Entergy

ENTERGY NUCLEAR
Engineering Report Cover Sheet

Engineering Report Title:

2017 MITIGATING STRATEGIES ASSESSMENT FOR FLOODING DOCUMENTATION REQUIREMENTS AT ARKANSAS NUCLEAR ONE

Engineering Report Type:

New ☒ Revision ☐ Cancelled ☐ Superseded ☐
Superseded by: _____

Applicable Site(s)

IP1	☐	IP2	☐	IP3	☐	JAF	☐	PNPS	☐	VY	☐	WPO	☐
ANO1	☒	ANO2	☒	ECH	☐	GGNS	☐	RBS	☐	WF3	☐	PLP	☐

EC No. 69327

Report Origin: ☐ Entergy ☒ Vendor
Vendor Document No.: ENTCORP038-REPT-004

Quality-Related: ☐ Yes ☒ No

Prepared by: ENERCON / See attached Date: _____
Responsible Engineer (Print Name/Sign)

Design Verified: N/A Date: _____
Design Verifier (if required) (Print Name/Sign)

Reviewed by: Brian Adkison (owner's review) /Brian Adkison/ Date: 4-25-17
Reviewer (Print Name/Sign)

Approved by: Jimmy Kinder /Jimmy Kinder/ Date: 4/29/17
Supervisor / Manager (Print Name/Sign)

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Title:	2017 MITIGATING STRATEGIES ASSESSMENT FOR FLOODING DOCUMENTATION REQUIREMENTS AT ARKANSAS NUCLEAR ONE	REPORT NO.: ENTCORP038-REPT-004
		REVISION: 0
		Client: Entergy
		Project Identifier: ENTCORP038

Item	Cover Sheet Items	Yes	No
1	Does this Project Report contain any open assumptions, including preliminary information that require confirmation? (If **YES**, identify the assumptions.)	☐	☒
2	Does this Project Report supersede an existing Project Report? (If **YES**, identify the superseded Project Report.) **Superseded Project Report No.** _____	☐	☒

Scope of Revision:

Initial Issue

Revision Impact on Results:

N/A

Safety-Related ☐ **Non-Safety-Related** ☒

Originator: **Brian Froese** Digitally signed by Brian Froese Date: 2017.04.17 15:19:13 -04'00'

Design Verifier [1] (Reviewer for Non-Safety-Related): **Mike Cymbor** Digitally signed by Michael Cymbor Date: 2017.04.17 15:58:37 -04'00'

Approver: **Jared Monroe** Digitally signed by Jared Monroe Date: 2017.04.17 23:24:06 -04'00' **Date:** **4/17/2017**

Note 1: Design Verification is required for all safety-related Project Reports. A review is adequate for non-safety-related Project Reports.

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2017 MITIGATING STRATEGIES ASSESSMENT FOR FLOODING DOCUMENTATION REQUIREMENTS AT ARKANSAS NUCLEAR ONE	REPORT NO.: ENTCORP038-REPT-004	
	REVISION: 0	

PROJECT REPORT REVISION STATUS

REVISION	DATE	DESCRIPTION
0	4/17/2017	Initial Issue

ATTACHMENT REVISION STATUS

APPENDIX NO.	NO. OF PAGES	REVISION	ATTACHMENT NO.	NO. OF PAGES	REVISION
A	4	0			

2017 Mitigating Strategies Assessment
Flooding Documentation Requirements
Arkansas Nuclear One

Acronyms:

- CDB – Current Design Basis
- EC – Engineering Change
- ELAP – Extended Loss of AC Power
- FHRR – Flood Hazard Re-evaluation Report
- FIP – Final Integrated Plan
- FLEX DB – FLEX Design Basis (flood hazard)
- FSB – FLEX Storage Building
- FSG – FLEX Support Guideline
- ISR – Interim Staff Response
- LIP – Local Intense Precipitation
- LUHS – Loss of Ultimate Heat Sink
- MSA – Mitigating Strategies Assessment
- MSFHI – Mitigating Strategies Flood Hazard Information
- MSL – Mean Sea Level
- NGVD29 – National Geodetic Vertical Datum of 1929
- NRC – Nuclear Regulatory Commission
- NSRC - National SAFER Response Center
- PSF – Pounds per Square Foot

Definitions:

FLEX Design Basis: the flood hazard for which FLEX was designed.

FLEX Design Basis Flood Hazard: the controlling flood parameters used to develop the FLEX flood strategies.

