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

July 11, 2017

Mr. Thomas D. Ray
Vice President, Oconee
Nuclear Station
Duke Energy Corporation
7800 Rochester Highway
Seneca, SC 29672-0752

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NOS. MF7950, MF7951 AND MF7952)

Dear Mr. Ray:

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.54(f), "Conditions of Licenses" (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force report (ADAMS Accession No. ML111861807).

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their site(s) using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses. Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not have been based on present-day methodologies and guidance, in the development of their mitigating strategies.

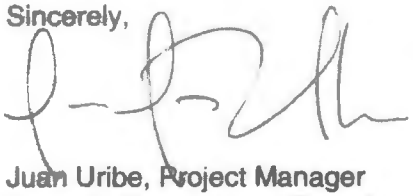
By letter dated January 31, 2017 (ADAMS Accession No. ML17044A016, non-publicly available), Duke Energy Carolinas, LLC (the licensee) submitted its flooding mitigation strategies assessment (MSA) for Oconee Nuclear Station, Units 1, 2, and 3 (Oconee). The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. The purpose of this letter is to provide the NRC's assessment of the Oconee MSA.

Enclosure 1 transmitted herewith contains Security-Related Information. When separated from Enclosure 1, this document is decontrolled.

The NRC staff has concluded that the Oconee MSA was performed consistent with the guidance described in Appendix G of Nuclear Energy Institute 12-06, Revision 2, as endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, and that the licensee has demonstrated that the mitigation strategies are reasonably protected from reevaluated flood hazards conditions for beyond-design-basis external events. This closes out the NRC's efforts associated with CAC Nos. MF7950, MF7951 and MF7952).

If you have any questions, please contact me at 301-415-3809 or at Juan.Uribe@nrc.gov

Sincerely,



Juan Uribe, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-269, 50-270 and 50-287

Enclosures:
1. Staff Assessment Related to the Mitigating Strategies for Oconee (Non-Public)
2. Staff Assessment Related to the Mitigating Strategies for Oconee (Public)

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO MITIGATION STRATEGIES FOR OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3 AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE RECOMMENDATION 2.1 – FLOODING (CAC NOS. MF7950, MF7951 AND MF7952)

1.0 INTRODUCTION

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), "Conditions of Licenses" (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their respective site(s) using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses. Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). That order requires holders of operating reactor licenses and construction permits issued under 10 CFR Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit to the NRC for review a final integrated plan that describes how compliance with the requirements of Attachment 2 of the order was achieved. In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not have been based on present day methodologies and guidance, in the development of their mitigating strategies.

The NRC staff and industry recognized the difficulty in developing and implementing mitigating strategies before completing the reevaluation of flood hazards. The NRC staff described this issue and provided recommendations to the Commission on integrating these related activities in COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flood Hazards," dated November 21, 2014 (ADAMS Accession No. ML14309A256). The Commission issued a staff requirements memorandum on March 30, 2015 (ADAMS Accession No. ML15089A236), affirming that the Commission expects licensees for operating nuclear power plants to address the reevaluated flood hazards, which are considered beyond-design-basis external events, within their mitigating strategies.

Nuclear Energy Institute (NEI) 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625), has been endorsed by the NRC as an appropriate methodology for licensees to perform assessments of the mitigating strategies against the reevaluated flood hazards developed in response to the March 12, 2012 50.54(f) letter. The guidance in NEI 12-06, Revision 2, and Appendix G in particular, supports

the proposed Mitigation of Beyond-Design-Basis Events rulemaking. The NRC's endorsement of NEI 12-06, including exceptions, clarifications, and additions, is described in Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) 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"" (ADAMS Accession No. ML15357A163). As discussed in JLD-ISG-2012-01, Appendix G of NEI 12-06, Revision 2, describes acceptable methods for demonstrating that the reevaluated flooding hazard is addressed within the Oconee Nuclear Station Units 1, 2, and 3 (Oconee) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letters dated March 12, 2013, and March 6, 2015 (ADAMS Accession Nos. ML13079A227 and ML15072A099, respectively), Duke Energy Carolinas, LLC (Duke, the licensee) submitted its flood hazard reevaluation report (FHRR) for Oconee. By letter dated September 24, 2015 (ADAMS Accession No. ML15239B261), the NRC issued an interim staff response (ISR) letter for Oconee. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Oconee, which were to be used in conducting the mitigating strategies assessment (MSA), as described in NEI 12-06. For Oconee, the mechanisms listed as not bounded by the CDB in the ISR letter are: local intense precipitation (LIP); rivers and streams, and dam failure. By letter dated April 14, 2016 (ADAMS Accession No. ML15352A207), the NRC issued a FHRR staff assessment that provided the documentation supporting the NRC staff's conclusions summarized in the ISR letter.

