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

March 27, 2017

Mr. Brian Sullivan
Site Vice President
Entergy Nuclear Operations, Inc.
James A. FitzPatrick Nuclear Power Plant
P.O. Box 110
Lycoming, NY 13093

SUBJECT: JAMES A. FITZPATRICK NUCLEAR POWER PLANT – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (TAC NO. MF6106)

Dear Mr. Sullivan:

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 that licensees reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated March 12, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15082A250), Entergy Nuclear Operations, Inc. (Entergy, the licensee), responded to this request for James A. FitzPatrick Nuclear Power Plant.

By letter dated September 4, 2015 (ADAMS Accession No. ML15238B537), the NRC staff sent the licensee a summary of the staff's review of the licensee'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, the reevaluated flood hazard result for local intense precipitation (LIP), streams and rivers, and combined storm surge event were not bounded by the current design-basis flood hazard. The NRC staff anticipates that the licensee will perform and document a focused evaluation for LIP and a focused evaluation or revised integrated assessment for streams and rivers, and the combined storm surge event.

This closes out the NRC's efforts associated with CAC No. MF6106.

If you have any questions, please contact me at (301) 415-1132 or e-mail at Joseph.Sebrosky@nrc.gov.

Sincerely,

Joseph M. Sebrosky, Senior Project Manager
Hazards Management Branch
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Office of Nuclear reactor Regulation

Docket No. 50-333

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

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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

JAMES A. FITZPATRICK NUCLEAR POWER PLANT

DOCKET NO. 50-333

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* (10 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] Review of Insights from the Fukushima Dai-ichi Accident" (NRC, 2011b).

Recommendation 2.1 in that document recommended that the 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 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).

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 the Flooding Hazard Reevaluation Report (FHRR) deadlines for individual plants. On May 11, 2012, the staff issued its prioritization of the FHRRs (NRC, 2012c).

By letter dated March 12, 2014 (Entergy, 2015a), Entergy Nuclear Operations, Inc. (Entergy, the licensee) provided its FHRR for James A. FitzPatrick Nuclear Power Plant (FitzPatrick). The NRC staff conducted a site audit with the licensee on July 15, 2015. The licensee provided responses to information requests made by staff during the audit (NRC, 2016b). The staff issued an Audit Summary Report summarizing additional information obtained during this audit (NRC, 2016b). The FHRR (Entergy, 2015a), model input files (Entergy, 2015b), and staff's audit summary (NRC, 2016b) provide the flood hazard input necessary to support the NRC staff's review.

By letter dated September 4, 2015, the NRC issued an interim staff response (ISR) letter to the licensee (NRC, 2015c). The ISR letter provides the reevaluated flood hazard elevations for the local intense precipitation (LIP), rivers and streams, and combined storm surge event, which are the mechanisms not bounded by the current design basis (CDB). These elevations are referred to as mitigating strategies flood hazard information in COMSECY-15-0019 (NRC, 2015a), and are suitable for the assessment of mitigating strategies for beyond-design basis events developed in response to NRC Order EA-12-049 (NRC, 2012b). The flood reevaluated hazard mechanism values presented in the letter's enclosures match the values in this staff assessment. However, in this staff assessment, the NRC staff corrected the CDB entries for

"Storm Surge at Screenwell" in Table 3.1-2. These changes did not change any conclusions regarding the reevaluated hazard transmitted in the ISR letter.

As mentioned in the ISR letter and discussed below, the reevaluated flood hazard results for LIP, the rivers and streams, and the combined storm surge event (probable maximum storm surge (PMSS), probable maximum precipitation (PMP)[1], and Waves; "PMSS+PMP+Waves") flood-causing mechanisms are not bounded by the plant's CDB hazard. Consistent with the 50.54(f) letter and amended by the process outlined in COMSECY-15-0019 and Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2016-01, Revision 0 (NRC, 2015b and NRC, 2016c), the staff anticipates that for LIP, the licensee will perform and document a focused evaluation to assess the impact of the LIP hazard on the site and evaluate and implement any necessary programmatic, procedural or plant modifications to address this hazard exceedance. Additionally, for the rivers and streams and the combined event flood-causing mechanisms, the NRC staff anticipates that the licensee will submit (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 any flood event duration (FED) and associated effects (AE) parameters currently not provided to conduct the mitigating strategies assessment and focused evaluations or revised integrated assessments.

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 plant 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 (FSAR) 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 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 "design bases" as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values

[1] The FHRR refers to the combined event scenario as a combination of PMSS, PMP, and waves; this staff assessment will retain that scenario name but will refer to the riverine PMF as the result of the PMP.

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 a 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 FSAR. 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 applications submitted 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 flooding-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 that the licensee should consider, and 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 run-up 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 Effect 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 effect flood." Even if some or all of the 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 should 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

Flood event duration was defined in JLD-ISG-2012-05 (NRC, 2012d) 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.

2.2.5 Actions Following the FHRR

For the sites where the reevaluated flood hazard is not bounded by the CDB 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 hazards

- 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) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c) outline 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 focused evaluation that will assess the impact of the LIP hazard on their site and then evaluate and implement any necessary programmatic, procedural, or plant modifications to address this hazard exceedance. For other flood hazard mechanisms that exceed the CDB, licensees can assess the impact of these reevaluated hazard on their site by performing either a focused evaluation or a revised integrated assessment (NRC, 2015b and NRC, 2016c).

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of the FitzPatrick site. 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 FHRR, the licensee made calculation packages available to the staff via an electronic reading room. The staff's review and evaluation is provided below.

3.1 Site Information

The 50.54(f) letter (NRC, 2012a) includes the SSCs important to safety (e.g., the Ultimate Heat Sink) in the scope of the hazard reevaluation. The licensee included pertinent data concerning these SSCs in the FHRR (Entergy, 2015a). The staff requested additional information from the licensee to supplement the FHRR. The licensee provided this additional information during an audit on July 15, 2015. This information was summarized in the staff's audit report (NRC, 2016b). The staff reviewed and summarized this information in the sections below.

3.1.1 Detailed Site Information

The FitzPatrick FHRR (Entergy, 2015a) describes the site-specific information related to the flood hazard evaluation. The licensee used United States Lake Survey of 1935 (USLS35) datum for elevations in the FHRR.

The licensee described in its FHRR the following site information related to the site flood hazard reevaluation. The FitzPatrick site is located on the southern shore of Lake Ontario, in Oswego County, New York, about 7 mi northeast of the City of Oswego. The FitzPatrick site is less than 1 mi to the east of the Nine Mile Point site and therefore considered to be in the same hydrological setting as the Nine Mile Point site. FitzPatrick site buildings are about 150 ft landward of the cliffs to the north of the site near the shore of Lake Ontario. An unnamed perennial stream (hereafter referred to as unnamed stream) is situated southwest of the FitzPatrick site and east of the Nine Mile Point site before flowing into Lake Ontario. The licensee included a figure in the FHRR that shows the FitzPatrick buildings and delineates the vehicle barrier system (VBS), culverts, and the unnamed stream; this figure is reproduced in this staff assessment as Figure 3.1-1. The licensee stated that the contributing area to the unnamed stream is 0.62 mi^2 and could cause site flooding due to overbank flow. The licensee stated that floodwaters drain from the FitzPatrick site through culverts and storm sewers and that buildings and the VBS could alter flow paths. The licensee stated that drainage ditches carry runoff on the east site of the FitzPatrick site. The licensee noted that a natural berm runs along the north edge of the site separating the FitzPatrick site from Lake Ontario.

The site grade at the powerblock is elevation 272.0 ft USLS35 (Entergy, 2015a). Table 3.1-1 provides the summary of controlling reevaluated flood-causing mechanisms including (1) LIP, and (2) Streams and Rivers PMP, for which the licensee computed flood hazard elevations to be higher that the powerblock elevation (Entergy, 2015a).

3.1.2 Design-Basis Flood Hazards

The CDB flood levels are summarized by flood-causing mechanism in Table 3.1-2 of this staff assessment. The licensee presented CLB flood elevation information in FHRR Table 4-1. The licensee stated that the only mechanisms that have a CDB are storm surge; combined effect of PMSS, Probable Maximum Flood (PMF) and waves, which the FHRR refers to as "PMSS+PMP+Waves"; and combined effect for PMSS and PMP at the Screenwell, which the FHRR refers to "Screenwell PMSS+Waves". The licensee reported that all other mechanisms were not evaluated in terms of CLB flood elevations. In its FHRR, the licensee often used "current licensing basis" and clarified that this was considered equivalent to the "current design basis" (NRC, 2016b). The staff refers to CDB throughout this staff assessment with this understanding. 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 (NRC, 2012a).

3.1.3 Flood-Related Changes to the Licensing Basis

The FHRR describes the evaluation the licensee conducted to demonstrate that FitzPatrick roofs were capable of accommodating PMP event loadings and drainage, as such there is no water surface elevation CDB. The licensee referenced its Flood Walkdown Report (Attachment 1 to Entergy, 2012) for further details of this analysis. The NRC staff reviewed the information provided in the FHRR 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 stated in its FHRR that there have been insignificant changes to the FitzPatrick watershed. The licensee noted one local change was the installation of the VBS, which could have a potential influence on site surface water drainage. These effects are discussed in Section 3.2 of this staff assessment. The licensee identified no other changes to the watershed and local area in its FHRR.