1. Summary

The MSFHI provided in the ANO ISR (Ref. 2) reflects the FHRR (Ref. 1) evaluation of the eight flood-causing mechanisms and Combined Effect flood, identified in Attachment 1 to Enclosure 2 of the NRC information request (Ref. 4). The FHRR (Ref. 1) and ISR (Ref. 2) identified the flood mechanism listed below as not bounded by the CDB:

- (1) LIP

For Mechanism (1), the LIP, flooding along a section of the North Access Road that is approximately 360 ft in length (Ref. 16, Attachment 10.003) impacts the as-designed FLEX strategies. This section only begins to fully recede after 6 hours and is expected to become passible after 9-10 hours. This impacts the sequence of events timeline, as the FLEX 480V generator is required to be connected by 6 hours. Several other FLEX activities are also scheduled to use deployed equipment prior to 10 hours. Modifications to the FLEX strategy to pre-stage required equipment, in combination with procedural updates, can address this impact. Pre-staging will be initiated based on a trigger-point that will be developed in accordance with NEI 15-05

(Ref. 9). A complete list of equipment to be pre-staged will also be developed, although based on the ANO FLEX Validation (Ref. 10) it is expected this will include the 480V generator and several supporting trailers.

With the exception of inundation along a section of North Access Road, there are no other impacts to the FLEX strategy. Flooding around the FLEX Staging Area is minimal (<0.6 ft) and the LIP flood elevations identified in the ISR are bounded by the FLEX DB. Other re-evaluated flood hazard mechanisms (i.e.: tsunami, seiche, channel migrations/diversions, etc.), are bounded by the CDB and have no impact on the FLEX strategies. Additionally, Phase 3 activities were evaluated. These activities are also not impacted by the re-evaluated flood levels since they will have sufficiently receded by the time the Phase 3 strategy is implemented. Details of the FLEX strategies along with the bounding flood will be discussed later in this document.

2. Documentation

2.1. NEI 12-06, Rev. 2, Section G.2 – Characterization of the MSFHI

Characterization of the MSFHI is primarily summarized in Table 2 of the NRC's ISR (Ref. 2) to the FHRR submittal (Ref. 1). A more detailed description of the flood mechanisms identified in the ISR, along with the basis for inputs, assumptions, methodologies, and models, is provided in the following references:

- LIP: Reference 1, Section 3.1.
- Flooding in Streams and Rivers: Reference 1, Section 3.2.
- Dam Breaches and Failures: Reference 1, Section 3.3.
- Storm Surge: Reference 1, Section 3.4.
- Seiche: Reference 1, Section 3.5.
- Tsunamis: Reference 1, Section 3.6.
- Ice-Induced Flooding: Reference 1, Section 3.7.
- Channel Migration or Diversion: Reference 1, Section 3.8.
- Combined Effect Flood: Reference 1, Section 3.9.

Based on the results of the FHRR, the ISR issued by the NRC (Ref. 2) identified that only the LIP flood mechanism is not bounded by the ANO CDB. Therefore, only the LIP is included in this MSA developed in response to EA-12-049, the Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Ref. 13). All other mechanisms evaluated in the FHRR (tsunami, seiche, channel migrations/diversions, etc.) are bounded by the CDB flood level and have no impact on the site as noted in the ISR. Note that all elevations presented here and throughout the MSA are reported in NGVD29. At this location, MSL is considered equivalent to NGVD29 (Ref. 1, Section 1.5).

Local Intense Precipitation

Although the LIP is discussed in the ANO CDB, it does not include a specific evaluation or include an elevation and therefore is not bounded as reflected by the MSFHI. LIP flooding depths around the power block area range from 351.4 ft to 357.7 ft at the representative locations identified in the FHRR (Ref. 1). This results in maximum flood depths that range from 0.1 ft to approximately 2.0 ft at these representative locations. Flood levels around the plant beyond the power block are captured in Appendix C of the FHRR-LIP calculation (Ref. 3).

2.2. NEI 12-06, Rev. 2, Section G.3 – Comparison of the MSFHI and FLEX DB Flood

A complete comparison of the CDB, the FLEX DB, and re-evaluated flood hazards is provided in Table 1 for the LIP flooding mechanism.

Table 1 - Flood Causing Mechanism (LIP) or Bounding Set of Parameters

Flood Scenario Parameter		Plant Current Design Basis Flood Hazard	FLEX Design Basis Flood Hazard	MSFHI LIP	Bounded (B) or Not Bounded (NB) by FLEX DB
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft NGVD29)	N/I	361	See Note 1	B
	2. Max Wave Run-up Elevation (ft NGVD29)	N/I	361	See Note 2	B
	3. Max Hydrodynamic/Debris Loading (psf)	N/I	N/A	See Note 3	B
	4. Effects of Sediment Deposition/Erosion	N/I	N/A	See Note 3	B
	5. Concurrent Site Conditions	N/I	N/A	See Note 4	B
	6. Effects on Groundwater	N/I	N/A	N/A	B
Flood Event Duration	7. Warning Time (hours)	N/I	See Note 5	N/A	B
	8. Period of Site Preparation (hours)	N/I	N/A	N/A	B
	9. Period of Inundation (hours)	N/I	N/I	See Note 6	NB
	10. Period of Recession (hours)	N/I	N/I	See Note 6	NB
Other	11. Plant Mode of Operations	Modes 1-6	Modes 1-6	Modes 1-6	B
	12. Other Factors	N/A	N/A	N/A	N/A

