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External Flooding Assessment Guidelines

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Nuclear Energy Institute

External Flooding Assessment Guidelines

June 2016

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TABLE OF CONTENTS

1 PURPOSE 1

2 BACKGROUND 1

3 REFERENCES 5

4 TERMS AND DEFINITIONS 8

5 FLOODING IMPACT ASSESSMENT PROCESS OVERVIEW 11

6 INITIAL EVALUATION PROCESS (BOX 2-4) 13

6.1 Improve Realism of Flood Hazard Evaluation (Box 2) 13

6.2 Characterization of Flood Parameters (Box 3) 14

6.3 Initial Evaluation of Flood Impacts and Protection (Box 4) 15

6.3.1 Assess Flooding Impact on Plant Conditions 15

6.3.2 Determination Available Physical Margin (APM) 16

6.4 Determination of Appropriate Process Path 16

7 FOCUSED EVALUATION PROCESS (PATH 1-3) 18

7.1 Path 1: Demonstrate Flood Mechanism is Bounded (Box 2a-2b-2c) 18

7.2 Path 2: Demonstrate Effective Flood Protection (Box 5-6) 20

7.3 Path 3: Demonstrate a Feasible Response to LIP (Box 7-8) 21

8 FULL SCOPE INTEGRATED ASSESSMENT PROCESS (PATH 4-5) 22

8.1 Path 4: Demonstrate Effective Mitigation (Box 9-10) 22

8.2 Path 5: Scenario Based Approach (Box 11-12) 23

8.2.1 Objective 23

8.2.2 Develop and Characterize Scenarios (Box 11a) 26

8.2.3 Identify Scenarios with Effective Flood Protection (Box 11b-11c) 27

8.2.4 Determine Appropriate Evaluation for Scenarios (Box 11d) 28

8.2.5 Feasible Response of Appropriate Scenarios (Box 11e) 29

8.2.6 Effective Mitigation of Appropriate Scenarios (Box 11f) 30

8.2.7 Identification of Potential Enhancements (Box 11g) 30

APPENDIX A: REDUCTION OF CONSERVATISMS 31

A.1 Characterization of Conservatisms 31

A.2 Identify Flood Mechanisms with Conservatisms 31

A.3 Appendix A References 38

APPENDIX B: EVALUATION OF PASSIVE & ACTIVE COMPONENTS 40

B.1 Determination of Adequate Available Physical Margin 40

B.2 Evaluation of Flood Features 42

B.2.1 Permanent, Passive, Exterior and Incorporated Features 42
B.2.1.1 Earthen Embankments (Earth Dams, Levees, and Dikes) 42
B.2.1.2 Floodwalls 44
B.2.1.3 Seawalls 45
B.2.1.4 Concrete Barriers 45
B.2.1.5 Plugs and Penetrations Seals 46
B.2.1.6 Storm Drainage Systems 47
B.2.2 Active Features 47
B.2.2.1 Active Components 47
B.2.2.2 Flood Doors and Hatches 50
B.2.3 Temporary Features 51
B.2.4 Equipment Necessary to Perform Human Actions 51
B.3 Appendix B References 51

APPENDIX C: EVALUATION OF THE SITE RESPONSE 53

C.1 Objective 53
C.2 Overall Process of Evaluating a Flood Response Strategy 53
C.3 Defining Critical Path and Identifying Time Sensitive Actions (TSAs) 54
C.4 Evaluating Feasible Actions 55
C.5 Evaluating a Dependable Strategy 55
C.5.1 Procedural Trigger to Initiate Response 56
C.5.2 Organizational Response to Procedure Initiation 57
C.5.3 Expected Environmental Conditions 57
C.5.3.1 Qualitative Assessment 58
C.5.3.2 Quantitative Assessment 59
C.5.4 Flood Response Strategy Timeline Analysis 59

1 PURPOSE

This document describes the Flooding Impact Assessment Process (FIAP) to evaluate the strategies developed for the reevaluated flooding hazards which exceeded the facility's design basis flood level that were submitted to the NRC pursuant to the 50.54(f) request of March 12, 2012 as documented in the flood hazard reevaluation report (FHRR). The overall process concept is described in Section 5. The FIAP is only required if the reevaluated flooding hazards submitted pursuant to the 50.54(f) request are not bounded by the site's design/licensing basis. The process described in this guidance is intended to meet the requirement of an Integrated Assessment identified in the 50.54(f) letter, however it incorporates the changes described in the NRC closure plan detailed in COMSECY-15-0019. Specifically, COMSECY-15-0019 and this process includes the option for sites to perform a Focused Evaluation to fully complete their response to the 50.54(f) request without the need for sites to perform an Integrated Assessment and for NRC to perform Phase 2 decision making.

