 'adequate protection' for the health and safety of the public, which the NRC seeks to ensure on an ongoing basis through an 'evolving set of requirements and commitments for a specific plant that are modified as necessary over the life of a plant to ensure continuation of an adequate level of safety.'"[1] Adequate protection is not a fixed standard, but rather involves a case-by-case application of technical judgment of the Commission.[2] Adequate protection does not equate to zero risk from regulated activities, and the courts have long held that the NRC's adequate protection standard permits the acceptance of some level of risk.[3] When exercising engineering and scientific judgment in the light of all relevant and material information, the NRC reviews credible hazards identified by license applicants (following NRC published guidance), then requires that designs be able to cope with such hazards with sufficient safety margins and reliable backup systems. The NRC has previously determined that

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[1] *Massachusetts v. NRC*, 708 F.3d 63, 67 (1st Cir. 2013) (citations omitted).

[2] *Union of Concerned Scientists v. NRC*, 880 F.2d 552, 558 (D.C. Cir 1989).

[3] *Public Citizen v. NRC, 473 F.3d 916, 918 (1st Cir. 2009)* (quoting *Union of Concerned Scientists v. NRC*, 824 F.2d 108, 118 (D.C. Cir. 1987)).

compliance with the NRC's regulations provides "reasonable assurance of adequate protection," but has also concluded that "failure to comply with one regulation or another is [not] an indication of the absence of adequate protection . . . where the Commission has reviewed the noncompliance and found that it does not pose an 'undue risk' to the public health and safety."[4] The NRC's regulatory regime is discussed in more detail in Section 3 of the Investigative Report.

Given the technical nature of the allegations, I convened a working group to initiate the inquiry that resulted in the development of the enclosed Investigative Report, which addresses the matters identified in your letter. I have reviewed the Investigative Report and adopt its content and findings. As is detailed in the Report, the allegations referred by OSC are unsubstantiated. Contrary to the whistleblower's allegations, the NRC has taken the actions that the agency has determined to be necessary to ensure that the public health and safety is adequately protected from potential flooding caused by credible upstream dam failures at the Oconee Nuclear Station[5] and the other 18 nuclear power stations identified by OSC. In addition, as detailed in the report the NRC's actions have:

- been in accordance with the NRC's functions and authorities under the AEA;
- been in conformance with NRC programs, processes, and procedures, including those for addressing differing staff views; and
- followed normal NRC processes for resolution of technical issues and response to operating events.

The whistleblower's disagreement with the actions taken by the NRC does not equate to inaction.

I also note that it is not clear that there is necessarily disagreement between the whistleblower and the agency over whether the NRC has acted appropriately to address potential flooding hazards. During his interview the whistleblower acknowledged that his primary concern pertains to the non-public nature of certain NRC and other federal agency documents and not whether the NRC has fulfilled its statutory obligation regarding the identified facilities. In its regulation of nuclear power facilities and other licensed activities, the NRC endeavors to make a substantial portion of its documentation available to the public. Nonetheless, some information may be legitimately withheld from public disclosure to protect, for example, inter-agency information, proprietary information, or security-related information. The whistleblower has frequently availed himself of the processes afforded under the Freedom of Information Act to seek access to NRC non-public (FOIA) documents, and has been

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[4] *In the Matter of All Reactor Licensees with Installed Thermo-Lag Fire Barrier Material*, DD-96-3, 43 NRC 183, 195 (1996) (quoting *In the Matter of Ohio Citizens for Responsible Energy*, DPRM-88-4, 28 NRC 411 (1988)).

[5] The Investigative Report indicates that the NRC staff would not make a final determination on whether the licensee for Oconee had met the commitments of a June 22, 2010 Confirmatory Action Letter (CAL) completed until the permanent modifications were completed. On June 20, 2016, the NRC staff issued a follow-up inspection report documenting the NRC's determination that Oconee has satisfied the terms of the CAL and that the June 22, 2010 CAL is now closed. The June 20, 2016, letter also noted that additional ongoing external flooding issues will be addressed separately. Catherine Haney, NRC, letter to Scott Batson, Duke Energy Carolinas, LLC, "Oconee Nuclear Station – Confirmatory Action Letter Followup Inspection Report 05000269/2016009, 05000270/2016009, and 05000287/2016009, dated June 20, 2016. ADAMS Access No. ML16168A176.

informed that under FOIA the agency may permissibly withhold certain information from public disclosure. The whistleblower's dissatisfaction with the NRC's lawful use of FOIA withholding exemptions cannot be remedied through the OSC's disclosure process. Please note, however, that the Investigative Report being provided to you today does not contain any personally identifiable information, sensitive unclassified security-related information, or classified information that would require it to be withheld from the public.

Under 5 U.S.C. § 1213(d)(5), the investigative report provided in response to the OSC referral is to include a description of any action taken or planned as a result of the investigation. As I previously noted, the whistleblower's allegations were not substantiated and, therefore, no further action is warranted.

If you have any questions regarding this matter, please contact my Legal Counsel, Tracey Stokes, at (301) 415-1747.

Sincerely,

Stephen G. Burns

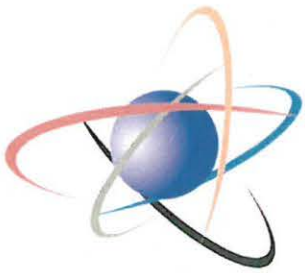
Enclosures:
NRC Investigative Report Re: OSC File No. DI-15-5254

cc: Commissioner Svinicki
Commissioner Ostendorff
Commissioner Baran

NRC FORM 8C
(7-94)
NRCMD 3.57

COVER SHEET FOR CORRESPONDENCE

USE THIS COVER SHEET TO PROTECT ORIGINALS OF MULTI-PAGE CORRESPONDENCE



U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

INVESTIGATIVE REPORT TO THE CHAIRMAN OF THE U.S. NRC

RE: OSC FILE NO. DI-15-5254

EXECUTIVE SUMMARY

This report documents the activities of the U.S. Nuclear Regulatory Commission (NRC) Flooding Working Group, which was established by NRC Chairman Stephen G. Burns to inquire into whistleblower disclosures provided to the Office of Special Counsel (OSC) with respect to the risk from flooding at nuclear power plants located downstream from dams. The specific allegations to be investigated are:

1. NRC has failed to require the Oconee Nuclear Station in South Carolina [referred to as Oconee] to take corrective measures to safeguard the plant from potential flooding should the Lake Jocassee Dam fail.

2. NRC has also failed to require 18 other nuclear power stations to take appropriate measures to protect against the risk of flooding in the event of upstream dam failures.

In addition, the Flooding Working Group considered whether any NRC action or inaction could be considered a failure to fulfill the agency's statutory obligation to provide reasonable assurance of adequate protection to public health and safety, such that it could constitute a violation of law, rule, or regulation; gross mismanagement; or abuse of authority.

During the investigation, the Flooding Working Group developed a practical understanding of, and significant insights into, the evolving scientific and engineering state of knowledge related to dam safety, dam failure likelihood, dam failure analysis, consequential flooding scenarios, and their implications for the health and safety of the public. The Flooding Working Group determined that it had sufficient knowledge and experience with NRC safety decision-making, regulatory programs, and legal processes; time and resources; access to both public and non-public information; and access to knowledgeable individuals to make an informed judgement on the matters referred to the NRC by OSC.

The report contains a sufficient amount of material to support the findings and conclusions while avoiding the disclosure of any personally identifiable information, sensitive unclassified security-related information, or classified information. It includes a summary of information investigated and a description of the conduct of the investigation. In addition, the report presents the evidence collected through a transcribed interview of the whistleblower, interviews of NRC staff directly involved in the evaluation of potential dam failures and their consequences, and NRC and licensee documents that described dam failure analyses, related NRC actions, and licensee modifications to their facilities and operations.

The report also provides responses to five specific questions posed by OSC:

1. *Has NRC required [Oconee] to take adequate corrective measures to safeguard the plant from potential flooding in the event of a failure of the Lake Jocassee Dam? If so, describe the measures and when they were taken.*

   Yes. Section 4.1 documents the NRC-required actions and related activities, both complete and ongoing, taken with respect to Oconee.

2. *Has NRC required the 18 other nuclear power stations identified in Appendix A [to the OSC referral] to take appropriate measures to protect against the risk of flooding in the event of upstream dam failures? If so, describe the measures and when they were taken.*

Yes. Section 4.2 documents the NRC-required actions and related activities taken with respect to the nuclear power plants at the other 18 sites identified.

3. *What action has been taken to address the risk of flooding from upstream dam failures? Are there actions planned that have not yet been completed?*

   Section 4.3 provides a summary of the numerous NRC and licensee actions related to the issue of potential dam failures and consequential flooding. Five specific and relevant topics are addressed for each plant. Further details are provided in Appendix B to this report for each topic for the 19 sites evaluated.

4. *What is the current risk to public health and safety from potential flooding of the 19 nuclear power plants identified in Appendix A [to the OSC referral letter]?*

   Section 4.4 presents the working group's views and conclusions on the current risk to from dam-failure-related flooding. In short, the current risks to public health and safety are very small and within the Commission's mandate to provide adequate protection.

5. *Would the risk to public health and safety from potential flooding of nuclear power plants identified in Appendix A [to the OSC referral letter] have been reduced if NRC had required those plants to take action to protect against flooding in 2013?*

   Section 4.5 presents information concluding that risk reductions were achieved before 2013, have been achieved since 2013, and are expected to be further enhanced upon completion of ongoing licensee actions that resulted from NRC requirements.

The report concludes the following with respect to the allegations regarding the NRC's response to the potential failure of dams upstream from Oconee and the other 18 sites:

- The NRC has required Oconee and the plants at the other 18 sites to take appropriate action to provide adequate protection to public health and safety from rare but credible upstream dam failures.

- The NRC actions have been in accordance with the functions and authorities of the Atomic Energy Act, as amended. No violation of law, rule, or regulation; gross mismanagement; or abuse of authority was found.

- The NRC actions, including orders, requests for information, enforcement actions, and rulemaking activities, have been in conformance with NRC programs, processes, and procedures, including those for addressing differing staff views.

- The NRC actions followed normal NRC processes for resolution of technical issues and response to operating events and were independent of the whistleblower disclosure.

- Continued timely, efficient, and effective use of these programs, processes, and procedures by NRC staff, implementing Commission decisions and considering all available information and technical viewpoints, provides the best and most appropriate means of bringing the ongoing dam failure and flooding reviews to appropriate conclusions. In addition, these programs, processes, and procedures constitute an appropriate and effective means of addressing emerging issues of potential safety significance in the future.

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1 Summary of Information Investigated

This report documents the investigation of the following two allegations transmitted to the Chairman of the U.S. Nuclear Regulatory Commission (NRC) by the Special Counsel of the United States.[1]

1. NRC has failed to require the Oconee Nuclear Station[2] in South Carolina to take corrective measures to safeguard the plant from potential flooding should the Lake Jocassee Dam fail.

2. NRC has also failed to require 18 other nuclear power stations to take appropriate measures to protect against the risk of flooding in the event of upstream dam failures.

The report also answers the following five questions that were also included in the letter from the Office of Special Counsel (OSC).

1. Has NRC required [Oconee] to take adequate corrective measures to safeguard the plant from potential flooding in the event of a failure of the Lake Jocassee Dam? If so, describe the measures and when they were taken.

2. Has NRC required the 18 other nuclear power stations identified in Appendix A [to the OSC referral letter] to take appropriate measures to protect against the risk of flooding in the event of upstream dam failures? If so, describe the measures and when they were taken.

3. What action has been taken to address the risk of flooding from upstream dam failures? Are there actions planned that have not yet been completed?

4. What is the current risk to public health and safety from potential flooding of the 19 nuclear power plants identified in Appendix A [to the OSC referral letter]?

5. Would the risk to public health and safety from potential flooding of nuclear power plants identified in Appendix A [to the OSC referral letter] have been reduced if NRC had required those plants to take action to protect against flooding in 2013

[1] Carolyn N. Lerner, U.S. Special Counsel, letter to Stephen G. Burns, NRC, "OSC File No. DI-15-5254," dated April 12, 2016.
[2] Referred to in the remainder of the report as Oconee.

2 Conduct of Investigation

After receiving the April 12, 2016, letter from OSC, Chairman Stephen G. Burns convened a Flooding Working Group to inquire into the whistleblower disclosure provided to OSC and to provide a report to the Chairman of the working group's findings. The working group consists of the following senior NRC staff members[3] who were assigned to the Chairman's office to conduct the investigation: Sara Kirkwood (legal team lead), Gary Holahan (technical team lead), and Theresa Clark (technical staff).

The working group began the investigation by reviewing the referral letter from the OSC. The working group also examined hundreds of public and non-public documents in the NRC's Agencywide Documents Access and Management System (ADAMS), as well as documents provided to the working group by the whistleblower and other interviewed employees.[4] These documents are summarized and referenced in the sections that respond to the OSC questions.

In addition, the working group considered testimonial evidence provided in interviews with four NRC staff members, including the whistleblower. The interview with the whistleblower was transcribed, and the working group prepared summaries of the other interviews (which the interviewees were given an opportunity to review). The working group used these documents as references in considering the insights gained from the interviews.

2.1 Summary of the Testimonial Evidence

2.1.1 Summary of Evidence from Whistleblower Interview

On May 19, 2016, the working group interviewed the whistleblower, Mr. Lawrence Criscione, in a transcribed interview. Mr. Criscione was accompanied by his attorney, Mr. Thomas Devine.

Mr. Criscione stated that he became involved in the evaluation of flooding from upstream dam failures in February 2010. At the time, colleagues in his branch in the Office of Nuclear Regulatory Research (the generic issues branch) were working on a screening analysis on upstream dam failures for what later became Generic Issue 204. He was not assigned to this project, but stated that they consulted with him because of his experience as an operator at commercial nuclear power plants. Mr. Criscione also stated that the authors of the screening analysis report felt pressure to not include certain information in their documents, but that they submitted the report they wanted to submit in the end. Mr. Criscione did not know what information the authors felt pressured to exclude from the report, and encouraged the working group to speak with the authors of the report. Mr. Criscione stated that he was satisfied that the screening analysis report was complete and had all the necessary information.

Mr. Criscione stated the he provided to OSC the list of 19 sites, and that the list came from the Generic Issue 204 screening analysis report. He stated that he did not have any specific concerns about any of the 19 sites, but that they were just the ones in the screening analysis report. Mr. Criscione indicated that he had no insights into these matters other than what he had read in the Generic Issue 204 report, and that he believed that his colleagues thought that

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[3] In this report, "NRC staff" is used as a collective term for the staff of the NRC, as distinct from the Commission. The Commission has delegated authority to the NRC staff to take certain actions, and "NRC staff" actions reflect agency positions on these matters. It does not imply action taken by an individual; in specific cases (such as the statement of a differing view from the agency position), the term "NRC staff member" is used instead.

[4] The publicly available version of ADAMS is accessible via http://adams.nrc.gov/wba/ and the hyperlinked accession numbers within this document.

flooding issues were not being appropriately addressed. Mr. Criscione stated that he did not know the current status of Generic Issue 204. Mr. Criscione stated that he thought Fort Calhoun had a particularly credible hazard from dam failure. He said that he knew the NRC had a study on Fort Calhoun, but that he had not been given access to the study. He further stated that he had heard that H.B. Robinson, Watts Bar, Browns Ferry, and Sequoyah were of concern to some people, but he did not know specifics for any of these sites. He stated that he had observed dams leak in the past while hiking on the Appalachian Trail. He stated that he was not a civil engineer or a hydrologist and did not know if seepage through a dam is acceptable or not.

Specifically with respect to Oconee, Mr. Criscione stated that he did not know if the NRC had completed its review of the potential for dam failure to affect the site. He stated that he has never been assigned to work on Oconee. Mr. Criscione could not specifically identify what provisions he would view as sufficient to protect Oconee and suggested that the working group speak with Mr. Jeffrey Mitman. He stated that technical staff members felt pressured to "pencil-whip" their calculations to the point that the risk estimates were acceptable. Mr. Criscione stated that he had not personally experienced this pressure. Mr. Criscione stated that he did not think he had read any documents on Oconee that were written after 2012, but that he had heard a rumor that the NRC was accepting a lower flood height. He referred the working group to Dr. Michelle Bensi for further information. Mr. Criscione stated that Oconee had committed to shut down the plant if the reservoir water level in Lake Jocassee goes over a certain height, but that he was concerned that still today it was not in the plant procedures. He believes that this shows that the potential for dam failure flooding at Oconee had not been adequately addressed. Mr. Criscione stated that he did not know at what water level Oconee should shut down, and he was not sure in what document Oconee committed to a plant shut down. He suggested that Mr. Mitman would have more information on this topic

Mr. Criscione stated that, in his view, adequate protection could not be provided by mitigation measures. He based this on his 22 years working in nuclear power. He defined adequate protection as meaning that the installed safety equipment could survive the flood, and mitigation as meaning that the installed safety equipment might not survive, but that other equipment could prevent the reactor core from melting. He further stated that adequate protection meant that the reactor core had to be cooled with installed equipment.

Mr. Criscione stated that he believed the working group had all of the documents it needed to investigate his concerns. He was not aware of any documents that were wrong or inaccurate.

Mr. Criscione stated that he had not closely followed the issues regarding flooding from dam failures since 2013, and that the working group should speak with others who were more involved with this issue than he was. Mr. Criscione provided the names of several other individuals who he believed had concerns. He stated that Dr. Bensi had concerns that she would not share with Mr. Criscione because he did not have a need to know. He stated that Mr. Jacob Philip had concerns about the walkdowns that had been done. He stated that Mr. Joseph Kanney expressed a willingness to speak with the working group, but Mr. Criscione did not identify any specific concerns that Mr. Kanney would share. He stated that Mr. Mitman could describe a concern that the Oconee analysis was not conservative because Mr. Mitman believed that it was possible for the dam to fail by erosion if flood waters exceed the dam height (generally referred to as overtopping). Mr. Criscione relayed what he believed these concerns to be, as well as his view on Oconee's planned actions to avoid overtopping.

Additionally, Mr. Criscione stated the following concerns that were outside the scope of the investigation:

1. Mr. Criscione stated that he believed that the NRC had not appropriately considered whether there was sufficient security around dams. His basis for this was that he had sent a request to the NRC Inspector General under the Freedom of Information Act requesting any studies on the topic; he was told that there were no records that met his request in the Inspector General's office. Mr. Criscione stated that in his position he would not have any way of knowing whether or not such a study had ever been done.

2. Mr. Criscione believes that the NRC should communicate to the public that the NRC is, in his view, relying on mitigation rather than adequate protection and that, in his view, this communication had not been done. He believes that it needs to be unequivocally stated to Congress and the public that the agency is not going to ensure adequate protection for a dam failure.

3. Mr. Criscione stated that his main concern is that the documents concerning these issues needed to be publicly available.

4. Mr. Criscione stated that staff members were restricted from speaking to people even within their own branch, claiming they did not have a need to know. Mr. Criscione believes this is affecting the open and collaborative work environment in the agency. Mr. Devine stated that he believes that the suppression of necessary work-related communications is within the scope of the disclosure.

2.1.2 Summary of Evidence from Dr. Michelle Bensi

The working group met with Dr. Bensi at the suggestion of Mr. Criscione, who had indicated multiple times that she was in a better position than he was to speak to the technical aspects of his concerns. Dr. Bensi has a doctorate in civil engineering and works primarily in the area of seismic risk. She was involved in Generic Issue 204 while she was in the Office of Nuclear Regulatory Research. Dr. Bensi later transferred to the Office of New Reactors, where she became involved in the reviews of flooding information submitted by licensees after the Fukushima Dai-ichi accident. Dr. Bensi expressed that there was significant technical disagreement within the NRC staff regarding the appropriate way to resolve flooding concerns. She stated that she found her division director, Mr. Scott Flanders, to be an amazingly supportive person, and stated that while she has not always agreed with the ultimate technical conclusion, she believes that she has been heard.

Dr. Bensi identified herself as an author of the screening analysis for Generic Issue 204. She denied ever being asked to remove anything from the screening analysis for Generic Issue 204.[5] She stated that the list of plants was included in the Generic Issue 204 screening analysis report to indicate that those sites had an upstream dam; therefore, multiple sites had the potential to be affected by an upstream dam failure, establishing that upstream dam failures was a potential generic issue rather than a plant-specific issue.

[5] On Friday, June 10, 2016, Dr. Bensi contacted the working group and clarified that there had been discussion regarding whether some of the detailed information for GI-204 was necessary. The ultimate resolution was to create a public and a non-public version.

Dr. Bensi stated that she was responsible for the NRC review of the seismic failure analysis for Jocassee Dam upstream from Oconee and agreed that seismic failure could be appropriately screened out.

Dr. Bensi stated that the NRC staff has not been restricted in what they write in their reports as a result of security concerns; however, portions of those reports have been withheld from the public because of the security sensitivity of certain information. She further stated that she believes the security concerns have restricted the free flow of information among NRC staff, but she has not been personally affected by this.

2.1.3 Summary of Evidence from Mr. Jeffrey Mitman

The working group met with Mr. Jeffrey Mitman at the suggestion of Mr. Criscione. Mr. Mitman is a Senior Reliability and Risk Analyst. He has 35 years of experience in the nuclear industry and 20 years of probabilistic risk assessment experience. Mr. Mitman stated that his involvement in the Oconee dam flooding issues occurred when his division was asked to look at the dam failure frequency following an inspection finding at Oconee in 2006. Once the probabilistic portion of the NRC staff's assessment was complete, he was no longer involved in the review.

Mr. Mitman filed a non-concurrence in 2011 on the NRC staff's assessment of the licensee's dam failure flooding analysis, because he did not find the assumptions used to eliminate an overtopping failure of the Oconee dam to be sufficiently conservative. In the interview, Mr. Mitman provided clarifying information on the basis for this non-concurrence that facilitated the working group's evaluation of available documents.

2.1.4 Summary of Evidence from Dr. Christopher Cook

The working group met with Dr. Christopher Cook since his staff is responsible for many of the documents that the working group has been reviewing. Dr. Cook is the supervisor of a hydrology and meteorology group in the NRC's Office of New Reactors. He has a doctorate in civil engineering and has over 16 years of experience working with dams.

Dr. Cook was not involved with reviews of Oconee prior to the flooding reviews conducted in response to the Fukushima Dai-ichi accident in Japan in 2011. He was generally aware of the issues at Oconee and has always thought the licensee's dam failure flooding analysis accepted by the NRC staff in 2011 was very conservative. Dr. Cook stated that the NRC staff suggested to the licensee that they could simply use this earlier flooding evaluation to respond to the NRC's request for information after the Fukushima Dai-ichi accident, rather than doing a new hazard reevaluation, but that the licensee opted to do the reevaluation.

Dr. Cook stated that in reviewing the flooding hazard reevaluation, the NRC staff carefully considered the different potential failure modes of Jocassee Dam. He stated that he was not aware of any disagreement among the review team regarding the appropriate flood level at Oconee. He stated that he was not familiar with Mr. Mitman's 2011 non-concurrence, but that he was thoroughly convinced that an overtopping failure did not need to be further evaluated. He provided additional background on the NRC staff's visits to Oconee, discussions with staff of the licensee and the Federal Energy Regulatory Commission, and independent evaluations that provided the basis for the NRC staff to conclude that the flood level was reasonable. In particular, he described the conservatisms in the modeling of the water inflow to Jocassee Reservoir during an extreme storm and the reasonableness of the assumptions on outflow based on the operation of the dam.

Furthermore, Dr. Cook stated that the NRC staff's assessment was a collaborative effort with input from Dr. Nebiyu Tiruneh (another hydrologist in his branch), Dr. Bensi, consultants from the Center for Nuclear Waste Regulatory Analysis, contractors at Oak Ridge National Laboratory, staff of the Federal Energy Regulatory Commission, and Dr. Tony Wahl (a researcher at the U.S. Bureau of Reclamation). All of these individuals and groups had free access to all the information they needed to review the hazard analysis. He stated that the other plant reviews had a similar level of collaboration and emphasized that his staff had not raised any safety concerns to him regarding the flooding assessments that had been completed to date.

Dr. Cook stated that all dams leak, and leakage alone does not indicate a problem with the dam. Dr. Cook stated that there is a tremendous amount of engineering judgment involved in determining how a dam fails and how floods develop. In order to do the analysis, calculations are performed in multiple analytical models and ranges of parameters and results are considered.

2.2 Weighing of the Evidence

No person who was interviewed identified any concerns with the validity of the documents reviewed by the working group, and none expressed a concern that any specific document had been altered or modified. Thus, the working group relied on the documents as the primary source of information for this report.

The working group credited the testimony of individuals within the scope of their own personal knowledge and expertise. For issues regarding dam failures, the working group primarily credited the testimony of Dr. Cook, due to his academic degrees in a related field (civil engineering related with a focus on hydrology issues), his lengthy experience with dams, and his personal involvement with the reviews at issue. Similarly, the working group credited the testimony of Dr. Bensi and Mr. Mitman for the reviews they were personally involved in. Mr. Criscione testified that he was not personally involved in any of the reviews at issue. Moreover, Mr. Criscione does not have an academic background or professional experience in seismology, hydrology, or civil engineering. Thus, to the extent that his testimony conflicted with others', the other testimony was given more weight.

While the working group has carefully reviewed actions taken related to all 19 sites identified in the OSC referral letter, the working group specifically notes the testimony of Mr. Criscione that he obtained the list of sites from the Generic Issue 204 screening analysis report, and that he did not have any specific concerns about those sites. The working group also noted the testimony of Dr. Bensi that the list of 19 sites in the Generic Issue 204 screening analysis report was included to establish that upstream dam failures was a generic issue, not to indicate any particular concern with any of those sites.

From the testimony, it was clear that reasonable people can come to different conclusions regarding technical and regulatory questions. In some areas, such as the standards to be used for licensing plants or the use of mitigation versus protection, the Commission has taken relevant positions. In other areas, technical judgment may differ, such as in estimating the likelihood of a dam failure and how a dam failure would progress and result in a flood that could affect a nuclear power plant. This is a complex technical issue, and there is not a uniformly accepted technical model.

There was testimony from Mr. Mitman, Dr. Bensi, and Mr. Criscione that restrictions on dissemination of information regarding dam failure was restricting the free exchange of ideas within the NRC staff. Mr. Criscione expressed this particularly forcefully. However, Mr. Criscione was not able to identify any projects to which he was assigned wherein he was not allowed free access to all information he needed. Similarly, Dr. Bensi testified that these restrictions had not inhibited her work. Mr. Mitman identified that he requested but did not receive a copy of a specific detailed flooding analysis for Oconee in the context of preparing his non-concurrence in 2011. However, Mr. Mitman was later told that the NRC staff did not actually have the report. Dr. Cook testified credibly that all staff members assigned to a project had access to all the information they needed. Similarly, he testified that the reviews were done in a collaborative manner, and involved multiple NRC staff members, as well as contractors and staff from other Federal agencies. Since Dr. Cook has the most personal knowledge of how these reviews are being conducted, the working group credited his testimony on this issue. The working group does not find that concerns regarding a "need to know" have adversely affected the conclusions the NRC staff has drawn regarding the likelihood or consequences of dam failures either at Oconee or the other 18 sites identified by OSC.

2.3 Standard of Proof

As explained above, the working group did not have significant factual or legal disputes to resolve in answering the questions in the OSC referral. The working group did find that there were examples of significant technical and regulatory disputes among NRC staff regarding what actions the NRC should take on these issues. The working group did not attempt to resolve these individual technical or regulatory disputes, or to apply a standard of proof to their resolution. Rather, the working group developed its responses to the OSC questions by considering the overall agency actions and positions that were taken or are planned to be taken. In the view of the working group, resolution of these technical and regulatory disputes has been addressed and is best achieved within the agency using existing agency processes.

3 NRC Regulatory Context

A brief summary of the NRC's regulatory approach is provided below as context for understanding the agency's actions regarding dam failures. More detailed background, including definitions and additional references, is presented in Appendix A.

The NRC is provided authority under the Atomic Energy Act[6] to execute its mission: to license and regulate the Nation's civilian use of radioactive materials to protect public health and safety, promote the common defense and security, and protect the environment. This mission is primarily implemented through licensing, oversight, rulemaking, and research. The NRC licenses commercial nuclear power plants using an "adequate protection" standard, which is a case-by-case judgment using all relevant engineering and scientific information. One aspect of licensing reviews is the evaluation of natural hazards, including flooding, to determine that a proposed site is a safe place to build a nuclear power plant.

After a license is issued, the NRC has various processes for addressing new information and taking appropriate action. Steps in these processes include collecting appropriate information, evaluating the information for safety significance (including whether immediate action is warranted), considering the legal and procedural implications of the new information, considering any differing technical views, soliciting public input as appropriate, and taking necessary regulatory action. These deliberative processes can take significant time and technical and regulatory resources to complete. The NRC strives to make well-informed decisions in a timeframe appropriate to the safety significance of the various issues it considers.

The NRC has a formal office procedure to determine whether an immediate plant shutdown is warranted given new information.[7] If so, the process for issuing a safety order would generally be implemented. If not, this decision is documented, along with an appropriate justification for continued operation while the issue is resolved. Often, licensees implement interim compensatory measures while resolution of the issue is pursued. This report includes several examples of such measures.

In considering whether it should require changes at a plant as a result of new information, the NRC uses a structured process referred to as the "backfit" process. The NRC considers whether changes are necessary to provide adequate protection to the public health and safety, to ensure compliance with the plant's licensing basis, or to provide a substantial safety enhancement for which the costs are justified. Licensees also voluntarily make plant changes to enhance safety. Some of these enhancements are formalized by NRC action after they are implemented.

An example of this deliberative approach is the NRC's response to the Fukushima Dai-ichi accident, flooding aspects of which are described in detail in this report. The NRC's Near Term Task Force charged with evaluating this accident recommended several safety enhancements that ultimately resulted in orders and formal requests for information.[8] However, the Near Term Task Force also concluded that "continued operation and licensing activities do not pose

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[6] The Atomic Energy Act of 1954, as amended. Public Law 83-703. The full text of the Act is provided in NUREG-0980, Volume 1, Number 10, "Nuclear Regulatory Legislation – 112th Congress; 2nd Session," dated September 2013. ADAMS Accession No. ML13274A489.

[7] LIC-504, Revision 4, "Integrated Risk-Informed Decision-Making Process for Emergent Issues," dated June 2, 2014. ADAMS Accession No. ML14035A143.

[8] The authority to issue such requests is included in Section 182a of the Atomic Energy Act and implemented in Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54, "Conditions of licenses," paragraph f, which is referred to as 10 CFR 50.54(f) in this report.

imminent risk to public health and safety," and the later orders included the same statement about continued operation. The requests for information that were issued inherently recognize the safety of continued operation, since the request is for information "to enable the Commission to determine whether or not the license should be modified, suspended, or revoked" in the future. As the NRC completes its evaluation of the information obtained through these requests, actions already implemented by licensees—both voluntarily and as a result of other NRC requirements—provide further confidence in the safety of the operating fleet.

In addition, throughout the NRC staff activities related to dam failure analysis, the NRC has implemented various processes to ensure that differing views were raised and addressed, such that well-informed technical decisions were made. These processes range from informal conversations among staff and management to formal reconsideration of a final agency position. These processes, all of which were used in addressing the issues discussed in this report, are described in Section A.6 of this report.

4 Response to OSC Questions

This section presents the answers to the five specific questions contained in the OSC referral. These answers also form the basis for the overall findings with respect to the whistleblower disclosure, which are presented in Section 5 of this report.

4.1 Question 1: Evaluation of NRC-Required Actions at Oconee

Question 1 in the OSC letter asked:

> Has NRC required Oconee to take adequate corrective measures to safeguard the plant from potential flooding in the event of a failure of the Lake Jocassee Dam? If so, describe the measures and when they were taken.

Yes, the NRC has taken appropriate regulatory action as the state of knowledge developed and potential safety implications were identified.

4.1.1 2012 NRC Orders and Information Requests

As described in detail in Appendix B, on March 12, 2012, the NRC issued an immediately-effective order (designated Order EA-12-049[9]) to Oconee and all other reactor licensees "with regard to requirements for mitigation strategies for beyond-design-basis external events." Order EA-12-049 required licensees to develop a three-phase approach to an extended loss of all electrical power as a result of a beyond-design-basis external event. Order EA-12-049 also required licensees to address flooding from dam failure or from other sources as a category of external events.

The specific flooding events to be addressed by the mitigation strategies are being established for each site (including Oconee) through reevaluations of flooding hazards using insights from state-of-the-art information and techniques similar to those used to assess new reactor sites. The hazard reevaluations were required by the NRC as part of the information request (referred to as a 10 CFR 50.54(f) letter) issued to Oconee and all other reactor licensees on March 12, 2012.[10] Enclosure 2 to the 10 CFR 50.54(f) letters provided detailed instructions on the required evaluation, including a hazard reevaluation report and an integrated assessment report to be prepared if "the current design basis floods do not bound the reevaluated hazard for all flood causing mechanisms."

Duke Energy, the licensee for Oconee, submitted its reevaluation of potential flooding events on March 6, 2015.[11] The NRC completed its review and approval of the reevaluated hazard on April 14, 2016.[12]

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[9] EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012. ADAMS Accession No. ML12054A735.

[10] "Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights From the Fukushima Dai-ichi Accident," dated March 12, 2012. ADAMS Accession No. ML12053A340.

[11] Scott L. Batson, Duke Energy, letter to NRC, "Oconee, Units 1, 2 and 3 – Submittal of Revised Flood Hazard Reevaluation Report per NRC"s Request for Additional Information," dated March 6, 2015. ADAMS Accession No. ML15072A106.

[12] Jack R. Davis and Anne Boland, NRC, letter to Scott Batson, Duke Energy Carolinas, LLC, "Oconee Nuclear Station, Units 1, 2, and 3 – Staff Assessment of Response to 10 CFR 50.54(f) Information Request Flood-Causing

In addition, the 10 CFR 50.54(f) letter included a request for licensees to perform flooding "walkdowns" (physical verification of the state of the plant with respect to flood protection features) using an NRC-endorsed methodology. Licensees were expected to identify conditions of concern, identify actions taken or planned to enhance flood protection, and verify the adequacy of maintenance and monitoring for flood protection features. Specific information on the conduct and findings of the flooding walkdowns at Oconee is included in the response to Question 3 below.

The facility changes that resulted from the NRC's actions in issuing this order and information request are detailed in the response to Question 3.

4.1.2 Additional NRC Actions

The NRC, and its predecessor the Atomic Energy Commission, always considered and addressed the potential for dam failures to affect reactor safety. The state of knowledge associated with the likelihood and causes of dam failures has evolved over the last half century, within the NRC and in the scientific community in general

1994-1995 NRC Inspection and Risk Assessment

NRC inspection activities at Oconee during 1994 and discussions of newly available flooding information led to a licensee commitment to study the safety significance of the issues more fully. That study was conducted as part of the Individual Plant Examination for External Events (IPEEE) performed in response to NRC Generic Letter 88-20, an NRC program requesting licensees to conduct more thorough probabilistic risk assessments for reactors.[13] In 1995, the licensee concluded that a flood level above the barrier around key equipment housed in a "standby shutdown facility"[14] had a frequency of approximately once in 75,000 years. Since the IPEEE showed that dam failures were very unlikely, no additional action was determined to be necessary, and the NRC issued a letter closing the IPEEE project for Oconee.

2005-2006 NRC Inspection and Enforcement

In June 2005, during a periodic risk-informed flood inspection under the NRC's Reactor Oversight Process, NRC inspectors identified a breach in the flood-protection wall of the standby shutdown facility. In April 2006, the NRC staff concluded that the licensee failed to effectively control maintenance activities associated with removing a fire suppression refill access cover (an element of a flood protection barrier) in the standby shutdown facility south wall to facilitate installation of temporary electrical power cables. The NRC staff also noted that the licensee may not have appropriately addressed the potential consequences of flooding based on information in a 1992 study of inundation from dam failures conducted by the Federal Energy Regulatory Commission.

Mechanism Reevaluation (CAC Nos. MF1012, MF1013, and MF1014) and Path Forward on Confirmatory Action Letter," dated April 14, 2016. ADAMS Accession No. ML15352A207.

[13] Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities," dated November 23, 1988, requested plants to perform a systematic examination to identify any plant-specific vulnerabilities to severe accidents and report the results to the Commission. Five supplements to Generic Letter 88-20 provided additional guidance, notably Supplement 4, dated June 8, 1991, which requested that plants perform an IPEEE. The initial Generic Letter and its supplements are available on the NRC Web site at http://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1988/.

[14] More information on this facility is provided in Appendix B to this report.

2007-2008 NRC Independent Analysis and Information Request

Following this inspection finding, the NRC staff conducted an independent review of the Jocassee Dam failure frequency that the licensee had used in developing its probabilistic risk assessment in the 1980s. From that review, the NRC staff concluded that a higher frequency estimate of Jocassee Dam failure was more appropriate and that the licensee's estimate was not adequately supported by operating experience and actual performance data of similar rock-filled dam structures. The NRC staff also concluded that the licensee had an inadequate basis for applying a reduction factor to further reduce the risk estimate (i.e., the assumption that only 20 percent of floods would exceed the existing standby shutdown facility flood wall). On August 15, 2008, an 10 CFR 50.54(f) letter was issued to the licensee to obtain further information on the hazard from the potential failure of Jocassee Dam.[15]

2010 NRC Confirmatory Action Letter

In 2010, the NRC issued a Confirmatory Action Letter to assure that licensee commitments to interim and compensatory actions to strengthen flooding protections were taken and maintained.[16]

2015 NRC Rulemaking on Mitigation of Beyond-Design-Basis Events

On August 27, 2015, the Commission approved the NRC staff recommendation to promulgate an NRC regulation to incorporate all of the NRC post-Fukushima Dai-ichi accident actions into the NRC regulations.[17] The previously issued orders would be written into the NRC"s permanent regulations, so that their requirements would apply to any future reactors. The proposed regulation would apply the requirements of both Order EA-12-049 and an additional order on spent fuel pool instrumentation[18] (EA-12-051) to all operating or future U.S. nuclear power plants.[19] The proposed rule also incorporates many other recommendations of the Fukushima Dai-ichi accident Near-Term Task Force, including requirements related to:

- onsite emergency response capabilities
- emergency plans to address prolonged station blackout and multiunit events
- command and control structure and qualification
- enhanced onsite emergency response resources

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[15] Joseph G. Giitter, NRC, letter to Dave Baxter, Duke Energy Carolinas, LLC, "Information Request Pursuant to 10 CFR 50.54(F) Related to External Flooding, Including Failure of the Jocassee Dam at Oconee Nuclear Station, Units 1, 2, and 3 (TAC Nos. MD8224, MD8225, and MD8226)," dated August 15, 2008. ADAMS Accession No. ML081640244.

[16] Luis A. Reyes, NRC, letter to David A. Baxter, Duke Energy Carolinas, LLC, "Confirmatory Action Letter – Oconee Nuclear Station, Units 1, 2, and 3 Commitments to Address External Flooding Concerns (TAC Nos. ME3065, ME3066 and ME3067)," dated June 22, 2010. ADAMS Accession No. ML101730329.

[17] Annette L. Vietti-Cook, NRC, memorandum to Mark A. Satorius, NRC, "Staff Requirements – SECY-15-0065 – Proposed Rule: Mitigation of Beyond-Design-Basis Events (RIN 3150-AJ49)," dated August 27, 2015. ADAMS Accession No. ML15239A767.

[18] EA-12-051, "Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation." ADAMS Accession No. ML12056A044.

[19] Information on the proposed rule issued in November 2015 is available at https://www.regulations.gov/#!documentDetail;D=NRC-2014-0240-0003.

4.2 Question 2: Evaluation of NRC-Required Actions at Other Power Stations

Question 2 in the OSC letter asked:

> Has NRC required the other 18 nuclear power stations identified in Appendix A [to the OSC letter] to take adequate measures to protect against the risk of flooding in the event of upstream dam failures? If so, describe the measures and when they were taken.

Yes, the NRC issued immediately-effective orders to the facilities at each of these 18 sites on March 12, 2012, requiring licensees to provide mitigation strategies for beyond-design-basis external events. All licensees were required to develop a three-phase approach to an extended loss of all electrical power as a result of a beyond-design-basis external event, including flooding events that could credibly be caused by an upstream dam failure.

In addition, the plants at each of the 18 sites were issued requests for information under 10 CFR 50.54(f) on March 12, 2012, requiring analysis of external hazards, including potential flooding caused by failure of upstream dams. They were also requested to identify actions taken or planned.

The response to Question 3 includes sections for each site listed in Appendix A, on plant-specific actions taken, as well as activities related to this order and 10 CFR 50.54(f) letter.

4.3 Question 3: Summary of Actions Taken to Address Risk

Question 3 in the OSC letter asked:

> What action has been taken to address the risk of flooding from upstream dam failures? Are there actions planned that have not yet been completed?

The NRC and licensees have taken a large number of actions in response to the risk of flooding from potential upstream dam failures at each of the 19 sites listed in Appendix A to the OSC letter. A summary of these actions is provided in this section, and additional details are provided in Appendix B to this report. While additional sites may have dams upstream that were considered either in the original licensing of the plant or in more recent evaluations, the general approach and actions taken are the same; therefore, these 19 sites can be seen as examples representing the spectrum of issues.

Many of the actions discussed address prevention and mitigation of flooding from all external sources, including upstream dam failures. For a given plant, upstream dam failure may be the cause of the most significant flooding, or another flooding source may be more significant than a dam failure, or some combination of dam failure and other flooding sources may be most significant.

The NRC's responsibility to provide reasonable assurance of adequate protection of public health and safety involves a continuous process in which the original licensing process is complemented by an ongoing evaluation of operating experience, and new engineering and scientific information that is collected and evaluated for its safety significance. As such, some of these actions were included in the original licensing documents; others were taken in response

to NRC requirements such as orders or as part of licensees' response to NRC requests for information, generic communications, or inspection findings.

The five subjects presented in detail for each site in Appendix B to this report are described below. In general, the topics are addressed in Appendix B using this order and scope; for some sites, there have been significant changes to the facility or analyses that necessitate a deviation from this structure to present the information more clearly. Table 1 summarizes the actions taken for each site after initial plant licensing, as well as actions planned to be taken.

4.3.1 Initial Plant Design and Licensing

Flooding was considered in the initial design and licensing of every plant, as supplemented by later changes, as appropriate. For some older plants, the NRC requirements and guidance at the time of licensing may not have necessitated consideration of an upstream dam failure in establishing design-basis flood. In some cases, the potential for flooding from dam failures was revised in the plant's design or licensing basis as new information emerged.

4.3.2 Plant-specific Regulatory Actions

Depending on the site, there may have been specific actions taken related to potential flooding or dam failures as a result of inspections, licensee-identified issues, generic evaluations, or other reasons. While not every action related to external flooding throughout the licensed history of the plants is presented, the most significant actions identified by the Flooding Working Group (particularly those relating to dam failures) are included. Plant-specific actions in response to the Fukushima Dai-ichi accident are described separately in the following sections, as they are relevant to every site.

4.3.3 Flooding Walkdowns

As noted above, after the Fukushima Dai-ichi accident, the NRC issued a request for information under 10 CFR 50.54(f). Response to this request required performing walkdowns using an NRC-endorsed methodology, identifying conditions of concern, identifying actions taken or planned to enhance flood protection, and verifying the adequacy of maintenance and monitoring for flood protection features.

The licensees for all 19 sites completed these walkdowns and took action to address any identified deficiencies. For each site, the NRC staff has issued assessments documenting the sufficiency of the actions taken.

4.3.4 Reevaluation of Flooding Hazard and Related Actions

The NRC's request for information also asked all licensees to reevaluate the flooding hazards for their sites based on present-day methodologies and guidance, establish interim actions if the reevaluated hazard were found to be higher than the design-basis hazard, and conduct, as appropriate, an integrated assessment (including additional protection and mitigation features) to address the reevaluated hazard. The submittal dates for the flooding hazard reevaluation reports was prioritized based on the complexity of analyses and available industry and staff resources.[20] For a small number of sites, the hazard reevaluation is not yet complete because

[20] Eric J. Leeds, NRC, letter to all power reactor licensees and holders of construction permits, "Prioritization of Response Due Dates for Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f)

the U.S. Army Corps of Engineers is finalizing its inputs to the analysis (particularly for the dams that for which it has responsibility). After the licensee's flooding hazard reevaluation report is received, the NRC staff reviews it and provides an interim response once it determines that the reevaluated flood levels are appropriate for use in further assessments, including the evaluation of mitigating strategies described in the next section. The NRC staff then issues a staff assessment to document in more detail its review of the reevaluation.

As indicated in the initial request for information, licensees are expected to assess how the plant would respond to reevaluated flood levels that exceed the design basis—an activity that is referred to as "Phase 1." The NRC deferred the submittal schedules for these integrated assessments while it updated its guidance to reflect Commission direction.[21] This guidance, which will be completed during the summer of 2016, would enable some licensees to perform focused evaluations (rather than a full integrated assessment) to ensure appropriate actions are taken to protect the plant from the reevaluated flooding hazard, and that these actions are reasonable, effective, and implemented in a timely manner.[22] Focused evaluations will be submitted by June 2017, and integrated assessments will be submitted by December 2018. These assessments are also expected to consider any changes to the evaluation of upstream dams as a result of the seismic hazard reevaluations also requested in the 10 CFR 50.54(f) letter.[23] In Phase 2, the NRC staff will evaluate the integrated assessments and determine the need for further regulatory action, which could include imposing new requirements using agency processes. The final decision-making criteria to be used in Phase 2 is currently being considered with input from stakeholders. The NRC staff plans to complete the Phase 2 guidance later in 2016.

For this reason, the NRC's final regulatory decisions on the acceptability of design-basis floods at these sites—including any requirements it might impose to ensure appropriate protection or mitigation—are not complete at this time. In the interim, licensees have implemented compensatory measures to ensure continued safe operation even if the flooding hazard is found to be higher than expected. Furthermore, licensees are currently implementing mitigating strategies that consider the effects of a flood at the reevaluated level.