By letter dated January 31, 2017 (ADAMS Accession No. ML17044A016, non-public), Duke submitted the Oconee MSA for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

By letter dated February 28, 2013 (ADAMS Accession No. ML13063A065, not publicly available, security related information), Duke submitted its Overall Integrated Plan (OIP) for Oconee in response to Order EA-12-049. At 6 month intervals following the submittal of its OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111 'Regulatory Audits' (ADAMS Accession No. ML082900195). By letters dated February 10, 2014 (ADAMS Accession No. ML13365A258), and October 6, 2015 (ADAMS Accession No. ML15259A387), the NRC staff issued an Interim Staff Evaluation and audit report, respectively, on the licensee's progress. By letter dated January 26, 2017 (ADAMS Accession No. ML17031A431), Duke submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

The NRC staff is in the process of reviewing the above information and plans to issue a safety evaluation documenting the results of its review of the FLEX strategies for Oconee.

The purpose of the safety evaluation is to inform Duke on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049. A brief summary of Oconee's FLEX strategies are listed below:

- The reactor coolant pumps (RCPs) coast down and flow in the reactor coolant system (RCS) transitions to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by isolating potential RCS letdown paths. Decay heat is removed by steaming to atmosphere from the steam generators (SGs) through the atmospheric dump valves (ADVs) or SG safety valves

- Plant operators will go to the standby shutdown facility (SSF), which is seismically qualified, and start the SSF diesel generator (DG). They will then start the SSF auxiliary service water (ASW) pump, which is capable of pumping water to all six Steam Generators (SGs) (two per unit).

- At the SSF operators will also start the reactor coolant makeup (RCMU) pumps (one per unit), which inject borated water from the SFPs into the shaft seals of the RCPs to protect the RCP seals from overheating that may result in excessive leakage, and which also provide makeup water to the RCS

- The SSF was designed to operate for 72 hours, however, the licensee has FLEX equipment at the site that can be ready for use in several hours. When the SSF can no longer be operated reliably, a FLEX pump will be used to add water to one SG per unit from the intake canal, which is connected to Lake Keowee. The licensee plans to use a diesel-driven high-pressure FLEX pump to add borated water to the RCS, with suction from the unit's borated water storage tank (BWST). The BWST is seismically qualified and has protection against tornado-borne missiles. For Phases 1 and 2, the licensee's calculations demonstrate that no actions are required to maintain reactor building (containment) pressure below design limits for more than 72 hours.

- One 500-kilowatt (kW), 600 volt alternating current (Vac) DG will be deployed from the FLEX storage building (FSB) to each unit. These portable generators will be used to repower the vital battery chargers and recharge the vital batteries, which will then repower the vital 120 Vac panelboards via the vital inverters.

- The National SAFER [Strategic Alliance for FLEX Emergency Response] Response Center (NSRC) will provide high capacity pumps and large turbine-driven DGs which could be used to support the Phase 2 strategy. There are two NSRCs in the United States

The NRC staff notes that in the FIP the licensee stated that consideration of external flooding hazards is not applicable at Oconee in order to comply with the requirements of Order EA-12-049, or the guidance given in NEI 12-06, Revision 0, since the site does not have any external flooding hazards as part of the design-basis. The licensee also stated that although consideration of the external flooding hazards is not required for compliance with Order EA-12-049, enhancements to the current FLEX strategies have been designed and are intended to provide protection against external flooding hazards.

