UNITED STATES
NUCLEAR REGULATORY COMMISSION
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October 30, 2017

Mr. Bryan C. Hanson
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SUBJECT: PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM RE-EVALUATION (CAC NOS. MF6598 AND MF6599)

Dear Mr. Hanson:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (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 August 12, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15233A066), Exelon Generation Company, LLC (Exelon, the licensee) responded to this request for Peach Bottom Atomic Power Station, Units 2 and 3 (Peach Bottom).

By letter dated March 31, 2016 (ADAMS Accession No. ML16091A120), the NRC staff sent the licensee a summary of its review of Peach Bottom's reevaluated flood-causing mechanisms. The enclosed staff assessment provides the documentation supporting the NRC staff's conclusions summarized in the letter. As stated in the letter, because local intense precipitation, storm surge, seiche, and ice-induced flooding at Peach Bottom are not bounded by the plant's current design basis, additional assessments of these flood hazard mechanisms are necessary. The licensee submitted the additional assessment, the Focused Evaluation, by letter dated March 17, 2017 (ADAMS Accession No. ML17079A052). The Focused Evaluation is currently under review.

The NRC staff has no additional information needs at this time with respect to Peach Bottom's 50.54(f) response related to flooding. This staff assessment closes out the NRC's efforts associated with CAC Nos. MF6598 and MF6599.

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 by electronic mail at Lauren.Gibson@nrc.gov.

Sincerely,

Lauren Kate Gibson

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Docket Nos. 50-277 and 50-278

Enclosures:
1. Staff Assessment of Flood Hazard Reevaluation Report (Non-Public)
2. Staff Assessment of Flood Hazard Reevaluation Report (Public)

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3

DOCKET NOS. 50-277 AND 50-278

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), 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* (CFR), Section 50.54(f) (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 (NTTF) report (NRC, 2011a). Recommendation 2.1 in that document recommended that the NRC staff issue orders to all licensees to reevaluate seismic and flooding for their sites against current NRC requirements and guidance. Subsequent staff requirements memoranda associated with SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d), directed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f) to address this recommendation.

Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that NRC staff would provide a prioritization plan indicating Flooding Hazard Reevaluation Report (FHRR) deadlines for each plant. On May 11, 2012, the NRC staff issued its prioritization of the FHRRs (NRC, 2012b).

By letter dated August 12, 2015 (Exelon, 2015), Exelon Generation Company, LLC (Exelon, the licensee) submitted the FHRR for Peach Bottom Atomic Generating Station, Units 2 and 3 (Peach Bottom). The NRC staff performed an audit as documented in the audit report (NRC, 2017).

On March 31, 2016, the NRC issued an interim staff response (ISR) letter to the licensee (NRC, 2016). The purpose of the ISR letter is to provide the flood hazard information suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 (NRC, 2012b) and the additional assessments associated with NTTF Recommendation 2.1: Flooding. The ISR letter also made reference to this staff assessment, which documents NRC staff's basis and conclusions. The flood hazard mechanism values presented in the letter's enclosures match the values in this staff assessment without change or alternation.

As mentioned in the ISR letter (NRC, 2016), the reevaluated flood hazard result for LIP, storm surge, seiche and ice-induced flood-causing mechanisms are not bounded by the plant's current design basis (CDB). Consistent with the 50.54(f) letter and amended by the process outlined in COMSECY-15-0019 (NRC, 2015b), Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, Revision 1 (NRC, 2016a) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b), the NRC staff anticipates that the licensee will perform and document a focused evaluation (FE) for LIP that assesses the impact of the LIP hazard on the site, and evaluates and implements any necessary programmatic, procedural, or plant modifications to address this hazard exceedance. Additionally, for the storm surge, seiche and ice-induced flood-causing mechanisms, the NRC staff anticipates that the licensee will submit either (a) a revised integrated assessment or (b) a focused evaluation confirming the capability of existing flood protection or implementing new flood protection consistent with the process outlined in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

Additionally, for any reevaluated flood hazards that are not bounded by the plant's CDB hazard, the licensee is expected to develop flood event duration (FED) and associated effects (AE) parameters. These parameters will be used to conduct the mitigating strategies assessment (MSA) and FE or integrated assessment. By letter dated June 30, 2016, the licensee submitted the MSA (Exelon, 2016b). The NRC staff's review of the MSA is documented in a separate staff assessment dated January 11, 2017 (NRC, 2017a). The licensee submitted the FE by letter dated March 17, 2017 (Exelon, 2017a). It is currently under review.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter (NRC, 2012a) 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 ESPs and COLs. This section of the staff assessment describes present-day regulatory requirements that are applicable to the FHRR.

Sections 50.34(a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4), of 10 CFR, describe the required content of the preliminary and final safety analysis reports, including a discussion of the facility site with a particular emphasis on the site evaluation factors identified in 10 CFR Part 100. The licensee should provide any pertinent information identified or developed since the submittal of the preliminary safety analysis report in the final safety analysis report.

General Design Criterion 2 in Appendix A of 10 CFR Part 50 states that structures, systems, and components (SSCs) important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena, such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without the loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Section 50.2 of 10 CFR defines the design-basis as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design which each licensee is required to develop and maintain. These values may be (a) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (b) requirements derived from analysis (based on calculation, experiments, or both) of the effects of a postulated accident for which an SSC must meet its functional goals.

Section 54.3 of 10 CFR defines the "current licensing basis" (CLB) as "the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect." This includes 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 52, 54, 55, 70, 72, 73, 100 and appendices thereto; orders; license conditions; exemptions; and technical specifications, as well as the plant-specific design-basis information as documented in the most recent updated final safety analysis report (UFSAR). The licensee's commitments made in docketed licensing correspondence, which remain in effect, are also considered part of the CLB.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for site applications on or after January 10, 1997) state, in part, that the physical characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site. Factors to be considered when evaluating sites include the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.21(d)).

2.2 Enclosure 2 to the 50.54(f) Letter

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter (NRC, 2012a) requested, in part, that licensees reevaluate the flood-causing mechanisms for their respective sites using present-day methodologies and regulatory guidance used by the NRC for the ESP and COL reviews.

2.2.1 Flood-Causing Mechanisms

Attachment 1 to Enclosure 2 of the 50.54(f) letter discusses flood-causing mechanisms for the licensee to address in its FHRR (NRC, 2012a). Table 2.2-1 lists the flood-causing mechanisms the licensee should consider and lists the corresponding Standard Review Plan (SRP) (NRC, 2007) section(s) and applicable ISG documents containing acceptance criteria and review procedures.

2.2.2 Associated Effects

In reevaluating the flood-causing mechanisms, the "flood height and associated effects" should be considered. Guidance document JLD-ISG-2012-05 (NRC, 2012d) defines "flood height and associated effects" as the maximum stillwater surface elevation plus:

- Wind waves and runup effects
- Hydrodynamic loading, including debris
- Effects caused by sediment deposition and erosion
- Concurrent site conditions, including adverse weather conditions
- Groundwater ingress
- Other pertinent factors

2.2.3 Combined Effects Flood

The worst flooding at a site that may result from a reasonable combination of individual flooding mechanisms is sometimes referred to as a "combined effects flood". It should also be noted that for the purposes of this staff assessment, the terms "combined effects" and "combined events" are synonyms. Even if some or all of these individual flood-causing mechanisms are less severe than their worst-case occurrence, their combination may still exceed the most severe flooding effects from the worst-case occurrence of any single mechanism described in the 50.54(f) letter (see SRP Section 2.4.2, Areas of Review (NRC, 2007)). Attachment 1 of the 50.54(f) letter describes the "combined effect flood" as defined in American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1992 (ANSI/ANS, 1992) as follows:

> For flood hazard associated with combined events, American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.

