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

March 20, 2014

Mr. Scott Batson
Site Vice President
Oconee Nuclear Station
Duke Energy Carolinas, LLC
7800 Rochester Highway
Seneca, SC 29672-0752

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3, REQUEST FOR ADDITIONAL INFORMATION REGARDING FUKUSHIMA LESSONS LEARNED FLOOD HAZARD REEVALUTION REPORT (TAC NOS. MF1012, MF1013, AND MF1014)

Dear Mr. Batson:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as a part of implementing lessons-learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested licensees to perform a flood hazard reevaluation using present-day methodologies and guidance.

By letter dated March 12, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13079A227), Duke Energy Carolinas, LLC (Duke Energy), submitted a response to Enclosure 2, Required Response 2 of the 50.54(f) letter. The NRC staff has determined that additional information, as requested in the enclosure, is needed to complete its review of your Flooding Hazard Reevaluation Report for Recommendation 2.1. Please provide a response to the questions within 30 days of the date of this letter.

This request was discussed with Mr. Dean Hubbard of your staff on March 12, 2014. The NRC staff's determination was confirmed that the proposed request for additional information (RAI) does not contain sensitive information that should be withheld from the public.

The NRC staff considers that timely responses to requests for additional information help ensure sufficient time is available for NRC staff review and contribute toward the NRC's goal of efficient and effective use of NRC staff resources. If circumstances result in the need to revise the requested response date, please contact me at 301-415-1030 or via e-mail at Richard.Guzman@nrc.gov.

Sincerely,

Richard V. Guzman, Senior Project Manager
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

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

Enclosure:
Request for Additional Information

cc w/encl: Distribution via Listserv

REQUEST FOR ADDITIONAL INFORMATION

FUKUSHIMA LESSONS LEARNED

FLOODING HAZARD REEVALUATION REPORT

DUKE ENERGY CAROLINAS, LLC

OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3

DOCKET NOS. 50-269, 50-270, AND 50-287

On March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a "Request for Information pursuant to Title 10 of the *Code of Federal Regulations* (10 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" (the 50.54(f) letter, publicly available at Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340) to all power reactor licensees and holders of construction permits in active or deferred status. By letter dated March 12, 2013 (ADAMS Accession No. ML13079A227), Duke Energy Carolinas, LLC (Duke Energy, the licensee) submitted the "Oconee Flood Hazard Reevaluation Report," dated March 6, 2013 (ADAMS Accession No. ML13240A016), for the Oconee Nuclear Station, Units 1, 2, and 3 (ONS).

The NRC staff has determined that additional information, as requested below, is needed to complete its review.

RAI-1 Seismic Dam Performance

Background and Discussion

The March 12, 2012, 50.54(f) letter requests that licensees reevaluate flooding hazards using present-day guidance and methodologies applicable to new reactors. For flooding hazards, the 50.54(f) letter indicates that NUREG/CR-7046, "Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America," documents present-day methodologies used by the NRC to review early site permit and combined license applications. Consistent with ANSI-ANS-2.8 (1992), NUREG/CR-7046, Appendix H defines the following load combinations for evaluation of floods caused by seismic dam failures:

- Alternative 1 – Combination of:
  - A 25-year flood
  - A flood caused by dam failure resulting from a safe shutdown earthquake (SSE), and coincident with the peak of the 25-year flood
  - Waves induced by 2-year wind speed applied along the critical direction.

- Alternative 2 – Combination of:
  - The lesser of one-half of the probable maximum flood (PMF) or the 500-year flood

Enclosure

- A flood caused by dam failure resulting from an operating basis earthquake (OBE), and coincident with the peak of the flood selected above
- Waves induced by 2-year wind speed applied along the critical direction.

Present-day NRC requirements and guidance with respect to characterizing seismic hazards use a probabilistic approach in order to develop a risk-informed, performance-based ground motion response spectrum (GMRS) for a site. This approach is described in Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion." The GMRS represents the first part of the development of the SSE for a site as a characterization of the regional and local seismic hazard. The steps necessary to develop the final SSE are described in Chapter 3, "Design of Structures, Components, Equipment, and Systems," of NUREG-0800, "Standard Review Plan." The OBE is not defined in Regulatory Guide 1.208, but is typically taken as one-half the SSE when used as a design input.

