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

September 25, 2017

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

SUBJECT: NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF EXELON GENERATION COMPANY, LLC'S FLOOD HAZARD REEVALUATION REPORT SUBMITTAL RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3 (CAC NOS. MF6598 AND MF6599)

Dear Mr. Hanson:

By letter dated August 26, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15230A235), the U.S. Nuclear Regulatory Commission (NRC) informed you of the staff's plan to conduct a regulatory audit of Exelon Generation Company, LLC's (the licensee) Flood Hazard Reevaluation Report (FHRR) submittal related to the Near-Term Task Force Recommendation 2.1-Flooding for Peach Bottom Atomic Power Station, Units 2 and 3 (Peach Bottom). The audit was intended to support the NRC staff review of the licensee's FHRR and the subsequent issuance of a staff assessment.

The audit meetings conducted on February 12, 2016, March 4, 2016, March 11, 2016, and June 17, 2016, were performed consistent with NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (ADAMS Accession No. ML082900195). Therefore, the purpose of this letter is to provide you with the final audit report, which summarizes and documents the NRC's regulatory audit of the licensee's FHRR submittal.

Enclosure 1 transmitted herewith contains Security-Related Information. When separated from Enclosure 1, this document is decontrolled.

If you have any questions, please contact me at (301) 415-1056 or e-mail at Lauren.Gibson@nrc.gov.

Sincerely,

Lauren Kate Gibson

Lauren K. Gibson, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-277 and 50-278

Enclosures:
1. Audit Report (Non-Public)
2. Audit Report (Public)

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NUCLEAR REGULATORY COMMISSION AUDIT REPORT FOR THE AUDIT OF EXELON GENERATION COMPANY, LLC'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3

BACKGROUND AND AUDIT BASIS

By letter dated March 12, 2012, 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 license" (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 Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident. Recommendation 2.1 in that document recommended that the NRC staff issue orders to all licensees to reevaluate seismic and flooding hazards for their sites against current NRC requirements and guidance. Subsequent Staff Requirements Memoranda associated with Commission Papers SECY 11-0124 and SECY 11-0137, instructed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f).

By letter dated August 12, 2015 (Agencywide Documents Access and Management System Accession No. ML15233A067), Exelon Generation Company, LLC (Exelon, the licensee) submitted its Flood Hazard Reevaluation Report (FHRR) for Peach Bottom Atomic Power Station, Units 2 and 3 (Peach Bottom). The NRC is in the process of reviewing the aforementioned submittal and has completed a regulatory audit of the licensee to better understand the development of the submittal, identify any similarities/differences with past work completed, and ultimately aid in its review of the licensees' FHRR. This audit summary is being completed in accordance with the guidance set forth in NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (ADAMS Accession No. ML082900195).

AUDIT LOCATION AND DATES

The audit was completed by document review via a webinar session in conjunction with the use of the licensee's established electronic reading room (ERR) and teleconference on February 12, 2016, March 4, 2016, March 11, 2016, and June 17, 2016.

Enclosure 2

AUDIT TEAM

Title	Team Member	Organization
Team Leader, NRR/JLD	Tekia Govan	NRC
Technical Monitor	Richie Rivera-Lugo	NRC
Technical Staff	Ken See	NRC
Technical Deputy Division Director	Andy Campbell	NRC
Technical Branch Chief	Christopher Cook	NRC
NRC Contractor	Roger Kay	U.S. Army Corp of Engineers (USACE)
NRC Contractor	Curtis Miller	USACE
NRC Contractor	John Quinn	Argonne National Laboratory (ANL)
NRC Contractor	Eugene Yan	ANL

A list of the licensee's participants can be found in Attachment 2.

DOCUMENTS AUDITED

Attachment 1 of this report contains a list which details the documents that were reviewed by the NRC staff, in part or in whole, as part of this audit. The documents were located in an ERR during the NRC staff's review. No additional information was requested to be submitted on the docket as a result of this audit.

AUDIT ACTIVITIES

In general, the audit activities consisted mainly of the following actions:

- Review background information on site topography and geographical characteristics of the watershed.
- Review site physical features and plant layout.
- Understand the selection of important assumptions and parameters that would be the basis for evaluating the individual flood causing mechanisms described in the 50.54(f) letter.
- Review model input/output files to computer analyses such as Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS) and FLO-2D to have an understanding of how modeling assumptions were programmed and executed.
- Status of the submittal for associated effects and flood event duration.

Table 1 summarizes specific technical topics (and resolution) of important items that were discussed and clarified during the audit. The items discussed in Table 1 may be referenced/mentioned in the staff assessment in more detail.