As part of the MSA review, the NRC staff evaluated the reevaluated flood hazards (as described in the ISR letter) and the design enhancements described in the MSA against the guidance in Appendix G of NEI 12-06, Revision 2. As stated, the purpose of the NRC staff's review is to confirm Oconee's capability to protect FLEX equipment and strategies against the reevaluated hazard levels.

3.2 Evaluation of Current FLEX Strategies Against Reevaluated Hazard(s)

The licensee has assessed the potential impacts of the LIP, streams and rivers, and failure of dams as described in the ISR letter against the mitigating strategies designed to meet Order EA-12-049. The purpose of the MSA was to determine if the licensee's mitigating strategies are adequate as-is, need to be modified, or new mitigating strategies need to be developed to address hazard exceedances as described in the ISR letter.

Overall, the licensee determined in its evaluation that only the LIP has the potential to impact the existing mitigating strategies and as a result, a planned modification to the site will be performed in order to adequately protect the SSF. The rest of the current FLEX strategies, response, equipment, and procedures can be implemented without modifications, as described in the FIP and the Oconee flooding MSA.

3.2.1 Summary of Mitigating Strategies Assessment

In its FIP, the licensee described that implementation of the FLEX strategies at Oconee is divided into three phases. In general, the first phase is to initially cope by relying on installed plant equipment and on-site resources, the second phase is to transition from installed plant equipment to the on-site FLEX equipment, and the third phase is to obtain additional capability and redundancy from off-site equipment.

For the Jocassee Dam breach flood-causing mechanism, the licensee indicated that the resulting peak water above nominal site grade is bounded by the current FLEX design capability. Specifically, since the Oconee FLEX strategies were designed using a more conservative dam breach analysis than the analysis provided in the FHRR, the site FLEX response addresses this reevaluated flood-causing mechanism. In addition, the FHRR analysis results in flood water elevations that are below the SSF flood walls, therefore the FLEX strategy is expected to provide a backup role, if any SSF equipment were to fail. As a result, Duke determined that the dam failure flood-causing mechanism does not impact the site's current FLEX strategies.

For the streams and rivers flood-causing mechanism, the licensee stated that the probable maximum flood (PMF) peak level on Lake Keowee is 812.2 ft mean sea level (MSL) including wind/wave runup. However, the crest of the dam and dikes for the reservoir are located at elevation 815 ft MSL and as such, the PMF flooding is contained without any impact occurring at the site. As a result, Duke determined that the streams and rivers flood-causing mechanism does not impact the site's current FLEX strategies.

For the LIP flood-causing mechanism, the licensee stated flooding is above site grade for 5 hours and the peak site inundation results in levels 4.4 ft above site grade, and that FLEX warning time scenarios were not originally developed to include a LIP event. Therefore, this scenario potentially impacts equipment credited for a FLEX response. Specifically, on the south

side of the courtyard inside the SSF, the LIP rainwaters may intrude via the access door and double doors since they are not flood protected and challenge personnel accessibility, as well as the capacity of the SSF sump pumps. The modification to the site in order to address LIP is a permanent passive civil feature (roof structure over the courtyard) that diverts water away from the courtyard, thus protecting the SSF. The SSF is required for the Phase 1 FLEX response.

Finally, the licensee indicated that if a LIP event were to occur concurrent with an extended loss of alternating current power (ELAP) (and the SSF was not impacted by LIP, as described above), the FLEX Phase 1 capabilities would exceed the duration of the LIP event and the Oconee site is expected to have sufficient time for the flood waters to recede prior to Phase 2 deployment to occur.

3.3 Technical Evaluation

The NRC staff has reviewed the information presented in the MSA, as well as supporting documentation. This included:

- Review of licensing documents and previous NTTF flooding submittals;
- Review of the site features; and
- Review and documentation of existing mitigating strategies under Order EA-12-049.

The NRC staff reviewed the flood hazard elevations in the MSA in order to confirm if the elevations matched the values provided in the Oconee ISR letter. The ISR letter identified the following reevaluated flood-causing mechanisms as not bounded by the CDB: LIP, streams and rivers; and dam failure.

