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

May 7, 2018

Vice President, Operations
Entergy Operations, Inc.
Grand Gulf Nuclear Station
P.O. Box 756
Port Gibson, MS 39150

SUBJECT: GRAND GULF NUCLEAR STATION, UNIT 1 - STAFF ASSESSMENT OF FLOODING FOCUSED EVALUATION (CAC NO. MF9897; EPID L-2017-JLD-0015)

Dear Sir or Madam:

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, under 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 in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807). Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). By letter dated March 11, 2013 (ADAMS Accession No. ML13071A457), Entergy Operations, Inc. (the licensee) responded to this request for Grand Gulf Nuclear Station, Unit 1 (Grand Gulf). The response was supplemented by letter dated January 9, 2014 (ADAMS Accession No. ML14014A277).

On December 4, 2015 (ADAMS Accession No. ML15329A043), the NRC issued a supplemental staff assessment for Grand Gulf. The letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Grand Gulf and parameters that are a suitable input for the mitigating strategies assessment (MSA). As stated in the letter, because the local intense precipitation (LIP), a probable maximum flood (PMF) associated with Stream "A," and a dam failure coincident with a PMF on the Mississippi River flood-causing mechanisms at Grand Gulf are not bounded by the plant's CDB, additional assessments of these flood hazard mechanisms are necessary.

By letter dated June 27, 2017 (ADAMS Accession No. ML17179A364), the licensee submitted the focused evaluation (FE) for Grand Gulf. The FE is intended to confirm that the licensee has adequately demonstrated, for the unbounded mechanisms identified in the December 4, 2015, staff supplemental assessment, that: 1) a flood mechanism is bounded based on a reevaluation

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

of flood mechanism parameters; 2) effective flood protection is provided for the unbounded mechanism; or 3) a feasible response is provided if the unbounded mechanism is local intense precipitation. The purpose of this letter is to provide the NRC's assessment of the Grand Gulf FE.

The NRC staff concludes that the Grand Gulf FE was performed consistent with the guidance described in Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178). Guidance document NEI 16-05, Revision 1, has been endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301). The staff has further concluded that the licensee has demonstrated that effective flood protection exists for the LIP, PMF associated with Stream "A," and dam failure coincident with a PMF on the Mississippi River flood mechanisms during a beyond-design-basis external flooding event. This closes out the NRC's efforts associated with CAC No. MF9897.

If you have any questions, please contact me at 301-415-1132 or by email at Joseph.Sebrosky@nrc.gov.

Sincerely,

Joseph Sebrosky, Senior Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Enclosure:
Staff Assessment Related to the
Flooding Focused Evaluation for Grand Gulf

Docket No: 50-416

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE FOCUSED EVALUATION FOR

GRAND GULF NUCLEAR STATION, UNIT 1

AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE

RECOMMENDATION 2.1 - FLOODING

(CAC NO. MF9897)

1.0 INTRODUCTION

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, under 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 in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

Enclosure 2 of the 50.54(f) letter 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 and combined licenses (ADAMS Accession No. ML12056A046). If the reevaluated hazard for any flood-causing mechanism is not bounded by the plant's current design basis (CDB) flood hazard, an additional assessment of plant response would be necessary. Specifically, the 50.54(f) letter stated that an integrated assessment should be submitted, and described the information that the integrated assessment should contain. On November 30, 2012 (ADAMS Accession No. ML12311A214), the NRC staff issued Japan Lessons-Learned Project Directorate (JLD) interim staff guidance (ISG) JLD-ISG-2012-05, "Guidance for Performing the Integrated Assessment for External Flooding."

On June 30, 2015 (ADAMS Accession No. ML15153A104) the NRC staff issued COMSECY-15-0019, describing the closure plan for the reevaluation of flooding hazards for operating nuclear power plants. The Commission approved the closure plan on July 28, 2015 (ADAMS Accession No. ML15209A682). COMSECY-15-0019 outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes a graded approach in which licensees with hazards exceeding their CDB flood will not be required to complete an integrated assessment, but instead will perform a focused evaluation (FE). As part of the FE, licensees will assess the impact of the hazard(s) on their site and then evaluate and implement any necessary programmatic, procedural, or plant modifications to address the hazard exceedance.

Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178), has been endorsed by the NRC as an appropriate methodology for licensees to perform the FE in response to the 50.54(f) letter. The NRC's endorsement of NEI 16-05, including exceptions, clarifications, and additions, is described in NRC JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301). Therefore, NEI 16-05, Revision 1, as endorsed, describes acceptable methods for

demonstrating that Grand Gulf Nuclear Station, Unit 1 (Grand Gulf) has effective flood protection.

2.0 BACKGROUND

This NRC staff assessment is the last staff assessment associated with the information that Entergy Operations, Inc. (Entergy, the licensee) provided in response to the reevaluated flooding hazard portion of the 50.54(f) letter for Grand Gulf. Therefore, the background section includes a discussion of the reevaluated flood information provided by the licensee and the associated staff assessments. The reevaluated flood information includes: 1) the flood hazard reevaluation report (FHRR); 2) the mitigation strategies assessment (MSA); and 3) the FE.

Flood Hazard Reevaluation Report

By letter dated March 11, 2013 (ADAMS Accession No. ML13071A457), the licensee responded to the 50.54(f) request for Grand Gulf and submitted its FHRR. The response was supplemented by letter dated January 9, 2014 (ADAMS Accession No. ML14014A277). On December 4, 2015 (ADAMS Accession No. ML15329A043), the NRC staff issued a supplemental assessment for Grand Gulf. The supplemental staff assessment provided the reevaluated flood hazard mechanisms that exceeded the CDB for Grand Gulf and parameters that are a suitable input for the MSA. As stated in the letter, because the local intense precipitation (LIP), a probable maximum flood (PMF) associated with Stream "A," and a dam failure coincident with a PMF on the Mississippi River flood-causing mechanisms at Grand Gulf are not bounded by the plant's CDB, additional assessments of the flood hazard mechanisms are necessary.

The December 4, 2015, staff supplemental assessment noted that it was issued to address open items documented in the staff's original FHRR assessment dated November 24, 2014 (ADAMS Accession No. ML14323A019). A second purpose of the December 4, 2015, staff supplemental assessment was to reflect changes in the NRC's approach to the flood hazard reevaluation that were approved by the Commission in the July 28, 2015, staff requirements memorandum associated with COMSECY-15-0019.