The staff reviewed the International Joint Commission (IJC) proposed revised plan to alter the regulation of the water surface elevation (WSE) in Lake Ontario (IJC, 2014). The staff determined that proposed revision, if enacted, would not significantly affect the flood hazard conclusions at the FitzPatrick site.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

The licensee stated in its FHRR that the CLB flood protection is provided by conduit seals at manholes, which include conduits with connections to the Reactor Building. The licensee assumed that credited drains remain effective on the Reactor Building roof for analysis during the Individual Plant Evaluation for External Events. The licensee referenced the Flood Walkdown Report (Attachment 1 to Entergy, 2012) for further details of this analysis. The licensee identified no other flood protection or flood mitigation features in its FHRR.

3.1.6 Additional Site Details to Assess the Flood Hazard

The licensee provided electronic versions of the input and output file used for numerical model analysis of LIP and streams and rivers PMP in the FHRR (Entergy, 2015a; Entergy, 2015b).

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 parts of 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 27, 2012, Entergy (Entergy, 2012) provided the Flooding Walkdown Report for FitzPatrick site (Attachment 1 to Entergy, 2012). The NRC staff issued a staff assessment, dated June 17, 2014 (NRC, 2014a), which documented its review of the Flooding Walkdown Report. In the staff assessment of the Walkdown Report (NRC, 2014a) the NRC staff concluded that the licensee's implementation of flooding walkdown methodology met the intent of the walkdown guidance.

3.2 Local Intense Precipitation

The licensee reported in its FHRR (Entergy, 2015a) that the reevaluated flood hazard for LIP results a stillwater-surface elevation of 272.1 ft USLS35 to 272.8 ft USLS35. This flood-causing mechanism is not discussed in the licensee's CDB for ground surface flooding related to LIP. To reevaluate the hazards for the LIP event, the licensee used the two-dimensional hydrodynamic computer model FLO-2D Pro, Build 14.03.07 (referred to hereafter as FLO-2D), to calculate the WSE due to LIP (FLO-2D, 2014). The computational boundary of the model was delineated based on the FitzPatrick topographic survey (Entergy, 2015a) and includes portions of the local watershed associated with the small unnamed stream to the west of the FitzPatrick site (Figure 3.2-1). The licensee included rainfall runoff from portions of the watershed beyond the model's boundary by creating an input hydrograph for the unnamed stream. The licensee calculated the hydrograph using the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) model (U.S. Army Corps of Engineers (USACE), 2010a) using the 6-hour (h) LIP hyetograph as input to the FLO-2D model. The HEC-HMS model was created for the PMF streams and river reevaluation (see Section 2.3.1) and modified for the LIP hazard assessment model (Entergy 2015a).

The staff provided information needs related to LIP and the streams and rivers flood hazard to the licensee. These were discussed in a webinar-format audit on July 15, 2015. The staff summarized the licensee's responses in the audit report (NRC, 2016b).

The reevaluation of flood hazard for LIP is based on the 6-h, 10-mi^2 PMP, calculated from the tables presented in the National Oceanic and Atmospheric Administration (NOAA) Hydrometeorological Reports (HMR) No. 51 (NOAA, 1978) and No. 52 (NOAA, 1982). The licensee created the front-end, 1-h distribution for the synthetic PMP hydrograph and used equal increments of rainfall for the remaining 5 hours of the storm to obtain the 23.3 in. of precipitation estimated from HMR 52 for the 6-h, 10-mi^2 PMP. The total rainfall for the 1-h rainfall is approximately 15.9 in. NUREG/CR-7046 (NRC, 2011e) recommends the use of the 1-h, 1-mi^2 PMP. However, as the 6-h, 10-mi^2 PMP encompasses the 1-h, 1-mi^2 PMP, the licensee chose to use the 6-h storm as a more conservative approach.

The licensee modeled the FitzPatrick site and its surrounding area using a 10-ft FLO-2D grid with elevations from a combination of regional Light Detection and Ranging (LiDAR) maps and a site-specific Digital Terrain Model. The boundary of the site includes all onsite buildings and was delineated based on the topography as shown in Figure 3.1-1. The licensee assigned the inflow hydrograph to the grid cell along the southern boundary of the site at the unnamed stream's location. The licensee assumed an overall conservative nature for the model such that all rainfall is converted directly to runoff and that all drainage routes (e.g., culverts) are completely blocked. These assumptions are consistent with NUREG/CR-7046.

The licensee used high-resolution orthoimagery to determine the land cover of the site. By visual assessment of the imagery, the licensee assigned a Manning's *n* coefficient of flow resistance for each land cover. The higher, more conservative, values from the suggested ranges provided in the FLO-2D reference manual (FLO-2D, n.d.) were used in the licensee's model. The licensee stated (in response to an information need provided for the July 2015 audit (NRC, 2016b)) that patches of short grass within the proximity of the power block are conservatively assigned with Manning's *n* values that are associated with smoother surfaces (i.e. concrete). The licensee noted that because the surface area of the patches is minimal and therefore would not have a significant impact on the WSE at critical doors, these areas were not identified as grass within the model as model instability may occur at the transition of the Manning's *n* coefficients. The licensee also noted that the lower n value is more reflective of the strict maintenance of the grass at the FitzPatrick site and the overall conservativeness of the model would account for slight variation in roughness coefficients.

The licensee conservatively assigned the WSE at the grid cells representing Lake Ontario (north boundary of the site) at the predicted elevation that would occur for a 100-year storm event as determined in the reevaluation of the PMSS calculation section for the FHRR (Entergy, 2015a). The licensee modified the grid cell elevations representing buildings to account for the building roof drainage. The building cells were assigned arbitrary elevations of at least 5 ft higher than the surrounding ground surface elevation to account for the blockage of flow. The relative height order between buildings was maintained to create a realistic representation of flow pattern among adjacent buildings. Parapets, which create water storage, were conservatively not modeled and therefore all rainfall on the rooftops of buildings discharges directly to the ground surface within the model. The licensee created an analysis comparing this alteration of elevation at building cells with methods of modeling structures suggested for the FLO-2D software in the reference manual (FLO-2D, n.d.) in response to an information need for the July 2015 audit (NRC, 2016b) and determined that the difference in calculation methods is negligible.

The licensee modeled the VBS at FitzPatrick in FLO-2D with the levee structure modeling capability of the software. The licensee configured the VBS based on high-resolution orthoimagery. A sensitivity analysis by the licensee consisted of model runs that included and excluded the VBS. The licensee's analysis concluded that although the model including the VBS has slightly reduced flood depths within the power block, the grid elevations near critical structures were not affected. Therefore, the licensee concluded the VBS was conservatively ignored in the final reevaluation model.

The licensee reported that the WSE above door sill elevations due to LIP has a duration of up to 8.8 h (and further characterized the duration as less than 9.0 h for these doors). The licensee reported that period of inundation for the plant as a whole was 20 h (Entergy, 2015a). The associated warning time, site preparation time, and period of recession were not identified by the licensee.

The staff reviewed details of the licensee's FLO-2D model implementation and determined that the approaches and assumptions were conservative and appropriate. The model output files reviewed by NRC staff did not report any errors related to model stability or mass balance.

The staff confirmed the licensee's conclusion that the maximum WSE is equal to or greater than 11 of the 12 known door sill elevations at critical features of the site. The maximum water depth above a door sill is 0.7 ft.

The staff confirmed that the licensee's reevaluation of the hazard for LIP and associated site drainage used present-day methodologies and regulatory guidance. The staff also confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated drainage is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit a focused evaluation.

3.3 Streams and Rivers

The licensee reported in its FHRR, that the reevaluated flood hazard, including associated effects, for streams and rivers is based on a stillwater-surface elevation ranging up to 272.1 ft North American Vertical Datum of 1988 (NAVD88) (272.8 ft USLS35). This flood-causing mechanism is not discussed in the licensee's CDB.

The staff provided information needs related to LIP and the streams and rivers flood hazard to the licensee. These were discussed in a webinar-format audit on July 15, 2015. The staff summarized the licensee's responses in the audit report (NRC, 2016b).

The streams and rivers flooding assessment of the site is focused on an unnamed stream that flows along the west side of the property. The stream drains a watershed comprised of onsite and offsite areas totaling 0.62 mi^2 (Figure 3.2-1). The offsite upper watershed is to the south of the property. Most of the onsite areas, including the power block, drain into the unnamed stream. The unnamed stream is not gaged.

The overall process used by the licensee for evaluating the streams and rivers flood hazard was to first determine an input hydrograph for the unnamed stream using HEC-HMS, and then using this as input to the same FLO-2D model discussed in Section 3.2. This approach combines the strength of a HEC-HMS analysis for proper estimation of flow with the two-dimensional hydrodynamic FLO-2D model for determining the spatial distribution of calculated WSE at various key locations.

The PMP was determined using HMR 51 (NOAA, 1978) and HMR 52 (NOAA, 1982). Three alternatives were considered, consistent with NUREG/CR-7046. Alternative 1 is the all-season 72-h PMP. Alternative 2 is the 100-year rainfall and snowmelt from an unlimited snowpack. Alternative 3 is the cool-season PMP and snowmelt from a 100-year snowpack. The largest PMP determined was that of alternative 1, amounting to 32.9 in. This alternative also has the greatest intensity of rainfall.

The input hyetograph for the PMF was determined through a scenario of an antecedent storm of 40 percent of the PMP during the first 72 hours, then a 72-h dry period, and finally the 72-h PMP event.

The licensee created a HEC-HMS model of the local watershed, which includes most of the FitzPatrick site as well as offsite areas shown on Figure 3.2-1, using the PMF along with conservative assumptions of wet antecedent moisture conditions and an impervious surface with no precipitation losses. Non-linearity adjustments were applied. The peak discharge from the local watershed to Lake Ontario was 2,340 ft^3/s.