Table 2 summarizes, for each of the 19 sites, how dam failures were considered in establishing the design-basis flood and in reevaluating the flooding hazard. In many cases, while there are dams upstream of the sites, the resulting floods from failure of those dams are bounded by other flooding scenarios or are lower than site protective features. Where dam failures are significant to a site, licensees have taken protective action (in the case of the design-basis flood) or have taken interim actions (in the case of a higher reevaluated hazard). Licensees will

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Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated May 11, 2012. ADAMS Accession No. ML12097A509.

[21] William M. Dean, NRC, letter to power reactor licensees, "Response Requirements for Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Flooding Hazard Integrated Assessments for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dal-Ichi Accident," dated May 26, 2015. ADAMS Accession No. ML15112A051. The referenced Commission direction was provided in response to the NRC staff's papers designated COMSECY-14-0037 and COMSECY-15-0019. These staff requirements memoranda are available at ADAMS Accession No. ML15089A236 and ADAMS Accession No. ML15209A682.

[22] SECY-16-0043, "Ninth 6-Month Status Update on Response to Lessons Learned from Japan's March 11, 2011, Great Tōhoku Earthquake and Subsequent Tsunami," dated April 5, 2016. ADAMS Accession No. ML16054A296.

[23] This issue was raised by the Advisory Committee on Reactor Safeguards in its review of the Phase 1 guidance and is expected to be clarified in the final guidance. (Dennis Bley, Advisory Committee on Reactor Safeguards, letter to Victor McCree, NRC, "Draft Interim Staff Guidance JLD-ISG-2016-01, 'Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluation; Focused Evaluation and Integrated Assessment,'" dated May 18, 2016. ADAMS Accession No. ML16130A453.)

also take additional actions either based on current commitments (e.g., for Sequoyah and Watts Bar) or as needed based on the ongoing Phase 1 flooding assessments.

4.3.5 Mitigating Strategies for Beyond-Design-Basis External Events

As introduced above, Order EA-12-049 directed all licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities following a beyond-design-basis external event. Depending on the site, external flooding (of which a source may be upstream dam failures) was one of the external events considered by licensees in developing their strategies.

According to NRC guidance for compliance with Order EA-12-049, licensees' strategies are expected to mitigate an extended loss of alternating current (ac) power concurrent with a loss of normal access to the ultimate heat sink.[24] The industry approach to this scenario is generally referred to as FLEX (shorthand for "Diverse and Flexible Coping Strategies") and consists of onsite response using installed and portable equipment, supported by provision of offsite equipment from Regional Response Centers maintained collectively by the industry. The NRC guidance also notes that protection of onsite power sources and normal access to the ultimate heat sink from the flooding hazard is an acceptable method of mitigating a simultaneous loss of all ac power and loss of normal access to the ultimate heat sink.

This guidance also addresses the need to assess the effect of the flooding hazard reevaluation on mitigating strategies that may have been developed before the reevaluation was completed.[25] If the reevaluated flood level is higher, either the mitigating strategies need to be modified to ensure that functional capability is maintained, or alternative or targeted strategies need to be developed that can be implemented at the higher flood level. As noted above, the NRC is preparing a final regulation on mitigating beyond-design-basis events that will, in part, make the requirements of Order EA-12-049 generically applicable. Compliance with this regulation is expected to include ensuring that the mitigating strategies are sufficient to address the reevaluated flooding hazard. While the final regulation is not yet effective, licensees are nonetheless expected to address higher reevaluated flood levels and any potential effects on their established mitigating strategies through their current corrective action programs, consistent with the guidance described above.

The licensees for all 19 sites have submitted their Overall Integrated Plans in response to Order EA-12-049. Plant modifications and implementation of the mitigating strategies are either complete or well underway at every site. In general, the licensees' actions include plant modifications to provide installed and portable equipment that is protected from external floods applicable to the site.

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[24] JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated January 22, 2016. ADAMS Accession No. ML15357A163. Nuclear Energy Institute (NEI) 12-06, Revision 2, which the NRC staff accepts for use with specific limitations and conditions, is available at ADAMS Accession No. ML16005A625.

[25] Specific guidance is included in Appendix G to NEI 12-06, Revision 2.

Table 1. Summary of actions taken or planned to address the risk from external flooding, including potential upstream dam failures. (Details of each action are presented in Appendix B.)

Site	Flooding Walkdowns	Flooding Hazard Reevaluations	Mitigating Strategies for Beyond-Design-Basis Events	Additional Plant-Specific Actions
Arkansas Nuclear One	• Licensee walkdown complete (November 2012) • NRC inspections complete (August 2013) • NRC staff assessment complete (June 2014)	• U.S. Army Corps of Engineers input complete (March 2016) • Licensee report due in September 2016	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (September 2015) • Order compliance achieved (January 2016) • Mitigating strategies assessment expected after flooding hazard reevaluation complete	• Improved roof drainage for Unit 1 in 1990s based on IPEEE • Corrected deficiencies in flood protection features after 2013 heavy load drop
Beaver Valley	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2016) • NRC staff review in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (January 2014) • NRC audit complete (November 2015) • Order compliance achieved for Unit 2 (December 2015); compliance expected for Unit 1 in Fall 2016 • Mitigating strategies assessment in progress	• None identified in preparing this report
Browns Ferry	• Licensee walkdown complete (November 2012) • NRC inspections complete (May 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2015) • NRC interim response complete (September 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (December 2013) • NRC audit complete (April 2015) • Order compliance expected by the end of 2016 • Mitigating strategies assessment in progress	• Recalculated flooding levels in 1990s and 2012; design-basis level remained the same • Modified earth portions of upstream dams to prevent overtopping and failure

Site	Flooding Walkdowns	Flooding Hazard Reevaluations	Mitigating Strategies for Beyond-Design-Basis Events	Additional Plant-Specific Actions
Columbia	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (May 2014)	• U.S. Army Corps of Engineers input in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (January 2014) • NRC audit complete (June 2015) • Order compliance expected in Spring 2017 • Mitigating strategies assessment expected after flooding hazard reevaluation complete	• None identified in preparing this report
Cooper	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (February 2015) • NRC interim response complete (December 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal and two-dimensional modeling in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (May 2016) • Order compliance expected in Fall 2016 • Mitigating strategies assessment in progress	• Provided temporary barriers to protect against a higher flood level (based on upstream dam failure) • Evaluated and screened out higher floods in 1990s
Fort Calhoun	• Licensee walkdown complete (November 2012) • NRC inspections complete (December 2012) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (February 2015) • NRC interim response complete (December 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal and two-dimensional modeling in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (May 2016) • Order compliance expected in December 2016 • Mitigating strategies assessment in progress	• Added portable pumps, upgraded doors, provided sandbags, sealed conduit, and updated procedures based on IPEEE evaluation of dam failures • Made multiple flooding-related improvements (barriers, procedures, etc.) after NRC inspection finding and Confirmatory Action Letter

Site	Flooding Walkdowns	Flooding Hazard Reevaluations	Mitigating Strategies for Beyond-Design-Basis Events	Additional Plant-Specific Actions
H.B. Robinson	• Licensee walkdown complete (November 2012) • NRC inspections complete (April 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2014) • NRC interim response complete (December 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (June 2015) • Order compliance achieved (August 2015) • NRC inspection complete • NRC safety evaluation complete (March 2016) • Mitigating strategies assessment in progress	• None identified in preparing this report
Hope Creek / Salem	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2014) • NRC interim response complete (September 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (March 2015) • Order compliance expected for Hope Creek in January 2017 and for Salem in Summer 2016 • Mitigating strategies assessment in progress	• Addressed river-borne debris on circulating water system intake for Salem • Evaluated flood levels to support 2016 early site permit issuance for an additional new reactor (dam failures resulted in floods well below the design-basis flood)
Indian Point	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (December 2013) • NRC interim response complete (April 2016) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (January 2014) • NRC audit complete (February 2016) • Order compliance expected in Summer 2016 • Mitigating strategies assessment in progress	• Reassessed wave runup in 1980s and determined protection was adequate • Increased valve surveillance, added weather stripping and screens based on IPEEE evaluation of probable maximum precipitation (PMP)

Site	Flooding Walkdowns	Flooding Hazard Reevaluations	Mitigating Strategies for Beyond-Design-Basis Events	Additional Plant-Specific Actions
McGuire	• Licensee walkdown complete (November 2012) • NRC inspections complete (April 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2014) • NRC interim response complete (September 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (January 2014) • NRC audit complete (October 2014) • Order compliance achieved (December 2015) • Mitigating strategies assessment in progress	• None identified in preparing this report
Oconee	• Licensee walkdown complete (November 2012) • NRC inspections complete (April 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2013, updated in March 2015) • NRC interim response complete (September 2015) • NRC staff assessment complete (April 2016) • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (October 2015) • Order compliance achieved for Unit 2 (Fall 2015); compliance expected for Unit 3 in Spring 2016 and for Unit 1 in Fall 2016 • Mitigating strategies assessment in progress	• Protected standby shutdown facility with a 5-foot flood wall in 1980s; updated licensing basis to document 4.71-foot flood from Jocassee Dam failure • Reassessed flood potential from dam failure in 1990s, considered higher flood levels not likely enough to provide further protection • Made multiple improvements (dam inspections and monitoring, new procedures, etc.) after NRC inspection findings and Confirmatory Action Letter
Peach Bottom	• Licensee walkdown complete (November 2012) • NRC inspections complete (January 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2015) • NRC interim response complete (March 2016) • NRC staff assessment in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (November 2013) • NRC audit complete (September 2015) • Order compliance expected by end of 2016 • Mitigating strategies assessment in progress	• None identified in preparing this report

Site	Flooding Walkdowns	Flooding Hazard Reevaluations	Mitigating Strategies for Beyond-Design-Basis Events	Additional Plant-Specific Actions
Prairie Island	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (May 2016) • NRC staff review in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (August 2015) • Order compliance achieved for Unit 2 (January 2016); compliance expected for Unit 1 in Fall 2016 • Mitigating strategies assessment in progress	• Corrected issues with protective panels in early 2000s • Enhanced inspections of intake canal and other locations following license renewal
Sequoyah	• Licensee walkdown complete (November 2012) • NRC inspections complete (May 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2015) • NRC interim response complete (September 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (March 2015) • Order compliance achieved (February 2016) • Mitigating strategies assessment in progress	• Modified dams in 1980s to ensure hydrologic and structural integrity and recalculated lower design-basis flood • Modified earth portions of upstream dams to prevent overtopping and failure • Made multiple improvements (flood barriers, dam enhancements, new processes, etc.) after NRC inspection findings and Confirmatory Action Letter • Designed an improved flood mitigation system to be implemented by December 2016
South Texas Project	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2013) • NRC staff assessment complete (September 2014) • NRC mitigating strategies response complete (November 2015)	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (January 2014) • NRC audit complete (May 2015) • Order compliance achieved (February 2016) • Mitigating strategies assessment in progress	• Evaluated failure of Colorado River dams to support licensing of Units 3 and 4; resulting flood level was well below flood caused by failure of main cooling reservoir

Site	Flooding Walkdowns	Flooding Hazard Reevaluations	Mitigating Strategies for Beyond-Design-Basis Events	Additional Plant-Specific Actions
Surry	• Licensee walkdown complete (November 2012) • NRC inspections complete (April 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2015) • NRC interim response complete (September 2015) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2014) • NRC audit complete (April 2015) • Order compliance achieved (January 2016) • Mitigating strategies assessment in progress	• Updated procedures and structures to address heavy rainfall and ponding based on IPEEE • Sealed open penetrations below flood level
Three Mile Island	• Licensee walkdown complete (November 2012) • NRC inspections complete (April 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2013) • NRC interim response complete (March 2016) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (February 2016) • NRC audit complete (February 2016) • Order compliance expected in Spring 2016 • Mitigating strategies assessment in progress	• Updated procedures to mitigate river flooding • Recalculated flood levels in 2010 and increased protection level • After NRC inspection findings, fixed flood seal and updated river level at which plant would be shut down
Waterford	• Licensee walkdown complete (November 2012) • NRC inspections complete (August 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (July 2015) • NRC interim response complete (April 2016) • NRC staff assessment in progress • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (November 2013) • NRC audit complete (October 2015) • Order compliance expected by July 2016 • Mitigating strategies assessment in progress	• None identified in preparing this report

Site	Flooding Walkdowns	Flooding Hazard Reevaluations	Mitigating Strategies for Beyond-Design-Basis Events	Additional Plant-Specific Actions
Watts Bar	• Licensee walkdown complete (November 2012) • NRC inspections complete (February 2013) • NRC staff assessment complete (June 2014)	• Licensee reevaluation complete (March 2015, updated in June 2015) • NRC interim response complete (September 2015) • NRC staff assessment complete (December 2015) • Licensee's Phase 1 submittal in progress	• Licensee plan submitted (February 2013) • NRC interim evaluation complete (December 2013) • NRC audit complete (May 2014) • Order compliance achieved (March 2015) • NRC inspection complete (June 2015) • NRC safety evaluation complete (March 2016) • Mitigating strategies assessment in progress	• Modified dams in 1980s to ensure hydrologic and structural integrity and recalculated lower design-basis flood • Modified earth portions of upstream dams to prevent overtopping and failure • Made multiple improvements (preparation of tools and equipment, updating flood-response timeline, etc.) after NRC inspection findings and Confirmatory Action Letter • Designed an improved flood mitigation system to be implemented by December 2016

Table 2. Summary of consideration of upstream dam failures in plant design basis and flooding hazard reevaluation.

Site	Licensee's Consideration of Upstream Dam Failures in Design Basis	Licensee's Consideration of Upstream Dam Failures in Hazard Reevaluation
Arkansas Nuclear One	***Included in limiting flood*** • Probable maximum flood (PMF) with failure of Ozark Dam is the limiting flood.	***TBD*** • Report is due in September 2016 after considering U.S. Army Corps of Engineers input.
Beaver Valley	***Bounded by other flooding sources or excluded from analysis*** • Flood from failure of Conemaugh Dam would be lower than the PMF level. • Cascading dam failures were not considered given separate tributaries. • Simultaneous seismic failure of dams were not considered credible.	***Bounded by other flooding sources*** • Current design-basis PMF bounds reevaluated dam failure flooding hazard.
Browns Ferry	***Included in limiting flood*** • Erosion and overtopping of earth portions of upstream dams were included in calculating flood level. • Seismic dam failures were not considered.	***Bounded by other flooding sources*** • Current design-basis flood bounds combined effects from cascading dam failures. • Seismic failure of an upstream dam results in an even lower flood level.
Columbia	***Bounded by other flooding sources*** • Flood level from failure of Grand Coulee Dam would be lower than the probable maximum precipitation flood level.	***TBD*** • U.S. Army Corps of Engineers is developing input.
Cooper	***Excluded from analysis*** • Upstream dam failure was not considered probable. • Estimated flood level from dam failures as lower than the protection level at the intake structure.	***Included in limiting flood*** • Postulated flood from dam breaches and failures is not bounded by current licensing basis. • Licensee took interim actions to monitor reservoir conditions and develop mitigating strategies. • Phase 1 submittal will provide further evaluation and actions.
Fort Calhoun	***Included in limiting flood*** • PMF with failure of Oahe Dam or Fort Randall Dam is the limiting flood.	***Included in limiting flood*** • Postulated flood from dam breaches and failures is not bounded by current licensing basis. • Licensee took interim actions to monitor river conditions and develop mitigating strategies. • Phase 1 submittal will provide further evaluation and actions.
H.B. Robinson	***Excluded from analysis*** • Flooding from dam breaches and failures were not considered applicable.	***Bounded by other flooding sources*** • Postulated flood from seismic dam failures with 500-year flood, plus wave action, is above site grade. • Licensee took interim actions to add procedures and pumps. • Phase 1 submittal will provide further evaluation and actions.

Site	Licensee's Consideration of Upstream Dam Failures in Design Basis	Licensee's Consideration of Upstream Dam Failures in Hazard Reevaluation
Hope Creek / Salem	***Bounded by other flooding sources*** • Flood at Hope Creek from failure of Tock's Island Dam would be lower than the probable maximum hurricane (PMH) level • Dam failures are not included in Salem's licensing basis.	***Excluded from analysis*** • No critical dams in watershed, so there is no adverse impact from dam failures.
Indian Point	***Included in limiting flood*** • Standard project flood with failure of the Ashokan Dam and storm surge in New York Harbor is limiting flood. • Flood level was low enough to not be considered a hazard.	***Bounded by other flooding sources*** • Dam failures resulted in a higher flood level than in the licensing basis, but still below site grade. • Licensee took interim actions to add sandbags and flood barriers.
McGuire	***Bounded by other flooding sources*** • Flood from failure of Bridgewater Dam combined with the standard project flood would be lower than the PMP flood level.	***Included in limiting flood*** • Dam failures resulted in a higher flood level than the licensing basis, but still lower than the plant's earthen dike. • Licensee took several interim actions to enhance capabilities. • Phase 1 submittal will provide further evaluation and actions.
Oconee	***Excluded from analysis*** • Failure of Jocassee Dam was not considered credible, based on the design and construction of the dam.	***Explicitly considered in reevaluation*** • Other hazards could cause floods that exceed the design basis. • Dam failures were explicitly included, where they had not been in the design basis. • Phase 1 submittal will provide further evaluation and actions.
Peach Bottom	***Included in limiting flood*** • PMF coincident with failure of Holtwood Dam is the limiting flood. • Estimated flood level from dam failures was lower than the protection level.	***Bounded by other flooding sources*** • Current licensing-basis evaluation of dam failures bounds reevaluated flood level.
Prairie Island	***Bounded by other flooding sources*** • Flood from failure of Lock and Dam Number 2 would be lower than the PMF level.	***Explicitly excluded from analysis*** • Failure of upstream dams would not affect the plant given distance, volume, and peak flow.
Sequoyah	***Included in limiting flood*** • Dam failures were considered in original design basis. • PMP coincident with failure of Watts Bar Dam was limiting flood in 2012 update. • Seismic dam failures were considered in 2012, but resulting flood levels were lower than PMF.	***Bounded by other flooding sources*** • Enhancements to dams were credited in reducing flood levels from other hazards below the 2012 evaluation. • Flooding from dam failures would be below site grade.
South Texas Project	***Included in limiting flood*** • Failure of the on-site main cooling reservoir embankment results in the limiting flood.	***Included in limiting flood*** • Failure of the main cooling reservoir remained the limiting flood (at the same level). • Failure of upstream dams would result in much lower flood levels.

Site	Licensee's Consideration of Upstream Dam Failures in Design Basis	Licensee's Consideration of Upstream Dam Failures in Hazard Reevaluation
Surry	***Excluded from analysis*** • Flooding from dam failures was not expected, as the James River had no river control features.	***Bounded by other flooding sources*** • Flooding from PMF combined with dam failures would be below site grade.
Three Mile Island	***Bounded by other flooding sources*** • Failure of the Raystown Lake Dam would result in a flood below the level of the plant dike.	***Included in limiting flood*** • Flood from PMF, dam break, and wind waves would be below the updated protection level. • Flood from seismic dam failures combined with a high discharge event and wind waves would be below the level of the plant dike.
Waterford	***Included in limiting hazard*** • Failure of the on-site levee, combined with PMF and PMH events, results in the limiting flood. • Seismic failure of upstream dams did not present a threat to the site.	***Included in limiting hazard*** • Flood level from 25-year flood, storm surge, levee failure, and wind waves was higher than licensing basis, but would not affect safety-related equipment. • Floods from upstream dam failures would be below the protection level.
Watts Bar	***Included in limiting flood*** • Dam failures were considered in original design basis. • NRC-approved 2015 licensing-basis update included upstream dam failures in PMF calculation. • Seismic dam failures were considered in updated calculations, but resulting flood levels were lower than PMF.	***Bounded by other flooding sources*** • Enhancements to dams were credited in reducing flood levels. • Flooding from dam failures would be below site grade.

4.4 Question 4: Evaluation of Current Risk

Question 4 in the OSC letter asked:

> What is the current risk to public health or safety from potential flooding of the 19 nuclear power plants identified in Appendix A [to the OSC letter]?

The current risk to public health and safety from potential dam failures that could result in flooding a nuclear power plant is very small. Public health and safety is adequately protected by the past and ongoing actions by the NRC. These conclusions are based on an evaluation of the available qualitative information and quantitative assessments discussed below.

Under the Atomic Energy Act, as amended, the NRC and its predecessor the Atomic Energy Commission have licensed and overseen nuclear power plants based on providing reasonable assurance of adequate protection to public health and safety. The reasonable assurance standard is satisfied based on sound technical judgement applied on a case-by-case basis considering all the information available. Quantitative estimates of risk to public health and safety are developed in some cases where suitable information is available on initiating event frequency, plant and human response, component and system reliability, event progression and consequence analysis. For flooding hazards, few plants have developed a quantitative estimate of flooding risks.

The Commission has emphasized that its long-standing defense-in-depth philosophy (informed by risk insights, engineering margins, and conservative judgement) should be the primary foundation for regulatory decision making. Quantitative risk estimates are therefore useful but not essential in making sound safety decisions. In fact, quantitative risk assessments have been used to address internal events (plant equipment failures and human errors) much more often than to address external events.

The July 2010 memorandum from the NRC Office of Nuclear Reactor Regulation to the NRC Office of Nuclear Regulatory Research requesting consideration of the upstream dam failure issue in the Generic Issues Program described the likelihood of dam failures as follows.[26]

> In multiple [final safety analysis reports] and IPEEEs, dam failures are described as "not credible" (Fort Calhoun Station, Cooper Nuclear Station), "highly unlikely" (McGuire Nuclear Station), or "extremely unlikely" (Arkansas Nuclear One, Sequoyah Nuclear Plant, Watts Bar Nuclear Plant) by taking into account individual or combinations of severe events hydrologic and seismic events. From a preliminary review, at least four sites have considered quantitative dam failure rate: Oconee Nuclear Station (South Carolina), Cooper Nuclear Station (Nebraska), Fort Calhoun Station (Nebraska), and H.B. Robinson (South Carolina). All four sites considered failure rates in the range between $5x10^{-5}$ [per] year and $1x10^{-5}$ [per] year.[27] Flooding requirements are considered for a number of sites, including the use of sandbagging and other mitigative actions which assume ample lead time for implementation. However, a preliminary review of the IPEEEs indicates that, since dam failures were

[26] Lois James, NRC, memorandum to Benjamin Beasley, NRC, "Identification of a Generic External Flooding Issue due to Potential Dam Failures," dated July 19, 2010. ADAMS Accession No. ML101900305.
[27] This corresponds to an approximate range of once in 20,000 to 100,000 years.

> excluded from consideration in most [final safety analysis reports], its risk contribution has not been addressed to date.

The estimated risk to public health and safety of dam failures stems from the combination of the dam failure likelihood and the plant's ability to protect safety equipment or otherwise mitigate the effects of flooding from the dam failure. At each site, the mitigating strategies for beyond-design-basis events that are currently being implemented, with due consideration of reevaluated flooding levels, provide confidence in the ability of plants to mitigate external floods in a way that protects the public. For example, at Oconee there is an installed safe shutdown facility that can be used to mitigate floods up to a certain level, as well as an additional mitigating strategy that can be implemented at the highest estimated flood levels. Although significant uncertainty exists with respect to quantifying both the dam failure likelihood and a plant's mitigation reliability, the approaches developed to mitigate such an unlikely event support the conclusion that the current risks to public health and safety are very small and within the Commission's statutory mandate to provide adequate protection.

Consistent with the established plans to complete actions from the 10 CFR 50.54(f) letters issued on March 12, 2012, and given that the reevaluated flood levels resulting from potential dam failures exceed their design basis at certain sites, an additional assessment of plant response will be performed by licensees. The NRC will close this issue when sufficient information is available to conclude that all appropriate measures have been taken.

4.5 Question 5: Evaluation of Risk Reduction Potential

Question 5 in the OSC letter asked:

> Would the risk to the public health or safety from potential flooding of nuclear plants identified in Appendix A [of the OSC letter] have been reduced if NRC had required those plants to take action to protect against flooding in 2013?

As indicated above, the NRC did take action for all plants at these sites on March 12, 2012, through Order EA-12-049 and information requests issued in accordance with 10 CFR 50.54(f). Appropriate measures to prevent and mitigate flooding events are included in the response to Question 3. In addition, NRC took action prior to 2012 on specific plants, when warranted, as relevant information became available. Several examples of prior actions are also included in the response to Question 3.

Furthermore, all plants, including those for which the reevaluation of flooding hazards indicates that the original plant design and construction continues to provide adequate protection from flooding, were required to implement additional measures to provide the plant with the ability to cope with an extended loss of all electrical power from any cause. These actions were required in manner consistent with the NRC safety philosophy of defense-in-depth, providing both enhanced protection (from flooding and other hazards) and enhanced mitigation capability.

Therefore, risk reductions have been achieved before and since 2013 as a result of NRC requiring plants to take action.

5 Conclusions

The Flooding Working Group has interviewed the whistleblower and reviewed the transcript of that interview; reviewed the documents provided by the whistleblower; independently collected, reviewed, and evaluated hundreds of relevant NRC and licensee documents; met with NRC staff members directly involved with dam failure and flooding reviews; and reviewed NRC processes and procedures for addressing emerging issues. As a result of these activities, the Flooding Working Group developed a practical understanding of, and significant insights into, the evolving scientific and engineering state of knowledge related to dam safety, dam failure likelihood, dam failure analysis, consequential flooding scenarios, and their implications for the health and safety of the public.

The Flooding Working Group concludes that it has had sufficient knowledge and experience with NRC safety decision-making, regulatory programs, and legal processes; time and resources; access to both public and non-public information; and access to knowledgeable individuals to make an informed judgement on the matters referred to the NRC by OSC.

The Flooding Working Group also concludes the following with respect to the allegations regarding the NRC's potential failure to require Oconee and the other 18 sites to take appropriate actions related to the failure of upstream dams:

- The NRC has required Oconee and the plants at the other 18 sites to take appropriate action to provide adequate protection to public health and safety from rare but credible upstream dam failures.

- The NRC actions have been in accordance with the functions and authorities of the Atomic Energy Act, as amended. No violation of law, rule, or regulation; gross mismanagement; or abuse of authority was found.

- The NRC actions, including orders, requests for information, enforcement actions, and rulemaking activities, have been in conformance with NRC programs, processes, and procedures, including those for addressing differing staff views.

- The NRC actions followed normal NRC processes for resolution of technical issues and response to operating events and were independent of the whistleblower disclosure.

- Continued timely, efficient, and effective use of these programs, processes, and procedures by NRC staff, implementing Commission decisions and considering all available information and technical viewpoints, provides the best and most appropriate means of bringing the ongoing dam failure and flooding reviews to appropriate conclusions. In addition, these programs, processes, and procedures constitute an appropriate and effective means of addressing emerging issues of potential safety significance in the future.

Appendix A: Background on Regulatory Approach

A.1 Agency Responsibilities

Responsibilities of the U.S. Nuclear Regulatory Commission (NRC) for providing adequate protection of public health and safety include: licensing facilities (e.g., nuclear power plants); oversight (through monitoring, inspection, and enforcement); backfitting (imposing new requirements where appropriate); rulemaking; and conducting nuclear safety research. To fulfill these responsibilities, the NRC has developed and used several mechanisms as discussed below.

The licensing process involves detailed safety, security, environmental, and legal reviews of licensee applications. Reviews are conducted with public participation and in accordance with established programs, processes, procedures, and publicly available application and review guidance. The response to the questions from the U.S. Office of Special Counsel (OSC) includes information on the treatment of dam failures that was considered in the original licensing of the nuclear power plants at the 19 sites in question. As a condition for receiving a licensee, licensees are required to respond to NRC requests for information. In addition to readily available information, these information requests can, and have, required licensees to undertake studies and perform analyses to develop the information needed to respond the NRC. Examples of this type of NRC action are presented in the response to OSC questions.

The NRC reactor oversight responsibilities are executed through an inspection program that includes NRC resident inspectors at all nuclear power plants, and additional inspectors based in NRC regional offices. These inspectors monitor plant activities on a daily basis and undertake a formal "baseline" inspection program, supplemented as appropriate. Examples of inspection activities and inspection findings leading to licensee action are also presented in the responses to the OSC questions.

A.2 Agency Regulatory Approach

The NRC issues licenses for commercial power plants pursuant to Sections 103 and 182 of the Atomic Energy Act when the Commission finds that the use of special nuclear material will be in accord with the common defense and security and will provide adequate protection to the health and safety of the public from risks associated with the use of this material.[28] "Adequate protection" is not a fixed objective standard, but rather is a case-by-case judgment utilizing the technical judgment of the Commission.[29] Adequate protection is not absolute protection or zero risk, and the courts have long held that the adequate protection standards permit the acceptance of some level of risk.[30] Exercising engineering and scientific judgment in the light of all relevant and material information, the NRC reviews credible hazards identified by license applicants (following NRC published guidance), then requires that designs be able to cope with such hazards with sufficient safety margins and reliable backup systems. Adequate protection can be assured using mitigation measures when the Commission determines, in its technical

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[28] The Atomic Energy Act of 1954, as amended. Public Law 83-703. The full text of the Act is provided in NUREG-0980, Volume 1, Number 10, "Nuclear Regulatory Legislation – 112th Congress; 2nd Session," dated September 2013. ADAMS Accession No. ML13274A489.

[29] *Union of Concerned Scientists v. NRC*, 880 F.2d 552, 558 (D.C. Cir 1989).

[30] *Public Citizen v. NRC*, 573 F.3d 916, 918 (9th Cir. 2009) (quoting *Union of Concerned Scientists v. NRC,* 824 F.2d 108, 118 (D.C. Cir. 1987). The NRC provided additional discussion of this topic in "Revision of Backfitting Process for Power Reactors; Final Rule," dated June 6, 1988. *Federal Register,* Volume 53, Number 108, pages 20603-20611 (referred to as 53 FR 20603), at page 20606.

judgment, that mitigation is appropriate. For example, in the 2007 rulemaking to revise the design-basis threat, the Commission stated that adequate protection was in part assured by the mitigative measures that licensees had been ordered to take to mitigate against an aircraft strike.[31] Nonetheless, compliance with the NRC's regulations in conformance with NRC guidance may be presumed to assure adequate protection at a minimum.

New information may, however, reveal that, for example, an unforeseen hazard exists or that there is a substantially greater potential for a known hazard to occur. In such situations, the NRC has the statutory authority to require licensee action above and beyond existing regulations to maintain the level of protection necessary to avoid undue risk to public health and safety.[32] The issuance of orders to licensed facilities is an example of backfitting. The responses to the OSC questions include NRC action in the form of an order imposed on the licensed facilities at each of the 19 sites in question. The NRC backfit process is described in Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.109, "Backfitting," with additional guidance in an NRC report, NUREG/BR-0058.[33] A backfit analysis is not required when the modification is necessary to bring the facility into compliance with its current licensing basis, or if the NRC determines that a design change is necessary to provide adequate protection to the health and safety of the public. If the action is not necessary for either compliance or adequate protection, the Commission must determine that there is a substantial increase in the overall protection of the public health and safety, and that the direct and indirect costs of implementation are justified in view of this increased protection.

Separate from the imposition of requirements by the NRC, licensees may determine that it is appropriate to make changes to their facilities or operating practices to enhance safety. When certain criteria are met, these changes can be made without prior approval by the NRC. The NRC receives documentation of the changes and can inspect them to ensure their implementation is consistent with NRC requirements. For more significant changes, the NRC must first review and approve the change, generally issuing a license amendment and accompanying safety evaluation if the change is found acceptable. Licensees can propose to the NRC that they will take certain actions to deal with a particular issue. If the NRC agrees the actions are appropriate, the NRC can issue a Confirmatory Action Letter to confirm a licensee's agreement to take the actions. Further information on Confirmatory Action Letters and other similar regulatory tools can be found in the NRC Enforcement Manual.[34] As indicated in the response to OSC questions, Confirmatory Action Letters have been used to address flooding issues at some sites.

A nuclear power plant's current licensing basis is the set of NRC requirements applicable to a specific plant, as well as a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed

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[31] "Design Basis Threat; Final Rule," dated March 19, 2007 (72 FR 12705). Upheld by *Public Citizen v. NRC*, referenced above.

[32] John C. Hoyle, NRC, memorandum to L. Joseph Callan, NRC, "Staff Requirements – COMSAJ-97-008 – Discussion on Safety and Compliance," dated August 25, 1997. Available at http://www.nrc.gov/reading-rm/doc-collections/commission/comm-secy/1997/1997-008comsrm.pdf.

[33] NUREG/BR-0058, Revision 4, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," dated September 2004. Available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0058/br0058r4.pdf.

[34] "Nuclear Regulatory Commission Enforcement Manual," dated December 10, 2015. ADAMS Accession No. ML102630150.

and in effect.[35] In relevant part, the current licensing basis includes the plant-specific design basis information, as documented in the most recently updated final safety analysis report.

Design bases, as defined in 10 CFR 50.2, "Definitions," means that information which identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. Every domestic nuclear power plant has a design-basis flood level (for both internally and externally sourced floods) included in the licensing basis of the plant. Safety-related systems, structures, and components[36] must remain functional during the defined design-basis flood. Historically, the design basis for external hazards, such as flooding, was established at the time the plant was initially licensed. There is no requirement that licensees periodically assess new external hazards. When new information is discovered, the NRC must determine the appropriate course of action. Licensees are also obligated to inform the NRC of issues that they determine have a significant implication for public health and safety, according to 10 CFR 50.9, "Completeness and accuracy of information," paragraph b.

A.3 Evaluation of Flooding Hazards

Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 includes General Design Criterion 2:

> Structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design basis for these structures, systems, and components shall reflect, among other things, appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Guidance to applicants in establishing their design-basis floods is provided in Regulatory Guide 1.59.[37] The NRC staff's review is guided by the Standard Review Plan, for which there are specific sections on hydrology and various types of floods.[38] To evaluate the design-basis flood for a new applicant, the NRC staff uses the guidance in NUREG/CR-7046.[39]

In most cases, the plants described in this report received their construction permits (the licensing stage at which many siting issues are resolved) before this guidance was issued, so their assessment of external hazards does not necessarily follow the same approaches. In addition, some plants were licensed before the General Design Criteria were promulgated; in these cases, the plant-specific licensing basis includes principal design criteria for the plant that

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[35] 10 CFR 54.3, "Definitions," paragraph a.

[36] As defined in 10 CFR 50.2, safety-related structures, systems, and components are those that are relied upon to remain functional during and following design-basis events to assure: (1) the integrity of the reactor coolant pressure boundary; (2) the capability to shut down the reactor and maintain it in a safe shutdown condition; or (3) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in 10 CFR 50.34(a)(1) or 10 CFR 100.11, as applicable.

[37] Regulatory Guide 1.59, Revision 2, "Design Basis Floods for Nuclear Power Plants," dated August 1977. ADAMS Accession No. ML003740388.

[38] NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition — Site Characteristics and Site Parameters," Chapter 2, Sections 2.4.1-2.4.14, available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/ch2/.

[39] NUREG/CR-7046, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America," dated November 2011. ADAMS Accession No. ML11321A195.

may be based on the draft General Design Criteria or other similar provisions. Where appropriate, the remainder of the report highlights these distinctions.

As an illustration of this approach, if the NRC determined based on new information that safety-related equipment would not remain functional during a design-basis flood at a particular plant, the plant would not be in compliance with its licensing basis and would be required to correct the issue. If the NRC determined based on new information that the design-basis flood level, as documented in a plant's licensing basis, did not ensure adequate protection, the NRC would require the necessary changes to ensure that there was adequate protection. If the NRC determined that a plant was within its current licensing basis, and that no change was necessary to ensure adequate protection, the NRC would assess whether any proposed new requirements would provide a substantial increase in the overall protection of public health and safety, and whether the direct and indirect costs of implementation were justified.

A.4 Generic Issues Program

On October 8, 1976, the Commission directed the NRC staff to develop "a program plan for resolution of generic issues and completion of technical projects." This direction was reemphasized on December 12, 1977, when Congress added Section 210 to the Energy Reorganization Act,[40] requiring the NRC to develop a plan for the specification and analysis of unresolved safety issues relating to nuclear reactors. To meet both Commission and congressional directives, the NRC staff developed a Generic Issues Program, which has evolved over the years.[41] This program addresses only issues that meet the following criteria.[42]

1. The issue affects public health and safety, the common defense and security, or the environment (with respect to radiological health and safety). For issues that are not amenable to quantification using risk assessment, qualitative factors may be developed and applied as necessary to assess safety/risk significance.

2. The issue applies to two or more facilities and/or licensees/certificate holders, or holders of other regulatory approvals.

3. The issue is not being addressed using other regulatory programs and processes; existing regulations, policies, or guidance.

4. The issue can be resolved by new or revised regulation, policy, or guidance.

5. The issue's risk or safety significance can be adequately determined in a timely manner (i.e., it does not involve phenomena or other uncertainties that would require long-term study and/or experimental research to establish the risk or safety significance).

6. The issue is well defined, discrete, and technical.

7. Resolution of the issue may involve review, analysis, or action by the affected licensees, certificate holders, or holders of other regulatory approvals.

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[40] Energy Reorganization Act of 1974, as amended. Public Law 93-438. The full text of the Act is provided in NUREG-0980, Volume 1, Number 10, "Nuclear Regulatory Legislation – 112th Congress; 2nd Session," dated September 2013. ADAMS Accession No. ML13274A489.

[41] NUREG-0933, "Resolution of Generic Safety Issues," available at http://nureg.nrc.gov/sr0933/.

[42] NRC Management Directive 6.4, "Generic Issues Program," dated January 2, 2015. ADAMS Accession No. ML14245A048.

When a potential generic issue first emerges, the Office of Nuclear Reactor Regulation, which is responsible for regulating operating plants, typically evaluates the issue pursuant to its office instruction for risk-informed decision-making, LIC-504, to determine whether or not it is an immediate safety concern.[43] If it is determined that it is not an immediate safety concern, this is documented including any justification for continued operation while the generic issue is resolved.

A generic issues review panel convenes to determine whether or not the proposed generic issue satisfies all seven of the screening criteria listed above. If the panel concludes that it does, it prepares a memorandum that also includes a justification for continued operation while the issue is being resolved. The issue then moves into the assessment phase. During this phase, an assessment team is formed to prepare an evaluation of risk significance, safety significance, security significance, regulatory compliance, as well as a limited regulatory analysis and a proposed regulatory path forward. Once the review panel and the Director of the Office of Nuclear Regulatory Research (the process owner) agree with the proposed regulatory path forward, this evaluation is transmitted to the program office (e.g., the Office of Nuclear Reactor Regulation) for implementation, along with a justification for continued operation during the implementation phase. During the implementation phase, the program office determines the appropriate regulatory requirement and closes out the generic issue.

A.5 Response to Fukushima Dai-ichi Accident

On March 11, 2011, a 9.0 magnitude earthquake struck Japan, followed by a 45-foot tsunami.[44] As a result of the earthquake, offsite power was lost to the entire facility. The emergency diesel generators started at all six units providing alternating current (ac) electrical power to critical systems at each unit, and the facility response to the seismic event appears to have been normal.

Approximately 40 minutes following the earthquake and shutdown of the operating units, the first large tsunami wave inundated the site followed by multiple additional waves. The estimated height of the tsunami exceeded the site design protection from tsunamis by approximately 27 feet. The tsunami resulted in extensive damage to site facilities and a complete loss of ac electrical power at Units 1 through 5, a condition known as station blackout. Despite the actions of the operators following the earthquake and tsunami, cooling was lost to the fuel in the Unit 1 reactor after several hours, the Unit 2 reactor after about 71 hours, and the Unit 3 reactor after about 36 hours. Damage to the nuclear fuel began shortly after the loss of cooling.

Following the accident at Fukushima Dai-ichi, the NRC convened a Near-Term Task Force to evaluate the need for NRC action. The task force concluded that earthquakes and flooding hazards warranted further consideration given significant advancements in the state of knowledge and the state of analysis in these areas in the time period since the operating plants were sited and licensed. Since 1977, flood estimation techniques have significantly improved, with the availability of more accurate datasets and newer hydrologic, hydraulic, and hydrodynamic models. With regard to flooding hazards, the assumptions and factors that were considered in flood protection at different sites vary. In some cases, the design basis does not consider the probable maximum flood (PMF). In other cases, the PMF is calculated differently

[43] LIC-504, Revision 4, "Integrated Risk-Informed Decision-Making Process for Emergent Issues," dated June 2, 2014. ADAMS Accession No. ML14035A143.

[44] Background information on the accident is taken from "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated July 12, 2011. ADAMS Accession No. ML111861807.

at units co-located at the same site, depending on the time of licensing, resulting in different design-basis flood protection. The task force observed that some plants had an overreliance on operator actions and temporary flood mitigation measures such as sandbagging, temporary flood walls and barriers, and portable equipment to perform safety functions. In addition, potential dam failures had been addressed inconsistently in the establishment of the design-basis flood. In some cases, emphasis was placed on dam failures coincident with seismic events, while other mechanisms for dam failures were not fully considered.

The Near-Term Task Force made three recommendations pertinent to this report:

- Recommendation 2.1 was to order licensees to reevaluate the seismic and flooding hazards at their sites against current NRC requirements and guidance, and if necessary, update the design basis and structures, systems, and components important to safety to protect against the updated hazards.

- Recommendation 2.3 was to order licensees to perform seismic and flood protection walkdowns to identify and address plant-specific vulnerabilities and verify the adequacy of monitoring and maintenance for protection features such as watertight barriers and seals in the interim period until longer term actions are completed to update the design basis for external events.

- Recommendation 4.2 was to order licensees to provide reasonable protection for equipment currently provided pursuant to 10 CFR 50.54(hh)(2) from the effects of design-basis external events and to add equipment as needed to address multiunit events while other requirements are being revised and implemented.

On October 18, 2011, the Commission approved these three task force recommendations, as well as others.[45]

Furthermore, on December 23, 2011, the Consolidated Appropriations Act for fiscal year 2012 was signed into law.[46] Section 402 of this law required a reevaluation external hazards, stating that the NRC:

> ...shall require reactor licensees to reevaluate the seismic, tsunami, flooding, and other external hazards at their sites against current applicable Commission requirements and guidance for such licenses as expeditiously as possible, and thereafter when appropriate, as determined by the Commission, and require each licensee to respond to the Commission that the design basis for each reactor meets the requirements of its license, current applicable Commission requirements and guidance for such license. Based upon the evaluations conducted pursuant to this section and other information it deems relevant, the Commission shall require licensees to update the design basis for each reactor, if necessary.

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[45] Annette L. Vietti-Cook, NRC, memorandum to R.W. Borchardt, NRC, "Staff Requirements – SECY-11-0124 – Recommended Actions to Be Taken without Delay from the Near-Term Task Force Report," dated October 18, 2011. ADAMS Accession No. ML112911571. The NRC staff's referenced Commission paper, SECY-11-0124, dated September 9, 2011, is available at ADAMS Accession No. ML11245A127.

[46] Consolidated Appropriations Act, 2012. Public Law 112-074. Available at https://www.gpo.gov/fdsys/pkg/PLAW-112publ74/pdf/PLAW-112publ74.pdf.

Consistent with Commission and Congressional direction, on March 12, 2012, the NRC staff issued a request for information pursuant to 10 CFR 50.54(f) to all power reactor licensees. Specific to flooding, the letter indicates that its purpose was:

- To gather information with respect to Recommendation 2.1, as amended by staff requirements memoranda associated with SECY-11-0124 and SECY-11-0137,[47] and the Consolidated Appropriations Act, 2012, Section 402, to reevaluate seismic and flooding hazards at reactor sites

- To collect information to facilitate NRC"s determination if there is a need to update the design basis and systems, structures, and components important to safety to protect against the updated hazards at reactor sites

- To collect information to address Generic Issue 204 regarding flooding of nuclear power plant sites following upstream dam failures

The letter required licensees to perform a reevaluation of all appropriate external flooding sources, including the effects from local intense precipitation on the site, PMF on streams and rivers, storm surges, seiches, tsunami, and dam failures. The reevaluation was to apply present-day regulatory guidance and methodologies being used for new reactor reviews, including current techniques, software, and methods used in present-day standard engineering practice to develop the flooding hazard.

For the sites where the reevaluated flood exceeds the design basis, licensees were required to submit an interim action plan that documented actions planned or taken to address the reevaluated hazard with the hazard evaluation. Subsequently, licensees were expected to further assess the capabilities of the plant to identify vulnerabilities and necessary actions. The responses were due within one to three years depending on the priority assigned to the facility by the NRC staff.

A.6 Programs for Addressing Differing Views

The NRC has several programs and mechanisms for raising and addressing differing technical views. In general, it is the NRC's expectation that employees raise concerns promptly and discuss their views with their immediate supervisors on a regular, ongoing basis. The NRC's processes also provide for other means of making views known and having them formally dispositioned. All of these programs have been used during the NRC's consideration of flooding and dam failure issues. They have contributed to more fully informed and technically sound decision-making processes.

Individual NRC staff have the explicit legal right to raise issues directly with the Presidentially-appointed Commission: "Any officer or employee under the Commission may communicate directly to the Commission, or to any member of the Commission, whenever in the view of such officer or employee critical problem or public health and safety or common defense and security is not being properly addressed."[48] As an extension of this provision, the NRC has an Open

[47] SECY-11-0137, "Prioritization of Recommended Actions to Be Taken in Response to Fukushima Lessons Learned," dated October 3, 2011, is available at ADAMS Accession No. ML11269A204, and the subsequent staff requirements memorandum dated December 15, 2011, is available at ADAMS Accession No. ML113490055.
[48] Section 4(a) of the Reorganization Plan No. 1 of 1980, dated March 27, 1980. The full text of the Plan is provided in NUREG-0980, Volume 1, Number 10, "Nuclear Regulatory Legislation – 112th Congress; 2nd Session," dated September 2013. ADAMS Accession No. ML13274A489.

