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

January 10, 2017

Mr. Bryan C. Hanson
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: THREE MILE ISLAND NUCLEAR STATION, UNIT 1– FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NO. MF1113)

Dear Mr. Hanson:

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 June 29, 2016 (ADAMS Accession No. ML16181A202), Exelon Generation Company, LLC (the licensee) submitted the mitigation strategies assessment (MSA) for Three Mile Island Nuclear Station, Unit 1 (TMI). 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 TMI MSA.

The NRC staff has concluded that the TMI 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 No. MF1113.

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 TMI

Docket No. 50-289

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO MITIGATION STRATEGIES FOR THREE MILE ISLAND NUCLEAR STATION, UNIT 1, AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE RECOMMENDATION 2.1- FLOODING CAC NO. MF1113

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).

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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 Three Mile Island Nuclear Station, Unit 1 (TMI) mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated March 31, 2016 (ADAMS Accession No. ML16091A091), the NRC issued an interim staff response (ISR) letter for TMI. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for TMI and parameters that are a suitable input for the mitigating strategies assessment (MSA). For TMI, the mechanisms listed as not bounded by the CDB in the ISR letter are the local intense precipitation (LIP), failure of dams and onsite water control/storage structures, and ice-induced flooding. By letter dated June 29, 2016 (ADAMS Accession No. ML16181A202), Exelon Generation Company, LLC (the licensee) submitted the TMI MSA for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 TMI's Current FLEX Strategies

A brief summary of TMI's FLEX strategies are listed below:

- The site has redundant FLEX diesel generators that can provide the power required for vital instrumentation and all FLEX equipment. The FLEX diesel fuel supply is provided by on-site fuel oil storage tanks, which are not affected by a flooding event.

- The control room indications of vital instruments are initially powered by the station batteries and eventually by the FLEX diesel generators.

- Core cooling is maintained by ensuring adequate reactor coolant system (RCS) inventory for natural circulation with the use of the once through steam generators (OTSGs) for decay heat removal. The submersible FLEX feedwater pumps provide OTSG makeup and take suction from either the condensate storage tanks, demineralized water storage tank, the hotwell or flood waters inundating the site.

The TMI MSA states that the FLEX strategies were designed for a 320 ft flood level, which they state completely bounds the ISR flood levels, with the exception of the LIP flood. The licensee initially designed the strategy such that FLEX equipment is either submersible or located above the flood level thus protecting it from a flood event and allowing the strategies to be implemented. Therefore, the TMI MSA was performed for the ISR flood levels for LIP and the licensee found they did not need to make any changes to their FLEX strategy. The licensee outlines the conservative assumptions they made when assessing the impacts of a LIP event and provides justification why they are conservative in nature.

Furthermore, the licensee analyzed all the components necessary for FLEX that are located outside of a safety-related building, turbine building, or the FLEX storage facility. The licensee also analyzed components that are below the 320 ft elevation in the turbine building. Table 3 in the TMI MSA assesses how a LIP event affects each of the identified components and did not identify any components that would be adversely affected during a LIP event. Therefore, the current FLEX strategies can be successfully deployed as designed for all applicable flood-causing mechanisms and no further actions, including modifications to FLEX, are required.

3.2. Evaluation of Associated Effects

The NRC staff reviewed the TMI flood hazard reevaluation report (FHRR) (ADAMS Accession No. ML15225A266) provided by the licensee regarding associated effects parameters for 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 in the ISR letter. Associated effects parameters not directly associated with water surface elevation are discussed below and are summarized in Table 3.2.2-1 of this staff assessment.

For the LIP event, the licensee stated in Table 27 of the TMI FHRR, that hydrostatic and hydrodynamic loads would be negligible because the LIP flood depth is less than 1 ft and the maximum velocity is less than 2 ft/s. The licensee also stated that the effects of sediment deposition and erosion or localized scouring are not expected because of generally low flow velocities around the power block area and that the effects of the infiltration of precipitation and groundwater ingress would likely be minimal due to the relatively impervious cover immediately around the power block buildings and the short-duration (1-hr) of the postulated LIP event. In addition, the licensee concluded that concurrent site conditions and other factors are not applicable. The NRC staff confirmed these statements by reviewing the licensee-provided input and output files for the LIP model. The NRC staff found that the inundation depths and flow velocities are accurate and the modeling is reasonable for use as part of the MSA review. The NRC staff agrees with the licensee's conclusion that the associated effects parameters for LIP are either minimal or not applicable.

