UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
WASHINGTON, D.C. 20555-0001

January 9, 2015

NRC INFORMATION NOTICE 2015-01: DEGRADED ABILITY TO MITIGATE FLOODING EVENTS

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of and applicants for a power reactor early site permit, combined license, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Reactors." All applicants for a standard design certification, including such applicants after initial issuance of a design certification rule.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of recent operating experiences related to external flood protection where deficiencies with equipment, procedures, and analyses relied on to either prevent or mitigate the effects of external flooding at licensed facilities have resulted in degraded ability to mitigate flooding events. Information from the following events may apply to the design and maintenance of physical protection features such as flood barriers, the ability to effectively implement abnormal operating procedures to mitigate the effects of external flooding, and the accuracy of analyses that are used to determine design-basis flooding elevations, as well as flood water inundation times. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

St. Lucie Plant, Unit 1

On January 9, 2014, St. Lucie Unit 1 was operating at 100 percent reactor power when the site experienced a period of unusually heavy rainfall. Although this event was below the design basis flood, St. Lucie declared an unusual event because of storm drain capacity degradation. Blockage in the site's storm drain system caused water to backup within the emergency core cooling system (ECCS) pipe tunnel outside of the Unit 1 reactor auxiliary building (RAB). Water entered the RAB through two degraded conduits that lacked internal flood barriers. Operators

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managed the inflow of water into the RAB via operation of floor drain valves between the affected elevation and the location of safety-related systems. An extent-of-condition review identified four additional conduits on Unit 1 that lacked the required internal flood barriers. The modification that had installed the conduits had not considered the need for internal flood barriers for conduits installed below the design-basis flood elevation. Previous walkdowns at St. Lucie, performed in 2012 using the guidance contained in Nuclear Energy Institute (NEI) 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," dated May 2012, had failed to identify the degraded conduit or the missing conduit internal flood barriers. Additionally, St. Lucie determined that previous engineering evaluations used to assess the results of the 2012 NEI 12-07 walkdowns did not account for the site flood inundation times and therefore underestimated the volume of external flood leakage through degraded flood barriers. The licensee implemented corrective actions that included installing qualified internal water seals on all of the affected conduits. Additional information regarding this event is available in Licensee Event Report (LER) 50-335/2014-001-00, dated March 10, 2014, and in NRC Integrated inspection reports 05000335/2014009 and 05000389/2014009, dated September 24, 2014.

Brunswick Steam Electric Plant, Units 1 and 2

On April 20, 2011, NRC inspectors identified that the emergency diesel generator (EDG) fuel oil tank chamber (FOTC) enclosure contained openings that would adversely impact the ability to mitigate external flooding of the EDG FOTCs in the event of a probable maximum hurricane (PMH). The licensee subsequently performed extent-of-condition walk downs and identified numerous examples of degraded or nonconforming flood protection features, the majority of which were flood penetration seals. During walkdowns of flood protection features in accordance with NEI 12-07 during August through September 2012, the licensee identified additional degradation in the reactor buildings and the EDG building, specifically degraded flood penetration seals, conduit seals, and a 7.6-centimeter (3-inch) gap in the weather stripping along the bottom of the Unit 2 reactor building railroad door. This gap would have allowed leakage into the reactor building during a PMH. The inspectors also identified an EDG rollup door that could have allowed water intrusion into the EDG building during a PMH. Additionally, the licensee identified unsealed shims under the base plates of the service water pumps (SWPs), as well as leaking flood penetration seals and an unsealed conduit in the service water building (SWB) that could have allowed flood water to enter the SWB during a PMH. The licensee also identified a potential flood pathway from the intake canal into the SWB through unsealed SWP leak off hub drains, a condition that had existed since construction of the plant. These conditions were caused by a historical lack of a flood protection program at Brunswick. Multiple examples were identified where credited flood mitigation equipment had no established preventative maintenance program. Corrective actions included correcting the degraded seals, developing and implementing an engineering program to mitigate consequences of external flooding, and developing topical design basis for internal and external flooding. Additional information regarding this issue is available in NRC inspection reports 05000324/2014011 and 05000325/2014011, dated May 29, 2014.