Door Policy that emphasizes that NRC staff may raise concerns with any member of the agency's leadership, including the Commission, without the requirement to go through the management chain in hierarchal order.[49]

A somewhat more formal process is the Non-Concurrence Process.[50] This process allows NRC staff to document their concerns in writing during the concurrence process regarding a document that they had a role in creating or reviewing. Employees are encouraged, but not required, to use the non-concurrence process to address their concerns. This process enables the agency to understand and respond to the concerns—including changing the outcome of the decision—before a final staff position is taken. The process begins with an informal discussion stage, which can be followed by a formal expression of the nature and basis for the non-concurrence. Both the immediate supervisor and the individual responsible for the document (normally the document signer) are required by procedure to respond in writing to the non-concurrence. The non-concurrence and the responses to it are presented to any other individuals in the document concurrence chain for their consideration. On Commission-level documents, for example, non-concurrences are acknowledged in the document and attached for Commission information and consideration.

The Differing Professional Opinion Program provides a formal venue for NRC employees or contractors to provide a conscientious expression of a judgment or position that differs from an established staff view, disagrees with a management decision or policy position, or takes issue with an established agency practice involving technical, legal, or policy issues.[51] Differing professional opinions are addressed at a senior management level, normally at the Office Director level, based on input from the submitter and an independent panel of 3 subject-matter experts (established with input from the submitter). The process also provides for appeals reviewed by the NRC Executive Director for Operations or the Chairman or the Commission, depending on the office in which the process was initiated.

The actions described in response to the OSC Question 3 include several examples of NRC staff raising differing views. Those differing views, their consideration, and their resolution all contributed to the agency's deliberative process.

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[49] NRC Management Directive 10.160, "Open Door Policy," dated October 26, 2015. ADAMS Accession No. ML15219A454.
[50] NRC Management Directive 10.158, "NRC Non-Concurrence Process," dated March 14, 2014. ADAMS Accession No. ML13176A371.
[51] NRC Management directive 10.159, "NRC Differing Professional Opinion Program," dated August 11, 2015. ADAMS Accession No. ML15132A664.

Appendix B: Additional Detail on Actions Taken at Sites

This appendix provides additional detail associated with the response to Question 3 from the U.S. Office of Special Counsel (OSC) in Section 4.3 of this report, focusing on the licensing basis, plant-specific actions, and actions taken in response the Fukushima Dai-ichi accident for each of the 19 sites. Further information is available in the referenced documents. Specific values and mechanisms associated with failure of dams are not included, both because they are not necessary for a clear discussion and because the U.S. Nuclear Regulatory Commission (NRC) approach, agreed upon with its Federal partners with shared responsibility for dam safety, is not to include this information in NRC-generated publicly available documents.

B.1 Arkansas Nuclear One

Arkansas Nuclear One (ANO), located 6 miles west-northwest of Russellville, AR, has two units. Unit 1 is a pressurized-water reactor (PWR) of Babcock & Wilcox design.[52] Its operating license was issued in 1974 and renewed in 2001 for a term that expires in 2034. Unit 2 is a PWR of Combustion Engineering design.[53] Its operating license was issued in 1978 and renewed in 2005 for a term that expires in 2038.

B.1.1 Initial Plant Design and Licensing[54]

ANO is surrounded on three sides by the Dardanelle Reservoir, which is part of the Arkansas River navigation project and is created by the Dardanelle Dam. The dam is managed and controlled by the U.S. Army Corps of Engineers. The upper end of the Dardanelle Reservoir lies beneath the Ozark Dam, which is approximately 51 miles upstream. Site grade is at 353 feet mean sea level (MSL).

The licensee stated that the design-basis flooding hazards are: (1) the probable maximum flood (PMF) on the Dardanelle reservoir in the Arkansas River, coincident with an instantaneous failure of the Ozark Dam; and (2) groundwater intrusion during floods. The design-basis flood level established based on these hazards is 361 feet MSL, and splash effects on critical equipment and components are considered up to 368 feet MSL.

The licensee considered its initial estimate of the flood level for an instantaneous Ozark Dam failure coincident with the PMF "so unlikely as to be practically impossible." This estimate was based on a very conservative river channel assumption and did not account for 50 square miles of flood plain. Therefore, the final flooding calculation estimates a smaller additional flood level above the PMF.

The licensee's adverse weather procedures for both units specify actions to be taken based on different levels of the Dardanelle Reservoir, as measured at the intake structures. To maintain offsite power to the plant, when flood levels exceed 356.5 feet MSL, temporary jumper cables are installed from an offsite power transmission line to an onsite transformer. The procedures also address verification or closure of flood doors, as well as installation of temporary flooding barriers.

In addition, for Unit 2, the technical specifications in the license require closure of identified openings and penetrations when the water level of the Dardanelle Reservoir exceeds 350 feet

[52] http://www.nrc.gov/info-finder/reactors/ano1.html.
[53] http://www.nrc.gov/info-finder/reactors/ano2.html.
[54] Information in this section is drawn from the licensee's walkdown reports referenced below.

MSL at the intake structure. The Unit 2 technical specifications also require monitoring of water level.

B.1.2 Additional Plant-Specific Actions

Ongoing regulatory processes throughout ANO's operating period have resulted in several flooding-related enhancements, though they are not specific to dam failure.

Based on the results of its Individual Plant Examination of External Events (IPEEE), the licensee committed to conduct drain and scupper inspections on the Unit 1 roof, confirming that these features would provide adequate drainage to maintain roof loads below structural limits in the event of local intense precipitation. [55]

In addition, there were flooding protection challenges revealed by the March 31, 2013, heavy component drop event at ANO, which resulted in one fatality and eight injured personnel.[56, 57] Both Unit 1 and Unit 2 final safety analysis reports require that the auxiliary building and safety-related pumps rooms be watertight. The licensee, however, identified over 100 deficient flood protection features after the event, including unsealed electrical cable conduit and degraded hatches and floor plug seals in the auxiliary and emergency diesel fuel storage buildings. NRC inspections subsequently identified additional problems, necessitating further reviews.

The NRC concluded that the licensee had failed to design, construct, and maintain the flood protection features in both units in accordance with the approved design requirements. The overall finding included multiple examples of violations and was determined to have substantial safety significance. The primary contributor to the safety significance was the theoretical maximum rainfall event, which could lead to core damage if equipment were disabled as a result of the degraded flood protection features.

In response to the degraded performance at ANO, the NRC conducted a broad-scope supplemental inspection, and the licensee is preparing a Comprehensive Recovery Plan. As discussed in a public meeting on April 6, 2016, the NRC will issue a Confirmatory Action Letter to identify key actions from the Comprehensive Recovery Plan that will receive follow-up inspections.[58] When all of the Confirmatory Action Letter items are closed, the Confirmatory Action Letter will be closed. Historically, this process has taken plants at least two years.

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[55] This information on the IPEEE is drawn from Volume 2 of NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," dated April 2002, available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1742/.

[56] http://www.nrc.gov/info-finder/reactors/ano/special-oversight.html#features.

[57] This event is one of the subjects of NRC Information Notice 2015-01, "Degraded Ability to Mitigate Flooding Events," dated January 9, 2015. ADAMS Accession No. ML14279A268.

[58] Neil O'Keefe, NRC, letter to Jeremy Browning, Entergy Operations, Inc., "Summary of Meeting to Discuss Supplemental Inspection Results and Annual Assessment Meeting with Entergy Operations Inc. Regarding 2015 Performance of Arkansas Nuclear One," dated April 18, 2016. ADAMS Accession No. ML16109A364.

B.1.3 Flooding Walkdowns

In November 2012, ANO notified the NRC that it had completed its flooding walkdowns.[59, 60] The licensee indicated that walkdowns were performed consistent with Nuclear Energy Institute (NEI) 12-07, the NRC-endorsed industry guidance.[61, 62]

In the walkdown reports, the licensee noted that some observed conditions of features that did not meet the NEI 12-07 acceptance criteria were entered into the Corrective Action Program; however, none of these observations were determined to be deficiencies as defined in NEI 12-07. The operability determinations for these conditions concluded that the feature could perform its intended flood protection function when subject to its design-basis flooding hazard. The licensee initiated a work order to repair a watertight door that had evident gaps between the door and door seal at the top of the door. The gap was above the design-basis flood level therefore did not challenge plant design.

In 2013, the licensee recognized that water would potentially enter the Unit 2 Auxiliary Building Extension during a design-basis flood. The Auxiliary Building Extension does not house any safety-related equipment, but it is adjacent to the Unit 2 Auxiliary Building, which does contain safety-related equipment. To mitigate the effects of a flood on the safety-related equipment in the Unit 2 Auxiliary Building, the licensee revised procedures to direct the installation of a temporary barrier during floods at the connection between the Unit 2 Auxiliary Building and Auxiliary Building Extension below the design-basis flood level.

In 2014, the licensee conducted additional walkdowns and provided revised walkdown reports that addressed the flooding protection challenges revealed by the March 13, 2013, heavy component drop event described above.[63] These reports described deficiencies in flood protection features such as degraded or missing seals and gaskets, drain cross-connections, and groundwater intrusion.[64] The licensee stated that these deficiencies were either promptly repaired or addressed with compensatory measures. Repairs included installing or replacing flood seals and isolating abandoned-in-place equipment. The compensatory measures included fabricating and properly staging temporary flood barriers and staging seal material to be installed in the event of external flooding.

The NRC staff reviewed the walkdown reports and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the request for

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[59] Christopher J. Schwarz, Entergy Operations, Inc., letter to NRC, "Flooding Walkdown Report – Entergy's Response to NRC Request for Information (RFI) Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Arkansas Nuclear One – Unit 1," dated November 27, 2012. ADAMS Accession No. ML123340008.

[60] Christopher J. Schwarz, Entergy Operations, Inc., letter to NRC, "Flooding Walkdown Report – Entergy's Response to NRC Request for Information (RFI) Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Arkansas Nuclear One – Unit 2," dated November 27, 2012. ADAMS Accession No. ML123340007.

[61] Adrian P. Heymer, NEI, letter to David L. Skeen, NRC, "NRC Endorsement of NEI 12-07, Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," dated June 18, 2012. ADAMS Accession No. ML12172A030.

[62] David L. Skeen, NRC, letter to Adrian P. Heymer, NEI, "Endorsement of Nuclear Energy Institute (NEI) 12-07, 'Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," dated May 31, 2012. ADAMS Accession No. ML12144A142.

[63] Jeremy G. Browning, Entergy Operations, Inc., letter to NRC, "Arkansas Nuclear One, Units 1 and 2, Additional Revised Response to NRC 10 CFR 50.54(f) Request for Information Regarding Near-Term Task Force (NTTF) Recommendation 2.3, Flooding," dated May 15, 2014. ADAMS Accession No. ML14139A374.

[64] These deficiencies and corrective actions were also described in Licensee Event Report 50-313/ 2014-01-00. ADAMS Accession No. ML14125A483.

information issued in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) (referred to as a 10 CFR 50.54(f) letter).[65] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features.[66] No findings were identified during these inspections.[67,68]

B.1.4 Reevaluation of Flooding Hazard

The NRC staff prioritized ANO as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter.[69] Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The licensee later requested that the NRC assist it in obtaining information on upstream dams managed by the U.S. Army Corps of Engineers.[70] The NRC staff considered the licensee's planned approach and relaxed the final response date to account for the time needed to obtain the input from the U.S. Army Corps of Engineers and complete the analysis.[71] The licensee also provided interim information on flooding calculations (including multiple upstream dams that would be considered) to support the U.S. Army Corps of Engineers analysis.[72] The NRC transmitted the results of the U.S. Army Corps of Engineers analysis to the licensee in March 2016 and noted that the licensee needs to complete its flooding hazard reevaluation report by September 2016.[73]

After the reevaluation is complete, the NRC staff will provide feedback for the use of this information in updating (as needed) the mitigating strategies for the site, and the licensee will perform either a focused evaluation or a broader integrated assessment of the plant's protection capabilities against flood mechanisms. Finally, the NRC will determine the need for further actions based on this information.

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[65] Peter J. Bamford, NRC, letter to Entergy Operations, Inc., "Arkansas Nuclear One, Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0194 and MF0195)," dated June 27, 2014. ADAMS Accession No. ML14178A821.

[66] Temporary Instruction (TI) 2515/187, "Inspection of Near-Term Task Force Recommendation 2.3 Flooding Walkdowns," dated June 27, 2012. ADAMS Accession No. ML12129A108.

[67] Donald B. Allen, NRC, letter to Jeremy Browning, Entergy Operations, LLC, "Arkansas Nuclear One – NRC Integrated Inspection Report 05000313/2012005 and 05000368/2012005," dated February 13, 2013. ADAMS Accession No. ML13045A520.

[68] Donald B. Allen, NRC, letter to Jeremy Browning, Entergy Operations, LLC, "Arkansas Nuclear One – NRC Integrated Inspection Report 05000313/2013003 and 05000368/2013003," dated August 13, 2013. ADAMS Accession No. ML13225A747.

[69] Eric J. Leeds, NRC, letter to all power reactor licensees and holders of construction permits, "Prioritization of Response Due Dates for Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated May 11, 2012. ADAMS Accession No. ML12097A509.

[70] Stephenie L. Pyle, Entergy Operations, Inc., letter to G. Edward Miller, NRC, "Assistance in Obtaining Information on Dams," dated September 30, 2013. ADAMS Accession No. ML13275A067.

[71] Daniel H. Dorman, NRC, letter to Entergy Operations, Inc., "Arkansas Nuclear One Units 1 and 2 – Relaxation of Response Due Date Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the NTTF Review of the Insights from the Fukushima Dai-ichi Accident," dated July 17, 2014. ADAMS Accession No. ML14171A529.

[72] Stephenie L. Pyle, Entergy Operations, Inc., letter to NRC, "Data Request Supporting United States Army Corps of Engineers (USACE) Flood Analysis – Arkansas Nuclear One – Units 1 and 2," dated September 9, 2014. ADAMS Accession No. ML14262A083.

[73] Victor Hall, NRC, letter to Entergy Operations, Inc., "Arkansas Nuclear One, Units 1 and 2 Transmittal of U.S. Army Corps of Engineers Flood Hazard Reevaluation Information," dated March 21, 2016. ADAMS Accession No. ML16071A452.

B.1.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[74, 75] In this plan, the licensee restated the design-basis flooding information described above and noted that ANO is not considered a "dry" site and that flooding is screened in as a hazard to mitigate. The licensee assumed that a flood of the magnitude of the PMF will be forecast about five days prior to the flood's arrival at the plant site. Therefore, it is assumed that at least 24 hours are available for the deployment of FLEX equipment for the preparation for a flooding scenario, and that power is available during this time.

The licensee's plan to mitigate an extended loss of ac power concurrent with a loss of normal access to the ultimate heat sink (referred to in this appendix as an ELAP/LUHS event) addresses inventory control in the reactor coolant system, maintaining containment, maintaining spent fuel pool cooling, and providing appropriate support functions. The plan also describes the additional feed pumps, inventory transfer pumps, hoses, diesel generators, and debris removal equipment and other equipment for accessibility that would be obtained to implement these strategies, both on-site and from the Regional Response Center. The sequence of events presents, for both units, the time needed to shed loads on batteries, deploy a portable generator, align portable pumps, and perform other actions.

The strategy and modifications for core cooling are described in this section as an example. The licensee described procedural modifications for the initial phase of mitigation using installed equipment (feeding the steam generators using emergency feedwater pumps and the "Q" condensate storage tank and relieving steam through the atmospheric dump valves and main steam safety valves), including manual actions when power is unavailable. In Phase 2 (the transition period), portable diesel-driven pumps are used to transfer additional water to the "Q" condensate storage tank. In Phase 3 (the indefinite period), additional offsite sources of water and fuel are used, and a hose connection will be made to a pump from the Regional Response Center to provide service water cooling to the plant from the ultimate heat sink.

The NRC staff performed an interim evaluation of this plan and identified an open item related to the use of the Unit 2 charging pump to supply makeup to the Unit 1 reactor coolant system for inventory control, as well as several confirmatory items.[76] The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[77] During the audit, the NRC

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[74] Jeremy G. Browning, Entergy Operations, Inc., letter to NRC, "Overall Integrated Plan in Response to March 12, 2012, Commission Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) – Arkansas Nuclear One – Units 1 and 2," dated February 28, 2013. ADAMS Accession No. ML13063A151.

[75] These initial plans were developed using earlier revisions of the guidance referenced above, specifically NEI 12-06, Revision 0, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," dated August 21, 2012. ADAMS Accession No. ML122420493. NEI 12-06, Revision 0 was accepted for use by the NRC staff in JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated August 29, 2012. ADAMS Accession No. ML12229A174.

[76] Jeremy S. Bowen, NRC, letter to Entergy Operations, Inc., "Arkansas Nuclear One, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigating Strategies) (TAC Nos. MF0942 and MF0943)," dated February 25, 2014. ADAMS Accession No. ML14007A459.

[77] Peter Bamford, NRC, letter to Entergy Operations, Inc., "Arkansas Nuclear One, Units 1 and 2 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0942, MF0943, MF0944, and MF0945)," dated September 1, 2015. ADAMS Accession No. ML15236A340.

staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

On January 12, 2016, the licensee notified the NRC that ANO is in full compliance with Order EA-12-049.[78] All modifications have been installed, procedures and training are complete, and the licensee has responded to all of the NRC staff's open and confirmatory items. The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.2 Beaver Valley

Beaver Valley Power Station (Beaver Valley), located on the Ohio River in Shippingport, PA, has two units of Westinghouse PWR design.[79] The operating licenses for Unit 1 and Unit 2 were issued in 1976 and 1987, respectively. The licenses were renewed in 2009 for terms that expire in 2036 and 2047, respectively.

B.2.1 Initial Plant Design and Licensing[80]

Normal level of the Ohio River is 664.5 feet MSL, and the flooding analysis considers several higher river levels up to a PMF of 730 feet.

The licensee's design-basis flooding evaluation considered upstream dam failure. In this evaluation, the Conemaugh Dam was the most critically located dam with respect to flooding resulting from a dam failure. The licensee noted that even though the Conemaugh Dam has been analyzed to be safe against combinations of earthquakes and floods considered in the design, a scenario was evaluated in which this dam failed coincident with the standard project flood (a flood less significant than the PMF). An analysis performed by the U.S. Army Corps of Engineers showed that the resultant peak stage at the site would be lower than the PMF level.

The licensee's design-basis flooding evaluation also considered the possibility of multiple dam failures. The licensee concluded, however, that all dams that could potentially affect water levels at the plant site are located on separate tributaries of the Ohio River and cascading effects need not be considered. In addition, the seismic design of the dams meant that simultaneous failure was not considered credible.

All seismic Category I structures are protected from the PMF level of 730 feet. All safety-related equipment and connecting piping and wiring is either located above the 730-foot elevation or adequately protected so that its function is unaffected by a flood to this elevation.

When river level reaches 670 feet, the licensee enters an Abnormal Operating Procedure for flooding; an alert is issued at 690 feet, and protective actions (including shutting down the plant depending on the forecast) are taken starting at 695 feet. Beaver Valley also has a written plant procedure for dam failure, which provides relevant guidance and refers to the flooding procedure for additional actions.

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[78] Jeremy G. Browning, Entergy Operations, Inc., letter to NRC, "Notification of Full Compliance with NRC Order EA-12-049 Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (BDBEEs) – Arkansas Nuclear One – Units 1 and 2," dated January 12, 2016. ADAMS Accession No. ML16014A396.

[79] http://www.nrc.gov/info-finder/reactors/bv1.html and http://www.nrc.gov/info-finder/reactors/bv2.html.

[80] Information in this section is drawn from the licensee's walkdown report referenced below.

B.2.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Beaver Valley.

B.2.3 Flooding Walkdowns

In November 2012, Beaver Valley notified the NRC that it had completed its flooding walkdowns.[81] The licensee indicated that walkdowns were performed consistent with NEI 12-07. The licensee did not identify any deficiencies where a flood protection feature would not be able to perform the intended function. Several observations were noted for which condition reports were issued and were being addressed at the time of the walkdown report. These included, for example, an open piece of pipe that needed a blind flange, sealant needed to protect a water curb box from corrosion, a cable vault that needed further evaluation.

No modifications to flood protection systems were necessary as a result of the licensee's walkdown evaluations. The licensee noted that it was preparing new watertight covers to be used when pumps in the intake structure are removed for service, but that this had been in progress before the walkdowns.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[82] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during this inspection.[83]

B.2.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Beaver Valley as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The NRC staff later approved an extension of this schedule to allow for input on dams managed by the U.S. Army Corps of Engineers.[84] The NRC provided the relevant information to the licensee in September 2015.[85]

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[81] Peter P. Sena, III, FirstEnergy Nuclear Operating Company (FENOC), letter to NRC, "FENOC Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML12335A341.

[82] Jeffrey A. Whited, NRC, letter to Eric A. Larson, FENOC, "Beaver Valley Power Station Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0196 and MF0197)," dated June 16, 2014. ADAMS Accession No. ML14156A233.

[83] Gordon K. Hunegs, NRC, letter to Paul A. Harden, FENOC, "Beaver Valley Power Station – NRC Integrated Inspection Report 05000334/2012005 and 05000412/2012005," dated February 5, 2013. ADAMS Accession No. ML13036A302.

[84] Daniel H. Dorman, NRC, letter to Eric A. Larson, FENOC, "Beaver Valley Power Station Units 1 and 2 – Relaxation of Response Due Date Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident (TAC Nos. MF3589 and MF3590)," dated July 17, 2014. ADAMS Accession No. ML14171A461.

[85] Juan F. Uribe, NRC, letter to Eric A. Larson, FENOC, "Beaver Valley Power Station, Units 1 and 2 – Transmittal of U.S. Army Corps of Engineers Flood Hazard Reevaluation Information (TAC Nos. MF3286 AND MF3287)," dated September 10, 2015. ADAMS Accession No. ML15254A273.

In March 2016, the licensee submitted the flooding hazard reevaluation report for Beaver Valley.[86] The licensee noted that the current design basis for the plant (i.e., the 730-foot PMF) bounds the reevaluated dam failure hazard. The licensee only identified one issue that could result in plant modifications—several doors that could be susceptible to postulated water infiltration from local intense precipitation. After reassessment, the water volumes entering most of these doors was determined by the licensee to be inconsequential, such that no action was needed; for two doors, a modification is underway to install flood barrier panels.

The NRC staff has begun its review of the hazard reevaluation and plans to conduct an audit to aid in its review. The NRC staff will provide feedback for the use of this information in updating (as needed) the mitigating strategies for the site, and the licensee will perform either a focused evaluation or a broader integrated assessment of the plant's protection capabilities against flood mechanisms. Finally, the NRC will determine the need for further actions based on this information.

B.2.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[87] Based on the PMF described above, flooding needed to be considered in the development of the mitigating strategies.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the approach at Beaver Valley to maintain core cooling during an ELAP/LUHS event is to initially remove core decay heat by adding water to the steam generators releasing steam to the atmosphere. The water will initially be added by the turbine-driven auxiliary feedwater pump, taking suction from the respective unit's primary plant demineralized water storage tank, with subsequent makeup provided from the other unit's demineralized water storage tank or the ultimate heat sink (the Ohio River). A FLEX generator for each unit will be connected to the existing plant electrical distribution system. This will allow the energizing of selected loads in the distribution system to implement the FLEX strategy, such as critical instrumentation and battery chargers. Recharging the batteries will support continued operation of the direct current distribution system and the vital bus inverters. The FLEX diesel will also power a FLEX reactor coolant system makeup pump. When the turbine-driven auxiliary feedwater pump can no longer be operated reliably due to the lowering steam generator pressure, a diesel-driven FLEX pump will be used to add water to the steam generators. In the long term, additional equipment, such as large diesel generators, will be delivered from one of the Regional Response Centers.

The NRC staff performed an interim evaluation of this plan and identified an open item related to tornado missile protection, as well as several confirmatory items.[88] The NRC staff later

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[86] Marty L. Richey, FENOC, letter to NRC, "FirstEnergy Nuclear Operating Company (FENOC) Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-ichi Accident," dated March 2, 2016. ADAMS Accession No. ML16063A288.

[87] Peter P. Sena, III, FENOC, letter to NRC, "FirstEnergy Nuclear Operating Company's (FENOC's) Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 27, 2013. ADAMS Accession No. ML13064A243.

[88] Jeremy S. Bowen, NRC, letter to Eric A. Larson, FENOC, "Beaver Valley Power Station, Units 1 and 2 – Interim Staff Evaluation Related to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0841 and MF0842)," dated January 29, 2014. ADAMS Accession No. ML13364A166.

conducted an audit to evaluate the licensee's progress in implementing the order.[89] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected. The NRC staff identified an issue regarding the protection of FLEX equipment stored in a commercial warehouse from beyond-design-basis external events, among other audit questions. No issues specific to flooding or dam failures were identified.

On December 21, 2015, the licensee notified the NRC that Beaver Valley, Unit 2 is in full compliance with Order EA-12-049.[90] All modifications have been implemented, procedures and training are complete, and the licensee has responded to all of the NRC staff's open and confirmatory items. For Beaver Valley, Unit 1, the NRC staff approved relaxation of the compliance date to Fall 2016 so that technical issues associated with the reactor coolant pump seals could be resolved.[91]

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.3 Browns Ferry

Browns Ferry Nuclear Plant (Browns Ferry), located 32 miles west of Huntsville, AL, has three units of General Electric boiling-water reactor (BWR) design. The operating licenses were issued in 1973, 1974, and 1976, respectively. The licenses were renewed in 2006 for terms that expire in 2033, 2034, and 2036, respectively.[92]

B.3.1 Initial Plant Design and Licensing[93]

Site grade at Browns Ferry is 565 feet, and the design-basis flood level is 572.5 feet, combined with wind wave heights where applicable to a total of 578 feet. The source of this flood could be the Tennessee River, a small stream northwest of the plant, or intense local storms that overcome the site drainage system. All of these situations are described in the plant's final safety analysis report.

Consistent with guidance at the time of licensing, Browns Ferry's licensing basis does not include an evaluation of the potential for dams upstream of the plant to fail because of

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[89] John D. Hughey, NRC, letter to Eric A. Larson, FENOC, "Beaver Valley Power Station, Units 1 and 2 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0799, MF0800, MF0841 and MF0842)," dated November 2, 2015. ADAMS Accession No. ML15292A139.

[90] Timothy F. Steed, FENOC, letter to NRC, "Completion of Required Action by NRC Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (TAC No. MF0842) and NRC Order EA-12-051, Reliable Spent Fuel Pool Instrumentation (TAC No. MF0800)," dated December 21, 2015. ADAMS Accession No. ML15355A397.

[91] Eric J. Leeds, NRC, letter to Eric A. Larson, FENOC, "Beaver Valley Power Station, Unit 1 – Relaxation of the Schedule Requirements for Order EA-12-049, 'Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events," dated May 20, 2014. ADAMS Accession No. ML14120A049.

[92] http://www.nrc.gov/info-finder/reactors/bf1.html, http://www.nrc.gov/info-finder/reactors/bf2.html, and http://www.nrc.gov/info-finder/reactors/bf3.html.

[93] Information in this section is drawn from the licensee's walkdown and hazard reevaluation reports referenced below.

earthquakes. The licensee does, however, consider failures of earth-filled dams[94] upstream of the plant in calculating the maximum flood level. The concrete portions of all dams, including the main river dams, were found to be stable in the evaluated situations.

The licensee has a plant procedure for floods that reach above 558 feet, including shutdown of the plant and other preparatory activities if projections from River Operations are beyond site grade. The plant also has protective features that include structural requirements, watertight doors, and portable bulkheads.

The licensee made multiple updates to the Browns Ferry flooding analysis following initial licensing, although no changes to the design-basis flood level were necessary. These revisions are described in the "Additional Plant-Specific Actions" section below.

B.3.2 Additional Plant-Specific Actions[95]

In 1982, the Tennessee Valley Authority (TVA) established the Dam Safety Program and began a safety review of TVA dams. This dam safety effort was designed to be consistent with Federal guidelines and similar efforts by other Federal agencies. Technical studies, engineering analyses, and modifications were performed to ensure hydrologic and seismic integrity of TVA dams. Table 4-3 in the licensee's flooding hazard reevaluation report summarizes the dam modifications made by 1998, including raising of multiple embankments, addition of spillway bays, and post-tensioning of dams. The reassessment addressed the effects of these dam safety modifications on maximum flood levels at Browns Ferry and the time available for safe plant shutdown. The controlling event resulted in a flood level that was bounded by the design-basis flood level of 572.5 feet.

In 2008, as part of the NRC's review of the combined license application for the proposed Units 3 and 4 at the Bellefonte site (another TVA project), the NRC staff audited the licensee's hydrologic modeling and issued three violations associated with quality assurance and design control.[96] In response to these violations, the licensee completed a revised hydrologic analysis for the combined license application. This analysis directly affected Browns Ferry, since the analysis is similar for all TVA plants on the Tennessee River. As a result, in November 2012, the licensee updated the Browns Ferry final safety analysis report to supplement and clarify the current licensing basis based on this updated hydrologic analysis. The calculated PMF level resulting from the revised hydrologic analysis was lower than the design-basis flood level. The licensee did not reduce its design-basis flood level after this reanalysis.

The 2012 analysis included many updates to the evaluation of dam failures. For example, the potential for failure of Cherokee, Fort Loudoun, Tellico, and Watts Bar Dams was identified in the revised PMF analysis. As described further for Sequoyah Nuclear Plant (referred to as Sequoyah) below, the licensee took various actions to prevent failure of these dams.

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[94] These are dams constructed from compacted earth, also referred to in this report as earth embankments or earthen dams, in contrast to rock-fill dams with an impervious zone made of concrete, metal, or another material.
[95] Unless otherwise noted, information in this section is summarized from Section 3.4.3 and Section 4.2 of the licensee's flooding hazard reevaluation report referenced below.
[96] Patrick L. Hiland, NRC, letter to Ashok S. Bhatnagar, TVA, "Bellefonte Combined License Application – Nuclear Regulatory Commission Inspection of the Implementation of the Quality Assurance Program Governing the Simulated Open Channel Hydraulics Model – Inspection Report Numbers 05200014/ 2008-001 and 05200015/2008-001 and Notice of Violation," dated March 19, 2008. ADAMS Accession No. ML080640487.

B.3.3 Flooding Walkdowns

In November 2012, Browns Ferry notified the NRC that it had completed its flooding walkdowns.[97] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

In the walkdown report, the licensee noted that there were no new degraded, non-conforming conditions identified, and Browns Ferry can withstand the design-basis flood. The walkdown teams did notice several deficiencies with the integrity of some watertight doors and penetrations. These were entered in to the licensee's program for corrective action. The licensee also noted several areas where procedures and preventive maintenance could be enhanced. The licensee submitted an updated response in June 2013, after it had completed walkdowns of areas that had restricted access during the first walkdowns, and noted that six deficiencies associated with seals were found and corrected.[98]

The NRC staff reviewed the walkdown reports and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[99] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[100, 101]

B.3.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Browns Ferry as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The licensee later requested a relaxation in this schedule so that it could complete the evaluation of 21 upstream dams and 1 downstream dam in assessing the flooding hazard for the Browns Ferry site; the NRC staff granted this relaxation after reviewing the detailed schedule for preparing the report, as well as in consideration of the forecasting and procedural actions that the licensee had in place to address potential floods.[102]

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[97] J.W. Shea, TVA, letter to NRC, "Tennessee Valley Authority – Fleet Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Flooding Walkdown Results of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML12335A340.

[98] .W. Shea, TVA, letter to NRC, "Tennessee Valley Authority – Supplemental Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident for Browns Ferry Nuclear Plant, Unit 2," dated June 6, 2013. ADAMS Accession No. ML13161A351.

[99] Farideh E. Saba, NRC, letter to Joseph W. Shea, TVA, "Browns Ferry Nuclear Plant Units 1, 2, and 3 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0200, MF0201, and MF0202)," dated June 27, 2014. ADAMS Accession No. ML14168A090.

[100] Eugene F. Guthrie, NRC, letter to Joseph W. Shea, TVA, "Browns Ferry Nuclear Plant – NRC Integrated Inspection Report 05000259/2012005, 05000260/2012005, AND 05000296/2012005," dated February 8, 2013. ADAMS Accession No. ML13039A321.

[101] Victor M. McCree, NRC, letter to Joseph W. Shea, TVA, "Browns Ferry Nuclear Plant – NRC Integrated Inspection Report 05000259/2013002, 05000260/2013002, and 05000296/2013002, and Assessment Follow-Up," dated May 14, 2013. ADAMS Accession No. ML13134A237.

[102] Eric J. Leeds, NRC, letter to Joseph W. Shea, TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident (TAC Nos. MF3620, MF3621, and MF3622)," dated May 9, 2014. ADAMS Accession No. ML14115A287.

The licensee submitted its flooding hazard reevaluation report on schedule in March 2015.[103] The licensee noted that some flood levels exceed the current licensing basis, given the use of newer methodologies and guidance. As such, the licensee committed to conduct an integrated assessment.

Following the latest NRC guidance, the licensee assessed multiple types of dam failures: potential upstream dam failures resulting from their project-specific PMFs, sunny-day failures,[104] and seismically induced failures (which had been qualitatively evaluated in previous analyses and determined to be non-controlling). The licensee identified six dams that could cause flooding at Browns Ferry if they failed randomly. The licensee also assumed in the analysis that downstream dams are closed and inoperable to provide a bounding scenario for cascading dam failures. Considering combined effects and wind wave height, the highest PMF level cited by the licensee for their reevaluation of dam failures was lower than the flood level previously considered in the design for PMF plus wind waves. The seismic failure of an upstream dam, which was not part of the design basis, resulted in a flood level below site grade.

Since certain dam failure scenarios were not included in the design basis, the licensee committed to perform an integrated assessment. In the interim, however, the licensee stated that no specific actions were needed, because these dam failure scenarios resulted in flood levels below site grade, and safe operation would not be affected by such a flood.

The NRC staff audited supporting details for the Browns Ferry flooding hazard reevaluation report (along with others TVA prepared for Sequoyah and Watts Bar Nuclear Plant (referred to as Watts Bar)) in 2015.[105] In September 2015, the NRC staff issued an interim response to the Browns Ferry flooding hazard reevaluation report.[106] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for Browns Ferry. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

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[103] J.W. Shea, TVA, letter to NRC, "Flood Hazard Reevaluation Report for Browns Ferry Nuclear Plant, Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated March 12, 2015. ADAMS Accession No. ML15072A130.

[104] A "sunny-day" failure is a random failure of a dam, not caused by a flood or earthquake. These dam failures may occur because of failures of embankments, foundations, or other dam components, potentially because of an inherent design flaw. NRC guidance indicates that sunny-day failures cannot be screened out. For more information, see JLD-ISG-2013-01, "Guidance for Assessment of Flooding Hazards due to Dam Failure," dated July 29, 2013. ADAMS Accession No. ML13151A153.

[105] Juan Uribe, NRC, letter to Joseph W. Shea, TVA, "Nuclear Regulatory Commission Report for the Audit of Tennessee Valley Authority's Flood Hazard Reevaluation Report Submittals Relating to the Near-Term Task Force Recommendation 2.1-Flooding for: Browns Ferry Nuclear Plant, Units 1, 2, and 3; Sequoyah Nuclear Plant, Units 1 and 2; and Watts Bar Nuclear Plant, Units 1 and 2 (TAC Nos. MF6034, MF6035, MF6036, MF6032, MF6033, MF5857 and MF5858)," dated October 30, 2015. ADAMS Accession No. ML15294A203.

[106] Juan Uribe, NRC, letter to Joseph W. Shea, TVA, "Browns Ferry Nuclear Plant, Units 1, 2 and 3 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC Nos. MF6034, MF6035 and MF6036)," dated September 3, 2015. ADAMS Accession No. ML15240A183.

B.3.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[107] In this plan, the licensee restated the design-basis flooding information described above and stated that the FLEX strategies developed will include documentation ensuring that any storage locations, deployment routes, and connection points meet the FLEX flooding criteria or are at an elevation not susceptible to flooding (except for those strategy elements not credited for flooding).

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by using both the steam-driven high pressure coolant injection system and the steam-driven reactor core isolation cooling system pumps to supply water to the reactor vessel from either the condensate storage tank or the suppression pool. Steam would be vented through safety-relief valves to the suppression pool. Reactor core isolation cooling would continue to be used as long as possible; then, FLEX diesel generators will power the core spray pumps to inject water into the reactor vessel. FLEX diesel generators will also enable the use of motor-operated valves and other components. Additional equipment such as large diesel generators, diesel-driven pumps, fuel, and demineralized water will be provided by the Regional Response Centers to maintain core cooling.

The NRC staff performed an interim evaluation of this plan and concluded that the licensee provided sufficient information to determine that there is reasonable assurance that the plan, when properly implemented, will meet the requirements of Order EA-12-049 at Browns Ferry.[108] The NRC staff identified three open items, emphasizing one related to permanent staging of diesel generators in an approach different from NEI 12-06, as well as several confirmatory items. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[109] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

The licensee expects to implement the requirements of Order EA-12-049 for all three units by the end of 2016, following the Unit 1 refueling outage.[110] After the licensee notifies the NRC that it is in compliance, the NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

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[107] J.W. Shea, TVA, letter to NRC, "Tennessee Valley Authority (TVA) – Overall Integrated Plan in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant," dated February 28, 2013. ADAMS Accession No. ML13064A465.

[108] Jeremy S. Bowen, NRC, letter to Joseph W. Shea, TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0902, MF0903, and MF0904)," dated December 19, 2013. ADAMS Accession No. ML13225A541.

[109] Tony Brown, NRC, letter to Joseph W. Shea, TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0902, MF0903, MF0904, MF0881, MF0882, and MF0883)," dated April 6, 2015. ADAMS Accession No. ML15069A358.

[110] J.W. Shea, TVA, letter to NRC, "Sixth Six-Month Status Report in Response to the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 26, 2016. ADAMS Accession No. ML16063A470

B.4 Columbia

Columbia Generating Station (Columbia) has one unit of General Electric BWR design. The operating license was issued in 1984 and renewed in 2012 for a term that expires in 2043.[111] Columbia is located on the U.S. Department of Energy Hanford Reservation, approximately 3 miles west of the Columbia River and 10 miles north of Richland, WA.

B.4.1 Initial Plant Design and Licensing[112]

Site grade at Columbia is 441 feet MSL, which is approximately 8 feet above the design-basis flood level derived from a probable maximum precipitation (PMP) event and wind wave action. In establishing the design-basis flood, the licensee also evaluated the sudden catastrophic failure of the Columbia River's Grand Coulee Dam, which is approximately 245 river miles upstream of the Columbia site. The limiting flood from this event, including wind wave action, was estimated at over 15 feet below site grade.

Flood protection is achieved by site drainage. There are no flood protection features or flood mitigation procedures credited in Columbia's current licensing basis for protection and mitigation of external flooding because Columbia is considered a "dry" site—i.e., safety-related structures, systems, and components were built above the design-basis flood level by terrain.

B.4.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Columbia.

One flooding issue was identified in recent years, but was not related to external flooding or dam failures. In 2014, NRC inspectors identified issues with the removal of floor plugs in the room above the emergency core cooling system and reactor core isolation cooling pump rooms in a manner that was non-conservative and non-compliant with technical specifications. These issues were documented in a Licensee Event Report and resulted in non-cited violations of NRC requirements.[113, 114] The licensee noted that it would update its barrier impairment process to address this issue.

B.4.3 Flooding Walkdowns

In November 2012, Columbia notified the NRC that it had completed its flooding walkdowns.[115] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

In the walkdown report, the licensee noted that no degraded, non-conforming, or unanalyzed conditions credited for flood protection were identified. Further, no additional flood protection systems or flood mitigation measures were found to be necessary.

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[111] http://www.nrc.gov/info-finder/reactors/wash2.html.
[112] Information in this section is drawn from the licensee's walkdown reports referenced below.
[113] W.G. Hettel, Energy Northwest, letter to NRC, "Columbia Generating Station, Docket No. 50-397 – Licensee Event Report No. 2015-001-00," dated April 30, 2015. ADAMS Accession No. ML15120A642.
[114] Wayne C. Walker, NRC, letter to Mark E. Reddemann, Energy Northwest, "Columbia Generating Station – NRC Integrated Inspection Report 05000397/2015001," dated April 29, 2015. ADAMS Accession No. ML15113B354.
[115] D.A. Swank, Energy Northwest, letter to NRC, "Columbia Generating Station Flooding Walkdown Report," dated November 12, 2012. ADAMS Accession No. ML123190555.

The NRC staff reviewed the walkdown report and provided its assessment in May 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[116] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[117]

B.4.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Columbia as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The NRC staff later approved an extension of this schedule to allow for input on dams managed by the U.S. Army Corps of Engineers, also considering Columbia's status as a dry site.[118] This information is still being developed.

Once the NRC staff transmits this information to the licensee, the licensee is expected to complete its reevaluation within 60 days. The NRC staff will then review the hazard reevaluation and plans to conduct an audit to aid in its review. The NRC staff will provide feedback for the use of this information in updating (as needed) the mitigating strategies for the site, and the licensee will perform either a focused evaluation or a broader integrated assessment of the plant's protection capabilities against flood mechanisms. Finally, the NRC will determine the need for further actions based on this information.

B.4.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[119]

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the approach at Columbia to maintain core cooling during the ELAP/LUHS event is to initially remove the core decay heat by using the steam-driven reactor core isolation cooling system, supplying water to the reactor from the condensate storage tank or the suppression pool, depending on availability. Steam from the reactor is vented through the safety relief valves to the suppression pool to control reactor pressure. Makeup water can be obtained from several sources. In addition, a trailer-mounted diesel generator will be used to reenergize selected load centers to power critical loads such as valves and instrumentation to support the overall strategy, including continued operation of

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[116] Carl F. Lyon, NRC, letter to Mark E. Reddemann, Energy Northwest, "Columbia Generating Station – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC No. MF0213)," dated May 16, 2014. ADAMS Accession No. ML14127A406.

[117] Wayne Walker, NRC, letter to M.E. Reddemann, Energy Northwest, "Columbia Generating Station – NRC Integrated Inspection Report 05000397/2012005," dated February 8, 2013. ADAMS Accession No. ML13039A078.

[118] Eric J. Leeds, NRC, letter to Mark E. Reddemann, "Columbia Generating Station – Relaxation of Response Due Date Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident (TAC No. MF3039)," dated May 21, 2014. ADAMS Accession No. ML14098A141.

[119] Alex L. Javorik, Energy Northwest, letter to NRC, "Columbia Generating Station, Docket No. 50-397 – Energy Northwest's Response to NRC Order EA-12-049 – Overall Integrated Plan for Mitigating Strategies," dated February 28, 2013. ADAMS Accession No. ML13071A614.

reactor core isolation cooling. In the long term, additional equipment, such as large generators, will be delivered from one of the Regional Response Centers.

Specific to flooding, the licensee stated that because Columbia is built above the design-basis flood level it is not required to evaluate flood-induced challenges for the protection and deployment of FLEX equipment. The licensee stated that FLEX equipment storage will be at or above the design-basis flood level. The licensee also noted that, as the flooding hazard reevaluation is conducted, appropriate issues will be entered into its corrective action system and addressed on a schedule commensurate with other licensing basis changes.

The NRC staff performed an interim evaluation of this plan and identified two open items related to maintaining containment, as well as several confirmatory items.[120] The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[121] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

All modifications associated with mitigating strategies for beyond-design-basis external events have been installed, procedures and training are complete. The mitigation strategies contained in the Overall Integrated Plan are dependent, in part, on separate requirements for a severe-accident-capable hardened containment wetwell vent. Therefore, the NRC staff relaxed the schedule for the licensee's notification of full compliance until the completion of the Spring 2017 refueling outage, allowing the licensee sufficient time to implement this vent.[122]

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.5 Cooper

Cooper Nuclear Station (Cooper), located on the Missouri River in Brownville, NE, has one unit of General Electric BWR design. The operating license was issued in 1974 and renewed in 2010 for a term that expires in 2034.[123]

B.5.1 Initial Plant Design and Licensing[124]

Site grade at Cooper is 903 feet MSL (raised 13 feet above the natural grade level), which is also the PMF level calculated by the licensee. This level is above the height of the Missouri

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[120] Jeremy S. Bowen, NRC, letter to Mark E. Reddemann, Energy Northwest, "Columbia Generating Station – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC No. MF0796)," dated January 29, 2014. ADAMS Accession No. ML13337A266.

[121] Stephen Monarque, NRC, letter to Mark E. Reddemann, Energy Northwest, "Columbia Generating Station – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0796 and MF0797)," dated June 16, 2015. ADAMS Accession No. ML15139A462.

[122] Eric J. Leeds, NRC, letter to Mark E. Reddemann, Energy Northwest, "Columbia Generating Station – Relaxation of Certain Schedule Requirements for Order EA-12-049, 'Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events,'" dated April 15, 2014. ADAMS Accession No. ML14071A572.

[123] http://www.nrc.gov/info-finder/reactors/cns.html.

[124] Information in this section is drawn from the licensee's walkdown report referenced below.

River levee that corresponds to the 10,000-year flood level (902 feet MSL). In addition, the intake structure is protected by concrete structures against wave action up to 919 feet MSL.

At the time of Cooper's licensing, the Atomic Energy Commission staff independently evaluated the flooding potential at Cooper and concluded that a PMF considering wave and surge effects could exceed site grade at exposed safety-related structures. Therefore, Cooper was required to protect safety-related structures and systems up to these levels such that the plant could be safely shut down under these conditions.

