



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

November 4, 2015

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
4300 Winfield Rd
Warrenville, IL 60555

SUBJECT: DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3 – SUPPLEMENT TO
STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION
REQUEST – FLOOD-CAUSING MECHANISMS REEVALUATION (TAC
NOS. MF1795 AND MF1796)

Dear Mr. Hanson:

The purpose of this letter is to transmit the supplement to the U.S. Nuclear Regulatory Commission (NRC) staff's assessment of Dresden Nuclear Power Station, Units 2 and 3 (Dresden) reevaluated flood hazard information that was issued to you by a letter dated March 31, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15072A007). The supplement updates the original staff assessment to address changes in the NRC's approach to next steps following the review of the flood hazard reevaluations as directed by the Commission. The letter also addresses the next steps associated with the mitigation strategies assessment with respect to the reevaluated flood hazards.

By letter dated March 12, 2012 (ADAMS Accession No. ML12053A340), the 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 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 reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated March 10, 2013 (ADAMS Accession No. ML13135A120), Exelon Generation Company, LLC (the licensee) responded to this request for Dresden. In response to NRC staff questions, this response was supplemented by letter dated May 19, 2014 (ADAMS Accession No. ML15092A821). The NRC staff has completed its review of the information provided, as documented in the staff assessment and the enclosed supplement to the staff assessment. This closes out the NRC's efforts associated with TAC Nos. MF1795 and MF1796.

The enclosed supplement to the staff assessment updates the NRC staff's conclusions in accordance with the flood hazard reevaluation approach described in NRC letter dated September 1, 2015 (ADAMS Accession No. ML15174A257), concerning the coordination of requests for information regarding flooding hazard reevaluations and mitigating strategies for beyond-design-basis external events. This letter describes the changes in the NRC's approach to the flood hazard reevaluations that were approved by the Commission in its Staff Requirements Memorandum (ADAMS Accession No. ML15209A682) to COMSECY-15-0019 (ADAMS Accession No. ML15153A104) that described the NRC's mitigating strategies and flooding hazard reevaluation action plan.

B. Hanson

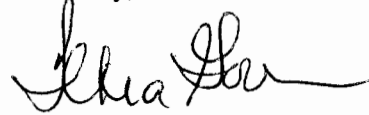
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As documented in the NRC staff assessment and the enclosed supplement, the NRC staff has concluded that the licensee's reevaluated flood hazard information is suitable for the assessment of mitigation strategies developed in response to Order EA-12-049 (i.e., defines the mitigating strategies flood hazard information described in guidance documents currently being finalized by the industry and NRC staff) for Dresden. Further, the NRC staff continues to assert that the licensee's reevaluated flood hazard information is suitable for other assessments associated with Near-Term Task Force Recommendation 2.1 "Flooding."

The reevaluated flood hazard results for local intense precipitation and upstream dam failures were not bounded by the current design-basis flood hazard. In order to complete its response to Enclosure 2 to the 50.54(f) letter, the licensee is expected to submit a revised integrated assessment or focused evaluation(s), as appropriate, to address these reevaluated flood hazards, as described in the NRC's September 1, 2015 letter.

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

Sincerely,

A handwritten signature in black ink, appearing to read "Tekia Govan", written in a cursive style.

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

Docket Nos. 50-237 and 50-249

Enclosure:
Supplement to Staff Assessment of Flood
Hazard Reevaluation Report

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SUPPLEMENT TO
STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATED TO FLOODING HAZARD REEVALUATION REPORT
NEAR-TERM TASK FORCE RECOMMENDATION 2.1
RELATED TO THE FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT
DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3
DOCKET NOS. 50-237 AND 50-249

1.0 INTRODUCTION

This document is a supplement to the U.S. Nuclear Regulatory Commission (NRC) staff assessment that was transmitted by letter dated March 31, 2015 (NRC, 2015a), to Exelon Generation Company, LLC (the licensee) for Dresden Nuclear Power Station, Units 2 and 3 (Dresden, DNPS). With the exceptions of the Table 3.1.2-1 and the Reference section, this supplement only contains the sections that were changed to resolve the open items and reflect the changes in the NRC's approach to the flood hazard reevaluations that were approved by the Commission in its Staff Requirements Memorandum (SRM) (NRC, 2015b) to COMSECY-15-0019 (NRC, 2015c), which described the NRC's mitigating strategies and flooding hazard reevaluation action plan. Table 3.1.2-1 at the end of the supplement is copied from the staff assessment for convenience. Instead of repeating the Reference section in its entirety, only the additions to the list of references are included in the supplement.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

There are no changes or updates to this section of the NRC staff assessment.