Mitigation Strategies Assessment

By letter dated December 30, 2016 (ADAMS Accession No. ML16365A194), Entergy submitted the MSA for Grand Gulf for review by the NRC staff. The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. By letter dated March 2, 2017 (ADAMS Accession No. ML17038A521), the NRC issued its assessment of the Grand Gulf MSA. The NRC staff has concluded that the Grand Gulf MSA was performed consistent with the guidance described in Appendix G of Nuclear Energy Institute (NEI) 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625). The NRC's endorsement of NEI 12-06, Revision 2, is described in JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML15357A163). The NRC staff further concluded that the licensee has demonstrated that the mitigation strategies, if appropriately implemented, are reasonably protected from reevaluated flood hazards conditions for beyond-design-basis external events.

Focused Evaluation

By letter dated June 27, 2017 (ADAMS Accession No. ML17179A364), the licensee submitted the FE for Grand Gulf. The FE is intended to confirm that the licensee has adequately demonstrated, for unbounded mechanisms identified in the staff's December 4, 2015, staff supplemental assessment that: 1) a flood mechanism is bounded based on a reevaluation of flood mechanism parameters; 2) effective flood protection is provided for the unbounded mechanism; or 3) a feasible response is provided if the unbounded mechanism is local intense precipitation. These 3 options associated with performing an FE are referred to as Path 1, 2, or 3, as described in NEI 16-05, Revision 1. The purpose of this staff assessment is to provide the results of the NRC's evaluation of the Grand Gulf FE.

3.0 TECHNICAL EVALUATION

Entergy stated that its FE followed Path 2 of NEI 16-05, Revision 1 and utilized Appendix B for guidance on evaluating the site strategy. As described in the December 4, 2015, staff supplemental assessment, LIP, a PMF associated with Stream "A," and a dam failure coincident with a PMF on the Mississippi River flood-causing mechanisms at Grand Gulf are not bounded by the plant's CDB. The evaluation of these mechanisms are addressed in Sections 3.1, 3.2, and 3.3 of this document, respectively.

3.1 Evaluation of Flood Impact Assessment for Local Intense Precipitation

3.1.1 Description of Impact of Unbounded Hazard

The LIP calculation was revised after submittal of the FHRR. This was done primarily to revise the building modeling methodology, specifically the treatment of roofs in the FLO-2D model, and use a later version of the FLO-2D code. The revised LIP calculation was the basis for the licensee's MSA, which was reviewed by the staff. The licensee's FE noted that the staff's supplemental assessment of the FHRR dated December 4, 2015, identified two concerns with the licensee's original LIP analysis. The licensee's FE includes an Appendix that addresses the two concerns identified in the December 4, 2015, staff supplemental assessment.

The staff reviewed the Grand Gulf FE Appendix and concludes that the licensee satisfactorily addressed the underlying concerns and that the FE appropriately reflects treatment of roof runoff in the FLO-2D model and water budget equality between the simulated inflow and outflow components. The staff's detailed assessment of the revised LIP model can be found in the attachment to this assessment. Because the LIP flood levels, associated effects (AEs) and flood event duration (FED) described in the licensee's MSA are based on the revised LIP model, the staff's assessment of the LIP MSA remain unchanged from that found in the staff's March 2, 2017, assessment.

Table 3.1-1 provides the revised LIP elevations for key locations around the Grand Gulf site.

Table 3.1-1 Local Intense Precipitation Elevations

Structure System or Component Sealed Door Identification	Maximum Flood Depth (ft.)	Protection Height (ft.)
Door OC313	0.7	1.5*
Door OCT5	1.0	1.0
Door 1D301	0.5	1.0
Door 1D308	0.6	1.5*
Door 1D309	0.6	1.5*
Door 1D310	0.8	1.5*

Door 1D312	0.8	1.5*
Door 1M110	0.7	1.5*
Door 1M111	0.5	1.5*
Equipment/Switchgear	0.3	0.625
Door 2M110	0.5	1.5*
Door 2M111	0.8	1.5*
Equipment/Switchgear	0.3	0.625

*Protection credits use of sandbags

3.1.2 Evaluation of Available Physical Margin and Reliability of Flood Protection Features

The licensee's FHRR notes that external probable maximum precipitation (PMP) doors have seals that are vulnerable to damage during normal door use and require adjustment to function correctly. To mitigate the effects of possible damage to the seals the FHRR states that sandbags will be placed in the vicinity of most of these doors if predefined criteria are met. The licensee credits external PMP door seals at two inactive doors (1D301 and OCT5). The other PMP door seals are not credited for protection of key safety functions. The licensee's FE describes the process for placement of sandbags in more detail. Table 3.1-1 identifies the door locations where temporary sandbags are to be deployed to maintain key safety functions during a LIP event.

The staff reviewed the licensee's plans for the nine doors found in Table 3.1-1 that credit the installation of sandbags for protection of key safety functions. As described in the licensee's FE the deployment of the sandbags at the selected door locations is performed in accordance with procedure 05-01-02-VI-2, "Hurricanes Tornadoes, and Severe Weather." Procedure 05-1-02-VI-1, "Flooding," is consistent with procedure 05-01-02-VI-2 associated with hurricanes and refers to procedure 05-01-02-VI-2 for sandbag installation instructions. The staff performed an audit of these procedures (i.e., 05-01-02-VI-1, Revision 115, and 05-01-02-VI-2, Revision 131) in accordance with the NRC staff's audit plan for flooding focused evaluations dated July 18, 2017 (ADAMS Accession No. ML17192A452). The staff confirmed the licensee's statements in the FE that these procedures provide explicit instruction on the number of sandbags and the stacking configuration for each of the nine doors. Procedure 05-1-02-VI-2 directs operators to check sandbagged areas for unacceptable leakage past sandbag enclosure periodically and to report unacceptable leakage past the sandbag enclosure to the control room immediately. Subsequent to Entergy's June 27, 2017, submittal, the licensee revised procedures 05-01-02-VI-1 and 05-01-02-VI-2 such that the most current revisions of these procedures are Revision 116 and Revision 136, respectively. The staff audited the current version of these procedures and confirmed that, like the versions of the procedures referenced in the FE, the procedures provide explicit instruction on the number of sandbags and the stacking configuration for each of the nine doors.

The sandbags are credited for providing reliable flood protection to 1.5 feet (ft.) above the grade elevation. The installation of the sandbags follows U.S Army Corps of Engineers (USACE) recommendations. The staff concludes that the use of sandbags at the nine doors provides reliable effective flood protection for key safety functions at these locations in accordance with NEI 16-05, Revision 1 guidance, as endorsed, because the installation of the sandbags is consistent with USACE recommendations.