EXIT MEETING/BRIEFING

On June 17, 2016, the NRC staff closed out the discussion of the technical topics described above.

Table 1: Peach Bottom, Units 2 and 3 Information Needs and Response Summary

INFORMATION NEED NO.	INFORMATION NEED REQUEST	RESPONSE
1	**All Flood-Causing Mechanisms – Comparison of Reevaluated Flood Hazard with Current Design Basis** Background: Recommendation 2.1 of the 50.54(f) letter (NRC, 2012) provides instructions for the Flood Hazard Reevaluation Report (FHRR). Under Section 1, Hazard Reevaluation Report, Items c and d, licensees are requested to perform: c. Comparison of current and reevaluated flood-causing mechanisms at the site. Provide an assessment of the current design basis flood elevation to the reevaluated flood elevation for each flood-causing mechanism. Include how the findings from Enclosure 4 of this letter (i.e., Recommendation 2.3 flooding walkdowns) support this determination. If the current design basis flood bounds the reevaluated hazard for all flood-causing mechanisms, include how this finding was determined. d. Interim evaluation and actions taken or planned to address any higher flooding hazards relative to the design-basis, prior to completion of the integrated assessment described below, if necessary. The Peach Bottom Atomic Power Station, Units 2 and 3 (Peach Bottom) FHRR (Exelon, 2015a) appears in the text to inconsistently provide comparison of the	In response to the information request (Exelon, 2016a), the licensee stated that the CLB and the CDB are synonymous, i.e. they have the same meaning. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.

INFORMATION NEED NO.	INFORMATION NEED REQUEST	RESPONSE
	reevaluated flood hazards with the current design basis (CDB) for each flood hazard mechanism, as requested. <u>Request:</u> Clarify and where necessary correct the description and/or comparison of the reevaluated flood hazard to the CDB for any flood hazard mechanism throughout the report that may have been incorrectly compared with the current licensing basis (CLB). Please confirm that this has been verified throughout the FHRR.	
2	**<u>Local Intense Precipitation – Model boundary area</u>** <u>Background</u>: The local intense precipitation (LIP) is equivalent to the 1–hour (hr), 1-square mile (mi^2) probable maximum precipitation (PMP) as described in NUREG/CR-7046 (NRC, 2011; Exelon, 2015a). The modeling boundary area chosen by the licensee for the LIP analysis is only 0.13 mi^2, and doesn't capture all flood-contributing rainfall within the site area. The contour lines indicate a valley in the topographic map of Figure 6.2 of calculation package PEAS-FLOOD-03 Rev 0 (Exelon, 2015b) clearly show that runoff can enter the Peach Bottom site from outside the current model boundary through the northwest corner. <u>Request:</u> Explain how the current model boundary area captures the entire drainage basin entering the surface drainage system of the site, or correct the model if needed.	The licensee stated (Exelon, 2016a) that the safety-related doors would not be subject to flow from the area outside the model domain because the doors have higher elevations than the ground surface at the boundary location receiving flow from the outside drainage area. Additionally, the licensee listed all critical door locations and their elevations in Table 1 of the response (which came from the FHRR). The table's footnote states that the Turbine Building (Door 111) is at a non-safety-related structure and is not flood-protected. After reviewing, the staff requested a reference indicating that the Turbine Building is not safety-related structure. For this request, the licensee provided an excerpt from the Updated Final Safety Analysis Report's (UFSAR) Appendix C.2.5.4, which describes that the Turbine Building is not one of the structures included in a safe shutdown during flooding. The NRC staff confirmed the information from the UFSAR and no further information is needed. The NRC staff concluded it was sufficient to address the information need request.
3	**<u>Local Intense Precipitation – Missing site structures</u>**	In response to the information request (Exelon, 2016a), the licensee stated that these structures were not included in the model because they have been removed from the site.