Sequoyah Nuclear Plant, Units 1 and 2

On December 12, 2012, the licensee at Sequoyah, Tennessee Valley Authority (TVA), performed an inspection of an electrical manway and confirmed that inadequate electrical conduit penetration seals provided an in-leakage path into the essential raw cooling water (ERCW) pumping station. The condition had previously been identified and evaluated as a degraded condition based on the fact that flood barriers were not installed to seal the subject

electrical conduit penetrations as required by the pertinent design drawings. Subsequent physical inspection of the conduits revealed that inadequate flood barriers were actually installed. The licensee concluded that an external flooding event exceeding the elevation that would impact the conduits would inundate the ERCW pumping station, with impacts to both Unit 1 and Unit 2. The nonconforming seals would have allowed flood waters to enter the pumping station at a rate greater than the capacity of the sump pump and could have resulted in the ERCW system being unavailable to perform its design function during a flood event below plant grade. Based on a review of the supporting documents, the licensee determined that the electrical conduit penetration seals were meant to be the flood barrier. However, there was no clear identification of the flood barriers and their requirements. The licensee took corrective actions that included installing qualified conduit seals and revising design-basis documents and flood barrier drawings to identify flood boundaries and to include seal details. Additional information regarding this issue is available in LER 05000327, 328/2012-001-00, dated February 8, 2013, and in NRC inspection reports 05000327/2013011 and 05000328/2013011, dated June 4, 2013.

Watts Bar Nuclear Plant, Unit 1

In 2013, the licensee at Watts Bar (TVA) identified that it could not demonstrate the capability to implement site external flood mitigation procedures in the time assumed between the notification of an imminent design-basis flood event and flood waters reaching the Watts Bar site. The design-basis flood event for Watts Bar would result in flooding above plant grade. Accordingly, the licensee relied on procedures used to reconfigure plant systems in preparation for site inundation to ensure the ability to safely shut down the reactor and remove decay heat. Examples of issues that challenged the assurance that the flood mitigation procedures could be implemented within the available time included:

- Work activities in the implementing procedures were directed in a sequential manner, which added to the overall time required.

- Piping interferences and the lack of suitable rigging locations for inter-system spool pieces.

- Mislabeled or missing equipment was used in the implementing procedures.

- The time to perform some of the more complex and coordinated work activities was underestimated.

This issue resulted in a violation of technical specification for failure to establish adequate flood mitigation procedures. The licensee took corrective actions that included revising the flood mitigation procedures to add more detail, increasing the frequency of the training for the procedures, and staging equipment and developing preventive maintenance activities to periodically validate that the equipment is in place. Additional information regarding this issue is available in NRC inspection report 05000390/2013009, dated June 4, 2013.

Sequoyah Nuclear Plant, Units 1 and 2; Watts Bar Nuclear Plant, Unit 1; and Browns Ferry Units 1, 2 and 3

On July 28, 2009, TVA determined that computer modeling inconsistencies predicting the performance of dams located in the watershed upstream of the Sequoyah, Watts Bar, and Browns Ferry sites adversely affected the probable maximum flood (PMF) design-basis

analyses. Corrections to those issues identified that there would be less flow through the dam spillways at the high headwater elevation during a PMF event and would result in over-topping the earthen portions of the affected dams. Failure of the dams was assumed if their earthen portions over-topped. Based on these results, TVA determined that the PMF elevations may exceed the original design-basis flooding elevations at the Watts Bar, Sequoyah, and Browns Ferry nuclear sites. On April 8, 2013, TVA determined that the issue was reportable as an unanalyzed condition and submitted LERs to the NRC for each of the three affected sites. One of the root causes for the event was over-confidence in the design-basis analyses, which allowed latent computer modeling errors to remain undetected. An additional contributing cause was that formal process controls were not established to ensure that the flood protection program protected critical safety systems. Additional information regarding this issue is available in NRC inspection reports 05000327/2013011, 05000328/2013011, and 05000390/2013009, dated June 4, 2013. The NRC is currently reviewing the circumstances associated with this issue at the Browns Ferry site.