The licensee did not consider failure of a large upstream dam probable in developing the design basis of the plant, based on the size of the dams, frequent inspections, height of the dam above the expected water level, adequacy of spillways, and low seismic activity. The closest dam is Gavins Point Dam, over 275 miles upstream. The U.S. Army Corps of Engineers estimated that a maximum natural flood combined with failure of a major flood control dam (either Oahe or Fort Randall) could result in flooding above site grade. An Atomic Energy Commission staff estimate of dam failure effects was slightly lower, but still above site grade when wave and surge effects were considered. The Atomic Energy Commission staff also concluded that seismically induced dam failure coincident with a PMF was not credible, but did consider a dam break concurrent with a one-half PMF event. The results of this analysis indicated that the resulting flood level was lower than the PMF event alone.

The finished floor of all seismic Category I structures is placed at elevation 903.5 feet MSL, or 6 inches above the PMF event. These structures were designed for a hydraulic load equivalent to a groundwater level of 903 feet and reviewed for integrity for a river level up to 906 feet MSL. Grade level openings on exterior walls of buildings other than the intake structure (where there is additional protection) are protected up to 906 feet MSL by walls and temporary flood barriers, which is above the PMF and dam-failure flooding levels estimated by the U.S. Army Corps of Engineers and Atomic Energy Commission at the time of licensing. A floor drain sump needed for functioning of the standby gas treatment system is located at a lower elevation, but the licensee indicates it will not be affected by flooding since penetrations are sealed and its functioning is monitored when flood levels reach 890 feet MSL.

The plant's Technical Requirements Manual includes a limiting condition for operation based on river level that requires operators to begin following the flooding procedure at 895 feet MSL and to begin shutting down the plant if flood waters are projected to reach 902 feet MSL within the next 36 hours. The flooding procedure directs operators to install temporary flood control barriers and other features. In addition, the final safety analysis report describes the need for special equipment to be available and inventoried annually. The licensee provides examples of special equipment such as hoses and two gasoline-powered portable pumps.

B.5.2 Additional Plant-Specific Actions[125]

As part of its IPEEE, Cooper again evaluated the potential for dam failures. The licensee's analysis of the Fort Randall Dam failure showed that waters released would take multiple days to reach the site. If this event occurred, river levels above the ground floor were estimated. To address this situation, an emergency procedure was prepared to install sandbags and wood planks, protecting the plant up to 907.6 feet MSL (several feet above the projected flood level). This procedure was successfully implemented during a flood in 1993.

[125] Information in this section is drawn from the licensee's walkdown report referenced below.

At the time of the IPEEE, the US. Army Corps of Engineers had recently estimated that a peakflood level significantly above the ground floor could be reached if the Oahe Dam (upstream from the Fort Randall Dam) failed coincident with a 100-year flood. This dam failure would take multiple days for the resulting flood to reach the site. The licensee screened this failure from further analysis or action using criteria in NUREG-1407,[126] considering the estimated contribution to core damage frequency, conservative assumptions on the initial water level and catastrophic failure, and the close management of the dam and reservoir level by the U.S. Army Corps of Engineers.

B.5.3 Flooding Walkdowns

In November 2012, Cooper notified the NRC that it had completed its flooding walkdowns.[127] The licensee indicated that walkdowns were performed consistent with NEI 12-07. In the walkdown report, the licensee described the non-conforming flood protection features identified during the walkdowns (e.g., open pathways, a degraded valve, and non-conforming seals). At the time the report was submitted, several of these had already been corrected, and others were entered into the licensee's corrective action program for correction in the near future. The licensee also noted inaccessible areas that could not be walked down and committed to inspect them during an upcoming refueling outage.

The licensee noted several additional flooding protection features that were being installed or considered. These included:

- Replacement of the sandbag and plywood barrier construction method with a system of removable pre-engineered aluminum stop log beams at various exterior doors located at ground level[128]
- Construction of a reinforced concrete flood wall around the high pressure coolant injection access hatch in the plant yard, which historically had also been flood-protected by sandbags and plywood (to be completed by the end of 2012)
- Installation of a temporary external flood barrier system for the fire pump house building
- Construction of a permanent building located above flood level to house the diesel generator and associated equipment designated for use in severe accidents
- Installation of new piping penetration seals
- Correction of non-conformances associated with manholes
- Installation of water level monitoring instrumentation in specific manholes

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[126] NRC, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," NUREG-1407, dated June 1991. ADAMS Accession No. ML063550238.

[127] Brian J. O'Grady, Nebraska Public Power District, letter to NRC, "Cooper, Flooding Walkdown Report in Response to NRC"s Request for Information Pursuant to 10 CFR 50.54(f) Re: the Flooding Aspects of Recommendation 2.3 of Near-Term Task Force Review of Insights from Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML123330418.

[128] The walkdown report indicated that these would be installed by the end of 2012. By the time of the flooding hazard reevaluation report described in the next section, the licensee observes that engineered barriers are used, and sandbags are available for contingencies.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[129] By that time, the licensee had completed procedural corrections for all deficiencies identified during the walkdowns, and remaining flood protection feature deficiencies were planned to be corrected during a refueling outage later that year. In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. The inspectors documented a non-cited violation of very low safety significance.[130] The inspection finding related to the licensee's failure to write condition reports for certain non-conformances identified during flooding walkdowns within the timeframe established in plant procedures.

B.5.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Cooper as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The licensee requested a relaxation in this schedule so that it could incorporate information developed by the U.S. Army Corps of Engineers that was not provided to the licensee until April 2014. The NRC staff granted this relaxation after reviewing the detailed schedule for preparing the report, as well as in consideration of the complexity of the analysis and the interim actions taken by the licensee after it had received the U.S. Army Corps of Engineers information.[131, 132]

The licensee submitted its flooding hazard evaluation report on schedule in February 2015.[133] The reevaluated hazard was not completely bounded by the current licensing basis, or considered new sources of flooding not included in the current licensing basis. Given the higher flooding hazard, the licensee committed to conduct an integrated assessment. The licensee also developed interim actions associated with the two mechanisms that were not bounded by the current licensing basis (dam breaches and failures and channel migration or diversion).

The licensee's interim actions described in the flooding hazard reevaluation report include the following:

- In cooperation with the U.S. Army Corps of Engineers, the licensee will analyze the projected reservoir conditions based on snowpack and predicted runoff to determine the projected worst-case scenario for the current water year. To be certain that current

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[129] Andrea E. George, NRC, letter to Oscar A. Limpias, Nebraska Public Power District, "Cooper Nuclear Station – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC No. MF0216)," dated June 24, 2014. ADAMS Accession No. ML14149A146.

[130] David Proulx, NRC, letter to Oscar A. Limpias, Nebraska Public Power District, "Cooper Nuclear Station – NRC Integrated Inspection Report 05000298/2012005," dated February 14, 2013. ADAMS Accession No. ML13045A297.

[131] Oscar A. Limpias, Nebraska Public Power District, letter to NRC, "Nebraska Public Power District's Flood Hazard Reevaluation Interim Actions for Cooper Nuclear Station," dated June 4, 2014. ADAMS Accession No. ML14167A340.

[132] Daniel H. Dorman, NRC, letter to Oscar A. Limpias, Nebraska Public Power District, "Cooper Nuclear Station – Relaxation of Response Due Date Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the NTTF Review of the Insights from the Fukushima Dai-ichi Accident (TAC No. MF3632)," dated July 17, 2014. ADAMS Accession No. ML14171A088.

[133] Oscar A. Limpias, Nebraska Public Power District, letter to NRC, "Cooper Nuclear Station, Response to Request for Information Pursuant to 10 CFR 50.54(f) Regarding Flooding Aspects of Recommendation 2.1 of Near-Term Task Force Review of Insights from Fukushima Dai-ichi Accident," dated February 3, 2015. ADAMS Accession No. ML15041A523.

conditions do not exceed analyzed conditions, a monitoring plan was established. The licensee's plan also includes trigger points that consider the reservoir system volume and time that a potential flood could take to reach the site's design-basis flood level.

- The licensee established a beyond-design-basis flooding plan to maintain the core and spent fuel pool temperature below 200 degrees Fahrenheit for an extended period of time. This plan uses cooling towers and fan coil units in conjunction with several heat exchangers positioned on rooftops. Much of the necessary equipment is currently offsite, but the licensee notes that the companies will provide the necessary equipment immediately upon request. This plan will be refined as a part of the integrated assessment. (Further discussion of the licensee's mitigating strategies for beyond-design-basis external events is in the next section.)

The NRC staff audited supporting details for the Cooper flooding hazard reevaluation report in 2015.[134] In December 2015, the NRC staff issued an interim response to the Cooper flooding hazard reevaluation report.[135] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for Cooper. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

In Enclosure 1 to the NRC staff's interim response, the NRC staff noted that certain analyses of dam failures were ongoing. An evaluation of these scenarios using a two-dimensional model is expected to be submitted by September 30, 2016. The NRC staff noted that the reevaluated flood evaluation is expected to be bounded by another scenario already submitted, but that the effects and durations will differ and will be separately evaluated in this later submittal.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.5.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[136] The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by using the steam-driven reactor core isolation cooling system, with water supplied from the emergency condensate storage tank or the suppression pool, depending on timing. Steam from the reactor will then be vented through the safety relief valves to the suppression pool. Containment will be vented, with makeup to the suppression pool provided by a diesel-driven portable FLEX pump supplied from a new well to be installed at the site. The backup source of raw water will be the Missouri River. A portable generator will be used to provide power to the

[134] The NRC staff's audit report is currently under development.
[135] Tekia Govan, NRC, letter to Oscar A. Limpias, Nebraska Public Power District, "Cooper Nuclear Station – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation," dated December 22, 2015. ADAMS Accession No. ML15355A416.
[136] Oscar A. Limpias, Nebraska Public Power District, letter to NRC, "Overall Integrated Plan in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) – Cooper Nuclear Station, Docket No. 50-298, DPR-46," dated February 28, 2013. ADAMS Accession No. ML13070A009.

installed battery chargers before station batteries are depleted. In the long term, additional equipment, such as large generators, will be delivered from one of the Regional Response Centers.

Specific to flooding, the licensee acknowledged that the reevaluated flooding hazard was not yet considered in the mitigating strategies. During an audit conducted by the NRC staff, the licensee was asked multiple questions about its ability to deploy FLEX equipment during a flood.[137] The licensee's responses are documented in the NRC staff's interim evaluation, and the NRC staff concluded that there was reasonable assurance that the requirements of Order EA-12-049 will be met in a flooding event at the current design-basis level.[138] The NRC staff will engage further with the licensee regarding the assessment of mitigating strategies using the reevaluated flooding hazard, as noted above.

The licensee is in the process of developing procedures and training and procuring FLEX equipment and has completed the response plan needed to coordinate with the Regional Response Center. Several open questions from interactions with the NRC staff remain to be resolved. The licensee expects to be in full compliance with Order EA-12-049 in Fall 2016.[139]

The NRC staff identified several confirmatory items in its interim evaluation referenced above. As noted above, the NRC staff also conducted an audit that included discussing the technical evaluations performed by the licensee and walking down the locations where equipment would be used and connected. The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.6 Fort Calhoun

Fort Calhoun Station (Fort Calhoun), located on the Missouri River 19 miles north of Omaha, NE, has one unit of Combustion Engineering PWR design. The operating license was issued in 1973 and renewed in 2003 for a term that expires in 2033.[140] Because of its location on the Missouri River, some of the same dams discussed above for Cooper are also of interest for Fort Calhoun.

B.6.1 Initial Plant Design and Licensing[141]

Site grade at Fort Calhoun is at 1004.5 feet MSL. Consistent with the requirements at the time of its initial licensing, the plant is designed to be protected from the effects of river flooding and local rainwater. The design basis includes maximum rainfall, but not PMP as defined in NEI 12-07.

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[137] This audit was planned for late May 2016. The audit report was not available at the time this report was developed.

[138] Jeremy S. Bowen, NRC, letter to Oscar A. Limpias, Nebraska Public Power District, "Cooper Nuclear Station – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC No. MF0972)," dated February 11, 2014. ADAMS Accession No. ML14007A650.

[139] Oscar A. Limpias, Nebraska Public Power District, letter to NRC, "Nebraska Public Power District's Sixth Six-Month Status Report in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 16, 2016. ADAMS Accession No. ML16054A799.

[140] http://www.nrc.gov/info-finder/reactors/fcs.html.

[141] Information in this section is drawn from the licensee's walkdown report referenced below.

During review of the construction permit application for Fort Calhoun, the Atomic Energy Commission staff requested consideration of a PMF both with and without a hydrologically induced dam failure. The PMF resulting from maximum rainfall downstream of Gavins Point Dam and an assumed maximum outflow from Gavins Point Dam would produce a peak flood level several feet above site grade. The failure of Oahe Dam or Fort Randall Dam would require additional maximum probable conditions; however, if such a failure were postulated coincident with a PMF, it would produce a higher flood level.

Based on these evaluations, a design-basis flood level of 1014 feet MSL was established that would protect Fort Calhoun against the flood estimated to result from a PMF coincident with the failure of Oahe Dam or Fort Randall Dam.

When one or more of the following events occur, flood response actions and entry conditions are initiated:

- The National Weather Service or the U.S. Army Corps of Engineers forecasts the possibility of Missouri River level exceeding 1004 feet.
- Missouri River level reaches 1000 feet.
- The U.S. Army Corps of Engineers notifies the licensee that an upstream dam or dams have failed with flooding expected in the Fort Calhoun area.

Additional flood-related design and procedural features are described in the following sections.

B.6.2 Additional Plant-Specific Actions

In completing its IPEEE, Fort Calhoun determined that the bounding events for the "high winds, floods, and others" category were floods caused by dam failures and intense rainstorms.[142] The licensee determined that it would take multiple days after failure of Oahe Dam for water to crest at the plant. Based on its evaluations, the licensee sealed potential entrance locations against a higher flood level and made additional provisions for flooding, including portable pumps, updated procedures, upgraded doors, sandbags, and sealing of conduit.

Since 2009, the NRC and the licensee have engaged extensively on issues related to flooding protection at Fort Calhoun. During a component design bases inspection in 2009, NRC inspectors identified multiple flooding-related issues.[143] The NRC staff conducted a follow-up inspection in 2010 and, following the NRC staff's significance determination process, issued a Yellow inspection finding (indicating a substantial importance to safety) to Fort Calhoun for failure to maintain procedures for combating a significant flood.[144, 145]

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[142] This information on the IPEEE is drawn from Volume 2 of NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," dated April 2002, available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1742/.

[143] Thomas Farnholtz, NRC, letter to David J. Bannister, Omaha Public Power District, "Fort Calhoun Station – NRC Component Design Bases Inspection Report 05000285/2009006," dated December 30, 2009. ADAMS Accession No. ML093641134.

[144] Roy J. Camiano, NRC, letter to David J. Bannister, Omaha Public Power District, "Fort Calhoun Station – NRC Followup Inspection – Inspection Report 05000285/2010007; Preliminary Substantial Finding," dated July 15, 2010. ADAMS Accession No. ML101970547.

[145] Elmo E. Collins, NRC, letter to David J. Bannister, Omaha Public Power District, "Final Significance Determination for a Yellow Finding and Notice of Violation, NRC Inspection Report 05000285/2010007, Fort Calhoun Station," dated October 6, 2010. ADAMS Accession No. ML102800342.

Specifically, the licensee's procedures did not adequately prescribe steps to mitigate external flood conditions in the auxiliary building and intake structure up to the level documented in the final safety analysis report. The NRC inspection reports observed that, in 1993, the licensee obtained updated information from the U.S. Army Corps of Engineers that estimated flood levels higher than those in the final safety analysis report. The licensee determined that the design basis would remain the same and updated the final safety analysis report in 2008 to reflect the evaluation of the information. A 2003 update by the U.S. Army Corps of Engineers noted higher flood frequencies and river levels. The licensee initiated corrective actions associated with the new information and tasked its risk assessment staff with updating the external flood analysis. This analysis was completed in 2005, indicating higher flood levels than the licensee had initially estimated during licensing. The licensee, however, did not update its procedures or include this information in the final safety analysis report—the issue that led to the Yellow finding.

The licensee responded to the violation in a November 2010 letter and noted that actions had been completed to address deficiencies in the station design basis, procedures, equipment and training, including:[146]

- Purchasing and staging four new gasoline-fueled pumps to provide emergency feedwater to the steam generators in the event of a flood-induced station blackout
- Updating procedures and training to use the fire water storage tank as a long-term source of make-up water to support decay heat removal in the event of an interruption in the commercial water supply
- Purchasing a new sandbagging machine and staging related materials
- Demonstrating the activities of the emergency response organization during an external flood and the effectiveness of the organization in constructing a sandbag berm
- Performing a timed, videotaped demonstration of the fabrication and installation of selected floodgates that documented the ease, timeliness, and ability of craft personnel to perform these activities

In April 2011, Fort Calhoun shut down for a scheduled refueling outage, but that outage was subsequently extended to address longstanding technical issues, as well as issues associated with the Missouri River flooding that affected the plant from June through September 2011. The NRC modified its regulatory oversight of Fort Calhoun in late 2011 to follow Inspection Manual Chapter 0350,[147] used for plants shut down for significant issues, rather than its normal oversight process. Other flooding-related issues were addressed under the umbrella of this oversight approach.[148, 149, 150]

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[146] Jeffrey A. Reinhart, Omaha Public Power District, letter to NRC, "NRC Inspection Report 05000285/2010008, Reply to a Notice of Violation (NOV); EA-10-084," dated November 5, 2010. ADAMS Accession No. ML103120073.
[147] NRC Inspection Manual Chapter 0350, "Oversight of Reactor Facilities in a Shutdown Condition Due to Significant Performance and/or Operational Concerns," dated June 6, 2005, available at http://www.nrc.gov/reading-rm/doc-collections/insp-manual/manual-chapter/mc0350.pdf.
[148] Jeffrey A. Clark, NRC, letter to David J. Bannister, Omaha Public Power District, "Fort Calhoun – NRC Integrated Inspection Report Number 05000285/2012002," dated May 11, 2012. ADAMS Accession No. ML12132A395.
[149] Michael Hay, NRC, to Louis P. Cortopassi, Omaha Public Power District, "Fort Calhoun – NRC Inspection Report Number 05000285/2013011 and Notice of Violation," dated March 11, 2013. ADAMS Accession No. ML13070A399.
[150] D.J. Bannister, Omaha Public Power District, letter to NRC, "Response to NRC Inspection Report 05000285/2012002, EA-2012-095," dated June 11, 2012. ADAMS Accession No. ML12164A431.

In addition, the NRC issued a Confirmatory Action Letter that documented the commitments that the licensee needed to satisfy before starting the plant, based on the licensee's Post-Flooding Recovery Action Plan.[151] These commitments related to site restoration, plant systems and equipment, equipment reliability, design and licensing basis, emergency planning, and security. The licensee completed all of the necessary actions and documented them in an integrated report submitted to the NRC in December 2013.[152]

Of the variety of corrective actions taken by the licensee associated with these issues, those related to ensuring that the plant could withstand its design-basis flood included:[153]

- Redesigning removable flood barriers that protect vital equipment at the intake building and in the auxiliary building to provide protection up to the design-basis flood level
- Updating flood mitigation procedures to provide protection to vital areas and equipment required to ensure that the reactor can achieve and maintain cold shutdown for flooding events up to the design-basis flood level
- Developing a contingency plan to provide fuel to the emergency diesel generators for postulated long-duration floods
- Repairing deficiencies in flood barrier penetration seals and developing a procedure to address barrier issues
- Implementing an NRC-approved modification that revised the design-basis method for controlling the raw water intake cell level during periods of elevated river levels[154]
- Developing multiple calculations and documents to describe the external flood design basis, including updates to the safety analysis report to describe flood protection levels
- Implementing NRC-approved changes to the emergency action thresholds associated with flooding and revisions to the technical specification on river level to clarify the flood protection requirements[155]

B.6.3 Flooding Walkdowns

In November 2012, Fort Calhoun notified the NRC that it had completed its flooding walkdowns.[156] The licensee indicated that walkdowns were performed consistent with

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[151] Elmo E. Collins, NRC, letter to David J. Bannister, Omaha Public Power District, "Confirmatory Action Letter – Fort Calhoun Station," dated September 2, 2011. ADAMS Accession No. ML112490164.

[152] Louis P. Cortopassi, Omaha Public Power District, letter to Marc L. Dapas, NRC, "Integrated Report to Support Restart of Fort Calhoun Station and Post-Restart Commitments for Sustained Improvement," dated December 2, 2013. ADAMS Accession No. ML13336A785.

[153] These corrective actions are drawn from the licensee's integrated report to support restart, supplemented with additional references where noted.

[154] Carl F. Lyon, NRC, letter to Louis P. Cortopassi, Omaha Public Power District, "Fort Calhoun Station, Unit No. 1 – Issuance of Amendment Re: Revising Method for Controlling Raw Water Intake Cell Level (TAC No. MF2591)," dated June 30, 2015. ADAMS Accession No. ML15111A399.

[155] Joseph M. Sebrosky, NRC, letter to Louis P. Cortopassi, Omaha Public Power District, "Fort Calhoun Station, Unit No. 1 – Issuance of Amendment Re: Revision to Technical Specifications 2.16, 'River Level,' and 3.2, 'Equipment And Sampling Tests,' and Establishment of the Emergency Action Level Classification Criteria for External Flooding Events Under the Radiological Emergency Response Plan (TAC No. ME8550)," dated January 28, 2014. ADAMS Accession No. ML14003A003.

[156] Louis P. Cortopassi, Omaha Public Power District, letter to NRC, "Fort Calhoun, Unit 1 – 180-Day Response to NRC Request for Information re Flooding Aspects of Recommendation 2.3 of Near-Term Task Force Review of

NEI 12-07. In the walkdown report, the licensee described 14 condition reports that were initiated as a result of the walkdowns, but noted that no deficiencies were observed as defined in NEI 12-07 and none of the observed conditions resulted in an operability concern. The observed conditions included cracks in certain walls, potentially leaking penetrations, and issues with valves.

The licensee noted several additional flooding protection enhancements were being developed:

- developing a procedure for periodic surveillance and maintenance of flood protection penetrations that are not already covered by such a program
- installing wireless level measurement in manholes containing safety-related cables
- controlling the raw water intake cell level to ensure that the raw water pumps remain available during a flood

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[157] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. The inspectors documented a finding of very low safety significance related to the scoping of flood protection features in the walkdown; the licensee subsequently revised the scoping list and committed to implement a preventive maintenance program for the associated valves.[158]

B.6.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Fort Calhoun as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The licensee requested a relaxation in this schedule so that it could incorporate information developed by the U.S. Army Corps of Engineers that was not provided until April 2014. The NRC staff granted this relaxation after reviewing the detailed schedule for preparing the report, as well as in consideration of the complexity of the analysis, interim actions taken by the licensee to mitigate flooding hazards above the design basis, and the licensee's sharing of resources with Cooper.[159, 160, 161]

Insights from the Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML123350126. The NRC staff provided additional background on this license amendment in response to a stakeholder inquiry, available at ADAMS Accession No. ML15223A984.

[157] Jennevine K. Rankin, NRC, letter to Louis P. Cortopassi, Omaha Public Power District, "Fort Calhoun Station, Unit No. 1 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC No. MF0230)," dated June 24, 2014. ADAMS Accession No. ML14157A079.

[158] Michael Hay, NRC, letter to Louis P. Cortopassi, Omaha Public Power District, "Fort Calhoun – NRC Integrated Inspection Report 05000285/2012011," dated December 31, 2012. ADAMS Accession No. ML12366A158.

[159] Louis P. Cortopassi, Omaha Public Power District, letter to NRC, "Superseding Omaha Public Power District's (OPPD) Response to NRC Request for a Timeline to Implement Strategies at Fort Calhoun Station Unit 1 to Address Higher Flooding Hazards Relative to the Design Basis," dated October 26, 2013. ADAMS Accession No. ML13322B308.

[160] Louis P. Cortopassi, Omaha Public Power District, letter to NRC, "Extension Request – Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flooding Hazard Reevaluation Report," dated June 5, 2014. ADAMS Accession No. ML14167A344.

[161] Daniel H. Dorman, NRC, letter to Louis P. Cortopassi, Omaha Public Power District, "Fort Calhoun Station, Unit 1 – Relaxation of Response Due Date Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the NTTF

The licensee submitted its flooding hazard evaluation report on schedule in February 2015.[162] The reevaluated hazard was not bounded by the current licensing basis for two mechanisms: (1) flooding in rivers and streams combined with wave action and (2) flooding due to dam breaches and failures. Given the higher flooding hazard, the licensee committed to conduct an integrated assessment. The licensee also took interim actions that included monitoring Missouri River basin conditions and developing a strategy for addressing beyond-design-basis floods (including procuring equipment, training staff, and updating procedures).[163, 164]

The NRC staff audited supporting details for the Fort Calhoun flooding hazard reevaluation report in 2015.[165] In December 2015, the NRC staff issued an interim response to the Fort Calhoun flooding hazard reevaluation report.[166] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for Fort Calhoun. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

In Enclosure 1 to the NRC staff's interim response, the NRC staff noted that certain analyses of dam failures were ongoing. An evaluation of these scenarios using a two-dimensional model is expected to be submitted by September 30, 2016. The NRC staff noted that the reevaluated flood evaluation is expected to be bounded by another scenario already submitted, but that the effects and durations will differ and will be separately evaluated in this later submittal.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if plant-specific regulatory actions should be undertaken.

B.6.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[167] In this plan, the licensee restated the design-basis flooding information described above and noted that flooding is screened in as a hazard to mitigate. The licensee indicted that the current design provides protection of the auxiliary

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Review of the Insights from the Fukushima Dai-ichi Accident (TAC No. MF3633)," dated July 17, 2014. ADAMS Accession No. ML14169A267.

[162] Louis P. Cortopassi, Omaha Public Power District, letter to NRC, "Response to Request for Information Regarding Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – Fort Calhoun Station Flood Hazard Reevaluation Report," dated February 4, 2015. ADAMS Accession No. ML15042A127.

[163] Louis P. Cortopassi, Omaha Public Power District, letter to NRC, "Extension Request – Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flooding Hazard Reevaluation Report," dated February 26, 2014. ADAMS Accession No. ML14058A225.

[164] Louis P. Cortopassi, Omaha Public Power District, letter to NRC, "Extension Request – Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flooding Hazard Reevaluation Report," dated June 5, 2014. ADAMS Accession No. ML14167A344.

[165] The NRC staff's audit report is currently under development.

[166] Tekia Govan, NRC, letter to Louis Cortopassi, Omaha Public Power District, "Fort Calhoun Station, Unit 1 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (TAC No. MF4711)," dated December 22, 2015. ADAMS Accession No. ML15355A087.

[167] Louis P. Cortopassi, Omaha Public Power District, letter to NRC, "Omaha Public Power District's Overall Integrated Plan in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events (Order Number EA-12-049)," dated February 28, 2013. ADAMS Accession No. ML13116A208.

building via removable flood barriers and sandbags that can be installed in openings that lead to safety-related equipment on the 1007- and 1011-foot elevations. Sandbags can also be installed at the 1013-foot elevation of the equipment hatch room. Flooding protection is also provided for the intake structure using removable flood barriers that extend to at least the design-basis flood level and intake cell level control maintained by the raw water pumps.

The licensee further references the IPEEE and notes that FLEX modifications are being made, where practical, to accommodate higher, beyond-design-basis flood levels. For example, the FLEX storage building will located near the current owner-controlled access point at approximately 1090 feet MSL, which the NRC staff's interim evaluation notes is significantly higher than the maximum conceivable flood level currently predicted by the U.S. Army Corps of Engineers.[168] In addition, the equipment credited for these beyond-design-basis flooding scenarios will be only that which is submersible (e.g., the FLEX pump) or located above the anticipated flood level (e.g., the FLEX diesel generator). The licensee also noted that, as the flooding hazard reevaluation is conducted, appropriate issues will be entered into its corrective action system and addressed on a schedule commensurate with other licensing basis changes. The licensee observes as well that there is generally sufficient advance warning before a flood would reach the design-basis level for the plant to be shut down, using available equipment and offsite power.

An example of the licensee's overall strategies, as summarized by the NRC staff in their interim evaluation, is that the licensee will initially remove core decay heat by supplying the steam generators with water from the emergency feedwater storage tank using the turbine-driven auxiliary feedwater pump, with manual use of the main steam safety valves or atmospheric dump valves to release steam. The licensee will isolate the reactor coolant pump seal leakage controlled bleedoff to maintain inventory and commence a rapid cooldown, allowing the safety injection tanks to inject borated water. A FLEX diesel generator will be aligned to power a FLEX pump that will provide makeup to the emergency feedwater storage tank from the safety injection and refueling water tank. In the longer term, water can be directly added to the steam generators from an electric-driven well pump or a fire truck pump or portable diesel-driven pump supplying water from the Missouri River. Additional equipment and supplies can be provided by the Regional Response Centers to support long-term activities.

The NRC staff's interim evaluation identified one open item related to the event sequence, as well as several confirmatory items, including one related to deploying equipment during a flood. The NRC staff also conducted an audit to evaluate the licensee's progress in implementing the order.[169] The purpose of the audit included discussing the technical evaluations performed by the licensee and walking down the locations where equipment would be used and connected.

The licensee has updated its procedures and created a training plan for its strategies and is in the process of procuring associated equipment. All open items from the NRC staff's review have been addressed according to the licensee (though some confirmatory items remain), and the licensee expects to be in full compliance with Order EA-12-049 by December 2016.[170]

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[168] Jeremy S. Bowen, NRC, letter to Louis Cortopassi, Omaha Public Power District, "Fort Calhoun Station, Unit 1 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC No. MF0969)," dated February 27, 2014. ADAMS Accession No. ML14007A693.

[169] This audit was planned for mid-May 2016. The audit report was not available at the time this report was developed.

[170] Shane M. Marik, Omaha Public Power District, letter to NRC, "Omaha Public Power District's Six-Month Status Report for the Implementation of Order EA-12-049, Order Modifying Licenses with Regard to Requirements for

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.7 H.B. Robinson

H.B. Robinson Steam Electric Plant (H.B. Robinson), located in Hartsville, SC, has one operating unit of Westinghouse PWR design, designated as Unit 2.[171] The operating license was issued in 1970 and renewed in 2004 for a term that expires in 2030.

B.7.1 Initial Plant Design and Licensing[172]

H.B. Robinson is situated near Lake Robinson, which was created by the impoundment of Black Creek at the Lake Robinson Dam for industrial cooling purposes. Site grade is at 225 feet MSL, and the normal level of the lake is 220 feet MSL. The lake level is controlled by Tainter gates on the Lake Robinson Dam. The current licensing basis for the plant is focused on flooding from streams and rivers. In this analysis, the peak flows calculated by the licensee from hypothetical storms are bounded by the design-basis capacity of the Tainter gates; therefore, lake level is not postulated to exceed 222 feet MSL. Other sources of flooding, including dam breaches and failures, were not considered applicable in the current licensing basis. As a result, the current licensing basis indicates that flooding on site will not occur.

B.7.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at H.B. Robinson.

B.7.3 Flooding Walkdowns

In November 2012, H.B. Robinson notified the NRC that it had completed its flooding walkdowns.[173] The licensee indicated that walkdowns were performed consistent with NEI 12-07. The licensee noted that, in general, the flood walkdowns verified that the flood protection systems are available, functional and implementable; as necessary, any degraded, nonconforming features were entered in the licensee's corrective action program.[174]

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[175] In addition, NRC inspectors independently verified that the licensee implemented the

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Mitigation Strategies for Beyond-Design-Basis External Events)," dated February 29, 2016. ADAMS Accession No. ML16060A500.

[171] http://www.nrc.gov/info-finder/reactors/rob2.html. The other units on site are not nuclear power plants.

[172] Information in this section is drawn from the licensee's flooding hazard reevaluation report referenced below.

[173] Brian J. O'Grady, Nebraska Public Power District, letter to NRC, "Cooper, Flooding Walkdown Report in Response to NRC"s Request for Information Pursuant to 10 CFR 50.54(f) Re: the Flooding Aspects of Recommendation 2.3 of Near-Term Task Force Review of Insights from Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML123330418.

[174] This information is drawn from the licensee's flooding hazard reevaluation report referenced below.

[175] Martha Barillas, NRC, letter to William R. Gideon, Duke Energy Progress, "H.B. Robinson Steam Electric Plant, Unit 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC No. MF0273)," dated June 27, 2014. ADAMS Accession No. ML14176B089.

flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[176]

B.7.4 Reevaluation of Flooding Hazard

The NRC staff prioritized H.B. Robinson as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. The licensee submitted its report on schedule on March 12, 2014.[177]

The flooding hazard reevaluation report shows that some flood levels exceed the current licensing basis, given the use of newer methodologies and guidance. As such, the licensee committed to conduct an integrated assessment. The licensee tabulated the flood levels from various mechanisms, showing a range of flood levels that could exceed site grade. As a result, local intense precipitation, flooding in streams and rivers, and combined-effects floods will be considered in the integrated assessment.

Specific to dam failures, the licensee noted that the postulation of simultaneous upstream dam failures with a 500-year flood and maximum normal pool level in Lake Robinson resulted in a flood level below site grade. The licensee's evaluation of a combined-effects flood caused by seismic dam failure, a 500-year flood, maximum normal pool level, and 2-year wind waves resulted in a flood level above site grade. Therefore, the licensee will consider this scenario in its Phase 1 submittal.[178]

The licensee noted that it would take several interim actions pending the completion of the integrated assessment (even though it was considering additional site-specific meteorological analyses to refine the bounding hazard). These included:

- providing procedures to manually start an auxiliary feedwater pump and its diesel generator during a local intense precipitation event
- obtaining a new high-pressure portable pump to inject borated water into the reactor coolant system using guidance provided by Westinghouse
- updating procedures to ensure safe shutdown before a flood reaches the site
- updating guidelines to pre-stage a new pump above the flood level to provide feedwater to the steam generators

The NRC staff audited supporting details for the H.B. Robinson hazard reevaluation report in 2015.[179] In December 2015, the NRC staff issued an interim response to the H.B. Robinson

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[176] Randall A. Musser, NRC, letter to William Gideon, Carolina Power and Light Company, "H.B. Robinson Steam Electric Plant – NRC Integrated Inspection Report 05000261/2013002," dated April 22, 2013. ADAMS Accession No. ML13112A171.

[177] W.R. Gideon, Duke Energy Progress, letter to NRC, "Flood Hazard Reevaluation Report, Response to NRC 10 CFR 50.54(f) Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review Of Insights from the Fukushima Dai-ichi Accident, Dated March 12, 2012," dated March 12, 2014. ADAMS Accession No. ML14086A384.

[178] The licensee's report also discusses failures of the Lake Robinson Dam. As this is a downstream dam failure, it is not discussed further in this report. Failures of this dam in combination with the PMF actually lead to lower water levels than the PMF alone.

[179] The NRC staff's audit report is currently under development.

flooding hazard reevaluation report.[180] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.7.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[181] In this plan, the licensee restated the design-basis flooding information described above and noted that per NEI 12-06, H.B. Robinson is classified as a dry site and the external flooding hazard is, therefore, not applicable.

The licensee's plan includes strategies to mitigate an ELAP/LUHS event such as removing core decay heat by adding water from the condensate storage tank to the steam generators using the steam-driven auxiliary feedwater pump. A portable FLEX pump will be used once the steam-driven pump can no longer be operated reliably. Makeup to the condensate storage tank is provided by a FLEX pump that takes suction from Lake Robinson or the discharge canal. The circulating water inlet basin can be used as a backup to the condensate storage tank. A portable diesel-powered high pressure pump will also be available to provide borated makeup to the reactor coolant system.

The NRC staff performed an interim evaluation of this plan and identified two open items related to core sub-criticality and pre-staged equipment, as well as several confirmatory items.[182] The NRC staff found the licensee's treatment of flooding to be consistent with NEI 12-06. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[183] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

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[180] Juan F. Uribe, NRC, letter to Richard Michael Glover, Duke Energy, "H.B. Robinson Steam Electric Plant, Unit No. 2 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC No. MF3586)," dated December 23, 2015. ADAMS Accession No. ML15357A064.

[181] William R. Gideon, Duke Energy, letter to NRC, "Carolina Power and Light Company's Overall Integrated Plan in Response to March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2013. ADAMS Accession No. ML13071A415.

[182] Jeremy S. Bowen, letter to William R. Gideon, Duke Energy Progress, "H.B. Robinson Steam Electric Plant, Unit 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC No. MF0720)," dated February 19, 2014. ADAMS Accession No. ML13365A291.

[183] Jason C. Paige, NRC, letter to Richard M. Glover, Duke Energy, "H.B. Robinson Steam Electric Plant, Unit No. 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0720 and MF0793)," dated June 12, 2015. ADAMS Accession No. ML15154B098.

On August 19, 2015, the licensee notified the NRC that H.B. Robinson is in full compliance with Order EA-12-049.[184] All modifications have been installed, procedures and training are complete, and the licensee has responded to all of the NRC staff's open and confirmatory items.

In March 2016, the NRC staff completed a final safety evaluation considering the licensee's notification of full compliance.[185] The NRC staff concluded that the licensee had developed guidance and proposed designs that, if implemented appropriately, adequately addressed Order EA-12-049. The NRC staff also conducted an inspection of the licensee's implementation.[186] The NRC expects to document the licensee's compliance with the order in the future, given the pending flooding integrated assessment.

B.8 Hope Creek / Salem

"Artificial Island" in Hancocks Bridge, NJ, has two separately named reactor sites. Hope Creek Generating Station (Hope Creek) has one unit of General Electric BWR design. The operating license was issued in 1986 and renewed in 2011 for a term that expires in 2046.[187] Salem Nuclear Generating Station (Salem) has two units of Westinghouse PWR design. Their operating licenses were issued in 1976 and 1981 and were renewed in 2011 for terms that expire in 2036 and 2040.[188]

B.8.1 Initial Plant Design and Licensing[189]

The site is located on the Delaware River, two miles north of where it enters the head of Delaware Bay; tidal flows in the estuary dominate over fresh water discharge. Because of the different times that Hope Creek and Salem were licensed, the licensing basis and supporting evaluations are somewhat different, though the key scenarios are the same.

For Hope Creek, site grade was raised slightly to 10.5 MSL, which is equivalent to 99.5 Public Service Datum (PSD), the reference scale used by the licensee. The turbine and auxiliary building are located at 100 feet PSD. The design-basis flood level, based on surge and waves from a probable maximum hurricane (PMH), is a still water level of 113.8 feet PSD (wave runup to 124.4 feet PSD at the main plant structures and 134.4 feet at the intake structure). The licensee's procedures, which are triggered when river level reaches 95 feet PSD at the intake structure, include provisions for closing flood doors and shutting down the facility.

The licensee also considered the flooding hazard for single and multiple dam failures upstream of Hope Creek, all of which were bounded by the PMH event. Single dam failures for the proposed Tocks Island Dam and proposed modified Francis E. Walter Dam were postulated to determine the most critical single dam failure condition. The postulated failure of the dam was equated to the instantaneous disappearance of the dam. The resulting flood levels (both still

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[184] R. Michael Glover, Duke Energy Progress, letter to NRC, "Compliance Letter and Final Integrated Plan in Response to the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for H. B. Robinson Steam Electric Plant, Unit No. 2," dated August 19, 2015. ADAMS Accession No. ML15232A007.

[185] Michael A. Brown, NRC, letter to Richard M. Glover, Duke Energy, "H.B. Robinson Steam Electric Plant, Unit 2 – Safety Evaluation Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (CAC Nos. MF0720 and MF0793)," dated March 31, 2016. ADAMS Accession No. ML16075A377.

[186] The report for this inspection was not available at the time this report was developed.

[187] http://www.nrc.gov/info-finder/reactors/hope.html.

[188] http://www.nrc.gov/info-finder/reactors/salm1.html and http://www.nrc.gov/info-finder/reactors/salm2.html.

[189] Information in this section is drawn from the licensee's walkdown and flooding hazard reevaluation reports referenced below.

water and wave runup) were more than 10 feet below the design-basis flood level. Postulated multiple failures of Cannonsville, Pepacton, and Tocks Island Dams were also analyzed, resulting in flood levels that were also well below the design-basis flood level.

For Salem, PMH is similarly the bounding site flood event. The design-basis flood for the plant is a still water level of 113.8 feet PSD (wave runup to 120.4 feet PSD at the main plant structures and 127.3 feet at the intake structure). Dam failures are not included in Salem's current licensing basis. All structures that house safety-related equipment at Salem are seismic Category I structures. They are designed to withstand the loads and effects of postulated floods and are watertight to an elevation of 115 feet PSD. The licensee's severe weather procedures include provisions for confirming the availability of equipment and verifying the closure of watertight doors.

B.8.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Hope Creek or Salem.

Salem has had operating experience with river-borne debris in flood conditions affecting the circulating water system intake structures. Particularly, during Hurricane Sandy in October 2012, the site lost the function of four out of six circulating water pumps because of heavy river debris on the traveling screens for the intake.[190] The reactor was safely shut down, and all safety systems operated as required. The licensee's notification of the event included two other manual reactor shutdowns in 2010 and 2011 that resulted from issues with the traveling screens. As a result, the licensee inspected the screens, removed debris, and made repairs. The licensee noted that a root cause analysis was being conducted to assess the ability of the circulating water system to withstand severe weather and to develop operating strategies for the future.

In 2014, the NRC approved movement of the requirements for flood protection from Hope Creek's NRC-controlled technical specifications to the technical requirements manual (licensee-initiated changes to which are controlled by 10 CFR 50.59, "Changes, tests, and experiments").[191] In the safety evaluation, the NRC staff clarified that the flood protection requirements did not meet the criteria in 10 CFR 50.36, "Technical specifications," for inclusion in the technical specifications. The NRC staff also noted that Hope Creek had never needed to initiate a plant shutdown due to a high water level of 99.5 feet PSD, and the historical high-water mark of 97.5 feet in November 1950 is below site grade. The NRC staff also referenced the Hope Creek IPEEE, which screened out the "high winds, floods, and other" category based on conformance to the NRC staff's Standard Review Plan.

In addition, on May 5, 2016, the NRC issued an early site permit for a potential future reactor on a site located on the southern part of Artificial Island, adjacent to Hope Creek and Salem.[192] While this action does not affect the operation of Hope Creek or Salem, it is a relevant and recent determination by the NRC staff of the site's suitability from a flooding perspective. As

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[190] Carl J. Fricker, PSEG Nuclear LLC, letter to NRC, "Loss of Circulating Water and Manual Reactor Trip Due to Hurricane Sandy," dated December 26, 2012. ADAMS Accession No. ML13002A004.
[191] Carleen J. Parker, NRC, letter to Thomas Joyce, PSEG Nuclear LLC, "Hope Creek Generating Station – Issuance of Amendment Re: Request to Relocate Flood Protection Technical Specification to the Technical Requirements Manual (TAC NO. MF2738)," dated December 18, 2014. ADAMS Accession No. ML14108A399.
[192] PSEG Power, LLC and PSEG Nuclear, LLC – PSEG Site Early Site Permit – Docket No. 52-043," dated May 6, 2016. ADAMS Accession No. ML16084A798.

part of the early site permit review, multiple site characteristics were established by the licensee and found acceptable by the NRC staff, including a design-basis flood level from combined effects (including wave action) of 32.1 feet based on the NAVD88 datum (approximately 121 feet PSD[193]). In its safety evaluation, the NRC staff accepted this flood level, noting its conservatism.[194] For example, the highest storm surge of record in the United States, during Hurricane Katrina in New Orleans in 2005, was more than three feet less than this design-basis flood level. Further, during 2012, when Hurricane Sandy made landfall approximately 75 miles northwest of the site, it resulted in a maximum storm surge more than 25 feet lower than the design-basis flood level. Finally, the NRC staff noted that the applicant has established the site grade for the early site permit at 4.8 feet above the maximum flood level.

Specific to dam failures, the applicant indicated that, when tidal effects and wind waves are added, the maximum flood level is more than 20 feet below the design-basis flood level. This scenario includes 10 percent high tide exceedance, coincident with the 500-year flood, the combined failures of Pepacton and Cannonsville Dams, and the 2-year wind speed in the critical direction. The NRC staff concluded that the applicant met NRC requirements relating to dam failures and had considered the most severe natural phenomena that have been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

B.8.3 Flooding Walkdowns

In November 2012, Hope Creek and Salem notified the NRC that they had completed their flooding walkdowns.[195, 196] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

The licensee noted 149 potential deficiencies at the Hope Creek site. For flood protection features with potential deficiencies, detailed observations, photographs, and qualitative dispositions were entered into the corrective action program for further review. Based on the walkdowns, the licensee also determined that it was necessary to improve a maintenance procedure for watertight doors.

In general, the licensee found that Salem's flood protection features (e.g., walls, floors, roofs, penetration seals, doors, sump pumps, check valves) were installed per design, functional, in good material condition, and procedurally controlled to ensure continued functionality. The licensee did identify potential deficiencies at Salem that were entered into the corrective action program, mainly observations of historical leakage, unidentified penetrations, small cracks, corrosion issues, and degraded seals. The licensee, however, did not determine that any new or changed flood protection systems or flood mitigation measures were needed to enhance flood protection at Salem.

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[193] Estimated by the NRC staff in the preparation of this report, as the early site permit documentation is written in terms only of NAVD88.

[194] Frank M. Akstulewicz, NRC, letter to James Mallon, PSEG Power, LLC, "Final Safety Evaluation Report for the PSEG Early Site Permit Application," dated September 25, 2015. ADAMS Accession No. ML15229A119.

[195] John F. Perry, PSEG Nuclear LLC, letter to NRC, "Hope Creek Generating Station Response to Recommendation 2.3: Flooding Walkdown of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 26, 2012. ADAMS Accession No. ML12334A452.

[196] Carl J. Fricker, PSEG Nuclear LLC, letter to NRC, "Salem, Units 1 and 2 – Response to Recommendation 2.3: Flooding Walkdown of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML123340583.