For hydrologic dam failure combined with a probable maximum flood (PMF) event, the licensee reevaluated the hydrostatic, hydrodynamic (both current and wave impacts), and debris loads at the safety-related structures as part of the TMI FHRR. The licensee states in Table 23 of the TMI FHRR that the associated effects caused by sediment deposition and erosion in the immediate vicinity of TMI are minimal, and that TMI is not subject to effects with concurrent site condition or groundwater ingress. The NRC staff reviewed the licensee-provided model input and output files, and found that the licensee's associated parameters related to hydrostatic, hydrodynamic, and wave loads are reasonable and acceptable for use as part of the MSA review.

The licensee reevaluated natural and man-made debris loads in the Susquehanna River during the dam failure combined with PMF event. They evaluated debris impact loads near safety-related buildings for representative large tree debris with weight equal to 1,000 lb coming from the heavily-forested upper reaches of the Susquehanna River Basin. The maximum flood velocity near the buildings was selected and added to the wave flow velocity to compute the debris load. The estimated maximum debris impact load with a maximum total flow velocity of

9.3 ft/s on the intake screen and pump house (ISPH) west exterior wall is 9,580 pounds. The licensee also conservatively estimated a potential barge load of 2,874,080 pounds at the same location. However, the licensee concluded that this event is not plausible because: 1) the barge will not be able to cross the dike given the maximum estimated water depths over the dike (5 ft) being smaller than the typical values of barge draft (a minimum of 6 ft), and 2) the predicted barge impact load on the ISPH exterior walls is smaller than the design loads reported by the hypothetical aircraft impact loading for the ISPH. The NRC staff reviewed the calculation of the debris loads and the maximum velocities applied to the calculation. The NRC staff confirmed that the postulated tree log debris and barge loads follow the guideline of American Society of Civil Engineers Standard 7-10. The NRC staff found that the calculation is accurate and the assumptions are conservative. Therefore, the NRC staff concluded that the licensee's estimation of the debris loads are reasonable.

For ice-induced flooding, the licensee states that development of associated effects parameters is not required (and not applicable) because the reevaluated ice-induced flooding is bounded by the corresponding dam failure flooding combined with river PMF. The NRC staff agrees with the licensee's conclusion as this approach is consistent with the guideline provided by Appendix G of NEI 12-06, Revision 2.

In summary, the NRC staff determined that the licensee's methods were appropriate, that the provided associated effects parameters are reasonable for use in the MSA, and that associated effects have no impact on FLEX strategies.

3.3 Evaluation of Flood Event Duration

The NRC staff reviewed information provided by the licensee in the TMI FHRR 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 3.2.1-1.

For the LIP event, the licensee did not explicitly calculate warning time, but instead stated in the TMI FHRR that the LIP event has no appreciable warning time except those provided by a weather (precipitation) forecast and stated in the TMI FHRR that no warning time for LIP was assumed as part of the MSA. The LIP event created maximum water elevations and inundation periods for different locations across the power block, as listed in Table 3 of the TMI FHRR. The licensee used results from a 2-dimensional numerical model, as described in the TMI FHRR, to determine the inundation duration parameters. The NRC staff noted that the inundation period at the maximum water elevation for the side of the powerblock is 0.8 hours for the 1-hr, 1-mi^2, and a probable maximum precipitation event. The NRC staff confirmed that the licensee's reevaluation of the inundation periods for LIP and associated drainage uses present-day methodologies and regulatory guidance. Although the licensee did not directly provide the recession period for LIP, the recession period parameter can be obtained from the output of LIP modeling as discussed in supplemental TMI FHRR information.

