UNITED STATES
NUCLEAR REGULATORY COMMISSION
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June 14, 2017

Mr. Joel P. Gebbie
Senior Vice President and Chief
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Indiana Michigan Power Company
Nuclear Generation Group
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Bridgman, MI 49106

SUBJECT: DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2– FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NOS. MF7916 AND MF7917)

Dear Mr. Gebbie:

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 (ADAMS Accession No. ML12056A046). 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 December 15, 2016 (ADAMS Accession No. ML16355A017), Indiana Michigan Power Company (the licensee) submitted the mitigation strategies assessment (MSA) for Donald C. Cook Nuclear Plant, Units 1 and 2 (D.C. Cook). 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 D.C. Cook MSA.

The NRC staff has concluded that the D.C. Cook 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. MF7916 and MF7917.

If you have any questions, please contact me at 301-415-6197 or at Tekia.Govan@nrc.gov.

Sincerely,

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

Enclosure:
Staff Assessment Related to the
Mitigating Strategies for D.C. Cook

Docket Nos. 50-315 and 50-316

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO MITIGATION STRATEGIES FOR

DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2,

AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM

TASK FORCE RECOMMENDATION 2.1- FLOODING CAC NOS. MF7916 AND MF7917

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 sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). 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 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 is addressed within the Donald C. Cook Nuclear Plant, Units 1 and 2 (D.C. Cook) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated December 4, 2015 (ADAMS Accession No. ML15334A413), the NRC issued an interim staff response (ISR) letter for D.C. Cook. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for D.C. Cook and parameters that are suitable input for the mitigating strategies assessment (MSA). For D.C. Cook, the mechanism listed as not bounded by the CDB in the ISR letter is local intense precipitation (LIP) flooding. By letter dated December 15, 2016 (ADAMS Accession No. ML16355A017), Indiana Michigan Power Company (the licensee) submitted the D.C. Cook MSA for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

The NRC staff evaluated the D.C. Cook strategies as developed and implemented under Order EA-12-049, as described in the final integrated plan (FIP) for D.C. Cook (ADAMS Accession No. ML15169A106). The NRC staff's safety evaluation is dated November 9, 2015 (ADAMS Accession No. ML15264A851). The safety evaluation concluded that the licensee has developed guidance and proposed design that, if implemented appropriately, will adequately address the requirements of Order EA-12-049.

3.2 D.C. Cook's FLEX Strategies

A brief summary of D.C. Cook's FLEX strategies are listed below:

- For Phase 1, immediately following the occurrence of an extended loss of alternating current (ac) power (ELAP)/loss of ultimate heat sink (LUHS) event, with the steam generators available, core cooling would be accomplished by natural circulation. Steam generator inventory would be supplied by the turbine driven auxiliary feedwater pump with suction from the condensate storage tank. Reactor coolant system boration and makeup is not needed during the cooldown that occurs in Phase 1. The licensee strips non-essential loads within one hour to ensure battery power for essential loads for at least 12 hours following the event initiation.

- For Phase 2, the primary strategy for core cooling would be to continue using the steam generators as a heat sink and supplying makeup water with the turbine driven auxiliary feedwater pump. Upon depletion of the condensate storage tank inventory, a portable diesel-driven FLEX lift pump will be deployed to take suction from Lake Michigan at the circulating water forebay and discharge to a section of essential service water piping, which has a connection to the turbine driven auxiliary feedwater pump suction. The alternate core cooling strategy involves routing the discharge of the FLEX lift pump to a FLEX booster pump to achieve sufficient pressure to feed the steam generators. Borated water would be added to the reactor coolant system to make up for reactor coolant system contraction and leakage, as well as to maintain subcriticality. This is accomplished by the use of a portable FLEX boric acid reserve tank (BART) lift pump, a portable FLEX boric acid pump, and the boric acid reserve tank, which serves as the borated water source. FLEX portable 500 kilowatt (kW), 600 volt alternating current (Vac) diesel generators (DGs) will be deployed from the FLEX storage building and connected to power selected 600 Vac motor control centers to repower battery chargers or instrumentation prior to battery depletion. In addition, a 250 kW FLEX DG that powers the FLEX BART lift pump and the FLEX boric acid pump is deployed from the FLEX storage building.

- For Phase 3 the equipment provided by a National SAFER [Strategic Alliance for FLEX Emergency Response] Response Center (NSRC) will be transported to staging area B and will utilize the same deployment pathways as Phase 2 equipment for reactor coolant system inventory. Diesel generators provided by the NSRC would provide 4 kV power and allow operation of equipment necessary to establish residual heat removal cooling using the west component cooling water pump and the west residual heat removal pump on that unit. The NSRC will also deliver diesel-driven, low pressure-high flow raw water pumps and hydraulically driven floating lift pumps with a diesel driven hydraulic driver unit to provide flow to the essential service water system.

3.3 NRC's Evaluation

3.3.1 Evaluation of D.C. Cook's Current FLEX Strategies

The licensee stated that the design-basis flood event used to develop the FLEX mitigating strategies was the seiche occurring on Lake Michigan. Since the reevaluated LIP event could result in flood water levels that are not bounded by the design-basis flood elevation, the licensee performed the MSA to evaluate the impact of LIP on FLEX mitigating strategies.