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	Background: Some structures that could obstruct flow are not considered in the FLO-2D modeling (Exelon, 2015b). Request: Provide justifications for why these structures were not represented in the model, or correct if needed.	The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
4	**Current Licensing Basis-Flooding in Streams and Rivers** Background: The staff noticed that the discharge of 1,750,000 cubic feet per second (cfs) does not correspond to the discharge of 1,625,000 cfs utilized previously by Three Mile Island (TMI) near Harrisburg (Exelon, 2015a). Request: Please clarify or explain the difference in the numbers presented.	In response to this information need request (Exelon, 2016a), the licensee clarified that the differences in discharge were due to accounting for flood control projects (i.e. dams) versus unregulated flow. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
5	**Rivers and Streams** Background: The NRC staff noticed that the licensee did not provide the storm orientations for other storms in Table 3.2.4.2.1.1 of the FHRR (Exelon, 2015a). Request: Please clarify if the orientation of all storms other than the TMI Watershed Centroid differed from the selected TMI Watershed Centroid storm.	In response to this information need request, the licensee provided a table of values listing the storm orientation associated with each storm centering (Exelon, 2016a). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
6	**Rivers and Streams** Background: The NRC staff noticed that the results for TMI such as discharge are presented on page 76 (and others) in the FHRR (Exelon, 2015a).	In response to this information need request, the licensee clarified that the discharges were presented for informational purposes only, as both sets of values were derived from the same HEC-HMS model (Exelon, 2016a). Upon further request for clarification, the licensee presented a comparison of hydrographs from HEC-HMS and HEC-RAS to confirm that both models were

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	Original Request: Please clarify why the results of discharge are presented for TMI in this report instead of Peach Bottom's results. Supplemental Request: Background: Hydrologic routing methods performed by the Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS) tend to be much more simplified than the equations used by the unsteady Hydrologic Engineering Center - River Analysis System (HEC-RAS). Due to these computational differences, HEC-HMS routings may differ significantly from HEC-RAS over an equivalent reach of a river at certain discharges, particularly if the reach contains structures (such as run-of-river dams). These differences may impact the magnitude and timing of the peak, particularly over longer reaches. It is noted that the same HEC-HMS model was utilized for both TMI and Peach Bottom, although the hydraulic models used to determine peak stages at each site differ significantly in upstream length (approximately 1 mile (mi) versus 28 mi). It is anticipated that there may be some differences in results between models, particularly as discharges exceed the calibration range. Supplemental Request: Please provide a comparison of the HEC-HMS and HEC-RAS hydrographs where the two models overlap in routing flow to the Peach Bottom site to provide some context as to how sensitive HEC-HMS results may be to length of hydraulic reach and presence of hydraulic control structures.	providing roughly equivalent routing over the entire range of discharges considered (Exelon, 2016b). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.

INFORMATION NEED NO.	INFORMATION NEED REQUEST	RESPONSE
7	**Rivers and Streams** Background: In the Calibration and Validation Results section of the FHRR (Exelon, 2015a), the staff noticed that the text indicated the HEC-HMS model was calibrated against Tropical Storm Lee, Hurricane Agnes, and Hurricane Ivan. No other storms are indicated in this section, yet the heading indicates model validation was performed. Request: Please clarify what storm event(s) were considered for model validation.	In response to this information need request, the licensee clarified that the combined model was validated against the three individual storms, while the three individual storms had been used to derive three individually calibrated models, which in turn had been combined to produce the combined model (Exelon, 2016a). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
8	**Rivers and Streams** Background: In the Calibration and Validation Results section of the FHRR (Exelon, 2015a), the staff noticed that the text indicated that the HEC-RAS model was calibrated against Tropical Storm Lee and validated against the March 1936 Storm, Hurricane Ivan and Hurricane Agnes events. Request: Please clarify why only one storm was used for calibration, and why the one storm selected was not the largest event.	In response to this information need request, the licensee clarified that Tropical Storm Lee was selected for calibration because it was the most recent of the large events and it best matches the geometry used in the HEC-RAS model (Exelon, 2016a). The licensee further explained that the validated storms all matched observed high water marks at the plant site within 0.1 feet (ft), while not concurrently over- or under-predicting The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
9	**Rivers and Streams** Background: The staff noticed in Table 3.2.6.2.1 (and elsewhere in text) of the FHRR (Exelon, 2015a) that model calibration was indicated to be acceptable in relation to stage only. Request: Please clarify if timing of the hydrograph was of any concern in calibrating the HEC-RAS model to be	In response to this information need request, the licensee provided values of mean absolute error, root mean squared error and correlation coefficient (R) to demonstrate the timing match by comparing values of computed and observed discharge from the same time step over the duration of the hydrograph (Exelon, 2016a). The licensee also provided graphical comparison between computed and observed hydrographs that allowed better