Following receipt of the NRC staff assessment of the FHRR, the FIAP can be completed to satisfy the 50.54(f) request and subsequent NRC guidance provided on September 1, 2015 (reference XX, ML15174A257).

2 BACKGROUND

In response to the nuclear fuel damage at the Fukushima-Dai-ichi power plant due to the March 11, 2011 earthquake and subsequent tsunami, the United States Nuclear Regulatory Commission (NRC) established the Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations, and to make recommendations to the Commission for its policy direction. The NTTF reported a set of recommendations that were intended to clarify and strengthen the regulatory framework for protection against natural phenomena.

On March 12, 2012, the NRC issued an information request pursuant to Title 10 of the Code of Federal Regulations, Section 50.54 (f). In Enclosure 2 of the 50.54(f) letter, the NRC requested that licensees 'reevaluate the flooding hazards at their sites against present-day regulatory guidance and methodologies being used for early site permits and combined license reviews'. Licensees were requested to perform a reevaluation of all appropriate external flooding sources, including the effects from local intense precipitation on the site, probable maximum flood (PMF) on stream and rivers, storm surges, seiches, tsunami, and dam failures. Key guidelines used to perform the reevaluations include:

- U.S. Nuclear Regulatory Commission (NRC). 2007. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition – Site Characteristics and Site Parameters (Chapter 2)," ML070400364, March 2007.

- U.S. Nuclear Regulatory Commission (NRC). 2011. NUREG/CR-7046, PNNL-20091, *Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America.* ML11321A195, November 2011.

- U.S. Nuclear Regulatory Commission (NRC). 1977. *Design Basis Flood for Nuclear Power Plants*. Regulatory Guide 1.59, Rev. 2, Washington, D.C.

- American Nuclear Society (ANS). 1992. *American National Standard for Determining Design Basis Flooding at Power Reactor Sites*. Prepared by the American Nuclear Society Standards Committee Working Group ANS-2.8, La Grange Park, Illinois.

- U.S. Nuclear Regulatory Commission (U.S. NRC), "NUREG/CR-6966: Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America", Springfield, VA: National Technical Information Service, March 2009.

- U.S. Nuclear Regulatory Commission (U.S. NRC), "NUREG/CR-7134: The Estimation of Very-Low Probability Hurricane Storm Surges for Design and Licensing of Nuclear Power Plants in Coastal Areas", Springfield, VA: National Technical Information Service, October 2012.

- U.S. Nuclear Regulatory Commission (U.S. NRC), "Guidance for Performing a Tsunami, Surge and Seiche Hazard Assessment, Revision 0," Japan Lessons-Learned Project Directorate Interim Staff Guidance, JLD-ISG-2012-06, January 4, 2013.

- U.S. Nuclear Regulatory Commission (U.S. NRC), "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.

The 50.54(f) request also required utilities to provide an Integrated Assessment Report for sites where the design/licensing basis floods do not bound each of the reevaluated flood mechanisms.

Subsequent to the 50.54(f) request, ongoing discussions within the NRC and industry resulted in a reassessment of the Flooding Impact Assessment Process. On May 26, 2015, the NRC deferred until further notice, the due date for licensees to respond to the request for the Integrated Assessment Reports (ML15112A051, reference XX). This deferral was due to the staff's ongoing effort to respond to the Commission's direction in the Staff Requirements Memorandum (SRM) to COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of

Flooding Hazards," issued on March 30, 2015 (ML15089A236, reference XX). On June 30, 2015, the staff issued COMSECY-15-0019, describing the closure plan for the reevaluation of flooding hazards for operating nuclear power plants (ML15153A104, reference XX). The commissioners approved the closure plan on July 28, 2015 (ML15209A683, reference XX).