Recognizing that development of a GMRS is a resource intensive effort, supplemental guidance was developed by NRC staff to support the evaluation of dam failures as part of the NTTF R2.1 flood hazard reevaluations. This supplemental guidance is contained in JLD-ISG-2013-01, "Interim Staff Guidance for Estimating Flooding Hazards due to Dam Failure." JLD-ISG-2013-01 provides some "relief" with respect to definition of the dam-specific GMRS and specifies the following load combinations for evaluation of floods caused by seismic dam failures:

- Ground motion corresponding to 10^{-4} annual frequency of exceedance combined with a 25-year flood
- Ground motion corresponding to half of the 10^{-4} ground motion combined with a 500-year flood.

In the above combinations, the 10^{-4} ground motion is defined using data and software tools available from the U.S. Geological Survey rather than being developed using the methods of RG 1.208. When using tools from USGS, it is still necessary to account for site effects when defining the site-specific seismic hazard. The final version of JLD-ISG-2013-01 was issued in July 2013, which was after a subset of licensees (including Oconee Nuclear Station) submitted their flood hazard reevaluation reports in March 2013. However, ONS may, at its discretion, exercise the option to define the seismic hazard at the site using USGS 2008 software and tools rather than developing a site-specific hazard using the methodologies of RG 1.208 in responding to this request for additional information.

In its flood hazard reevaluation report (FHRR), Duke Energy summarized an evaluation of the seismic performance of Jocassee Dam using a deterministic assessment that demonstrated factors of safety ranging from 1.13 to 1.24 based on an "earthquake acceleration of 0.12g horizontal at the base on the dam" for three loading scenarios. Duke Energy also summarized a fragility study performed of the dam in which the fragility of the dam is represented as "the median peak ground acceleration of a scaled uniform hazard motion, which represents the median hard rock hazard motion of the ONS site as given in the 1989 EPRI uniform hazard study." The fragility of the dam was characterized by the fragility of the downstream embankment slope. The cover letter for the fragility study indicates that "[i]f the Oconee seismic hazard is revised in the future, the seismic fragility of Jocassee Dam must be reassessed."

In light of the above discussion, the licensee is requested to provide the following:

Requested information – 1a: Evaluation of seismic hazard for Jocassee Dam

Evaluation of seismic hazard at the location of Jocassee Dam based on present-day guidance and methods applicable to new reactors (i.e., methods described in Regulatory Guide 1.208) or the alternative and simplified methodology described in JLD-ISG-2013-01 (i.e., using data and software tools available from USGS). Specifically, the licensee is requested to provide the following:

a) Site-specific mean hazard curves over a range of spectral frequencies (including relevant fundamental frequency range for the dam and 1Hz, 5Hz, 10Hz and peak ground acceleration) and range of annual exceedance frequencies (10^{-6} and higher) determined from a probabilistic seismic hazard analysis.

b) Site-specific, performance-based GMRS or 10^{-4} uniform hazard response spectrum (UHRS) developed from the new site-specific seismic hazard curves at relevant elevation(s), including at the foundation of the dam.

c) Description of site characterization.

d) Description of the methodology used to evaluate the site-specific seismic hazard including: models and assumptions that were used in the evaluations, the location at which the GMRS or UHRS is defined, and the approach for accounting for site effects.

Requested information-1b: Seismic Dam Performance

An evaluation of seismic performance of the dam and associated appurtenances (including, but not limited to, spillways and saddle dikes) in response to the following load combinations:

Alternative 1 – Combination of:

- A 25-year flood
- A flood caused by dam failure resulting from a safe shutdown earthquake (SSE), and coincident with the peak of the 25-year flood, where the SSE is defined as (1) the SSE consistent with RG 1.208 (GMRS) and Chapter 3, "Design of Structures, Components, Equipment, and Systems," of NUREG-0800, "Standard Review Plan" or (2) as the 10^{-4} UHRS defined using USGS software and tools consistent with JLD-ISG-2013-01, and
- Waves induced by 2-year wind speed applied along the critical direction.

Alternative 2 – Combination of:

- The lesser of one-half of the PMF or the 500-year flood
- A flood caused by dam failure resulting from an OBE, and coincident with the peak of the flood selected above, where the OBE is defined as half the SSE defined above, and
- Waves induced by 2-year wind speed applied along the critical direction.