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	used in unsteady flow, and if so, what was acceptable hydrograph timing differences for calibration.	comparison of the timing of the rising, falling and peak portions of the hydrographs. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
10	**Ice Jams** Background: The staff noticed that there was no discussion of certain details regarding the modeling of the ice jam release in the FHRR (Exelon, 2015a). Request: Please clarify if the hydraulic modeling of the released ice jam took into account the volume of ice released from the jam and if increased roughness was considered to account for the interaction of ice flows passing downstream.	In response to this information need request the licensee indicated that the cumulative conservatisms included in other parameters would encompass the uncertainties pertaining to ice volume and roughness (Exelon, 2016a). The licensee also demonstrated that water surface profiles in the vicinity of the Peach Bottom site were relatively insensitive to the ice parameters selected due to the backwater influences posed by [redacted] The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
11	**Error/ Uncertainty** Background: The staff noticed that the uncertainty range listed in Table 3.9.3.3.1 of the FHRR (Exelon, 2015a) was not related to any statistic such as the standard deviation Request: Please clarify if the uncertainty range presented represents one standard deviation or two standard deviations in elevation.	In response to this information need request, the licensee clarified that the results presented were in response to sensitivity in Conowingo gate operations, not as a statistical uncertainty analysis, as was done for topographic uncertainty (Exelon, 2016a). The licensee further clarified that topographic uncertainty was not considered simultaneously with gate sensitivity. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
12	**Rivers and Streams**	In response to this information need, the licensee clarified that the correct crest elevation of the [redacted] is

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	Background: The staff noticed text pertaining to [redacted] that states that the crest elevation is [redacted] while the HEC-RAS model uses an invert elevation of [redacted] (assume this is also in NAVD88 per description in section 3.2.2.12) (Exelon, 2015a). The invert elevation of the crest impacts the routing and the discharge through the dam. Request: Please clarify which crest elevation is correct.	[redacted] and noted that the typographical error does not impact results presented in the FHRR (Exelon, 2016a). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
13	**Rivers and Streams** **Original Request** Background: The staff noticed in Figure 3.2.2.15.1 of the FHRR (Exelon, 2015a) that some low roughness values (n=0.0143) are used in the downstream reach of the HEC-RAS model. Also, abrupt changes in roughness from 0.0143 to 0.03 to 0.0375 are included in the model (Exelon, 2015b). Low roughness values decrease the computed water surface elevation (WSE). Justification for the use of low roughness values for the calibration effort is provided in the Exelon Transmittal of Design Information (TODI) and Attachment 5 of the TODI. Request: Please clarify or add justification to support the assumption that the low roughness values would be valid for higher discharges (i.e. probable maximum flood [PMF]). Also, please clarify if abrupt changes in roughness from 0.0143 to 0.03 to 0.0375 are supported by physical changes in the river/floodplain or if the changes are a result of calibration efforts.	In response to this request for information, the licensee provided discussion on the applicability of the lower roughness values for higher discharges (Exelon, 2016a). The licensee also provided aerial imagery overlaid with the location of abrupt changes in roughness values. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request for the first portion of the request (low roughness values). The staff performed sensitivity analyses on the roughness values to determine the impact to computed water surfaces. Two general sensitivity analyses were conducted; the first included adjusting Manning's roughness values for the entire reach while the second adjusted Manning's roughness values for an upstream reach.The results indicated a relatively high sensitivity of the model to the roughness coefficients. The high sensitivity of the model to roughness value was considered justification for an additional request for information. The licensee's second response (Exelon, 2016b) provided further information on a sensitivity analysis that the licensee conducted on roughness values in the upstream portion of the reach. The conclusion of their sensitivity analysis was that higher roughness

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	Supplemental Request <u>Background</u>: The response to the first portion of the request (low roughness values) is acceptable. The second portion of the request pertaining to abrupt changes in roughness is not fully addressed in the response. Based on Figures 13.3 and 13.4 of the FHRR (Exelon, 2015), it appears that the reach just downstream from [redacted] would have a higher roughness value than the reach above [redacted] but the roughness values are opposite (higher upstream, lower downstream). Additionally, from the aerial photography available, it is not clear that the downstream reach with n=0.0143 is significantly different from the reach between [redacted] (n=0.0375) or upstream from [redacted] (n=0.03). Sensitivity analyses were conducted on the roughness values to determine the impact to computed water surfaces. Results indicated a relatively high sensitivity of the model to the roughness coefficients. <u>Request</u>: Please provide detailed clarification, or show additional data and/or aerial imagery to support the justification for the significant changes in roughness values.	values in the upstream reach do not affect peak stages at the site. A thorough investigation of what would normally be considered a very low channel roughness value was documented in the Exelon TODI and was deemed acceptable. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
14	**<u>Rivers and Streams</u>** <u>Background</u>: The staff noticed that for [redacted] an average open rate of [redacted] is assumed (Exelon, 2015a)). The rate at which gates	In response to this information need the licensee provided further clarification on the open rate of the gates and described the use of the 10 gate clusters (Exelon, 2016a). While the written response did not directly address the request, the staff and licensee discussed the request during a conference call on February 12,