On September 1, 2015, the NRC described changes in the NRC's approach to the flood hazard reevaluations (ML15174A257, reference XX). This letter describes the approach for the Flooding Impact Assessment Process that licensees should follow. As described in the letter:

> *Licensees for operating nuclear reactors have submitted or are currently preparing the information requested in the 50.54(f) letter. The flood hazard reevaluations apply present-day guidance and methods to calculate postulated, conservative flooding hazards. This information supports assessing the potential impact of such flooding events on the sites. Integrated assessments were originally requested for those plants with calculated values exceeding their design-basis flood to help identify plant vulnerabilities, potential plant improvements, and to support the evaluation of possible regulatory actions in response to the flooding reevaluations prepared in response to the 50.54(f) letter. Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies using the most recent external hazard information in accordance with NRC Order EA-12-049, "Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML 12054A735).*
>
> *The NRC staff and industry have long recognized the difficulty in developing and implementing mitigating strategies before completing the reevaluation of flood hazards. The staff described these issues and provided recommendations to the Commission on how best to integrate these related activities in COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated November 21, 2014 (ADAMS Accession No. ML 14309A256). The Commission issued a Staff Requirements Memorandum (SRM) on March 30, 2015 (ADAMS Accession No. ML 15089A236), affirming that the Commission expected licensees for operating nuclear power plants to address the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events and directing the NRC staff to develop a plan for revising guidance and developing criteria for appropriately assessing the reevaluated flooding hazards.*
>
> *The NRC staff has, as directed by the Commission, revised the original regulatory approach and developed a graded approach for determining the need for, and scope of, plant-specific integrated assessments such that the agency's focus is commensurate with the safety significance of the reevaluated flooding hazards.*

The letter goes on to describe the Mitigating Strategies Assessment for flooding which has been included in Appendix G of NEI 12-06, Revision 2 (reference XX), endorsed by the NRC in reference XX. In addition, it describes guidance for "a graded approach to flooding reevaluations and provide for more focused evaluations of local intense precipitations and available physical margin in lieu of proceeding to an integrated assessment. The guidance describing this screening process and clarification of the guidance for performing revised integrated assessments to reflect lessons learned and the Commission's SRM on COMSECY-14-0037 is expected to be issued by mid-2016."

This document, NEI 16-05, describes the revised Flooding Impact Assessment Process that licensees should use to close out the 50.54(f) request for flooding. This process will allow licensees with unbounded flood mechanisms identified in the FHRR to complete the flooding reevaluation efforts pursuant to the 50.54(f) request.

3 REFERENCES

1. U.S. Nuclear Regulatory Commission Regulatory Guide 1.59, Design Basis Flood for Nuclear Power Plants, Rev. 2, 1977.

2. American Nuclear Society, ANS-2.8, American National Standard for Determining Design Basis Flooding at Power Reactor Sites. Prepared by the American Nuclear Society Standards Committee Working Group, 1992.

3. Nuclear Regulatory Commission NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition – Site Characteristics and Site Parameters (Chapter 2)", March 2007, ADAMS Accession No. ML070400364.

4. U.S. Nuclear Regulatory Commission NUREG/CR-6966: Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America", March 2009, ADAMS Accession No. ML082810348.

5. U.S. Nuclear Regulatory Commission, "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 SECY-11-0093, July 12, 2011, ADAMS Accession No. ML111861807.

6. U.S. Nuclear Regulatory Commission NUREG/CR-7046, PNNL-20091, Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America, November 2011, ADAMS Accession No. ML11321A195.

7. U.S. Nuclear Regulatory Commission, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, March 12, 2012, ADAMS Accession No. ML12053A340.

8. U.S. Nuclear Regulatory Commission. "Recommended Actions to be Taken Without Delay From the Near Term Task Force Report," SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

9. U.S. Nuclear Regulatory Commission. "Prioritization of Recommended Actions to be taken in Response to Fukushima Lessons Learned," SECY-11-0137, October 3, 2011, ADAMS Accession No. ML11272A111.

10. U.S. Nuclear Regulatory Commission. Staff Requirements - SECY-11-0093 - Near-Term Report and Recommendations for Agency Actions Following the Events in Japan, August 19, 2011, ADAMS Accession No. ML112310021.

11. U.S. Nuclear Regulatory Commission. Staff Requirements - SECY-11-0124 - Recommended Actions to be Taken Without Delay From the Near-Term Task Force Report, October 18, 2011, ADAMS Accession No. ML112911571.