The licensee used the FLO-2D hydrodynamic model developed for the LIP analysis, described in Section 3.2, to determine the WSEs at critical locations resulting from the all-season PMF discharge calculated by the HEC-HMS model. The 72-h PMP of the local watershed was added to the model as an inflow hydrograph at a model cell along the south edge of the site where the unnamed stream enters the property. This is a conservative aspect of the modeling approach, as the full watershed's PMP discharge is applied at a location near the center of the local watershed. The model boundary, elevation, structures, and Lake Ontario WSEs are the same as those provided in Section 3.2. The 72-h PMP was not modeled as rainfall directly in FLO-2D to avoid double counting its effect and to remain focused on one flood mechanism. The 40-percent PMP antecedent rainfall was not modeled because it was found to recede fully during the 72-h dry period preceding the PMP.

The PMF results for door locations and other reporting locations near critical plant structures ranged from 271.1 ft NAVD88 to 272.1 ft NAVD88 (271.8 ft USLS35 to 272.8 ft USLS35). Flow depths at these locations ranged up to 1.3 ft.

The licensee reported that FLO-2D output were inspected for errors associated with volume conservation and for high (greater than 10 ft/s) velocities indicative of numerical surging. The licensee stated that no issues were present.

The licensee reported that the WSE above door sill elevations due to PMF has a duration of up to 5.5 h (Entergy, 2015a). The licensee stated that period of inundation for the site was 49.5 h. The associated warning time was not stated, but considered by the licensee to be bounded by the CDB. The licensee provided no description of site preparation time but considered it to be bounded. The licensee described the period of recession as not bounded. Flood levels determined at most doors and other key locations were above seven door sill elevations, ranging up to a depth of 0.8 ft.

The staff note that the St. Lawrence River provides a downstream control on Lake Ontario and that the river's impact on the Lake Ontario WSE is incorporated implicitly in Lake Ontario for the establishment of reevaluated hazards. Flooding due to ice jams on the St. Lawrence River is discussed in Section 3.8.

The staff note the Oswego River flows into Lake Ontario about 7 miles of Lake Ontario shoreline distance from the FitzPatrick site. The river's impact is through Lake Ontario itself rather than directly to the FitzPatrick site. Flooding due to ice jams on the Oswego River is discussed in Section 3.8.

The staff reviewed the hydrological setting of the FitzPatrick site and confirmed that the unnamed stream was the only perennial stream that has the potential to cause PMF inundation of the site. The staff reviewed the site topography and found that the licensee delineation of the site watershed was reasonable. The staff's review of the FLO-2D model used in the PMF analysis is the same as was reviewed in the LIP analysis. Discussion of staff's review is in Section 3.2 of this report and is not repeated here. The staff reviewed the licensee use of HEC-HMS to develop watershed runoff as an input to the FLO-2D model and determined that its use was appropriate.

The staff determined the 72-h PMP event precipitation depth was appropriately developed using HMR 51 (NOAA, 1978) and HMR 52 (NOAA, 1982) methods. The staff found the 72-hour precipitation depth for the FitzPatrick site was nearly identical as that determined for the adjacent Nine Mile Point site, which was previously reviewed by staff.

During the audit, the staff requested additional information related to: 1) the selection of ground surface roughness used by the licensee in their analysis, 2) the basis for the ground surface elevations used in the analysis, 3) the manner in which buildings were accounted for in the flow model, and 4) impact of the downstream (Lake Ontario) WSE on the upstream WSEs. The licensee's responses to these requests were reviewed by staff and are detailed in the staff audit report (NRC, 2016b).

The staff confirmed that the licensee's reevaluation of the hazard from streams and rivers used present-day methodologies and regulatory guidance. The staff confirmed the licensee's conclusion that flooding from streams and rivers was not considered during initial licensing and the reevaluated flood hazard is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit a focused evaluation or revised integrated assessment.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated hazard for failure of dams and onsite water control or storage structures does not inundate the plant site, but did not report a flood elevation. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee reported the use of the Hierarchical Hazard Assessment (HHA) approach to reevaluate dam failure flood hazards. The licensee stated that there are no onsite water control/storage structures that could contribute to inundation of SSCs important to safety from their failure. The licensee noted the proximity of the Nine Mile Point site to the FitzPatrick site and concluded that the two sites are located within the same hydrological setting and thus adopted the characterization for dam failure flood hazards as was previously made in the Nine Mile Point, Unit 3 COL FSAR, Revision 1 (Unistar, 2008). The licensee noted that there are six dams/locks on the Oswego River and that the Oswego River watershed does not contribute to the drainage area of the FitzPatrick site. The licensee computed the change in Lake Ontario WSE to account for the entirety of the volume of water stored behind the dams on the Oswego River and determined that the lake WSE would rise by 0.2 in. The licensee concluded that the failure of the dams on the Oswego River would not affect the FitzPatrick site and noted this conclusion is consistent with that made for the Nine Mile Point, Unit 3 site (Unistar, 2008).

The staff confirmed the conclusion that the licensee made in its FHRR with regard to the rise expected in the Lake Ontario due to the combined failures of dams on the Oswego River was consistent with that in the Nine Mile Point, Unit 3 COL FSAR, Revision 1 (Unistar, 2008) for this flood-causing mechanism. The staff had previously determined, in bounding analysis, that if all of the dams that staff identified in a 2013 National Inventory of Dams database (maintained by the USACE (USACE, 2013)) as potentially contributing to Lake Ontario were to fail, the WSE would rise by about 0.4 ft (NRC, 2014b). The staff determined a WSE increase that was slightly larger than that reported by the licensee but determined this difference was inconsequential in determining a conclusion for inundation at the FitzPatrick site.

The staff confirmed that the licensee's reevaluation of the hazard from failure of dams and onsite water control or storage structures used present-day methodologies and regulatory guidance. The 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 flood hazard. Therefore, the NRC staff determined that flooding from failure of dams or onsite water storage facilities does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.5 Storm Surge

The licensee reported in its FHRR that the reevaluated flood hazard, including associated effects, for storm surge is based on a stillwater-surface elevation of 252.8 ft USLS35. Including wind waves and run-up results in an elevation of 268.0 ft USLS35.

This flood-causing mechanism is discussed in the licensee's CDB. The CDB flood elevation for storm surge is based on a stillwater-surface elevation of 254.1 ft USLS35. This is based on an initial lake WSE of 250 ft USLS35 plus a 4.1 ft wind setup. The licensee further describes that additional combined event CDBs include the increases to account for precipitation on the lake or 0.35 ft and wave run-up (excluding the Screenhouse) of 7.5 ft. These "PMSS+PMP+Waves" and "Screenwell PMSS+PMP" CDB elevations are given in Table 3.1-2 which differ from those for the storm surge alone. The NRC staff notes that the CDB for the "Screenwell PMSS+PMP" is given as 255 ft USLS35, a rounded value, and that the PMSS CDB plus the effect of precipitation would yield 254.5 ft USLS35.

3.5.1 Information Provided in the FHRR

The licensee stated that the probable maximum wind storm (PMWS) affecting Lake Ontario near the FitzPatrick site are strong extra-tropical cyclones, which move from west to east over the lake. The PMWS produces the PMSS. The licensee used the HHA approach to evaluate the flood hazard associated with the PMWS and the resulting PMSS. The licensee used the NOAA Great Lakes Environmental Research Laboratory's Great Lakes Storm Surge Planning Program (SSPP) (NOAA, 1987) to develop the PMSS values at the FitzPatrick site.

The licensee evaluated historical storm surge and meteorological data to characterize the PMWS. The licensee selected the lesser of the maximum controlled lake level and the 100-year high WSE of Lake Ontario as the antecedent lake level for their PMSS reevaluation and stated that this selection methodology was consistent with NRC guidelines (NRC, 2011e). The current maximum controlled lake level of 248 ft USLS35 was the lesser of the two. The licensee applied the PMWS to the Lake Ontario at this antecedent lake level to develop a reevaluated PMSS using SSPP.

The licensee reviewed historical hurricane and moving squall events and their correlation to the peak WSE in Lake Ontario and determined that hurricane events (i.e. PMH events) were not the cause of significant Lake Ontario surges. The licensee determined that extra-tropical low-pressure non-convective systems were the strongest storm type (i.e. PMWS) to affect Lake Ontario surges, including the portion of the lake near the FitzPatrick site. These storms result in a maximum historical setup of 1.8 ft at Cape Vincent. Although wind data was not available for this maximum event, data is available for the second-highest setup of 1.7 ft event, which, based on hourly data, occurred on February 17, 2006. The licensee also reported a 1.9 ft setup at Cape Vincent for the February 17, 2006, event based on 6-minute data.

The licensee statistically analyzed storm surge and wave event data, and identified that winter events presented the largest surge and wave event. The licensee associated these with extra-tropical storms. The licensee determined that the February 17, 2006, event, was the controlling design storm. The licensee stated that both the historical wind speed and central pressure observation near the FitzPatrick site are less severe than ANSI/ANS-2.8 values (ANSI/ANS, 1992) and therefore concluded that ANSI/ANS-2.8 values are more conservative than the historical event. The licensee developed a 100-mi/h wind speed synthetic storm based on this historical event by scaling winds and pressure fields to be consistent with ANSI/ANS-2.8 standards for conservative parameterization of the PMWS.

The licensee evaluated the combination of the PMWS and the antecedent water WSE of 248.0 ft USLS35 as input to SSPP. The PMWS was applied for wind direction ranging from 250 degrees to 300 degrees (consistent with winds blowing toward the northeast to winds blowing toward the southeast). The licensee found that the largest surge near the FitzPatrick site was 4.8 ft (i.e. a PMSS stillwater elevation of 252.8 ft USLS35). The licensee stated that the PMSS elevation is about 19.2 ft below the FitzPatrick site grade.