For the streams and rivers flood-causing mechanism, the licensee stated that since there is no inundation at the plant site resulting from the analyzed PMF flooding from the Keowee Reservoir, this flood-causing mechanism is excluded (not applicable) from further analysis in the MSA. The NRC staff agrees with the licensee's screening determination and notes that this approach is consistent with the guidelines provided by Appendix G of NEI 12-06, Revision 2.

For the dam failure flood-causing mechanism, the licensee stated in its FIP that Oconee does not have any external flooding hazards as part of the design-basis; however, FLEX strategies were designed and enhanced to respond to a Jocassee dam failure that is more conservative than the revised reevaluated hazard provided in the FHRR, which was reviewed by the NRC staff and documented in the ISR letter.

In regards to the more conservative level, Oconee developed a warning time strategy that will be initiated upon receipt of notification of imminent or potential failure of the Jocassee main dam. The licensee stated that the Jocassee Hydro personnel are trained and authorized to make this notification in accordance with the Emergency Action Plan for the Jocassee Hydro Station. Oconee will enter the procedure for flood mitigation, and all three units will begin shutdown. The licensee stated that the notification of external flooding will be provided approximately 8 hours before the potential loss of the SSF by flood waters in the Oconee yard overtopping the SSF flood wall. Furthermore, the licensee stated in its FIP that it plans to deploy FLEX equipment during the warning time period, or deploy the equipment after the flood waters have receded.

The NRC staff also reviewed if FLEX deployment path(s) and/or staging areas were adversely impacted by this flood-causing mechanism. Given that the reevaluated flood hazard level relevant to this evaluation is lower than the level used as the FLEX design criteria, and the licensee plans to deploy necessary FLEX equipment prior to flood waters arriving on site, the NRC staff agrees that flooding is not expected to adversely impact deployment paths from the FSB to the power block.

The NRC staff also reviewed if FLEX storage locations were adversely impacted by the reevaluated hazard level for a sunny-day dam failure. As stated in the FIP, the FSB is located at an elevated portion of the site and is well above any potential flood caused by a dam failure. Specifically, the FSB is a single, large building located in the northwest area of the plant. The FSB is a reinforced concrete dome structure with an outside diameter of 144 ft and a height of 43 ft. It has two equipment doors and two personnel doors. Given that the reevaluated flood hazard level relevant to this evaluation is lower than the level used as the FLEX design criteria, the NRC staff agrees that flooding is not expected to adversely impact the applicable FLEX storage locations, which include the FSB and alternate storage locations as described in Section 3.5.2 of the FIP. Therefore, the NRC staff agrees that the FSB appears to be reasonably protected from external flooding.

For LIP, the NRC staff evaluated if the reevaluated LIP hazard impacted any of the storage location(s) of FLEX equipment, any staging areas, haul paths, connection points, activities, etc. During its review of the MSA, the NRC staff determined that additional information was necessary in order to complete its evaluation. By letter dated December 5, 2016 (ADAMS Accession No. ML16259A189), the NRC staff had issued a generic audit plan to perform regulatory audits of licensees' MSAs on an as-needed basis, in order to support the NRC staff's review of the MSAs and issuance of the associated NRC staff assessments. As a result, this was the mechanism used to exchange information with Duke for Oconee, consistent with NRR LIC-111.

In regards to LIP flood-causing mechanism, the NRC staff requested additional information related to the proposed schedule and path forward to complete the permanent passive civil feature (roof structure over the SSF courtyard) that is intended to divert water away from the courtyard. In its response, the licensee stated that the modification to install the roof is estimated to be completed by the end of 2017.

In its MSA, the licensee stated that the SSF, as the Phase 1 response, can be accessed throughout the event via a covered and elevated security walkway from the Auxiliary Building and then "a short transit through flood waters (peak 4.4 feet deep) to reach the steps that go over the SSF floodwall." The NRC staff requested additional information intended to clarify if there were any triggers based on monitoring conditions that would pre-deploy any staff needed to operate the SSF given that 4.4 ft deep waters (peak level) may be challenging and present limited accessibility conditions.