The PMP door seals are credited for inactive doors OCT5 and 1D301. The staff considers these seals to be reliable in accordance with NEI 16-05, Revision 1 guidance, as endorsed, because these door seals are considered to serve a safety-related function and as such are subject to periodic maintenance to ensure they continue to perform their flood protection

function. The staff further concludes that reliable effective flood protection for Equipment/Switchgear in SSW Basin Alpha and Bravo is provided via the grade elevation at these locations.

Because increased focus has been placed on flood protection since the accident at Fukushima, licensees and NRC inspectors have identified deficiencies with equipment, procedures, and analyses relied on to either prevent or mitigate the effects of external flooding at a number of licensed facilities. Recent examples include those found in Information Notice 2015-01, "Degraded Ability to Mitigate Flooding Events" (ADAMS Accession No. ML14279A268). In addition, the NRC is cooperatively performing research with the Electric Power Research Institute to develop flood protection systems guidance that focuses on flood protection feature descriptions, design criteria, inspections, and available testing methods in accordance with a memorandum of understanding dated September 28, 2016 (ADAMS Accession No. ML16223A495). The NRC staff expects that licensees will continue to maintain flood protection features in accordance with their current licensing basis. The staff also expects that licensees will use the site corrective action program to disposition flood-related maintenance, operations, and design issues, consistent with the provisions of NEI 16-05 and NEI 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," as endorsed by the NRC, where appropriate. Continued research involving flood protection systems will be performed and shared by the NRC staff with licensees in accordance with the guidance provided in Management Directive 8.7 "Reactor Operating Experience Program" (ADAMS Accession No. ML122750292).

The NRC staff concludes that the Grand Gulf flood protection features described above meet the definition of being reliable to maintain key safety functions found in Appendix B of NEI 16-05, Revision 1, as endorsed by the NRC.

The staff concludes that the available physical margin (APM) for the LIP event that varies from 0 inches at Door OCT5 to 1 ft. at doors 1M111 and 2M110 is acceptable in accordance with NEI 16-05, Revision 1 guidance, as endorsed, because of the following conservatisms found in the licensee's LIP analysis:

- The vehicle barrier system openings were conservatively assumed to be 30 percent blocked. In addition the Northwest drainage ditch culvert and the switchyard channel culverts were conservatively assumed to be 50 percent blocked.

- Roof drains connected to subsurface drainage systems were assumed to be blocked and the potential storage resulting from roof parapet walls was not incorporated.

3.1.4 Overall Site Response

As discussed above, the licensee's FE describes the installation of sandbags around nine doors. The staff assessed the deployment of these sandbags in accordance with NEI 16-05, Revision 1, Appendix C, "Evaluation of Site Response," as endorsed by the NRC. The licensee considers the placement of the sandbags to be a time sensitive action, as defined in NEI 16-05, Revision 1, Appendix C.

The procedural trigger for the placement of the sandbags is whenever the 24-hour weather forecast calls for rainfall amounts of 12 inches or more. As stated in the attachment to this assessment, the NRC staff concludes that the 24-hour LIP forecasting time is consistent with guidelines provided by NEI 15-05, "Warning Time for Local Intense Precipitation Events," Revision 6, dated April 8, 2015 (ADAMS Accession No. ML15104A158) as endorsed by the staff in a letter dated April 23, 2015 (ADAMS Accession No. ML15110A080).

The licensee's FE states that the triggering deployment, setup, and testing of sandbags were developed in accordance with EC 41518, Revision 0, "New Strategy for Protection PMP External Doors." Per the FHRR the licensee estimates the installation of the sandbags takes two people approximately six hours to install sandbags at the nine external doors. The licensee's FE states that per CR-GGN-2011-07687 CA 20, the site successfully performed sandbag dike installation at the nine external doors on May 16, 2013, which required 2 hours to complete with seven individuals. The licensee stated in the Grand Gulf FE that the May 16, 2013, trial installation of the sandbags was done consistent with Work Order WO-GGN-00336989, "Sandbag Dike Installation."

The staff audited EC 41518, Revision 0, GGN-2011-07687 CA 20, dated May 21, 2013, and WO-GGN-00336989, dated June 21, 2011, in accordance with the staff's July 18, 2017, audit plan. The staff confirmed that EC 41518 describes the triggering, deployment and testing of the sandbags consistent with that described in the licensee's FE. The staff also confirmed that CR-GGN-2011-07687 CA 20 documents the trial installation of the sandbags in accordance with WO-GGN-00336989. The licensee's FE stated that preventative maintenance tasks were created in accordance with EC 41518 to install sandbag dikes at a minimum of one door once every 2 years and at every door every 5 years.

The staff concludes that based on the warning time associated with the LIP event, the licensee's assertion that the placement of the sandbags by two individuals, which is estimated to take 6 hours for two individuals or 2 hours with seven individuals, within the 24 hour warning time period associated with the LIP event is reasonable. Therefore, based on the licensee's FE statements the staff concludes that the license should be able to adequately respond to the revised LIP event. The staff further concludes that the licensee's plans for responding to such an event meet the guidance found in NEI 16-05, Revision 1, as endorsed by the NRC.

3.2 Evaluation of Flood Impact Assessment for Probable Maximum Flood Associated with Stream "A"

3.2.1 Description of Impact of Unbounded Hazard

The PMF associated with Stream "A" is 132.5 ft. mean sea level (MSL), which is the Grand Gulf site grade. Protection of key safety functions is provided by site grade, which is permanent and passive requiring no manual actions.

3.2.2 Evaluation of Available Physical Margin and Reliability of Flood Protection Features

Guidance is provided in NEI 16-05, Revision 1, Appendix B, as endorsed by the NRC, that negligible or zero APM can be justified if the use of conservative inputs, assumptions, and/or methods in the flood hazard reevaluation can be established. The PMF associated with Stream "A" has zero APM. This mechanism includes the following conservative assumptions:

- Conservative antecedent rainfall condition was used for the PMF simulation
- The probable maximum precipitation was calculated using the conservative methodology of hydrometeorological report (HMR) 51 and HMR 52

Based on these assumptions the staff concludes that the Grand Gulf APM for the PMF event associated with Stream "A" is acceptable. Because the key safety functions are protected from the PMF associated with Stream "A" by the Grand Gulf site grade the staff concludes that the flood protection features are reliable in accordance with NEI 16-05, Revision 1, Appendix B guidance as endorsed by the NRC.

3.2.3 Overall Site Response

The licensee does not rely on any personnel actions or new modifications to the plant in order to respond to the beyond-design-basis PMF Stream "A" event. As described above, the licensee's evaluation relied on passive existing flood protection features to demonstrate adequate flood protection. Therefore, the staff concludes there is no need to review overall site response.