The licensee considered the combined effects of precipitation-induced flooding of the unnamed stream, Lake Ontario surge, and wave effects (referred to as Scenario H.4 Alternatives). The licensee considered three H.4 alternative scenarios based on differing combinations of surge cause events, river flood events, and wave conditions per guidance (NRC, 2011e). The licensee stated that the combination of the PMSS, wave effects, and the unnamed stream PMF bounded the H.4 alternative scenarios. The licensee reasoned that considering this combination was a reasonable approach to bound the H.4 combined effects flood hazard. Conceptually, this combination of events is based on a precipitation event inducing a flow in the unnamed stream, which at its downstream end is controlled by surge and wind-wave conditions on Lake Ontario.

The licensee analyzed the combined event by applying SWAN (Deltares, n.d.) on a coarse grid (0.01 degree longitude/latitude resolution) covering the entirety of Lake Ontario to obtain offshore wave parameters at the PMSS stillwater elevation. The licensee compared the coarse grid SWAN results with wave parameters developed to the USACE at Lake Ontario Wave Information Studies (WIS) stations (USACE/WIS, n.d.-a, b, c, d, and e) close to the FitzPatrick site. The licensee then applied a 5-times finer SWAN (nested) model into the coarse SWAN results to provide wave parameter information near the FitzPatrick site. The licensee stated that the deepwater wave parameters were within the range of the WIS hindcast data. This nesting approach allowed the licensee to simulate wave transformation appropriate for the combined event analysis. The licensee examined the nested model results for five representative offshore-to-onshore transects that intersected the FitzPatrick site. The licensee computed wave run-up based on the nested SWAN results and the site shoreline geometry for both beach and shoreline cases. Each of these steps that the licensee undertook and staff reviewed are discussed sequentially below.

The licensee evaluated waves effects using a sequential step process: 1) applied a coarse wave model to obtain deepwater wave conditions for use by a finer wave model, 2) applied a finer wave model to obtain nearshore wave parameters, and 3) used Federal Emergency Management Agency (FEMA) guidance for the Great Lakes and the nearshore wave parameters to obtain estimates of wave run-up. The licensee set the combined event Lake Ontario stillwater level to the PMSS stillwater value of 252.8 ft USLS35, which is consistent with the Nine Mile Point, Unit 3 COL FSAR (UniStar, 2008). The licensee adjusted the PMWS forward speed to obtain conservative deepwater wave parameters; the forward speed adjustments were limited to those represented in the historical record of extreme wind storms.

The licensee used the deepwater wave parameters as a source of boundary condition information for a finer resolution nearshore application of SWAN to develop the nearshore wave characterization. The licensee reported nested SWAN results along five offshore-to-onshore transects (Figure 3.5-1). For the five transects, the licensee used the nearshore model results as input parameters (significant wave heights, periods, and setup) for wave effects estimation at the site shoreline (i.e. maximum wave crest elevations):

- significant wave heights ranging from 8.6 to 10.0 ft,
- wave periods ranging from 9.4 to 9.9 s,
- maximum wave setup ranging from 1.3 to 1.7 ft, and
- maximum wave crest elevations ranging from 261.3 to 262.9 ft USLS35.

The licensee reported wave runup at FitzPatrick for both beaches (Transects 1 and 5) and cliff faces (Transects 2, 3 and 4) (Figure 3.5-1). The licensee reported a maximum run-up of 13.8 ft with a wave setup of 1.4 ft (at Transect 5). The licensee then stated that the maximum combined effects water elevation is 268.0 ft USLS35, which is about 4 ft below site grade.

3.5.2 Staff Review of Information Provided in the FHRR

The staff reviewed the methodology used by the licensee for the FitzPatrick site and found the methodology consistent with that reported for the Nine Mile Point, Unit 3 site (Unistar, 2008). The staff determined that the licensee's review of historical storm information was reasonable.

The staff reviewed the FEMA's Appendix D.3 of "Great Lakes Coastal Guidelines" (FEMA, 2012) that supports the licensee's determination that extra-tropical storms are generally the cause of surges on the Great Lakes. The staff noted the licensee reported a 1.7 ft and a 1.9 ft setup at Cape Vincent for the February 17, 2006, event based on differing time-averaging. The NRC staff determined the difference was not consequential for the staff assessment because the same event was identified regardless of averaging interval. The staff reviewed maximum WSE records from 1960 to present (NOAA, 2016) for Cape Vincent, New York (NOAA Station 9052000); the staff noted the difference between the highest WSE and the regulated water level in Lake Ontario was 1.5 ft, which is in reasonable agreement with and smaller than the February 17, 2006, storm setup. The staff concluded that the licensee use of this event was reasonable as the basis for the PMWS for the surge analysis at the FitzPatrick site.

The staff reviewed the licensee's antecedent water level (AWL) determination. The current Lake Ontario regulated water level on Lake Ontario is 248.0 ft USLS35 according to IJC documents (IJC, 2014). The staff found that the highest Lake Ontario water level shown graphically in IJC (2014) for a 100-year period is about 249.2 ft USLS35. The lesser of these two WSEs is appropriate for use as the AWL and, therefore, the staff confirmed that licensee's AWL value of 248.0 ft USLS35.

The staff computed a stillwater elevation based on the SSPP documentation and the licensee's PMWS synthetic wind speed of 100-mi/h, AWL value of 248.0 ft USLS35 and staff's implementation of SSPP. The staff confirmed the licensee's results and wind direction sensitivity analysis results and in so doing, confirmed that the PMWS direction selected, combined with the SSPP methodology, maximized the PMWS stillwater elevation as determined by the licensee.

The staff reviewed the selection and application of the SWAN model by the licensee as applied to the entirety of Lake Ontario, which is a standard-practice model for wind-wave characterization. The staff reviewed the comparison between the USACE wave analysis (USACE/WIS, n.d.-a, b, c, d, and e) near the FitzPatrick site and the licensee's results. The staff found that the licensee's application of the SWAN model was appropriate. The staff compared these results with those described in the Nine Mile Point, Unit 3 FSAR (UniStar, 2008). The staff found that the previous evaluation (UniStar, 2008) estimated deepwater significant wave height of 23.3 ft with a wave period 12 seconds. The staff found the results reported in the FHRR are in reasonable agreement with what is reported by UniStar (Unistar, 2008).

The staff compared the ranges of significant wave heights, and associated periods developed with the finer resolution nearshore application of SWAN as reported by the licensee for the FitzPatrick site with those reported by UniStar (2008) for the Nine Mile Point site. The staff found these values were reasonably consistent considering site-specific conditions between the FitzPatrick site and the Nine Mile Point site.

The staff compared the wave run-up values the licensee reported for the FitzPatrick site transects and those reported for the Nine Mile Point, Unit 3 site (UniStar, 2008). The staff found the range of wave run-up values for the FitzPatrick site were reasonably consistent with the Nine Mile Point site and the degree of difference expected due to site-specific conditions. The staff's review indicated that the licensee's reevaluated flood hazard for the combined event ("PMSS+PMP+Waves") exceeded the CDB (NRC, 2015c).

3.5.3 Conclusion

The staff reviewed the licensee's approach and found it consistent with present-day guidance and methodology.

The combination "PMSS+PMP+Waves" was shown by the licensee to exceed CDB flood height. Therefore, the NRC staff determined that flooding from this combination does need to be analyzed in a focused evaluation or integrated assessment.

3.6 Seiche

The licensee reported in its FHRR that the reevaluated hazard for seiche does not inundate the plant site, but did not report a flood elevation (Entergy, 2015a). This flood-causing mechanism is not discussed in the licensee's CDB.

Due to the coastal setting of the FitzPatrick site on the shore of Lake Ontario, the licensee used the HHA approach described in NUREG/CR-7046 (NRC, 2011e) to determine whether a seiche in Lake Ontario can result in significant flooding. The licensee's seiche evaluation methodology included: (1) the determination of the natural period of Lake Ontario at Oswego (nearest NOAA water level station); (2) identification of the periods of meteorological external forcing events (e.g., extra-tropical storms) and comparison of the external forcing and lake periods to determine if resonance is expected; and (3) evaluation of potential seiche heights. The licensee evaluated the natural periods of Lake Ontario using historical observations and determined that historical observations show the same natural periods (about 5 h) as reported in the literature (Hamblin, 1982).

The licensee stated that observable seiches occur in Lake Ontario after a long period, non-convective extra-tropical storms with wind directed parallel to the lake axis. The licensee stated that after these storms pass, seiches are observed, but decay rapidly. The licensee evaluated the historical record of wind speed at Rochester, NY and found that wind speeds had periodicities that were distinct from the natural periodicity of Lake Ontario, which suggested that Lake Ontario winds would not play a role in contributing to significant resonance in Lake Ontario near the FitzPatrick site.

The licensee identified the largest tsunami-like (non-meteorologically induced) wave in the Great Lakes as 9 ft rise in lake level initiated by an 1823 earthquake, which is discussed in the FHRR and Section 3.7 of this staff assessment. The licensee concluded that seiche WSEs are not expected to be greater than initial surge WSEs, therefore, seiche flooding is not a controlling flood event at the FitzPatrick site.

The staff agreed with the licensee's conclusion that the statistical analysis of the WSE observations at Oswego, NY (NOAA Station 9052030) showed consistent natural periodicity with those reported in the literature (Hamlin, 1982). The staff used Merian's formula (Scheffner, 2008) to estimate the natural seiche period for Lake Ontario, which is consistent with the observed periods (Simpson and Anderson, 1964; Hamblin, 1982).