If two less severe mechanisms are plausibly combined per ANSI/ANS-2.8-1992 (ANSI/ANS, 1992), then the licensee will document and report the result as part of one of the hazard sections. An example of a situation where this may occur is flooding at a riverine site located where the river enters the ocean. For this site, storm surge and river flooding are plausible combined events and should be considered.

2.2.4 Flood Event Duration

The FED was defined in JLD-ISG-2012-05 (NRC, 2012c) as the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation, and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2-1 illustrates flood event duration.

2.3 <u>Actions Following the FHRR</u>

For the sites where the reevaluated flood hazard is not bounded by the CDB flood hazard elevation for any flood-causing mechanisms, the 50.54(f) letter (NRC, 2012a) 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 to (a) evaluate the effectiveness of the CDB (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.

If the reevaluated flood hazard is bounded by the CDB flood hazard for all flood-causing mechanisms at the site, licensees were not required to perform an integrated assessment. COMSECY-15-0019 (NRC, 2015b) outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes an approach in which licensees with LIP hazards exceeding their CDB flood will not be required to complete an integrated assessment, but instead will perform a FE. As part of the FE, licensees will assess the impact of the LIP hazard on their sites and then evaluate and implement any necessary programmatic, procedural, or plant modifications to address the hazard exceedance. For other flood hazard mechanisms that exceed the CDB, licensees can assess the impact of these reevaluated hazards on their site by performing either an FE or a revised integrated assessment (NRC, 2015 and NRC, 2016a).

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of the Peach Bottom site (Exelon, 2015). 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.

To provide additional information in support of the summaries and conclusions in the Peach Bottom FHRR, the licensee made calculation packages available to the NRC staff via an electronic reading room. The NRC staff did not rely directly on these calculation packages in its review; they were found only to expand upon and clarify the information provided in the Peach Bottom FHRR, and so those calculation packages are not docketed or cited.

3.1 Site Information

The 50.54(f) letter (NRC, 2012a) requested that relevant SSCs important to safety be included in the scope of the hazard reevaluation. The licensee included this pertinent data concerning these SSCs in the FHRR (Exelon, 2015). The NRC staff reviewed and summarized this information as follows in the sections below.

3.1.1 Detailed Site Information

The Peach Bottom FHRR (Exelon, 2015) described the site specific information related to the flood hazard evaluation. The Peach Bottom site is located on Conowingo Pond on the Susquehanna River in southeastern Pennsylvania, 38 miles northeast of Baltimore, MD and 63 miles southwest of Philadelphia, PA. Conowingo Pond is formed by the Conowingo Dam, about 9 miles downstream of the Peach Bottom site, and the Holtwood Dam, located about 6 miles upstream of the Peach Bottom site. The Peach Bottom site is approximately 620 acres with most streams draining to the Susquehanna River. The site grade at the powerblock is elevation 115.9 ft. on the North American Vertical Datum of 1988 (NAVD88). Unless otherwise stated, elevations in this staff assessment are given with respect to the NAVD88 datum. Table 3.0-1 summarizes the controlling reevaluated flood-causing mechanisms the licensee computed to be higher than the powerblock elevation.

3.1.2 Design-Basis Flood Hazards

The NRC staff noted that the FHRR referred to both the CLB and the CDB. At the NRC staff's request, the licensee stated that the two terms are synonymous (NRC, 2017b). The NRC staff found this response to be reasonable. The CDB flood levels are summarized by flood-causing mechanism in Table 3.1-1. The CLB flood elevation at Peach Bottom is 131.4 feet (ft.) NAVD88 during the probable maximum flood (PMF) for a river flooding event. With a coincident failure of [redacted] the maximum stillwater level at Peach Bottom is [redacted] NAVD88. Superimposing the maximum wave runup (5.4 ft.) on the steady-state PMF elevation of 131.4 ft. NAVD88 results in a maximum water level with runup of 136.8 ft. NAVD88. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.3 Flood-Related Changes to the Licensing Basis

The Peach Bottom FHRR states that there are no flood-related changes or flooding protection-related changes, including mitigation, have been made since the latest license issuance. The licensee stated that any licensing-related changes are actively captured in the Peach Bottom UFSAR (Exelon, 2017). The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.4 Changes to the Watershed and Local Area

The licensee's FHRR states that the most significant change since the 1969 PMF study was the construction of three flood control dams in the upper portions of the watershed in 1979 (Tioga, Hammond, and Cowanesque Dams). Land use has also changed in the Susquehanna River watershed due to development, changes in land use, and planning practices, such as efforts to reforest agricultural areas. In addition, stormwater management practices such as Pennsylvania Stormwater Management Act 167 (enacted since 1978) plans and changes in agricultural practices have been implemented throughout the watershed to achieve peak flow reduction. Table 3.1.4-1 summarizes the land use changes in the watershed based on an evaluation of available land use data obtained from a 1970 study and 2011 study from the Susquehanna River Basin Commission. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

The Peach Bottom FHRR states that existing flood mitigation features include watertight doors at all structures, waterproofing installed to elevation 134.9 ft. NAVD88, and sealed penetrations in the exterior walls to ensure there are no areas through which water may leak and adversely affect plant safety.

The licensee also identified the structures that are required for safe shutdown of Peach Bottom, Units 2 and 3. These structures include: the Reactor Building, which has a minimum number of watertight doors at 134.9 ft. NAVD88; the Main Control Room Complex, which is above flood level but the emergency switchgear room is at 134.9 ft. NAVD88; the Diesel Generator Building, which has watertight doors to 137.9 ft. NAVD88; the Pump Storage Structure, which is protected up to 137.4 ft. NAVD88 and capable of continuous operation; and the Emergency Heat Sink Facility and Cooling Tower, which has one watertight door below the maximum wave runup elevation. In addition, the Radwaste Building is flood protected to elevation 134.9 ft. NAVD88, but is not required for safe plant shutdown.

The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.6 Additional Site Details to Assess the Flood Hazard

The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.7 Results of Plant Walkdown Activities

The 50.54(f) letter (NRC, 2012a) requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable. Other requests described in the 50.54(f) letter asked the licensee to report any relevant information from the results of the plant walkdown activities (NRC, 2012a).

By letter dated November 19, 2012 (Exelon, 2012), the licensee submitted the flooding walkdown report for Peach Bottom. This response was updated by letter dated January 31, 2014 (Exelon, 2014). The NRC staff issued a staff assessment on June 17, 2014 (NRC, 2014), which documented its review of the flooding walkdown report and concluded that the licensee's implementation of the flooding walkdown methodology met the intent of the 50.54(f) letter.

