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

May 24, 2017

Mr. Dean Curtland
Site Director
NextEra Energy
Duane Arnold Energy Center
3277 DAEC Road
Palo, IA 52324-9785

SUBJECT: DUANE ARNOLD ENERGY CENTER – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NO. MF7923)

Dear Mr. Curtland:

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).

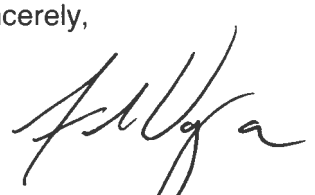
Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses. Concurrent with the reevaluation of flood hazards, licensees 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 be based on present-day methodologies and guidance, in the development of their mitigating strategies.

By letter dated January 25, 2017 (ADAMS Accession No. ML17026A415), NextEra Energy Duane Arnold, LLC (NextEra, the licensee) submitted the mitigation strategies assessment (MSA) for Duane Arnold Energy Center (Duane Arnold). 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 Duane Arnold MSA.

The NRC staff has concluded that the Duane Arnold 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 appear reasonably protected from reevaluated flood hazards conditions for beyond-design-basis external events. This closes out the NRC's efforts associated with CAC No. MF7923.

If you have any questions, please contact me at 301-415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,



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

Enclosure:
Staff Assessment Related to the
Mitigating Strategies for Duane Arnold

Docket No. 50-331

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO MITIGATION STRATEGIES FOR DUANE ARNOLD ENERGY CENTER, AS A

RESULT OF THE REEVALUATED FLOODING HAZARD

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

CAC NO. MF7923

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 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 (FIP) that describes how compliance with the requirements of Attachment 2 of the order was achieved. 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 be 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 NRC 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). Therefore, Appendix G of NEI 12-06, Revision 2, describes acceptable methods for demonstrating that the reevaluated flooding hazard at the Duane Arnold Energy Center (Duane Arnold) site is addressed against mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated March 10, 2014 (ADAMS Accession No. ML14072A019), NextEra Energy Duane Arnold, LCC (NextEra, the licensee) submitted its flood hazard reevaluation report (FHRR) for Duane Arnold. By letter dated March 31, 2016 (ADAMS Accession No. ML16084A767), the NRC issued an interim staff response (ISR) letter for Duane Arnold. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Duane Arnold, which were to be used as suitable input for the mitigating strategies assessment (MSA). For Duane Arnold, the mechanisms listed as not bounded by the CDB in the ISR letter are the local intense precipitation (LIP) and streams and rivers. The NRC staff subsequently issued the staff assessment of the FHRR for Duane Arnold by letters dated April 3, 2017 (ADAMS Accession No. ML17076A193), and April 14, 2017 (ADAMS Accession No. ML17103A440), containing additional details supporting the NRC staff's conclusions summarized in the ISR letter. The NRC staff review of the flood event duration (FED) and associated effects (AE) parameters associated with LIP and streams and rivers flooding mechanisms is provided below. By letter dated January 25, 2017 (ADAMS Accession No. ML17026A415), NextEra submitted the MSA for Duane Arnold for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

Duane Arnold's FLEX strategy is described in the document, "Compliance Letter and Final Integrated Plan (FIP) Beyond Design Basis FLEX Mitigation Strategies", which was submitted by letter dated December 7, 2016 (ADAMS Accession No. ML16347A010). The NRC staff is evaluating the strategies in the plan and will document the review in a safety evaluation. The purpose of the safety evaluation is to ensure the licensee has developed guidance and proposed designs that, if implemented appropriately, will adequately address the requirements of Order EA-12-049. An inspection will confirm compliance with the order.

A brief summary of Duane Arnold's FLEX strategies is listed below:

- Decay heat is removed when the safety relief valves (SRVs) open on high pressure and dump steam from the reactor pressure vessel (RPV) to the suppression pool located in the containment. Makeup to the RPV is provided by the reactor core isolation cooling (RCIC) turbine-driven pump. Within 30 minutes after initiation of the event, the operators take manual control of the SRVs to perform a controlled cooldown and depressurization of the reactor. When the suppression pool heats up to a predetermined setpoint, the vent to atmosphere is opened to mitigate the temperature rise and allow the RCIC system to continue to function.

- When the RCIC system is no longer available, the preferred RPV makeup supply in Phase 2 comes from one of two diesel-driven FLEX pumps. The suction source for the FLEX pump will be the circulating water pit or the condenser hotwell.

- Containment venting is expected to be required at roughly 13 hours into the event However, as stated above, to preserve RCIC, procedural guidance will direct operators to open the containment vent at approximately 4 hours after the initiation of the ELAP to reduce the heatup rate in containment. Opening the containment vent will allow containment temperature and pressure to stay within acceptable levels until equipment from the National Strategic Alliance for FLEX Emergency Response (SAFER) Response Center (NSRC) can be set up for cooling of the suppression pool.