In its response, the licensee stated that Oconee assessed the reevaluated LIP event and determined that it would not adversely impact the timeline of events (or the sequence) stated in the FIP for the Oconee FLEX strategy. Specifically, the licensee stated that there is reasonable confidence that an operator action to access the SSF via a covered and elevated walkway (from the Auxiliary Building) and a short transit (about 15 feet through the flood waters to reach the steps that go over the SSF floodwall) will not have an adverse impact. This area is enclosed by

buildings and security barriers creating an alcove with low flow velocities. ONS has considered the time impact to this operator activity and determined it adds negligible time to the operator action. In addition, the licensee also stated that the reevaluated LIP hazard adds negligible time to the operator action and therefore, no impact is expected on this activity.

The licensee described that during a reevaluated LIP event, Oconee would enter Procedure RP/0/A/1000/035, "Severe Weather Preparations". This procedure provides instruction for site preparation for severe weather prior to the rainfall event, and therefore provides defense-in-depth for the response to the FHRR rainfall hazard. Furthermore, the licensee stated that the severe weather preparations procedure has various entry conditions which include a rainfall forecast in excess of 4 inches of rain in any 6 hour period. When this rainfall prediction is made RP/0/A/1000/035 directs the control room SRO to enter the "Natural Disaster" procedure AP/0/A/1700/006. In the natural disaster procedure, enclosures exist for both a severe weather event and a probable maximum precipitation event. In both of these enclosures there are monitoring activities that allow for the staffing of the SSF prior to the rainfall event. These procedure steps are Enclosure 5.4 Step 2 and Enclosure 5.8 Step 11 of Abnormal Procedure AP/0/A/1700/006.

Based on the response, the NRC staff agrees that the FLEX strategies appear to be reasonably protected from a reevaluated LIP event and that no impact to the FLEX strategies is expected to occur as a result of this event.

3.3.1 Evaluation of Flood Event Duration

The NRC staff reviewed information provided by Duke regarding the flood event duration (FED) parameters needed to perform the MSA for flood hazards not bounded by the CDB. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 3.3.1-1.

For the LIP flood event, the licensee stated in its MSA that the peak flood level is 800.4 ft MSL, which results in a ponding depth of 4.4 ft above the site grade. The period of inundation from LIP flooding is also provided in the MSA and is reported to be 5 hours. The licensee further stated in its MSA, that warning time for the LIP event is not needed to enable FLEX to be executed as designed for the ELAP, and that the site's ultimate heat sink system for this event is Lake Keowee, which is not challenged by the LIP event.

The licensee stated that water levels are projected to decline to nominal levels within 4 hours after the LIP rainfall has subsided; therefore, the period of recession was provided to be 4 hours. As described in its FHRR, the licensee used a coupled 1-D and 2-D hydraulic model called InfoWorks CS, Version 11.5 (IWCS). The licensee determined the site depth-duration relationships for precipitation events of 5-, 15-, and 30-min for a one square mile area and 1-, 6-, 12-, 24-, 48- and 72-hour for a 10 square mile area. In addition, a 6-hour LIP event was developed using 5-minute precipitation intervals for the analysis. After reviewing the 6-hour and 72-hour results, it was determined that the longer duration LIP event could have a potentially higher flooding impact.

Based on that determination, the licensee modified the 72-hour event to include the peak intensity identified in the 6-hour event. Using the IWCS model, the licensee then evaluated the sensitivity of flood water surface elevations on the site to the temporal distribution of rainfall

within the 72-hour event The licensee used the results to determine the inundation duration and period of recession parameters.

The NRC staff confirmed that the licensee's reevaluation of the periods of inundation and recession for the LIP and associated drainage flood-causing mechanism are acceptable for use in the MSA as they used present-day methodologies and regulatory guidance

For the streams and rivers flood-causing mechanism, the licensee analyzed the combined effects of the PMF with wind-driven waves for both Keowee and Jocassee reservoirs.

For Keowee Reservoir, the combined event of the reevaluated PMF with wind-wave runup results in a flood elevation of 812.2 ft MSL, leaving 2.8 ft of freeboard at the West Saddle Dam. The flooding from the PMF is contained within Lake Keowee where the crest elevations of the dams and dikes for the reservoir are at 815 ft MSL. The Keowee dam and spillways are capable of safely passing the PMF with no flooding on site at Oconee. Since the analysis shows that no flooding occurs on site due to the PMF, the FED parameters for this flood causing mechanism were not included in the MSA report as they are not applicable The NRC staff confirmed that the licensee's approach is consistent with the guidelines provided by Appendix G of NEI 12-06, Revision 2.