12. U.S. Nuclear Regulatory Commission NUREG/CR-7134: The Estimation of Very-Low Probability Hurricane Storm Surges for Design and Licensing of Nuclear Power Plants in Coastal Areas, October 2012, ADAMS Accession No. ML12310A025.

13. U.S. Nuclear Regulatory Commission, NRC Responses to Public Comments, Japan Lessons-Learned Project Directorate Interim Staff Guidance JLD-ISG-2012-05: Guidance for Performing the Integrated Assessment for Flooding in Response to the March 2012 Request for Information Letter, November 30, 2012, ADAMS Accession No. ML12311A216.

14. U.S. Nuclear Regulatory Commission, Japan Lessons-Learned Project Directorate Interim Staff Guidance, JLD-ISG-2012-06: Guidance for Performing a Tsunami, Surge and Seiche Hazard Assessment, Revision 0, January 4, 2013, ADAMS Accession No. ML12314A412.

15. U.S. Nuclear Regulatory Commission, Japan Lessons-Learned Project Directorate Interim Staff Guidance, JLD-ISG-2013-01: Guidance for Assessment of Flooding Hazards Due to Dam Failure, Revision 0, July 29, 2013, ADAMS Accession No. ML13151A153.

16. U.S. Nuclear Regulatory Commission, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards", November, 21, 2014, COMSECY-14-0037, ADAMS Accession No. ML14309A256.

17. U.S. Nuclear Regulatory Commission, "Staff Requirements – COMSECY-14-0037 – Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards", March 30, 2015, ADAMS Accession No. ML150089A236.

18. U.S. Nuclear Regulatory Commission, "Response Requirements for Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Flooding Hazard Integrated Assessments for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident", May 26, 2015, ADAMS Accession No. ML15112A051.

19. U.S. Nuclear Regulatory Commission. "Staff Requirements – COMSECY-15-0019 – Closure Plan for the Revaluation of Flooding Hazards for Operating Nuclear Power Plants", July 28, 2015, ADAMS Accession No. ML15209A682.

20. U.S. Nuclear Regulatory Commission. "Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-

Design-Basis External Events", September 1, 2015, ADAMS Accession No. ML15174A257.

21. NEI 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 2, December 2015.

22. U.S. Nuclear Regulatory Commission, Japan Lessons-Learned Project Directorate Interim Staff Guidance, JLD-ISG-2012-01, Revision 1 and Comment Resolution, January 22, 2016, ADAMS Accession No. ML15357A142.

23. EPRI Report 3002003013, Riverine Probabilistic Flooding Hazard Analysis Pilot, Technical Update, August 2014.

24. EPRI Report 3002004400, Local Precipitation-Frequency Studies, Development of 1-Hour/1-Square Mile Precipitation-Frequency Relationships for Two Example Nuclear Power Plant Sites, Final Report, October 2014.

25. EPRI Report 3002005292, External Flooding Hazard Analysis, State of Knowledge Assessment, Technical Update, October, 2015.

26. EPRI Report 3002005423, Flood Protection Systems Guide, Final Report, November 2015.

4 TERMS AND DEFINITIONS

AIMs – assumptions, inputs, and methods

Anticipatory action – Actions completed in preparation for the occurrence of an event based upon the receipt of notification of the event due to the availability of warning time.

Available physical margin (APM) - The difference between the flood parameter(s) expected to result in failure of a flood protection feature and the corresponding reevaluated flood parameter(s)

BDB – Beyond design basis

Consequential flooding – Flood conditions that adversely affects a key SSC

Dependable strategy – A strategy which can be implemented successfully by appropriately trained crews in an organized pre-planned manner under the expected environmental conditions

Design/licensing basis flood – The established flood that the site is currently required to withstand. The design/licensing basis includes the set of NRC requirements applicable to a specific plant, plus a licensee's docketed and currently effective written commitments for ensuring compliance with, and operation within, applicable NRC requirements and the plant-specific design basis (defined by 10 CFR 50.2), including all modifications and additions to such commitments over the life of the facility operating license

Exceedance Frequency – 1/p, where p = probability that a flood is equaled or exceeded in any given year

Feasible Response – Protection or mitigation response strategies that meet the requirements of NEI 12-06

FLEX - Diverse and Flexible Coping Strategies (FLEX) as described in NEI 12-06, also known as mitigating strategies

Flood hazard – The potential for flood causing mechanisms to adversely affect a nuclear plant site

Flood hazard reevaluation report (FHRR) - The reevaluated flooding hazard information that was submitted by each licensee to the NRC pursuant to the 50.54(f) request of March 12, 2012 and any relevant response to requests for additional information.