2.2 Enclosure 2 to the 50.54(f) Letter

By letter dated March 12, 2012 (NRC, 2012a) the NRC issued a request for information Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The 50.54(f) letter requests all power reactor licensees and construction permit holders reevaluate all external flooding-causing mechanisms at each site. The reevaluation should apply present-day methods and regulatory guidance that are used by the NRC staff to conduct early site permit (ESP) and combined license (COL) reviews. This includes current techniques, software, and methods used in present-day standard engineering practice. If the reevaluated flood-causing mechanisms are not bounded by the current plant design-basis flood hazard, an integrated assessment may be necessary.

Enclosure

2.2.1 Flood-Causing Mechanisms

There are no changes or updates to this section of the NRC staff assessment.

2.2.2 Associated Effects

There are no changes or updates to this section of the NRC staff assessment.

2.2.3 Combined Effects Flood

There are no changes or updates to this section of the NRC staff assessment.

2.2.4 Flood Event Duration

There are no changes or updates to this section of the NRC staff assessment.

2.2.5 Actions Following the Flooding Hazard Reevaluation Report (FHRR)

For the sites where the reevaluated probable maximum flood elevation is not bounded by the current design-basis probable maximum flood elevation for all flood-causing mechanisms, the 50.54(f) letter requests licensees and construction permit holders to:

- Submit an Interim Action Plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard.
- Perform an integrated assessment subsequent to the FHRR to (a) evaluate the effectiveness of the current licensing basis (i.e., flood protection and mitigation systems), (b) identify plant-specific vulnerabilities, and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the flood event duration.

After issuance of the 50.54(f) letter, the NRC changed the approach to the steps following the review of the flood hazard reevaluations, as directed by the Commission, to permit use of focused evaluations as an alternative to an integrated assessment. The NRC letter dated September 1, 2015 (NRC, 2015d) describes the changes in the NRC's approach to the flood hazard reevaluations.

If the reevaluated flood hazard is bounded by the current design-basis flood hazard for all flood-causing mechanisms at the site, licensees are not required to perform an integrated assessment or focused evaluation(s) at this time.

3.0 TECHNICAL EVALUATION

There are no changes or updates to this section of the NRC staff assessment.

3.1 Site Information

There are no changes or updates to this section of the NRC staff assessment.

3.2 LIP and Associated Site Drainage

There are no changes or updates to this section of the NRC staff assessment.

3.2.1 Model Inputs and Assumptions

There are no changes or updates to this section of the NRC staff assessment.

3.2.2 Probable Maximum Precipitation

The licensee's analysis developed the 1-hour, 1-square mile probable maximum precipitation (PMP) event distribution using Hydrometeorological Reports (HMRs) 51 and 52 (National Oceanic and Atmospheric Administration (NOAA), 1978 and 1982). The licensee stated that the local intense precipitation (LIP) event is defined by NUREG/CR-7046 (NRC, 2011d) as the 1-hour, 1-square mile PMP event. The licensee extrapolated from the PMP depth contour map provided in HMR 52. The licensee developed the distribution of the 1-hour PMP from the 5-, 15-, 30- and 60-minute time intervals from HMR 52. The licensee computed a cumulative depth of the 1-hour, 1-square mile PMP of 17.97 inches (45.28 cm). The NRC staff verified the HMR 51 and HMR 52 computations based on the location of the DNPS, and concluded the PMP depths are appropriate.

The NRC staff notes that a reasonable estimate of the site's LIP PMP is the application of an appropriate NOAA HMR estimate for any rainfall duration used in NUREG/CR-7046, regardless of temporal distribution of the rainfall. The licensee obtained 1-sq. mile PMP depths for durations ranging between 5-minutes to 1-hour using HMR-51 and HMR-52. Therefore, the NRC staff confirmed that the licensee selected appropriate rainfall rate values to satisfy the 50.54(f) information request.