Three Mile Island Station

On August 2, 2012, while observing the licensee flooding walkdowns at Three Mile Island Station in accordance with Temporary Instruction (TI) 2515/187, "Inspection of Near-Term Task Force Recommendation 2.3 Flooding Walkdowns," NRC inspectors noted degradation on several conduit couplings in the air intake tunnel. The air intake tunnel provides a source of air for safety-related ventilation systems and also contains both safety- and nonsafety-related electrical conduits. The couplings, which by design should have been injected with sealant to provide a barrier to design-basis flooding events, showed signs of exposure to wet environments, indicating that the sealant was missing. The licensee eventually determined that 43 conduit couplings were missing sealant. The original construction deficiency had not been identified by the licensee during a comprehensive review performed in 2010. Without adequate protection from flooding (flood seals), flood water could have bypassed all flood barriers through the conduits and impacted the operability of decay heat removal equipment. The licensee implemented prompt compensatory actions, including staging extra sandbags and earth moving equipment to restore operability of the flood barriers. The licensee implemented permanent corrective actions that included sealing the conduits by injecting watertight qualified sealant material into the associated cable conduits. Additional information regarding this issue is available in NRC inspection report 05000289/2012005, dated February 11, 2013.

R.E. Ginna Nuclear Power Plant

On May 29, 2013, while performing flooding walkdowns in accordance with NEI 12-07, the licensee at R.E. Ginna Nuclear Power Plant discovered two penetrations that appeared to be unsealed leading to one of the battery rooms. Although the licensee determined that drains in the manhole would prevent the water level from reaching the unsealed penetrations, NRC inspectors raised questions about the operability of these drains, since they were not included in any maintenance or test program. In response to these questions, the licensee tested the drains and determined that they were not capable of draining enough water to prevent a design-basis flood from reaching the unsealed penetrations and flooding battery room B. Battery room A would also be flooded by a non-watertight fire door that connects it with battery room B. The potential existed to also lose offsite power leading to the loss of all alternating current power to the site and an unrecoverable station blackout. In 1983, as part of the Systematic Evaluation Process, the licensee's design basis was changed to include additional external flooding events and the flood protection level was agreed to by the licensee at a level that was above the

elevation of the manhole. The licensee did not evaluate the potential for flooding through the manhole and, therefore, did not seal the cable penetrations that were at an elevation below the new level. The licensee took corrective actions that included installing permanent hydrostatic seals in both penetrations between the manhole and the battery room. Additional information regarding this issue is available in NRC inspection report 05000244/2013005, dated February 14, 2014.

Monticello Nuclear Generating Plant

During an inspection from September 12, 2012, to May 15, 2013, NRC inspectors identified that the Monticello Nuclear Generating Plant site failed to maintain a flood mitigation procedure such that it could support the implementation of flood protection activities within the 12-day timeframe credited in the updated safety analysis report (USAR) to protect against a PMF event. The inspectors made this observation while watching the licensee perform flooding walkdowns in accordance with TI 2515/187. The licensee believed that flood mitigation actions for the protected area could be taken within the 12 days specified in the USAR by citing an independent engineering assessment performed in 2001. However, the licensee did not perform a verification walkthrough of the activities in the procedure and, therefore, did not identify vulnerabilities in its flood plan. NRC inspectors noted that according to that evaluation, construction of a bin wall around vulnerable portions of the site would take 12 days to complete, assuming that two crews were operating and all the materials were available on site. The evaluation also specified a total time of 25 days for bin wall construction, including procurement of bin wall materials. Although the timeframe for constructing a levee could be reduced to less than 12 days with two crews operating, the licensee had not taken actions to support that reduction. The licensee took corrective actions, which included revising its procedure to add more detail, as well as pre-staging materials necessary to complete the bin wall in the timeframe cited in the USAR. Additional information regarding this issue is available in NRC inspection report 05000263/2013008, dated June 11, 2013.

Point Beach Nuclear Plant

In March 2013, inspectors found that the Point Beach Nuclear Plant licensee failed to establish procedural requirements to implement external wave run-up protection design features as described in the final safety analysis report (FSAR). The inspectors made this observation while watching the licensee perform flooding walkdowns in accordance with TI-2515/187. Flood protection procedures directed installation of concrete jersey barriers to protect the turbine building and pumphouse from flooding. While performing the flooding walkdowns, the licensee discovered that it did not have enough jersey barriers to cover the full length of the area that needed to be protected. Furthermore, when the barriers were installed, gaps were created and there were no provisions in the procedure for using sandbags to protect the openings in the jersey barriers or the gaps between the barriers and the ground. The licensee also had failed to consider the time that would be required to erect the barriers. The licensee took corrective actions, including modifying existing jersey barriers to eliminate openings, revising the procedure to direct the installation of jersey barriers in conjunction with sandbags, and pre-staging additional sandbags and jersey barriers. Additional information regarding this issue is available in NRC inspection report 05000266/2013002, dated May 13, 2013.