3.2 Local Intense Precipitation

The licensee reported in the Peach Bottom FHRR (Exelon, 2015) that the reevaluated flood hazard for LIP and associated site drainage is based on stillwater-surface elevations at the safety-related structures ranging from 117.5 ft. NAVD88 at the Pump Structure to 135.9 ft. NAVD88 at the Unit 3 Recirculation MG Set Room. Locations of the evaluated doors that provide protection to safety-related equipment and safety-related structures are presented in Figure 3.2-1.

This flood-causing mechanism is not discussed in the licensee's CDB. The CDB protection level is based on a flood protection elevation of 134.9 ft. NAVD88 elevation.

The NRC staff requested information needs from the licensee to supplement the FHRR. The licensee provided the information needs through a site audit conducted on February 12, 2016. The audit summary was docketed and is discussed in the appropriate sections below.

3.2.1 Probable Maximum Precipitation

The licensee considered the 1-hour, 1-mi^2 probable maximum precipitation (PMP) for the LIP event as suggested in NUREG-7046 (NRC, 2011e). The total rainfall depth for the 1-hour PMP was derived using the methods described in National Oceanic and Atmospheric Association (NOAA) Hydrometeorological Report (HMR) 51 and HMR 52 (NOAA, 1978 and 1982). The estimated 1-h PMP is 18.0 in., with a peak intensity of 6.0 in. during the first 5 minutes of the event. Based on the 1-hour PMP, the licensee evaluated three temporal distributions (front-, central-, and end-loaded) to assess the flood hazard impacts caused by the LIP event. The NRC staff reviewed the HMR 51 and HMR 52 calculations based on the location of the Peach Bottom site and confirmed that the PMP depths are appropriate.

3.2.2 LIP Model Construction and Parameters

The licensee performed the LIP analysis using the two-dimensional (2D) hydrodynamic FLO-2D model, build version 13.11.06 (FLO-2D, undated), for the Peach Bottom FHRR (Exelon, 2015). The following key assumptions were made in the FLO-2D model: (a) all the storm water drainage structures are completely blocked during the LIP event and not included in the model, (b) the runoff infiltration loss was assumed to be zero, and (c) buildings are assigned as elevated grid elements to ensure that precipitation on building roofs flows off the building to the surrounding ground and the overland flow runs around the buildings.

The NRC staff reviewed these assumptions and concludes that they are conservative and consistent with present-day guidance.

The FLO-2D model was constructed using the ground surface topography, a digital terrain model (DTM), referenced to NAVD88. The FLO-2D model domain covers the entire site, including the power block area, switchyard, parking lots, and some upstream contributing areas. A grid cell size of 10 ft. by 10 ft. was used in the model to incorporate detailed site structures.

The NRC staff reviewed the grid size and agrees it is reasonable for the FLO-2D modeling. However, the NRC staff noticed that the model boundary was assigned without capturing the drainage area that generates flows entering the Peach Bottom site through the northwest corner of the current model domain. The licensee provided additional analysis explaining that the surface runoff from the drainage area outside of the FLO-2D model domain will enter the model domain area via a valley at an elevation of approximately 116 ft. NAVD88, and all critical doors for the safety-related structures are located above the ground surface elevation of 125 ft. NAVD88 (except for Door 111 at Turbine Building). Therefore, those doors would not be impacted by flows contributed from the outside of the FLO-2D model domain. Although Door 111 at the Turbine Building has a ground surface elevation less than 116 ft. NAVD88, the licensee explained during the audit that the Turbine Building is not a safety-related structure and is not required to be flood protected (NRC, 2017).

The NRC staff compared the model grid map showing plant structures and barriers with Google Earth aerial imagery taken on September 6, 2015, and found that the buildings are well represented in the model. For the small trailers, small storage containers, and highly movable objects, the NRC staff agrees that inclusion of these structures in the model is not essential.

In order to determine the Manning's *n* roughness coefficients, the licensee identified the land cover using topographical survey information and available aerial imagery. For each specific land cover type, the licensee considered the suggested *n*-value ranges in the FLO-2D Reference Manual (FLO-2D, n.d.) and then assigned appropriate *n* values to the grid elements from 0.018 for shot-concrete lining to 0.4 for forested areas. The NRC staff reviewed the site in the Google Earth imagery and verified that selected Manning's *n* is reasonable.

3.2.3 LIP Model Results

The licensee evaluated maximum flood depths and maximum water surface elevations (WSE) at 13 locations using FLO-2D model results. Those locations include seven doors that provide flood protection to the safety-related structures, one door location at the Turbine Building, which is not a safety-related structure, four corners around the Diesel Generator Building, and the Pump Structure (Figure 3.2-1). The maximum flood depth ranges from 0.1 ft. at the northeast corner of the Diesel Generator Building to 3.3 ft. at the northwest corner of the Diesel Generator Building. The maximum WSEs vary from 117.5 ft. NAVD88 at the Pump Structure to 135.9 ft. NAVD88 at the Unit 3 Recirculation MG Set Room. The NRC staff reviewed the FLO-2D model results and concludes that the licensee's evaluation of WSEs at 13 critical locations is reasonable and acceptable.

Flooding due to LIP was not evaluated in the Peach Bottom CDB, so the reevaluated maximum WSEs at Peach Bottom are not bounded by the CDB. However, based on the CLB protection level of 134.9 ft. NAVD88, maximum WSEs at the six doors around the Unit 2 Reactor Building, Unit 3 Reactor Building, Unit 2 Recirculation MG Set Room and Unit 3 Recirculation MG Set Room are not bounded, but other safety-related structures are bounded by the CLB flood protection level.

The licensee performed a sensitivity analysis by varying Manning's *n* within a reasonable range and found changes in the maximum WSEs due to uncertainty of Manning's *n* is in a range of -0.1 ft. to +0.2 ft. The NRC staff reviewed the licensee's sensitivity analysis and confirmed that the worst scenarios from the sensitivity analysis would not change the status of "bounded" or "not bounded" relative to the protection level (134.9 ft. NAVD88) at all critical locations.

3.2.4 Conclusion

The NRC staff reviewed the analysis and concluded that the licensee's approach is consistent with present-day methodologies and regulatory guidance for LIP analysis. The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated site drainage is not bounded by the CDB flood hazard. Therefore, the NRC staff expected that the licensee would submit an FE for LIP and associated site drainage for the Peach Bottom site. The licensee submitted its FE by letter dated March 17, 2017 (Exelon, 2017a). It is currently under review.

3.3 <u>Streams and Rivers</u>

The licensee reported in its FHRR that the reevaluated flood hazard for streams and rivers is based on a stillwater-surface elevation of 126.0 ft. NAVD88 at the Peach Bottom site for the Susquehanna River and 118 ft. NAVD88 at the Peach Bottom site for Rock Run Creek. Wind and wave runup was not added to the PMF water surface elevation; instead, wind and wave runup was added to the hydrologic dam failure coincident with PMF as discussed in Section 3.4 of this staff assessment. The licensee determined that the PMF from streams and rivers is bounded by the dam failure scenario.

This flood-causing mechanism is discussed in the licensee's CDB. The CDB PMF elevation for streams and rivers is based on a stillwater-surface elevation of 131.4 ft. NAVD88. Including wind waves and runup results in an elevation of 136.8 ft. NAVD88.