N/A = Not Applicable N/I = Not Included

1. A LIP event, in nature, is not a site wide flood level but rather areas of local ponding. LIP flooding elevations range from 351.4 ft to 357.7 ft at the representative locations around the power block area identified in the FHRR (Ref. 1). These are bounded by the FLEX DB elevation of 361 ft (Ref. 6). The FSBs are also not impacted by the flood heights (see Section 2.3.1.1). Therefore, this parameter is considered bounded.
2. Consideration of wind-wave action for the LIP event is not explicitly required by NUREG/CR-7046 (Ref. 14) and is judged to be negligible because of the minimal flow depths.
3. The FHRR (Ref. 1) did not identify any hydrodynamic loading, debris loading, sediment deposition or erosion. These were not considered credible effects due to the relatively low flow velocities in general for a LIP event and limited debris sources within the protected area.
4. No antecedent storm was considered with the LIP event. LIP is a singular event per NUREG/CR-7046 (Ref. 14).
5. No warning time for a LIP flooding event was credited in the original FLEX strategy, which only considered a warning time for a high lake-level event. However, due to the MSFHI, a warning time will be credited for pre-deployment of required equipment, utilizing the guidance of NEI 15-05 (Ref. 9). This will be incorporated into Natural Emergencies Procedures OP-1203.025 (Ref. 11) and OP-2203.008 (Ref. 12) as well as the FLEX Strategy. No other warning time is credited for this MSA.
6. Flood heights around the FLEX Staging Area are typically low (<0.6 ft maximum) and recede significantly by 2 hours into the event as shown in the hydrographs from the FHRR (Ref. 1, Appendix A). However, a section of the deployment route along the North Access Road does not begin to fully recede until after 6 hours as shown in Appendix A of this report. This section is expected to become passible after 9-10 hours, which is considered to be the period of inundation. Therefore, these parameters are considered not bounded.

2.3. NEI 12-06, Rev. 2, Section G.4 – Evaluation of Mitigating Strategies for the MSFHI

2.3.1. NEI 12-06, Rev. 2, Section G.4.1 – Assessment of Current FLEX Strategies

2.3.1.1. LIP

Two flooding scenario parameters for the LIP are not bounded by the ANO CDB or FLEX DB: Period of Inundation and Period of Recession (See Table 1).

The equipment stored in FSB #1, which is located northeast of the plant (Ref. 6), is at an elevation of 412.8 ft (Ref. 8). This is higher in elevation than the surrounding area and therefore storage of the equipment is not impacted in this building. As a point of reference, the maximum flooding heights in this area are <0.5 ft (Ref. 3, Appendix C). These flooding heights do not take credit for the existing plant storm drainage system, which would direct storm runoff away from the building as determined in the Grading and Drainage Analysis performed as a part of the FLEX Storage Building EC (Ref. 15). The deployment pathway along the North Access Road from this building has a section, approximately 360 ft long (Ref. 16, Attachment 10.003), where maximum flood heights exceed 5.5 ft. Appendix A of this report presents figures that identify the flooded area and corresponding hydrographs. As indicated, this section only begins to fully recede after 6 hours and is expected to become passible after 9-10 hours by extrapolating the hydrographs. Deployment of FLEX equipment, which starts as early as 3 hours (Ref. 10, Attachment 2), could be impacted by these flood heights. Per the sequence of events timeline in the FIP (Ref. 6, Table 1), at a minimum the deployment of the FLEX 480V generator and associated electrical trailers will be impacted. Backfilling the QCST from the BWST, refueling the diesel equipment, and providing portable fans to the Control Room may also be impacted since equipment from the FSBs is required for these actions.

The equipment stored in FSB #2, located east of the plant and just north of the intake canal, is at an elevation of 360.5 ft (Ref. 8). Note that this equipment is pre-staged in the event of a river flood, so the current FLEX DB protection elevation of 361 ft is retained. This FSB elevation is higher than the expected LIP flood levels, which remain below 350 ft in this area (Ref. 3, Appendix C). However, there is significant flooding expected between the FSB and May Road. These flood heights can reach greater than 8 ft and are expected to recede at a later time than the flooded area along the North Access Road. As such, deployment of FLEX equipment at 3 hours from FSB #2 may also be impacted.