- To maintain SFP cooling capabilities, the licensee stated that the required action is to establish the water injection lineup before the environment on the SFP operating deck degrades due to boiling in the pool so that personnel can access the refuel floor to accomplish the coping strategies. In addition, supplemental ventilation will be established by opening reactor building doors and a vent above the SFP prior to the onset of boiling.

- The operators will perform dc bus load stripping within the initial 2 hours following event initiation to ensure safety-related battery life is extended up to 10 hours. Following dc load stripping and prior to battery depletion, one 405-kilowatt (kW), 480 volt alternating current (Vac) generator will be deployed from an emergency response storage building. These portable generators will be used to repower essential battery chargers within 6 hours of ELAP initiation, as well as repowering the hardened containment vent system (HCVS) uninterruptable power supply.

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

For the streams and rivers flood causing mechanisms, the licensee provided a summary of Duane Arnold's FLEX design-basis (DB) flood in its MSA, which is a probable maximum flood (PMF) of the Cedar River in combination with wind-generated waves. According to the CLB, the maximum still water elevation combined with wind-wave run up would result in a flood elevation of 767.0 ft. mean sea level (MSL). The licensee stated that even though CLB flood elevation is lower than the reevaluated flood hazard elevation reported in the ISR of 767.8 ft. MSL, the FLEX design assumed flood conditions of at least 769 ft. MSL, which exceeds the reported value in the ISR letter.

Based on the staff's review of the FLEX storage locations, deployment paths, staging areas and overall strategy proposed in the FIP, the NRC staff concludes that the FLEX strategies can be successfully implemented considering the Mitigating Strategies Flood Hazard Information (MSFHI) provided in the ISR.

For the LIP flood causing mechanism, the licensee stated that water accumulations adjacent to plant buildings could potentially enter through normally closed doors in the turbine building. The licensee also stated that this potential ingress of water to the turbine building would flow to lower levels of the building and will not impact equipment relied on for the FLEX strategies. Additionally, the licensee stated that, given the small depth and short duration of the LIP event,

it would not impact the deployment times considered in the FLEX DB. Therefore, the licensee concluded that the FLEX DB bounds the MSFHI for LIP.

The NRC staff reviewed the information provided by the licensee in the MSA, along with the information provided in the FIP that confirmed the FLEX DB flood. The NRC staff confirmed that the water surface elevation reported in the MSA matches the value in the ISR letter of 758.2 ft. MSL. The NRC staff also 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. The staff agrees that, based on a period of inundation of 1.0 hour, this event would not impact any FLEX strategy, since no FLEX deployment activity is assumed to occur in the first 2 hours of an ELAP for any FLEX strategy. As a result, the NRC staff agrees that there appears to be sufficient time for flood waters to recede prior to the FLEX response activity taking place and therefore, no impact is expected to occur as a result of the reevaluated LIP hazard. The NRC staff concludes that the licensee has adequately assessed the MSFHI for the LIP event and that the applicable FLEX strategy can be implemented.

3.3 Confirmation of the Flood Hazard Elevations in the MSA

The NRC staff reviewed the flood hazard elevations in the MSA and confirmed the elevations match values in Table 2 of the ISR letter.

3.4 Evaluation of Flood Event Duration

The NRC staff reviewed the information provided by the licensee regarding Flood Event Duration (FED) parameters needed to perform the MSA for flood hazards not bounded by the CDB at the Duane Arnold. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 1 of this assessment.

3.4.1 Local Intense Precipitation

The licensee states in its MSA report that warning time is not credited (not applicable) in the flood protection strategy for LIP flood since only permanent/passive flood protection measures are relied on, and therefore, warning time was not considered as part of the MSA. The NRC staff notes that this approach is consistent with guidance provided by Appendix G of NEI 12-06, Revision 2. The NRC staff also notes that the licensee has the option to use NEI 15-05, "Warning Time for Local Intense Precipitation Events" (ADAMS Accession No. ML15104A158), to estimate warning time (as needed) for further analyses.

The maximum water surface elevations (WSEs) generated during the LIP event exceeding the CDB at four turbine building door locations were previously described in the Tables 4-5 and 4-6 of the FHRR. For the purposes of Table 2 of the ISR letter, only the maximum WSEs were reported. The licensee reported in its MSA that the duration of LIP inundation is approximately 1 hour and that the time necessary for LIP-related flood waters to recede from the site would be no more than 2 hours regardless of location.

The licensee used results from a 2-dimensional numerical modeling, as described in the FHRR, to determine the inundation and recession durations. The NRC staff confirmed that the licensee's reevaluation of the FED parameters for LIP and associated drainage uses present-day methodologies and regulatory guidance. Based on this review, the NRC staff determined that the licensee's FED parameters for the LIP flood-causing mechanism appear reasonable and acceptable for use in the MSA.