The staff found the evaluation for seiche at the FitzPatrick site was consistent with the Nine Mile Point staff assessment (NRC, 2014b).

The staff confirmed that the licensee's reevaluation of the hazard from seiche used present-day methodologies and regulatory guidance. The staff confirmed the licensee's conclusion that the reevaluated hazard from flooding from seiche is bounded by the CDB flood hazard. Therefore, flooding from seiche does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.7 Tsunami

The licensee reported in its FHRR that the reevaluated flood hazard for tsunami is based on a stillwater-surface elevation of 250.2 ft USLS35. Including wind waves and run-up resulted in an elevation of 259.2 ft USLS35. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee stated in the FHRR that the flood hazard associated with tsunami would not impact the FitzPatrick site. The licensee used the HHA approach (NRC, 2011e) to reevaluate the tsunami flooding hazards at the site, including a regional assessment of the region's potential for tsunamis, an assessment of the site area's potential for tsunamis and their effects, and tsunami hazards at the site. The licensee considered near-field and far-field tsunamigenic sources and conducted a regional survey using the NOAA NGDC Global Historical Tsunami Database (NOAA/WDS, 2015a) and NOAA/WDS Significant Volcanic Eruption Database (NOAA/WDS, 2015b). The licensee stated that within the FitzPatrick site region "probable or definite" tsunami events were identified in their search but none occurred on Lake Ontario or the Great Lakes.

The licensee considered the tsunamigenic sources including earthquakes, landslides, and volcanoes. The licensee concluded that the FitzPatrick site is aseismic due to historical earthquake strength and distance. The licensee also evaluated the Lake Ontario bathymetry for potential sites of submarine landslides and subsequent potential tsunamis, and concluded that earthquakes, landslides and volcanic events were not plausible tsunamigenic sources that could inundate the FitzPatrick site. The licensee referenced the Nine Mile Point, Unit 3 FSAR (UniStar, 2008) to establish the maximum lake WSE of 250.2 ft USLS35. The licensee identified the largest tsunami-like (non-meteorologically induced) wave in the Great Lakes as 9 ft, which the licensee combined with that the maximum lake WSE to get a 259.2 ft USLS35 flood hazard elevation. The licensee concluded the tsunami flood hazard are screened out, rather than considering 259.2 ft USLS35 as the reevaluated tsunami flood hazard.

The staff conducted an independent tsunami study of the FitzPatrick site, focusing on submarine landslides and coastal bluff failure. Consistent with the licensee's analysis, the staff considered submarine landslides as a possible source mechanism, but concluded that the orientation of this source would not directly affect the FitzPatrick site.

The staff confirmed the information described by the licensee in its FHRR for both the NOAA/WDS Global Historical Tsunami Database (NOAA/WDS, 2015a) and NOAA/WDS Significant Volcanic Eruption Database (NOAA/WDS, 2015b).

The staff determined that the licensee's HHA approach to its reevaluation of the tsunami hazards to the FitzPatrick site was consistent with NRC (2011e). The water level analysis portions of the staff's confirmatory analysis used COULWAVE (Cornell University Long and Intermediate Wave Modeling Package) (Lynett and Liu, n.d.). The staff independently determined that the maximum probable maximum tsunami stillwater elevation in Lake Ontario was 256 ft USLS35, which is 16.0 ft below the FitzPatrick site grade of 272.0 ft USLS35.

Therefore, the staff concludes that the tsunami effects would not result in a flood in excess of the site grade.

The staff confirmed that the licensee's reevaluation of the hazard from tsunami used present-day methodologies and regulatory guidance. The staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from tsunami is bounded by the CDB flood hazard. Therefore, the NRC staff determined that flooding from tsunami does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated hazard, including associated effects, for ice-induced flooding does not inundate the plant site, but did not report a flood elevation. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee's reevaluation of ice-induced flooding for the Fitzpatrick site referenced the Nine Mile Point, Unit 3 FSAR (Unistar, 2008), which was also the basis for the reevaluation of ice-induced flooding for the Nine Mile Point, Units 1 and 2 FHRR (Constellation Energy Nuclear Group (CENG), 2013). The licensee stated that the Nine Mile Point site and the FitzPatrick site are within 1 mi of each other, and concluded both sites are located in the same hydrological setting and thus adopted the conclusions of the previous analysis done for Nine Mile Point with regard to this flood-causing mechanism (CENG, 2013). The licensee screened out ice-induced flooding as a plausible flood-causing mechanism for the FitzPatrick site.

The staff previously evaluated the potential for ice-induced flooding from the Oswego and St. Lawrence rivers as part of the staff assessment for Nine Mile Point site (NRC, 2014b). The staff agreed with the licensee's conclusion that the FitzPatrick site is within the same hydrological setting as the Nine Mile Point site and therefore, this staff assessment is consistent with that previously made with regard to its conclusions for this flood-causing mechanism. The staff confirmed that the licensee's reevaluation of the hazard from ice-induced flooding used present-day methodologies and regulatory guidance. The staff confirmed the licensee's conclusion that the reevaluated hazard for ice-induced flooding of the site is bounded by the CDB flood hazard. Therefore, the NRC staff determined that ice-induced flooding does not need to be analyzed in a focused evaluation or a revised integrated assessment.

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. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee's reevaluation of channel migrations or diversions for the Fitzpatrick site referenced the Nine Mile Point, Unit 3 FSAR (Unistar, 2008), which was also the basis for the reevaluation of channel migrations or diversions for the Nine Mile Point, Units 1 and 2, FHRR (CENG, 2013). The licensee stated that the Nine Mile Point site and the FitzPatrick site are within 1 mi of each other and concluded that both sites are located in the same hydrological setting and thus, adopted the conclusions of the previous analysis done for Nine Mile Point FHRR with regard to this flood-causing mechanism (CENG, 2013). Thus, the licensee screened out channel migration or diversion as a plausible flood-causing mechanism for the FitzPatrick site.

The staff previously evaluated the potential for flooding resulting from channel migrations and diversions as part of the staff assessment for Nine Mile Point site (NRC, 2014b). The staff agreed with the licensee's conclusion that the FitzPatrick site is within the same hydrological setting as the Nine Mile Point site, therefore, this staff assessment is consistent with that previously made with regard to its conclusions for this flood-causing mechanism.

Based on the review of the information in the FHRR, the staff confirmed the licensee's conclusion that the hazard from channel migrations or diversion flooding would not impact the site. Therefore, channel migration or diversion flooding does not need to be analyzed in a focused evaluation or a revised integrated assessment.

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

4.1 Reevaluated Flood Height for Hazards Not Bounded by the CDB

Section 3 of this staff assessment documents the staff review of the licensee's flood hazard water elevation results. Table 4.1-1 contains the maximum flood elevation results, including waves and run-up, for flood mechanisms not bounded by the CDB. The staff agrees with the licensee's conclusion that LIP, streams and rivers, and the combined "PMSS+PMP+Waves" event are the flood-causing mechanisms not bounded by the CDB. Consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c), the NRC staff anticipates the licensee will submit a focused evaluation for LIP. For the streams and rivers and combined storm surge flood-causing mechanism, the NRC staff expects the licensee will perform additional assessments of plant response, either a focused evaluation or an integrated assessment, as discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

4.2 Flood Event Duration for Hazards Not Bounded by the CDB

The staff reviewed information provided in Entergy's 50.54(f) response (Entergy, 2015a; NRC, 2016b) regarding the FED parameters needed to perform the additional assessments of plant response for flood hazards not bounded by the CDB. The FED parameters for the flood hazards not bounded by the CDB are summarized in Table 4.2-1.

The warning time parameters for LIP or streams and rivers were marked as "not identified" in FHRR Tables 4-2 and 4-4 (Entergy, 2015a). During the audit, the licensee described that the warning time for the LIP and streams and rivers flood event was not developed to support the FHRR because significant plant preparation for the beyond-design-basis LIP event is not credited or deemed necessary at the site (NRC, 2016b); the licensee stated that the only plant action assumed in the FHRR was a procedure to close the exterior doors during periods of intense precipitation, which is not predicated on having significant advance warning (NRC, 2016b). During the audit, the licensee stated that during plant operation, only two doors are potentially left open unattended: (1) Door C to the Screenwell Building, and (2) Door G to the Turbine Building. The licensee stated that water intrusion through Door C would not impact any equipment important to safety (NRC, 2016b). The licensee stated that Door G would be closed per abnormal operating procedure (AOP)-13 (FitzPatrick, 2015) during a LIP event and that the maximum water volume that could enter through Door G would produce a water level below equipment important to safety (NRC, 2016b).

The LIP event creating the maximum WSEs and inundation periods as well as the duration that the LIP flood depths were above grade at different locations across the site are listed in FHRR Table 4-3 (Entergy, 2015a). The licensee used the modeling methods, as described in Section 3.2 of this staff assessment, to determine the FED parameters. The staff confirmed that the licensee's reevaluation of the inundation periods for LIP and associated drainage used present-day methodologies and regulatory guidance.

The period of inundation resulting from the PMF event are stated as up to 5.5 h for doors and up to 49.5 h for the site in FHRR Table 4-4 (Entergy, 2015a). The periods of recession for stream and rivers PMF were marked as "not identified" in FHRR Table 4-4 (Entergy, 2015a). The licensee used the modeling methods, as described in Section 3.3 of this staff assessment, to determine the FED parameters. The staff confirmed that the licensee's reevaluation of the inundation periods for the streams and river PMF used present-day methodologies and regulatory guidance.