Since flood levels around the FLEX Staging Area are low (<0.6 ft maximum) and recede significantly within 2 hours (Ref. 1, Appendix A), the FLEX Staging Area and associated activities around the power block are not impacted. Other time-sensitive activities listed in the FIP sequence of events timeline (Ref. 6, Table 1) were reviewed. All additional activities can be implemented as intended.

In summary, while the FLEX DB flood elevation of 361 ft bounds the LIP flooding elevations, this bounding value is for a PMF on the Arkansas River that credits pre-deployment several days in advance. For a LIP event, inundation along the North Access road may impact deployment of FLEX equipment. This is the only potential impact to the FLEX strategy.

2.3.1.2. Phase 3

For Phase 3, the NSRC's ability to transport equipment to Staging Area B (site location where equipment will be pre-staged, parked, or placed prior to movement into the final location) is covered in the ANO SAFER Response Plan (Ref. 7). This includes multiple means and pathways of transporting NSRC equipment to the site. Therefore, since Phase 3 is not credited sooner than 24 hours into the event (Ref. 6, FIP Section 2.2), transportation of NSRC equipment to the site is bounded given the general flooding levels and recession times discussed in Section 2.3.1.1. If required, the Phase 2 strategy can also continue almost "indefinitely". The primary Staging Area B is located in the parking lot, just south of the cooling tower and next to the site. Flood levels in the area are minimal (<0.5 ft maximum) and the same deployment pathways are used to get to the site as Phase 2. There are also three additional Staging Area B options. The two northern options are nearby FSB #1, where the maximum flooding heights in this area are <0.5 ft. The southern option at the Helipad also has minimal flooding (<0.5 ft maximum). Therefore, the primary Staging Area B and all three alternate options are expected to be available during Phase 3. As such, the Phase 3 strategy can be implemented as intended and is not impacted by the LIP flooding mechanism evaluated in this MSA.

2.3.2. NEI 12-06, Rev. 2, Section G.4.2 – Assessment for Modified FLEX Strategies

The overall plant response strategies to an ELAP and LUHS event using the current FLEX procedures, equipment, and personnel can be implemented with the following modifications to the strategy:

- Pre-deploy the FLEX 480 V generator, supporting trailers, and any other equipment deemed necessary to the anticipated Staging Area for a LIP event. This prevents having to deploy equipment along the North Access Road during the inundation period. Flooding around the Staging Area is minimal (<0.6 ft maximum) and below the ground clearance of FLEX Equipment, such that manual actions to deploy and operate the equipment would not be impacted by the ponding during a LIP event. Pre-staging is already credited in the FIP for lake flooding in Natural Emergencies Procedures OP-1203.025 for Unit 1 (Ref. 11) and OP-2203.008 for Unit 2 (Ref. 12).

- Trigger-point entry conditions for pre-staging will be developed for a LIP event in accordance with NEI 15-05 (Ref. 9). This will be integrated into Natural Emergencies Procedures OP-1203.025 (Ref. 11) and OP-2203.008 (Ref. 12).

As an alternative, ANO may elect to modify the section of the North Access Road that becomes inundated by raising an approximate 360 ft long section (Ref. 16, Attachment 10.003. This would rectify the deployment concern from FSB #1 such that the FLEX strategies could be implemented as currently designed without the need for pre-staging.