For the dam failure flood-causing mechanism, the licensee reported in the MSA and the FHRR that the reevaluated hazard, including associated effects, for site flooding due to failure of dams and onsite water control or storage structures is based on a stillwater surface elevation of [[ ]] MSL. This flood elevation is due to a sunny-day piping failure of the Jocassee Main Dam followed by the cascading failures of the Keowee Main Dam and West Saddle Dam due to overtopping. Flooding as a consequence of the sunny-day failure of Jocassee Main Dam results in a flood level of [[ ]] MSL at the SSF This flood level results in an inundation of [[ ]] above the nominal site grade of 796 ft MSL.

The licensee used a suite of numerical modeling software and empirical methods to determine the flood water elevations and resulting flood event duration parameters. The modeling software used by the licensee included U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System, which was used to model the dam-breach process and resulting hydrograph; route the flow through Keowee Reservoir; model the subsequent breaching of Keowee Dam and the appurtenant West Saddle Dam; and determine flood water elevations at the site In addition, the licensee implemented a two-dimensional (2-D) hydraulic modeling process to perform the breach-induced flow analysis and provide hydrodynamic details regarding water velocity and inundation at the site For the analysis presented in its revised FHRR, the licensee used the modeling software TUFLOWFV (finite volume) which is a 2-D depth-averaged computer model (Build Version 2014.01.007). (BMT WBM, 2013, BMT WBM, 2014). The licensee also reported in its MSA that the FED, as measured from the initial warning-time notification to the point that floodwater recedes below site grade, is approximately 12 hours. This includes a warning time of 8 hours and a period of inundation of 4 hours during which the flood waters will remain above the site grade The period of preparation for this flooding event was reported to be 8 hours and a period of recession of 2.66 hours

The staff confirmed that the licensee's reevaluation of the inundation periods for flooding from the dam breach flood-causing mechanism used present-day methodologies and regulatory guidance

In summary, the staff agrees with the licensee's conclusion related to determining the FED parameters as the approach is consistent with the guideline provided by Appendix G of NEI 12-06, Revision 2. Based on this review, the staff determined that the licensee's FED parameters for all flood-causing mechanisms are reasonable and acceptable for use in the MSA.

3.3.2 Evaluation of Associated Effects

The NRC staff reviewed information provided by Duke regarding reevaluated associated effects (AE) parameters for flood-causing mechanisms not bounded by the CDB. The AE parameters related to water surface elevation (i.e., stillwater elevation with wind waves and runup effects) were previously reviewed by staff, and were transmitted to the licensee via the ISR letter. The AE parameters not directly associated with water surface elevation are discussed below and are summarized in Table 3.3.2-1.

For the LIP flood-causing mechanism, the licensee stated in its MSA report that the hydrostatic and hydrodynamic loads are minimal. The licensee stated that flow velocities derived from the 2-D model described in its FHRR were reviewed at relevant door openings to safety-related structures to determine whether hydrodynamic loading is of concern at any of the critical locations. The results indicate that maximum velocities are generally below 1-ft/sec, with occasional exceedance at locations where flow is constrained between two buildings. The licensee stated that the reported flow velocities are generally not orthogonal to the doors and the associated water-borne loads are expected to be minimal. The licensee also stated that debris effects from the LIP flood-causing mechanism are negligible because the areas that could potentially serve as a debris source are paved or covered with gravel or paved surfaces with very little vegetation or loose materials. In addition, the relatively-low flow velocities minimize the movement of debris throughout the powerblock.

Similarly, erosion and sediment deposition from the LIP event are not expected to be significant because the water velocities necessary to erode the surface media within the powerblock area are an order of magnitude higher than the estimated maximum water velocity associated with the LIP event. With the LIP event being a localized rainfall event, the associated runoff is also not expected to carry significant amounts of sediment. Groundwater levels at the site are not expected to increase as a result of LIP flooding which has a reported period of inundation of 5 hours. The licensee also stated that the site is protected against groundwater ingress.