The NRC staff reviewed the walkdown reports and provided its assessments in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[197, 198] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during either inspection.[199, 200] The licensee submitted an updated walkdown report for Hope Creek in April 2013 that reflected resolution of the NRC inspectors' comments.[201]

B.8.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Hope Creek and Salem as "Category 1" sites for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2013. The NRC staff granted additional time to enable the licensee to develop hurricane storm parameters and analyze the potential storm surge.[202] The licensee submitted the flooding hazard reevaluation reports on schedule in March 2014.[203, 204]

For Hope Creek, the licensee found that the reevaluated hazard was within the current licensing basis for all categories other than local intense precipitation and "associated effects." The licensee committed to conduct an integrated assessment because the local intense precipitation flood level and time needed for site preparation exceeded the current licensing basis. In the interim, the licensee is integrating severe weather forecast guidance into procedural guidance to provide adequate response time for mitigative actions (e.g., closing watertight doors).

For Salem, the licensee found that the current licensing basis did not include a local intense precipitation event, so there were no triggers to close watertight doors. The reevaluated flood

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[197] John Lamb, NRC, letter to Thomas Joyce, PSEG Nuclear LLC, "Hope Creek Generating Station – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC No. MF0236)," dated June 16, 2014. ADAMS Accession No. ML14042A329.

[198] John Lamb, NRC, letter to Thomas Joyce, PSEG Nuclear LLC, "Salem Generating Station Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC No. MF0276 and MF0277)," dated June 16, 2014. ADAMS Accession No. ML14140A307.

[199] Daniel L. Schroeder, NRC, letter to Thomas P. Joyce, PSEG Nuclear LLC, "Hope Creek Generating Station, Unit 1 – NRC Integrated Inspection Report 05000354/2012005," dated February 11, 2013. ADAMS Accession No. ML13042A376.

[200] Daniel L. Schroeder, NRC, letter to Thomas P. Joyce, PSEG Nuclear LLC, "Salem Nuclear Generating Station, Unit Nos. 1 and 2 – NRC Integrated Inspection Report 05000272/2012005 and 05000311/2012005," dated February 7, 2013. ADAMS Accession No. ML13038A672.

[201] John F. Perry, PSEG Nuclear LLC, letter to NRC, "Response to Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – Changes to Hope Creek Generating Station's Flood Walkdown Report," dated April 12, 2013. ADAMS Accession No. ML13106A066.

[202] Eric J. Leeds, NRC, letter to Thomas Joyce, PSEG Nuclear LLC, "Salem Nuclear Generating Station, Unit Nos. 1 and 2 and Hope Creek Generating Station – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident," dated April 12, 2013. ADAMS Accession No. ML13095A281.

[203] Paul J. Davison, PSEG Nuclear LLC, Letter to NRC, "PSEG Nuclear LLC's Response to Request for Information Regarding Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – Hope Creek Generating Station Flood Hazard Reevaluation," dated March 12, 2014. ADAMS Accession No. ML14071A505.

[204] John F. Perry, PSEG Nuclear LLC, letter to NRC, "PSEG Nuclear LLC"s Response to Request for Information Regarding Flooding Aspects of Recommendation 2.1 of Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – Salem Generating Station Flood Hazard Reevaluation," dated March 11, 2014. ADAMS Accession No. ML14071A399.

level for local intense precipitation is above grade, but below the protected elevations. As at Hope Creek, the licensee intended to integrate severe weather forecast guidance into its procedural guidance. In addition, the licensee found that the licensing basis for safety-related structures does not require evaluation of the effects of water-borne debris during a storm surge. As an interim action, the licensee committed to evaluate the capability of flood protection features to withstand this debris. Furthermore, the licensee committed to reassess the conditions for closure of watertight doors to consider the conditions of the reevaluated storm surge event. The licensee committed to conduct an integrated assessment to address both local intense precipitation and storm surge events.

Specific to dam failures, the licensee concluded that there are no critical dams in the watershed above the site and, therefore, neither Hope Creek nor Salem would be adversely affected by potential dam failures.

The NRC staff audited supporting details for the Hope Creek flooding hazard reevaluation report in 2015.[205, 206] In September 2015, the NRC staff issued an interim response to the Hope Creek flooding hazard reevaluation report.[207, 208] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.8.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted Overall Integrated Plans for Hope Creek and Salem that presented information on the applicable hazards, relevant strategies, and

[205] Tekia V. Govan, NRC, letter to Robert Braun, PSEG Nuclear LLC, "Nuclear Regulatory Commission Report for the Audit of PSEG Nuclear LLC's Flood Hazard Reevaluation Report Submittals Relating to the Near-Term Task Force Recommendation 2.1-Flooding for Hope Creek Generating Station (CAC No. MF3789)," dated January 8, 2016. ADAMS Accession No. ML15364A055.

[206] Tekia V. Govan, NRC, letter to Robert Braun, PSEG Nuclear LLC, "Nuclear Regulatory Commission Report for the Audit of PSEG Nuclear LLC's Flood Hazard Reevaluation Report Submittals Relating to the Near-Term Task Force Recommendation 2.1-Flooding for Salem Nuclear Generating Station, Units 1 and 2 (CAC Nos. MF3790 and MF3791)," dated January 8, 2016. ADAMS Accession No. ML15364A073.

[207] Tekia V. Govan, NRC, letter to Robert Braun, PSEG Nuclear LLC, "Hope Creek Generating Station – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (TAC No. MF3789)," dated September 10, 2015. ADAMS Accession No. ML15238B655.

[208] Tekia V. Govan, NRC, letter to Robert Braun, PSEG Nuclear LLC, "Salem Nuclear Generating Station Units 1 and 2 Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (TAC No. MF3790 and MF3791)," dated September 10, 2015. ADAMS Accession No. ML15238B704.

implementation steps, consistent with the guidance in NEI 12-06.[209, 210] Flooding was considered an applicable hazard for these plants.

The licensee's plans present strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy for Hope Creek provides for using the steam-driven reactor core isolation cooling and high pressure coolant injection systems to supply water to the reactor from the condensate storage tank, with the suppression pool available as a backup. Steam will be vented through the safety relief valves to the suppression pool; depressurization will be stopped at a pressure sufficient to maintain continued reactor core isolation cooling operation. Once FLEX pumps are deployed, they can be used to inject Delaware River water into the vessel. FLEX generators will also be used to keep instrument buses energized. The Regional Response Centers will provide additional generators that will enable use of the residual heat removal system.

Similarly, as summarized by the NRC staff, the approach at Salem to maintain core cooling during the ELAP/LUHS event is to inject water from the auxiliary feedwater storage tank to the steam generators using the turbine-driven auxiliary feedwater pump. When this tank is empty, an alternate supply from the demineralized water storage tanks or fresh water storage tanks can be used, or the FLEX pumps can be used to feed the steam generators from the Delaware River. A FLEX generator can be used to support normal charging injection of borated water to the reactor coolant system, with a FLEX charging pump available as a backup using hose connections. In its assessment, the NRC staff noted that the tanks listed above are not protected from flood effects. The only flood that could damage these tanks is from a hurricane, for which there would be advance warning. In this case, the licensee would deploy submersible FLEX pumps and FLEX generators to pump flood water from the turbine building basement to the suction of the turbine-driven auxiliary feedwater pumps.

The NRC staff performed interim evaluations of these plans and identified several open items, as well as additional confirmatory items.[211, 212] The open items for Hope Creek related to BWR containment issues and the use of pre-staged generators. The open items for Salem related to snow removal, thermal-hydraulic analyses, core sub-criticality, and tornado protection. The NRC staff later conducted audits to evaluate the licensee's progress in implementing the

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[209] John F. Perry, PSEG Nuclear LLC, letter to NRC, "PSEG Nuclear LLC"s Overall Integrated Plan for the Hope Creek Generating Station in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 27, 2013. ADAMS Accession No. ML130590336.

[210] Carl J. Fricker, PSEG Nuclear LLC, letter to NRC, "PSEG Nuclear LLC"s Overall Integrated Plan for the Salem Generating Station in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 28, 2013. ADAMS Accession No. ML130590378.

[211] Jeremy S. Bowen, NRC, letter to Thomas Joyce, PSEG Nuclear LLC, "Hope Creek Generating Station – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC No. MF0867)," dated February 11, 2014. ADAMS Accession No. ML13365A253.

[212] Jeremy S. Bowen, NRC, letter to Thomas Joyce, PSEG Nuclear LLC, "Salem Nuclear Generating Station, Unit Nos. 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (CAC Nos. MF0868 and MF0869)," dated January 24, 2014. ADAMS Accession No. ML13339A667.

order.[213, 214] During the audits, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

The licensee has completed most of its guidance development and all training for its strategies and is in the process of implementing the necessary modifications. Given a Fall 2016 implementation outage, the licensee expects Hope Creek to be in full compliance with Order EA-12-049 by the end of 2016 (with notification to the NRC to occur in January 2017).[215] For Salem, modifications have been implemented for Unit 2 and are being implemented for Unit 1 (including final validation of the associated guidance) in May 2016; therefore, the licensee intended to notify the NRC of full compliance for both units by Summer 2016.[216, 217]

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.9 Indian Point

Indian Point Nuclear Generating (Indian Point), located on the Hudson River in Buchanan, NY, has two operating units of Westinghouse PWR design, designated Units 2 and 3.[218] The operating licenses were issued in 1973 and 1975. Although the original licenses have expired, Indian Point is in "timely renewal" status in accordance with 10 CFR 2.109, "Effect of timely renewal application," and is allowed to continue to operate while the NRC staff reviews the license renewal application.

B.9.1 Initial Plant Design and Licensing[219]

Site grade at Indian Point is 15 feet MSL, and the licensee notes that river water could seep into buildings on site if it reached the "critical control elevation" of 15.25 feet. The most severe flooding condition at Indian Point results from the simultaneous occurrence of a standard project flood, a failure of the Ashokan Dam, and a storm surge in New York Harbor at the mouth of the Hudson River resulting from a standard project hurricane. This combination, including

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[213] John Boska, NRC, letter to Robert Braun, PSEG Nuclear LLC, "Hope Creek Generating Station – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0867 and MF1031)" dated March 25, 2015. ADAMS Accession No. ML16053A151.

[214] John Boska, NRC, letter to Thomas Joyce, PSEG Nuclear LLC, "Salem Nuclear Generating Station, Unit Nos. 1 and 2 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0868, MF0869, MF0913, and MF0914)" dated October 10, 2014. ADAMS Accession No. ML14258A308.

[215] Paul J. Davison, PSEG Nuclear LLC, letter to NRC, "PSEG Nuclear LLC"s Sixth Six-Month Status Report for the Hope Creek Generating Station in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 29, 2016. ADAMS Accession No. ML16063A241.

[216] John F. Perry, PSEG Nuclear LLC, letter to NRC, "PSEG Nuclear LLC"s Sixth Six-Month Status Report for the Salem Generating Station in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 29, 2016. ADAMS Accession No. ML16060A480.

[217] John F. Perry, PSEG Nuclear LLC, letter to NRC, "Salem Generating Station Unit 2 Compliance with March 12, 2012, NRC Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated April 23, 2016. ADAMS Accession No. ML16116A053.

[218] http://www.nrc.gov/info-finder/reactors/ip2.html and http://www.nrc.gov/info-finder/reactors/ip3.html. Indian Point, Unit 1 is permanently shut down.

[219] Information in this section is drawn from the licensee's walkdown reports referenced below.

consideration of wind waves, results in a flood level below the critical control elevation. Therefore, flooding was not considered a hazard to Indian Point.

Indian Point Unit 2 has external flooding procedures that are followed when river water levels are rising above 4.5 feet MSL or in the event of a high tide advisory or flood warning. These procedures include plugging of floor drains in the turbine building, opening a breaker to service water strainer pit heaters, and installation of temporary pumps as necessary to assist the sump pump in maintaining the strainer pit dry. At a river level of 5 feet 8 inches MSL, the procedure includes additional protective actions and monitoring for the strainer pit.

Similarly, Unit 3 has procedures that are entered when river water levels are rising above 7 feet MSL or in the event of a high tide advisory or flood warning. These procedures include monitoring the strainer pit for leakage and installing temporary pumps as necessary to assist the sump pump in maintaining the strainer pit dry. There are also provisions for placing sandbags around the strainer pit as necessary and to install temporary pumps as necessary to maintain the service water valve pits dry. When the river reaches 10 feet, operators are to remove power from the service water strainer pit sump pump and close the discharge valve. When the river reaches 11 feet, maintenance workers are to install sandbags around the service water pump area (to be completed before level reaches 15 feet). (An additional maintenance procedure provides for additional sandbagging.) The plant is shut down when river level reaches 12.5 feet MSL.

B.9.2 Additional Plant-Specific Actions[220]

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Indian Point.

In the 1980s, the NRC staff evaluated whether the overall flooding protection requirements at Indian Point were sufficient.[221] The final safety analysis report for Unit 3 indicated that wave activity combined with severe river levels could exceed site grade near the intake structure, and, in the 1973 NRC staff safety evaluation, a technical specification on river level was determined to result in acceptable protection against flooding. The Unit 2 technical specifications, however, did not include a similar provision. Since the Unit 2 intake structure would be exposed to the same conditions, the NRC staff expressed a concern that a PMH combined with storm surge, flooding, and a dam failure could be hazardous to the plant. The licensee indicated that, given the extremely small contribution of external floods to core damage frequency and the characterization of site flooding as a "highly unlikely possibility," the plant abnormal operating procedures and emergency plan for river flooding were sufficient. To support its evaluation of the issue, the NRC staff conducted an independent estimation of flood levels and determined that there could be a several-foot runup of waves on vertical walls. Since there is not such a vertical wall, however, the NRC staff expected that runup would be smaller; furthermore, the service water pumps are located 20-30 feet back from the face of the intake structure, so wave runup could not reach the pump motors. As a result, the NRC staff concluded in 1988 that the

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[220] Information in this section is drawn from the licensee's walkdown reports and flooding hazard reevaluation report referenced below.

[221] David Langford, NRC, letter to Stephen B. Bram, Consolidated Edison Company of New York, Inc., "External Flooding Condition Technical Specifications for Indian Point Nuclear Generating Unit No. 2 (TAC No. 51921)," dated November 15, 1988. This document is not publicly available in ADAMS because of its age.

service water pump motors would not be incapacitated in such an event and a technical specification for Unit 2 was not necessary.

As part of the IPEEE, the licensee also evaluated the plant's ability to withstand PMP events and implemented several enhancements as a result that could benefit overall flooding protection. In particular, Indian Point Unit 2 evaluated a flooding scenario for the control building, in which a PMP event could cause water to back up into the switchgear and deluge rooms if a flapper valve failed in the open position. Although the IPEEE indicated that the probability of this valve failure was low enough for this not to be a risk-significant scenario, the licensee committed to periodic surveillance of the flapper valve. The licensee also added weather stripping to the doors leading into the switchgear room from the transformer area and placed screens on the equipment room hub drains in the 480-volt switchgear room to preclude foreign material inclusion. According to the licensee, these changes were sufficient for the NRC staff to consider Generic Issue 103 (related to design of plants to protect against the PMP[222]) to be addressed for Indian Point Unit 2. In addition, the Unit 3 IPEEE assessed how a PMP could affect flooding and roof ponding. The roofs of safety-related structures were evaluated and determined to maintain their integrity. Ground drainage was determined to be sufficient to address ponding at grade level, avoiding an ingress of water that would affect safety-related equipment.

B.9.3 Flooding Walkdowns

In November 2012, Indian Point notified the NRC that it had completed its flooding walkdowns.[223, 224] The licensee indicated that walkdowns were performed consistent with NEI 12-07. The licensee later provided supplemental responses to address completion of walkdowns of features for which access was restricted during the initial walkdowns.

In the walkdown reports, the licensee noted several deficiencies based on the NEI 12-07 criteria. These deficiencies included the ability of a Unit 3 flapper valve to provide backflow protection for the diesel generator building, observations about sandbagging from Hurricane Sandy, and the conditions of several seals. As a result, the licensee evaluated enhancements to its flood protection and confirmed the operation of affected equipment. No new flood protection enhancements or mitigation measures were planned.

The NRC staff reviewed the walkdown reports and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[225] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently

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[222] http://nureg.nrc.gov/sr0933/Section%203.%20New%20Generic%20Issues/103r1.html.

[223] John A. Ventosa, Entergy Nuclear Northeast, "Flooding Walkdown Report – Entergy's Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – Indian Point Unit No. 2," dated November 27, 2012. ADAMS Accession No. ML12354A313.

[224] John A. Ventosa, Entergy Nuclear Northeast, "Flooding Walkdown Report – Entergy's Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – Indian Point Unit No. 3," dated November 27, 2012. ADAMS Accession No. ML12354A311.

[225] Douglas V. Pickett, NRC, letter to Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Unit Nos. 2 and 3 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0237 and MF0238)," dated June 18, 2014. ADAMS Accession No. ML14119A073.

performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[226, 227]

B.9.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Indian Point as a "Category 1" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2013. The NRC staff, however, relaxed the response schedule to enable the licensee to consider insights gained from Hurricane Sandy.[228] In evaluating the duration of the delay, the NRC staff considered the licensee's interim actions to supplement the site's flood protection with pre-staged sandbags and deployable temporary barriers.

The licensee submitted its flooding hazard reevaluation report on schedule in December 2013.[229] Based on the results of the new flood evaluation, four flood mechanisms exceed the current licensing basis.

- Combined effects from coastal processes can result in a flood above the current licensing basis. However, the 1988 NRC staff evaluation referenced above bounds the new flood results; therefore, the licensee expects that there would be no effect on safety-related structures, systems, or components from such a flood.

- The reevaluated flood level from streams and rivers is higher than the current licensing basis, but below site grade.

- The calculated flood level from dam failures is higher than the current licensing basis, but below site grade.

- Local intense precipitation can result in flooding of the Unit 2 transformer yard above door entry levels, which could affect safety-related equipment. Pre-filled sandbags have been staged in the vicinity of the doors, and procedures have been revised to protect all of the vulnerable doors.

As a result of these exceedances, the licensee committed to complete an integrated assessment. The licensee has taken multiple interim actions described in the report, including sandbags and Tiger Dams, to address these potential floods. The licensee states that these measures provide current protection up to 17 feet 11 inches, which is above the flood level associated with each of the reevaluated hazards listed above. In addition, all of the conduit that communicates with the 480-volt switchgear rooms and originates in manholes will be sealed

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[226] Arthur L. Burritt, NRC, letter to John Ventosa, Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Unit 2 – NRC Integrated Inspection Report 05000247/2012005," dated February 11, 2013. ADAMS Accession No. ML13042A133.

[227] Arthur L. Burritt, NRC, letter to John Ventosa, Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Unit 2 – NRC Integrated Inspection Report 05000286/2012005," dated February 8, 2013. ADAMS Accession No. ML13039A047.

[228] Eric J. Leeds, NRC, letter to Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Station Unit Nos. 2 and 3 – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident," dated April 12, 2013. ADAMS Accession No. ML13095A297.

[229] John A. Ventosa, Entergy Nuclear Northeast, letter to NRC, "Entergy's Required Response for NTTF Recommendation 2.1: Flooding – Hazard Reevaluation Report – Indian Point Unit Numbers 2 and 3," dated December 23, 2013. ADAMS Accession No. ML13364A005.

with sealant tested and shown to be capable of resisting hydrostatic head pressures that can result from the reevaluated flooding hazard.

Specific to dam failure, the licensee's report indicates that there are over 1000 dams in the Hudson River watershed. Of these, 11 have either significant height or storage to be of interest to the analysis. Three dams (Merriman Dam, Olive Bridge Dam, and Conklingville Dam) were included in the dam failure analysis based on proximity to the site and estimated breach flow. An additional four dams in series (Lake Te-Ata Dam, Lake Popolopen Dam, Mine Lake Dam, and Stillwater Dam) were included for the cascade failure simulation.

The licensee reports that the controlling dam failure scenario is the PMF with the failure of Conklingville Dam, which was calculated to result in a flood level below the site grade. Seismic dam failures resulted in a lower flood level.

In April 2016, the NRC staff issued an interim response to the Indian Point flooding hazard reevaluation report.[230] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.9.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[231] In this plan, the licensee restated the design-basis flooding information described above and noted that Indian Point is not considered a "dry" site and that flooding is screened in as a hazard to mitigate. Specific to flooding, the plan indicates that necessary equipment will be stored above the 15-foot elevation.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by feeding the steam generators from the condensate storage tank using the turbine-driven auxiliary boiler feedwater pump. When the operating conditions of this pump cannot be maintained, FLEX pumps will be used, taking suction from the condensate storage tank, the city water tank, the fire water storage tanks, the primary water storage tanks, the refueling water storage tanks, or the Hudson River. Borated water can be added to the reactor coolant system using a FLEX pump. FLEX generators will be

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[230] Victor Hall, NRC, letter to Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Unit Nos. 2 and 3 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (CAC Nos. MF3313 and MF3314)," dated April 25, 2016. ADAMS Accession No. ML15355A416.

[231] John A. Ventosa, Entergy Nuclear Northeast, letter to NRC, "Overall Integrated Plan in Response to March 12, 2012, Commission Order to Modify Licenses With Regard To Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) – Indian Point Unit Numbers 2 and 3," dated February 28, 2013. ADAMS Accession No. ML13079A348.

used to support instrument buses, and equipment from the Regional Response Centers can be used to reenergize certain plant safety buses.

The NRC staff performed an interim evaluation of this plan[232] and identified open items related to tornado protection and the consideration of the reevaluated flooding hazard, as well as multiple confirmatory items. The NRC staff later conducted audits to evaluate the licensee's progress in implementing the order.[233, 234] During the audits, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

The licensee has completed guidance development, training, and procurement for its strategies. Modifications have been implemented for Unit 3 and are being implemented for Unit 2 during the Spring 2016 refueling outage; therefore, the licensee intends to notify the NRC of full compliance for both units by Summer 2016.[235, 236]

The NRC staff will complete a final safety evaluation considering the updated information—including integration of the reevaluated hazard described above into the plan—and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.10 McGuire

McGuire Nuclear Station (McGuire) is located on Lake Norman (part of the Catawba River system) 17 miles north of Charlotte, NC. McGuire has two units of Westinghouse PWR design. The operating licenses were issued in 1981 and 1983 and renewed in 2003 for terms that expire in 2041 and 2043.[237]

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[232] Jeremy S. Bowen, NRC, letter to Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Unit Nos. 2 and 3 – Interim Staff Evaluation Related to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0744 and MF0745)," dated January 24, 2014. ADAMS Accession No. ML13337A594.

[233] John Boska, NRC, letter to Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Unit Nos. 2 and 3 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0744, MF0745, MF0737, and MF0738)," dated December 9, 2014. ADAMS Accession No. ML14335A642.

[234] John Boska, NRC, letter to Entergy Nuclear Operations, Inc., "Indian Point Nuclear Generating Unit No. 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0744 and MF0737)," dated February 25, 2016. ADAMS Accession No. ML16042A388.

[235] Lawrence Coyle, Entergy Nuclear Northeast, letter to NRC, "Indian Point Energy Center's Sixth Six-Month Status Report for the Implementation of Order EA-12-049 Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (TAC Nos. MF0744) – Indian Point Unit Number 2," dated February 29, 2016. ADAMS Accession No. ML16067A091.

[236] Lawrence Coyle, Entergy Nuclear Northeast, letter to NRC, "Notification of Full Compliance with Order EA-12-049 'Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events' and Order EA-12-051 'Modifying Licenses with Regard to Requirements for Reliable Spent Fuel Pool Instrumentation' (TAC Nos. MF0745 and MF0738) – Indian Point Unit Number 3," dated May 20, 2015. ADAMS Accession No. ML15149A140.

[237] http://www.nrc.gov/info-finder/reactors/mcg1.html and http://www.nrc.gov/info-finder/reactors/mcg2.html.

B.10.1 Initial Plant Design and Licensing[238]

In determining the flood levels for McGuire, the licensee considered two postulated events:

- PMF resulting from the probable maximum precipitation in the drainage area
- Standard project flood (half of the PMF) passing through Lake Norman, combined with the seismic failure of one of the five upstream dams, which are part earth embankment and part concrete gravity structures

Safety-related structures at McGuire are protected from the possible flooding of Lake Norman by an earthen dike with an elevation of 780 feet MSL at the plant site. (Lake Norman has a full pond level of 760 feet MSL.) The licensee indicates that this dam height protects against the PMF with waves, which results in a flood level approximately 6 feet below the height of the earthen dike. This bounds the PMH flood level as well.

Specific to upstream dam failure, the licensee analyzed seismic failure of each of the upstream dams coincident with the standard project flood. The failure of Bridgewater Dam upstream of the site produced the highest water level at McGuire, but this flood level was more than 10 feet below the level of the earthen dike.

B.10.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at McGuire.

B.10.3 Flooding Walkdowns

In November 2012, McGuire notified the NRC that it had completed its flooding walkdowns.[239] The licensee indicated that walkdowns were performed consistent with NEI 12-07. No deficiencies were identified during the walkdowns. The licensee did not identify a need for any new or changed flood protection systems or flood mitigation measures. In particular, the licensee's walkdown included confirmation of the elevation of the earthen dike, which was found to have no physical impairments.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[240] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently

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[238] Information in this section is drawn from the licensee's walkdown report referenced below.

[239] Steven D. Capps, Duke Energy, letter to NRC, "McGuire Nuclear Station (MNS), Units 1 and 2 – Flooding Walkdown Information Requested by NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident; dated March 12, 2012," dated November 26, 2012. ADAMS Accession No. ML12361A006.

[240] Ed Miller, NRC, letter to Steve D. Capps, Duke Energy Carolinas, LLC, "McGuire Nuclear Station, Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0244 and MF0245)," dated June 10, 2014. ADAMS Accession No. ML14156A287.

performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[241, 242]

B.10.4 Reevaluation of Flooding Hazard

The NRC staff prioritized McGuire as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. The licensee submitted its report on schedule in March 2014.[243]

The licensee's reevaluation resulted in several flood levels that exceed the current licensing basis. Of these, the highest are from upstream dam failures and storm surge, but the resulting floods from both were still below the height of the onsite earthen dike. As a result of these exceedances, the licensee committed to complete an integrated assessment. In the interim, the licensee committed to taking several actions that would enhance the current capability to maintain the plant in a safe condition should such a beyond-design-basis flood occur.

In September 2015, the NRC staff issued an interim response to the McGuire hazard reevaluation report.[244] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.10.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[245] In this plan, the licensee noted that external flooding is applicable, but that seismic Category I structures are not susceptible to flooding from PMP or PMF conditions. The licensee states that FLEX storage facilities will be located above

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[241] Jonathan H. Bartley, NRC, letter to Steven D. Capps, Duke Energy Corporation, "McGuire Nuclear Station – NRC Integrated Inspection Report 05000369/2012005 and 05000370/2012005 and Emergency Preparedness Inspection Report 05000369/2012502 and 05000370/2012502," dated January 25, 2013. ADAMS Accession No. ML13028A143.

[242] Jonathan H. Bartley, NRC, letter to Steven D. Capps, Duke Energy Corporation, "McGuire Nuclear Station – NRC Integrated Inspection Report 05000369/2013002 and 05000370/2013002," dated April 24, 2013. ADAMS Accession No. ML13115A200.

[243] Steven D. Capps, Duke Energy, letter to NRC, "Flood Hazard Reevaluation Report, Response to NRC 10 CFR 50.54(f) Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 12, 2012," dated March 12, 2014. ADAMS Accession No. ML14083A415.

[244] Juan F. Uribe, NRC, letter to Steven D. Capps, Duke Energy Carolinas, LLC, "McGuire Nuclear Station, Units 1 and 2 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (TAC Nos. MF3623 and MF3624)," dated September 3, 2015. ADAMS Accession No. ML15230A161.

[245] Steven D. Capps, Duke Energy, letter to NRC, "McGuire Nuclear Station (MNS), Units 1 and 2 – Response to March 12, 2012, Commission Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events, EA-12-049," dated February 28, 2013. ADAMS Accession No. ML13063A185.

any potential site flood level, or the effects of localized flooding will be evaluated in the FLEX facility design and equipment deployment.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by feeding the steam generators from the auxiliary feedwater storage tank or underground condenser circulating water pipe using the turbine-driven auxiliary feedwater pump. After this pump is no longer available, a FLEX pump will be used. Borated water can be added to the reactor coolant system from the refueling water storage tank using a diesel-driven high-pressure FLEX pump. FLEX generators will be used to maintain instrument buses. Regional Response Centers will be used to provide equipment for the long term.

The NRC staff performed an interim evaluation of this plan and identified one open item related to boric acid mixing, as well as multiple confirmatory items.[246] The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[247] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

On December 7, 2015, the licensee notified the NRC that McGuire is in full compliance with Order EA-12-049.[248] All modifications have been installed, procedures and training are complete, and the licensee has responded to all of the NRC staff's open and confirmatory items from the interim staff evaluation.

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.11 Oconee

Oconee, located on Lake Keowee in Seneca, SC, has three units of Babcock & Wilcox PWR design.[249] The operating licenses were issued in 1973 (for Units 1 and 2) and 1974 (for Unit 3) and renewed in 2000 for terms that expire in 2033 (for Units 1 and 2) and 2034 (for Unit 3).

Because of the focus of this investigation on Oconee and the multiple actions taken over several years, this subsection is presented for clarity in a different order than the subsections for other plants.

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[246] Jeremy S. Bowen, NRC, letter to Steven D. Capps, Duke Energy Carolinas, LLC, "William B. McGuire Nuclear Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF1160 and MF1161)," dated January 16, 2014. ADAMS Accession No. ML13338A406.

[247] Jason Paige, NRC, letter to Steven D. Capps, Duke Energy Carolinas, LLC, "McGuire Nuclear Station, Units 1 and 2 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF1160, MF1161, MF1062, and MF1063)," dated October 9, 2014. ADAMS Accession No. ML14241A454.

[248] Steven D. Capps, Duke Energy, letter to NRC, "Final Notification of Full Compliance with Order EA-12-049, 'Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events' and with Order EA-1 2-051, 'Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation' for McGuire Nuclear Station," dated December 7, 2015. ADAMS Accession No. ML15343A010.

[249] http://www.nrc.gov/info-finder/reactors/oco1.html, http://www.nrc.gov/info-finder/reactors/oco2.html, and http://www.nrc.gov/info-finder/reactors/oco3.html.

B.11.1 Actions Taken Before the Fukushima Dai-ichi Accident

Oconee is situated on the shores of Lake Keowee, which is formed by two earth-fill dams (Keowee Dam and Little River Dam), and downstream from a large rock-fill dam (Jocassee Dam) that forms Jocassee Lake. During initial licensing, the licensee calculated a PMF of 808 feet MSL still water level in Lake Keowee, increased to 813.3 feet by wave runup.[250] While their independent calculations had slightly higher results, the Atomic Energy Commission staff found the dams and protective dike near the intake, with an elevation of 815 feet, to be adequate to protect the site from this flood. Site grade is 796 feet MSL.

When Oconee was first licensed, failure of the upstream Jocassee Dam was not considered to be a credible event, based on the design and construction of the dam. In addition, the Atomic Energy Commission staff's consultant indicated that the composition of Jocassee Dam would preclude failure based on the wave action that had been estimated.

In the early 1980s, the licensee built a standby shutdown facility that would provide an independent means of achieving and maintaining safe shutdown of one or more units in certain scenarios such as fires, turbine building floods, and security incidents.[251] In particular, the licensee justified the use of this facility to address the new requirements of 10 CFR Part 50, Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979." The standby shutdown facility includes subsystems that provide reactor coolant makeup, auxiliary service water for steam generator injection, electrical power via a diesel generator and batteries, and support systems. The licensee's design included structural, piping, and seismic qualification provisions consistent with safety-related equipment. The NRC staff's safety evaluation for the facility documented that the entrance to the standby shutdown facility was at 797.0 feet, which was above the maximum expected flood level on site at the time. The NRC staff found that the facility was consistent with the NRC's requirements and guidelines for protection against flooding.

As part of the probabilistic risk assessment conducted by the licensee and the Electric Power Research Institute in the early 1980s, Jocassee Dam was estimated to have a failure frequency of about once in 40,000 years. Considering various failure modes, timing, and lake levels, the licensee determined that there could be a resulting flood above the grade of the plant yard. In this evaluation, the intake dike from the Little River Basin is overtopped, causing the flood, and the Keowee Dam is overtopped but does not fail. Since the standby shutdown facility had no flooding protection at the time, the licensee assumed it would be unavailable and treated the dam failure as a core damage event. To protect the facility from the more likely flooding scenarios, the licensee determined it was appropriate to construct a flood barrier about 5 feet high at the doorway of the standby shutdown facility, protecting it from floods up to 801 feet. The licensee considered the capability of this facility, as well as updated information on dam failures, in estimating a lower core damage frequency for this flooding scenario in its 1990 Individual Plant Examination in response to Generic Letter 88-20.

In the early 1990s, the licensee's fossil/hydro department conducted an inundation study for the failure of Jocassee Dam in response to a Federal Energy Regulatory Commission requirement. The licensee indicated that this study used the latest computer models at the time (which

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[250] A. Schwencer, NRC, letter to Austin C. Thies, Duke Power Company, "Safety Evaluation by the Directorate of Licensing, U. S. Atomic Energy Commission, in the Matter of Duke Power Company, Oconee Nuclear Station Units 2 and 3, Docket Nos. 50-270/287," dated July 6, 1973. ADAMS Accession No. ML122760346.

[251] John F. Stolz, NRC, letter to H.B. Tucker, Duke Power Company, dated April 28, 1983. This document is not available in ADAMS because of its age.

considered downstream flow restrictions) and several conservative assumptions, including the overtopping failure of the Keowee Dam before flood waters could spread in the Little River Basin. The resulting flood level in the yard was estimated to be significantly above grade.[252] The licensee noted at the time that it could not reproduce the analysis from the probabilistic risk assessment, but that the 5-foot flood barrier provided "some protection for best estimate types of dam failure modes." Given its most recent estimate of dam failure frequency at about once in 63,000 years, the licensee stated that additional effort to quantify the flood level was unwarranted.

In its IPEEE, the licensee updated this evaluation and estimated Oconee's risk from external floods to contribute about 10 percent of the total core damage frequency.[253] The NRC staff noted that these floods were caused by seismically-induced failure of Jocassee Dam, which could result in flood levels exceeding the 5-foot flood barrier at the standby shutdown facility and render it inoperable. While this issue was identified in the IPEEE, it was not considered a vulnerability.

In February 1994, the NRC staff issued an inspection report for the Oconee service water system that requested a response to several topics, one of which was a statement that the standby shutdown facility could not withstand a postulated failure of Jocassee Dam, inconsistent with the Individual Plant Examination submittal. In March 1994, the licensee responded to this item and provided the information summarized above that compared these analyses.[254]

In 1998, the licensee considered severe accident mitigation alternatives as part of its application for license renewal.[255] The licensee described changes that had been made based on previous studies, including installing the 5-foot barrier at the standby shutdown facility. The licensee estimated external floods to contribute about 9 percent of the total core damage frequency. The licensee specifically considered enhancements that could be made associated with the potential Jocassee Dam failure and reached the following conclusions.

- The cost to redesign and strengthen Jocassee Dam to reduce its failure frequency would far exceed the benefit of the reduction in core damage frequency.

- The cost to increase the height of the standby shutdown facility barrier to 10 feet was estimated at $500,000, which was not justified as it would avert only $1800 worth of risk based on the licensee's calculation of the value of averted dose from potential accidents.

The NRC staff determined that the licensee's cost estimates were reasonable and adopted them in completing its environmental impact statement associated with approval of the renewed licenses.[256]

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[252] Various estimates of the flood level are included in the 2008 10 CFR 50.54(f) letter and March 1994 licensee response to an inspection report, both referenced below.
[253] David E. LaBarge, NRC, letter to W.R. McCollum, Jr., Duke Energy Corporation, "Oconee Nuclear Station, Units 1, 2, and 3 Re: Review of Individual Plant Examination of External Events (TAC Nos. M83649, M83650, and M83651)," dated March 15, 2000. ADAMS Accession No. ML003694349.
[254] J.W. Hampton, Duke Power, letter to NRC, "Oconee Nuclear Site – Inspection Report 50-269, -270, -287/93-25," dated March 14, 1994. ADAMS Accession No. ML15261A316. This response is the source of the information in this section on the 1980s and 1990s flooding and risk evaluations.
[255] "Application for Renewed Operating Licenses, Oconee Nuclear Station, Units 1, 2, and 3, Volume IV, Attachment K, 'Oconee Nuclear Station Severe Accident Mitigation Alternatives (SAMAs) Analysis,'" dated April 1998. Available at http://www.nrc.gov/reactors/operating/licensing/renewal/applications/oconee/exhibitd.pdf.
[256] "Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Oconee Nuclear Station, Units 1, 2 & 3 – Final Report (NUREG-1437, Supplement 2)," dated December 1999, Section 5.2, "Severe Accident

In August 2003, the licensee removed a 6-inch by 10-inch access cover around a carbon dioxide supply pipe in one corner of the standby shutdown facility so that temporary power cables could be routed. In June 2005, NRC inspectors identified that this breach in the flood-protection wall still existed, and the licensee removed the cables and restored the flood barrier in August 2005. The licensee also updated its design-basis document for the standby shutdown facility to emphasize the importance of this access cover, reclassified the flood barrier as having high safety significance, and documented that maintenance activities that necessitate opening this cover would result in a bypass of this barrier.[257] These changes corrected issues that the NRC inspectors had identified with the licensee's processes for complying with 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants."

The NRC staff issued a White finding (low to moderate safety significance) associated with the licensee's failure to assess and manage the risk associated with this degradation of the flood protection capability of the standby shutdown facility.[258, 259, 260] The NRC staff reconsidered the significance of this finding twice in response to the licensee's appeal and submittal of information on the seismic stability of Jocassee Dam. The NRC staff determined that the original White finding was appropriate.[261, 262, 263] Specifically, the NRC staff agreed that the seismic contribution to the likelihood of Jocassee Dam failure was negligible, but estimated the frequency of a sunny-day failure of the dam at approximately once in 5,500 years rather than about once in 71,000 years as estimated by the licensee at the time. The NRC staff noted that this higher failure frequency would also compensate for uncertainties in other parameters such as the predicted flood level on site. The NRC staff also issued an Information Notice to inform licensees that there could be nonconservatisms in the estimation of dam failure frequencies in probabilistic risk assessments; licensees were expected to review this information for applicability to their facilities and consider actions as needed.[264]

Given the concerns raised about the underlying assumptions for dam failure and the potential implications for the site, in August 2008, the NRC staff issued an information request in

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Mitigation Alternatives," available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/supplement2/#_1_60.

[257] An example of these changes is in the July 2009 submittal of an update to the "Selected Licensee Commitments Manual," which is a licensee-controlled document similar in structure to the technical specifications. (Dave Baxter, Duke Energy, letter to NRC, "Oconee Nuclear Station – Selected Licensee Commitments (SLC)," dated July 28, 2009. ADAMS Accession No. ML092230608.)

[258] D. Charles Payne, NRC, letter to B.H. Hamilton, Duke Power Company, "Oconee Nuclear Station – Integrated Inspection Report 05000269/2006002, 05000270/2006002, 05000287/2006002," dated April 28, 2006. ADAMS Accession No. ML061180451.

[259] Charles Casto, NRC, letter to Bruce H. Hamilton, Duke Power Company, "Oconee Nuclear Station – NRC Inspection Report 05000269/2006016, 05000270/2006016, And 05000287/2006016; Preliminary White Finding," dated August 31, 2006. ADAMS Accession No. ML080780143.

[260] William D. Travers, NRC, letter to B.H. Hamilton, Duke Power Company, "Final Significance Determination for a White Finding and Notice of Violation (Oconee Nuclear Station – NRC Inspection Report Nos. 05000269/2006017, 05000270/2006017, and 05000287/2006017)," dated November 22, 2006. ADAMS Accession No. ML063260282.

[261] Bruce H. Hamilton, Duke Energy Corporation, letter to NRC, "Oconee Nuclear Station, Units 1, 2, and 3 – Seismic Fragility Study," dated February 5, 2007. ADAMS Accession No. ML070440337.

[262] William D. Travers, NRC, letter to B.H. Hamilton, Duke Power Company, "Response to Appeal of Final Significance Determination for a White Finding and Denial of Notice of Violation (Oconee Nuclear Station – NRC Inspection Report Nos. 05000269/2007007, 05000270/2007007, and 05000287/2007007)," dated March 1, 2007. ADAMS Accession No. ML070650190. The appeal panel report enclosed with this letter is available in ADAMS at Accession No. ML070610460.

[263] William D. Travers, NRC, letter to Bruce H. Hamilton, Duke Power Company, LLC, "Reconsideration of Final Significance Determination Associated with Standby Shutdown Facility Flood Barrier White Finding," dated November 20, 2007. ADAMS Accession No. ML073241045.

[264] NRC Information Notice 2012-002, "Potentially Nonconservative Screening Value for Dam Failure Frequency in Probabilistic Risk Assessments," dated March 5, 2012. ADAMS Accession No. ML090510269.

accordance with 10 CFR 50.54(f).[265] The licensee was asked to explain its bounding external flooding hazard, assess the early-1990s inundation study and whether it represents the expected flood level, and describe the safety implications of floods that could render the standby shutdown facility unavailable concurrent with a loss of all alternating-current power.

In January 2010, the licensee described interim actions taken to mitigate flooding from a sunny-day failure of Jocassee Dam.[266] These actions included:

- extending the height of the flood wall around the standby shutdown facility by 2.5 feet to 803.5 feet
- replacing the operating chains on the spillway gates at Jocassee Dam
- conducting periodic safety inspections of Jocassee Dam, observing the dam during routine maintenance, and coordinating additional inspections with the Federal Energy Regulatory Commission
- monitoring the dam continuously from the Hydro Central operating center in Charlotte, NC, as well as using level alarms to detect developing dam failure
- developing procedures, including an Emergency Action Plan for Jocassee Dam that includes notifying Oconee of an actual or imminent failure and a plant procedure to mitigate dam failure that included pre-staging a portable pump to feed the steam generators

The licensee provided a further set of committed actions that the NRC staff documented in a June 22, 2010, Confirmatory Action Letter.[267, 268] Near this time, the NRC staff reevaluated the failure rate of rock filled dams as about once in 3,600 years (slightly higher than the 2008 estimate).[269] The Confirmatory Action Letter documented that the licensee had already completed or implemented multiple compensatory actions:

- performing flooding studies using an updated model to determine flood levels in the west yard
- implementing guidance and procedures to mitigate postulated flood events that could render the standby shutdown facility inoperable
- consolidating river management and storm management processes into one guidance document
- inspecting Jocassee Dam at various frequencies, by both licensee and Federal Energy Regulatory Commission representatives

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[265] ADAMS Accession No. ML081640244. (Full reference above.)
[266] Dave Baxter, Duke Energy, letter to NRC, "Oconee External Flood Interim Actions," dated January 15, 2010. ADAMS Accession No. ML100210199.
[267] Dave Baxter, Duke Energy, letter to NRC, "Oconee External Flood Commitments," dated June 3, 2010. ADAMS Accession No. ML101610083.
[268] ADAMS Accession No. ML101730329. (Full reference above.)
[269] "Generic Failure Rate for Jocassee Dam," dated March 15, 2010. ADAMS Accession No. ML13039A084.

- monitoring various hydrologic parameters, including continuous remote monitoring from the Hydro Central Operating Center
- assigning an Oconee engineer as the Jocassee Dam contact
- installing electrical meters on Keowee spillway gates to monitor the condition of equipment
- providing level alarms for Jocassee Dam to detect a developing dam failure
- adding a storage building adjacent to the Jocassee spillway to house backup gate operating equipment
- staging a portable generator and motor near the Jocassee spillway gates to serve as secondary backup gate operating equipment

By November 2010, the licensee indicated that it had completed all of the actions documented in the Confirmatory Action Letter except for an emergency response drill that was planned for December 2010.[270] The licensee also noted that a temporary flood diversion wall had been constructed on the north portion of the Oconee intake dike, improving flood protection for equipment and areas associated with compensatory measures. Furthermore, the licensee committed to several major plant modifications that it intended to protect the standby shutdown facility from flooding. At the time of the letter, the licensee was considering various conceptual modifications. The licensee committed to further develop these concepts and present its plan by April 2011, which it did.[271] This April 2011 letter described the overall mitigation strategy and plans to construct a dedicated, flood-protected power path; to construct several 10-15 foot walls and two additional sets of flood barriers; and to provide a means of spent fuel pool makeup.

In reviewing this April 2011 submittal, the NRC staff requested and received additional information on the design basis for Oconee, the assumptions and actions needed to undertake the mitigating strategy, the quality standards applied, and the construction codes and seismic criteria for the walls.[272, 273] In September 2012, the NRC staff accepted the licensee's proposal to design and construct the structures that protect against sunny-day dam failures using structural codes accepted by the Federal Energy Regulatory Commission.[274] In this letter, the NRC staff also found it acceptable for the licensee to begin its committed implementation timeline later to account for submittal of the flooding hazard reevaluation report; therefore, modifications were expected to be implemented by June 2016.

In parallel, the licensee completed a reanalysis of the flooding hazard from dam failures and submitted the results in response to the 10 CFR 50.54(f) letter and Confirmatory Action

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[270] T. Preston Gillespie, Duke Energy, letter to Luis A. Reyes, NRC, "Oconee Response to Confirmatory Action Letter (CAL) 2-10-003," dated November 29, 2010. ADAMS Accession No. ML103490330.
[271] T. Preston Gillespie, Duke Energy, letter to Victor McCree, NRC, "Oconee Response to Confirmatory Action Letter (CAL) 2-10-003," dated April 29, 2011. ADAMS Accession No. ML111460063.
[272] T. Preston Gillespie, Duke Energy, letter to NRC, "Response to Requests for Additional Information Regarding Necessary Modifications to Enhance the Capability of the ONS Site to Withstand the Postulated Failure of the Jocassee Dam," dated October 17, 2011. ADAMS Accession No. ML11294A341.
[273] T. Preston Gillespie, Duke Energy, letter to NRC, "Response to Requests for Additional Information Regarding Modifications to Address External Flooding Concerns," dated June 14, 2012. ADAMS Accession No. ML12167A372.
[274] Michele G. Evans, NRC, letter to Preston Gillespie, Duke Energy Carolinas, LLC, "Oconee Nuclear Station, Units 1, 2 and 3 – Modifications to Address External Flooding Hazards (TAC Nos. ME7970, ME7971, AND ME7972)," dated September 20, 2012. ADAMS Accession No. ML12219A163.