3.3 Evaluation of Flood Impact Assessment for Dam Failure Coincident with a Probable Maximum Flood on the Mississippi River

3.3.1 Description of Impact of Unbounded Hazard

The reevaluated flood hazard associated with a dam failure coincident with a PMF on the Mississippi river is 117.4 ft MSL which is 15.1 ft below the Grand Gulf site grade of 132.5 ft MSL. Protection of key safety functions is provided by site grade, which is permanent and passive requiring no manual actions.

3.3.2 Evaluation of Available Physical Margin and Reliability of Flood Protection Features

The 15.1 ft. APM for the dam failure coincident with a PMF on the Mississippi river meets the guidance in NEI 16-05, Revision 1, as endorsed by the NRC for adequate APM. Therefore, the staff concludes the APM for this event is acceptable. Because the key safety functions are protected from the dam failure coincident with a PMF on the Mississippi river by the Grand Gulf site grade, the staff concludes that the flood protection features are reliable in accordance with NEI 16-05, Revision 1, Appendix B guidance as endorsed by the NRC.

3.3.3 Overall Site Response

The licensee does not rely on any personnel actions or new modifications to the plant in order to respond to the beyond-design-basis dam failure coincident with a PMF on the Mississippi river. As described above, the licensee's evaluation relied on passive existing features to demonstrate adequate flood protection. Therefore, there is no need to review overall site response.

4.0 AUDIT REPORT

The July 18, 2017, generic audit plan describes the NRC staff's intention to issue an audit report that summarizes and documents the NRC's regulatory audit of the licensee's FE. The NRC staff's Grand Gulf audit was limited to the review of the calculations and procedures described above. Because this staff assessment appropriately summarizes the results of the audit, the NRC staff concludes a separate audit report is not necessary, and that this document serves as the audit report described in the July 18, 2017, letter.

5.0 CONCLUSION

The NRC staff concludes that Entergy performed the Grand Gulf FE in accordance with the guidance described in NEI 16-05, Revision 1, as endorsed by JLD-ISG-2016-01, and that the licensee has demonstrated that effective flood protection exists from the reevaluated flood hazards. Furthermore, the NRC staff concludes that Grand Gulf screens out for an integrated assessment based on the guidance found in JLD-ISG-2016-01. As such, the staff concludes that in accordance with Phase 2 of the process outlined in the 50.54(f) letter, additional regulatory actions associated with the reevaluated flood hazard, beyond those associated with mitigation strategies assessment, are not warranted. The staff further concludes that the

licensee has satisfactorily completed providing responses to the 50.54(f) activities associated with the reevaluated flood hazards.

Attachment – Staff Assessment of Grand Gulf Nuclear Station, Unit 1
Revised Local Intense Precipitation Model

1.0 Confirmation of the Revised Flood Hazard Elevations in the Focused Evaluation

The purpose of this Attachment is to document the staff's assessment of the revised local intense precipitation (LIP) analysis that is referenced in Entergy Operations, Inc. (Entergy, the licensee), June 27, 2017, submittal (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17179A364). The licensee's June 27, 2017, submittal provided the flooding focused evaluation for Grand Gulf Nuclear Station, Unit 1 (Grand Gulf). The LIP revision accounts for modifications to the simulation methodology, primarily for treatment of building runoff, and a corresponding revision to the FLO-2D software (Build No. 14.03.07). The revised peak flood elevations for LIP increased by 0.2 feet (ft.) for some locations as compared to the respective values in the licensee's March 11, 2013 (ADAMS Accession No. ML13071A457), flood hazard reevaluation report (FHRR).

For the LIP analysis presented in the FHRR, the licensee used the FLO-2D model (Build No. 12.09.09). The licensee also used probable maximum precipitation (PMP) depths of 19.3 inches (in.) within 1 hour and 31.4 in within 6 hours, which were based on National Oceanic and Atmospheric Administration (NOAA)'s hydrometeorological reports. For the revised LIP analysis in the FE, the licensee used the same model grid, boundary conditions, and rainfall scenarios as the FHRR FLO-2D model, but revised the simulation methodology for buildings available in a newer version of the FLO-2D code. The revised LIP model improved roof-runoff processes to better mimic actual roof runoff conditions and overland flow on and around structures in the power block area.

The licensee revised the FLO-2D model by manually adjusting model grid elevations based on the site survey and the high resolution topography images. In general, setting a FLO-2D model with actual rooftop elevations would often create undesirable numerical instabilities associated with large vertical changes in elevation between the roof and adjacent ground-level grid cells. Therefore, the licensee assigned arbitrary uniform elevations of 2 ft. above the surrounding ground-level to roof grid elements to simulate the runoff out of the building roofs. The licensee stated using a building elevation of 2 ft. is sufficient to differentiate the potential maximum inundation depths between roof and ground created by the peak 1-hour duration LIP depth of 19.3 inches. With this building-modeling methodology, the licensee distributed roof runoff uniformly to the power block area and more-correctly simulated overland flow around the structures. The staff found the licensee's approach reasonable for this submittal.

Both the original and revised FLO-2D models incorporated the following culverts:

- Culvert 1 is a 15 ft. corrugated metal pipe culvert on Stream B that runs beneath the Plant Access Road and is lined with concrete and riprap to limit sources of debris which could block Culvert 1.
- Culvert 9A is located in the Northwest Drainage Ditch and is comprised of three 48-in diameter corrugated metal pipes.
- Culvert 11 is a 6 ft. wide by 4 ft. high concrete box culvert located northwest of the Switchyard.
- Culvert 8A is a 48-in diameter corrugated metal pipe located under the road leading to the south Switchyard.

The licensee stated in the FE letter they have procedures to ensure that these culverts are free from debris that can block these culverts. As a measure of conservatism, the licensee assumed these culverts would be 50 percent blocked in the FLO-2D model. The licensee estimated the stage-discharge relations (rating curves) of all culverts with the exception of Culvert 1 using Culvert Master v3.3. Culvert 1 was modeled directly (without use of a rating curve) in FLO-2D by (1) setting the culvert to a reduced diameter of 10.6 ft. instead of 15 ft. to mimic 50 percent blockage, and (2) raising the culvert invert elevations (both upstream and downstream ends) by 4.4 ft. above the actual invert elevation (NRC, 2015). Regarding Stream A and Culvert 9, the licensee did not model these culverts as they were conservatively assumed to be fully blocked during the LIP event. The licensee also incorporated the concrete security barriers and vehicle barrier system that encircle the plant site into the FLO-2D model.