For dam failure combined with PMF, the licensee states in Table 22 of the TMI FHRR that the warning time from initiation of rainfall to the beginning of inundation (at an elevation of 303.36 ft North American Vertical Datum of 1988 (NAVD88)) is 105.4 hours, and that the preparation time from the ISPH water surface elevation of 283.4 ft NAVD88 (or a river discharge greater than 200,000 cfs) to the beginning of site inundation is 37.7 hours. The licensee reported an

inundation period of 30.7 hours during which time the floodwaters are at or above the dike top elevation of 303.6 ft NAVD88 (comparable to the normal site grade). The licensee determined 8 hours for the period of recession for floodwaters to recede from elevation 303.6 ft NAVD88 to the elevation of the air intake pagoda, which is the lowest safe shutdown structure. To determine the adequacy of the flood event duration parameters, the NRC staff reviewed the licensee's hydrologic and hydraulic model for the combined riverine flood event. As a result, the NRC staff determined that the range of the licensee-proposed warning time trigger points adequately covers the PMF propagation time for the river-basin flooding event. The NRC staff agrees with the licensee's conclusion regarding the warning time, period of inundation, and period of recession for the dam failure combined with PMF event.

For ice-induced flooding, the licensee states that development of FED parameters are not required (and not applicable) because the reevaluated ice-induced flooding is bounded by the corresponding dam failure flooding combined with river PMF.

In summary, the NRC staff agrees with the licensee's results regarding the FED parameters, and also finds that the licensee determined the FED parameters consistent with Appendix G of NEI 12-06, Revision 2. The NRC staff determined that the FED has no impact on FLEX strategies.

4.0 CONCLUSION

The NRC staff has reviewed the information provided in the TMI MSA related to the 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 deployment of the FLEX strategies is not affected by the impacts of the ISR flood levels.

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

Therefore, the NRC staff concludes that the licensee has followed the guidance in NEI 12-06, Revision 2, and demonstrated the capability to deploy the original FLEX strategies, as designed, against a postulated beyond-design-basis event for the LIP, failure of dams and onsite water/control storage structures, and ice-induced flood-causing mechanisms, including associated effects and flood event duration.

Table 3.2.1-1. 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	No Appreciable Warning Time (1)	0 ~ 0.8 hour	Values can be obtained from LIP model output
Failure of Dams and Onsite Water Control/Storage Structures: Overtopping Dam Failure Combined with PMF	105.4 hours for warning time, or 37.7 hours for preparation time	37.7 hours	8 hours
Ice-Induced Flooding (2)	Not Applicable	Not Applicable	Not Applicable

Source: (TMI FHRR; and TMI FHRR, Supplemental Response)

Notes:

(1) The licensee states that a LIP event has no appreciable warning time except those provided by a weather forecast, thus no warning time for this event was assumed.

(2) FED parameters for ice-induced flooding are not applicable because the reevaluated flood level for this event is bounded by that for dam failure combined with PMF event.

Table 3.2.2-1. Associated Effects Parameters not Directly Associated with Total Water Height for Flood-Causing Mechanisms not Bounded by the CDB.

	Flooding Mechanism		
Associated Effects Parameter	**Local Intense Precipitation**	**Dam Failure Combined with PMF**	**Ice-Induced Flooding** (1)
Hydrodynamic loading at plant grade	Minimal	At Air Intake, 531 psf for hydrostatic pressure, and 104 psf for hydrodynamic pressure	Not Applicable
Debris loading at plant grade	No Impact	At ISPH West Exterior Wall, 9,580 lb for log load and 2,874,000 lb for barge load	Not Applicable
Sediment loading at plant grade	No Impact	Minimal	Not Applicable
Sediment deposition and erosion	No Impact	Minimal	Not Applicable
Concurrent conditions, including adverse weather	No Impact	No Impact	Not Applicable
Groundwater ingress	No Impact	No Impact	Not Applicable
Other pertinent factors (e.g., waterborne projectiles)	No Impact	No Impact	Not Applicable

Source: (TMI FHRR; and TMI FHRR, Supplemental Response)

Notes:

(1) FED parameters for ice-induced flooding are not provided because the reevaluated flood level for this event is bounded by that for dam failure combined with PMF event.

SUBJECT: THREE MILE ISALND NUCLEAR STATION, UNIT 1– FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED January 10, 2017

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