Based on the NRC staff's reviews of FHRRs to date, the NRC staff observed that, when using transient rainfall runoff models, PMP events having longer than 1-hour durations may result in higher LIP flood elevations and longer periods of inundation than the 1-hour event. NRC staff also noted that LIP events deriving from PMPs having relatively short durations may result in limiting warning time and may likewise result in consequential LIP flood elevation (e.g., flood elevations above the openings to plant structures).

3.2.3 Site Topography

There are no changes or updates to this section of the NRC staff assessment.

3.2.4 Site Land Cover

There are no changes or updates to this section of the NRC staff assessment.

3.2.5 FLO-2D Results

The licensee computed the water surface elevations, maximum flooding depths, maximum velocity, maximum resultant impact loading (forces due to moving water), and maximum resultant static load (height of water) using the FLO-2D model. The maximum flood elevation of 518.1 ft (157.9 m) occurs at several Category 1 structures. The flooding depths range between 0.1 ft (0.03 m) (Reactor Building, Unit 3) to 1.7 ft (0.5 m) (Turbine Building, Unit 2), which produce a maximum static load of 85.0 lbs. per ft (126.5 kg-force per m). The velocities are generally less than 1 foot per second (ft/s; 0.3 meters per second (m/s)), with resultant impact loads of 5 lbs. per ft (7.5 kg-force per m) or less.

The licensee noted that based on the sensitivity analysis of the grid size and Manning's n values (n-values), an accuracy of +/- 0.1 ft (0.03 m) should be taken when considering the flood elevations.

The NRC staff reviewed the FLO-2D model input and output files provided by the licensee. In the course of the review, NRC staff performed a mass balance verification and concluded that the runoff amount passing through the model boundary is less than the amount of rainfall. The difference in mass could result in a potential underestimation of the maximum water levels around the site. The licensee is requested to resolve numerical modeling issue associated with the LIP flood analyses, specifically the reduction of volume of outflow runoff as compared to the inflow precipitation, accounting for infiltration. This issue may relate to runoff from rooftops being removed from the numerical model domain rather than discharging to the ground surface near the structure or an adjacent area.

3.2.6 Site-Specific Probable Maximum Precipitation

There are no changes or updates to this section of the NRC staff assessment.

3.2.7 NRC Staff Conclusion

The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated site drainage is not bounded by the current design-basis flood hazard. Therefore, the licensee is expected to submit a focused evaluation for LIP and associated site drainage consistent with the process outlined in COMSECY-15-0019 (NRC, 2015b) and associated guidance that will be issued. Under this approach, the NRC staff anticipates that licensees will perform and document a focused evaluation for LIP and associated site drainage that evaluates the impact of the LIP hazard on the site and implements any necessary programmatic, procedural or plant modifications to address this hazard exceedance. The modelling issues that are discussed in Section 3.2.5 should be addressed in the focused evaluation, if the licensee uses the same FLO-2D model in its focused evaluation. The NRC staff anticipates that licensees will submit letters providing a summary of the evaluation and, if needed, regulatory commitments to implement and maintain appropriate programmatic, procedural or plant modifications to protect against the LIP hazard.

3.3 Streams and Rivers

There are no changes or updates to this section of the NRC staff assessment.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

There are no changes or updates to this section of the NRC staff assessment.

3.4.1 Critical Dam Evaluation and Selection

There are no changes or updates to this section of the NRC staff assessment.

3.4.2 Upstream Dam Failure Mechanism Summary

There are no changes or updates to this section of the NRC staff assessment.

3.4.3 Hydrologic Dam Failure Analysis

There are no changes or updates to this section of the NRC staff assessment.

3.4.4 Seismic Upstream Dam Failure

There are no changes or updates to this section of the NRC staff assessment.

3.4.5 Upstream Dam Failure Timing and Duration

There are no changes or updates to this section of the NRC staff assessment.

3.4.6 Other Associated Effects of Upstream Dam Failure

3.4.7 NRC Staff Conclusion

The NRC staff reviewed the assumptions and approach used in the flooding from upstream dams analysis, and concluded the approach appropriate and assumptions to be reasonable. The NRC staff verified that the models were consistent with results presented in the FHRR and that in cases where the one model output was used as an input to another model, the two data sets were exactly the same. The NRC staff verified the references used, to ensure that they met standard engineering practices and NRC guidance. The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for failure of dams and onsite water control or storage structures is not bounded by the current design-basis flood hazard. Therefore, the treatment of the upstream dam failures should be addressed in the integrated assessment or focused evaluation consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015c).