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	are opened impacts the flood routing and computed discharges/stages. Request: Please clarify whether the average open rate of [redacted] takes into account moving the cranes. Also, please clarify whether using gate groups consisting of up to 10 gates influences open/close rate (i.e. does HEC-RAS open [redacted] gates in [redacted]	2016. During the call, the staff gained clarification on the order of gate openings modeled within HEC-RAS. The discussion noted that the group o[redacted] gates does open in [redacted] However, an example of when the [redacted] group would be opened is when the model is going from [redacted] to [redacted] gates. Prior to operation there would be two [redacted] groups, a [redacted], and two [redacted] groups open. The operation would include closing the [redacted] and [redacted] groups and opening another [redacted] group. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
15	**Rivers and Streams** Background: The staff noticed that on page 69, Sections 3.2.3.8 and 3.2.3.9 of the FHRR (Exelon, 2105a), that cross sections extend through Unit 1 and other buildings in the vicinity. The buildings would likely act as obstructions and would decrease conveyance through the cross sections. Request: Please clarify whether Unit 1 and other buildings in the vicinity were accounted for in either the cross section development (i.e. blocked obstructions) or in roughness values.	The response from the licensee provided a narrative describing the conclusion that the inclusion of Unit 1 structures would not significantly decrease the conveyance and therefore not increase water surfaces enough to adversely impact Unit 2 and Unit 3 safety-related Structures, Systems, and Components (SSCs) (Exelon, 2016a). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
16	**Dam Failure** Background: The staff noticed that for the [redacted] was modeled (Exelon, 2015b). The breach size directly impacts downstream discharges and stages.	In response to this information need the licensee directed the reviewers to a separate calculation package (PEAS-FLOOD-20) where additional information pertaining to the selected breach parameters was contained (Exelon, 2016a). PEAS-FLOOD-20 Revision 0 provided details regarding Gee's Method for estimating the breach width.

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	Request: Please clarify how the [redacted] width for the breach was determined.	The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
17	**Dam Failure** Background: The staff noticed that in Tables 3.3.6.1 and 3.3.6.2 of the FHRR (Exelon, 2015a), that the maximum WSE for the seismically induced dam failure is [redacted] than the maximum WSE for the precipitation driven dam failure but maximum discharges are not significantly different. Request: Please clarify why the discharges are relatively similar even though the stages are much different (i.e. is it due to backwater effects?)	In response to this information need the licensee provided additional information pertaining to the hydrographs and associated volume of water for the two scenarios (Exelon, 2016a). Further review of the hydraulic modeling showing the [redacted] indicates the highly variable stage-discharge rating curve is appropriately modeled. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
18	**Error/Uncertainty** Background: The staff noticed in Section 3.9 of the FHRR (Exelon, 2015a) that the text describes a sensitivity analysis conducted to determine the impacts to stage due to a [redacted] gate failure. No other uncertainty is described in the text. The ranges in WSE due to both knowledge and model uncertainty for hydrology and hydraulics may be relatively significant. Request: Please clarify why uncertainty due to hydrologic and hydraulic analyses (other than failure of [[Conowingo Gates]]) is not described.	In response to this information need, the licensee clarified that because calibration and validation criteria were satisfied, further examination of uncertainty was deemed unnecessary (Exelon, 2016a). While additional examination of uncertainty would increase knowledge about the system, the response from the licensee was sufficient to address the information need request.
19	**Rivers and Streams**	In response to this information need, the licensee discussed the need to use interpolated cross sections to maintain the gradually varied unsteady flow regime which is the fundamental basis for