Figures A1-1 and A1-2 show the model grid and inundation flood map results using the revised FLO-2D model. The licensee verified the water budget calculation for the simulations as discussed in their calculation. The licensee reported in its FE report that the total model inflow (rainfall) is equal to the sum of outflow and storage components, indicating nearly zero water budget errors. The staff confirmed the water budget equality between the simulated inflow and outflow components, and also confirmed there were no numerical stability issues. Therefore, the staff determined that the revised FLO-2D model and simulation results are acceptable for use in the FE.

In addition to the conservatisms introduced by blocking the culverts, the licensee also conservatively assumed the Vehicle Barrier System openings were 30 percent blocked. The licensee conservatively assumed the Northwest Drainage Ditch Culvert and the Switchyard Channel Culverts to be 50-percent blocked, and hence the calculated discharges through these drain systems were reduced by approximately 50 percent.

The licensee stated in its FE that they checked the high-tail elevations in hydrographs for the representative FLO-2D grid cells assigned to the doors of interest (Figure A1-3) and compared them with the topography map. In addition, the licensee investigated time-series output of flood parameters (i.e., maximum flow depth, maximum water surface elevation) by rechecking the output results with the revised FLO-2D (Entergy, 2017). They noted in the FE report the following two items:

- The licensee noticed zero inundation depth after approximately 11 hours of simulation time at the Door 2M110 (Grid Cell No.19579 with elevation 133.09 ft. MSL) (Figure A1-4, top). The licensee found that this grid cell has considerably higher elevation compared to nearby grid cells. Therefore, ponding for a long time with a relatively constant flow depth is not expected, justifying the full drain (flow depth down to zero) shown in the stage hydrograph.

- At the Door 0CT5 (Grid Cell No. 25481 with elevation 132.67 ft. MSL) location, the licensee noted approximately 0.2 ft. inundation depth at the tail of the hydrograph (see Figure A1-4, bottom). The licensee stated in its FE that this grid cell and other close-by cells are flat and have relatively lower elevations compared to the outer surrounding cells, justifying the prolonged inundation pattern at this location. They found the same inundation pattern at door locations 1D312, 1D310, and 2M111.

Therefore, the licensee concluded that the long-tails in the hydrographs are realistic and consistent with the topography and ground elevations surrounding these doors. Based on an independent review of the hydrographs generated from the revised FLO-2D output files, the staff determined the hydrographs simulated by the revised FLO-2D are reasonable. Table A1-1 summarizes the revised LIP flood elevations as well as flood depths at key monitoring locations.

Table A1-2 compares the LIP flood elevations for the FHRR and FE reports. Table A1-3 presents reevaluated flood hazards for flood-causing mechanisms, which are not bounded by the current design basis.

In summary, the staff concludes the revised maximum flood elevations reported in the FE are acceptable for use, and that the licensee used present-day methodologies and regulatory guidance.

2.0 Evaluation of Flood Event Duration

The NRC staff reviewed information provided in the licensee's mitigation strategies assessment (MSA) dated December 30, 2016 (ADAMS Accession No. ML16365A194), and FE regarding the flood event duration (FED) parameters for flood hazards not bounded by the current design basis (CDB) at the Grand Gulf, Unit 1. The LIP flood hazards, including the maximum flood elevations, as well as FED and AE parameters, for both the MSA and FE reports are identical as they are based on the revised LIP analysis. The FED parameters for flood-causing mechanisms not bounded by the CDB are summarized in Table A2-1.

As stated in the MSA, a warning time for the LIP flood-causing mechanism of 24 hours is used for prediction of over 12 inches of rain from the National Weather Service. In its FE, the licensee stated that the only time-sensitive actions for LIP events are to install sandbags at nine identified PMP doors whenever the 24-hour weather forecast predicts rainfall depths of 12 in or more. The NRC staff notes that the 24-hour LIP forecasting time is consistent with guidelines provided by NEI 15-05, "Warning Time for Local Intense Precipitation Events," Revision 6 dated April 8, 2015 (ADAMS Accession No. ML15104A158), as endorsed by the staff in a letter dated April 23, 2015 (ADAMS Accession No. ML15110A080). The licensee reported in its MSA that the period of inundation is longer than 15 hours and the period of recession is longer than 14 hours. The licensee used results from the revised FLO-2D model to determine these FED parameters as discussed in the MSA and FE. The staff determined that the licensee's evaluation of the inundation and recession periods using the revised LIP model is acceptable for use in the FE, and that the analysis used present-day methodologies and regulatory guidance.

The licensee stated in its MSA and FE, that FED parameters were not developed for the PMF on Stream A and combined dam failure flood-causing mechanisms because the maximum flood elevations for these two mechanisms are at or below the site grade elevation of 132.5 ft. MSL. The staff determined the licensee's approach to determine the FED parameters for these two flood-causing mechanisms is consistent with the guidelines provided by NEI 16-05 Revision 1 (ADAMS Accession No. ML16165A175), as endorsed by the NRC.

In summary, the staff concludes that the licensee's FED parameters provided in the FE letter are acceptable.

3.0 Evaluation of Flood Associated Effects

The NRC staff reviewed information provided by Entergy regarding associated effects (AE) parameters for flood hazards not bounded by the CDB. The AE parameters related to water surface elevations (i.e., stillwater elevation with wind waves and runup effects) are summarized in Table A3-1. The AE parameters not directly associated with water surface elevation are discussed below and are summarized in Table A3-1.

For the LIP flood-causing mechanism, the licensee reported in its MSA that hydrodynamic, hydrostatic, and debris loads are minimal due to the relatively low velocity and small depth of LIP flood waters in the vicinity of safety-related structures, systems and components (SSCs), in

addition to the lack of natural debris sources on the site. The licensee also stated in its MSA that erosion, sedimentation, and groundwater ingression are not applicable to this site, and therefore, do not need to be evaluated. The licensee identified in the MSA letter the 2-year return period wind speed of 45.2 miles oer hour (mph) as a potential concurrent site condition.

The licensee noted in its FE that the AE parameters for the LIP flood-causing mechanism used in the MSA are effective and applicable for use in FE. The staff confirmed small inundation depths and low water velocities based on simulation results from the revised LIP model. Therefore, the staff agrees with the licensee's conclusion that the AE parameters for the LIP flood-causing mechanism are either minimal or not applicable.

The licensee stated in its MSA and FE, that AE parameters were not developed for the PMF on Stream A and combined dam failure flood-causing mechanisms because the maximum flood elevations for these two flood-causing mechanisms are below the site grade elevation of 132.5 ft. MSL. The staff determined the licensee's approach to determine the AE parameters for these two flood-causing mechanisms is consistent with the guidelines provided by NEI 16-05 Revision1, as endorsed by the NRC.

In summary, the staff concludes that the licensee's methods to evaluate the AE parameters are appropriate and the AE parameters provided in the FE are acceptable.