The NRC staff confirmed the licensee's statements by reviewing the licensee-provided LIP model's input and output files. The staff verified that the inundation depths and flow velocities are acceptable and the modeling is reasonable for use as part of the MSA. Correspondingly, the NRC staff agrees with the licensee's assessment of the AE parameters for the LIP flood-causing mechanism.

As previously stated, for the streams and rivers flood-causing mechanism, the licensee stated that since there is no inundation at the plant site resulting from the analyzed PMF flooding from the Keowee Reservoir, this flood-causing mechanism is excluded (not applicable) from further analysis in the MSA. The NRC staff agrees with the licensee's screening determination and notes that this approach is consistent with the guidelines provided by Appendix G of NEI 12-06, Revision 2.

In regards to the Jocassee Dam sunny day failure and the cascading failure of Keowee Dam, several safety-related structures throughout the powerblock will be affected by the associated

effects of the dam failure. Based on the results of the 2-D modeling, the licensee reported that the water velocities in the Keowee Main Dam tailrace immediately downstream of the breach are estimated to be approximately 40-ft/sec. Water velocities adjacent to the Intake Canal Dike and the east slope of the powerblock are significantly lower because the inundation is due to backwater impacts and generally do not exceed 4-ft/sec.

The SSF is physically located to the west of the Unit 2 reactor building and is surrounded by site structures, therefore the maximum wave run-up elevation is expected to be minimal. In addition, the SSF has a top flood wall of elevation 803.5 ft MSL, and when compared to a still-water elevation of [[ ]] corresponding to a Jocassee sunny-day dam breach, there is a [[ ]] of available margin for this flood level.

Flood waters approach the power block area primarily from the southeast as water accumulates in the floodplain below the Keowee Dam and then rises above site grade. The licensee stated that flood water velocities around the SSF are low and hydrodynamic effects including debris would not challenge the SSF flood walls. The FLEX equipment credited at the site is stored in the FLEX Support Building which is above the floodplain or will be deployed to a protected location prior to arrival of the floodwaters.

Regarding groundwater ingress for the dam failure flood-causing mechanism, the licensee reported in its MSA that groundwater levels at the site will not increase as a result of the relatively-short duration of inundation of about 4 hours. Furthermore, the licensee stated that the site (including the SSF) is protected against groundwater ingress. The licensee also reported that all other AE parameters (including sediment deposition and erosion, concurrent conditions, and other pertinent factors) are minimal. After reviewing the information provided in the MSA and the FHRR, the NRC staff agrees with the licensee's conclusion regarding the AE parameters for the dam failure flood-causing mechanism as the licensee's approach is consistent with the guidelines provided by Appendix G of NEI 12-06, Revision 2.

In summary, the staff concludes the licensee's methods were appropriate and the AE parameter results for all flood-causing mechanisms are reasonable for use in the MSA.

3.4 Conclusion

The NRC staff has reviewed the information provided in the Oconee MSA related to the original FLEX strategies, as assessed against the reevaluated hazards. The staff concludes that the licensee has reasonably demonstrated the capability to implement FLEX strategies, as modified against the reevaluated hazards described in the ISR letter.

The NRC staff made its determination based upon:

- The site modification and plan to install a permanent passive civil feature (roof structure over the SSF courtyard) that is intended to divert water away from the courtyard during a LIP event, and reduce any potential impacts to personnel accessibility and FLEX equipment stored in the SSF.

- Consideration that FLEX storage building elevations are not impacted when compared against reevaluated flood hazard elevations.

- All Phase 1 strategies, as currently designed, contain sufficient margin to allow local floodwaters to recede prior to any established Phase 2 FLEX actions or deployment of additional equipment. As a result, implementation timelines as described in the FIP should not be impacted by LIP or a sunny-day Jocassee dam failure; and

- Two flood-causing mechanisms (streams and rivers and dam failure) that were determined to be not bounded in the ISR letter were appropriately screened out of further review in the MSA given that those events were bounded as described in Section 3 of this document. This approach was consistent with guidance provided in Appendix G of NEI 12-06, Revision 2.