3.5 Storm Surge

There are no changes or updates to this section of the NRC staff assessment.

3.6 Seiche

There are no changes or updates to this section of the NRC staff assessment.

3.7 Tsunami

There are no changes or updates to this section of the NRC staff assessment.

3.8 Ice-Induced Flooding

There are no changes or updates to this section of the NRC staff assessment.

3.9 Channel Migrations or Diversions

There are no changes or updates to this section of the NRC staff assessment.

4.0 REEVALUATED FLOOD HEIGHT, EVENT DURATION AND ASSOCIATED EFFECTS FOR HAZARDS NOT BOUNDED BY THE CDB

The NRC staff confirms that the reevaluated hazard results for LIP and dam failures are not bounded by the current design-basis flood hazard. Therefore, the NRC staff anticipates that the licensee will perform additional assessments (i.e., integrated assessment or focused evaluation) of plant response for DNPS, as described in NRC letter dated September 1, 2015 (NRC, 2015d).

The NRC staff reviewed the following flood hazard parameters needed to perform the additional assessments or evaluations of plant response:

- Flood event duration, including warning time and intermediate water surface elevations that trigger actions by plant personnel, as defined in Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-05. Flood event durations for the flood-causing mechanisms identified above are shown in Table 4.0-1.
- Flood height and associated effects, as defined in JLD-ISG-2012-05. Flood height and associated effects for the flood-causing mechanisms identified above are shown in Table 4.0-2.

Based upon the preceding analysis, the NRC staff confirmed that the reevaluated flood hazard information is appropriate input to other assessments or evaluations associated with Near-Term Task Force Recommendations, including the assessment of mitigation strategies developed in response to Order EA-12-049 (i.e., defines the mitigating strategies flood hazard information described in guidance documents currently being finalized by the industry and NRC staff).

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms of DNPS, Units 2 and 3. Based on its review, the NRC staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based on the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter. In reaching this determination, the NRC staff confirmed the licensee's conclusions that (a) the reevaluated flood hazard results for LIP and upstream dam failure are not bounded by the current design-basis flood hazard, (b) additional assessments of plant response will be performed for the local intense precipitation and upstream dam failure flood-causing mechanisms, and (c) the reevaluated flood-causing mechanism information is appropriate input to additional assessments or evaluations of plant response, as described in the 50.54(f) letter and COMSECY-15-0019 (NRC, 2015b), including the assessment of mitigation strategies developed in response to Order EA-12-049 (i.e., defines the mitigating strategies flood hazard information described in guidance documents currently being finalized by the industry and NRC staff).

The NRC staff has no additional information needs at this time with respect to the FHRR.

6.0 REFERENCES

6.1 U.S. Nuclear Regulatory Commission (NRC) Documents and Publications:

NRC (U.S. Nuclear Regulatory Commission), 2015a, letter from Victor Hall (NRC), to Bryan Hanson, Senior Vice President, Exelon Generation Company, LLC, "Dresden Nuclear Power Station, Units 2 and 3 – Staff Assessment of Response to 10 CFR 50.54(f) Information Request- Flood-Causing Mechanism Reevaluation" (TAC Nos. MF1795 AND MF1796) March 31, 2015, ADAMS Accession No. ML15072A007.

NRC (U.S. Nuclear Regulatory Commission), 2015b, "SRM – COMSECY-15-0019 – Closure Plan for the Reevaluation Of Flooding Hazards for Operating Nuclear Power Plants," COMSECY-15-0019, July 28, 2015, ADAMS Accession No. ML15209A682.

NRC (U.S. Nuclear Regulatory Commission), 2015c, "Closure Plan for the Reevaluation of Flooding Hazards For Operating Nuclear Power Plants," COMSECY-15-0019, June 30, 2015, ADAMS Accession No. ML15153A104.

NRC (U.S. Nuclear Regulatory Commission), 2015d, letter from William M. Dean, Director, to Power Reactor Licensees, "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design-Basis External Events", ADAMS Accession No. ML15174A257.

6.2 Codes and Standards

There are no additions to the references in this section.

6.3 Other References:

There are no additions to the references in this section.