Flood mechanism – Flooding from a particular cause, such as storm surge, dam failure, or local intense precipitation. The scope of flood mechanism for the FIAP are defined in the NRC 50.54(f) request from March 12, 2012

Flood mitigation – The capability to respond to flood conditions that can fail Key SSCs by maintaining or restoring KSFs using alternate SSCs or temporary equipment.

Flood protection – The capability to prevent flood conditions from adversely affecting Key SSCs.

Flood scenario – A particular event that presents specific flood conditions for a given flood mechanism. A flood mechanism can lead to multiple flood scenarios of varying consequence.

Focused Evaluation – A scope of the FIAP that follows Path 1, 2, or 3 on Figure 5-1 of this report. NRC Staff acceptance of this evaluation fulfills and concludes the information request pursuant to the 50.54(f) request of March 12, 2012 and does not require the completion of an integrated assessment or NRC Phase 2 decision making.

Integrated Assessment – A scope of the FIAP that follows Path 4 or 5 on Figure 5-1 of this report. NRC Staff acceptance of this evaluation fulfils the information request pursuant to the 50.54(f) request of March 12, 2012.

Hierarchical hazard assessment (HHA) – A method described in NUREG/CR-7046 (Ref 6) that uses increasing levels of refinement as needed to iteratively define a flood mechanism.

HMR – Hydrometeorological report issued by the National Weather Service.

Incorporated (flood protection) feature – An engineered passive or active flood protection feature that is permanently installed in the plant to protect safety-related SSCs from inundation and static/dynamic effects of external flooding.

Flooding Impact Assessment Process (FIAP) - The process used to evaluate the site response to the reevaluated flooding hazard information submitted to the NRC pursuant to the 50.54(f) request of March 12, 2012, and documented in the flood hazard reevaluation report (FHRR)

Key safety function (KSF) – One of the three functions that site strategies should be aimed at preserving as defined by NEI 12-06: core cooling, spent fuel pool cooling, and containment integrity.

Key SSCs - The site-specific SSCs where a failure could lead to a loss of any of the KSFs. This does not include the flood protection features that protect the SSCs from adverse flood conditions.

Mitigating strategies assessment (MSA) – The process of establishing a plant's mitigating strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in response to the mitigating strategies flood hazard information. Flooding MSAs are described in NEI 12-06, Appendix G.

SSCs – Systems, structures, and components.

Time sensitive actions (TSA) - Tasks, manual actions or decisions that are identified as having time constraints