The licensee used the same hydrologic and hydraulic analyses for the flooding from upstream dam failure mechanism discussed in Section 3.4 of this assessment, with the additional flood volume provided by the failure of upstream dams. The licensee compared the upstream peak flood elevations resulting from the flooding from rivers analysis and the flooding from upstream dam failure analysis, and determined that the riverine flood is bounded by the upstream dam failure flood.

3.3.1 Probable Maximum Flood Alternative Selection

The licensee analyzed the alternatives that combine multiple events as defined in NUREG/CR-7046 (NRC, 2011d) for the PMF from rivers, and determined that a combination of mean monthly base flow, median soil moisture, and 40 percent PMP followed by the main all-season PMP results in the governing PMF at Three Mile Island (TMI) with a peak flow of 1,530,000 cubic feet per second (cfs) (scenario 1). The inflow hydrographs downstream of TMI were then run in the unsteady U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center – River Analysis System (HEC-RAS) model (USACE, 2010a) to evaluate the PMF scenarios at Peach Bottom. The licensee reported the peak flow at Peach Bottom for Scenario 1 was 1,540,000 cfs. The licensee discussed all of the alternatives, which included analyses of the site specific PMP using the methods found in HMR 51 (NOAA, 1978) and HMR 52 (NOAA, 1982). The development of the site specific PMP was reviewed and endorsed by the Federal Energy Regulatory Commission (FERC) Board of Consultants (BOC) for the Conowingo Hydroelectric Project (BOC, 2015). The NRC staff participated as observers of the review process by attending several meetings of the BOC. Based on the review and endorsement of the BOC, the staff found the licensee's development of the site specific PMP to be acceptable.

3.3.2 Probable Maximum Snowpack and Snowmelt Analysis

For the combination of mean monthly base flow, probable maximum snowpack and 100-year cool-season rainfall, the licensee calculated the probable maximum snowpack using the techniques applied in HMR 42 (U.S. Weather Bureau, 1966) and Buckler (1968). Snowmelt rates for rain-on-snow and rain-free scenarios were computed in accordance with procedures found in EM 1110-2-1406 (USACE, 1998).

For the combination of mean monthly base flow, 100-year snowpack and cool-season PMP, the licensee spatially distributed the 100-year Snow Water Equivalent over the watershed in accordance with Cornell University's report (Wilks and McKay, 1994), with snowmelt rates developed in accordance with procedures found in EM 1110-2-1406 (USACE, 1998).

The NRC staff reviewed the snow melt analysis and noted that the methodology and procedures used are consistent with present-day regulatory guidance and methodology. The NRC staff verified that the inputs result in a reasonable level of conservatism for snowpack and snowmelt.

3.3.3 Probable Maximum Flood Hydrology

The licensee computed the PMF flow hydrograph at the Peach Bottom site using HEC-HMS [Hydrologic Modeling System] software, Version 3.5.0 (USACE, 2010b) for both Rock Run Creek and Susquehanna River. The delineation of watersheds was done with data obtained from the National Elevation Dataset (United States Geological Survey (USGS), 2013a). Inputs for precipitation and snowmelt are described above in Sections 3.3.1 and 3.3.2 and the USGS (2013b and n.d.-a). Loss rates were determined from Natural Resources Conservation Service (NRCS) soil data (NRCS, n.d.), while percent impervious data were taken from USGS (n.d.-b). The HEC-HMS models were calibrated and validated against historic storm events, including Tropical Storm Lee, Hurricane Ivan, and Hurricane Agnes, with data found in PEAS-FLOOD-23 (Exelon, n.d.-c). The licensee used the historical storm data to determine the appropriate rainfall-runoff transform parameters. The NRC staff reviewed the hydrologic analysis and noted that the methodology and procedures are consistent with present-day guidance and methodology. The NRC staff verified that the inputs result in a reasonable level of conservatism for the PMF hydrology.

3.3.4 Probable Maximum Flood Water Surface Elevations

To derive maximum flood elevations at the site from the PMF flow calculated by the HEC-HMS model, the licensee analyzed the dynamic channel routing of the inflow with a hydraulic model using the HEC-RAS software (version 4.1). The licensee obtained a maximum stillwater elevation of 126.0 ft. NAVD88 at Peach Bottom for the Susquehanna River and 118 ft. NAVD88 at the Peach Bottom site for Rock Run Creek, excluding the effects of dam failure.

3.3.4.1 Susquehanna River

The licensee developed the HEC-RAS model for a reach of the Susquehanna River of sufficient length to encompass the entire site. The licensee developed cross sections and floodplain geometries for the Susquehanna River using Lake Clarke and Lake Aldred bathymetry from a USGS survey, Conowingo Pond bathymetry from a 2012 survey, and overbank and island topography from LiDAR [Light Detection and Ranging]-derived 2-ft. contours. The licensee obtained bridge data for three bridges (SR-372, US-30, and EC-155) from the design drawings of the Commonwealth of Pennsylvania's Department of Highways, Bridge Division. The licensee also obtained geometric data for Safe Harbor, Holtwood, and Conowingo Dams from a combination of as-built drawings, published papers, and reports, which it used to define inline structures in the HEC-RAS model.

Calibration of the HEC-RAS model used observed streamflow data from three locations: USGS Gage 01576000 at Marietta, Pennsylvania, Conowingo Dam, and USGS gage 01578310 at Conowingo, Maryland. The licensee used four events in the calibration: Tropical Storm Lee (2011), Hurricane Ivan (2004), Hurricane Agnes (1972), and the Flood of March 1936.

The licensee used the HEC-HMS results for the upstream boundary conditions as well as lateral inflow boundary conditions for the HEC-RAS model. The normal depth option was used as the downstream boundary condition just below Conowingo Dam. The NRC staff verified the HEC-RAS model setup, including geometries and flow inputs, and also reviewed geometry files such as cross sections, structures, and the stream delineation. The NRC staff ran the model to ensure no modeling errors appeared.

3.3.4.2 Rock Run Creek

The licensee developed the HEC-RAS model for the Rock Run Creek reach using ground surface elevations from the PAMAP (Pennsylvania Map) Digital Elevation Model supplemented with topographic data from a survey performed in September 2013. Four bridges were included in the model based on the September 2013 survey. A lack of stream gage data and historical information prevented the calibration of the HEC-HMS and HEC-RAS models for Rock Run Creek.

Boundary conditions for the HEC-RAS model used peak flows from the HEC-HMS model at the upstream end and normal depth at the downstream boundary. A sensitivity analysis was conducted for the downstream boundary using three different slope values.

The NRC staff verified the HEC-RAS model setup, including geometries and flow inputs. The NRC staff verification involved a review of geometry files including a review of the cross sections, structures, and the stream delineation. The NRC staff executed the model to ensure there were no modeling errors.

3.3.5 Conclusion

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from streams and rivers is bounded by the CDB. Therefore, the NRC staff determined that flooding from streams and rivers does not need to be analyzed in an FE or a revised integrated assessment.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated flood hazard for failure of dams and onsite water control or storage structures is based on a stillwater-surface elevation o[redacted] NAVD88. Including wind waves and runup results in an elevation of [redacted] NAVD88.