The licensee did not provide FED parameters for the combined event including the PMSS, wind waves, and the stream and rivers PMF, as described in FHRR Section 3.9.2 (Entergy, 2015a). The missing FED parameters are expected to be provided in additional assessments. The staff notes that the while the CDB is exceeded, the flood hazard elevation is below the site grade by about 4 ft as stated in FHRR Section 3.9.2 (Entergy, 2015a). The staff further note that the combined event maximum flood WSE are lower than those associated with streams and rivers PMF.

The licensee is expected to develop and provide the missing FED parameters for the flood-causing mechanisms not bounded by the CDB as part of the additional assessments of plant response. The NRC staff will review these FED parameters as part of future additional assessments of plant response, if applicable to the assessment and hazard mechanism.

4.3 Associated Effects for Hazards Not Bounded by the CDB

The staff reviewed information provided in Entergy's 50.54(f) response (Entergy (2015a), (NRC, 2016b)) regarding the AE parameters needed to perform the additional assessments of plant response for flood hazards not bounded by the CDB. The AE parameters directly related to maximum total water height, such as wave and run-up, are presented in Table 4.1-1. The AE parameters not directly associated with total wave height are listed in Table 4.3-1.

For the LIP and streams and rivers events, FHRR Table 4-2 summarizes the licensee's evaluation of the AE parameters. The licensee stated that the hydrodynamic load, antecedent conditions, and groundwater effects were not evaluated. During the audit, the licensee provided maximum estimates of LIP-induced hydrostatic loads, which were determined to be minimal (NRC, 2016b). Flow velocities were stated to be below USACE threshold for paved surfaces at the site and therefore sediment mobilization was not further quantified. The staff confirmed that, based on the review of the licensee-provided LIP model input and output files, the above inundation depths and flow velocities are reasonable, as described in Section 3.2 of this report. Therefore, the NRC staff agrees with the licensee's conclusion that AE parameters that were provided for LIP and streams and rivers events are either minimal or not applicable.

For the combined event ("PMSS+PMP+Waves"), the staff notes that, within its FHRR, the licensee established that the rivers and stream PMF event is effectively decoupled from the PMSS (including wave effects). For the PMSS component of the combination (which does not produce a WSE in excess of site grade), the licensee stated in FHRR Section 3.9.3 that "because wind-wave activity during the PMSS does not exceed site grade, this mechanism does not generate hydrostatic, hydrodynamic, debris, or water-borne projectile loading onsite structures. Sediment erosion or deposition at site structures does not result from the flood mechanism." Thus, the staff notes that the AE parameters for this the combined event are equivalent to the parameters for rivers and streams due to the decoupling of the PMSS and stream and rivers PMF. Therefore, no additional consideration beyond those AE parameters associated with the rivers and streams event flood hazard is warranted.

The licensee is expected to develop the missing AE parameters for these flood-causing mechanisms to conduct the additional assessment. For AE parameters noted as minimal or not applicable, the staff confirms the licensee's AE parameter results are reasonable for use in additional assessments.

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 and COMSECY-15-0019, and associated guidance.

The licensee is expected to develop FED parameters and applicable flood AEs to conduct future additional assessments. The staff will evaluate the missing FED and AE parameters marked as "not provided" in these tables as part of future assessments of plant response, if applicable to the assessment and hazard mechanism.

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms for the FitzPatrick Nuclear Power Plant. Based on the review of the above available information provided in Entergy's 50.54(f) response (Entergy (2015a), (NRC 2016b)), the 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, staff confirms the licensee's conclusions that: (a) the reevaluated flood hazard results for LIP, PMF on the local unnamed stream, and a combined effect flood scenario ("PMSS + PMP + Waves") are not bounded by the CDB flood hazard; (b) additional assessments of plant response will be performed for the LIP, streams and rivers flood-causing mechanisms, and the "PMSS+PMP+Waves" combined event flood; and (c) the reevaluated flood-causing mechanism information is appropriate input to additional assessments of plant response, as described in the 50.54(f) letter, COMSECY-15-0019, and associated guidance.

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

U.S. Nuclear Regulatory Commission Documents and Publications

NRC (U.S. Nuclear Regulatory Commission), 2007, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," NUREG-0800, March 2007. [Available online at https://www.nrc.gov/reading-rm/basic-ref/srp-review-standards.html]

NRC, 2011a, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

NRC, 2011b, "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," Enclosure to Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML111861807.

NRC, 2011c, "Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report," Commission Paper SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

NRC, 2011d, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," Commission Paper SECY-11-0137, October 3, 2011, ADAMS Accession No. ML11272A111.

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

NRC, 2012a, 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, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the 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.

NRC, 2012b, 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, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Order EA-12-049, March 12, 2012, ADAMS Accession No. ML12054A736.

NRC, 2012c, letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, "Prioritization of Response Due Dates for Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Flooding Hazard Reevaluations for Recommendations 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," May 11, 2012, ADAMS Accession No. ML12097A510.

NRC, 2012d, "Guidance for Performing the Integrated Assessment for External Flooding," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2012-05, Revision 0, November 30, 2012, ADAMS Accession No. ML12311A214.

NRC, 2013a, "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2012-06, Revision 0, January 4, 2013, ADAMS Accession No. ML12314A412.

NRC, 2013b, "Guidance For Assessment of Flooding Hazards Due to Dam Failure," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2013-01, Revision 0, July 29, 2013, ADAMS Accession No. ML13151A153.

NRC, 2014a, "James A. FitzPatrick Nuclear Power Plant – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-Ichi Nuclear Power Plant Accident (TAC No. MF0229)," ADAMS Accession No. ML14127A023.

NRC, 2014b, "Nine Mile Point Nuclear Station Units 1 and 2 - Staff Assessment of Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC Nos. MF1104 and MF1105)," July 24, 2014, ADAMS Accession No. ML14153A410.

NRC, 2015b, "Mitigating Strategies and Flood Hazard Reevaluation Action Plan," Commission Paper COMSECY-15-0019, June 30, 2015, ADAMS Accession No. ML15153A104. (Package, two documents, (Publicly available): ML15153A105, "Closure Plan for the Reevaluation of Flooding Hazards for Operating Nuclear Power Plants" [cover letter] (Publicly available) and ML15153A110, "Enclosure 1 – Mitigating Strategies and Flooding Hazard Re-Evaluation Action Plan" [Publicly available]).

NRC, 2015c. Letter, Vice President, Entergy Nuclear Operations, Inc. from V. Hall, NRC regarding "James A. FitzPatrick Nuclear Power Plant – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information- Flood-Causing Mechanism Reevaluation (TAC No. MF6106)." Dated September 4, 2015 to ADAMS Accession No. ML15238B537.

NRC, 2016a, "Compliance with Order EA-12-049 Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Interim Staff Guidance JLD-ISG-2012-01, Revision 1 and Comment Resolution, January 22, 2016, ADAMS Accession No. ML15357A142.

NRC, 2016b, "NRC's Report for the Audit of Entergy Nuclear Operations, Inc.'s Flood Hazard Reevaluation Report Submittal Relating to the Near-Term Task Force Recommendation 2.1-Flooding for James A. FitzPatrick Nuclear Power Plant (TAC NO. MF6106)," April 12, 2016, ADAMS Accession No. ML16072A035.

NRC, 2016c, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluation; Focused Evaluation and Integrated Assessment," Interim Staff Guidance JLD-ISG-2016-01, Revision 0, July 11, 2016, ADAMS Accession No. ML16162A301.

Codes and Standards

ANSI/ANS (American National Standards Institute/American Nuclear Society), 1992, ANSI/ANS-2.8-1992, "Determining Design Basis Flooding at Power Reactor Sites," American Nuclear Society, LaGrange Park, IL, July 1992.

Other References

Constellation Energy Nuclear Group (CENG), 2013, "Nine Mile Point, Units 1 and 2, Transmittal of Flood Hazard Reevaluation Report," March 12, 2013, ADAMS Accession No. ML13074A032.

Deltares, n.d. User Manual SWAN Cycle III version 41.10. Delft University of Technology, Delft, The Netherlands, available at http://swanmodel.sourceforge.net/online_doc/swanuse/node1.html

Entergy Nuclear Operations (Entergy), 2012, Letter from Michael J. Colomb, Site Vice President to NRC dated November 27, 2012, Subject: "Flooding Walkdown Report - Entergy's Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," ADAMS Accession No. ML12332A379.

Entergy, 2015a, Flood Hazard Reevaluation Report – Response NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, James A. FitzPatrick Nuclear Power Plant, dated March 12, 2015, ADAMS Accession No. ML15082A250.

Entergy, 2015b, Flood Hazard Reevaluation Requested Files for James A. FitzPatrick, dated June 16, 2015, ADAMS Accession No. ML15187A226.

FEMA (Federal Emergency Management Agency), 2012, FEMA Great Lakes Coastal Guidelines, Appendix D.3 Update-DRAFT, May 2012, available at http://greatlakescoast.org/pubs/reports/FEMA_GL_CoastalGuidelines_AppendixD3_Update_DRAFT.pdf .

FitzPatrick, 2015, Procedure Change Request PCR# 1224 for "Severe Weather", AOP-13, 2015.

FLO-2D Pro Computer Software Inc., 2014, FLO-2D® software, build 14.03.07.

FLO-2D Pro Computer Software Inc., n.d., FLO-2D® Reference Manual Pro. Nutrioso, Arizona.

Google Earth, n.d., "Google Maps", (Web site), https://www.google.com/maps, accessed January 26, 2016.