Table A1-1 Revised Flood Hazard Values for LIP at the Selected Points

Structure	Grid Element Number	Grid Elevation (ft. MSL)	Peak Water Surface Elevation (ft. MSL)	Maximum Flood Depth (ft.)	Maximum Flow Velocity (feet per second)
Door OC313	25479	133.0	133.7	0.7	0.8
Door OCT5	25481	132.7	133.7	1.0	0.5
Door 1D301	26773	133.1	133.6	0.5	0.9
Door 1D308	26396	132.9	133.5	0.6	0.6
Door 1D309	25843	133.1	133.7	0.6	2.1
Door 1D310	25838	132.8	133.6	0.8	0.8
Door 1D312	25467	132.8	133.6	0.8	1.2
Door 1M110	21251	132.8	133.5	0.7	1.5
Door 1M111	21042	132.9	133.4	0.5	0.8
SSW Basin Alpha (Equ./Switchgear)	20422	133.3	133.6	0.3	0.4
Door 2M110	19579	133.1	133.6	0.5	0.6
Door 2M111	19367	132.8	133.6	0.8	0.5
SSW Basin Bravo (Equ./Switchgear)	19164	133.3	133.6	0.3	0.6
Southeast of ISFSI Pad	21082	133.0	133.6	0.6	0.7

Notes: Doors OCT5 and OC313 lead into the Control Building. The maximum water surface elevation and maximum flow velocities at these doors are 133.7 ft. and 0.8 ft. per second, respectively.

Table A1-2 Comparison of LIP Flood Depths (ft.) between FHRR and FE

Door Location	Inundation Depth (ft.)		
	FHRR (Entergy, 2013)	FE (Entergy, 2017)	Difference
Door OC313	0.5	0.7	0.2
Door OCT5	0.8	1.0	0.2
Door 1D301	0.5	0.5	0
Door 1D308	0.6	0.6	0
Door 1D309	0.4	0.6	0.2
Door 1D310	0.7	0.8	0.1
Door 1D312	0.7	0.8	0.1
Door 1M110	0.6	0.7	0.1
Door 1M111	0.4	0.5	0.1
SSW Basin Alpha (Equ./Switchgear)	0.3	0.3	0
Door 2M110	0.5	0.5	0
Door 2M111	0.8	0.8	0
SSW Basin Bravo (Equ./Switchgear)	0.3	0.3	0

Table A1-3. Reevaluated Flood Hazards for Unbounded Flood-Causing Mechanisms for Use in the FE.

Flood Causing Mechanism	Stillwater Elevation (ft. MSL)	Waves/Runup (ft.)	Reevaluated Hazard Elevation (ft. MSL)
Local Intense Precipitation and Associated Drainage	133.7 (See Table A1-1)	Minimal	133.7 (See Table A1-1)
Streams and Rivers - Stream A	132.1	0.4	132.5
Dam Failure Flooding with PMF on Mississippi River	117.4	Not Applicable (1)	117.4

1. The licensee noted that additional refinement of the dam failure flood analysis is not necessary due to the sufficient margin indicated by the initial conservative analysis (FHRR Subsection 3.3.3). The Grand Gulf plant grade is 132.5 ft. MSL.

Table A2-1 Flood Event Durations for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	24 hours, or Use NEI 15-05 (NEI, 2015)	>15 hours	>14 hours
Streams and Rivers - Stream A (1)	Not Applicable	Not Applicable	Not Applicable
Dam Failure Flooding with PMF on Mississippi River (2)	Not Applicable	Not Applicable	Not Applicable

1. PMF on Stream A with wind effects does not inundate any SSCs important to safety per the licensee's MSA
2. Dam Failure Flooding with PMF on Mississippi River does not inundate any SSCs important to safety per the licensee's MSA

Table A3-1 Associated Effects Parameters Not Directly Associated with Total Water Height for Flood-Causing Mechanisms Not Bounded by the CDB.

Associated Effects Parameter	Local Intense Precipitation and Associated Drainage	Streams and Rivers - Stream A (1)	Dam Failure Flooding with PMF on Mississippi River (2)
Hydrodynamic loading at plant grade	Minimal	Not Applicable	Not Applicable
Debris loading at plant grade	Minimal	Not Applicable	Not Applicable
Sediment loading at plant grade	Not Applicable	Not Applicable	Not Applicable
Sediment deposition and erosion	Not Applicable	Not Applicable	Not Applicable
Concurrent conditions, including adverse weather	High wind speed of 45.2 mph	Not Applicable	Not Applicable
Groundwater ingress	Not Applicable	Not Applicable	Not Applicable
Other pertinent factors (e.g., waterborne projectiles)	Not Applicable	Not Applicable	Not Applicable

1. PMF on Stream A does not inundate any SSCs important to safety as noted in the licensee's MSA
2. Dam Failure Flooding with PMF on Mississippi River does not inundate any SSCs important to safety as noted in the licensee's MSA