Therefore, the NRC staff concludes that the licensee has demonstrated the capability to implement the original FLEX strategies, as modified, under the conditions associated with the reevaluated LIP, rivers and streams, and dam failure, including associated effects and flood event duration, as described in NEI 12-06, Revision 2, and JLD-ISG-2012-01, Revision 1.

4.0 CONCLUSION

The NRC staff has reviewed the information presented by the licensee in its MSA for Oconee. The NRC staff confirmed that the licensee's flood hazard MSA for Oconee was performed consistent with the guidance in Appendix G of NEI 12-06, Revision 2, as endorsed by JLD-ISG-2012-01, Revision 1. Based on the licensee's use of the hazards characterized in the NRC staff's ISR letter, the methodology used in the Oconee MSA evaluation, and the description of its current FLEX strategy in the Oconee MSA and supporting documentation, the NRC staff concludes that the licensee has demonstrated that the mitigation strategies appear to be reasonably protected from reevaluated flood hazards conditions.

Table 3.3.1-1. Flood Event Durations for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	Not Credited(2)	5 hours	4 hours
Streams and Rivers(1)	Not Applicable	Not Applicable	Not Applicable
Failure of Dams and Onsite Water Control/Storage Structures	8 hours	4 hours	2.66 hours

Source: (Oconee FHRR and MSA)

Notes:

(1) The FED parameters for the streams and rivers flood-causing mechanism are not applicable because this mechanism will not inundate the plant site.

(2) If needed, develop consistent with NEI 15-05, "Warning Time for Local Intense Precipitation Events"

Table 3.3.2-1. Associated Effects Parameters Not Directly Associated With Total Water Height for Flood-Causing Mechanisms Not Bounded By the CDB

Associated Effects Parameter	Local Intense Precipitation and Associated Drainage	Streams and Rivers [3]	Failure of Dams and Onsite Water Control/Storage Structures
Hydrodynamic loading at plant grade	Minimal	Not Applicable	Minimal
Debris loading at plant grade	Minimal	Not Applicable	Minimal[1]
Sediment loading at plant grade	Minimal	Not Applicable	Minimal[2]
Sediment deposition and erosion	Minimal	Not Applicable	Minimal
Concurrent conditions, including adverse weather - Winds	Minimal	Not Applicable	Minimal
Groundwater ingress	Minimal	Not Applicable	Minimal
Other pertinent factors (e.g., waterborne projectiles)	Minimal	Not Applicable	Minimal

Source: (Duke FHRR and MSA)

Notes:

(1) Flood waters approach the power block area primarily from the south east as water accumulates in the flood plain below the Keowee dam and rise above site grade. Flood water velocities around the SSF are low and hydrodynamic effects including debris would not challenge the SSF flood walls.

(2) Even though there is a potential of significant sediment and erosion on the east side of the site which faces the floodplain, the west side of the site at the SSF will have minimal sediment and erosion due to the structures surrounding the SSF and the resultant low water velocities.

(3) The AE parameters for the streams and rivers flood-causing mechanism are not applicable because this mechanism will not inundate the plant site.

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED JULY 11, 2017

DISTRIBUTION:

PUBLIC	RidsNrrlaSLent Resource	JSebrosky, NRR
JLD R/F	RidsOgcMailCenter Resource	JBoska, NRR
RidsNRRJLD Resource	RidsOpaMail Resource	NSanfilippo, NRR
RidsNrrDorlLpl2-1 Resource	RidsAcrsAcnw MailCtr Resource	JUribe, NRR
RidsNrrDorl Resource	RidsNroDsea Resource	JHughey, NRR
RidsNrrPMOconee Resource	RidsRgn2MailCenter Resource	MShams, NRR

ADAMS Accession Nos. Pkg ML17166A242; ML17166A280 (Non-Public); ML17166A260 (Public)

OFFICE	NRR/JLD/JHMB/PM	NRR/JLD/LA	NRR/JLD/JOMB/PM	NRR/JLD/JHMB/BC	NRR/JLD/JHMB/PM
NAME	JUribe	SLent	JBoska	NSanfilippo	JUribe
DATE	6/15/2017	6/27/2017	7/10/2017	7/10/2017	7/11/2017

OFFICIAL RECORD COPY