Hamblin, 1982. "On the Free Surface Oscillations of Lake Ontario, Limnology and Oceanography", Vol. 27, No. 6 (Nov., 1982), pp. 1039-1049.

IJC (International Joint Commission), 2014, "Lake Ontario St. Lawrence River Plan 201: Protecting against extreme water levels, restoring wetlands and preparing for climate change," June 2014, ISBN:E95-2/18-2014E-PDF 978-1-100-24424-2. Available at http://www.ijc.org/files/tinymce/uploaded/LOSLR/IJC_LOSR_EN_Web.pdf

Lynett, P. J. and P. L.-F. Liu, n.d., "Modeling Wave Generation, Evolution, and Interaction with Depth-Integrated, Dispersive Wave Equations COULWAVE Code Manual Cornell University Long and Intermediate Wave Modeling Package," available at http://ceeserver.cee.cornell.edu/pll-group/doc/COULWAVE_manual.pdf.

NOAA (National Oceanic and Atmospheric Administration), 1978, "Probable Maximum Precipitation Estimates, United States, East of the 105th Meridian," NOAA Hydrometeorological Report No. 51, June 1978.

NOAA, 1982, "Application of Probable Maximum Precipitation Estimates, United States, East of the 105th Meridian," NOAA Hydrometeorological Report No. 52, August 1982.

NOAA, 1987, "Great Lakes Storm Surge Planning Program (SSPP)", NOAA Technical Memorandum GLERL-65, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan.

NOAA, 2016, Tides and Currents Water Levels, NOAA. Accessed on December 20, 2016, https://tidesandcurrents.noaa.gov/stations.html?type=Water+Levels

NOAA/NCEI (National Oceanic and Atmospheric Administration/National Centers for Environmental Information), n.d. Great Lakes Bathymetry, available at https://www.ngdc.noaa.gov/mgg/greatlakes/.

NOAA/WDS (National Oceanic and Atmospheric Administration/ World Data Service), 2015a, Global Historical Tsunami Database. National Geophysical Data Center, NOAA. Accessed on April 8, 2015, http://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=7&d=7

NOAA/WDS, 2015b, Significant Volcanic Eruptions Database, National Geophysical Data Center, NOAA, Accessed on April 8, 2015, http://www.ngdc.noaa.gov/nndc/servlet/ShowDatasets?dataset=102557&search_look=50&display_look=50

Nuclear Energy Institute (NEI), 2015a, white paper, "Warning Time for Maximum Precipitation Events" as endorsed by the NRC on April 23, 2015 (ADAMS Accession No. ML15110A080). The white paper was subsequently issued by NEI on May 1, 2015, as NEI 15-05, "Warning Time for Local Intense Precipitation Events."

NEI, 2015b, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide", NEI 12-06 Revision 2, December 2015, ADAMS Accession No. ML16005A625.

Scheffner N.W. 2008. "Water Levels and Long Waves." In: Demirbilek, Z., Coastal Engineering Manual, Part II, Coastal Hydrodynamics Chapter 5-6, Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.

Simpson, R. B., and D. V. Anderson 1964. The periods of the longitudinal surface seiche in Lake Ontario. Mich. Univ. Great Lakes Res. Div. Publ. 11, p. 369-381.

UniStar Nuclear Services (UniStar), 2008. "Nine Mile Point 3 Nuclear Power Plant Combined License Application Part 2: Final Safety Analysis Report, Revision 1 March 2009," (ADAMS Accession No. ML090970441), Chapter 1.0 (ADAMS Accession No. ML090970444), Chapter

2.01 (ADAMS Accession No. ML090970445), Chapter 2.02 (ADAMS Accession No. ML090970446), Chapter 2.03 (ADAMS Accession No. ML090970447), Chapter 2.04 (ADAMS Accession No. ML090970448), Chapter 2.05 (ADAMS Accession No. ML090970449, ADAMS Accession No. ML090970450, ADAMS Accession Nos. ML090970451, ML090970452, and ML090970453).

USACE (U.S. Army Corps of Engineers), 2010a, "Hydrologic Modeling System (HEC-HMS), Version 3.5.0," Hydrologic Engineering Center, U.S. Army Corps of Engineers, August 2010.

USACE, 2013, "National Inventory of Dams," available online at http://nid.usace.army.mil.

USACE/WIS (U.S. Army Corps of Engineers, Wave Information Studies), n.d.-a, "Wave Information Studies," available online at http://wis.usace.army.mil/

USACE/WIS, n.d.-b, "Extreme Analysis Plot (Return Period)", Station 91036, available online at http://wis.usace.army.mil/data/ont/XTRMS/ST91036_XTRM.png

USACE/WIS, n.d.-c, "Extreme Analysis Plot (Return Period)", Station 91037, available online at http://wis.usace.army.mil/data/ont/XTRMS/ST91037_XTRM.png

USACE/WIS, n.d.-d, "Extreme Analysis Plot (Return Period)", Station 91038, available online at http://wis.usace.army.mil/data/ont/XTRMS/ST91038_XTRM.png

USACE/WIS, n.d.-e, "Extreme Analysis Plot (Return Period)", Station 91039, available online at http://wis.usace.army.mil/data/ont/XTRMS/ST91039_XTRM.png

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

Flood-Causing Mechanism	SRP Section(s) and 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 is the Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NRC, 2007)

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

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

Table 3.1-1. Summary of Controlling Flood-Causing Mechanisms

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation (272.0 ft USLS35)[1]	ELEVATION, ft USLS35
Local Intense Precipitation and Associated Drainage	272.8
Streams and Rivers	272.8

[1]Flood height and associated effects as defined in JLD-ISG-2012-05, Guidance for Performing the Integrated Assessment for External Flooding" (NRC, 2012d).

Table 3.1-2. Current Design Basis Flood Hazards

Flooding Mechanism	Stillwater Elevation, ft USLS35	Associated Effects ft	CDB Flood Elevation, ft USLS35	Reference
Local Intense Precipitation and Associated Drainage	Not included in CDB	Not included in CDB	Not included in CDB	FHRR Table 4-1
Streams and Rivers	Not included in CDB	Not included in CDB	Not included in CDB	FHRR Table 4-1
Failure of Dams and Onsite Water Control/Storage Structures	Not included in CDB	Not included in CDB	Not included in CDB	FHRR Table 4-1
Storm Surge	254.1	7.9	262.0	FHRR Table 4-1
Storm Surge at Screenwell	255.0	minimal	255.0	FHRR Table 4-1
Seiche	Not included in CDB	Not included in CDB	Not included in CDB	FHRR Table 4-1
Tsunami	Not included in CDB	Not included in CDB	Not included in CDB	FHRR Table 4-1
Ice-Induced	Not included in CDB	Not included in CDB	Not included in CDB	FHRR Table 4-1
Channel Migrations or Diversions	Not included in CDB	Not included in CDB	Not included in CDB	FHRR Table 4-1

Source: Entergy (2015a), NRC (2015c)

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

Flood-Causing Mechanism	Stillwater Elevation	Waves/Run-up	Reevaluated Hazard Elevation	Reference
Local Intense Precipitation	272.8 ft USLS35	Minimal	272.8 ft USLS35	FHRR Table 4-1 and FHRR Appendix A
Streams and Rivers	272.8 ft USLS35	Not Applicable	272.8 ft USLS35	FHRR Table 4-1
Storm Surge "PMSS+PMP+Waves"	252.8 ft USLS35	15.2 ft	268.0 ft USLS35	FHRR Table 4-1, FHRR Sect ion 3.4.3, and FHRR Section 3.9.2.2.8

Source: Entergy (2015a), NRC (2015c)

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

Table 4.2-1. Flood Event Duration for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation [a]	Not provided	20 h	Not provided
Streams and Rivers Unnamed Stream	Not provided	49.5 h	Not provided
Storm Surge "PMSS+PMP+Waves"[b]	Not applicable	Not applicable	Not applicable

Notes:

a. The licensee has the option to use NEI guideline 15-05 (NEI, 2015a) to estimate the warning time necessary for flood preparation.
b. PMSS+PMP+Waves reevaluated hazard elevation is 268 ft which is approximately 4 feet below site grade. Therefore, flood event duration is not an applicable parameter for this hazard.

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

	Flooding Mechanism		
Associated Effects Factor	**Local Intense Precipitation[1]**	**PMF[2]**	**Combined Event ("PMSS+PMP+Waves")[3]**
Hydrodynamic loading at plant grade	Not Provided	Not Provided	Not Applicable
Debris loading at plant grade	No impact on the site	No impact on the site	No impact on the site
Sediment loading at plant grade	Minimal	Minimal	Minimal
Sediment deposition and erosion	Minimal	Minimal	Minimal
Concurrent Conditions, including adverse weather	Not Provided	40-percent PMP antecedent storm	Combined with PMF
Groundwater ingress	Not Provided	Not Provided	Not Provided
Other pertinent factors (e.g., water-borne projectiles)	Not Provided	Not Provided	Not Provided

[1]Information provided in FHRR Table 4-2.
[2]Information provided in FHRR Table 4-4.
[3]Information provided in FHRR Section 3.9.3.