3.4.2 Streams and Rivers

In its MSA, the license reported a warning time of 113 hours for the streams and rivers flood-causing mechanism, which is the PMF at the Duane Arnold site. The licensee further reported in its MSA that the duration of inundation due to a PMF is approximately 72 hours. Lastly, the licensee reported that the time necessary for PMF-related flood waters to recede from the Duane Arnold site is approximately 28 hours.

The licensee relied on the U.S. Army Corps of Engineers' Hydrologic Engineering Center's River Analysis System computer code to estimate the flooding elevation as well as FED parameters due to the streams and rivers flood-causing mechanism in the FHRR. Based on its review of the modeling result provided by the licensee and documented in the audit report (ADAMS Accession No. ML16127A556), the NRC staff concluded that the licensee's PMF modeling is acceptable and the FED parameters are reasonable for use as part of the MSA review.

3.5 Evaluation of Flood Associated Effects

The NRC staff reviewed the information provided by NextEra regarding AE parameters for flood hazards not bounded by the CDB. The AE parameters related to WSE (i.e., stillwater elevation with wind waves and runup effects) were previously reviewed by the NRC staff, and were transmitted to the licensee via the ISR. The AE parameters not directly associated with water surface elevation are discussed below and are summarized in Table 2 of this assessment.

For the LIP flood-causing mechanism, the licensee stated in its FHRR that the AEs resulting from LIP flooding were considered minimal or not applicable due to the relatively slow water velocities and limited debris effects within the protected area. The NRC staff confirmed this statement by reviewing the licensee-provided LIP model input and output files. The NRC staff concluded that the estimated inundation depths and water velocities are acceptable and that the modeling is reasonable for use in the MSA. The NRC staff agrees with the licensee's conclusion that the AE parameters for the LIP flood-causing mechanism are either minimal or not applicable due to low water velocities and depths.

For the streams and rivers flood-causing mechanism, the licensee estimated a hydrostatic load of 625 lb/ft^2 for a flood depth of 10 ft, or an equivalent static moment of 10,463 ft-lb. The licensee stated in its FHRR that the pump house located in the main channel is adequately protected from potential water-borne loads, including hydrodynamic, debris, and sediment loads, as this structure was designed to withstand a tornado missile of 20,000 pounds per square inch. Finally, the licensee stated that all other AE parameters are also minimal or not applicable. The NRC staff concluded that the assessment of the AE parameters is acceptable and the assumptions are reasonable for use as part of the MSA review.

In summary, the NRC staff determined the licensee's methods were appropriate and the provided AE parameters are reasonable for use in the MSA.

3.6 Conclusion

The NRC staff has reviewed the information provided in the Duane Arnold MSA related to the FLEX strategies, as evaluated against the reevaluated hazard(s) described in Section 3 of this staff assessment, and concludes that:

- The FLEX strategies are not affected by the impacts of the reevaluated flood levels;
- The deployment of the FLEX strategies is not affected by the reevaluated flood levels; and
- Associated effects and FED have been appropriately considered in the Duane Arnold MSA.

Therefore, the NRC staff concludes that the licensee has demonstrated the capability to implement the FLEX strategies, as designed, under the conditions associated with the reevaluated LIP and streams and rivers, including relevant AEs and FED, 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 the MSA for Duane Arnold. The NRC staff confirmed that the licensee's flood hazard MSA for Duane Arnold 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 Duane Arnold MSA evaluation, and the description of its current FLEX strategy in the Duane Arnold 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 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	NEI 15-05 (NEI, 2015)	1 hr	2 hr
Streams and Rivers	113 hr	72 hr	28 hr

TABLE 2. ASSOCIATED EFFECTS PARAMETERS NOT DIRECTLY ASSOCIATED WITH TOTAL WATER HEIGHT FOR FLOOD-CAUSING MECHANISMS NOT BOUNDED BY THE CDB

ASSOCIATED EFFECTS PARAMETER	FLOODING-CAUSING MECHANISM			
	Local Intense Precipitation and Associated Drainage		Streams and Rivers	
	Powerblock (1)	*Intake Structure*	*Powerblock* (1)	*Intake Structure*
Hydrodynamic loading at plant grade	Minimal	Minimal	Minimal	10,463 ft-lb for hydrostatic moment
Debris loading at plant grade	Minimal	Minimal	Minimal	Minimal
Sediment loading at plant grade	Minimal	Minimal	Minimal	Minimal
Sediment deposition and erosion	Minimal	Minimal	Minimal	Minimal
Concurrent conditions, including adverse weather	Minimal	Minimal	Minimal	Minimal
Groundwater ingress	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Other pertinent factors (e.g., waterborne projectiles)	Not Applicable	Not Applicable	Minimal	Minimal

(1) Refers to multiple locations with the powerblock.

DUANE ARNOLD ENERGY CENTER – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED MAY 24, 2017

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