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	Background: The staff noticed that the HEC-RAS model contains 2026 cross sections; however, fewer than 10% of the cross sections are based on topo data – the remainder are interpolated (Exelon, 2105b). The use of interpolated cross sections can have an effect on the discharge, hydrograph timing, and computed WSE. Request: Please clarify why so many interpolated cross sections were required and describe the impact on WSEs, peak discharges, and hydrograph timing within the model.	the HEC-RAS program equations (Exelon, 2016a). While using surveyed cross sections would be preferable, the staff understands that additional data was not available. The information provided by the licensee was sufficient to address the information need request.
20	**Flood Parameters and Comparison with CDB** Background: The staff noticed that on page 151, Hydraulic Model Calibration/Validation Events row that the March 1936 event is listed here as a validation event; however, Table 3.2.6.2.1 shows that the HEC-RAS model WSE is 1.91 ft lower than the reported historical WSE at Peach Bottom (Exelon, 2015a). Model validation reflects how well a model performs for simulations other than the event for which it was specifically calibrated. Request: Please clarify if other validation occurred for the March 1936 event.	In response to this information need request, the licensee provided additional background on the 1936 event and noted that the bathymetry in the current HEC-RAS model is likely not representative of the 1936 bathymetry (Exelon, 2016a). The licensee also noted that the event was listed as a validation event, but it did not contain enough substantial evidence to incorporate changes into the HEC-RAS model. Based on the discussion pertaining to the event's lack of available data, reliability of the available data, and potential changes in river bathymetry since 1936, the staff acknowledges that it may be more appropriate to remove the 1936 event from consideration as a validation event. The response was determined to be acceptable based on the lack of further storm events data.
21	**Rivers and Streams** Background: The staff noticed that in calculation package "Calc PEAS-FLOOD-06", Section 2.1.2.3, sheets 13-14 (Exelon, 2015b) that contraction/expansion coefficients appear to have been set only on the non-interpolated cross sections.	In response to this information need request, the licensee discussed how contraction/expansion coefficients are generally not used with an unsteady flow model (Exelon, 2016a). Additionally, a sensitivity analysis was conducted to show that water surfaces increased by a maximum of just over 1 ft at the site with an overly conservative assumption of using contraction/expansion coefficients at each cross section.

INFORMATION NEED NO.	INFORMATION NEED REQUEST	RESPONSE
	Contraction/expansion coefficients may have an impact on computed WSEs. <u>Request</u>: Please clarify whether contraction/expansion coefficients were set on the non-interpolated cross sections only (supplied geometry appears to not have any contraction/expansion coefficients on interpolated cross sections) and what impact this may have on computed WSEs.	The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
22	**<u>Rivers and Streams</u>** <u>Background</u>: The staff noticed that in calculation package "Calc PEAS-FLOOD-06", on Sheet 19, Table 2.2 that footnote 1 for the SR-472 bridge notes that the datum is unknown so mean sea level was assumed for the datum. A higher or lower bridge may have an impact on computed WSEs at the site. <u>Request</u>: Please clarify whether any sensitivity analyses were completed to evaluate effects of a higher or lower bridge and if so, what was the impact.	In response to this information need request the licensee noted that because of the minor vertical datum change expected and the distance between the bridge and the Peach Bottom site as well as the existence of [redacted] dams between the bridge and the Peach Bottom site, any impact from changing the bridge elevation would be negligible (Exelon, 2016a). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
23	**<u>Rivers and Streams</u>** <u>Background</u>: The staff noticed that in calculation package "Calc PEAS-FLOOD-06", that the text in section 2.4 notes that the rating curves for [redacted] were not directly used in the HEC-RAS model (generic equations within HEC-RAS were used instead) (Exelon, 2015b). The rating curves directly impact computed discharges and stages.	In response to this information need request, the licensee noted that the effects of submergence are better accounted for using HEC-RAS computed curves than user-specified rating curves (Exelon, 2016a). The staff agrees with this assertion but notes that at [redacted] where the differences between the HEC-RAS computed and "known" curves are greatest, submergence does not appear to be a concern (the maximum tailwater during the PMF appears to be roughly 40 ft below the outlets). A cursory sensitivity analysis was conducted by the staff using the user-defined rating curves that were included in the original model for [redacted] which appear to have been

INFORMATION NEED NO.	INFORMATION NEED REQUEST	RESPONSE
	Request: Please clarify why the dam rating curves were not directly input to the HEC-RAS model and describe the potential impact on discharges and stages downstream, especially considering the differences in computed vs. known rating curves reported in Section 7.5 of calculation package "Calc PEAS-FLOOD-06".	taken from the "known" rating curve. The sensitivity analysis indicates low sensitivity to the selected computation method. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
24	**Rivers and Streams** Background: The staff noticed that in calculation package "Calc PEAS-FLOOD-06", Section 7.1.3, sheet 51that the energy method was used to evaluate high flows through the US-30 bridge and the SR-462 bridge (Exelon, 2015b). The selected high flow computation method within HEC-RAS can have an impact on computed WSE. Request: Please clarify whether a sensitivity analysis was conducted to evaluate use of pressure/weir flow computations for high flow at the US-30 bridge and SR-462 bridge, and if so, what were the results.	In response to this information need request, the licensee noted the distance of the bridges from the site would result in negligible effects on the computed WSE at Peach Bottom (Exelon, 2016a). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
25	**Rivers and Streams** Background: The staff noticed that in calculation package "Calc PEAS-FLOOD-06", Section8, sheet 95, the first (#1) acceptance criteria notes that the calibration event is within +/- 0.1 ft of observed value; however, Table 7.4 on sheet 72 shows only one point out of four at which the modeled WSE is within 0.1 ft of the observed (Exelon, 2015b). Also, Table 8.1 only includes two calibration locations for Lee vs. the four shown in Table 7.4. The calibrated model was used to simulate the PMF and has a direct impact on the computed WSEs.	In response to this information need request, the licensee provided further clarification on the acceptance criteria, specifically that the +/- 0.1 ft criterion only applies at one location (Exelon, 2016a). While typical calibration methods would use a global value for calibration acceptance rather than at one point to ensure the entire model is reasonably replicating an event rather than at one location only. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.