This flood-causing mechanism is discussed in the licensee's CDB. The CDB PMF elevation for failure of dams and onsite water control or storage structures is based on a stillwater-surface elevation o[redacted] NAVD88. Including wind waves and runup results in an elevation of [redacted] at the Peach Bottom site.

3.4.1 Critical Dam Evaluation and Selection

The licensee reported that the USACE National Inventory of Dams (NID) Database shows 762 dams in the Susquehanna River watershed upstream of the Peach Bottom site. Of the 762 dams, 290 were identified as inconsequential and screened from further evaluation using JLD-ISG-2013-01. The licensee modeled 15 dams individually and grouped the remaining dams into 34 "hypothetical" dams. Figure 3.4.1-1 shows the modeled dams. The licensee used methodologies presented by Froehlich (2008) and Xu and Zhang (2009) to develop breach parameters for the dams for use in HEC-HMS.

3.4.2 Upstream Dam Failure Mechanism Summary

The licensee evaluated dam failures for two failure mechanisms, hydrologic and seismically induced. The licensee did not address a sunny day event, but stated that it is reasonable to assume that the sunny day failure mechanism would be bounded based upon the much greater PMF flow coincident with the hydrologic dam failure as well as by the seismic dam failure. The NRC staff agrees with the licensee's assumption.

3.4.3 Hydrologic Dam Failure Analysis

The licensee used the governing All-Season Site-Specific PMP values as input to the overtopping dam failure HEC-HMS models. The licensee set the individual dams upstream of [redacted] to breach at the time of [redacted] volume in the reservoir, estimated breach parameters based on Froehlich (2008) and Xu and Zhang (2009). The methods were compared for each dam, and the more conservative of the results were used in the HEC-HMS modeling.

The resulting discharges from the HEC-HMS dam break modeling were used as inputs to HEC-RAS. The licensee reported the peak water surface elevations for the governing PMF with overtopping dam failure as [redacted] NAVD88 at Peach Bottom.

The NRC staff reviewed the HEC-HMS and HEC-RAS models and concluded that the model parameters, modeling of structures, and roughness coefficients were reasonable and appropriate for the modeled conditions. Hence, the NRC staff concluded that the modeling results were reasonable and appropriate.

3.4.4 Seismic Upstream Dam Failure

For this scenario, the licensee estimated the peak discharge at the Peach Bottom site using HEC-HMS for simultaneous failure of all upstream dams due to a seismic event in conjunction with the lower of the 50 percent PMP or the 500-year rainfall, in accordance with NUREG/CR-7046, Section 3.9 and Appendix H.2. The licensee ran multiple simulations with all dams failing simultaneously to determine the critical peak flow rate associated with the limiting dam failure event. The timing of the simultaneous failures was varied from time step [redacted] to up t[redacted] hours after the start of the rainfall to bracket the bounding breach time configuration. Breach parameters were estimated based on Froehlich (2008) and Xu and Zhang (2009). The methods were compared for each dam, and the more conservative of the results were used in the HEC-HMS modeling.

The resulting discharges from the HEC-HMS dam break modeling were used as inputs to HEC-RAS. The licensee reported the peak water surface elevations for the seismically induced failure as [redacted] NAVD88. This failure mechanism is bounded by the hydrologic dam failure.

The NRC staff reviewed the HEC-HMS and HEC-RAS models and concluded that the model parameters, modeling of structures, and roughness coefficients were reasonable and appropriate for the modeled conditions. Hence, the NRC staff concluded that the modeling results were reasonable and appropriate.

3.4.5 Upstream Dam Failure Timing and Duration

As discussed in Sections 3.4.3 and 3.4.4, the timing of the upstream dam failures as modeled by the licensee was evaluated to produce the maximum peak discharge at the Peach Bottom site. The NRC staff reviewed the timing analyses by reviewing the hydrographs from each alternative analysis (hydrologic and seismic) and concluded that the evaluation of timing and duration was reasonable.

3.4.6 Conclusion

The NRC staff reviewed the assumptions and approach used in the flooding from upstream dams analysis, and concluded the approach was appropriate and assumptions were reasonable. The NRC staff verified that the models were consistent with results presented in the FHRR. The NRC staff verified the references used, to ensure that they met standard engineering practices and present-day guidance and methodologies. 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 bounded by the CDB. Therefore, the NRC staff determined that flooding from failure of dams or onsite water storage structures does not need to be analyzed in an FE or a revised integrated assessment.

3.5 Storm Surge

The licensee reported in its FHRR that the reevaluated flood hazard water surface elevation for storm surge is 118.5 ft. NAVD88 including 9.4 ft. of wind generated storm surge. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee followed the guidance in NUREG/CR-7046, and other associated guidance, to complete the storm surge analysis. The licensee provided both the calculation package and the bathymetry and topography used in the analysis. The licensee determined that the maximum water elevation during a wind-induced surge event of 100 miles per hour was 117.5 ft. NAVD88 with normal pool water level antecedent conditions and 118.5 ft. NAVD88 with maximum controlled water elevation antecedent conditions. The licensee determined that although the CLB does not consider flooding from storm surge, the maximum storm surge elevation is below the Peach Bottom protection level of 134.9 ft. NAVD88.

The NRC staff reviewed the information provided by the licensee for estimating the wind generated storm surge. The NRC staff reviewed the methods for calculating wind setup, wave setup, and wave runup. These three components are added together to estimate the total storm surge. The NRC staff reviewed parameter values such as fetch lengths, wind speed, wave shoaling and refraction coefficients and reservoir bathymetry.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from storm surge is not bounded by the CDB flood hazard since the CDB does not explicitly consider this mechanism. Therefore, the NRC staff expected that the licensee would submit either an FE or a revised integrated assessment for storm surge. The licensee submitted its FE by letter dated March 17, 2017 (Exelon, 2017a). It is currently under review.

3.6 Seiche

The licensee reported in its FHRR that the reevaluated flood hazard for seiche is based on a stillwater-surface elevation of 112.8 ft. NAVD88 in the length direction, and 112.3 ft. NAVD88 for the width direction. Including wind waves and runup results in an elevation of 112.8 ft. NAVD88 and 112.3 ft. NAVD88 in the length and width directions, respectively. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee followed the guidance in NUREG/CR-7046 to analyze the potential for seiche at the Peach Bottom site. The licensee determined the Eigen periods and concluded that seiche is possible at the Peach Bottom site because the Eigen periods were close to the wind forcing frequencies. The licensee determined that although the CLB does not consider flooding from seiche, the maximum seiche elevation including wind waves and runup is below the Peach Bottom protection level of 134.9 ft. NAVD88.

The NRC staff reviewed the methodologies used by the licensee to estimate the Eigen periods for the Conowingo Reservoir, wave setup, and wave runup. The NRC staff reviewed parameter values such as the length of the reservoir and reservoir bathymetry.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from seiche is not bounded by the CDB flood hazard since the CDB does not explicitly consider this mechanism. Therefore, the NRC staff expected that the licensee would submit either an FE or revised integrated assessment for seiche. The licensee submitted its FE by letter dated March 17, 2017 (Exelon, 2017a). It is currently under review.