Figure A1-1. Site Map with FLO-2D Model Layout

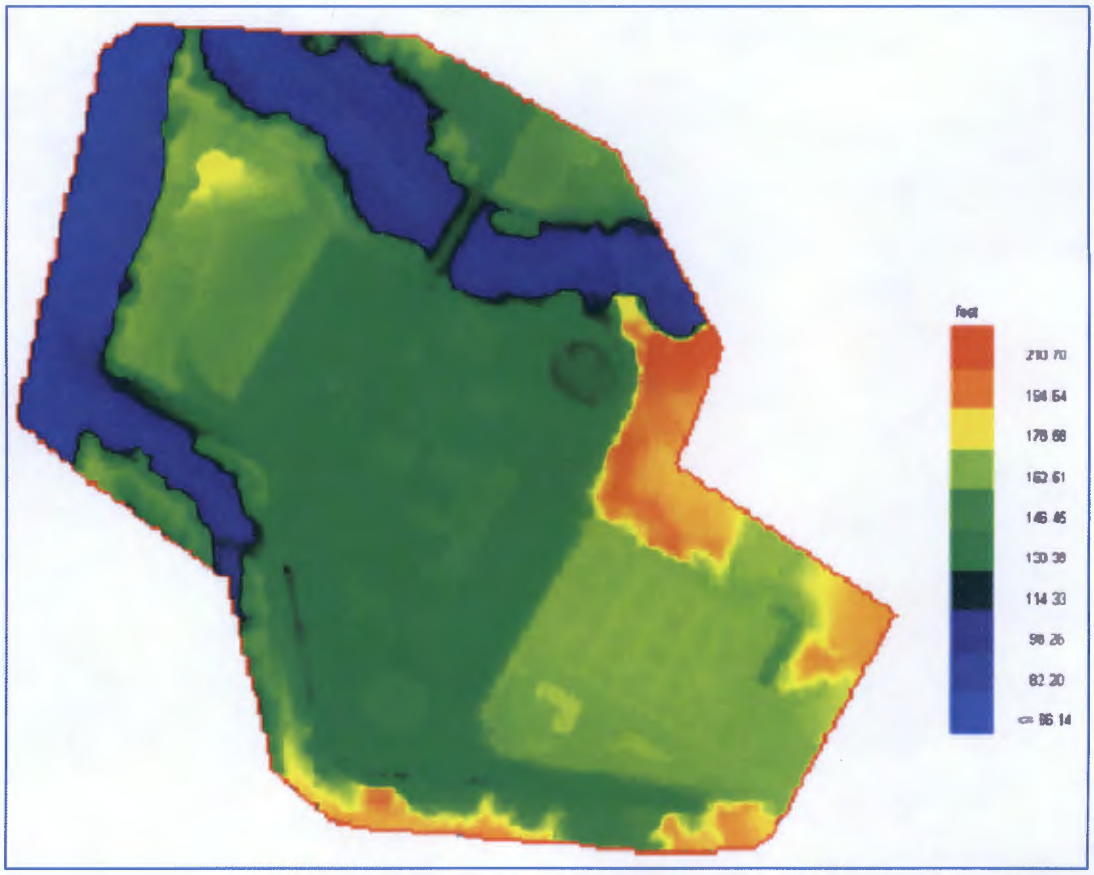

Figure A1-2 FLO-2D-Simulated LIP Flood Depth Map

[[

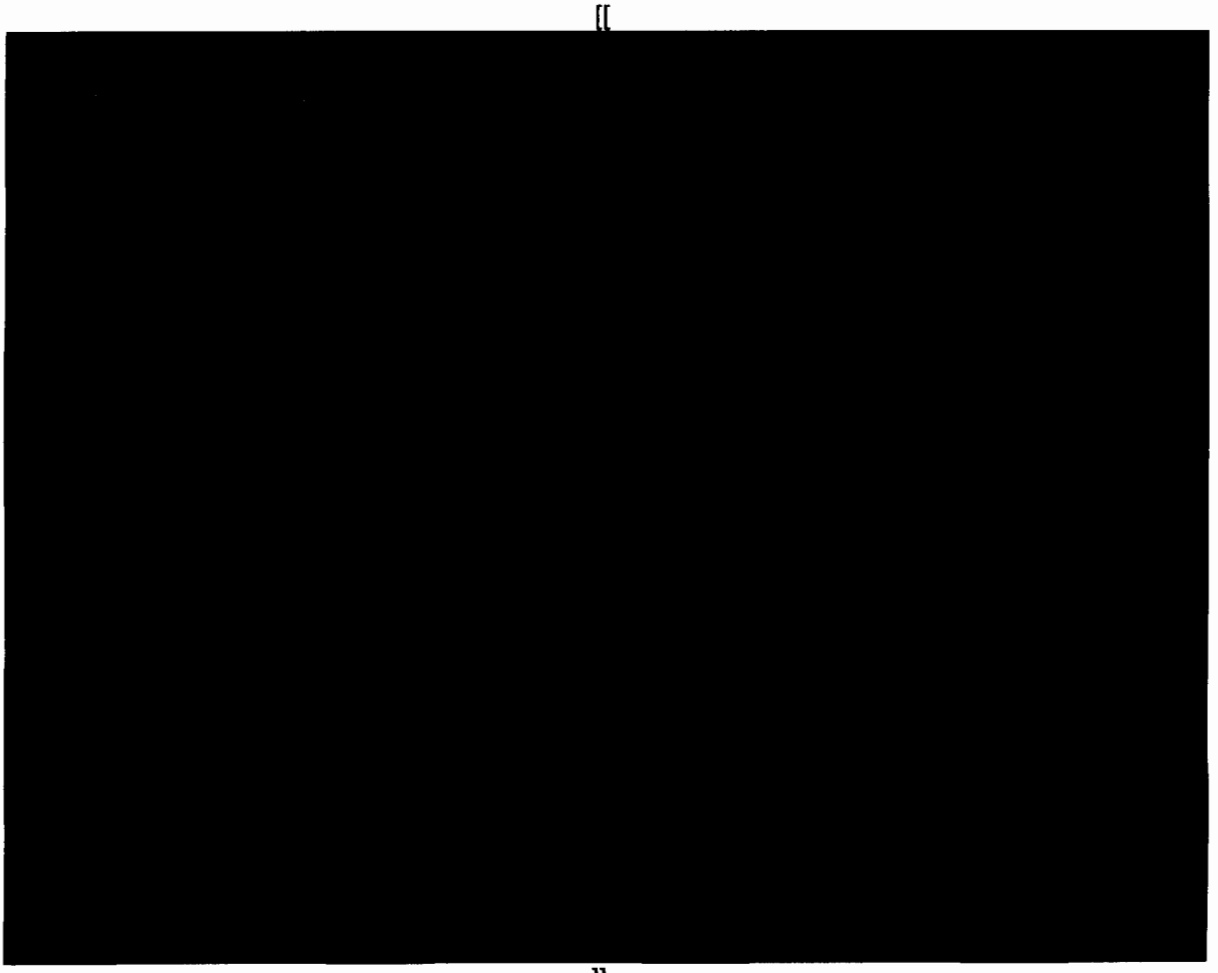

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Figure A1-3a. Location of point of interests for LIP flood analysis