The licensee performed an assessment consistent with Section G.4.1 of NEI 12-06 for the LIP flood hazard. Section G.4.1 of NEI 12-06 indicates the assessment should be performed by the licensee to address the impacts of the values provided in the ISR letter on: (1) the sequence of events; (2) the design and implementation of the FLEX strategies; (3) the FLEX equipment storage; (4) the robustness of plant equipment; (5) the location of FLEX connection points; and (6) the flood protection features credited in the FLEX strategies.

In addition, the licensee assessed the associated effects identified in NEI 12-06, Revision 2, Section G.2 that are potentially applicable. These associated effects include wave run-up, hydrodynamic loading, debris loading, sediment deposition, concurrent site conditions, and effects on groundwater intrusion. Specifically, the licensee indicated in D.C. Cook MSA Table 6-1 that wave run-up is minimal at the ten locations of interest described in the D.C. Cook MSA. For hydrodynamic loading, the licensee stated that the ten locations of interest are all in areas in

which there is only about 0.5 to 1.0 ft/s maximum storm water runoff velocity; thus, these areas are not subject to significant hydrodynamic loading. For debris loading, the licensee stated that the flood water velocity would be low in equipment staging areas near the protected area and near protected area entrances. With regard to sediment deposition, the licensee stated that the sand dunes to the east of the protected area may experience some degree of erosion. However, due to the watersheds and flow velocities and patterns, around the site, sedimentation is not expected to increase water surface elevations, within the protected area. Finally, the licensee stated in the D.C. Cook FHRR that the effects on groundwater intrusion for safety-related structures have a minimum margin of 0.8 ft. of protection (provided by the membrane waterproofing) above the potential ground water level resulting from the LIP event. The licensee explained that the increase in groundwater resulting from the postulated LIP event would not significantly increase the leakage rate. The NRC staff reviewed the licensee's disposition of each of the associated effects and finds it reasonable that the deployment and staging of FLEX equipment, and implementation of the FLEX mitigating strategies will not be impacted.

Based on the information provided in the D.C. Cook MSA, the NRC staff found that:

- The sequence of events for the FLEX strategies is affected by flood conditions as described in the ISR letter in such a way that the FLEX strategies cannot be implemented as currently developed;

- The validation performed for the deployment of the FLEX strategies is affected by the flood conditions provided in the ISR letter; and

- Certain FLEX equipment will need to be modified to ensure successful deployment and staging.

Therefore, the FLEX strategies, as designed, cannot be demonstrated to be effectively deployed to mitigate against a postulated LIP. The licensee is expected to modify the original strategies to address the impacts of the LIP event at the site.

In the D.C. Cook MSA, the licensee identified the specific actions that must be completed in order for successful implementation of its FLEX mitigating strategies during a LIP:

- Install, modify, or augment flood protection features for the auxiliary building and the Turbine Building and replace, qualify, or augment approximately 30 to 40 penetration seals;

- Modify several pieces of portable FLEX equipment to assure protection along the deployment pathway and/or the pre-staged locations; and

- Revise FLEX Support Guidelines (FSGs) and re-perform validations, as necessary.

The NRC staff's review of these specific actions that must be completed in order for successful implementation of its FLEX mitigating strategies is documented below.

3.3.2 Evaluation of D.C. Cook's Modified FLEX Strategies

The licensee identified the following actions that need to be taken in order to successfully deploy and implement its FLEX mitigating strategies:

- The FLEX Blended RCS makeup pump, which is pre-staged near the Unit 1 refueling water storage tank, may experience floodwaters of 0.1 ft. above the top of the trailer platform. The pumps and/or trailers will need to be modified to assure the pumps would remain functional;

- The FLEX 480V/600V "N+1" Transformer Trailer, which is pre-staged at the Unit 1 northeast staging location, may experience flood waters 0.7 ft. above the top of the trailer platform. The transformer and/or trailer will need to be modified to assure the transformers would remain functional. In addition, the FLEX 480V/600V "N+1" Transformer Trailer will need to be modified to ensure it is capable of traversing floodwaters along the deployment path;

- The administratively controlled minimum condensate storage tank water volume will be changed to assure that access to the UHS is not needed during the period when LIP floodwaters preclude deployment of FLEX equipment needed to supply UHS water to the turbine driven auxiliary feedwater pump;

- Plant flood protection features will be installed, replaced, augmented, or qualified as necessary to satisfactorily mitigate the ingress of flood water via the auxiliary building and turbine building pathways identified in D.C. Cook MSA, Table 8-1. In addition, new or modified flood protection features will be designed to perform the intended function under any new loads (i.e., flood height, associated effects, and flood event duration) due to the revised LIP event; and

- FSGs will be changed as needed, and validations will be re-performed as necessary. The validations will be performed in accordance with NRC accepted guidance that supports proposed regulation 10 CFR 50.155, "Mitigation of Beyond Design-Basis Events."