3.7 Tsunami

The licensee reported in its FHRR that the reevaluated hazard for tsunami does not inundate the plant site, and the licensee did not report a PMF elevation. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee reviewed the NOAA National Geophysical Data Center (NGDC) for historical tsunamis and the potential for a tsunami to propagate up the Susquehanna River to the Peach Bottom site. The licensee did not identify any tsunami events on the Susquehanna River that would be able to propagate upstream to the Peach Bottom site and concluded that tsunami is not a credible flood source for Peach Bottom.

The NRC staff reviewed the NGDC information and determined that there are no historical tsunami records that would affect the Peach Bottom site. The NRC staff agrees with the licensee that tsunami is not a plausible flood-causing mechanism for the Peach Bottom site. The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from tsunami is bounded by the CDB flood hazard. Therefore, the NRC determined that tsunami does not need to be analyzed in either an FE or a revised integrated assessment.

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated flood hazard for ice-induced flooding is based on a stillwater-surface elevation of 111.5 ft. NAVD88. Since the computed water surface for an ice jam flood is bounded by the PMF on the Susquehanna River, wind wave and runup were not included in this scenario. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee followed the hierarchical hazard assessment approach described in NUREG/CR-7046 (NRC, 2011) to initially assess the ice-induced flooding hazard. The licensee utilized the HEC-RAS hydraulic model used for analyzing the impacts of the PMF (Section 3.3.4 above), as well as historic ice jam data (USACE, 2012). An ice jam o[redacted] was assumed to fail instantaneously and concurrent with a 25-year flood flow.

The NRC staff reviewed the modeling of the ice jam performed by the licensee. The NRC staff noticed that certain details of the ice jam modeling were not discussed in the FHRR. The NRC staff asked the licensee to clarify if the analysis of the ice jam took into account the volume of ice released and the increased roughness due to interaction of flows downstream. The licensee stated that the cumulative conservatisms included in other parameters would encompass the ice volume and roughness uncertainties. The licensee also demonstrated that the water surface profiles are insensitive to the selected ice parameters due to the backwater effects from Conowingo Dam (NRC, 2017b).

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for ice-induced flooding of the site is not bounded by the CDB flood hazard since the CDB does not explicitly consider this mechanism. Therefore, the NRC staff expected that the licensee would submit either an FE or a revised integrated assessment for ice-induced flooding. The licensee submitted its FE by letter dated March 17, 2017 (Exelon, 2017a). It is currently under review.

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated hazard for channel migrations or diversions does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee examined stream channel data for the last 100 years, including historical maps and photos, and determined that there is no evidence of channel migration on the Susquehanna River or Rock Run Creek that would contribute to flooding at the Peach Bottom site. The NRC staff independently reviewed available stream channel data for evidence of channel migration but found no evidence to suggest that channel migration has affected the Peach Bottom site.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from channel migrations or diversions is bounded by the CDB flood hazard. Therefore, the NRC staff determined that flooding due to channel migrations or diversions does not need to be analyzed in a FE or a revised integrated assessment.

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

4.1 Reevaluated Flood Elevation for Hazards Not Bounded by the CDB

Section 3 of this staff assessment documents the NRC staff review of the licensee's flood hazard water height results. Table 4.1-1 contains the maximum flood height results, including waves and runup, for flood mechanisms not bounded by the CDB presented in Table 3.1-1. The NRC staff agrees with the licensee's conclusion that LIP, storm surge, seiche, and ice-induced flood-causing mechanisms are not bounded by the CDB.

The NRC staff anticipated that the licensee would submit an FE for LIP. For the storm surge, seiche, and ice-induced flood-causing mechanisms, the NRC staff anticipated the licensee would perform an additional assessment of plant response, either an FE or a revised integrated assessment. The licensee submitted its FE by letter dated March 17, 2017 (Exelon, 2017a). It is currently under review.

4.2 Flood Event Duration for Hazards Not Bounded by the CDB

The NRC staff reviewed the information provided in Exelon's 50.54(f) response (Exelon, 2015) and subsequent letter (Exelon, 2016c) regarding the FED parameters needed to perform the additional assessment of plant response for flood hazards not bounded by the CDB. The FED parameters for flood-causing mechanisms not bounded by the CDB are summarized in Table 4.2-1.

The licensee computed the duration of flooding above protection level for each individual door affected by flooding from LIP. In all cases, this duration of inundation above protection level was less than one hour. The licensee did not determine warning time for LIP but stated that it may use NEI-15-05 to determine the LIP warning time during additional assessments of plant response. The FED parameters for storm surge were defined for precipitation-driven hydrologic dam failure as a bounding riverine flood event as presented in FHRR Table 4.0.3.

By letter dated June 30, 2016, the licensee submitted its MSA to the NRC (Exelon, 2016b). The licensee provided FED parameters for the storm surge flood-causing mechanism as discussed in FHRR Table 4.0.3, based off of numerical modeling results associated with the dam failure analysis discussed in Section 3.4 of this staff assessment. The NRC staff reviewed these storm surge FED parameters as part of the MSA, and determined that they are reasonable and acceptable for use (NRC, 2017a). In addition, the NRC staff accepted the licensee's conclusion that FED parameters for both the seiche and the ice-induced flood-causing mechanisms are bounded by the FED values for storm surge. These FED values have been noted as 'bounded' in Table 4.2-1.

The NRC staff reviewed the licensee's response regarding FED parameters for all flood-causing mechanisms not bounded by the CDB (Exelon, 2015) and determined that the parameters are reasonable for use in future assessments of plant response.

4.3 Associated Effects for Hazards Not Bounded by the CDB

The NRC staff reviewed information provided in Exelon's 50.54(f) response (Exelon, 2015) and subsequent letter (Exelon, 2016c) regarding AE parameters needed to perform future additional assessments of plant response for flood hazards not bounded by the CDB. The AE parameters not directly associated with a maximum WSE are listed in Table 4.3-1.

The licensee estimated the hydrodynamic loading due to LIP and reported both the maximum total force and the hydrodynamic loading on individual doors. Table 4.3-1 of this staff assessment reflects the total maximum force on all doors as was reported in the MSA staff assessment (NRC, 2017a). The licensee noted that AE parameters for seiche and ice-induced flood-causing mechanisms are bounded by the storm surge flood-causing mechanism. The AE parameter values for these mechanisms have been noted as 'bounded' in Table 4.2-1. The NRC staff reviewed the AE parameters as part of the MSA and determined that the values are reasonable (NRC, 2017a).

The NRC staff reviewed the AE parameters provided by the licensee, and the NRC staff confirms the licensee's AE parameter results are reasonable for use in future assessments of plant response.

4.4 Conclusion

Based upon the preceding analysis, NRC staff confirmed that the reevaluated flood hazard information defined in Section 4 is an appropriate input to the additional assessments of plant response as described in the 50.54(f) letter (NRC, 2012a), COMSECY-15-0019 (NRC, 2015b), and associated guidance.

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms of Peach Bottom. Based on its review of the above available information provided in Exelon's 50.54(f) response (Exelon, 2015), 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 upon the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter dated March 12, 2012. In reaching this determination, NRC staff confirmed the licensee's conclusions that (1) the reevaluated flood hazard results for LIP, storm surge, seiche, and ice-induced flood-causing mechanisms are not bounded by the CDB flood hazard, (2) additional assessments of plant response will be performed for the LIP, storm surge, seiche and ice-induced flood-causing mechanisms, and (3) the reevaluated flood-causing mechanism information is appropriate input to the additional assessments of plant response as described in the 50.54(f) letter and COMSECY-15-0019 (NRC, 2015b) and associated guidance. The NRC staff has no additional information needs with respect to Exelon's 50.54(f) response for Peach Bottom.