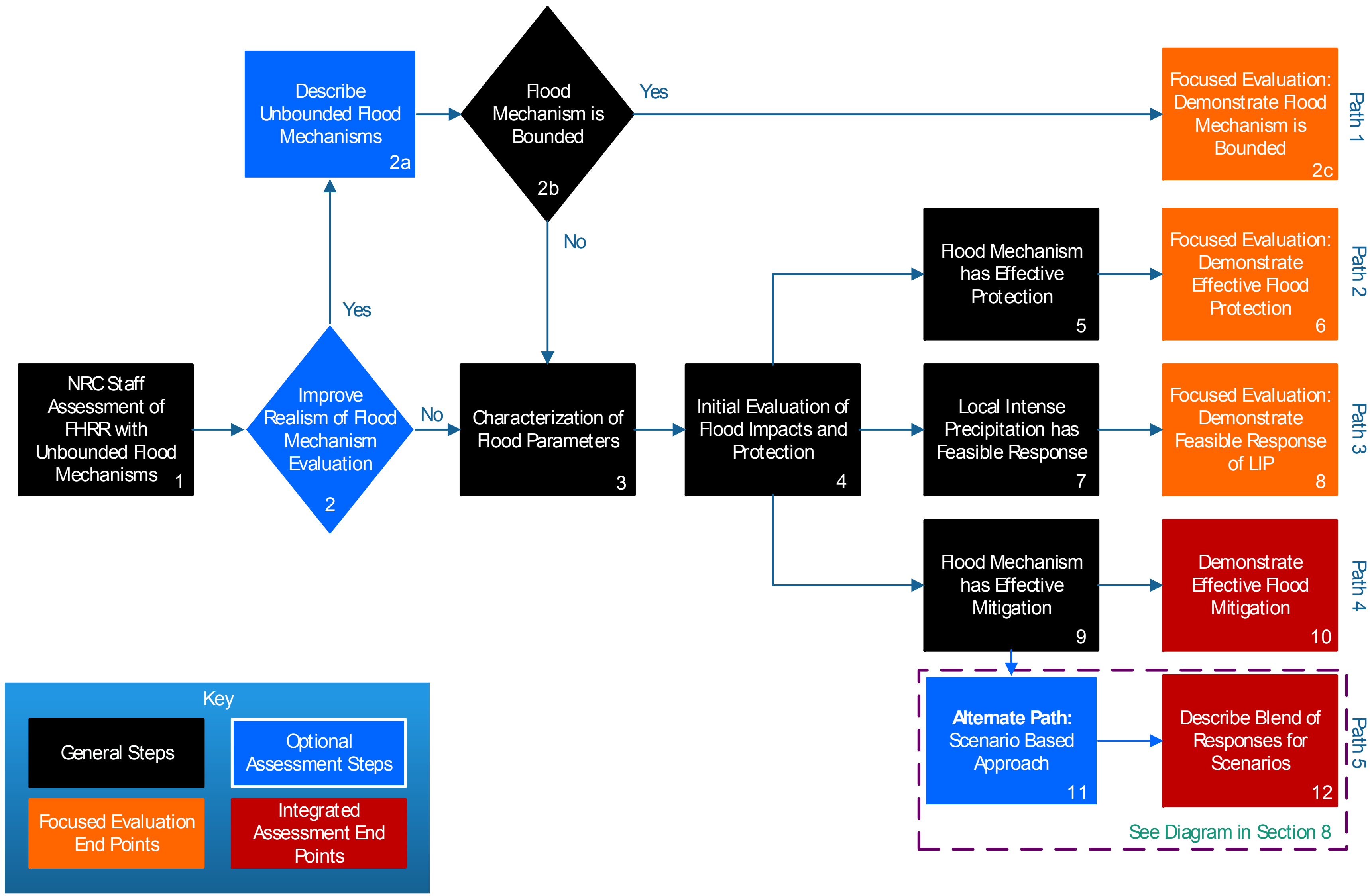
Warning time – The time between a trigger to act and the relevant adverse effect of flooding at a site. This is the period during which anticipatory actions may be taken.

5 FLOODING IMPACT ASSESSMENT PROCESS OVERVIEW

The Flooding Impact Assessment Process (FIAP) outlined in the guidance is intended to assess the impacts of flood mechanisms with unbounded flood parameters identified as a part of the 50.54(f) information request process as well as evaluate the adequacy of the site-specific response strategy. Figure 5-1 is a flowchart that illustrates the process described below. The initial input to the FIAP is the NRC's Staff Assessment of the site's FHRR. The FIAP was developed to utilize applicable portions of any previous site evaluations of flood response such as the Mitigating Strategies Assessments (MSAs). The licensee should review these evaluations for relevant information that can either be used as a part of this assessment or to better inform it.

Multiple paths are identified to address each unbounded flood mechanism. The intent is to have the licensee identify the appropriate path to address each unbounded flood mechanism prior to the performance of the evaluation. Path 1 through 3 are established as focused evaluations and NRC acceptance of these evaluations demonstrate the completion of actions necessary to close out the 50.54(f) process without further regulatory action. For these paths, the licensee can include existing or planned design features, equipment and actions as a part of their evaluation. However for planned changes, the licensee should discuss how these changes will be implemented as a part of their evaluation. Paths 4 and 5 of the FIAP are established as the full integrated assessment process.

Path	Required level of Evaluation	Elements to be Evaluated	Relevant Guidance
Path 1 (Section 7.1)	Flood Hazard Evaluation	Flood Mechanism Parameters	NEI 16-05 Appendix A:
Path 2 (Section 7.2)	Effective Flood Protection	Available Physical Margin	NEI 16-05 Appendix B:
		Reliability of Protection Features	NEI 16-05 Appendix B:
		Dependable Site Response	NEI 16-05 Appendix C:
Path 3 (Section 7.3)	Feasible Flood Response (Protection and/or Mitigation)	Reliability of Protection Features and Mitigation Equipment	NEI 12-06
		Feasibility of Manual Actions	
Path 4 (Section 8.1)	Effective Flood Mitigation	Reliability of Mitigation Equipment	NEI 16-05 Appendix B:
		Dependable Site Response	NEI 16-05 Appendix C:
Path 5 (Section 8.2)	Scenario Based Approach (Blend of Responses)	Various	Various