Letter.[275] The NRC staff documented its acceptance of these results in a January 28, 2011, safety evaluation.[276] The NRC staff found that the licensee's response provided sufficient justification that it had conducted a bounding analysis of the inundation at the Oconee site resulting from potential failure of Jocassee Dam. More specifically, the NRC staff confirmed that the "unmitigated Case 2 analysis" was conservative, with reasonable assurance that flood levels from a sunny-day failure of Jocassee Dam would not exceed the levels predicted by the licensee.

An NRC staff member did not agree with the NRC staff evaluation of the licensee's response to the Confirmatory Action Letter and documented the concerns in a detailed non-concurrence.[277] The non-concurring individual specifically noted that the reservoir levels used by the licensee were based on normal operating limits, rather than bounding values. If higher starting reservoir levels were used, the effects of the dam failure would be greater. The non-concurring individual proposed that the licensee be required to perform a sensitivity analysis that used a "technically defendable most severe limit." The NRC staff response to this concern noted that these reservoirs were evaluated by NRC staff hydrologists, as well as consultants from the U.S. Bureau of Reclamation, and determined to be appropriate for a sunny-day failure of the dam. This sunny-day scenario that was selected after NRC technical experts determined that overtopping and seismic failures were not credible; the NRC staff response also included the basis for excluding these other failure modes. The NRC staff clarified that its use of the word "bounded" in the Confirmatory Action Letter was meant to be in reference to conditions that bound the sunny-day failure of Jocassee Dam, not the absolute worst case. Some clarifications were made to the assessment letter as a result of the non-concurrence, and it was issued as noted above.

In April 2016, the licensee notified the NRC that it had completed the five major physical modifications to protect against external flooding that were associated with the 2010 Confirmatory Action Letter.[278] These final modifications provide for plant response to floods below grade level, between grade level and the height of the flood barrier at the standby shutdown facility, and above the height of that flood barrier (at which point mitigating strategies would be used because the standby shutdown facility would be unavailable). The licensee noted that modifications associated with mitigating strategies, described further below, would be completed on the schedule required by Order EA-12-049. The final modifications, which were developed considering the reevaluated flooding hazard described below, were as follows.[279]

- The licensee armored some of the slopes on site to protect embedded piping for the condenser circulating water system. This modification includes approximately 150,000 square feet of scour protection of various types to prevent flood waters from

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[275] Dave Baxter, Duke Energy, letter to NRC, "Oconee Response to Confirmatory Action Letter (CAL) 2-10-003," dated August 2, 2010. ADAMS Accession No. ML102170006.
[276] Eric J. Leeds, NRC, letter to Preston Gillespie, Duke Energy Carolinas, LLC, "Staff Assessment of Duke's Response to Confirmatory Action Letter Regarding Duke's Commitments to Address External Flooding Concerns at the Oconee Nuclear Station, Units 1, 2, And 3 (ONS) (TAC Nos. ME3065, ME3066, and ME3067)," dated January 28, 2011. ADAMS Accession No. ML110280153.
[277] "Non-Concurrence on Oconee Assessment Letter," dated January 28, 2011. ADAMS Accession No. ML110260443.
[278] Scott L. Batson, Duke Energy, letter to NRC, "Notification of External Flood Modifications Completion," dated April 29, 2016. ADAMS Accession No. ML16131A671.
[279] Scott L. Batson, Duke Energy, letter to NRC, "Establish the Fukushima Flood Response as the Basis to Govern Flood Mitigation Modifications from Postulated Upstream Dam Failure," dated August 8, 2014. ADAMS Accession No. ML14225A540.

eroding the embankment. This modification provides protection against floods that could reach heights above the standby shutdown facility flood barrier.

- The licensee armored the intake dike in high water velocity locations to protect both the dike and the condenser circulating water system piping. This modification includes scour protection and an auxiliary drain system to protect grass cover that is credited to prevent flood waters from eroding the embankment. This modification provides protection against floods that could reach heights above the standby shutdown facility flood barrier.

- The licensee directed water away from the site grade to protect the condenser circulating water system embedded piping and reduce initial flooding levels. This modification includes a 206-foot-long flood-diversion wall with a top elevation of 828 feet MSL. This modification provides protection against floods that could reach heights above the standby shutdown facility flood walls.

- The licensee relocated the back-up power transmission line towers above the floodplain to supply emergency power to the site. This modification included acquiring a new right-of-way and relocating 22 transmission towers. This modification provides additional protection against a flood with a peak level below site grade.

- The licensee installed a manually operated weir gate at the entrance of a turbine building drain line to prevent flood waters from back-flowing into the building basement. This modification provides additional protection against a flood with a peak level below site grade.

B.11.2 Flooding Walkdowns

The licensee considered two flooding hazards as the current licensing basis for Oconee in conducting its flooding walkdowns. These were a PMP that results in a flood level comparable to site grade and a sunny-day failure of Jocassee Dam that results in a flood level above site grade, but below the height of the flood barrier at the standby shutdown facility.

In November 2012, Oconee notified the NRC that it had completed its flooding walkdowns.[280] The licensee indicated that walkdowns were performed consistent with NEI 12-07. The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[281] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. In particular, the NRC inspectors described their walkdown of PMP rainfall flood barriers (e.g., sandbags) used as compensatory measures

[280] T.P. Gillespie, Jr., Duke Energy, letter to NRC, "Oconee Nuclear Station (ONS), Units 1, 2 and 3 – Flooding Walkdown Information Requested by NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident; dated March 12, 2012," dated November 27, 2012. ADAMS Accession No. ML123380111.

[281] James R. Hall, NRC, letter to Scott L. Baston, Duke Energy Carolinas, LLC, "Oconee Nuclear Station, Units 1, 2 and 3 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0253, MF0254, and MF0255)," dated June 30, 2014. ADAMS Accession No. ML14176A974.

because of issues that had been identified in 2012 the 6-inch sill surrounding the auxiliary, services, and turbine buildings. No findings were identified during these inspections.[282, 283]

B.11.3 **Mitigating Strategies**

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[284] The licensee indicated in its plan that it intended to locate the FLEX storage facility above the flood levels identified in the NRC staff's January 28, 2011, safety evaluation (referenced above), unless it determined a different approach was necessary based on its flooding hazard reevaluation. The licensee also indicated that it had constructed two flood protection features to address upstream dam failures that are not credited in the current licensing basis and had confirmed through analysis that these features would reduce the flood level.[285] The licensee documented two open items to incorporate ongoing analyses of local intense precipitation and sunny-day upstream dam failure. These open items would be addressed between the issuance of the initial Overall Integrated Plan and final compliance notification by the licensee.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. In general, the licensee's approach for removing core decay heat during an ELAP/LUHS event includes adding water to the steam generators from the upper surge tanks using the turbine-driven emergency feedwater pump and releasing steam from the steam generators to the atmosphere. Because this equipment may not be protected from certain external events, the licensee developed two additional strategies.

- For events such as an earthquake that can occur with no advance warning, the licensee plans to use the standby shutdown facility, which was designed to operate for 72 hours. Operators will use the diesel generator in this facility to energize the facility's auxiliary service water pump and add water to all of the steam generators for the three units. Borated water can be added to the reactor coolant system from the spent fuel pool using the reactor coolant makeup pump, powered from the standby shutdown facility. When the standby shutdown facility can no longer be operated reliably, a FLEX pump will be used to add water from the intake canal (connected to Lake Keowee) to one steam generator per unit. The licensee would either repower the reactor coolant makeup pumps from a FLEX generator or use a diesel-driven high-pressure FLEX pump to enable injection into the reactor coolant system from the borated water storage tank.

- If Jocassee Dam fails, the licensee indicates that the standby shutdown facility could be flooded, assuming the flood levels that had been accepted by the NRC staff in the January 28, 2011, safety evaluation. The licensee projects that there would be

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[282] Jonathan H. Bartley, NRC, letter to T. Preston Gillespie, Duke Energy Corporation, "Oconee Nuclear Station – NRC Integrated Inspection Report 05000269/2012005, 05000270/2012005, 05000287/2012005," dated January 25, 2013. ADAMS Accession No. ML13028A133.

[283] Jonathan H. Bartley, NRC, letter to Scott Baston, Duke Energy Corporation, "Oconee Nuclear Station – NRC Integrated Inspection Report 05000269/2013002, 05000270/2013002, 05000287/2013002," dated April 24, 2013. ADAMS Accession No. ML13115A063.

[284] T. Preston Gillespie, Jr., Duke Energy, letter to NRC, "Oconee Nuclear Station (ONS), Units 1, 2, and 3 – Submittal of the ONS Overall Integrated Plan, in accordance with the March 12, 2012, Commission Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events, EA-12-049," dated February 28, 2013. ADAMS Accession No. ML13063A065.

[285] The licensee did not state in its plan what these features are. It is reasonable to assume, based on the licensee's reference in the plan to a dike diversion wall calculation, that they are two of the features outlined below in the "Recent Plant-Specific Activities" section.

> adequate time to shut down all three units, borate the reactor coolant system, isolate the core flood tanks, and commence a cooldown of the reactor coolant system. The licensee would also prepare some FLEX equipment for operation. The licensee would inject water into the steam generators from a pond located above flood level using a FLEX pump and release steam to the atmosphere. When flood waters recede, the licensee either repower the reactor coolant makeup pumps from a FLEX generator or use a diesel-driven high-pressure FLEX pump to enable addition of water to the reactor coolant system from the borated water storage tank.

The NRC staff performed an interim evaluation of this plan and identified several open items, including one related to the ability to repower the reactor coolant makeup pumps after a flood.[286] The NRC staff also identified multiple confirmatory items, including the general need to confirm that "persistent, prohibitive flooding" will not occur and an item on reactor coolant pump isolation following a dam failure. The NRC staff specifically noted in its evaluation that although the licensee estimated a maximum flood level at the site in its Overall Integrated Plan, the NRC staff made no judgment on the estimated flood level in evaluating the mitigating strategies. The NRC staff intended to make a final decision based on the review of the flooding hazard reevaluation report.

The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[287] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

As of its last formal update to the NRC, the licensee was in the process of implementing its mitigating strategies to support compliance with Order EA-12-049.[288] Unit 2 is already in compliance, including modifications, training, and walkdowns, following its Fall 2015 refueling outage. Implementation for Unit 3 is scheduled for the Spring 2016 refueling outage, and the licensee intended to be in full compliance following the Fall 2016 refueling outage for Unit 1. This update also indicates that the two open items noted above regarding the PMP and dam-failure flooding analyses were closed based on an NRC staff audit in July 2015.

The NRC staff will complete a final safety evaluation considering the updated information for all three units and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

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[286] Jeremy S. Bowen, NRC, letter to Scott Batson, Duke Energy Carolinas, LLC, "Oconee Nuclear Station, Units 1, 2, and 3 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0782, MF0783 and MF0784)," dated February 10, 2014. ADAMS Accession No. ML13365A258.

[287] John P. Boska, NRC, letter to Scott Batson, Duke Energy Carolinas, LLC, "Oconee Nuclear Station, Units 1, 2, and 3 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0782, MF0783, MF0784, MF0785, MF0786, and MF0787)," dated October 6, 2015. ADAMS Accession No. ML15259A387.

[288] Scott L. Batson, Duke Energy, letter to NRC, "Sixth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 29, 2016. ADAMS Accession No. ML16064A091.

B.11.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Oconee as a "Category 1" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. The licensee submitted its report on schedule in March 2013.[289]

To address questions on the report raised by the NRC staff and the Federal Energy Regulatory Commission, the licensee obtained an independent review of its dam breach analysis for Jocassee Dam, which it provided to the NRC staff in May 2014.[290] The NRC staff requested in June 2014 that the Federal Energy Regulatory Commission review this information.[291] In addition, the NRC staff commissioned a study by the U.S. Bureau of Reclamation to determine the suitability of the dam breach parameter methodology selected by the licensee.[292] Both the Federal Energy Regulatory Commission and the U.S. Bureau of Reclamation questioned the appropriateness of this methodology as it was applied by the licensee in the flooding hazard reevaluation report. The NRC staff, therefore, requested in September 2014 that the licensee reanalyze and resubmit the dam failure analyses for the flooding hazard reevaluation report after applying alternate breach-parameter estimations, including a comparison of results for several appropriate models and an evaluation of uncertainties.[293]

The licensee submitted its revised flooding hazard reevaluation report in March 2015.[294] This report included alternate dam breach methodologies as requested by the NRC staff, as well as an updated seismic analysis specific to Jocassee Dam. The reevaluated flood level from streams and rivers was higher than the design-basis level. Local intense precipitation had not been included in the design basis, so the reevaluated flood level was considered to be an exceedance. Similarly, flooding from dam failures had not been included as part of the design-basis flooding hazard, so the reevaluated flood level was considered to be an exceedance.

In September 2015, the NRC staff issued an interim response to the Oconee flooding hazard reevaluation report.[295] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above. After completing the flooding hazard reevaluation report and receiving the NRC

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[289] T. Preston Gillespie, Duke Energy, letter to NRC, "Oconee Nuclear Station (ONS), Units 1, 2 and 3 – Flood Hazard Reevaluation Report in response to NRC letter; 'Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident,' dated March 12, 2012," dated March 12, 2013. ADAMS Accession No. ML13079A227. Then enclosed report is available at ADAMS Accession No. ML13240A016.

[290] Scott L. Batson, Duke Energy, letter to NRC, "Submission of Supporting Documentation for the March 12, 2013, Flooding Hazard Reevaluation Report," dated May 15, 2014. ADAMS Accession No. ML14139A174.

[291] Kenneth J. Karwoski, NRC, letter to William H. Allerton, Federal Energy Regulatory Commission, "Oconee Nuclear Station, Units 1, 2, and 3, Assessment of Supporting Documentation Related to the Flooding Hazard Reevaluation Report," dated June 13, 2014. ADAMS Accession No. ML14164A131.

[292] This methodology is referred to as the Xu and Zhang methodology, as described in Xu, Y. and L.M. Zhang, 2009. "Breaching parameters for earth and rockfill dams." *Journal of Geotechnical and Geoenvironmental Engineering*, 135(12):1957-1970.

[293] Robert Kuntz, NRC, email to David Haile, Duke Energy, "Request for Additional Information – Oconee Flooding Hazard Reevaluation Report (TAC Nos. MF1012, MF1013, and MF1014)," dated September 15, 2014. ADAMS Accession No. ML14258B222.

[294] ADAMS Accession No. ML15072A106.

[295] Juan F. Uribe, NRC, letter to Scott Batson, Duke Energy Corporation, "Oconee Nuclear Station, Units 1, 2, and 3 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (TAC Nos. MF1012, MF1013, and MF1014)," dated September 24, 2015. ADAMS Accession No. ML15239B261.

staff's interim response, the licensee also submitted a letter that communicated its complete, updated approach to addressing a flood caused by a postulated Jocassee Dam failure, based on the updated flood levels.[296]

In April 2016, the NRC staff completed its assessment of the flooding hazard reevaluation report.[297] The NRC staff concluded that the 2010 licensee analysis (previously accepted by the NRC staff in the January 28, 2011, safety evaluation) reflects a bounding flooding hazard analysis based on conservative assumptions. The 2015 reevaluation reflects a reasonable analysis that removes some conservatism and is consistent with recent Commission direction. Therefore, the NRC staff determined that the 2015 reevaluation satisfies the information requests for both of the 10 CFR 50.54(f) letters and provides an acceptable alternative analysis to meet the terms of the 2010 Confirmatory Action Letter. The NRC staff noted that it would not make a final determination on the closure of the Confirmatory Action Letter until the permanent plant modifications were completed (which they were in April 2016 as noted above).

After the licensee provides its Phase 1 submittal (e.g., integrated assessment or focused evaluation, as noted in the NRC staff's assessment), the NRC staff will review this information and make a final determination whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.12 Peach Bottom

Peach Bottom Atomic Power Station (Peach Bottom), located on the Susquehanna River in Delta, PA, has two operating units of General Electric BWR design, designated Units 2 and 3. The operating licenses were issued in 1973 and 1974 and renewed in 2003 for terms that expire in 2033 and 2034.[298]

B.12.1 Initial Plant Design and Licensing[299]

The licensee conducted the flooding evaluation for Peach Bottom based on the six greatest floods in Harrisburg, PA. To establish the design-basis flood, the licensee assumed that rain falls simultaneously over the entire Susquehanna River watershed to generate PMF river flows. Then, Holtwood Dam fails coincident with the PMF. Finally, the licensee assumed that the Conowingo Dam (nine miles downstream of the plant) remains intact to maximize the water level at Peach Bottom and provide analytical conservatism.

Based on these scenarios, including consideration of wind waves, a protection level of 135.0 feet was established. The licensee considered this level to provide a margin "more than adequate for the safety criteria of the plant." The licensee further discussed wave runup, noting that only 1 percent of waves would be expected to reach the maximum height of 5.4 feet, which would result in a 136.9-foot flood level when added to the PMF.

The emergency cooling tower structure, diesel generator building, and emergency pump structure are flood-protected to 137.5 feet. The reactor building and radioactive waste building

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[296] Scott L. Batson, Duke Energy, letter to NRC, "Supplemental Information Regarding NRC 2008 and 2012 Requests for Information Pursuant to 10 CFR 50.54(f) Pertaining to External Flooding at Oconee Nuclear Station (ONS) – Revision 1," dated January 8, 2016. ADAMS Accession No. ML16015A430.
[297] ADAMS Accession No. ML15352A207. (Full reference above.)
[298] http://www.nrc.gov/info-finder/reactors/pb2.html and http://www.nrc.gov/info-finder/reactors/pb3.html. Peach Bottom, Unit 1 is permanently shut down.
[299] Information in this section is drawn from the licensee's walkdown report referenced below.

are flood-protected to 135 feet. Watertight doors are provided on the diesel generator building, emergency pump structure, and reactor building. The reactor building doors above 135 feet are also weather-stripped for leak-tightness. The licensee allows the turbine building to flood to equalize the water level to avoid excessive unbalanced hydrostatic loads on the exterior walls.

The licensee initiates actions according to its high-river-level procedure when level reaches 109.5 feet (slightly above the normal Conowingo Pond level of 109.25 feet). At 111 feet (plus a high predicted flow rate), the licensee enters its flooding procedure, which includes shutting the plant down at 112 feet and starting the emergency cooling water system at 113 feet. The flooding procedure also directs licensee staff to replace flood barriers (if they had been removed) when river level is above 115 feet.

B.12.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Peach Bottom.

B.12.3 Flooding Walkdowns

In November 2012, Peach Bottom notified the NRC that it had completed its flooding walkdowns.[300] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

In the walkdown report, the licensee noted that penetration seals, watertight doors, and flood barriers were performing their intended functions. Several features were noted as not meeting the acceptance criteria—generally signs of water seepage or calcification, with one open floor penetration. Repairs were initiated as necessary, and the licensee did not identify any operability issues.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[301] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[302]

B.12.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Peach Bottom as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The NRC staff later relaxed this response date to

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[300] Michael D. Jesse, Exelon Generation Company, LLC, letter to NRC, "Exelon Generation Company, LLC's 180-day Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 19, 2012. ADAMS Accession No. ML123250714.

[301] Richard B. Ennis, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Peach Bottom Atomic Power Station, Units 2 and 3 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0261 and MF0262)," dated June 17, 2014. ADAMS Accession No. ML14119A057.

[302] Mel Gray, NRC, letter to Michael J. Pacilio, Exelon Generation Company, LLC, "Peach Bottom Atomic Power Station – NRC Integrated Inspection Report 05000277/2012005 and 05000278/2012005," dated January 29, 2013. ADAMS Accession No. ML13029A013.

March 12, 2015, to allow the licensee time to conduct a detailed hydrometeorological study for the Susquehanna River watershed.[303] In approving the relaxation, the NRC staff considered the margin between the 132-foot design-basis flood level and the 135-foot protection level, as well as the flood level of 113.5 feet during the record flood in 1972.

While the licensee was developing its flooding hazard reevaluation, the NRC staff also coordinated with the U.S. Army Corps of Engineers and the Federal Energy Regulatory Commission on Exelon Hydro's relicensing application for the Conowingo hydroelectric station, as well Exelon's flooding hazard reevaluation report for Three Mile Island (referred to as TMI), to ensure that lessons learned from each analysis were shared.[304]

The licensee submitted its report on schedule in March 2015.[305] In its evaluation, the licensee determined that several flood scenarios were completely bounded by the plant design basis or by other scenarios: Rock Run Creek flooding, sunny-day dam failure, storm surge, seiche, tsunami, ice-induced flooding, channel migration or diversion, and combination of flooding with seismic dam failure. The licensee noted two scenarios to which the site was potentially exposed:

- Local intense precipitation, which is not addressed in the current licensing basis, could result in a flood level of 135.91 feet. The licensee's report addresses associated effects including hydrodynamic and hydrostatic loading, duration, and warning time that are not included in the current licensing basis.

- The combination event of a Susquehanna River PMF including hydrologic dam failure would result in flood levels that are bounded by the current licensing basis values. The licensee noted that associated effects from this flood are not addressed in the final safety analysis report, though a limited evaluation determined that the hydrostatic and hydrodynamic loads would be bounded by the design basis.

Using NRC staff guidance, the licensee determined that only a limited evaluation of the effects of local intense precipitation (the only scenario not bounded by the design basis) was necessary, rather than an integrated assessment. In this evaluation, the licensee reviewed the amount of water that could enter reactor building rooms through secondary containment doors and compared it to safety-related sump pump capacity and the allowable volume in the those rooms. The licensee stated that the evaluation showed no effect on safety-related structures, systems, and components; therefore, no compensating actions were necessary.

In March 2016, the NRC staff issued an interim response to the Peach Bottom hazard reevaluation report.[306] The NRC staff concluded that the licensee's reevaluated flooding hazard

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[303] Daniel H. Dorman, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Peach Bottom Atomic Power Station, Units 2 and 3 – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident (TAC Nos. MF3671 and MF3672)," dated July 17, 2014. ADAMS Accession No. ML14174A879.

[304] Joseph M. Sebrosky, NRC, letter to Exelon Generation Company, LLC, "Summary of Public Teleconference Held on July 14, 2014, with Exelon Generation Company, LLC to Discuss the U.S. Army Corps of Engineers Flooding Hazard Reevaluation for Peach Bottom Atomic Power Station, Units 2 and 3 (TAC Nos. MF3991 and MF3992)," dated August 11, 2014. ADAMS Accession No. ML14216A264.

[305] James Barstow, Exelon Generation Company, LLC, letter to NRC, "Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report," dated March 12, 2015. ADAMS Accession No. ML15233A067.

[306] Tekia Govan, NRC, letter to Bryan C. Hanson, Exelon Nuclear, "Peach Bottom Atomic Power Station, Units 2 and 3 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f)

information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049.

In coordination with its other reviews of flooding hazard reevaluations, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.12.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[307] In this plan, the licensee notes that external flooding is an applicable hazard. Consistent with the information presented above, the licensee notes that critical equipment, systems, and structures essential to a safe shutdown of the reactor are protected up to 135 feet based on the combination of a PMF, failure of the upstream dam, and wind-generated waves. The licensee assumes that a long lead time exists before flood levels will reach site grade.

Specific to flood protection, the licensee states that FLEX equipment can be stored below flood level at Peach Bottom since sufficient warning time is available to relocate and/or deploy the equipment. FLEX equipment will be relocated to a position that is protected from the flood, either by barriers or by elevation, prior to the arrival of the potentially damaging flood levels. Both electrical and at least one mechanical FLEX connection will be protected from external flooding. Fuel oil storage tanks will be protected from flood conditions.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by using the steam-driven reactor core isolation cooling system pump to supply water to the reactor from the condensate storage tank or suppression pool, venting steam through the main steam relief valves to the suppression pool. The Conowingo Pond can be used to provide water makeup to the suppression pool; if it is unavailable, the emergency cooling tower can be used, a portable FLEX pump is available for injection. A FLEX generator will be used to power certain motor control centers to enable use of necessary motor-operated valves and instrumentation. The Regional Response Center will provide additional equipment, such as large diesel generators, to provide supplemental mitigation.

The NRC staff performed an interim evaluation of this plan and identified open items related to containment venting, freeze protection, lighting, and access to locked areas.[308] The NRC staff also identified multiple confirmatory items, including items related to the flood warning time and movement of equipment during a flood. The NRC staff later conducted an audit to evaluate the

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Information Request – Flood Causing Mechanism Reevaluation (CAC Nos. MF6598 and MF6599)," dated March 31, 2016. ADAMS Accession No. ML16091A136.

[307] Michael D. Jesse, Exelon Generation Company, LLC, letter to NRC, "Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 28, 2013. ADAMS Accession No. ML13059A305.

[308] Jeremy S. Bowen, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Peach Bottom Atomic Power Station, Units 2 and 3 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF1160 and MF1161)," dated November 22, 2013. ADAMS Accession No. ML13220A105.

licensee's progress in implementing the order.[309] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

The licensee has completed training and procurement for its strategies. The strategies (including physical modifications guidance development) have been implemented for Unit 3 and are being implemented for Unit 2 as part of the Fall 2016 refueling outage; therefore, the licensee is expected to notify the NRC of full compliance for both units by the end of 2016.[310]

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.13 Prairie Island

Prairie Island Nuclear Generating Plant (Prairie Island) is located in Red Wing, MN, on the west bank of the Mississippi River. The site has two units of Westinghouse PWR design. The operating licenses were issued in 1974 and renewed in 2011 for terms that expire in 2033 and 2034 for Units 1 and 2, respectively.[311]

B.13.1 Initial Plant Design and Licensing[312]

At Prairie Island, site grade surrounding the power block and screenhouse is 694.5 feet MSL. Normal pool level at Lock and Dam Number 3, 1.5 miles downstream of the plant, is at 674.5 feet MSL. The maximum reported flood at this location was at 687.7 feet MSL in 1965, which the U.S. Army Corps of Engineers estimated as a 150-year flood. The 1000-year flood was estimated by the U.S. Army Corps of Engineers as 691.8 feet.

According to the licensee, the PMF for the Mississippi River results in a peak flood level of 703.6 feet, with a maximum wave run-up to 706.7 feet. The licensee also considered the failure of Lock and Dam Number 2, located 17 miles upstream, but determined that the storage effect of the lower channel basin and resulting loss of head in the upper reservoir would limit flooding such that there would not be a hazard onsite.

The licensee's flooding procedures provide for various actions beginning at a three-day flood forecast of 678 feet. Examples of these actions include keeping fuel tanks full and making backup provisions for transport of personnel and supplies. The plant must be shut down (Mode 3, Hot Standby) when there is a three-day forecast of a flood higher than 692 feet at the site. At this point, bulkheads stored onsite are also installed to close all openings in flood-

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[309] Peter J. Bamford, NRC, letter to Bryan Hanson, Exelon Nuclear, "Peach Bottom Atomic Power Station, Units 2 and 3 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0845, MF0846, MF0849, and MF0850)," dated September 23, 2015. ADAMS Accession No. ML15254A135.

[310] David P. Helker, Exelon Generation Company, LLC, letter to NRC, "Sixth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2016. ADAMS Accession No. ML16057A009.

[311] http://www.nrc.gov/info-finder/reactors/prai1.html and http://www.nrc.gov/info-finder/reactors/prai2.html

[312] Information in this section is drawn from the licensee's walkdown report referenced below.

protection walls. If river level reaches 692 feet, the licensee would declare a Notice of Unusual Event; at 698 feet, the licensee would declare an Alert.

B.13.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Prairie Island. Two activities related to flood protection features in recent years are described in this section, as they relate to the mitigation of external floods in general.

In 2001, the licensee identified several deficiencies with flood panels that would prevent them from performing their design function without compensatory measures.[313] These flood panels protect residual heat removal pumps and emergency diesel generators that are located at or below the 695-foot elevation. The deficiencies included deteriorated gasket material, physical obstructions, and deficient bolting. The licensee restored the flood panels to a condition where they would meet their design function.[314] The licensee noted several root causes related to review of drawings, verification of drawing change implementation, oversight of flood preparedness procedures, and adequacy of flood panel inspection procedures. As noted in the licensee's walkdown report referenced below, the licensee implemented an annual surveillance procedure confirming that flood panels and any supporting materials or equipment are ready for use.

At the same time as the flood panel issue, the licensee identified an additional issue with removable steel panels that covered openings designed to allow removal of the emergency diesel generators from their building. These panels were not watertight; the issue was resolved by completing the seal weld on the panels.

In addition, as part of its license renewal application, the licensee also committed to enhance its program for inspection of water-control structures to include concrete and steel components below the water line at the screenhouse and intake canal.[315] The licensee also committed to inspect the approach canal, intake canal, emergency cooling water intake, and screenhouse immediately after extreme environmental conditions or natural phenomena, including floods. The licensee's inspections after such events would include looking for damage such as cracking, settlement, movement, broken bolted and welded connections, buckling, and other degraded conditions.

B.13.3 Flooding Walkdowns

In November 2012, Prairie Island notified the NRC that it had completed its flooding walkdowns.[316] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

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[313] Mano Nazar, Nuclear Management Company, LLC, letter to NRC, "LER 1-01-03: Plant in Unanalyzed Condition Due to Flood Panel Deficiencies," dated September 10, 2011. ADAMS Accession No. ML012610162.
[314] Mano K. Nazar, Nuclear Management Company, LLC, letter to NRC, "LER 1-01-03, Supplement 1 – Plant in Unanalyzed Condition Due to Flood Panel Deficiencies," dated April 12, 2002. ADAMS Accession No. ML021160306.
[315] NUREG-1960, "Safety Evaluation Report Related to the License Renewal of the Prairie Island Nuclear Generating Plant Units 1 and 2," dated August 2011. ADAMS Accession No. ML11235A622. The enhancement is discussed in Section 3.0.3.2.14 of the report.
[316] James E. Lynch, Xcel Energy, letter to NRC, "PINGP Final Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 26, 2012. ADAMS Accession No. ML12332A302.

In the walkdown report, the licensee documented one deficiency (as defined in NEI 12-07) related to the power supply for sump pumps during a loss-of-offsite-power event. The licensee indicated that it would develop a plan to provide portable sump pumps with power supplies that would be available. The licensee also indicated that the configuration of the structures had sufficient volume that water inleakage would remain below the levels that could affect structures, systems, and components important to safety.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[317] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance. No findings were identified during these inspections.[318]

B.13.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Prairie Island as a "Category 2" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2014. The NRC staff later approved an extension of this schedule to allow for input from the U.S. Army Corps of Engineers on the six dams upstream of the plant that are managed by that agency.[319] Although the licensee requested 10 months to incorporate this information, the NRC staff only granted a 6-month extension. The NRC provided the relevant information to the licensee in November 2015 and noted that the due date for the flooding hazard reevaluation was May 16, 2016.[320]

The licensee submitted the flooding hazard reevaluation report for Prairie Island on schedule in May 2016.[321] The report indicates that all reevaluated flooding hazards were either bounded by the design-basis flood or screened out, with the exception of local intense precipitation. The licensee determined that there would be no adverse impact on safety-related structures, systems, or components from the reevaluated local intense precipitation levels. The licensee further stated that there is no flooding hazard resulting from the potential failure of Lock and Dam Number 2 upstream of the plant, and that all upstream dams had been screened out from further analysis by the U.S. Army Corps of Engineers. The U.S. Army Corps of Engineers had presented additional information on these analyses during a closed meeting in July 2015, noting that these dams would not affect the plant, based on cumulative volume and cumulative peak flow that would result from simultaneous failures of the all dams in the basin.[322] Also, the

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[317] Scott Wall, NRC, letter to Kevin K. Davison, Northern States Power Company – Minnesota, "Prairie Island Nuclear Generating Plant, Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0268 and MF0269)," dated June 17, 2014. ADAMS Accession No. ML14148A477.

[318] Kenneth Riemer, NRC, letter to James E. Lynch, Northern States Power Company, Minnesota, "Prairie Island Nuclear Generating Plant, Units 1 and 2, NRC Integrated Inspection Report 05000282/2012005; 05000306/2012005; and 07200010/2012001," dated February 7, 2013. ADAMS Accession No. ML13038A671.

[319] Daniel H. Dorman, NRC, letter to Kevin K. Davison, Northern States Power Company – Minnesota, "Prairie Island Nuclear Generating Plant, Units 1 and 2 – Relaxation of Response Due Date Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident (TAC Nos. MF3589 and MF3590)," dated July 29, 2014. ADAMS Accession No. ML14171A166.

[320] Victor Hall, NRC, letter to Kevin K. Davison, Northern States Power Company – Minnesota, "Prairie Island Nuclear Generating Plant, Units 1 and 2 – Transmittal of U.S. Army Corps of Engineers Flood Hazard Reevaluation Information (TAC Nos. MF3697 and MF3698)," dated November 18, 2015. ADAMS Accession No. ML15324A371.

[321] Scott Northard, Xcel Energy, letter to NRC, "Prairie Island Nuclear Generating Plant, Units 1 and 2, Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report," dated May 9, 2016. ADAMS Accession No. ML16133A030.

[322] "Summary of July 9, 2015, Closed Meeting Between Representatives of the U.S. Army Corps of Engineers, U.S. Nuclear Regulatory Commission, and Northern States Power Company – Minnesota, to Discuss Flood Analysis

upstream dams were not modeled explicitly in the PMF analysis, given the long distance of the site from any large flood control projects.

As described for other plants, the NRC will review this information and provide an interim response regarding the suitability of the reevaluated hazard for the mitigating strategies assessment and further assessments by the licensee. After the licensee completes all of its necessary evaluations, the NRC staff will review the submitted information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.13.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[323] In this plan, the licensee notes that external flooding is an applicable hazard. The licensee included design-basis information consistent with that presented above and described the estimated duration of the flood.

Specific to flood protection, the licensee states that it plans to construct two separate FLEX storage locations that do not need to be structurally designed to withstand a severe flood, given the warning time available to remove and deploy equipment stored in those locations. The buildings, however, will be at elevations that will allow access to the FLEX equipment during the early stages of the flood. The licensee indicates that there will be sufficient time for pre-staging of portable FLEX equipment within flood-protected areas or above the flood level before the design-basis flood level is reached. Additional offsite equipment from the Regional Response Center can be requested prior to the flooding of the main access road and set up on site in advance of the probable maximum flood. Power supplies and pumps will be pre-staged as part of the plant procedures for construction of flood protection features referenced above.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by feeding the steam generators from the condensate storage tank or cooling water system using the turbine-driven auxiliary feedwater pump and releasing steam from the steam generator power operated relief valves or safety valves. The licensee will cool down the reactor coolant system to allow the safety injection accumulators to inject borated water; a portable FLEX diesel generator will be aligned later to power an installed charging pump for further makeup from the refueling water storage tank. In the longer term, portable, diesel-driven FLEX pumps, with appropriate power and water supplies, can be used to inject into the steam generators and the reactor coolant system. Additional equipment such as pumps, large diesel generators, and water filtration equipment will be provided by the Regional Response Centers.

The NRC staff performed an interim evaluation of this plan and identified several confirmatory items not specifically related to flooding.[324] In developing this evaluation, the NRC staff

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Associated with Monticello Nuclear Generating Plant and Prairie Island Nuclear Generating Plant, Units 1 and 2 (TAC Nos. MF3696, MF3697 and MF3698)," dated October 2, 2015. ADAMS Accession No. ML15271A207.

[323] James E. Lynch, Xcel Energy, letter to NRC, "Prairie Island Nuclear Generating Plant's Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2013. ADAMS Accession No. ML13060A379.

[324] Jeremy S. Bowen, NRC, letter to Kevin K. Davison, Northern States Power Company – Minnesota, "Prairie Island Nuclear Generating Plant Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to

discussed the flood protection strategy with the licensee, including evaluating supplies, setting up sump pumps, and installing flood panels. The NRC staff noted in their report that the licensee's approaches to mitigating the external flooding hazard were consistent with NRC-approved guidance, if they were implemented as currently understood. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[325] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be transported, connected, and used.

The licensee notified the NRC on January 14, 2016, that Unit 2 is in full compliance with Order EA-12-049.[326] For Unit 1, the licensee is in the process of procuring equipment and developing procedures and training. Full implementation of the modifications is expected as part of the Fall 2016 refueling outage.[327]

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.14 Sequoyah

Sequoyah, located on the Tennessee River in Soddy-Daisy, TN, has two units of Westinghouse PWR design.[328] The operating licenses were issued in 1980 and 1981 and renewed in 2015 for terms that expire in 2040 and 2041.[329]

B.14.1 Reference Flooding Levels[330]

The licensee has updated Sequoyah's flooding analysis several times since initial licensing—reducing the assumed flood levels as a result of reanalysis in the 1980s, then increasing them again in a 2012 analysis to address issues raised with the quality of hydrologic analyses that were identified in 2008. While the updated 2012 results are not the official licensing basis of the plant because they are still under NRC staff review, the licensee determined that it was more appropriate to use these flooding levels in its walkdowns and reevaluation comparison described below because, in some cases, they are higher than those included in the current licensing basis. Further details of these changes are described in the "Additional Plant-Specific

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Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0834 and MF0835)," dated February 27, 2014. ADAMS Accession No. ML14030A540.

[325] Peter J. Bamford, NRC, letter to Kevin K. Davison, Northern States Power Company – Minnesota, "Prairie Island Nuclear Generating Plant Units 1 and 2 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and Ea-12-051 (TAC Nos. MF0834, MF0835, MF0832, and MF0833)," dated August 20, 2015. ADAMS Accession No. ML15224B396.

[326] Kevin Davison, Xcel Energy, letter to NRC, "Notification of Compliance with NRC Order EA-12-049, 'Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,' Prairie Island Nuclear Generating Plant Unit 2 (TAC No. MF0835)," dated January 14, 2016. ADAMS Accession No. ML16014A754.

[327] Kevin Davison, Xcel Energy, letter to NRC, "Prairie Island Nuclear Generating Plant, Unit 1, Sixth Six-Month Status Report in Response to March 12. 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) (TAC No. MF0834)," dated February 24, 2016. ADAMS Accession No. ML16057A061.

[328] http://www.nrc.gov/info-finder/reactors/seq1.html and http://www.nrc.gov/info-finder/reactors/seq2.html.

[329] NRC Press Release 15-057, "NRC Renews License of Sequoyah Nuclear Plant in Tennessee," dated September 28, 2015. ADAMS Accession No. ML15271A135.

[330] Information in this section is drawn from the licensee's walkdown report referenced below.

Actions" section below. Therefore, the flood levels provided by the licensee to support the NRC's original licensing decision are not discussed in detail in this report.

The updated 2012 PMF scenario is based on a PMP event coincident with a failure of Watts Bar Dam. The resulting flood levels were several feet higher than the design-basis flood at the time, considering wave runup and surge. The licensee noted that the design analyses for the structures used flooding levels that were higher than both the design-basis flood and the 2012 updated results, providing margin.

In addition, the updated 2012 flood evaluation included an assessment of five different seismic dam failure events that could cause flooding above site grade. In this analysis, the licensee added the effects of failure of Tellico Dam (not included in the original licensee analyses) because the seismic stability analysis of this dam did not provide results conclusive enough to exclude its failure. The licensee's calculations resulted in a maximum flood level several feet below the updated 2012 PMF flood level.

Both the design-basis flood and the updated 2012 analysis result in flooding levels above site grade of 705 feet. For such floods, all equipment needed during the flood, and for 100 days after the beginning of the flood, is either designed to operate submerged, located above the maximum flood level, or otherwise protected. Operation in this condition is referred to as "flood mode"; the licensee describes multiple features that provide protection in this mode. The reactor building, diesel generator building, and essential raw cooling water intake station will be maintained dry during the time designated as "flood mode," with walls and penetrations designed to withstand the flooding forces.

Because wave runup from the PMF (in either analysis) could exceed the 722.0-foot elevation of the lowest floor in the diesel generator building, the entrances and penetrations into safety-related areas are sealed either before or during flood mode, and redundant sump pumps are provided in the building for minor leakage. Wave runup could also exceed the 722.0-foot elevation of the essential raw cooling water intake station deck, but outside walls provide protection, and traveling screen walls extend above the deck elevation up to the surge level. All exterior penetrations below the PMF level are permanently sealed, except for one that is designed for sealing in the event of a flood. Redundant sump pumps are also provided on the deck and in interior rooms. The licensee notes that all other structures, including the service, turbine, auxiliary, and control buildings, will be allowed to flood as the water exceeds their grade level entrances. All equipment, including power cables, that is located in these buildings and required for operation in the flood mode is either above the design-basis flood level or designed for submerged operation.

Plant procedures provide for shutting the plant down before the flood level reaches 703 feet, as well as other flood-related actions. The licensee evaluated the warning time available for upstream dam failure combinations and determined that there would be sufficient time to shut the plant down. If loss of or damage to an upstream dam is suspected by the licensee, the licensee will attempt to determine whether dam failure has occurred. If the critical case has occurred or it cannot be determined that it has not occurred, Stage I shutdown will be initiated.

B.14.2 Additional Plant-Specific Actions

In 1982, the NRC staff approved technical specification changes for Sequoyah related to flooding.[331] The first approved change corrected an error in the winter critical flood level,

[331] Elinor G. Adensam, NRC, letter to H.G. Parris, TVA, "Issuance of Amendment No. 22 to Facility Operating License

providing a uniform 703-foot MSL critical flood level for both summer and winter. The second approved change lowered the surveillance requirement level from 703 feet MSL to 698 feet MSL, with water level determined every 15 minutes if a flood goes above this level, providing additional time for the licensee to predict the arrival time of a flood peak and coordinate plant modifications before flooding would begin on site. The NRC staff denied a proposed change that would decrease communication frequency between the site and the TVA Division of Water Resources.

In 1982, TVA established the Dam Safety Program and began a safety review of TVA dams. This dam safety effort was designed to be consistent with the Federal Guidelines for Dam Safety and similar efforts of other Federal agencies. Technical studies, engineering analyses, and modifications were performed to ensure hydrologic and seismic integrity of TVA dams. This evaluation resulted in the reduction of the design-basis flood level below the 722.0-foot elevation.

As noted above for Browns Ferry, in 2008, the NRC staff audited the licensee's hydrologic modeling for the proposed new reactors at Bellefonte and issued three violations associated with quality assurance and design control. In response to these violations, the licensee completed a revised hydrologic analysis for the combined license application. This analysis directly affected Sequoyah, since the analysis is similar for all TVA plants on the Tennessee River.

As a result, the licensee filed a licensee event report in December 2009 (updated in 2010 when the root cause evaluation was completed) that stated that updated calculations raised the design-basis PMF level back to a level slightly below the original design-basis level.[332] This increase in calculated PMF level resulted from several calculation changes, including updated dam rating curves using model data and changes in reservoir operating policy. The plant was still generally protected against a flood at the original higher design-basis level, except for the diesel generators and spent fuel pool cooling pumps.[333] Based on preliminary information, the licensee had already issued a standing order in February 2009 to protect the diesel generators and spent fuel pool cooling pumps during a PMF event.

The licensee filed a further event report in April 2013 that described issues with the evaluation of upstream dam failures.[334] The licensee's report notes that in 1998 and again in 2004, significant changes to the design of the dams and operation of the river system were implemented. In both cases, the Simulated Open Channel Hydraulics model developed by TVA in the 1960s and 1970s was used to calculate the impact to the nuclear sites. The licensee acted on those results without questioning the validity of the model, the calculations it supported, or the resulting conclusions. The licensee observed that since the software and model had been used to license the nuclear stations, the licensee considered that they were correct. It was not until validation in 2009 (as described previously), that the licensee identified

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No. DPR-77 and Amendment No. 12 to Facility Operating License No. DPR-79 – Sequoyah Nuclear Plant, Units 1 and 2," dated December 27, 1982. ADAMS Accession No. ML013240537.

[332] Christopher R. Church, TVA, letter to NRC, "Licensee Event Report 327 and 328/2009-009, 'Unanalyzed Condition Affecting Probable Maximum Flood Level,' Revision 1," dated April 14, 2010. ADAMS Accession No. ML101090017.

[333] The licensee event report did not provide additional detail describing why the diesel generators and spent fuel pool cooling pumps were not designed to the 722.6-foot flood level. It is conceivable, though not confirmed, that some protection features were not maintained in a way that could be credited by the licensee following the reduction of the flood level in the 1980s.

[334] Joseph Shea, TVA, letter to NRC, "Licensee Event Reports: 50-390/2013-001-00; 50-327/2013-001-00; 50-259/2013-001-00," dated April 8, 2013. ADAMS Accession No. ML131010432.

inconsistencies in the inputs that, when corrected, resulted in the realization that some upstream dams could fail and affect planned flood protection actions at TVA's nuclear stations. To address this issue, the licensee implemented interim measures in the summer of 2009 to require site notifications if there was heavy rainfall in the Fort Loudoun and Tellico Dam watershed area. At this point, TVA would mobilize heavy equipment to preserve the integrity of Fort Loudoun Dam. During this period, TVA also began installation of HESCO modular flood barriers on Cherokee, Fort Loudoun, Tellico, and Watts Bar Dams.

The licensee made several commitments to address the issues raised by the revised hydrologic analysis. In June 2012, the NRC staff issued a Confirmatory Action Letter to both Sequoyah and Watts Bar to formally document the licensee's commitments and require notification to the NRC when the licensee completed them.[335] For example, by March 2013, the licensee installed flood protection barriers for various doors in the diesel generator building at the 722.0-foot elevation.[336] The licensee also capped the waste line from the toilet room and extended the oil storage tank external fuel fill ports up to 725.5 feet. Other documented commitments included permanent modifications to enhance the performance of Cherokee, Fort Loudoun, Tellico, and Watts Bar Dams that had been identified as possible in the event report referenced above.