6.0 REFERENCES

Notes: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

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Table 2.2-1. Flood-Causing Mechanisms and Corresponding Guidance

FLOOD-CAUSING MECHANISM	STANDARD REVIEW PLAN (SRP) SECTION(S) AND/OR JLD-ISG
Local Intense Precipitation and Associated Drainage	SRP 2.4.2 SRP 2.4.3
Streams and Rivers	SRP 2.4.2 SRP 2.4.3
Failure of Dams and Onsite Water Control/Storage Structures	SRP 2.4.4 JLD-ISG-2013-01
Storm Surge	SRP 2.4.5 JLD-ISG-2012-06
Seiche	SRP 2.4.5 JLD-ISG-2012-06
Tsunami	SRP 2.4.6 JLD-ISG-2012-06
Ice-Induced	SRP 2.4.7
Channel Migrations or Diversions	SRP 2.4.9

SRP refers to the "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (NRC, 2007).

JLD-ISG-2012-06 refers to the "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment" (NRC, 2013a).

JLD-ISFG-2013-01 refers to the "Guidance for Assessment of Flooding Hazards Due to Dam Failure" (NRC, 2013b).

Table 3.0-1. Summary of Controlling Flood-Causing Mechanisms

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation (115.9 ft. NAVD88.)[1]	ELEVATION
Local Intense Precipitation and Associated Drainage	135.9 ft. NAVD88
Failure of Dams and Onsite Water Control/Storage Structures	[redacted] NAVD88 (FHRR Section 3.6.3)

[1]Flood height and associated effects as defined in JLD-ISG-2012-05.

Table 3.1-1 – Current Design Basis Flood Hazards for Use in the MSA

Mechanism	Stillwater Elevation	Waves/ Runup	Design Basis Hazard Elevation	Reference
Local Intense Precipitation and Associated Drainage	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.3.1
Streams and Rivers				
Probable Maximum Flooding from Rock Run Creek	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.3.2.2
Probable Maximum Flooding from Susquehanna River	131.4 ft. NAVD88	Not applicable	131.4 ft. NAVD88	FHRR Section 2.3.2.1
Combined Event: Probable Maximum Flooding with Failure of [redacted] and Wind-generated Waves	[redacted] NAVD88	5.4 ft.	[redacted] NAVD88	FHRR Section 2.3.9
Failure of Dams and Onsite Water Control/Storage Structures				
Failure of [redacted]	[redacted] NAVD88	0.5 ft.	[redacted] NAVD88	FHRR Section 2.3.3
Storm Surge	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.3.4
Seiche	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.3.5
Tsunami	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.3.6
Ice-Induced	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.3.7
Channel Migrations or Diversions	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.3.8

Note: Reported values are rounded to the nearest one-tenth of a foot.

Table 3.1.4-1 Summary of Land Use Changes in Susquehanna River Watershed

	Land Use (percent of land area)					
Referenced Study	**Forest**	**Grass**	**Cultivated**	**Urban**	**Water/Wetland**	**Other**
1970 Susquehanna River Basin Study (Susquehanna River Basin Coordinating Committee, 1970)	51	20	25	4	N/A	N/A
2011 Nutrients and Suspended Sediment in the Susquehanna River Basin (Susquehanna River Basin Commission, 2012)	69	N/A	21	7	2	1

N/A - Land use category not reported in referenced study and therefore not available for comparison

Table 4.1-1. Reevaluated Flood Hazard Elevations for Flood-Causing Mechanisms Not Bounded by the Peach Bottom CDB

Mechanism	Stillwater Elevation	Waves/ Runup	Reevaluated Hazard Elevation	Reference
Local Intense Precipitation				
Emergency Cooling Tower (Emergency Heat Sink)	127.0 ft. NAVD88	Minimal	127.0 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Unit 3 Reactor Building Door 246	135.2 ft. NAVD88	Minimal	135.2 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Unit 3 Reactor Building Door 244	135.4 ft. NAVD88	Minimal	135.4 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Unit 3 Recirculation MG Set Room	135.9 ft. NAVD88	Minimal	135.9 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Unit 2 Recirculation MG Set Room	135.9 ft. NAVD88	Minimal	135.9 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Unit 2 Reactor Building Door 183	135.5 ft. NAVD88	Minimal	135.5 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Unit 2 Reactor Building Door 198	135.2 ft. NAVD88	Minimal	135.2 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Diesel Generator Building (SW)	132.0 ft. NAVD88	Minimal	132.0 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Diesel Generator Building (SE)	127.5 ft. NAVD88	Minimal	127.5 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Diesel Generator Building (NE)	117.6 ft. NAVD88	Minimal	117.6 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Diesel Generator Building (NW)	120.8 ft. NAVD88	Minimal	120.8 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Pump Structure	117.5 ft. NAVD88	Minimal	117.5 ft. NAVD88	FHRR Section 3.1.3 & Table 3.1.3.1
Storm Surge				
Conowingo Maximum Controlled Water Elevation Antecedent Condition	118.5 ft. NAVD88	Not applicable	118.5 ft. NAVD88	FHRR Section 3.4.3
Seiche				
Seiche in Length Direction (Conowingo Maximum	112.8 ft. NAVD88	Not applicable	112.8 ft. NAVD88	FHRR Section 3.4.4 & Table 3.4.3.2.4

Controlled Water Elevation Antecedent Condition) Seiche in Width Direction (Conowingo Maximum Controlled Water Elevation Antecedent Condition)	 112.3 ft. NAVD88	 Not applicable	 112.3 ft. NAVD88	 FHRR Section 3.4.4 & Table 3.4.3.2.4
Ice-Induced Flooding	111.5 ft. NAVD88	Not applicable	111.5 ft. NAVD88	FHRR Sections 3.7 & 3.7.3

Note 1: The licensee is expected to develop flood event duration parameters and applicable flood associated effects to conduct the MSA. The NRC staff will evaluate the flood event duration parameters (including warning time and period of inundation) and flood associated effects during its review of the MSA.
Note 2: Reevaluated hazard mechanisms bounded by the CDB (Table 3.1-1) are not included in this table.
Note 3: Reported values are rounded to the nearest one-tenth of a foot.

Table 4.2-1. Flood Event Duration for Flood-Causing Mechanisms Not Bounded by the Peach Bottom 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	Not provided but may use NEI 15-05	0.2 to 1 hour	0.2 to 0.4 hour
Storm Surge	126 hours	60 hours	22 hours
Seiche (2)	Bounded	Bounded	Bounded
Ice-induced(2)	Bounded	Bounded	Bounded

Source: NRC, 2017a.

Notes: (1) The licensee did not define the FED parameters for the seiche and ice-induced flood-causing mechanisms because the reevaluated flood level for these events are bounded by that for storm surge.