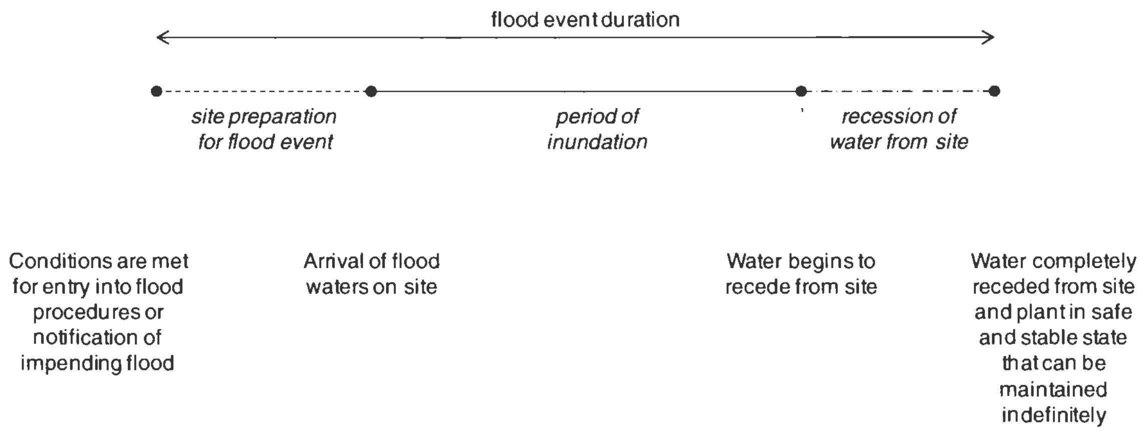

Figure 2.2-1. Flood Event Duration (NRC JLD-ISG-2012-05, Figure 6).

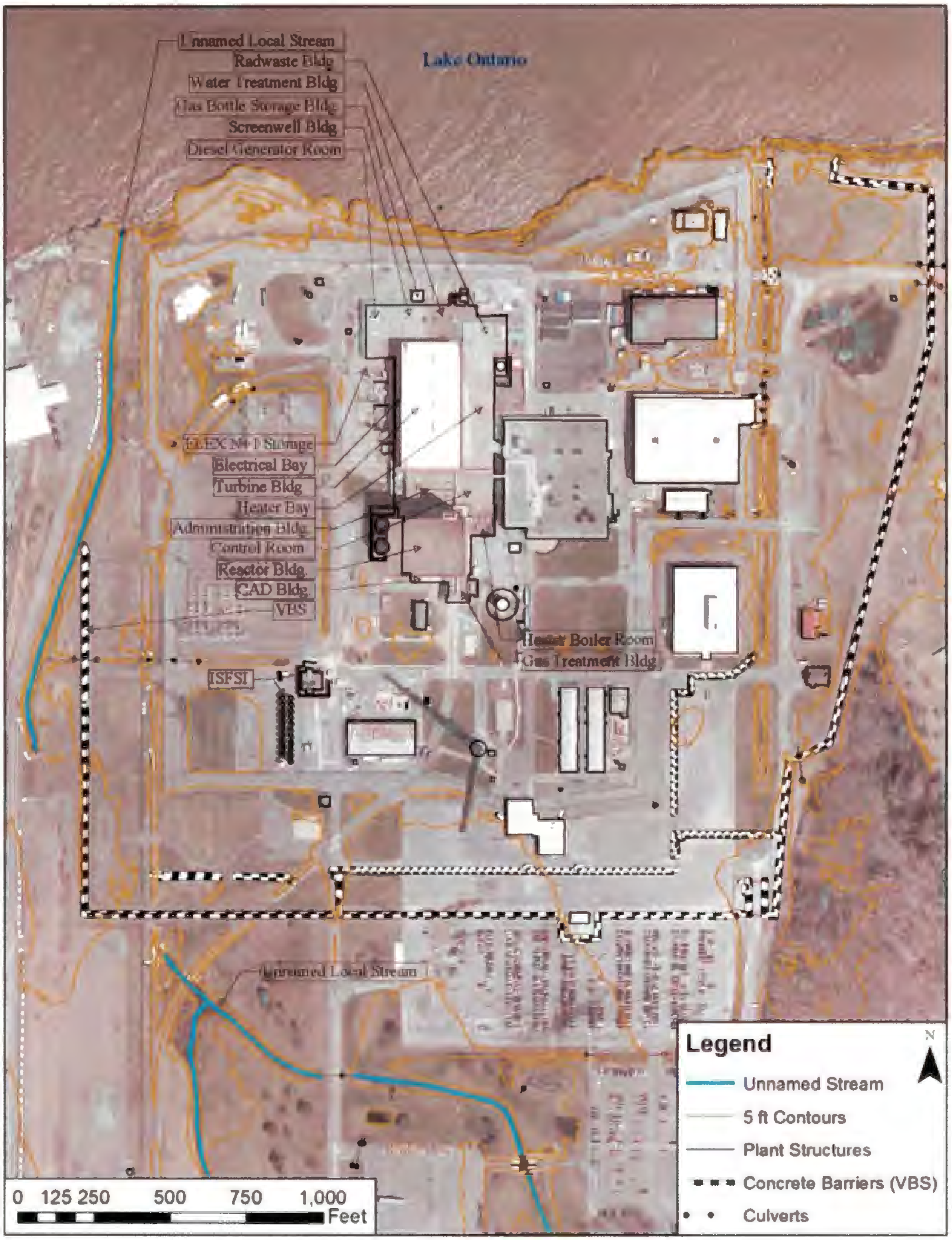

Figure 3.1-1. Site Topography and Layout (Source: FHRR Figure 2-2).

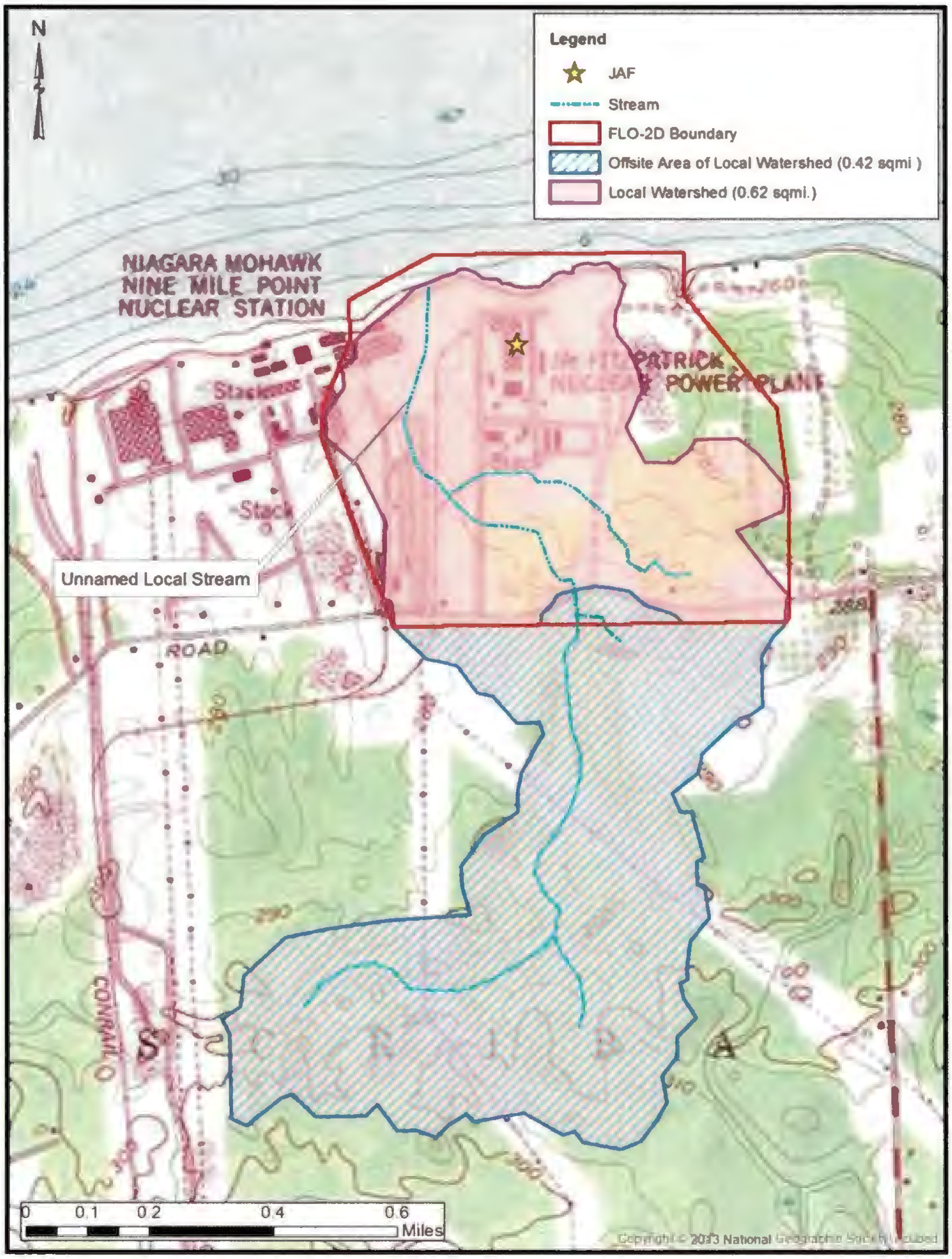

Figure 3.2-1 Local Watershed and unnamed stream course (Source FHRR Figure 3-1). Note: southern watershed (blue cross-hatched area) is modeled by licensee using HEC-HMS, which provides runoff to northern watershed (red area) is modeled by licensee using FLO-2D.

Figure 3.5-1. Wind-wave transects 1-5 and SWAN output locations (T1-T5) (adapted from FHRR unnumbered figure and FHRR Figure 3-44; locations are approximate); licensee determined that maximum combined flood hazard elevation location T5. (Base figure from Google Earth (Google Earth, n.d.))

JAMES A. FITZPATRICK NUCLEAR POWER PLANT – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION DATED MARCH 27, 2017

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