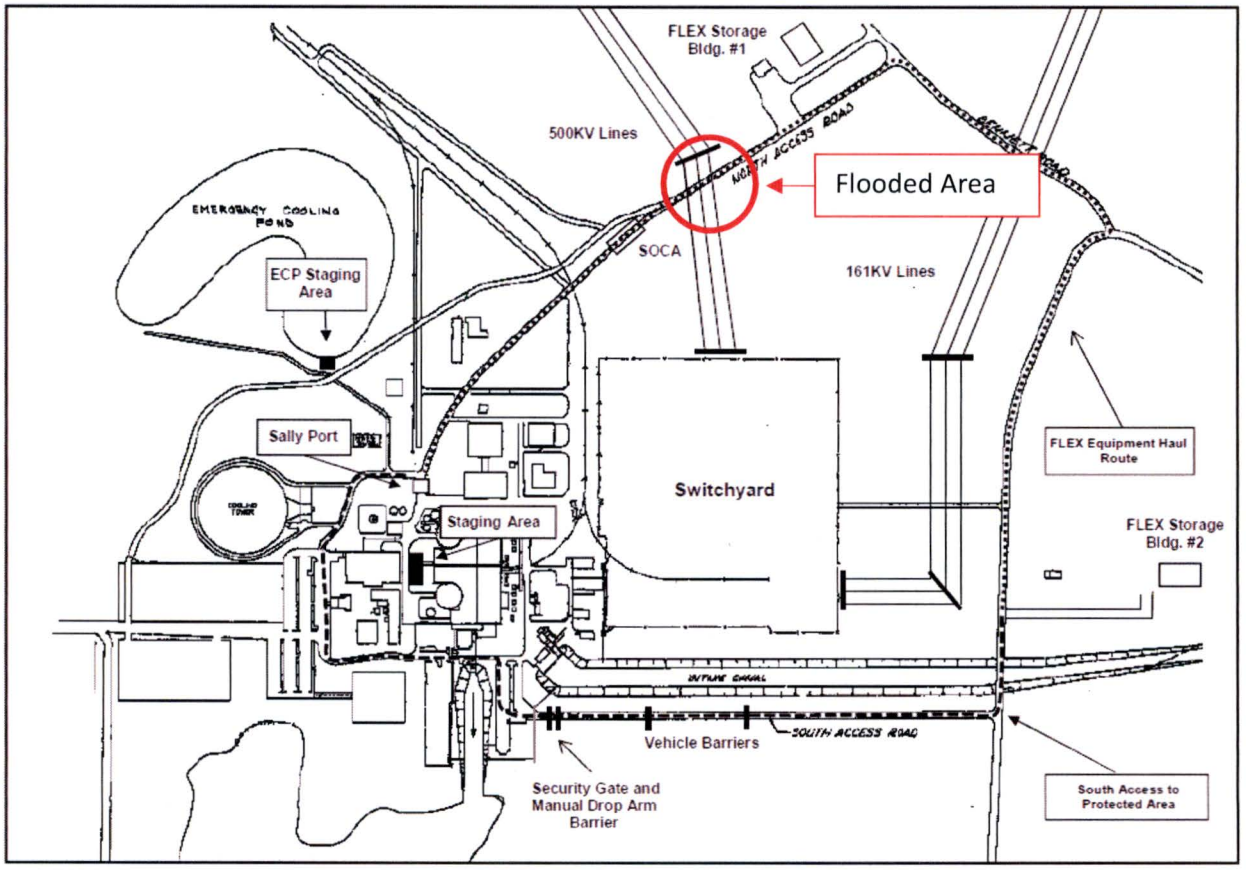
2.4. References

1. 0CAN091602, Flooding Hazard Re-evaluation Report – Required Response for Near-Term Task Force (NTTF) Recommendation 2.1 Arkansas Nuclear One – Units 1 and 2 Docket Nos. 50-313 and 50-368 License Nos. DPR-51 and NPF-6, dated September 14, 2016 (ML16260A060)
2. 0CNA121601, Arkansas Nuclear One, Units 1 and 2 – Interim Staff Response To Reevaluated Flood Hazards Submitted In Response To 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (CAC Nos. MF8379 AND MF8380), dated December 2, 2016 (ML16327A494)
3. CALC-ANOC-CS-14-00010 Sh. 4, Rev. 000, Arkansas Nuclear One Flooding Hazard Re-Evaluation – Local Intense Precipitation – Generated Flood Flow and Elevations
4. 0CNA031208, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident; dated March 12, 2012 (ML12053A340)
5. CFSG-005, Rev. 002, Initial Assessment and FLEX Equipment Staging
6. 0CAN011601, Notification of Full Compliance with NRC Order EA-12-049 Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (BDBEEs), January 12, 2016 (ML16014A396)
7. 38-9233737-000, Rev. 002, SAFER Response Plan for Arkansas Nuclear One
8. C-667 Sh 1, Rev. 000, Grading and Drainage Plan for FLEX Storage Building
9. NEI 15-05, Rev. 6, Warning Time for Local Intense Precipitation Events
10. ANO-2015-0078, Rev. 0, ANO Unit 1 Unit 2 Validation Plan Final – ANO FLEX Validation
11. OP-1203.025, Rev. 062, Natural Emergencies
12. OP-2203.008, Rev. 043, Natural Emergencies
13. EA-12-049, Issuance or Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, March 12 2012
14. NUREG-7046, Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America, November 2011
15. EC 44045, Rev. 000, ANO FLEX Storage Building
16. EC 69327 Rev. 0, Admin EC to issue ANO FLEX Flood MSA Report

Appendix A: North Access Road Flooded Area

Figure A-1 presents the deployment paths, Staging Area, and the approximate location of the inundated area along the North Access Road.

Figure A-1 - FLEX Equipment Deployment Routes and Staging Locations (Ref. 5)



Hydrographs were created from the FHRR FLO-2D model at three grid elements that are representative of the flooding levels along the North Access Road in this area. Figure A-2 presents the maximum flood depths (ft) around this area and identifies the three grid elements. As shown, they bisect the entirety of the North Access Road. Figures A-3 through A-5 present the three hydrographs.