Table 4.3-1 Associated Effects Parameters not Directly Associated with Total Water Height for Flood-Causing Mechanisms Not Bounded by the Peach Bottom CDB

	Flooding Mechanism			
Associated Effects Parameter	**Local Intense Precipitation**	**Storm Surge (2)**	**Seiche(3)**	**Ice-Induced Flooding(3)**
Hydrodynamic loading at plant grade	1,620 lb/ft. at Diesel Generator Building(1)	4,867 lb/ft. for hydrostatic load 47 lb/ft. got hydrodynamic load 2,462 lb/ft. for wave load	Bounded	Bounded
Debris loading at plant grade	Minimal	Assume a tree log debris of 1,000 lb in weight, 30 ft. in length, and 1 ft. in diameter traveling at 1.39 ft./s	Bounded	Bounded
Sediment loading at plant grade	Minimal	Minimal	Bounded	Bounded
Sediment deposition and erosion	Minimal	Minimal	Bounded	Bounded
Concurrent conditions, including adverse weather	Minimal	Not applicable	Bounded	Bounded
Groundwater Ingress	Minimal	Not applicable	Bounded	Bounded
Other pertinent factors (e.g., waterborne projectiles)	Minimal	Bounded	Bounded	Bounded

Notes: (1) Total force on all doors as given in FHRR Table 3.10.3.1.1.
(2) Defined for Precipitation-Driven Hydrologic Dam Failure
(3) The licensee did not define the FED parameters for the seiche and ice-induced flood-causing mechanisms because the reevaluated flood level for these events are bounded by that for storm surge.

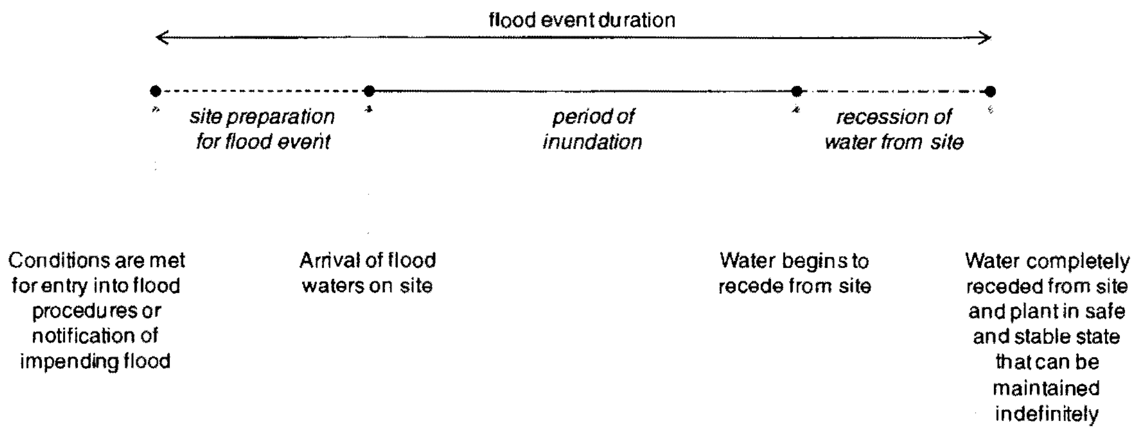

Figure 2.2-1. Flood Event Duration (NRC JLD-ISG-2012-05, Figure 6)

Figure 3.2-1. Location map showing the critical locations, which were evaluated in the LIP analysis, including (1) seven doors of safety-related structures, (2) one door of Turbine Building, which is not a safety-related structure, and (3) two other critical structures (Diesel Generator and Pump Structure) that are associated with five evaluated critical locations.

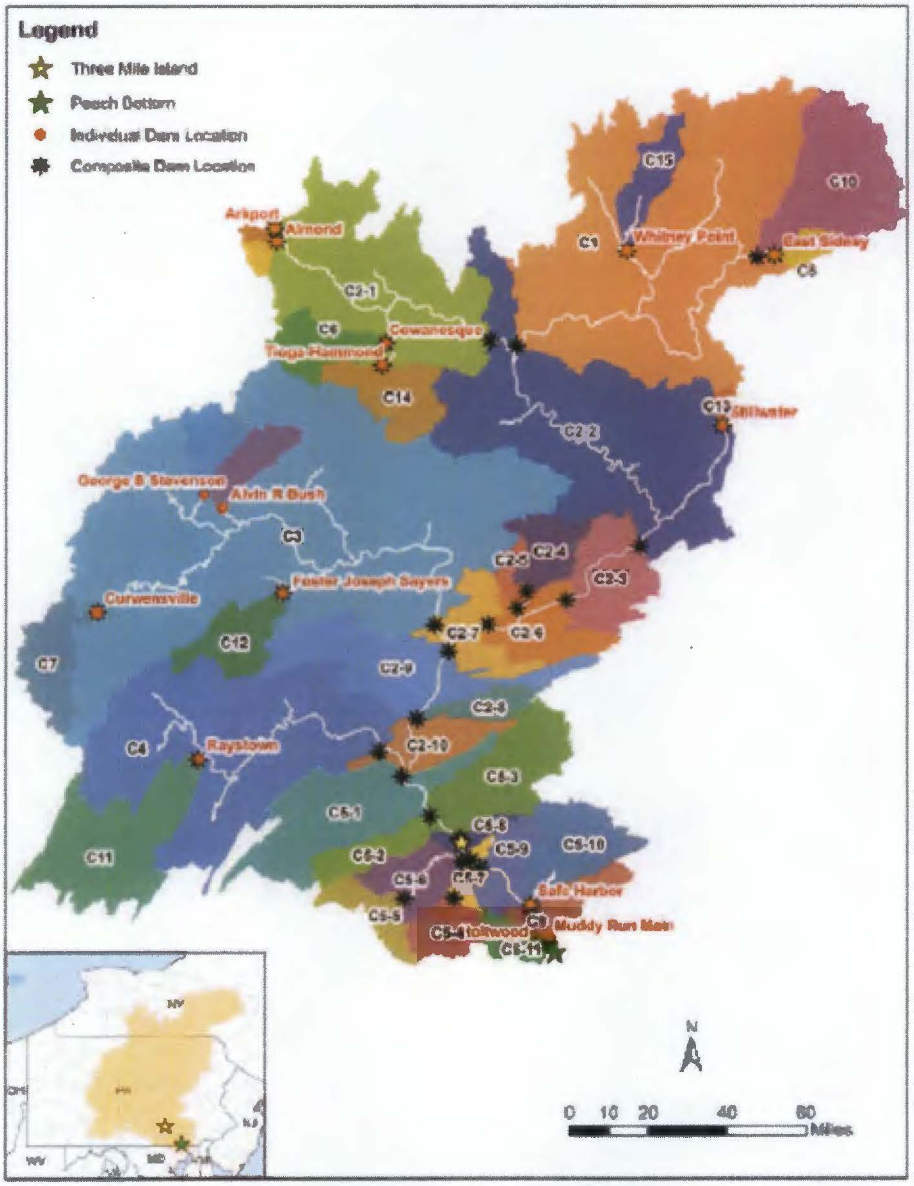

Figure 3.4.1-1. Individual and Composite Dam Locations within the Susquehanna Watershed

SUBJECT: PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM RE-EVALUATION DATED October 30, 2017

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