The licensee also submitted a license amendment request to the NRC in August 2012 to adopt the revised hydrologic analysis into its final safety analysis report.[337] The NRC staff began its review of this information, but determined that it was necessary to coordinate this review with the development of the flooding hazard reevaluation described below. Therefore, this license amendment request has not yet been approved; however, various interim corrective actions described above, as well as in sections below, have been completed.

At the same time, the NRC staff also evaluated the licensee's flood protection through inspections.[338] In June 2013, the NRC issued a White finding (low to moderate safety significance) for the licensee's failure (before September 30, 2009) to address the potential for dams to fail and flood the site, including submerging the diesel generators, as was identified in the event report referenced above. Furthermore, the NRC staff noted that when the licensee installed temporary flood barriers, the licensee failed to analyze the effects of the potential failure, report the issue as an unanalyzed condition, and clearly portray the reliance on the temporary barriers in their operability and design documentation. The failure to analyze the effects of a dam failure on the site PMF level resulted in an unclear characterization of the relationship between the HESCO barriers and the design basis of the plant. The NRC staff noted that this was a primary consideration in the issuance of the Confirmatory Action Letter noted above.

This finding, combined with another identified as part of the walkdowns described in the next section, resulted in Sequoyah entering the Degraded Cornerstone column of the NRC's Reactor

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[335] Eric J. Leeds, NRC, letter to Joseph W. Shea, TVA, "Confirmatory Action Letter – Watts Bar Nuclear Plant, Unit 1, and Sequoyah Nuclear Plant, Units 1 and 2, Commitments to Address External Flooding Concerns (TAC Nos. ME8805, ME8806, and ME8807)," dated June 25, 2012. ADAMS Accession No. ML12165A527.

[336] J.W. Shea, TVA, letter to NRC, "Completion of Commitments Related to Updated Hydrologic Analysis Results for Sequoyah Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 1 (TAC Nos. ME8805, ME8806, and ME8807)," dated April 29, 2013. ADAMS Accession No. ML13126A101.

[337] J.W. Shea, TVA, letter to NRC, "Application to Revise Sequoyah Nuclear Plant Units 1 and 2 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, (SQN-TS-1 2-02)," dated August 10, 2012. ADAMS Accession No. ML12226A561.

[338] Victor M. McCree, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant – Final Significance Determination of White Findings, Notices of Violations, and Assessment Followup Letter: NRC Inspection Report No. 05000327/2013011, 05000328/2013011," dated June 4, 2013. ADAMS Accession No. ML13155A560.

Oversight Process Action Matrix, necessitating additional inspection by the NRC staff to assure that root and contributing causes are understood, independently assess the extent of condition, determine whether safety culture components contributed to the issues, and assure that corrective actions are sufficient to address the causes and prevent recurrence. The NRC documented the results of this supplemental inspection in January 2014 and concluded that the licensee's corrective actions had been sufficient.[339] The corrective actions specifically discussed for this inspection (among others taken by the licensee to address flood protection issues) included:

- creating a flood protection program (including implementing procedures) within the corporate nuclear engineering organization, to ensure critical safety systems are protected from all postulated flooding conditions
- developing design standards and guides to control the flood calculation process
- creating a formal, documented risk management process for all engineering products
- incorporating industry best practices with respect to engineering technical rigor into engineering procedures
- preparing documents related to inleakage to the pumping station and diesel generator building and issuing drawings that identify flood protection boundaries and seals
- sealing shield building penetrations

The licensee provided further commitments related to improving flood mitigation at Sequoyah in an April 2013 letter, which the NRC staff confirmed in a July 2013 response.[340, 341] The licensee stated that it considered the current licensing basis approach sufficient to provide adequate protection against design-basis floods. To provide additional margin, however, the licensee decided to design an improved flood mitigation system, to be fully implemented by the end of December 2016. The system includes a hardened structure located at least 15 feet above current PMF levels, additional diesel generators, and hardened enhanced flood-mode systems for decay heat removal and reactor coolant system makeup. This approach will use certain elements of the FLEX equipment described further in the "Mitigating Strategies" section below. The licensee has provided twelve status reports on the progress of its activities and currently estimates that it will meet this December 2016 implementation schedule.[342] The preliminary design process, as well as the procurement of long-lead items, are complete; engineering design is ongoing.

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[339] Jonathan H. Bartley, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant – NRC Supplemental Inspection Report 05000327/2013013 and 05000328/2013013," dated January 27, 2014. ADAMS Accession No. ML14027A738.

[340] Preston D. Swafford, TVA, letter to NRC, "Commitment to Install Improved Flood Mitigation Systems," dated April 16, 2013. ADAMS Accession No. ML13108A107.

[341] Victor M. McCree, NRC, letter to Joseph W. Shea, TVA, "Tennessee Valley Authority Commitment to Install Improved Flood Mitigation Systems at Sequoyah Nuclear Plant, Units 1 and 2, and Watts Bar Nuclear Plant, Units 1 and 2," dated July 1, 2013. ADAMS Accession No. ML13182A615.

[342] J.W. Shea, TVA, letter to NRC, "Twelfth Progress Update on Improved Flood Mitigation System Project," dated March 31, 2016. ADAMS Accession No. ML16102A304.

B.14.3 Flooding Walkdowns

In November 2012, Sequoyah notified the NRC that it had completed its flooding walkdowns.[343] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

In the walkdown report, the licensee described several deficiencies. To address deficiencies related to flood-mode barriers, the licensee sealed emergency raw cooling water conduit penetrations and installed temporary sump pumps, as well as purchased and staged plugs for the diesel generator building drain. The licensee was also evaluating the potential for water transport through conduit below the flood level in shield building penetrations. The licensee also determined that it would take longer to make flood-mode preparations than it had estimated (although still less than the full window that included additional time for contingencies). This was identified as a fleet-level issue for resolution, as similar concerns existed for Watts Bar. The licensee implemented several site-specific enhancements, including improving accessibility of flood-mode components, staging tools and equipment, and enhancing procedures.

The licensee filed an event report related to the inadequate electrical conduit penetration seals identified during the walkdowns, noting that the condition could have allowed flood water to enter the pumping station at a rate greater than the sump pump capacity.[344] The licensee's report provides a timeline of the original design and various modifications to this conduit. After evaluating the issue, the NRC staff issued a White finding for the licensee's failure to translate the flooding design basis into the design documentation for the essential raw cooling water pumping station.[345] In particular, the penetration seals for this structure were not identified as flood barriers, even though the intake station is required to remain dry during the design-basis flood. As a result of degraded or missing seals, this pumping station could have flooded, submerging service water equipment necessary for the functioning of the diesel generators. In evaluating the significance of the event, the NRC staff considered the frequency of floods higher than the level of the seals and confirmed through walkdowns that there was no affected equipment below this level.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[346] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features.[347, 348] The inspectors identified a Green finding (very low safety significance) associated with timely identification and correction of issues with a conduit penetration seal entering the emergency raw cooling water building, two

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[343] J.W. Shea, TVA, letter to NRC, "Tennessee Valley Authority – Fleet Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Flooding Walkdown Results of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML12335A340.

[344] John T. Carlin, TVA, letter to NRC, "Licensee Event Report 50-327 / 2012-001, 'Unanalyzed Condition Affecting Essential Raw Cooling Water System due to External Flooding,'" dated February 8, 2013. ADAMS Accession No. ML13044A012.

[345] ADAMS Accession No. ML13155A560, as referenced above.

[346] Andrew Hon, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0281 and MF0282)," dated June 27, 2014. ADAMS Accession No. ML14143A336.

[347] Scott M. Shaeffer, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant – NRC Integrated Inspection Report 05000327/2012005, 05000328/2012005," dated February 13, 2013. ADAMS Accession No. ML13050A394.

[348] Scott M. Shaeffer, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant – NRC Integrated Inspection Report 05000327/2013002, 05000328/2013002," dated May 9, 2013. ADAMS Accession No. ML13129A330.

penetrations in the wall of the emergency raw cooling water building below the PMF level that were not sealed, and two diesel generator drain lines that could not be isolated. In response to this finding, the licensee took several actions:

- plugging emergency raw water cooling building penetrations
- installing larger capacity sump pumps that would ensure water could be removed from the emergency raw cooling water bays if the design-basis flood occurred before adequate seals could be installed
- procuring pipe plugs for all drain valves in the diesel generator building and preparing procedures for their installation

B.14.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Sequoyah as a "Category 1" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2013. The licensee later requested a relaxation in this schedule to complete its assessment using updated methodologies, which included migrating Tennessee River modeling from TVA's code to the U.S. Army Corps of Engineers program. The NRC staff granted this relaxation in consideration of the plans for permanent site modifications and performance drills, as well as the licensee's commitment to provide quarterly status reports.[349]

The licensee submitted its flooding hazard reevaluation report on schedule in March 2015.[350] The licensee indicated in the report that it submitted the 2012 update to the hydrological licensing basis to the NRC in August 2012, as noted above. Though this 2012 update has not yet been approved by the NRC, the licensee referred to it as the current licensing basis for purposes of the flooding hazard reevaluation report. The exception is the reevaluation of local intense precipitation, which is compared to the evaluation in the final safety analysis report, which the licensee revised in December 2014 using the 10 CFR 50.59 change process.

The reevaluated hazards for three scenarios exceeded what the licensee referred to as the current licensing basis: local intense precipitation, flooding from streams and rivers, and flooding from combined effects.

Local intense precipitation resulted in a flood level slightly higher than the updated 2012 evaluation. The licensee evaluated access points into buildings and determined that there would be no effect on equipment needed for safe operation as a result of this event and that no interim actions were needed.

Flooding from streams and rivers resulted in a flood level less than two feet higher than the updated 2012 evaluation. This value assumed that dam modifications were in place according to the proposed conditions described in the Supplement 27 to the NRC staff's safety evaluation

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[349] Eric J. Leeds, NRC, letter to J.W. Shea, TVA, "Sequoyah Nuclear Plant, Units 1 and 2 and Watts Bar Nuclear Plant, Units 1 and 2 – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident," dated July 1, 2013. ADAMS Accession No. ML13163A296.

[350] J.W. Shea, TVA, letter to NRC, "Flood Hazard Reevaluation Report for Sequoyah Nuclear Plant, Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated March 12, 2015. ADAMS Accession No. ML15071A462.

associated with the Watts Bar Unit 2 operating license.[351] At the time, the NRC staff considered it necessary to require in this condition that TVA submit a long-term modification plan to raise the height of Cherokee, Fort Loudoun, Tellico, and Watts Bar Dams, providing sufficient stability and functionality to ensure PMF limits would not be exceeded at Watts Bar. In Supplement 28 to the safety evaluation, the NRC staff described extensive interactions with TVA that resulted in a revised hydrologic analysis, updated flooding protection requirements, and revised dam stability acceptance criteria based on updated TVA River Operations standards.[352] Therefore, the NRC staff considered the previous concern not to be an issue and included a single flooding condition in the Watts Bar Unit 2 operating license, requiring TVA to implement permanent modifications at the Fort Loudoun Dam by February 1, 2017.[353]

In addition, this higher flood level assumed a failure at Douglas Dam. The licensee described an interim action to install temporary engineered barriers at the dam. The licensee has determined that there will be adequate time to install these barriers, given pre-staged material from offsite suppliers. Assuming these actions, the reevaluated flood level was bounded by the updated 2012 evaluation. As part of the integrated assessment, the licensee indicated it would evaluate long-term options to enhance the performance of this dam.

Similarly, flooding from combined effects resulted in a flood level slightly higher than that in the updated 2012 evaluation. With an additional assumption of the temporary barriers at Douglas Dam, the reevaluated flood level was bounded by the updated 2012 evaluation.

Specific to flooding from dam breaches and failures, the controlling evaluation (failure of Watts Bar Dam during a 500-year flood event) resulted in a flood level below site grade, consistent with the updated 2012 evaluation.

The NRC staff audited supporting details for the Sequoyah flooding hazard reevaluation report (along with others TVA prepared for Browns Ferry and Watts Bar) in 2015.[354] In September 2015, the NRC staff issued an interim response to the Sequoyah flooding hazard reevaluation report.[355] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for Sequoyah. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

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[351] NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Unit 2," Supplement 27, dated January 2015. ADAMS Accession No. ML15033A041.
[352] NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Unit 2," Supplement 28, dated August 2015. ADAMS Accession No. ML15229A195.
[353] "Tennessee Valley Authority – Docket No. 50-391 – Watts Bar Nuclear Plant, Unit 2 – Facility Operating License," dated October 22, 2015. ADAMS Accession No. ML15301A140. Issues specific to Watts Bar are discussed further below. The NRC staff's review of the Sequoyah flooding hazard reevaluation is still underway, so there is not a documented conclusion available related to the licensee's dam modification assumptions.
[354] Juan Uribe, NRC, letter to Joseph W. Shea, TVA, "Nuclear Regulatory Commission Report for the Audit of Tennessee Valley Authority's Flood Hazard Reevaluation Report Submittals Relating to the Near-Term Task Force Recommendation 2.1-Flooding for: Browns Ferry Nuclear Plant, Units 1, 2, and 3; Sequoyah Nuclear Plant, Units 1 and 2; and Watts Bar Nuclear Plant, Units 1 and 2 (TAC Nos. MF6034, MF6035, MF6036, MF6032, MF6033, MF5857 and MF5858)," dated October 30, 2015. ADAMS Accession No. ML15294A203.
[355] Juan Uribe, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant, Units 1 and 2 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC Nos. MF6032 and MF6033)," dated September 3, 2015. ADAMS Accession No. ML15240A163.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.14.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[356] In this plan, the licensee considered the flood levels from the updated 2012 evaluation. The licensee states that FLEX strategies will be developed for consideration of external flooding hazards, and that it is developing procedures and strategies for delivering offsite equipment that consider regional impacts from flooding. The licensee also notes that it will evaluate the impact of FLEX response actions on design-basis flood mode preparations, including the potential for extended preparation time for FLEX.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by injecting water into the steam generators from the protected auxiliary feedwater storage tank using the turbine-driven auxiliary feedwater pump and releasing steam through the steam generator atmospheric relief valves. A FLEX diesel generator will be aligned to power an installed safety injection pump to provide borated water to the reactor coolant system from either the boric acid tank or refueling water storage tank, in addition to the borated water that would be injected by the cold leg accumulator during cooldown. The longer-term strategy involves using the FLEX diesel generator to power the motor-driven auxiliary feedwater pump, component cooling system pump, and auxiliary air compressor. FLEX pumps would also be used to draw from remaining water sources and ultimately the Tennessee River. FLEX diesel generators will be used to power battery chargers to support critical loads. Additional equipment such as mobile purification and boration units will be provided by the Regional Response Centers.

The NRC staff performed an interim evaluation of this plan and identified open items related to reactor coolant pump seals, boration, containment, and the use of pre-staged diesel generators. The NRC staff also identified multiple confirmatory items, including one related to the ability to use the FLEX pump in flood mode.[357] The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[358] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

On February 11, 2016, the licensee notified the NRC that Sequoyah is in full compliance with Order EA-12-049.[359] All modifications have been installed, procedures and training are

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[356] J.W. Shea, TVA, letter to NRC, "Tennessee Valley Authority (TVA) – Overall Integrated Plan in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Sequoyah Nuclear Plant," dated February 28, 2013. ADAMS Accession No. ML13063A183.

[357] Jeremy S. Bowen, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0864 and MF0865)," dated February 19, 2014. ADAMS Accession No. ML14002A113.

[358] Tony Brown, NRC, letter to Joseph W. Shea, TVA, "Sequoyah Nuclear Plant, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0864, MF0865, MF0794, and MF0795)," dated March 3, 2015. ADAMS Accession No. ML15033A430.

[359] J.W. Shea, TVA, letter to NRC, "Completion of Required Action for Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-

complete, and the licensee has responded to the NRC staff's open and confirmatory items. For example, the licensee noted that its flood mode preparations included a provision for TVA's River Systems Operation to notify the Sequoyah control room if the instantaneous flow rate at Watts Bar Hydro reaches a level that approximates the 25-year flood. Such a notification would trigger implementation of external flood mitigation actions.

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.15 South Texas Project

South Texas Project is located in Bay City, TX, on the west bank of the Colorado River near the Gulf Coast of Texas. The site has two operating units of Westinghouse PWR design.[360] The operating licenses were issued in 1988 and 1989 for terms that expire in 2027 and 2028. The licensee's 2010 request for renewal of these licenses is currently under review by the NRC staff. In February 2016, the NRC staff issued combined licenses for two additional units of Advanced Boiling Water Reactor Design that may be constructed at the South Texas Project site in the future.[361]

B.15.1 Initial Plant Design and Licensing[362]

Plant grade for South Texas Project, Units 1 and 2 is 28 feet MSL.[363] Plant grade for Units 3 and 4 is set at 34 feet MSL.

The predominant surface-water feature near the South Texas Project site is the main cooling reservoir, a manmade lake that was constructed immediately south of Units 1 and 2. The typical maximum operating level of this reservoir is 49 feet MSL. The main cooling reservoir is the normal heat sink for Units 1 and 2; when Units 3 and 4 are constructed, it will also be part of their closed-loop cooling system. The licensee, therefore, will raise the normal maximum water level by two feet to support operation of the additional units. In addition, there is an essential cooling pond that contains enough water to supply the essential cooling water system for 30 days. The normal operating level of this pond is about 26 feet MSL.

Based a postulated failure of the earthen embankments around the main cooling reservoir, the licensee has established a flood protection level of 50.8 feet MSL in the current licensing basis. The licensee also evaluated local intense precipitation, flooding from streams and rivers, and storm surge, as well as the two most critical upstream dam failure scenarios. The resulting flood levels were at least 12 feet below the flood protection level. Buildings are equipped with

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049) March 12, 2012, for Sequoyah Nuclear Plant (TAC Nos. MF0864 and MF0865)," dated February 11, 2016. ADAMS Accession No. ML16049A635.

[360] http://www.nrc.gov/info-finder/reactors/stp1.html and http://www.nrc.gov/info-finder/reactors/stp2.html

[361] http://www.nrc.gov/reactors/new-reactors/col-holder/stp3.html and http://www.nrc.gov/reactors/new-reactors/col-holder/stp4.html.

[362] Information in this section is drawn from the NRC staff assessment of the licensee's flooding hazard reevaluation report referenced below, as well as the NRC staff's safety evaluation for the South Texas Project, Units 3 and 4 combined license application referenced below.

[363] The licensee generally uses National Geodetic Vertical Datum of 1929 (NGVD2)9 as the referenced vertical datum. The term MSL was used in the combined license review; however, since it is based on the NGVD29 it can be considered equivalent, where used in this report. In some cases, the licensee has used data referenced in the North American Vertical Datum of 1988 (NAVD88). There is a small difference of 0.16 feet between NGVD29 and NAVD88 near the South Texas Project site.

watertight panels and doors, water stops on construction joints and slabs, and other features to prevent flooding in safety-related areas. Seismic Category I buildings also have walls and surface slabs that are waterproofed below grade to protect against flooding from groundwater. The fuel handling building has sumps to remove infiltrated groundwater as needed.

B.15.2 Additional Plant-Specific Actions

As noted above, the NRC staff recently completed a licensing review for two additional units at the South Texas Project site. While this action does not currently affect the operation of Units 1 and 2, it is a relevant and recent determination by the NRC staff of the site's suitability from a flooding perspective. The NRC staff's final safety evaluation report describes the evaluation of the site and potential flooding effects.[364] As for Units 1 and 2, the design-basis flood is the result of a postulated breach of the main cooling reservoir embankment. Therefore, the design provides flood protection for structures, systems, and components in the power block area that are located below 40 feet MSL. The ultimate heat sink and reactor service water structures, which are watertight to an elevation 50 feet MSL, do not need flood protection.

The NRC staff also reviewed the licensee's assessment of potential failure of dams upstream on the Colorado River. The licensee analyzed a domino-type failure of upstream dams in a way that it considered would produce the largest flood, resulting in a peak flood level that was below the grade level for Units 3 and 4. The NRC staff concluded that further analysis of the upstream dam failure was not warranted, because the main cooling reservoir was determined to yield higher peak flood levels.

An NRC staff member did not agree with the conclusions drawn on the design-basis flood and documented the concerns in a non-concurrence, which the NRC staff summarized in a Commission paper written as part of the combined license hearing process for Units 3 and 4.[365] The non-concurrence included concerns regarding the conservatism of the flooding analysis for the main coolant reservoir breach and the hurricane storm surge analysis. To address these issues, the NRC staff solicited independent expert reviewers from the University of Maryland, U.S. Army Corps of Engineers, Bureau of Reclamation, Virginia Polytechnic Institute and State University, Taylor Engineering Research Institute (University of North Florida), and the University of North Carolina. The independent review panel concluded that the NRC staff had resolved the technical issues correctly, and the NRC staff revised the safety evaluation report to clarify some portions and incorporate a hurricane-related sensitivity study.

B.15.3 Flooding Walkdowns

In November 2012, South Texas Project notified the NRC that it had completed its flooding walkdowns.[366] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

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[364] Frank M. Akstulewicz, NRC, letter to Scott Head, Nuclear Innovation North America, LLC, "Final Safety Evaluation Report for the South Texas Project Units 3 and 4 Combined License Application," dated September 24, 2015. ADAMS Accession No. ML15212A125.

[365] SECY-15-0123, "The Staff's Statement in Support of the Uncontested Hearing for Issuance of Combined Licenses for the South Texas Project, Units 3 and 4," dated September 30, 2015. ADAMS Accession No. ML15176A532.

[366] D.W. Rencurrel, South Texas Project (STP) Nuclear Operating Company, letter to NRC, "Final Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML123330418.

In the walkdown report, the licensee stated that flood protection and mitigation measures were found to be available, functional, and maintained in accordance with the current licensing basis. The licensee identified several deficiencies related to missing or degraded seals that were replaced, watertight door features that were adjusted, a check valve with a missing flapper that was replaced, and various other flood protection features with minor degradation that were entered into the corrective action program for repair. The licensee also identified the need to relocate some seals to facilitate easier inspections and to update procedures to ensure timely preventive maintenance and repair. The licensee did not identify any immediate safety concerns.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[367] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[368]

B.15.4 **Reevaluation of Flooding Hazard**

The NRC staff prioritized South Texas Project as a "Category 1" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. This meant that the flooding hazard reevaluation would be due March 12, 2013, and the licensee submitted its flooding hazard reevaluation report on schedule.[369]

The licensee stated that its report demonstrates that the current design-basis flood for South Texas Project bounds the reevaluated flooding hazard for all mechanisms. Therefore, the licensee did not find it necessary to take any interim actions or conduct an integrated assessment. Specifically, the reevaluated flood level for the failure of the main cooling reservoir remained the same as the design-basis flood level. The reevaluated flood levels for local intense precipitation and storm surge were somewhat higher than those in the design basis but were still significantly lower than the level caused by a main cooling reservoir breach. The licensee also noted that the reevaluated flood levels for the upstream dam failure scenarios were 3 to 5 feet below the previous estimated levels. All of these flood levels are bounded by the main coolant reservoir breach scenario.

In September 2014, the NRC staff completed its assessment of the flooding hazard reevaluation report, concluding that the licensee provided sufficient information in response to the 10 CFR 50.54(f) letter.[370] The NRC staff also notified the licensee in 2015 that its reevaluated

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[367] Balwant K. Singal, NRC, letter to Dennis L. Koehl, STP Nuclear Operating Company, "South Texas Project, Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0283 and MF0284)," dated June 23, 2014. ADAMS Accession No. ML14150A191.

[368] Wayne C. Walker, NRC, letter to Dennis Koehl, STP Nuclear Operating Company, "South Texas Project Electric Generating Station – NRC Integrated Inspection Report 05000498/2012005 and 05000499/2012005," dated February 5, 2013. ADAMS Accession No. ML13037A195.

[369] G.T. Powell, STP Nuclear Operating Company, letter to NRC, "Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 Flooding of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, Enclosure 2, Required Response 2, Flood Hazard Reevaluation Report," dated March 12, 2013. ADAMS Accession No. ML13079A806.

[370] Robert F. Kuntz, NRC, letter to Dennis L. Koehl, STP Nuclear Operating Company, "South Texas Project, Units 1 and 2 – Staff Assessment of Response to 10 CFR 50.54(f) Information Request Flood-Causing Mechanism Reevaluation (TAC Nos. MF1110 and MF1111)," dated September 30, 2014. ADAMS Accession No. ML14259A195.

flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for South Texas Project.[371]

In coordination with its other reviews of flooding hazard reevaluations, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.15.5 **Mitigating Strategies**

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[372] In this plan, the licensee restated the design-basis flooding information described above. Therefore, the licensee noted that flooding must be assessed as part of the strategies.

Because the design-basis flood is assumed to progress very quickly, the licensee indicates that almost all equipment is pre-staged at its deployment location. In addition, the licensee's strategy includes pre-staging and protecting a 480-volt air-cooled generator on the top of a roof of the power block. This new generator would have a different cooling system, design, construction, and building from the safety-related diesel generators. Pre-staged, protected equipment would then be powered during the ELAP event. Although some portable equipment would be used, the licensee notes that the pre-staged equipment would be the primary equipment used. The FLEX generator will be protected from all design-basis external events, including missiles.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by injecting water in the steam generators from the safety-related auxiliary feedwater storage tank using the turbine-driven auxiliary feedwater pump, releasing steam from the steam generator power-operated relief valves. As noted above, 480-volt generators, including distribution switchgear, will be pre-staged on the mechanical auxiliary building roof in protected enclosures. These generators will be aligned via pre-staged cabling and conduit to power the installed positive displacement pump to provide borated water to the reactor coolant system from the refueling water storage tank (in addition to that provided by cold leg accumulator injection). The longer-term strategy uses the same FLEX generators to power the FLEX steam generator feed pump and reactor coolant fill pump. The strategies are backed up by two trailer-mounted diesel-driven pumps stored in diverse locations. The generators can power the Class 1E battery chargers to support motor-operated valves, instrumentation, lighting, and fuel transfer loads. Additional equipment, such as large diesel generators, will be delivered from the Regional Response Centers.

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[371] Juan Uribe, NRC, letter to Dennis L. Koehl, STP Nuclear Operating Company, "South Texas Project, Units 1 and 2 – Mitigating Strategies Assessment with Respect To the Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (CAC Nos. MF1110 and MF1111)," dated November 24, 2015. ADAMS Accession No. ML15314A061.

[372] Dennis L. Koehl, STP Nuclear Operating Company, letter to NRC, "STPNOC Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies For Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 28, 2013. ADAMS Accession No. ML13070A011.

The NRC staff performed an interim evaluation of this plan[373] and identified open items related to transient analysis, the sequence of events, deployment of trailer-mounted pumps, and justification for the pre-staged equipment. The NRC staff also identified a number of confirmatory items, including the use of sump pumps and temporary barriers during floods. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[374] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

On February 17, 2016, the licensee notified the NRC that South Texas Project, Units 1 and 2 are in full compliance with Order EA-12-049.[375] All modifications have been installed, procedures and training are complete, and the licensee has responded to all of the NRC staff's open and confirmatory items. The final plan includes, as indicated above, two diesel generators in protected structures on top of the mechanical auxiliary building roof, as well as pumps, hoses, associated equipment inside structures protected against design-basis external events. The licensee notes that the primary reason for pre-staging this equipment is due to difficulties in retrieving and deploying equipment following a design-basis flooding event.

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.16 Surry

Surry Power Station (Surry) is located 17 miles northwest of Newport News, VA, on the James River. The site has two units of Westinghouse PWR design. The operating licenses were issued in 1972 and 1973 and renewed in 2003 for terms that expire in 2032 and 2033.[376] The licensee has also submitted a letter of intent to apply in 2019 for a subsequent license renewal; if approved, this would authorize 20 additional years of operation.[377]

B.16.1 Initial Plant Design and Licensing[378]

The licensee determined Surry's design-basis flood by evaluating two events: the PMF on the James River and the PMH. The licensee's estimation of the PMF is slightly higher than the normal mean James River level, and results from watershed runoff and severe storm surge. PMH plus wave runup generates the most limiting flood levels, which are below the grade level

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[373] Jeremy S. Bowen, NRC, letter to Dennis L. Koehl, STP Nuclear Operating Company, "South Texas Project, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0825 and MF0826)," dated January 29, 2014. ADAMS Accession No. ML13339A736.
[374] Tony Brown, NRC, letter to Dennis L. Koehl, STP Nuclear Operating Company, "South Texas Project, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0825, MF0826, MF0827, and MF0828)" dated May 6, 2015. ADAMS Accession No. ML15111A465.
[375] G.T. Powell, STP Nuclear Operating Company, letter to NRC, "South Texas Project Units 1 & 2 – Notification of Full Compliance with Order EA-12-049 for Mitigation Strategies for Beyond Design Basis External Events and Update for Order EA-12-051 for Reliable Spent Fuel Pool Instrumentation," dated February 17, 2016. ADAMS Accession No. ML16067A088.
[376] http://www.nrc.gov/info-finder/reactors/sur1.html and http://www.nrc.gov/info-finder/reactors/sur2.html.
[377] Mark Sartain, Virginia Electric and Power Company, letter to NRC, "Surry Power Station Units 1 and 2 Intent to Pursue Second License Renewal," dated November 5, 2015. ADAMS Accession No. ML15314A078.
[378] Information in this section is drawn from the NRC staff's assessment of the licensee's walkdown report, as well as the licensee's flooding hazard reevaluation report, both referenced below.

of the power block (26.5 feet), but higher at the intake (where grade level is 8 feet MSL). The licensee has also indicated that the highest water level of record is approximately 8.6 feet MSL.

Therefore, site grade serves as the main flood-protection feature for the power block. In addition, several locations are protected above site grade, including the main steam and feedwater isolation valve cubicle, the control room, the reactor trip breaker cubicle, and the high-level intake structure. At the intake structure, flooding protection is needed. As a result, the emergency service water pumping equipment is housed in a watertight, reinforced concrete structure above the intake structure deck. Motor-operated dampers on the roof of the pump house would provide air intake for the pumps; the elevation of the exhaust centerline is 36.5 feet MSL, well above the design-basis flood level. In addition, the licensee notes that the flooding protection features of the intake canal are at least 4 feet above the river flooding and PMH flood levels. Finally, the licensee indicates that it has procedures to install temporary barriers at the pump house before a hurricane arrives, including air intake louver covers, seal plates and covers for doors, and a flood gate. These features provide protection up to 24 feet MSL.

The licensee's hurricane procedures also require that the plant be shut down with reactor coolant temperature less than or equal to 345 degrees Fahrenheit at least two hours before the hurricane arrives. The circulating water and service water systems are used to remove heat. If offsite power is lost in the hurricane, the diesel-driven emergency service water pumps are used. If the emergency service water pumps are affected by water ingress, the licensee indicates that there will be sufficient water in the intake canal for use until the water ingress is mitigated. Plant procedures require confirming an appropriate intake canal level before the hurricane arrives.

The final safety analysis report indicates that flooding from dam failures is not expected at the Surry site, as the James River had no known or planned river control features.

B.16.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Surry. The licensee has made several enhancements to its flooding protection and mitigation features; these are summarized below, as they relate to external flooding in general.

As a result of its IPEEE, the licensee implemented enhancements that it considered would reduce the risk from external flooding. These included a modified parapet to reduce ponding, as well as updated procedures used during heavy rainfall to allow water to flow out of the turbine building and restrict water flow into the main control room.[379]

In addition, the licensee filed a licensee event report in 2009 identifying that three oil cooler outlet lines for the emergency service water pumps were not sealed.[380] The unsealed outlet lines penetrated the pump base plates at approximately 18 feet MSL, which could have caused the pumps to become inoperable at a flood level lower than the design-basis flood. The licensee indicated that, beginning in the 1990s, threaded interface seals were no longer used on the outlet lines, but there was inadequate procedural guidance to seal the outlet lines. The

[379] This information on the IPEEE is drawn from Volume 2 of NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," dated April 2002, available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1742/.

[380] Gerald T. Bischof, Virginia Electric and Power Company, letter to NRC, "Report No. 50-280, 50-281/ 2009-002-00," dated November 23, 2009. ADAMS Accession No. ML093350531.

licensee installed seals and updated its maintenance procedure to prevent recurrence. The NRC staff issued a Green finding (very low safety significance) associated with this issue.[381]

B.16.3 Flooding Walkdowns

In November 2012, Surry notified the NRC that it had completed its flooding walkdowns consistent with NEI 12-07.[382] The walkdown report provided a description of the flooding hazards and the flood mitigation strategy used at Surry. The licensee also described the manual actions needed to implement flood protection procedures. The licensee simulated these flood mitigation activities and identified three deficiencies related to unsealed conduit and partially blocked storm drain inlets. The NRC staff noted that the licensee sealed the unsealed conduit. To address the storm drain issue, the licensee implemented periodic preventative maintenance, as well as programmatic controls to prevent yard changes from blocking flow paths.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[383] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features. No findings were identified during these inspections.[384]

B.16.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Surry as a "Category 3" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter, meaning that the flooding hazard reevaluation would be due March 12, 2015. The licensee submitted its flooding hazard reevaluation report on schedule.[385]

In its report, the licensee stated that the following flooding mechanisms resulted in floods exceeding the current licensing basis flood level: local intense precipitation, dam failures, storm surge, and combined effects flooding. Local intense precipitation was not evaluated in detail in the current licensing basis; the reevaluated flood levels are above plant grade. The controlling flood with combined effects, including storm surge, was determined by the licensee to affect the plant only through wave-related impacts near the low level intake structure and emergency service water pump house. The calculated height of the standing wave crest was below the level of the louvers noted above.

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[381] Gerald J. McCoy, NRC, letter to David A. Heacock, "Surry Power Station – NRC Integrated Inspection Report 05000280/2009005 and 05000281/2009005," dated January 28, 2010. ADAMS Accession No. ML100280948.
[382] David A. Heacock, Virginia Electric and Power Company, letter to NRC, "Surry, Units 1 and 2 – Report in Response to March 12, 2012, Information Request Regarding Flooding Aspects of Recommendation 2.3," dated November 27, 2012. This document is not publicly available in ADAMS.
[383] V. Sreenivas, NRC, letter to David A. Heacock, Virginia Electric and Power Company, "Surry Power Station, Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0286 and MF0287)," dated June 25, 2014. ADAMS Accession No. ML14162A577.
[384] Gerald J. McCoy, NRC, letter to David A. Heacock, Virginia Electric and Power Company, "Surry Power Station – NRC Integrated Inspection Report 05000280/2013002, 05000281/2013002," dated April 30, 2013. ADAMS Accession No. ML13120A194.
[385] Daniel G. Stoddard, Virginia Electric and Power Company, letter to NRC, "Surry, Units 1 and 2 – Flood Hazard Reevaluation Report in Response to March 12, 2012, Information Request Regarding Flooding Aspects of Recommendation 2.1," dated March 12, 2015. ADAMS Accession No. ML15078A291.

Specific to upstream dam failures, the licensee states that the PMF combined with upstream dam failure results in a calculated peak flood level over 10 feet below site grade. The selected flooding scenario also bounds other modes of dam failure, as it includes high upstream reservoir levels and river flows. Although the warning time for other scenarios might be smaller, the margin was large enough that the licensee considered that further action was not necessary.

The licensee also determined that failure of the intake canal embankment was not plausible under hydrologic and seismic loading conditions; however, a sunny-day failure could not be screened out. Using conservative assumptions consistent with local intense precipitation, the licensee calculated flood levels ranging from below to somewhat above site grade. The licensee determined that a failure would be relatively slow to develop and quickly identifiable through operator rounds, security towers and cameras, or other means. In such a scenario, operators would lower canal level below site grade. Therefore, the licensee determined that flooding from sudden failure of the intake canal embankment during normal conditions was not likely.

The licensee took interim actions related to the higher reevaluated hazards. For local intense precipitation, the licensee evaluated the locations where preventive action might be needed and noted that it would consider procedures to take actions such as verifying critical doors are closed, installing temporary flood barriers at specific locations, and using supplemental equipment and procedures to remove flood water. For combined effects floods, the licensee evaluated the loads on the structures that could be subject to wave action and determined qualitatively that the load was acceptable. For the intake canal embankment failure, the licensee determined that it would enhance procedures for identifying a breach and communicating it to the control room to initiate operator actions to mitigate the hazard. The licensee committed to develop its evaluations and actions further as part of an integrated assessment.

The NRC staff audited supporting details for the Surry flooding hazard reevaluation report in 2016.[386] In September 2015, the NRC staff issued an interim response to the Surry flooding hazard reevaluation report.[387] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for Surry. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.16.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[388] In this plan, the licensee restated the design-basis

[386] The audit report was not yet available at the time this report was developed.
[387] Victor Hall, NRC, letter to David A. Heacock, Virginia Electric and Power Company, "Surry Power Station, Units 1 and 2 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (CAC Nos. MF6102 and MF6103)," dated September 3, 2015. ADAMS Accession No. ML15078A291.
[388] David A. Heacock, Virginia Electric and Power Company, letter to NRC, "Surry Power Station Units 1 and 2 Overall Integrated Plan in Response to March 12. 2012 Commission Order Modifying Licenses with Regard to

flooding information described above and noted that Surry's mitigating strategies provide for protection from and mitigation of external flooding. The licensee indicates that the FLEX equipment (e.g., pumps, diesel generators, and fuel supplies) will be protected from flooding while stored in their designated building or in protected areas of the plant. In addition, the licensee assumes that the intake canal will be unavailable; the discharge canal provides water, as needed, for the mitigation strategies.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by feeding the steam generators from the emergency condensate storage tank and emergency condensate makeup tank using the turbine-driven auxiliary feedwater pump and release steam from the steam generator power-operated relief valves. The licensee's longer-term strategy includes using a portable, diesel-driven auxiliary feedwater pump, supported by a portable, diesel-driven high capacity makeup pump to refill the emergency condensate storage tank or provide suction directly from the circulating water discharge canal. Two diesel generators will be connected to electrical buses using pre-installed cabling and panels to supply necessary loads. Additional equipment, such as large diesel generators and pumps, will be delivered from the Regional Response Centers to provide supplemental mitigation.

The NRC staff performed an interim evaluation of this plan[389] and identified two open items related to core sub-criticality and the battery duty cycle, as well as several confirmatory items, including flooding protection of the FLEX connections. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[390] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

On January 25, 2016, the licensee notified the NRC that both units at Surry are in full compliance with Order EA-12-049.[391] All modifications have been installed, procedures and training are complete, and the licensee has responded to all of the NRC staff's open and confirmatory items.

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 28, 2013. ADAMS Accession No. ML13063A181.

[389] Jeremy S. Bowen, NRC, letter to David A. Heacock, Virginia Electric and Power Company, "Surry Power Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF1002 and MF1003)," dated February 19, 2014. ADAMS Accession No. ML14002A145.

[390] Tony Brown, NRC, letter to David A. Heacock, Virginia Electric and Power Company, "Surry Power Station, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF1002, MF1003, MF1004, and MF1005)," dated April 14, 2015. ADAMS Accession No. ML15096A391.

[391] Mark Sartain, Virginia Electric and Power Company, letter to NRC, "Surry Power Station Units 1 and 2 – Compliance Letter and Final Integrated Plan In Response to the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigating Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)" dated January 25, 2016. ADAMS Accession No. ML16033A353. This letter addresses both units but provides details only for Unit 2. The details for Unit 1 were included in an earlier letter dated July 22, 2015 (ADAMS Accession No. ML15209A503).

B.17 Three Mile Island

TMI is located on the Susquehanna River 10 miles southeast of Harrisburg, PA.[392] It has one operating unit of Babcock & Wilcox PWR design. The operating license was issued in 1974 and renewed in 2009 for a term that expires in 2034.

B.17.1 Current Licensing Basis[393]

The flood discharge used for the initial design of TMI was established based on a PMF defined by the U.S. Army Corps of Engineers in 1967, at the time of the construction permit application. Based on that design PMF, the predicted flood level at the intake structure was 303 feet. Flood protection was provided by a system of dikes.

In 1969, the U.S. Army Corps of Engineers revised the PMF calculation and predicted a higher peak river flow. As a result, the licensee committed to provide protection that would assure a safe and orderly shutdown at this higher river flow. The Atomic Energy Commission staff's 1973 safety evaluation stated that for floods greater than height of the dike, the licensee would initiate an immediate shutdown and cooldown. The safety evaluation indicated that the licensee had provided its flooding procedures, which included waterproofing. The licensee implemented this commitment to provide protection against higher flood levels by installing a flood barrier system, developing emergency procedures to install temporary barriers, and adding a technical specification to require plant shutdown before water level exceeds the height of the dike.

Because of various updates to its flooding evaluations and protective measures since initial licensing, the licensee references in its walkdown report (described below) a current licensing basis as of September 30, 2012. As described in the current licensing basis, the site has a water-tight boundary up to the 313.5-foot elevation. A seismic gap between interfacing buildings was also made watertight. Flood protection and mitigation features include flood gates, drain plugs, inflatable seals at certain doors, and closure of valves.

The licensee's flood protection procedure has four different levels of action based on river flow and level. The licensee enters the procedure if there is a 36-hour forecast of high river flow. If river flow at the next higher action level is forecast, flood gates on noncritical access doors are installed. If river flow at the third action level is forecast, the full flood barrier boundary system is closed. Finally, if river level reaches 300 feet, the reactor is shut down.

Specific to dam failure, the licensee indicates that original licensing process considered the potential for failure of upstream dams, with further evaluation by the U.S. Army Corps of Engineers in 1986. The failure of Raystown Lake Dam was determined to be the limiting event. The licensee has stated in correspondence that the current dam failure licensing basis results in a flood level that is lower than the protection level provided by the dike. The licensee determined that no additional protective measures were required.

B.17.2 Additional Plant-Specific Actions

The licensee has made several enhancements to its flooding protection and mitigation features; these are summarized below, as they relate to external flooding in general.

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[392] http://www.nrc.gov/info-finder/reactors/tmi1.html . TMI, Unit 2 is permanently shut down.

[393] Information in this section is drawn from the licensee's walkdown report, NRC inspection reports, and license amendment request referenced below.

Since the time of the IPEEE, TMI's probabilistic risk assessment identified river flooding as an important contributor to overall plant risk. The NRC staff's summary of IPEEE insights indicated that floods resulted in a core damage frequency of about once in 12,500 years.[394] While the licensee did not identify specific vulnerabilities, the NRC staff noted that the licensee updated its procedures to mitigate river flooding consequences.

In 2010, to better quantify the flood risk, the licensee updated the original licensing-basis flooding analysis. This new analysis predicted a flood level at the intake structure pump house that was higher than the previous estimate. In November 2011, the licensee filed an event report to document this issue.[395] The licensee took action to protect equipment up to 313.5 feet, an increase from the previous level of protection at 311 feet. The licensee noted that the validity of the flood analysis had not been reassessed previously because there had not been a programmatic requirement to do so; the licensee intended to institute such a recurring action.

NRC inspectors conducted multiple evaluations of the licensee's response to this issue.[396, 397, 398, 399] These inspections included an inspection of the flooding analysis itself, in-depth review of the licensee's corrective actions, review of the licensee's external flood protection strategy, and walkdowns of the flood protection system. These inspections resulted in several findings and violations.

- The NRC inspectors questioned the adequacy of a seismic gap (a three-inch gap between the reactor building and adjacent buildings) to function as a hydrostatic flood seal. This seal was supposed to be watertight, but had measurable leakage when tested. In addition, portions of the seal were not installed to the required minimum depth and the installation was configured differently than assumed. To assess the issue, the licensee estimated how much water could have leaked into the tendon access gallery and determined that the resulting flood level would have been below the equipment needed for safe shutdown. Therefore, the licensee determined that there would have been no adverse impact if a flood had occurred. In June 2012, the licensee implemented permanent modifications to restore the watertight function of the seismic gap barrier. NRC inspectors evaluated this modification and verified its appropriateness. The NRC staff issued a non-cited violation and Green finding (very low safety significance) for the initial seal problem.

- The NRC inspectors questioned whether the emergency diesel generator day tank vent was appropriately protected from wind waves and whether the underground fuel oil storage tank could be affected by water-borne debris. The NRC inspectors compared approved plant procedures and plant flood protection configurations to the descriptions in the updated final safety analysis report, the original 1973 final safety analysis report,

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[394] This information on the IPEEE is drawn from Volume 2 of NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," dated April 2002, available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1742/.

[395] Glen Earl Chick, Exelon Nuclear, letter to NRC, "Licensee Event Report (LER) NO. 2011-001-00, 'Unanalyzed Condition Affecting Probable Maximum Flood (PMF) Level,'" dated November 20, 2011. ADAMS Accession No. ML11326A282.

[396] Gordon K. Hunegs, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Three Mile Island Station, Unit 1 – NRC Integrated Inspection Report 5000289/2011005," dated February 8, 2012. ADAMS Accession No. ML12039A087.

[397] Gordon K. Hunegs, NRC, letter to Michael J. Pacilio, Exelon Nuclear," Three Mile Island Station, Unit 1 – NRC Integrated Inspection Report 5000289/2012002," dated May 1, 2012. ADAMS Accession No. ML12122A131.

[398] Gordon K. Hunegs, NRC, letter to Michael J. Pacilio, Exelon Nuclear," Three Mile Island Station, Unit 1 – NRC Integrated Inspection Report 5000289/2012003," dated August 1, 2012. ADAMS Accession No. ML12214A466.

[399] Gordon K. Hunegs, NRC, letter to Michael J. Pacilio, Exelon Nuclear," Three Mile Island Station, Unit 1 – NRC Integrated Inspection Report 5000289/2012005," dated February 11, 2013. ADAMS Accession No. ML13042A277.

and the 1973 safety evaluation report by the NRC staff to determine whether the licensee was specifically required to consider waves in addition to the PMF static water level. The inspectors did not identify any regulatory requirements or licensee commitments to consider wave action. Therefore, no performance deficiency was identified. The NRC staff, however, observed that the flooding hazard reevaluation would include consideration of wave action.