[[

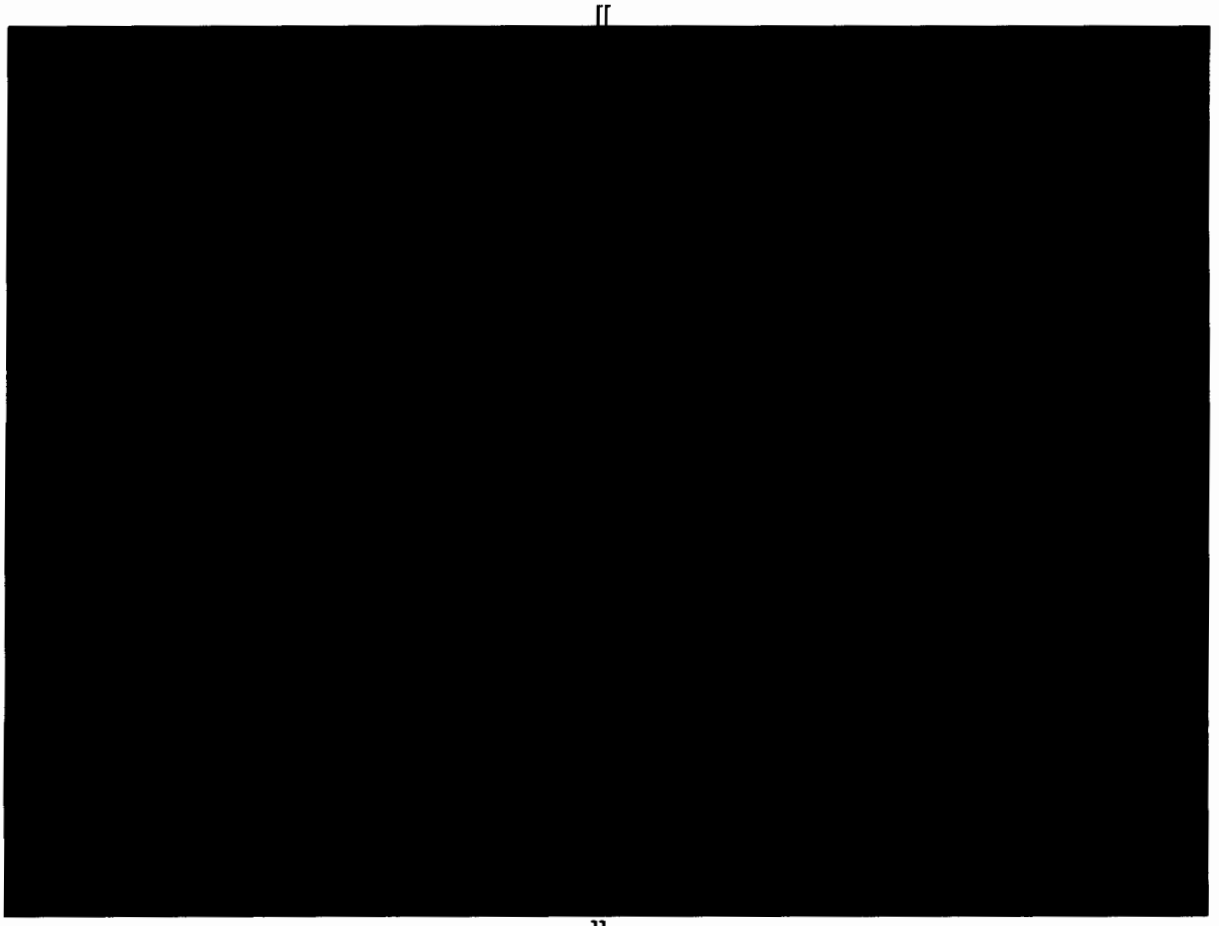

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Figure A1-3b Location of point of interests for LIP flood analysis

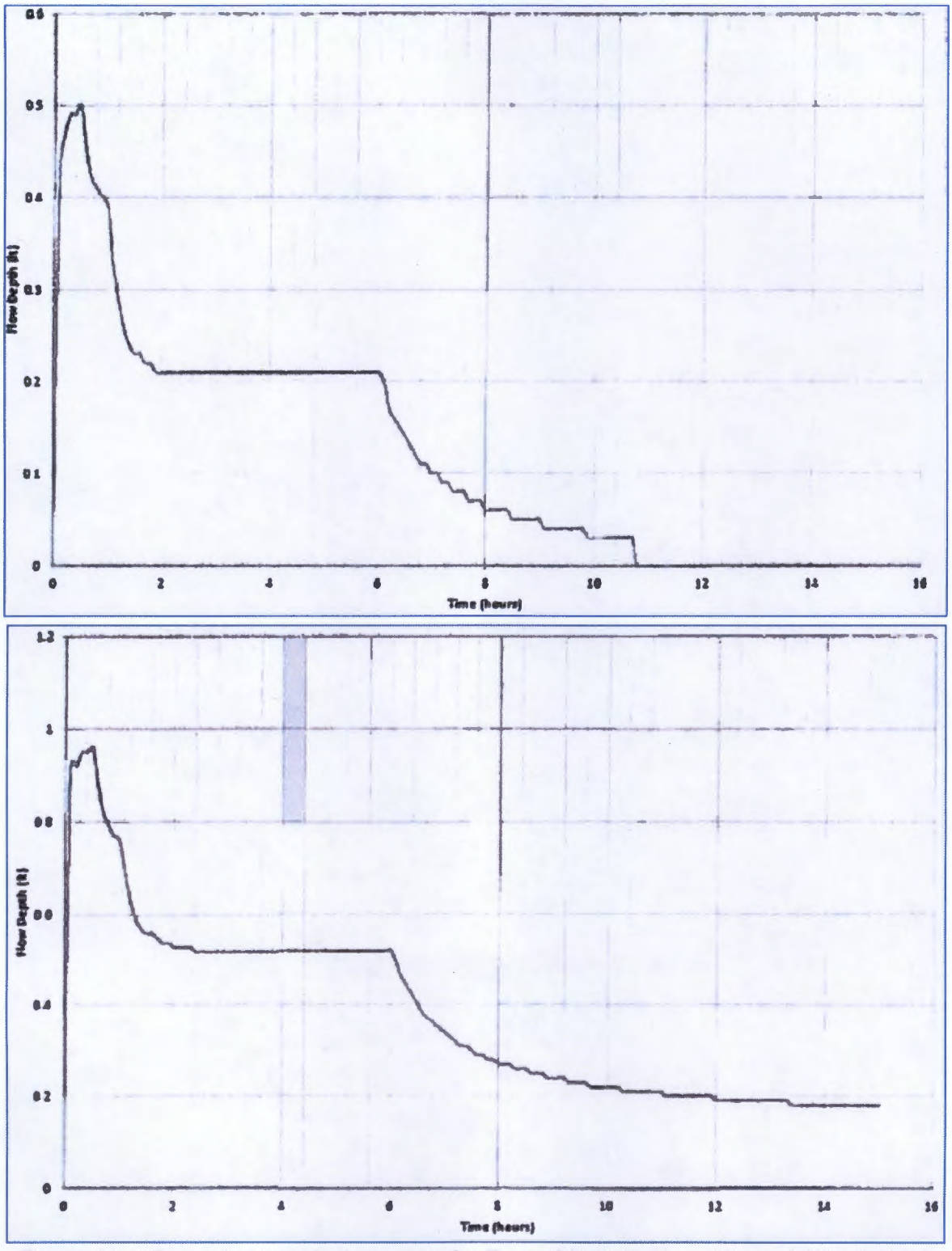

Figure A1-4 Example stage hydrographs for Door 2M111 (top) and Door OCT5 (below)

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