Describe Unbounded Flood Mechanisms 2a
Flood Mechanism is Bounded 2b
Yes
Focused Evaluation: Demonstrate Flood Mechanism is Bounded 2c
Path 1
No
Yes
Flood Mechanism has Effective Protection 5
Focused Evaluation: Demonstrate Effective Flood Protection 6
Path 2
NRC Staff Assessment of FHRR with Unbounded Flood Mechanisms 1
Improve Realism of Flood Mechanism Evaluation 2
No
Characterization of Flood Parameters 3
Initial Evaluation of Flood Impacts and Protection 4
Local Intense Precipitation has Feasible Response 7
Focused Evaluation: Demonstrate Feasible Response of LIP 8
Path 3
Flood Mechanism has Effective Mitigation 9
Demonstrate Effective Flood Mitigation 10
Path 4
Key
General Steps
Optional Assessment Steps
Focused Evaluation End Points
Integrated Assessment End Points
Alternate Path: Scenario Based Approach 11
Describe Blend of Responses for Scenarios 12
Path 5
See Diagram in Section 8

6 INITIAL EVALUATION PROCESS (BOX 2-4)

6.1 Improve Realism of Flood Hazard Evaluation (Box 2)

The initial step in the FIAP is to evaluate the NRC's Staff Assessment of the site's FHRR to identify flood mechanisms that will need to be addressed. The licensee should determine if this input is appropriate to use as a part of the FIAP or if the evaluation should be revisited to identify more realistic flood parameters. It is recommended that the licensee should only choose to perform a revised evaluation of a mechanism if they believe that it will either demonstrate that the flood mechanism is bounded by their design/licensing basis (Path 1) or that a reevaluation will better support a more appropriate path within the FIAP (Paths 2-5).

In Enclosure 2 of the NRC's March 12, 2012 50.54(f) information request following the Fukushima Dia-ichi events, licensees were requested to apply present-day regulatory guidance and methodologies to develop the NTTF Recommendation 2.1 Flood Hazard Reevaluations. At varying degrees, adopting conservative assumptions, inputs, and methods (AIMs) has been a common practice by licensees in developing the reevaluated flood hazard. The degree of conservatism can be measured by applying the AIMs to observations made from past significant flood events; reviewing literature to determine empirically-developed bounding limits of input parameters and understand applicability of methods to site-specific conditions; and sound judgement from experienced engineering professionals.

Licensees often go through an iterative process in developing the reevaluated flood hazards; first using simplified AIMs that can be clearly established as conservative to develop an initial bounding flood hazard estimate. Challenging results lead to re-visiting conservative AIMs to develop a more plausible yet bounding flood hazard. This process can continue and fits within the NUREG/CR-7046 hierarchical hazard assessment (HHA) approach; defined as "a progressively refined, stepwise estimation of site-specific hazards that evaluates the safety of SSCs with the most conservative plausible assumptions consistent with available data", starting with "the most conservative simplifying assumptions that maximize the hazards from the probable maximum event for each natural flood-causing phenomenon expected to occur in the vicinity of a proposed site."

Appendix A contains a catalog of potentially conservative AIMs for each flood-causing mechanism, combined-effect floods, and key associated effects. This catalog is not intended to be an all-inclusive list but contains some currently known areas of conservatisms. Appendix A addresses conservatisms in the context of how:

1) Standards are interpreted and/or applied in defining flood initiators (e.g. precipitation depth-area-duration-distribution, cool-season temperatures for snowmelt, upstream dam failures, and combinations of initiating events) or;
2) AIMs are established and used to simulate the system response.

In general, the flood hazard reevaluations were completed using deterministic inputs and methods. That is, flood scenarios were in most instances derived using "empirical and physical prediction relationships implemented into flood simulation models" and "given a particular set of inputs" (from Section 4 of NUREG/CR-7046). Probabilistic characterizations of the flood hazard were typically not included with the reevaluations (the exception being the Joint Probability Method (JPM) for Hurricane Storm Surge per NUREG/CR-7134). Therefore, the assessment of conservatisms is typically associated with deterministic AIMs.