Dresden Nuclear Power Station, Units 2 and 3

In August 2012, while observing licensee simulations for executing flood protection procedures as part of the NEI 12-07 walkdowns, NRC inspectors noted that the procedures did not account

for reactor coolant system (RCS) inventory losses. The procedures assumed flood duration of 4 days, during which time systems that provide normal and makeup capacity to the RCS would be flooded and unavailable. The licensee calculations accounted for the 5-gallon per minute (gpm) maximum technical specification allowance for unidentified RCS leakage, but it did not account for inventory losses from identified leakage, which could be as high as an additional 20 gpm. The licensee strategy did not originally provide for a method to maintain RCS inventory above the top of active fuel for RCS leakage rates that were allowable under technical specifications. The licensee took corrective actions, including modifying procedures to provide makeup capacity and to isolate the reactor recirculation loops during flood conditions when reactor vessel makeup capabilities are limited so that sources of identified leakage would no longer impact the reactor vessel level. Additional information regarding this issue is available in NRC inspection report 05000237/2013002, dated May 7, 2013.

Fort Calhoun Station

In September 2009, during a component design basis inspection, NRC inspectors identified that the licensee at Fort Calhoun Station failed to maintain adequate procedures to protect the intake structure and auxiliary building during external flooding events. These procedures described stacking and draping sandbags on top of installed floodgates to protect the plant up to the flood elevation described in the USAR. When inspectors asked plant staff to demonstrate this procedure, they were unable to complete the procedure as written because the cross section on the top of the floodgates was too small to accommodate enough sandbags to retain a 5-foot (1.5 meter) static head of water. The inadequate procedure was caused by the licensee missing several opportunities to implement appropriate corrective actions when new external flood information became available. During the extent of condition review, the licensee identified unsealed penetrations below the licensing basis flood elevation that could cause the intake structure to be vulnerable during an extreme flooding event. The licensee took corrective actions that included revising the procedures, redesigning and installing selected flood protection features such that they would not require the use of sandbags, and sealing the affected penetrations. Additional information regarding this issue is available in NRC inspection report 05000285/2010007, dated July 15, 2010.

Arkansas Nuclear One, Units 1 and 2

On March 31, 2013, following the collapse of a temporary lifting rig carrying the Unit 1 main turbine generator stator, a rupture in the fire water system resulted in water leakage past floor plugs in the auxiliary building and subsequent accumulation of water inflow in the safety-related decay heat removal room B through a room drain pipe. This event overlapped the timeframe in which the licensee was assessing flood mitigation features in response to Fukushima-related orders issued by the NRC. The extent of condition reviews by the licensee related to this event and those discrepancies identified during flood mitigation response efforts found numerous other pathways that were not effectively sealed against flooding in the auxiliary building and emergency diesel fuel storage buildings. These conditions were not identified during the licensee's initial flooding walkdowns in accordance with NEI 12-07.

The licensee's failure to design, construct, and maintain the Unit 1 and Unit 2 auxiliary and emergency diesel fuel storage buildings so that they would protect safety-related equipment during design-basis flood events caused the overall condition. The unsealed penetrations were not identified during the walkdowns because of incomplete information on flooding barriers, some information not being kept current, and inadequate oversight of the contractor performing the flood protection walkdowns. The licensee took corrective actions that included re-performing

the reviews of essential flood protection features, identifying those features that were initially not identified, completing the missed portions of the walkdowns, and submitting corrected information to the NRC. In this event, an internal flooding event resulted in the licensee discovering external flooding vulnerabilities. Additional information regarding this issue is available in NRC inspection reports 05000313/2014009 and 05000368/2014009, dated September 9, 2014.

BACKGROUND

Related NRC Generic Communications

NRC IN 2012-002, "Potentially Nonconservative Screening Value for Dam Failure Frequency in Probabilistic Risk Assessments," dated March 5, 2012. The NRC issued this IN to alert addressees of a potentially nonconservative screening value for dam failure frequency that originated in 1980's reference documents which may have been referenced by licensees in their probabilistic risk assessment (PRA) for external events.