Specifically, the licensee is requested to provide the following information:

a) A detailed description of relevant seismic failure modes for the main dam and associated appurtenances.

b) Evaluation of seismic performance of the dam and appurtenances considering relevant failure modes and the seismic load combinations described above.

c) Detailed description of the methodology used to evaluate seismic performance, including a description of the models and assumptions that were used in the evaluations and an explanation of the consistency of these evaluations with present-day guidance and methods as well as current data.

d) If it is not demonstrated that the dam and appurtenances withstand the seismic load combinations described above, the licensee is requested to provide the following information:

   i) Evaluation of breach parameters and inputs into hydraulic and hydrologic models resulting from relevant seismically-induced dam failure scenarios.
   ii) Estimation of stage, velocity, and discharge time-series hydrographs near the ONS site for relevant seismically-induced dam failure scenarios.

Requested information-1c: Use of existing analyses

Considering the existing evaluations described in the licensee's FHRR to demonstrate seismic performance of the dam and its appurtenances, the licensee is requested to provide the following information:

a) An explanation of the consistency of existing evaluations with present-day guidance and methods as well as current data.

b) A comparison of the seismic hazard characterization defined in response to item (1) with the seismic hazard characterization utilized in existing studies.

c) An evaluation of the effects of the seismic hazard characterization defined in response to item (1) on the factors of safety that are identified in Section 2.3.2 of the ONS FHRR.

d) Evaluation of the implications of changes in spectral shape and amplitude on the results of the fragility studies summarized in Section 2.3.2 of the FHRR and described in the Jocassee fragility study, particularly in light of the statement contained in the fragility study that indicates "[i]f the Oconee seismic hazard is revised in the future, the seismic fragility of Jocassee Dam must be reassessed."

e) Explanation of the comprehensiveness of failure modes (for dam and appurtenances) considered in assessment of dam performance.

f) Demonstration that the seismic fragility evaluation accounts for the contribution of all relevant seismic failure modes to the composite/aggregate seismic fragility of the dam and its appurtenances.

RAI-2: Local Intense Precipitation and Associated Site Drainage (Model Documentation and Input/Output Files)

The licensee performed the local intense precipitation flooding analysis using the modeling software Info Works CS (IWCS). A report provided in the electronic reading room (ERR) states that the model construction is described in a separate report dated November 2012 and titled "ONS Local Flooding Analysis Hydraulic Modeling Report, Yard and Roof Drainage Local Flooding, Current Licensing Basis." This November 2012 report was not provided in the ERR. Therefore, the NRC staff requests the following:

a) A detailed description of how the IWCS software was implemented for this site, including:
    1. Identification of the specific IWCS modules that were used and description of the methods implemented by these modules (e.g., 2-D depth averaged, etc.)
    2. Description of treatment of model's boundary conditions (inflow, outflow, surface boundary conditions), initial conditions, and convergence criteria.
    3. The NRC staff also requests electronic input and output files for this model including the AVI files listed in Appendix D of the technical document provided in the ERR.

b) Information on the methods used to calibrate the IWCS model against known conditions and solutions (i.e., the results of this calibration, but not the methods, are provided in Appendix C of the technical report provided in the reading room).

c) Information on the approaches used to assure conservation of mass associated with the solution transfer from the roof to the site grid and from rainfall to runoff in the IWCS model.

d) Clarify what physical aspect is modeled using the 1-D method for IWCS

RAI-3: Local Intense Precipitation and Associated Site Drainage (Choice of Methods and Technical Rationale)

The NRC staff requests information on the watershed delineation, the role of the various drainage structures, and onsite local intense precipitation flood hazard modeling. Specifically, the staff requests the following:

a) Technical rationale for the selection of the delineation of the boundary between the off-site sub-basins and the onsite area and reasoning for the two different treatments, i.e., Soil Conservation Service (SCS) runoff method for the offsite sub-basins and two-dimensional modeling for the onsite sub-basins.

b) Additional information on the modeling approach for local intense precipitation (LIP) and the conservatism of the analysis. More specifically, the NRC staff requests the technical

rationale and documentation for the SCS analysis and the SCS curve number (CN) values assigned to each of the offsite sub-basins. The NRC staff also requests technical rationale for not treating the offsite sub-basins as impervious and the rationales for selecting CN values and determining travel times.

c) Additional detailed representation of the location and type of drainage structures and any wall structures that may exist.

d) Technical rationale to explain how the overtopping of any drainage structure was handled in the modeling process for the offsite and onsite areas.