Figure A-2 – Maximum Flood Depths (ft) (Ref. 3, Appendix C)

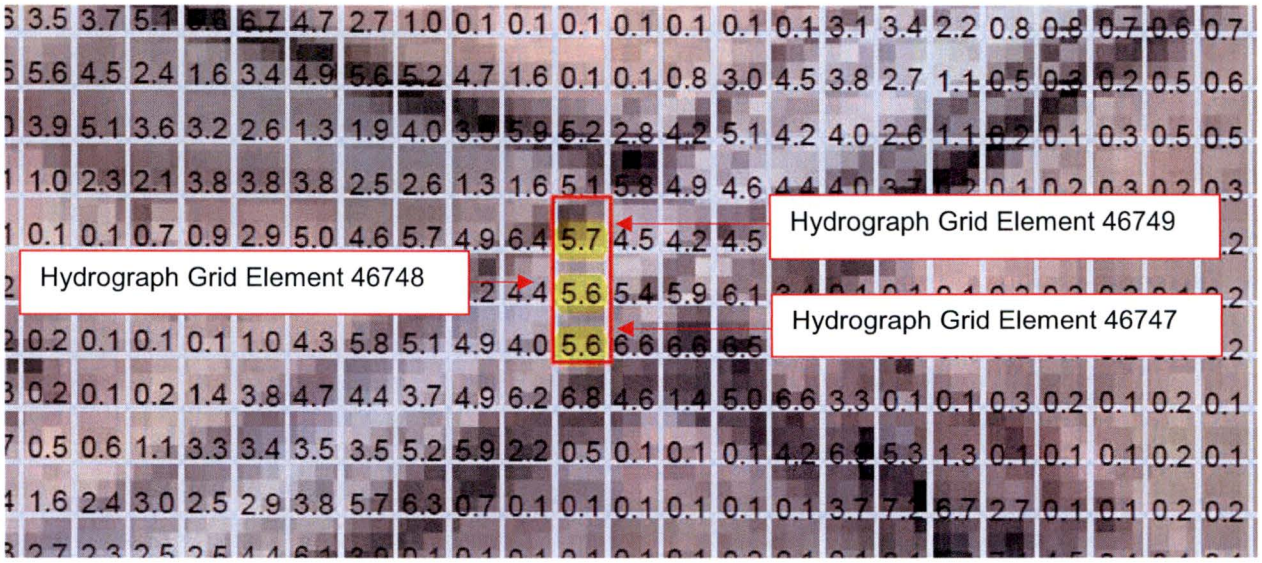


Figure A-3 – Grid Element 46749 Hydrograph

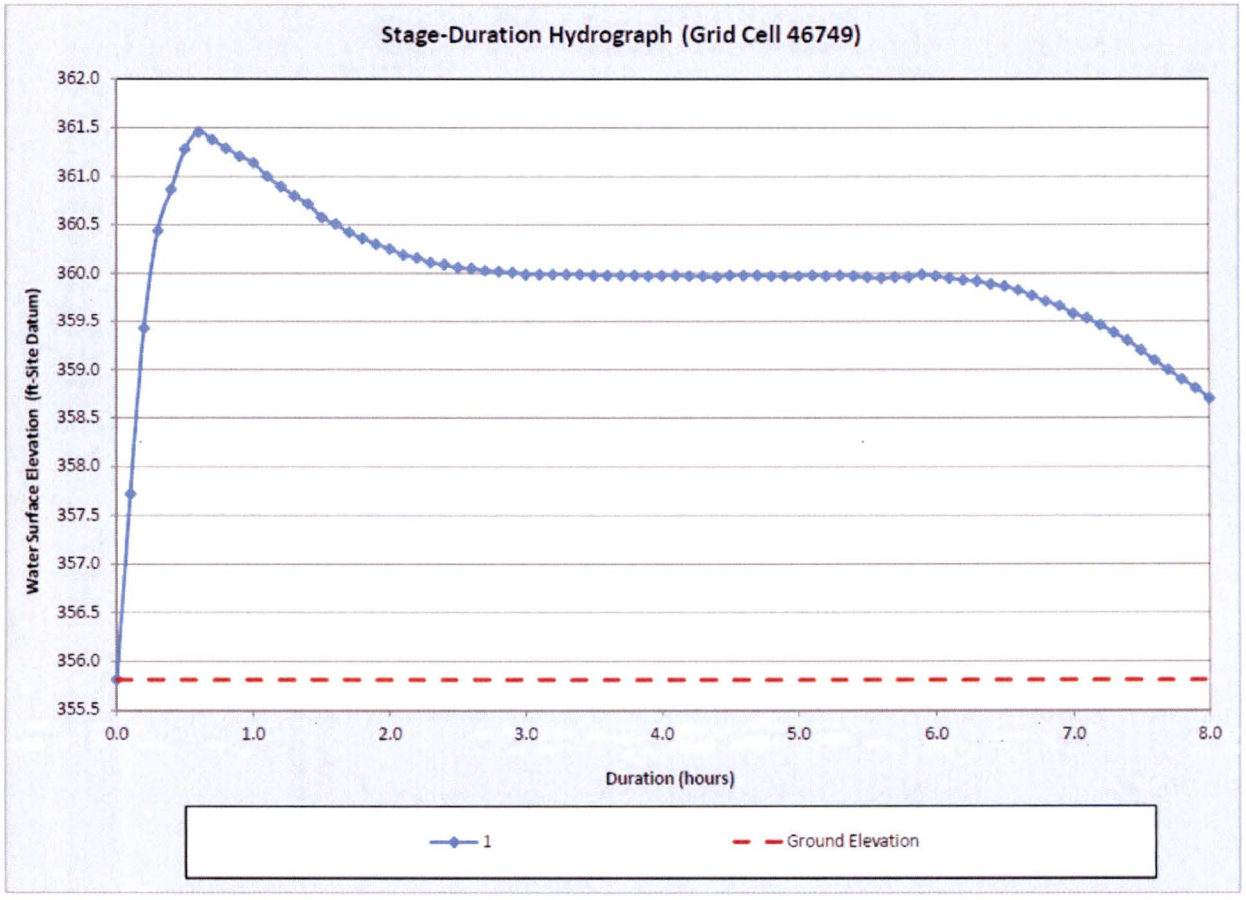


Figure A-4 – Grid Element 46748 Hydrograph

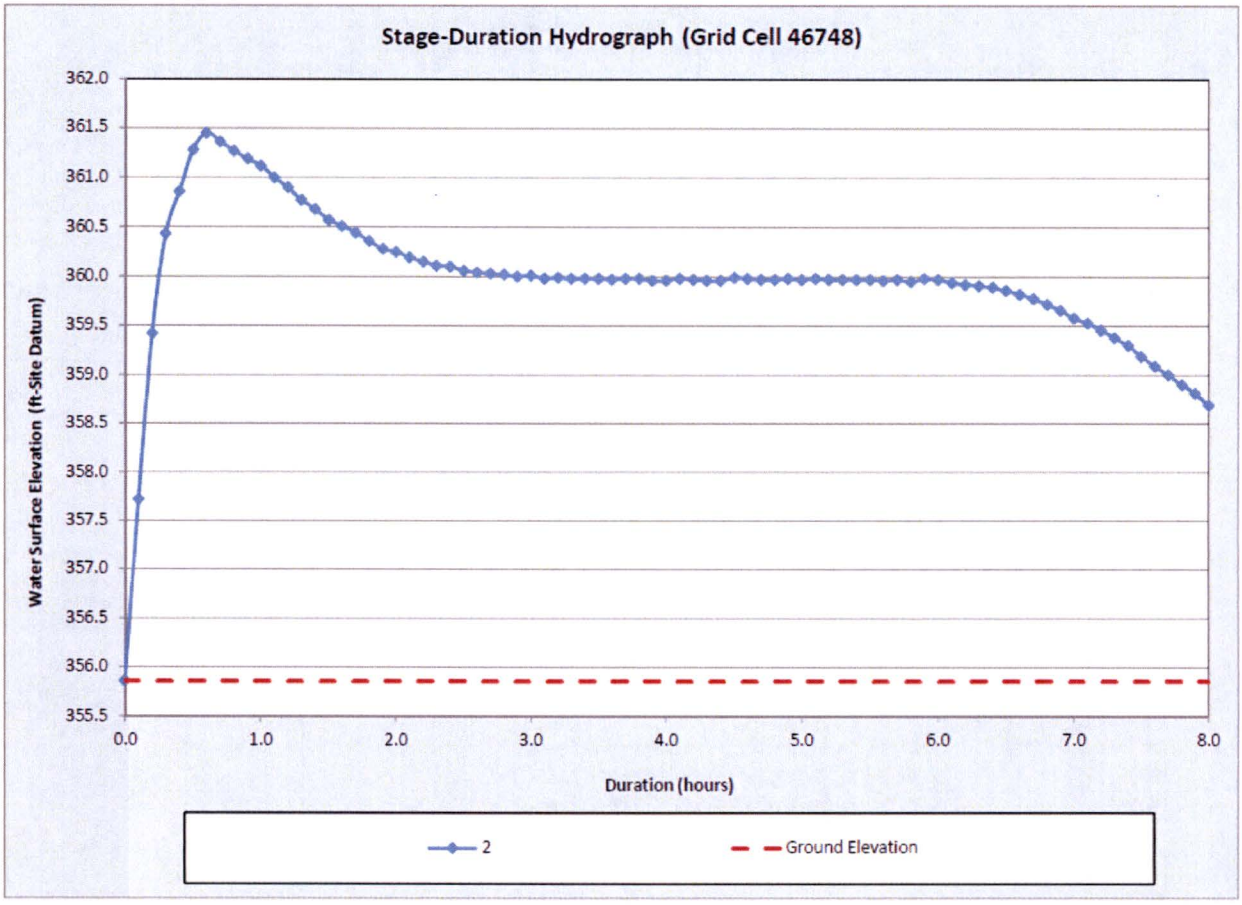
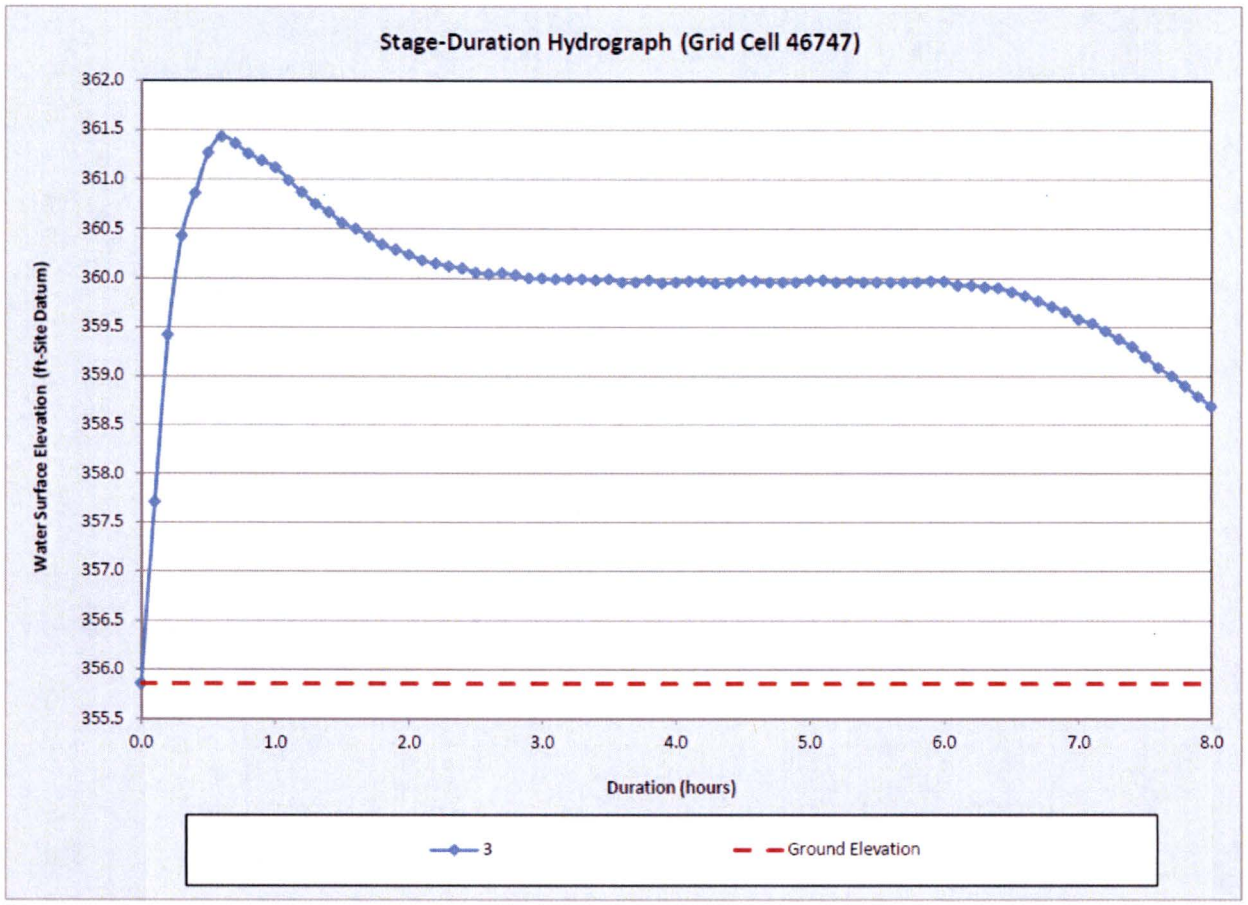


Figure A-5 – Grid Element 46747 Hydrograph



Attachment to

0CAN051703

List of Regulatory Commitments

LIST OF REGULATORY COMMITMENTS

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (check one)		SCHEDULED COMPLETION DATE
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
Trigger-point entry conditions for pre-staging will be developed for a local intense precipitation event in accordance with NEI 15-05. This will be integrated into Natural Emergencies Procedures OP-1203.025 and OP-2203.008. As an alternative, Entergy may elect to modify the section of the North Access Road that becomes inundated by raising an approximate 360 ft long section. This would rectify the deployment concern from FLEX Storage Building #1 such that the FLEX strategies could be implemented as currently designed without the need for pre-staging.	✓		September 30, 2019