INFORMATION NEED NO.	INFORMATION NEED REQUEST	RESPONSE
	Request: Please clarify the apparent contradiction between Sections 7.4.1.2 and 8.0.	
26	**Rivers and Streams** Background: The staff noticed that in calculation package "Calc PEAS-FLOOD-06", HEC-RAS model results that footnotes in Tables 7.5 and 7.7 indicate some oscillation of the WSE around certain values (Exelon, 2015b). Oscillations in the WSE may reflect other model inconsistencies. Request: Please clarify whether large oscillations (>5ft over 15 minutes) downstream of Conowingo Dam are justified and whether or not they impact water surfaces upstream.	In response to this information need request the licensee noted (and provided graphical supporting documentation) that the oscillations downstream of Conowingo Dam do not influence the conditions upstream (Exelon, 2016a). The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
27	**Rivers and Streams** Background: The staff noticed in calculation package "Calc PEAS-FLOOD-06", in the HEC-RAS model initial conditions/results section, the results of the HEC-RAS model show large initial adjustments in stage at certain cross sections (e.g. for Lee simulation, stage drops nearly 20 ft at RS 124639.1 over the first 14 hours) (Exelon, 2015b). Large adjustments at the start of the simulation may reflect inconsistent initial conditions within the HEC-RAS model. Request: Please clarify if this is based on observed data or is a model issue.	In response to this information need request, the licensee acknowledged that the large initial adjustments are a model issue, but noted that the initial adjustments in the water surface are frequently encountered in models during their "spin-up" period (Exelon, 2016a). The WSE stabilizes after 14 hours and is not expected to influence the peak PMF discharge or WSE. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.
28	**Rivers and Steams**	In response to this information need request, the licensee discussed model stability and the need for interpolated cross

INFORMATION NEED NO.	INFORMATION NEED REQUEST	RESPONSE
	Background: The staff noticed that in Section 7.1.1 of "Calc PEAS-FLOOD-06", sheet 49, second to last sentence of second to last paragraph, notes that cross sections were limited to every 1000 ft., then interpolated every 100 ft. to avoid conveyance and energy loss issues (Exelon, 2015b). The use of interpolated cross sections rather than actual topographical data can impact the computed WSE, discharge, and hydrograph timing. Request: Please clarify what conveyance and energy loss issues were experienced. Please clarify whether the Courant condition (or similar) was used to evaluate appropriate cross section spacing.	sections. While using surveyed cross sections is preferable to interpolated. The NRC staff reviewed the information provided by the licensee and concluded it was sufficient to address the information need request.

Sources:

Exelon, 2015a, "Peach Bottom Atomic Station, Flood Hazard Reevaluation Report, Revision 0," Enclosure to Letter from James Barstow to the NRC Document Control Desk, Subject: "Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2 Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report," August 12, 2015, ADAMS Accession No. ML15233A066 (Non-Public).

Exelon, 2015b, "Pertinent Site Data," CD-R, Enclosure to Letter from James Barstow to the NRC Document Control Desk, Subject: "Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2 Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report," August 12, 2015, ADAMS Accession No. ML15233A066 (Non-Public).

Exelon, 2016a, No title, Exelon Responses to NRC Information Need Requests for Peach Bottom and TMI, February 10, 2016.

Exelon, 2016b, No title, Exelon Submittal Responses to NRC Information Need Requests for Peach Bottom and TMI, April 4, 2016..

NRC, 2011, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United State of America," NUREG/CR-7046, November 2011, ADAMS Accession No. ML11321A195 (Public).