RAI-4: Local Intense Precipitation and Associated Site Drainage (Choice of Methods and Technical Rationale)

The NRC staff requests additional clarification on how the analysis for site drainage and flow at the site were performed in the IWCS and SCS models. More specifically, the NRC staff requests information on:

a) The termination point for the drainage that leaves the Yard area, and the assumptions associated with the conditions at the termination point and its effect on the operability of the underground drainage system.

b) Whether and how the coupled model considers drainage flow from the two-dimensional grid to the sub-basins, including identification of which sub-basins flow onto the site and which receive drainage from the site. More specifically, technical discussion on the possibility of backflow from onsite to the sub-basins.

c) How the drainage flow leaving the modeled sub-basin, "Offsite 5" in Figure A-7-A is accounted for in the model. More specifically, provide description of backflow or backwater effects with due consideration for the topographic configuration of "Offsite 5" and outside of the sub-basins.

d) Site terrain and drainage patterns (by providing a more legible and better resolution copy of the contour drawing initially received, including legible elevation numbers).

RAI-5: Local Intense Precipitation and Associated Site Drainage (Choice of Methods and Technical Rationale)

The report on the IWCS flow model results does not include a discussion on impacts of velocity distribution in the Yard. The NRC staff requests a technical discussion regarding the effects of flow velocities, hydrodynamic forces, and any debris loading in and around the Yard site.

RAI-6: Local Intense Precipitation and Associated Site Drainage (Documentation)

Background: Definitions for design bases and current licensing bases can be found in 10 CFR 50.2 and 10 CFR 54.3, respectively. The NTTF Recommendation 2.1 response Flood Hazard Reevaluation Report (FHRR) Section 3 Table 11 presents the current design basis flood elevation due to a local intense precipitation as 798.17 ft MSL. The NTTF Recommendation 2.3

response walkdown report does not identify 798.17 ft MSL as the design-basis elevation. The NRC staff also compared the information in the current revision 22 of the Oconee Nuclear Station Updated Final Safety Analysis Report (UFSAR), and the information is not available in the UFSAR. The comparison between the design basis and the reevaluated hazard is key for determining which hazards, if any, should be evaluated in the Integrated Assessment Report.

Request: The licensee is requested to provide a clarification regarding the apparent discrepancy between the FHRR (NTTF Recommendation 2.1 response) and the Walkdown Report (NTTF Recommendation 2.3 response) with respect to the design-basis flood elevation.

RAI-7: Streams and Rivers (Choice of Methods and Technical Rationale)

The FHRR Section 2.2.2 describes rainfall amount, duration, and location of the storm only for the Jocassee reservoir. The NRC staff requests clarification on the rainfall amount, duration, and location of storm for the Keowee reservoir. In addition, the staff requests clarification of the maximum water surface elevation of 809.4 ft identified in the 1966 study in Section 1.E of the report, "Report on the Analysis to Determine the PMF – March 29,1995," and how it compares with the value of 808.0 ft in FHRR Tables 1 and 11.

RAI-8: Streams and Rivers (Choice of Methods and Technical Rationale)

The NRC staff's review of the FHRR did not find discussions on the tailwater level below Keowee Dam as a result of PMF. The NRC staff requests information regarding the tailwater level below Keowee resulting from the PMF discharge (see FHRR Section 2.2.1) and discussion of the consideration given for any effects that the tailwater and possible backwater elevations may have on the site flooding hazard.

RAI-9: Streams and Rivers (Choice of Methods and Technical Rationale)

The NRC staff reviewed PMF levels and timing presented in Sections 2.2.1 and 2.2.2 of the FHRR and the associated documents provided in the electronic reading room. During the review and after subsequent discussions with the licensee on March 12, 2014, the staff noted that only one PMP distribution was used. The staff requests information on the temporal distributions of precipitation on the watershed. More specifically, the staff requests discussion and technical rationale that explains the considerations given to other PMP distribution types/scenarios, in order to demonstrate the selection of a conservative PMP distribution for the PMF analysis.

RAI-10: Streams and Rivers (Choice of Methods and Technical Rationale)

As described in Section 2.2.2, the Kirpich method was used to estimate time of concentration. The Kirpich method was derived based on data from agricultural watersheds with basin areas between 1 to 112 acres (0.004 to 0.45 square-kilometers) and topographical characteristics based on these watersheds located in Pennsylvania and Tennessee. The NRC staff requests technical rationale to determine suitability of the Kirpich method for determining the time of concentration to be consistent with the assumptions upon which the method was derived.

RAI-11: Streams and Rivers (Choice of Methods and Technical Rationale)

The NRC staff requests information on the upstream boundary conditions and flow velocity distributions for the dam breach model described in FHRR Section 2.3.3. Specifically, the NRC staff requests information pertaining to any considerations given for sensitivity runs made for various upstream locations for the inflow boundary condition and an increasingly refined grid. The NRC staff also requests a technical discussion on how an updated flow distribution and a grid independent solution could be expected to affect the results of the stepped breach progression of dam failure using the SRH-2D (Sedimentation and River Hydraulics) model.