- The NRC inspectors identified that the technical specifications that require action based on a particular river level were no longer properly correlated to river flow after the reanalysis, and were not conservative as written. The updated action level of 300 feet noted above is the appropriate level based on the updated correlation of river flow and level. The NRC staff issued a non-cited violation for the licensee's failure to promptly update the non-conservative technical specification. Referencing NRC guidance,[400] the licensee implemented administrative controls to apply revised action timing until an NRC-approved change to its technical specifications could be completed.

In April 2013, the licensee submitted a license amendment request to correct the error in its technical specification noted above, as well as to incorporate its updated flooding hazard information into the licensing basis.[401] The licensee withdrew this request, however, two months later, citing the NRC staff's ongoing review of the flooding hazard reevaluation.[402] In its acknowledgement of the withdrawal, the NRC staff noted that the licensee would maintain its administrative controls to compensate for the non-conservative technical specifications. The NRC staff stated that the licensee should resubmit its request after the NRC staff completes its evaluation of the flooding hazard reevaluation described below.[403]

Although not reviewed by the NRC staff, this license amendment request described the licensee's evaluation of sunny-day dam failures, including the current licensing basis information noted above. The licensee reanalyzed the effects of upstream dam failures in 2013, considering a simultaneous failure of all dams in the Susquehanna River Watershed at a river flow of one-half PMP. The resulting discharge at the site was well within the flow that could be accommodated by the dike design flow.

B.17.3 **Flooding Walkdowns**

In November 2012, TMI notified the NRC that it had completed its flooding walkdowns.[404] The licensee indicated that walkdowns were performed consistent with NEI 12-07. The licensee

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[400] NRC Administrative Letter 98-10, "Dispositioning of Technical Specifications that are Insufficient to Assure Plant Safety," dated December 29, 1998. Available at http://www.nrc.gov/reading-rm/doc-collections/gen-comm/admin-letters/1998/al98010.html.

[401] Michael D. Jesse, Exelon Generation Company, LLC, letter to NRC, "Three Mile Island Nuclear Power Station, Unit 1, Technical Specification Change Request 352, Revise Technical Specification 3.14.2 and the Licensing Basis Flood Hazard contained in the Updated Final Safety Analysis Report," dated April 10, 2013. ADAMS Accession No. ML13100A238.

[402] James Barstow, Exelon Generation Company, LLC, letter to NRC, "Withdrawal of the Three Mile Island Nuclear Power Station, Unit 1, Technical Specification Change Request 352, Revise Technical Specification 3.14.2 and the Licensing Basis Flood Hazard contained in the Updated Final Safety Analysis Report," dated June 24, 2013. ADAMS Accession No. ML13175A230.

[403] Peter Bamford, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Three Mile Island Nuclear Station, Unit 1 – Withdrawal Acknowledgement Letter for a License Amendment Request Regarding Revised Licensing Basis Flood Hazard Evaluation and Associated Technical Specification Changes (TAC No. MF1421)," dated July 12, 2013. ADAMS Accession No. ML13179A273.

[404] Michael D. Jesse, Exelon Generation Company, LLC, letter to NRC, "Three Mile Island Nuclear Station, Unit 1 – Exelon Generation Company, LLC's 180-day Response to NRC Request for Information Pursuant to 10 CFR 50.54(f)

further stated that the simulations demonstrated that the safe shutdown equipment can be protected with minimum staffing before the flood level exceeds the top of the dike.

The licensee tabulated approximately 80 features that did not meet acceptance criteria, including missing equipment, seals, or plugs, as well as an insufficient installation procedure. The licensee took actions to address these issues, including installing valves and seals, replacing gaskets, and updating procedures. The licensee also highlighted other improvements that had been implemented over the previous two years, including installation of flood gates, improved instrumentation, new conduit seals, higher barriers, and procedural enhancements.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[405] In addition, NRC inspectors evaluated the licensee's implementation of the flooding walkdowns and independently performed walkdowns of a sample of flood protection features.[406] During the walkdowns, the NRC inspectors identified 13 unsealed penetrations in the floor of the intake screen and pump house that could allow river water to bypass the flood barrier provided by the floor. While the licensee initially considered that use of pre-staged sump pumps with appropriate procedures would be sufficient to support operability, the licensee later identified that the required number of drain line plugs and one of the pumps were not stored in the designated location. The licensee promptly relocated the necessary equipment and also obtained a new discharge pipe in the correct size. The licensee later took permanent corrective action to seal the penetrations and documented these issues in its walkdown report. The NRC staff issued a non-cited violation associated with this issue.

NRC inspectors also determined that the licensee failed to identify during the walkdowns that electrical cable conduit couplings in the air intake tunnel were not sealed as designed. This condition meant that certain floods could have reached emergency core cooling system equipment through the air intake tunnel. The NRC staff issued a White finding (low to moderate safety significance).[407, 408] The licensee took prompt compensatory action by staging sand and earth-moving equipment that could be used to fill the yard cable vaults (the entrance to the unsealed cable conduit). The licensee then installed flood seals upstream of the conduit to provide a waterproof barrier. The sealant, as well as the underground concrete-encased conduit, became the credited flood barrier and was determined by the NRC staff to meet the current licensing basis requirements.

Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 19, 2012. ADAMS Accession No. ML123250692.

[405] Jeffrey A. Whited, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Three Mile Island Nuclear Station, Unit 1 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0290)," dated June 16, 2014. ADAMS Accession No. ML14156A238.

[406] Gordon K. Hunegs, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Three Mile Island Station – NRC Integrated Inspection Report 050000289/2012005," dated February 11, 2013. ADAMS Accession No. ML13042A277.

[407] Darrell J. Roberts, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Three Mile Island Nuclear Station, Unit 1 – Preliminary White Finding (NRC Inspection Report No. 05000289/2012005)," dated April 4, 2013. ADAMS Accession No. ML13094A219.

[408] William M. Dean, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Final Significance Determination for a White Finding with Assessment Follow-Up and Notice of Violation [NRC Inspection Report No. 05000289/2013009] – Three Mile Island Nuclear Station, Unit 1," dated April 30, 2013. ADAMS Accession No. ML13120A040.

B.17.4 Reevaluation of Flooding Hazard

The NRC staff prioritized TMI as a "Category 1" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. This meant that the flooding hazard reevaluation would be due March 12, 2013.

The licensee submitted a flooding hazard reevaluation report on schedule.[409] This report indicated that the current licensing basis flood levels bounded the reevaluated flood levels for all cases but local intense precipitation, which had not been addressed in the design basis. The resulting flood levels for local intense precipitation were below the plant's protection level. The licensee also stated that the flooding scenario including the combined effects of PMF, dam break, and wind waves resulted in a flood level below the protection level and slightly lower than the previous estimate. Finally, the licensee indicated that seismic dam failure combined with a high discharge event and wind waves resulted in a flood level lower than the previous estimate and well below the protection level. The licensee did not identify the need for any interim actions. The licensee also noted that it had implemented a mitigation strategy for beyond-design-basis external events to maintain core cooling given a flood level up to 320 feet, and that it was improving its strategies to enhance reliability and address spent fuel pool cooling.

The licensee submitted an updated flooding hazard reevaluation report in August 2015.[410] As noted for Peach Bottom, the licensee conducted a detailed hydrometeorological study for the Susquehanna River watershed.[411] In addition, this update supported the NRC staff's previously stated intent to use the U.S. Army Corps of Engineers flooding hazard reevaluation for Peach Bottom as a tool to review the TMI flooding hazard reevaluation report. The licensee did not identify any higher flood levels in this updated report than were identified in previous licensee documents.

In March 2016, the NRC staff issued an interim response to the TMI flooding hazard reevaluation report.[412] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for TMI. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

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[409] Michael D. Jesse, Exelon Generation Company, LLC, letter to NRC, "Three Mile Island Nuclear Station, Unit 1 – Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flooding Hazard Reevaluation Report," dated March 12, 2013. ADAMS Accession No. ML13093A260.

[410] David P. Helker, Exelon Generation Company, LLC, letter to NRC, "Three Mile Island, Unit 1 – Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report," dated August 13, 2015.

[411] Daniel H. Dorman, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Peach Bottom Atomic Power Station, Units 2 and 3 – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident (TAC Nos. MF3671 and MF3672)," dated July 17, 2014. ADAMS Accession No. ML14174A879.

[412] Tekia Govan, NRC, letter to Bryan C. Hanson, Exelon Nuclear, "Three Mile Island Nuclear Station, Unit 1 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (CAC No. MF1113)," dated March 31, 2016. ADAMS Accession No. ML16033A353.

B.17.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps, consistent with the guidance in NEI 12-06.[413] In this plan, the licensee indicates that the postulated external flooding event is caused by precipitation. The ELAP/LUHS is assumed to occur when the river level exceeds the height of the dike, by which point the reactor would already have been shut down.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by injecting water into the steam generators from an available condensate storage source using the steam-driven emergency feedwater pump and later using a FLEX pump. A FLEX generator will be used to reenergize safeguards buses, allowing the FLEX makeup pump to add water to the reactor coolant system. Additional equipment, including large diesel generators, will be provided by the Regional Response Centers later in the event.

In the plan, the licensee also described flooding protection for its mitigating equipment. The steam-driven emergency feedwater pump is located in a flood-protected building. The FLEX emergency feedwater pumps are submersible pumps located inside the FLEX emergency condensate storage tank, which is on the 292-foot elevation of the turbine building. Both the pumps and the tank will be designed for the flood condition. The condensate storage tanks are expected to maintain their structural integrity during the flood. The FLEX charging pumps are located on the 322-foot elevation of the control tower, above the projected maximum river level. The FLEX diesel generators and fuel oil tanks will be located above the 322-foot elevation of the turbine building. The licensee also described construction of a permanent building, designed for the flood condition, which will be used to store FLEX equipment.

The NRC staff performed an interim evaluation of this plan and identified open items related to the underlying analyses, the justification for assuming that tanks survive, and pre-staging of equipment.[414] The NRC staff also identified multiple confirmatory items. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[415] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

As of its last formal update to the NRC, the licensee was in the process of implementing its mitigating strategies to support compliance with Order EA-12-049.[416] The licensee indicated

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[413] Michael D. Jesse, Exelon Generation Company, LLC, letter to NRC, "Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 28, 2013. ADAMS Accession No. ML13059A299.

[414] Jeremy S. Bowen, NRC, letter to Michael J. Pacilio, Exelon Nuclear, "Three Mile Island Nuclear Station, Unit 1 – Interim Staff Evaluation and Audit Report Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC No. MF0803)," dated February 26, 2016. ADAMS Accession No. ML16057A010.

[415] John D. Hughey, NRC, letter to Bryan C. Hanson, Exelon Nuclear, "Three Mile Island Nuclear Station, Unit 1 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0803 and MF0866)," dated January 11, 2016. ADAMS Accession No. ML15357A102.

[416] David P. Helker, Exelon Generation Company, LLC, letter to NRC, "Sixth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2016. ADAMS Accession No. ML16057A010.

that all modifications other than those to the turbine building structure are complete, development and validation of procedures are underway, and training is complete. The licensee intended to be in full compliance by April 30, 2016, but has not yet made formal notification of this status.

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.18 Waterford

Waterford Steam Electric Station (Waterford) is located on the Mississippi River in Killona, LA. The site has one operating nuclear power plant of Combustion Engineering PWR design, designated as Unit 3.[417] The operating license was issued in 1985 for a term that expires in 2024. The NRC staff is reviewing the licensee's application for renewal of the operating license, which would (if approved) extend the license term for an additional 20 years.[418]

B.18.1 Initial Plant Design and Licensing[419]

In establishing the design basis, the licensee considered failure of levees adjacent to the plant, combined with a PMF in the Mississippi River and a surge from a PMH at the mouth of the river. The resulting design-basis flood level is 27.6 feet MSL.

The licensee also concluded that the seismic failure of upstream dams does not present a threat to the site. The nearest flood control reservoir is Grenada Reservoir on the Yalobusha River in northern Mississippi. Three additional reservoirs reside further upstream from the site. Although the combined storage of those reservoirs is considerable, the licensee indicates that the distance and channel storage between the reservoirs and the site would be great enough to reduce the flood level at the site to below the design-basis flood.

At Waterford, structures housing safety-related equipment are protected from floods up to 29.25 feet MSL.[420] The nuclear plant island structure has a common basemat and exterior wall structure designed to withstand flood loadings and minimize water intrusion. All exterior doors of this structure below 29.25 feet MSL that lead to areas with safety-related equipment are designed as flood-protection doors.

The licensee's procedures provide for actions to be taken based on various severe weather conditions that could result in floods, including closing flood doors and valves and ensuring the operability of sump pumps. Technical specifications and surveillance procedures require the licensee to monitor river level every 24 hours when river level at the intake exceeds 24 feet MSL, then every two hours when river level exceeds 27 feet MSL. In addition, backup diesel-driven sump pumps are available in case the motor-driven pumps fail.

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[417] http://www.nrc.gov/info-finder/reactors/wat3.html. Waterford, Unit 3 is the only nuclear power plant on site.
[418] http://www.nrc.gov/reactors/operating/licensing/renewal/applications/waterford.html.
[419] Information in this section is drawn from the licensee's walkdown report referenced below.
[420] The licensee notes that the 30-foot elevation (as noted on drawings) is actually at 29.25 feet MSL. During the initial phase of construction from 1975 to 1978, the plant settled approximately 9 inches. Other elevations were established based on the top of the basemat and were not adjusted as the plant settled; therefore, the established elevations of the plant on drawings are higher by approximately 9 inches than the actual elevations.

B.18.2 Additional Plant-Specific Actions

In preparing this report, the Flooding Working Group did not identify the completion of any additional plant-specific actions intended to enhance the mitigation of upstream dam failures at Waterford.

B.18.3 Flooding Walkdowns

In November 2012, Waterford notified the NRC that it had completed its flooding walkdowns.[421] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

In the walkdown report, the licensee noted that some conditions did not meet the acceptance criteria in the walkdown guidance, but none met the threshold to be considered a deficiency. Therefore, the licensee did not make any changes to its flood protection systems or flood mitigation measures as a result of the walkdowns.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f) letter.[422] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features.[423, 424]

During a walkdown of the reactor auxiliary building roof, the inspectors questioned whether electrical conduit and power cables were adequately protected from the design-basis PMP. The inspectors noted that expected ponding levels could challenge safety-related equipment such as the emergency feedwater flow control and isolation valves and cables, main steam isolation valves and cables, atmospheric dump valves, and back-up nitrogen accumulator components. The licensee performed a preliminary analysis to demonstrate that the installed scuppers and roof drains have margin to protect against a local PMP flooding event and that the ponding depth would have little or no effect on the safety-related equipment and cables located in the affected areas. The NRC staff issued a Green finding (very low safety significance) and non-cited violation for the licensee's failure to provide adequate design control measures for verifying the adequacy of these features.

B.18.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Waterford as a "Category 3" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2015. The NRC staff approved a relaxation of this schedule to July 24,

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[421] Donna Jacobs, Entergy Operations, Inc., letter to NRC, "Flooding Walkdown Report – Entergy's Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Waterford Steam Electric Station, Unit 3 (Waterford 3)," dated November 27, 2012. ADAMS Accession No. ML12333A147.

[422] Alan B. Wang, NRC, letter to Entergy Operations, Inc., "Waterford Steam Electric Station, Unit 3 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC Nos. MF0296)," dated June 23, 2014. ADAMS Accession No. ML14135A349.

[423] Donald B. Allen, NRC, letter to Donna Jacobs, Entergy Operations, Inc., "Waterford Steam Electric Station, Unit 3 – NRC Integrated Inspection Report 05000382/2012005," dated February 14, 2013. ADAMS Accession No. ML13045A582.

[424] Donald B. Allen, NRC, letter to Donna Jacobs, Entergy Operations, Inc., "Waterford Steam Electric Station, Unit 3 – NRC Integrated Inspection Report 05000382/2013003," dated August 13, 2013. ADAMS Accession No. ML13225A748.

2015, given time needed by the licensee to refine a new extreme scenario that considered a probable maximum storm surge combined with a 25-year flood and levee failure.[425] In approving this relaxation, the NRC staff considered the walkdowns described above, in which no deficiencies were found.

The licensee submitted its flooding hazard reevaluation report on schedule.[426] This report indicated that the current plant design was potentially vulnerable to a local intense precipitation event, assuming a loss of offsite power concurrent with loss of one of two diesel generators. The licensee took several interim actions to address this event:

- updating procedures to ensure that sump pumps would be operating within 30 minutes of the onset of the event
- verifying that containment roof drains were unobstructed (including updating a procedure to include this verification annually)
- revising guidance to note that maintenance on the sump pumps should not be started if heavy rain is forecast

The report also addressed the extreme scenario noted above (25-year flood, probable maximum storm surge including antecedent water level, levee failure, and wind waves). As summarized by the NRC staff, this scenario resulted in a still water level below the design-basis flood level, with the potential for waves to reach above the design-basis flood level. The licensee identified no effects on safety-related equipment from this flood and no need to take interim actions. Specific to dam failures, the licensee's reevaluation resulted in flood levels at the site that were well below the protection level of 29.25 feet MSL.

In April 2016, the NRC staff issued an interim response to the Waterford flooding hazard reevaluation report.[427] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for Waterford. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.18.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps,

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[425] William M. Dean, NRC, letter to Entergy Operations, Inc., "Waterford Steam Electric Station, Unit 3 – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident (TAC No. MF6086)," dated April 27, 2015. ADAMS Accession No. ML15103A618.

[426] Michael R. Chisum, Entergy Operations, Inc., letter to NRC, "Flood Hazard Reevaluation Report – Waterford Steam Electric Station, Unit 3 (Waterford 3)," dated July 21, 2015. ADAMS Accession No. ML15204A321.

[427] Victor Hall, NRC, letter to Entergy Operations, Inc., "Waterford Steam Electric Station, Unit 3 – Interim Staff Response to Reevalulated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (CAC No. MF7125)," dated April 12, 2016. ADAMS Accession No. ML16090A327.

consistent with the guidance in NEI 12-06.[428] In this plan, the licensee provided information similar to the design-basis flooding information described above. The licensee noted that it considered external flooding as one of the hazards for which it needed mitigating strategies.

The licensee's report includes discussion of the flooding protection for its mitigating equipment. With the exception of one booster pump used in a secondary strategy for feeding the steam generators, all equipment for core cooling will be stored within the reactor auxiliary building, which is protected from flooding. The licensee expects that this booster pump will be stored at or near its staging location. The primary FLEX generator will be stored and deployed on the roof of the reactor auxiliary building, protected from flooding.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by adding water to the steam generators from the condensate storage pool using the turbine-driven emergency feedwater pump and releasing steam to the atmosphere. When the turbine-driven pump can no longer be used, a FLEX pump will be used. A FLEX generator will be used to reenergize selected load centers, allowing for a FLEX makeup pump to add water to the reactor coolant system. Additional equipment, such as large generators, can be provided by the Regional Response Centers to provide supplemental mitigation.

The NRC staff performed an interim evaluation of this plan and identified several open items related to wind hazards, various analysis assumptions, core sub-criticality, ventilation in various rooms, lighting, and load reduction.[429] The NRC staff also identified multiple confirmatory items, including ones related to flooding. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[430] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

As of its last formal update to the NRC, the licensee was in the process of implementing its mitigating strategies to support compliance with Order EA-12-049.[431] The licensee indicated that design engineering is complete, and procedure development and plant modifications are underway. The licensee expects to be in full compliance with Order EA-12-049 by July 2016.

The NRC staff will complete a final safety evaluation considering the updated information and inspect the licensee's implementation before considering the order actions complete. This

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[428] Donna Jacobs, Entergy Operations, Inc., letter to NRC, "Overall Integrated Plan in Response to March 12, 2012, Commission Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) – Waterford Steam Electric Station, Unit 3 (Waterford 3)," dated February 28, 2013. ADAMS Accession No. ML13063A266.

[429] Jeremy S. Bowen, NRC, letter to Entergy Operations, Inc., "Waterford Steam Electric Station, Unit 3 – Interim Staff Evaluation and Audit Report Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC No. MF0977)," dated November 22, 2013. ADAMS Accession No. ML13220A402.

[430] Peter Bamford, NRC, letter to Entergy Operations, Inc., "Waterford Steam Electric Station, Unit 3 – Report for the Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0977 and MF0946)," dated October 6, 2015. ADAMS Accession No. ML15272A398.

[431] Michael R. Chisum, Entergy Operations, Inc., letter to NRC, "Resubmittal of Sixth Six Month Status Report for Implementation of Order EA-12-049, Commission Order Modifying License With Regard To Requirements for Mitigation Strategies for Beyond-Design-Basis External Events Waterford Steam Electric Station, Unit 3 (Waterford 3)," dated February 25, 2016. ADAMS Accession No. ML16056A633.

process is expected to take approximately a year after the licensee notifies the NRC of full compliance.

B.19 Watts Bar

Watts Bar, located on the Tennessee River in Spring City, TN, has two units of Westinghouse PWR design.[432] For Unit 1, the operating license was issued in 1996 for a term that expires in 2035. For Unit 2, construction was recently restarted after many years on hold, and the operating license was issued in 2015 for a term that expires in 2055. Unit 2 is conducting startup activities and has not yet begun commercial operation. Therefore, many of the activities described in this section applied only to Unit 1; Unit 2 included the latest information and enhancements from Unit 1 in its licensing basis to support issuance of its operating license.

B.19.1 Current Licensing Basis and Reference Flooding Levels for Walkdowns[433]

Site grade at Watts Bar is 728 feet MSL. At the time of the walkdowns described below, the design-basis flood level in Watts Bar's licensing basis (reflecting a late-1990s reduction to credit dam safety modifications TVA began in the 1980s) was 736.9 feet. The limiting flood was caused by a PMP event in the Tennessee River watershed upstream of the site, plus wind wave runup on slopes and the vertical wall of the intake pumping station.

In 2012, the licensee updated its flooding analyses to address issues identified above for Browns Ferry and Sequoyah, as well as newly identified potential leakage paths around two upstream dams. The updated 2012 results were submitted to the NRC for formal incorporation into the licensing basis through a license amendment request. While the updated 2012 results were still being reviewed by the NRC staff at the time, the licensee determined that it was more appropriate to use these higher flooding levels in its walkdowns.

As used in the walkdowns, the updated 2012 PMF level was 739.2 feet, created by a PMP event (similar to that described for Sequoyah) coincident with failure of Watts Bar Dam. Considering wind waves, the licensee estimated runup at the diesel generator building to be below all access points to the building. At the auxiliary, control, and shield buildings, all accesses and penetrations below the wave runup level are designed to be watertight. The limiting runup is at the intake pumping structure. At the time, the licensee had developed compensatory measures such as construction of a sandbag berm; the licensee later implemented a permanent change to enable passive flood barriers to be installed.

In addition, the updated 2012 flood evaluation included an assessment of five different seismic dam failure events that could cause flooding above site grade. In this analysis, the licensee added failure of Tellico Dam (not included in the original licensee analyses) because the seismic stability analysis of this dam did not provide results conclusive enough to exclude its failure. Therefore, the licensee calculated the resulting flood from failure of Norris, Cherokee, Douglas, and Tellico Dams, coincident with a 25-year flood with high reservoir level, plus wind waves. The resulting flood level was several feet below the updated 2012 PMF level.

The licensee states that all equipment needed during a flood above grade level, and for 100 days after the beginning of the flood, is either designed to operate submerged, located

[432] http://www.nrc.gov/info-finder/reactors/wb1.html and http://www.nrc.gov/info-finder/reactors/wb2.html.
[433] Information in this section is drawn from the licensee's walkdown report and license amendment requests referenced below.

above the maximum flood level, or otherwise protected. The reactor building and diesel generator building will remain dry. Other buildings will be allowed to flood, but necessary equipment is either submersible or above the flood level. Operation in this condition is referred to as "flood mode." The licensee indicates that it can prepare the plant for flood mode within 24 hours of notification that a flood above grade is expected, and provides additional time in its planning for contingencies.

Stage I of shutdown begins when a flood of a specific level is forecast, with the flood level set low enough that additional rain would not cause a flood above 727 feet (1 foot below grade) within the preparation time assumed by the licensee. The licensee has also determined that there is adequate warning time to shut the plant down before the flood arrives, in the event of a seismic dam failure upstream. Stage I includes actions the licensee terms "revocable," including shutting down the reactor and moving supplies. Stage II preparations begin when a flood of 727 feet or higher is forecast. The licensee notes that Stage II preparations are less revocable, including changing the source of steam generator makeup, using the essential raw water cooling system for multiple loads, and filling tanks to prevent flotation.

B.19.2 Additional Plant-Specific Actions

As noted above for Browns Ferry and Sequoyah, TVA completed a revised hydrologic analysis in response to the NRC staff's issuance of violations associated with the Bellefonte combined license application. This analysis directly affected Watts Bar, since the analysis is similar for all TVA plants on the Tennessee River. The April 2013 event report related to evaluation of upstream dam failures, described above for Sequoyah, also applied to Watts Bar.[434] The licensee made several commitments to address the issues raised by the revised hydrologic analysis. In June 2012, the NRC staff issued a Confirmatory Action Letter to both Sequoyah and Watts Bar to formally document the licensee's commitments and require notification to the NRC when the licensee completed them.[435, 436]

At the time this Confirmatory Action Letter and the 10 CFR 50.54(f) letter related to the Fukushima Dai-ichi accident were issued, some NRC staff members were concerned that the level of safety at Unit 1 was not adequate and filed a Differing Professional Opinion using the NRC's process for raising safety concerns.[437] The NRC staff members were particularly concerned that safety-related equipment could flood during the revised PMF, full compensatory measures were not in place, and the licensee was not in compliance with NRC requirements. The review panel that evaluated the Differing Professional Opinion determined that there was not an immediate safety concern with Watts Bar Unit 1, that the NRC staff's decision to issue the Confirmatory Action Letter was a reasonable regulatory decision, and that the decision to continue to work on this flooding issue in parallel with other activities related to the Fukushima Dai-ichi accident was appropriate. The panel observed that the issue could have been addressed better if a risk assessment and clear safety basis for continued operation of Watts Bar had been prepared, and that the NRC staff should have followed a structured process to

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[434] Joseph Shea, TVA, letter to NRC, "Licensee Event Reports: 50-390/2013-001-00; 50-327/2013-001-00; 50-259/2013-001-00," dated April 8, 2013. ADAMS Accession No. ML131010432.
[435] Eric J. Leeds, NRC, letter to Joseph W. Shea, TVA, "Confirmatory Action Letter – Watts Bar Nuclear Plant, Unit 1, and Sequoyah Nuclear Plant, Units 1 and 2, Commitments to Address External Flooding Concerns (TAC Nos. ME8805, ME8806, and ME8807)," dated June 25, 2012. ADAMS Accession No. ML12165A527.
[436] J.W. Shea, TVA, letter to NRC, "Completion of Commitments Related to Updated Hydrologic Analysis Results for Sequoyah Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 1 (TAC Nos. ME8805, ME8806, and ME8807)," dated April 29, 2013. ADAMS Accession No. ML13126A101.
[437] "DPO Case File for DPO-2012-003: Protection from External Flooding at Watts Bar Unit 1," including documents dated through March 19, 2013. ADAMS Accession No. ML13115A273.

assess and document the significance of the issue. The NRC staff committed to consider these insights in enhancing its decision-making processes.

As described above for Sequoyah, the licensee provided further commitments related to improving flood mitigation at Watts Bar in an April 2013 letter, which the NRC staff confirmed in a July 2013 response.[438, 439] To provide additional margin, the licensee decided to design an improved flood mitigation system, to be fully implemented by the end of December 2016. The system includes a hardened structure no less than 15 feet above current PMF levels, additional diesel generators, and hardened enhanced flood-mode systems for decay heat removal and reactor coolant system makeup. This approach will use certain elements of the FLEX equipment described further in the "Mitigating Strategies" section below. The licensee has provided twelve status reports on the progress of its activities and currently estimates that it will meet this December 2016 implementation schedule.[440]

Based on the analytical and physical changes that affected Watts Bar, the licensee requested approval in July 2012 to adopt its updated 2012 flooding analysis referenced above into the Unit 1 final safety analysis report.[441] This request was updated in March 2013 to incorporate an insight regarding chillers that could be affected in flood mode, described further in the "Flooding Walkdowns" section below.[442] Based on questions raised by the NRC staff during the review of this information, the licensee modified or reanalyzed multiple upstream dams using updated software and revised dam stability acceptance criteria. While the reanalysis resulted in a slightly lower flood level than the design-basis flood, the licensee maintained the design-basis flood level at 739.2 feet as stated in 2012. The licensee submitted this updated information to the NRC for approval in September 2014.[443]

The NRC staff issued the associated license amendment in January 2015, and this flooding analysis became the current licensing basis used for comparison in the flooding hazard reevaluation report.[444] In its safety evaluation, the NRC staff described in detail its basis for approving the updated flood levels, including its determination that the licensee's methods for computing PMF discharge and the modeling results were reasonable and acceptable. The NRC staff also imposed a license condition for the licensee to complete modifications to various upstream embankments by the date of implementation of this amendment, as well as a second license condition for TVA to implement permanent modifications to prevent failure of the Fort

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[438] Preston D. Swafford, TVA, letter to NRC, "Commitment to Install Improved Flood Mitigation Systems," dated April 16, 2013. ADAMS Accession No. ML13108A107.
[439] Victor M. McCree, NRC, letter to Joseph W. Shea, TVA, "Tennessee Valley Authority Commitment to Install Improved Flood Mitigation Systems at Sequoyah Nuclear Plant, Units 1 and 2, and Watts Bar Nuclear Plant, Units 1 and 2," dated July 1, 2013. ADAMS Accession No. ML13182A615.
[440] J.W. Shea, TVA, letter to NRC, "Twelfth Progress Update on Improved Flood Mitigation System Project," dated March 31, 2016. ADAMS Accession No. ML16102A304.
[441] J.W. Shea, TVA, letter to NRC, "Application to Revise Watts Bar Nuclear Plant, Unit 1 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, TAC No. ME8200 (WBN-UFSAR-12-01)," dated July 19, 2012. ADAMS Accession No. ML122360173.
[442] J.W. Shea, TVA, letter to NRC, "Watts Bar Unit 1, Supplement to Application to Revise Watts Bar Nuclear Plant Unit 1 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis (WBN-UFSAR-12-01)," dated March 1, 2013. ADAMS Accession No. ML13067A393.
[443] J.W. Shea, TVA, letter to NRC, "Watts Bar Unit 1, Submittal of Application to Revise Updated Final Safety Analysis Report re Changes to Hydrologic Analysis (WBN-UFSAR-12-01)," dated September 30, 2014. ADAMS Accession No. ML14289A106.
[444] Jeanne A. Dion, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant, Unit 1 – Issuance of Amendment to Revise Updated Final Safety Analysis Report Regarding Changes to Hydrology Analysis (TAC No. ME9130)," dated January 28, 2015. ADAMS Accession No. ML15005A314.

Loudoun Dam by February 1, 2017. These conditions are consistent with those described above for Sequoyah.

The NRC staff further documented the acceptability of plant modifications being implemented, several of which were included in the Confirmatory Action Letter noted above:

- permanent flood barriers (seismic Category I steel walls) for the thermal barrier booster pumps and spent fuel pit cooling pumps
- removable door panels at two doors on the 741-foot elevation of the intake pumping structure that are installed in advance of the design-basis flood
- a permanent flood barrier to protect the main control room and shutdown board room chillers and a new portable submersible pump to remove inleakage within the enclosure, as well as modifications and procedural actions to provide flood protection for ancillary equipment for the chillers

In parallel with this licensing action, the NRC staff also completed its review of the operating license application for Unit 2. The safety evaluation for Unit 2, referenced above, indicates that the two units have the same licensing basis. Therefore, the NRC staff's issuance of the operating license for Unit 2 also represents a final finding on the acceptability of this updated licensing-basis information for Watts Bar.

The NRC staff also evaluated the licensee's flood protection through inspections.[445, 446] In June 2013, the NRC issued a Yellow finding (substantial safety significance) associated with the licensee's inability to reconfigure and realign systems necessary for flood mode within the assumed preparation time. Issues had been identified with spool piece fit-up; inability to locate staged equipment; and, in general, lack of thorough understanding of the collective workload, workflow, and labor requirements for completing flood preparation tasks. As a result, the NRC staff determined in issuing the finding that the flood mitigation strategy was inadequate.

In the same letter, the NRC staff issued a White finding (low to moderate safety significance) for the licensee's failure (before September 30, 2009) to address the potential for earthen dams to fail and flood the site, including submerging the diesel generators. The details and basis for the finding are similar to those presented above for Sequoyah. The report also included a Green finding (very low safety significance) related to the potential for reactor coolant pump seals to fail during flood mode because of submergence of the thermal barrier booster pumps; the licensee had previously corrected the barrier around the pumps so that this was no longer an issue.

This finding, combined with another identified as part of the walkdowns described in the next section, resulted in Watts Bar entering the Degraded Cornerstone column of the NRC's Reactor Oversight Process Action Matrix, necessitating additional inspection by the NRC staff to assure that root and contributing causes were understood, independently assess the extent of condition, determine whether safety culture components contributed to the issues, and assure that corrective actions were sufficient to address the causes and prevent recurrence. The NRC

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[445] Richard P. Croteau, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant – NRC Inspection Report 05000390/2012009; Preliminary Yellow Findings, Preliminary White Finding and Apparent Violations," dated March 12, 2013. ADAMS Accession No. ML13071A289.

[446] Victor M. McCree, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Unit 1 Nuclear Plant – Final Significance Determination of Yellow Finding, White Findings and Notices of Violations; Assessment Followup Letter; Inspection Report No. 05000390/2013009," dated June 4, 2013. ADAMS Accession No. ML13155A572.

documented the results of this supplemental inspection in February 2014 and concluded that the licensee's corrective actions had been sufficient.[447] The corrective actions specifically discussed for this inspection (among others taken by the licensee to address flood protection issues) included:

- developing a detailed timeline and sequence based on actual plant walkdowns to be used in the flood-mode procedure
- preparing a detailed listing of tools and equipment for floods, as well as reviewing maintenance procedures to verify tools, equipment, permits, and clearances are appropriate and pre-staged for use
- creating a flood protection program (including implementing procedures) within the corporate nuclear engineering organization, to ensure critical safety systems are protected from all postulated flooding conditions

B.19.3 Flooding Walkdowns

In November 2012, Watts Bar notified the NRC that it had completed its flooding walkdowns.[448] The licensee indicated that walkdowns were performed consistent with NEI 12-07.

The licensee filed an event report that documented issues identified during the walkdowns.[449] As noted above, the PMF could result in a flood level outside the intake pumping station at which essential cooling water and high pressure fire protection equipment, as well as the thermal barrier booster pump motors, could be affected. The licensee noted that it had already staged sandbags in this area. The licensee also identified that the chilled water circulating pumps for the main control room and shutdown board room, as well as other equipment needed for air conditioning, could also become submerged during a PMF. The licensee determined that it would be able to mitigate a PMF event without this equipment operable; however, the licensee indicated that it would (and later did) install a flood protection barrier around the chillers and seal required ancillary equipment. The walkdown report describes this issue with the chillers as a deficiency as defined in NEI 12-07.

The licensee also noted that it would take longer to make flood mode preparations than it had estimated, as described above in the context of the Yellow finding. This was identified as a fleet-level issue for resolution. The licensee implemented several site-specific enhancements, including updating procedures, making tools and equipment more accessible, and training personnel. In addition, the licensee noted its plans to make the enhancements to flood barriers that were described above.

The NRC staff reviewed the walkdown report and provided its assessment in June 2014, concluding that sufficient information was provided to be responsive to the 10 CFR 50.54(f)

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[447] Jonathan H. Bartley, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant Unit 1 – NRC Supplemental Inspection Report 05000390/2013011," dated February 3, 2014. ADAMS Accession No. ML14034A096.
[448] J.W. Shea, TVA, letter to NRC, "Tennessee Valley Authority – Fleet Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Flooding Walkdown Results of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated November 27, 2012. ADAMS Accession No. ML12335A340.
[449] Timothy P. Cleary, TVA, letter to NRC, "Licensee Event Report 390/2012-002-1, Unanalyzed Condition Affecting Probable Maximum Flood Level," dated January 28, 2013. ADAMS Accession No. ML13029A626.

letter.[450] In addition, NRC inspectors independently verified that the licensee implemented the flooding walkdowns consistent with the intent of the walkdown guidance and independently performed walkdowns of a sample of flood protection features.[451] No additional findings were identified as a result of these inspections.

B.19.4 Reevaluation of Flooding Hazard

The NRC staff prioritized Watts Bar as a "Category 1" site for flooding hazard reevaluation in response to the 10 CFR 50.54(f) letter. Initially, this meant that the flooding hazard reevaluation would be due March 12, 2013; this schedule was extended in parallel with Sequoyah's, as noted above.[452]

The licensee submitted its flooding hazard reevaluation report on schedule in March 2015 and provided an update in June 2015.[453, 454] The updated version incorporated a refined calculation of wind wave effects at critical structures, removing the need for an interim action to protect the diesel generator building using pre-staged sandbags that had been included in the earlier version.

As noted above, the current licensing basis used for comparison in the flooding hazard reevaluation report is the updated version approved by the NRC in a January 2015 license amendment. The current licensing basis also included an evaluation of local intense precipitation that had not needed to be revised in either the 2012 update or the 2015 license amendment. In the flooding hazard reevaluation report, the licensee summarizes this current licensing basis information. In particular, the licensee notes that the design-basis flood level of 739.2 feet considers failure of multiple upstream dams. In addition, postulated failure of multiple upstream dams is evaluated in the scenario that combines effects from earthquakes and floods, with a much lower maximum flood level. The licensee describes the flood barriers that protect equipment in the intake pumping station and its "flood mode" procedures for protecting against floods above 727.0 feet.

The reevaluated hazards for three scenarios exceeded what the licensee referred to as the current licensing basis: local intense precipitation, flooding from streams and rivers, and flooding from combined effects.

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[450] Siva P. Lingam, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant, Unit 1 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-ichi Nuclear Power Plant Accident (TAC No. MF0297)," dated June 16, 2014. ADAMS Accession No. ML14149A150.

[451] Scott M. Shaeffer, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant – NRC Integrated Inspection Report 05000390/2012005," dated February 13, 2013. ADAMS Accession No. ML13050A237.

[452] Eric J. Leeds, NRC, letter to J.W. Shea, TVA, "Sequoyah Nuclear Plant, Units 1 and 2, and Watts Bar Nuclear Plant, Units 1 and 2 – Relaxation of Response Due Dates Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of the Insights from the Fukushima Dai-ichi Accident," dated July 1, 2013. ADAMS Accession No. ML13163A296.

[453] J.W. Shea, TVA, letter to NRC, "Flood Hazard Reevaluation Report for Watts Bar, Response to NRC Request for Information per Title 10 of CFR 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated February 25, 2015. ADAMS Accession No. ML15084A324.

[454] J.W. Shea, TVA, letter to NRC, "Revision 1, Flood Hazard Reevaluation Report for Watts Bar Nuclear Plant, Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated June 16, 2015. ADAMS Accession No. ML15169A904.

Local intense precipitation resulted in a slightly higher flood level than that estimated in the earlier evaluation. The licensee evaluated the site configuration and determined that no interim actions were needed.

Flooding from streams and rivers resulted in a flood level several feet above the current licensing basis. This value assumed that dam modifications were in place as described above for Sequoyah, but that there would be a failure at Douglas Dam. The licensee described the same interim action noted for Sequoyah to extend the height of Douglas Dam. Considering the implementation of this enhancement to Douglas Dam, the reevaluated flood level was reduced below the design-basis flood level. As part of the integrated assessment, the licensee indicated it would evaluate long-term options to enhance the performance of this dam.

Similarly, flooding from combined effects resulted in a flood level several feet higher than the current licensing basis. Considering the same enhancement at Douglas Dam, the reevaluated flood level was somewhat lower, though still higher than the design-basis flood level.

Specific to flooding from dam breaches and failures, the controlling evaluation resulted in a flood level below site grade and lower than the flood level estimated in the current licensing basis.

The NRC staff audited supporting details for the Watts Bar flooding hazard reevaluation report (along with others TVA prepared for Browns Ferry and Sequoyah) in 2015.[455] In September 2015, the NRC staff issued an interim response to the Watts Bar flooding hazard reevaluation report.[456] The NRC staff concluded that the licensee's reevaluated flooding hazard information is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 for Watts Bar. Further, the NRC staff concluded that the licensee's reevaluated flooding hazard information is a suitable input for further assessment such as the integrated assessment noted above.

In December 2015, the NRC staff completed its assessment of the flooding hazard reevaluation report, concluding that the licensee provided sufficient information in response to the 10 CFR 50.54(f) letter.[457]

After the licensee provides its Phase 1 submittal, the NRC staff will review this information and determine whether the licensee can address any identified plant vulnerabilities appropriately, or if a plant-specific backfit evaluation of potential regulatory actions should be undertaken.

B.19.5 Mitigating Strategies

In response to Order EA-12-049, the licensee submitted an Overall Integrated Plan that presented information on the applicable hazards, relevant strategies, and implementation steps,

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[455] Juan Uribe, NRC, letter to Joseph W. Shea, TVA, "Nuclear Regulatory Commission Report for the Audit of Tennessee Valley Authority's Flood Hazard Reevaluation Report Submittals Relating to the Near-Term Task Force Recommendation 2.1-Flooding for: Browns Ferry Nuclear Plant, Units 1, 2, and 3; Sequoyah Nuclear Plant, Units 1 and 2; and Watts Bar Nuclear Plant, Units 1 and 2 (TAC Nos. MF6034, MF6035, MF6036, MF6032, MF6033, MF5857 and MF5858)," dated October 30, 2015. ADAMS Accession No. ML15294A203.

[456] Juan F. Uribe, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant, Units 1 and 2 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC Nos. MF5857 and MF5858)," dated September 3, 2015. ADAMS Accession No. ML15239B287.

[457] Juan Uribe, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant, Units 1 and 2 – Staff Assessment of Response to Request for Information Pursuant to 10 CFR 50.54(f) Flood-Causing Mechanisms Reevaluation (TAC Nos. MF5857 and MF5858)," dated December 1, 2015. ADAMS Accession No. ML15310A085.

consistent with the guidance in NEI 12-06.[458] In this plan, the licensee considered the current licensing basis flood level (2015 update) to establish the external flooding hazard. The licensee states that FLEX strategies will be developed for consideration of this external flooding hazard, and that it is developing procedures and strategies for delivering offsite equipment that consider regional impacts from flooding.

The licensee's plan presents strategies for maintaining core cooling, containment, and spent fuel pool cooling. For example, as summarized by the NRC staff, the ELAP/LUHS strategy provides for removing core decay heat initially by injecting water into the steam generators from the protected auxiliary feedwater storage tank using the turbine-driven auxiliary feedwater pump and releasing steam from the steam generator atmospheric relief valves. A FLEX diesel generator will be aligned to power an installed safety injection pump to provide makeup to the reactor coolant system from either the refueling water storage tank or the boric acid tank (in addition to the water provided by the cold leg accumulator). The FLEX diesel generators can also be used to power other installed pumps and to connect FLEX pumps to draw water from remaining sources and ultimately the Tennessee River. Additional equipment, such as mobile purification and boration units, can be delivered from the Regional Response Centers to provide supplemental mitigation.

The NRC staff performed an interim evaluation of this plan and identified open items related to the sequence of events and the use of pre-staged diesel generators.[459] The NRC staff also identified multiple confirmatory items, including one related to the deployment of flex equipment in a flood. The NRC staff later conducted an audit to evaluate the licensee's progress in implementing the order.[460] During the audit, the NRC staff discussed the technical evaluations performed by the licensee and walked down the locations where equipment would be used and connected.

On March 12, 2015, the licensee notified the NRC that Watts Bar is in full compliance with Order EA-12-049.[461] All modifications have been installed, procedures and training are complete, and the licensee has responded to the NRC staff's open and confirmatory items. Final procedure verification will be completed as Unit 2 transitions to commercial operation.

In March 2016, the NRC staff completed a final safety evaluation considering the licensee's notification of full compliance.[462] The NRC staff concluded that the licensee had developed guidance and proposed designs that, if implemented appropriately, adequately addressed Order

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[458] J.W. Shea, TVA, letter to NRC, "Tennessee Valley Authority (TVA) – Overall Integrated Plan in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Watts Bar Nuclear Plant," dated February 28, 2013. ADAMS Accession No. ML13067A030.

[459] Jeremy S. Bowen, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0950 and MF1177)," dated December 20, 2013. ADAMS Accession No. ML13343A025.

[460] James Polickoski, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0950, MF1177, MF0951, and MF1178)," dated May 15, 2014. ADAMS Accession No. ML14128A129.

[461] J.W. Shea, TVA, letter to NRC, "Compliance Letter and Final Integrated Plan in Response to the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Watts Bar Nuclear Plant (TAC Nos. MF0950 and MF1177)," dated March 12, 2015. ADAMS Accession No. ML15072A116.

[462] Mandy Halter, NRC, letter to Joseph W. Shea, TVA, "Watts Bar Nuclear Plant, Units 1 and 2 – Safety Evaluation Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0950, MF0951, MF1177, and MF1178)," dated March 27, 2015. ADAMS Accession No. ML15078A193.

EA-12-049. The NRC staff also conducted an inspection of the licensee's implementation.[463] The team discussed the plans with plant staff, reviewed documentation, and examined equipment to verify that the strategies could be implemented as described. The NRC inspectors did not identify any findings during this inspection. The NRC expects to document the licensee's compliance with the order in the future, given the pending flooding Phase 1 submittal.

[463] Anthony D. Masters, NRC, letter to Joseph Shea, TVA, "Watts Bar Nuclear Plant Units 1 and 2 – NRC Team Inspection Report 05000390/2015009 and 05000391/2015616," dated June 22, 2015. ADAMS Accession No. ML15173A317.

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