NRC, 2012, Letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New Reactors, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, Subject: "Request for Information Pursuant to Title

10 of the *Code of Federal Regulations* 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," March 12, 2012, ADAMS Accession No. ML12056A046 (Public)

ATTACHMENT 1

Peach Bottom Atomic Power Station, Units 2 and 3 Audit Document List

1. Exelon, 2015, "Peach Bottom Atomic Station, Flood Hazard Reevaluation Report, Revision 0," Enclosure to Letter from James Barstow to the NRC Document Control Desk, Subject: "Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2 Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report," August 12, 2015, ADAMS Accession No. ML15233A066 (Non-Public).

2. Exelon, 2015b, Beyond Design Basis External Event – Flood Re-Evaluation – HEC-RAS Model of Susquehanna River Development and Calibration, Analysis No. PEAS-FLOOD-06, October 2014. Provided on CD-R as an Enclosure to Letter from James Barstow to the NRC Document Control Desk, Subject: "Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2 Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report," August 12, 2015, ADAMS Accession No. ML15233A068 (Non-Public).

3. Exelon, 2015c, Beyond Design Basis External Event – Flood Re-Evaluation – HEC-HMS Rock Run Creek Hydrologic Calculation, Analysis No. PEAS-FLOOD-07, July 2015.

4. Exelon, 2014a, Beyond Design Basis External Event – Flood Re-Evaluation – HEC-RAS Rock Run Creek Probable Maximum Flood (PMF) Hydraulic Calculation, Analysis No. PEAS-FLOOD-08, July 2014.

5. Exelon, 2014b, Beyond Design Basis External Event – Flood Re-Evaluation –Ice Effects, Analysis No. PEAS-FLOOD-09, April 2014.

6. Exelon, 2015d, Beyond Design Basis External Event – Flood Re-Evaluation – Site-Specific Probable Maximum Precipitation (PMP) and Climatology Calculation, Analysis No. PEAS-FLOOD-11, July 2015.

7. Exelon, 2015e, Beyond Design Basis External Event – Flood Re-Evaluation – HEC-RAS Probable Maximum Flood (PMF) Water Level, Analysis No. PEAS-FLOOD-16, April 2015.

8. Exelon, 2015f, Beyond Design Basis External Event – Flood Re-Evaluation – Combination Flooding. Analysis No. PEAS-FLOOD-20, April 2015.

9. Exelon, 2015g, Beyond Design Basis External Event – Flood Re-Evaluation – Error and Uncertainty Calculation, Analysis No. PEAS-FLOOD-21, July 2015.

ATTACHMENT 2
List of Exelon Audit Participants

Name	Organization
1. David Distel	Exelon
2. Joe Bellini	Aterra Solutions
3. Jesse Lucas	Exelon
4. Shaun Kline	Exelon
5. Vined Aggarwal	Exelon
6. Chuck Behrend	Exelon
7. Tom O'Reilly	Exelon
8. Kyle Kaminski	Exelon Consultant
9. Tim Dean	Exelon Consultant
10. James Barbis	Exelon Consultant
11. William Mcsorley	Exelon

SUBJECT: NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF EXELON GENERATION COMPANY LLC'S FLOOD HAZARD REEVALUATION REPORT SUBMITTAL RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3 DATED SEPTEMBER 25, 2017

DISTRIBUTION:
PUBLIC
LGibson, NRR
RidsNrrDorlLpl1 Resource
RidsRgn1MailCenter Resource
RidsOpaMail Resource
RRivera-Lugo, NRO
MWillingham, NRO
NSanfilippo, NRR
JLD R/F
LQuinn-Willingham, NRO
RidsNrrDorl Resource
RidsNrrLASLent
RidsAcrsAcnw_MailCtr Resource
ACampbell, NRO
KSee, NRO
SDevlin-Gill, NRO
RidsNRRJLD Resource
RidsNroDsea Resource
RidsNrrPMPeachBottom Resource
RidsOgcMailCenter Resource
CCook, NRO
MShams, NRR
BHarvey, NRO

ADAMS Accession Nos.: Pkg: ML17255A475; Non Public: ML17255A501; Public: ML17255A524

OFFICE	NRR/JLD/JHMB/PM	NRR/JLD/JHMB/LA	NRR/JLD/JHMB/BC	NRO/DSEA/RHM1/TR
NAME	LGibson	SLent	NSanflipo (SWyman for)	KSee
DATE	09/15/2017	09/13/2017	09/18/2017	09/15/2017
OFFICE	NRO/DSEA/RHM1/BC	NRR/JLD/JHMB/PM		
NAME	CCook (SDevlin-Gill for)	LGibson		
DATE	09/15 /2017	09/25/2017		

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