RAI-12: Failure of Dams and Onsite Water Control/Storage Structures (Choice of Methods and Technical Rationale)

The Jocassee-Keowee Dam Failure Assessment 1-D HEC-RAS Model Report described in FHRR Section 5 indicates that sensitivity runs including different expansion and contraction coefficients and Manning's roughness coefficient *n* were made to the 1-D model to match the 2-D model results. The NRC staff requests the technical rationale for making changes to the 1-D model based on the 2-D model while the 2-D model itself has not been independently calibrated and validated. Particularly, the NRC staff requests the technical rationale for determining that the 2-D model is producing appropriately conservative results and how the model is validated to appropriately address the effects of the canal restriction on the flow.

RAI-13: Failure of Dams and Onsite Water Control/Storage Structures (Model Documentation and Input/Output Files)

The NRC staff requests additional information on the geometry of the reservoir near the Keowee Dam (including the Little Arm, the cove area, and the canal restriction) and their treatment in the 1-D and 2-D models described in FHRR ection 2.3.3. More specifically, the NRC staff requests:

a) Electronic input and output files for the HEC-RAS 1-D and SRH-2-D model runs.

b) Information explaining how the storage effects of the Little River Arm and the "cove" are modeled in the 1-D HEC-RAS and the assumptions considered.

RAI-14: Hazard input to the integrated assessment: Flood event duration parameters

Background: The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded by the current design basis. Flood scenario parameters from the flood hazard reevaluation serve as the input to the integrated assessment. To support efficient and effective evaluations under the integrated assessment, the NRC staff will review flood scenario parameters as part of the flood hazard reevaluation and document results of the review as part of the staff assessment of the flood hazard reevaluation.

The licensee has provided reevaluated flood hazards at the site including local intense precipitation flooding, probable maximum flooding on contributing watershed, flooding in streams and rivers, and flooding from breach of dams. The local intense precipitation flooding is

reported to exceed the current licensing basis and subsequently the licensee has committed to perform integrated assessment.

Request: The licensee is requested to provide the applicable flood event duration parameters (see definition and Figure 6 of the Guidance for Performing an Integrated Assessment, JLD-ISG-2012-05) associated with mechanisms that trigger an integrated assessment using the results of the flood hazard reevaluation. This includes (as applicable) the warning time the site will have to prepare for the event (e.g., the time between notification of an impending flood event and arrival of floodwaters on site) and the period of time the site is inundated for the mechanisms that are not bounded by the current design basis. The licensee is also requested to provide the basis or source of information for the flood event duration, which may include a description of relevant forecasting methods (e.g., products from local, regional, or national weather forecasting centers) and/or timing information derived from the hazard analysis.

RAI-15: Input to integrated assessment: Flood height and associated effects

Background: The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded by the current design basis. Flood scenario parameters from the flood hazard reevaluation serve as the input to the integrated assessment. To support efficient and effective evaluations under the integrated assessment, the NRC staff will review flood scenario parameters as part of the flood hazard reevaluation and document results of the review as part of the staff assessment of the flood hazard reevaluation.

The licensee has provided reevaluated flood hazards at the site including local intense precipitation flooding, probable maximum flooding on contributing watershed, flooding in streams and rivers, and flooding from breach of dams. The local intense precipitation flooding is reported to exceed the current licensing basis and subsequently the licensee has committed to perform integrated assessment.

Request: The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded by the current design basis. The licensee is requested to provide the flood height and associated effects (as defined in Section 9 of JLD-ISG-2012-05) that are not described in the flood hazard reevaluation report for mechanisms that trigger an Integrated Assessment. This includes the following quantified information for each flooding mechanism (as applicable):

- Hydrodynamic loading, including debris,
- Effects caused by sediment deposition and erosion (e.g., flow velocities, scour),
- Concurrent site conditions, including adverse weather, and
- Groundwater ingress

The NRC staff considers that timely responses to requests for additional information help ensure sufficient time is available for NRC staff review and contribute toward the NRC's goal of efficient and effective use of NRC staff resources. If circumstances result in the need to revise the requested response date, please contact me at 301-415-1030 or via e-mail at Richard.Guzman@nrc.gov.

Sincerely,

/ra/

Richard V. Guzman, Senior Project Manager
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

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

Enclosure:
Request for Additional Information

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