NRC IN 2009-006, "Construction-Related Experience with Flood Protection Features," dated July 21, 2009. The NRC issued this IN to alert addressees of construction-related operating experience involving inadequate flood protection features.

NRC IN 2007-001, "Recent Operating Experience Concerning Hydrostatic Barriers," dated January 31, 2007. The NRC issued this IN to alert addressees of deficient hydrostatic barriers that allowed water to leak into rooms that contained safety-related equipment.

NRC IN 2005-030, "Safe Shutdown Potentially Challenged by Unanalyzed Internal Flooding Events and Inadequate Design," dated November 7, 2005. The NRC issued this IN to alert addressees to the importance of establishing and maintaining the plant flooding analysis and design, consistent with NRC requirements and principles of effective risk management, to ensure that internal flooding risk is effectively managed.

NRC IN 2005-011, "Internal Flooding/Spray-Down of Safety-Related Equipment due to Unsealed Equipment Hatch Floor Plugs and/or Blocked Floor Drains," dated May 6, 2005. The NRC issued this IN to alert addressees of the possibility of flooding safety-related equipment as a result of (1) equipment hatch floor plugs that are not water tight, and (2) blockage of the equipment floor drain systems that are credited to mitigate the effects of flooding in the FSAR and plant design-basis calculations.

NRC IN 2003-008, "Potential Flooding through Unsealed Concrete Floor Cracks," dated June 25, 2003. The NRC issued this IN to alert addressees of observed flooding in a room containing safety-related panels and equipment as a result of fire water seepage through unsealed concrete floor cracks.

NRC IN 1994-027, "Facility Operating Concerns Resulting from Local Area Flooding," dated March 31, 1994. The NRC issued this IN to alert addressees to emergency preparedness, equipment operability, and radiological control problems that may result from local area flooding.

DISCUSSION

The examples provided by this IN are operating experience related to deficiencies with equipment, procedures, and analyses that prevent or mitigate the effects of external flooding.

These issues directly contributed to periods of time where the affected sites were vulnerable to the impact of a flood event. Note that some cases involved actual external events (e.g., St. Lucie) or events that indicated a potential external flood vulnerability (e.g., ANO). Several cases indicate the existence of potential cliff edge effects, as described in the report "Near Term Task Force Review of Insights from the Fukushima Daiichi Accident." Other cases indicated the existence of a deficiency at levels below the existing licensing bases flood. The causal factors involved failure to comply with original design requirements, failure to maintain plant design basis, failure to implement adequate procedures to mitigate the effects of flooding, inadequate barrier control programs, inadequate flood protection programs, and inadequate modeling of the effects of design-basis flood events. Some of the issues had previously been entered into the site corrective action program but were not adequately resolved in a timely manner. In some cases, there was a lack of sensitivity by the licensee organization in understanding the potential impact of flooding events to safety-related equipment and structures. It should be noted that the examples discussed here are a subset of the operating experience which highlights the main insights gained. Although not explicitly discussed in this IN, there are additional examples of issues related to degraded external flood protection.

The examples discussed in this IN illustrate the importance of an effective flood protection program. Regulations in 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as floods without loss of capability to perform their safety functions.

Regulations in 10 CFR Part 50, Appendix B, Criterion III, "Design Control," requires that measures shall be established to assure that applicable regulatory requirements and the design basis as specified in the license are correctly translated into specifications, drawings, procedures, and instructions.

GENERIC IMPLICATIONS

Flood protection vulnerabilities can be a significant contributor to risk at nuclear power facilities. They have the potential to make multiple trains of safety-related equipment and support equipment simultaneously inoperable. They also have a significant impact on operator recovery actions, as demonstrated by the 2011 earthquake and tsunami that affected the Fukushima Dai-ichi facility in Japan. In 2012, the NRC issued a request for information to all power reactor licensees directing them to submit reevaluated flooding hazards report for their sites to confirm the appropriateness of the hazards assumed and to perform walkdowns to confirm their ability to protect against these hazards. The licensees completed their walkdowns by November 2012, and NRC inspectors performed follow-up inspections. The NRC staff is currently reviewing the results of these actions to determine whether additional regulatory actions are necessary to provide additional protection against the updated hazards.

CONTACTS

This information notice requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

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