Table 3.1.2-1. Current Design Basis Flood Hazards

Flooding Mechanism	Stillwater Elevation ft (m) NGVD29	Associated Effects	Current Design Basis Flood Elevation ft (m) NGVD29	Reference
LIP and Associated Drainage	517.5 (157.7)	Not discussed	517.5 (157.7)	Exelon, 2013b Section 5
Streams and Rivers	525.0 (160.0)	3.0 ft (0.9 m) (wind wave)	528.0 (160.9)	FHRR, Section 2.a
Failure of Dams and Onsite Water Control/Storage Structures	508.2 (154.9)	Not discussed	508.2 (154.9)	FHRR, Section 2.a
Storm Surge	Not applicable to DNPS site.			FHRR, Section 2.a
Seiche	Not applicable to DNPS site.			FHRR, Section 2.a
Tsunami	Not applicable to DNPS site.			FHRR, Section 2.a
Ice-Induced	No elevation provided in UFSAR.			FHRR, Section 2.a
Channel Migrations or Diversions	No elevation provided in UFSAR; discussed in reference to control of locks and dams by USACE.			FHRR, Section 2.a

Table 4.0-1: Flood Event Duration for Flood-Causing Mechanisms Not Bounded by CDB Hazard

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
LIP and Associated Drainage	See Section 3.2	See Section 3.2	See Sections 3.2
Failure of Dams and Onsite Water Control/Storage Structures	1 day, 12 hours, and 45 minutes (Kaegi, 2013)	6 days, 15 hours (Table 6.1, Barstow, 2014b)	11 days, 8 hours (Table 6.1, Barstow, 2014b)

Table 4.0-2: Reevaluated Flood Hazards for Flood-Causing Mechanisms Not Bounded by CDB Hazard

Flood-Causing Mechanism	Stillwater Elevation, ft (m) NGVD29	Associated Effects	Reevaluated Flood Hazard, ft (m) NGVD29	Reference
LIP and Associated Drainage	Varies with maximum of 518.1 (157.9)	None	Varies with maximum of 518.1 (157.9)	Exelon, 2013b, Section 4
Failure of Dams and Onsite Water Control/Storage Structures	Varies with a maximum of 524.8 (160.0)	Varies with a maximum of 4.2 (1.3) (Wind wave and wave runup)	Varies with a maximum of 529.0 (161.2)	FHRR, Section 3, Table 1, and Section 4, Table 6

Table 4.0-3 Associated Effects Inputs Not Bounded by CDB Hazard

Associated Effects Factor	Flooding Mechanism	
	Local Intense Precipitation	Failure of Dams and Onsite Water Control/Storage Structures
Hydrodynamic loading at plant grade	Minimal, not bounding (FHRR, Section. 4.2)	117.2 psf (572.2 kg-force/m ²) (FHRR, Table 4)
Debris loading at plant grade	None	Varies with maximum of 3,387 lbs (1,536 kg) at Unit 2 Turbine Building (Barstow, 2014b)
Sediment loading at plant grade	None	Minimal effect (Barstow, 2014b)
Sediment deposition and erosion	None	Minimal effect (Barstow, 2014b)
Concurrent conditions, including adverse weather	None	Hail, strong winds, and tornadoes (Barstow, 2014b)
Groundwater ingress	None	Bounded (Barstow, 2014b)
Other pertinent factors (e.g., waterborne projectiles)	None	Examined barge collision (Barstow, 2014b)

Table 5.0-1: Integrated Assessment Open Items

Deleted

As documented in the NRC staff assessment and the enclosed supplement, the NRC staff has concluded that the licensee's reevaluated flood hazard information is suitable for the assessment of mitigation strategies developed in response to Order EA-12-049 (i.e., defines the mitigating strategies flood hazard information described in guidance documents currently being finalized by the industry and NRC staff) for Dresden. Further, the NRC staff continues to assert that the licensee's reevaluated flood hazard information is suitable for other assessments associated with Near-Term Task Force Recommendation 2.1 "Flooding."

The reevaluated flood hazard results for local intense precipitation and upstream dam failures were not bounded by the current design-basis flood hazard. In order to complete its response to Enclosure 2 to the 50.54(f) letter, the licensee is expected to submit a revised integrated assessment or focused evaluation(s), as appropriate, to address these reevaluated flood hazards, as described in the NRC's September 1, 2015 letter.

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

Sincerely,

/RA/

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

Docket Nos. 50-237 and 50-249

Enclosure:
 Supplement to Staff Assessment of Flood
 Hazard Reevaluation Report

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*via email

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