The NRC staff noted that, during its assessment of the FLEX strategies, the licensee considered the inundation LIP flood levels and duration of floodwater inundation around the site. The NRC staff finds that, consistent with NEI 12-06, Section G.6.2, the licensee identified the impacts of the LIP event to the FLEX strategies; described the necessary modifications to protect FLEX equipment from LIP floodwaters; identified the pathways for ingress of floodwaters into the auxiliary building and turbine building that require flood protection features; confirmed that the sequence of events are not impacted by the LIP event; and will revise FLEX procedures accordingly based upon validations. Based on the specified actions identified by the licensee in Enclosure 5 of the D.C. Cook MSA, the NRC staff finds it reasonable that the modified FLEX strategies can be implemented to address the reevaluated LIP event.

3.3.3 Evaluation of Associated Effects

The NRC staff reviewed the information provided by the licensee regarding the associated effects parameters for the D.C. Cook flood hazards not bounded by the CDB. Associated effects parameters related to water surface elevation (i.e., stillwater elevation with wind waves

and runup effects) were previously reviewed by the NRC staff, and were transmitted to the licensee via an ISR dated December 4, 2015. The associated effects parameters not directly associated with water surface elevation are discussed below and are summarized in Table 3.3.3-1 of this document.

For the LIP flood-causing mechanism, the licensee stated that the associated effects parameters related to water-borne loads, including hydrostatic, hydrodynamic, debris, and sediment loads, would induce minimal impacts to plant operations due to the low water depths and slow velocities. They also stated that other associated effects, including sediment deposition and erosion, concurrent site conditions, and effects on groundwater intrusion are insignificant at the D.C. Cook site. The licensee estimated the water depths and velocities using a two-dimensional numerical modeling method as described in the revised D.C. Cook FHRR. The NRC staff reviewed the LIP modeling as part of reviewing the revised D.C. Cook FHRR and concluded that the modeling approach used present-day methodologies and regulatory guidance. The NRC staff also performed a confirmatory run of the licensee-provided LIP model and determined that the water depths and velocities used to estimate the associated effects parameters are reasonable. The NRC staff has determine that the licensee's assessment of the associated effects parameters for the LIP flood-causing mechanism are acceptable for use in the D.C. Cook MSA.

3.3.4 Evaluation of Flood Event Duration

The NRC staff reviewed information provided by the licensee 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 3.3.4-1 of this document.

For the LIP flood causing mechanism, the licensee stated that the plant response to a LIP flood event does not credit warning time because entrance into the FSG is based on loss of all ac power and other equipment/system conditions; it is not based on potential weather conditions. The NRC staff notes that the licensee may adopt the warning time method allowed by NEI 15-05 if needed to support preparatory actions for LIP. The D.C. Cook MSA provides the periods of inundation ranging from 2 to 7 hours depending on the locations within the power block area, and the period of recession of up to 3 days. The licensee used the two-dimensional numerical model described in the D.C. Cook FHRR to determine these inundation and recession periods. The NRC staff reviewed the licensee's two-dimensional LIP model during the review of the revised D.C. Cook FHRR and concluded that the licensee's modeling and the estimation of the FED parameters are acceptable for use in the MSA as they used present-day methodologies and regulatory guidance. The NRC staff finds that the licensee has adequately addressed the impact of FED on the mitigating strategies.

4.0 CONCLUSION

The NRC staff has reviewed the information provided in the D.C. Cook MSA related to the original FLEX strategies, as evaluated against the reevaluated hazard(s) described in Section 2 of this staff assessment, and found that:

- The FLEX strategies are not affected by the impacts of the ISR flood levels (including impacts due to the environmental conditions created by the ISR flood levels);

- The licensee has provided an adequate description and justification of the modifications (equipment, procedures, etc.) necessary to address the revised FLEX actions; and

- Associated effects and FED are reasonable and acceptable for use in the D.C. Cook MSA, and have been appropriately considered in the MSA.

Therefore, the NRC staff concludes that the licensee has followed the guidance in Appendix G of NEI 12-06, Revision 2, and demonstrated the capability to deploy the FLEX strategies, as designed, against a postulated beyond-design-basis event for the LIP flood-causing mechanisms, including associated effects and FED.

TABLE 3.3.3-1. D.C. Cook – Associated Effect Parameters not Directly Associated with Total Water Height for Flood-Causing Mechanisms not Bounded by the CDB.

Associated Effects Factor	Local Intense Precipitation [1]
Hydrodynamic loading at plant grade	Minimal
Debris loading at plant grade	Minimal
Sediment loading at plant grade	Minimal
Sediment deposition and erosion	Minimal
Concurrent Conditions, including adverse weather	Minimal
Groundwater ingress	Minimal
Other pertinent factors (e.g., waterborne projectiles)	Minimal

(1) D.C. Cook MSA Table 7-3.

Table 3.3.4-1. D.C. Cook - 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 (1)	Use NEI 15-05 Guide	2 to 7 h	Up to 3 days

Source: D.C. Cook MSA

(1) The licensee has the option to use NEI guideline 15-05 to estimate the warning time necessary for flood preparation.

DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2– FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED JUNE 14, 2017

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