However, conservatisms associated with defining flood initiators include considerations for combining flood-causing mechanisms, some of which are uncorrelated and/or independent events. Appendix H of NUREG/CR-7046 defines specific "Combined-Effects" flood scenarios and states, citing ANS-2.8 (1992), that the combinations are "thought to have a probability-of-exceedance of less than 1×10^{-6}" but "rigorous statistical analyses have not been completed for these estimates". Appendix A addresses potential conservatisms in the deterministic combinations based on a 1×10^{-6} threshold criteria and simplified joint probability estimates (assuming independent and non-correlated events).

Licensees should use Appendix A to determine aspects of their flood evaluation to consider to reduce conservatisms or identify areas with insufficient conservatisms. The licensee can determine whether alternate methods would be more appropriate for their evaluation and also describe why the alternate methods are appropriate.

As a part of this step of the evaluation, the licensee can choose between the following options:

1) Use the existing FHRR of this flood mechanism to perform the IAP. (Box 2-3)

2) Perform a new evaluation of this flood mechanism using alternate methods with the intent to demonstrate that a flood mechanism previously identified as unbounded is bounded by the design/licensing basis. For this option, the remaining portion of Section 6 is not required and the evaluation should follow Section 7.1 for Path 1. (Box 2a-2b-2c)

3) Perform a new evaluation of this flood mechanism using alternate methods with the intent to define new flood parameters that will result in a different evaluation path within the IAP. (Box 2a-2b-3)

6.2 Characterization of Flood Parameters (Box 3)

The flood parameters considered as part of the integrated assessment for a plant are based on the FHRR. The integrated assessment should be performed for a set(s) of flood scenario parameters defined based on the results of the FHRR or a new evaluation that improves realism as described in Section 6.1. This step should define the following parameters for the flooding mechanism to be used in the integrated assessment:

- Flood height and associated effects
- Flood event duration, including warning time and intermediate water surface elevations that trigger actions by plant personnel
- Plant mode(s) of operation during the flood event duration
- Other relevant plant-specific factors

These parameters should be defined for each of the flooding mechanisms. If appropriate, it is acceptable to identify a single set of flood parameters (e.g., the maximum water surface elevation and inundation duration with the minimum warning time) that bound the controlling parameters of all of the flood mechanisms being evaluated. This approach can be used instead of considering a separate set of flood parameters for each flood mechanism.

6.3 Initial Evaluation of Flood Impacts and Protection (Box 4)

6.3.1 Assess Flooding Impact on Plant Conditions

The purpose of this step is to identify the SSCs that would potentially lead to a loss of a key safety function (KSF), identify flood protection features being relied upon, and determine the impacts of the flood:

	Process Step	**Description**
1	Key SSC Identification	Identify the SSC's that must be protected to support the KSF's. These SSC's should be listed with their respective locations at the site.
2	Flood Protection Feature	Identify the flood protection features that prevent floodwaters from impacting the Key SSCs at each location.
3	Flooding Impact	Identify the critical flood elevations that impact Key SSCs
		Determine the manner by which the Key SSCs could be subjected to flooding (e.g., site inundation or building leakage)
		Identify potential pathways for ingress of water (e.g., through conduits or ducts)

Prior to evaluating the effectiveness of plant flood protection features, the licensee should identify which of the site's SSCs or combination of SSCs whose failure(s) could lead to a loss of any of the KSFs. These Key SSCs do not include the flood protection features themselves. Alternate SSCs not included in the site's design basis that can be used to maintain key safety functions can be evaluated later in the FIAP as mitigation equipment.

Next, the flood protection features being relied on to prevent floodwaters from entering or accumulating in the areas containing the Key SSCs should be determined. If the plant is planning to procure and implement new protection features, a clear description of any planned modifications should be provided that includes a clear distinction between existing flooding mitigation credited by the site and new planned modifications/ additions.

Lastly, the licensee should evaluate the impact of the flood caused by the mechanism on the Key SSCs and which flood protection features need to be evaluated further. This includes determining the critical flood elevations that lead to potential failure of the Key SSCs, the manner in which the Key SSCs are impacted by the flood, and pathways that led to the entrance and accumulation of water.

The FIAP may have the same or a similar scope to that of the MSA performed for the site, as both are focused on protecting KSFs. Therefore, flood impacts to the site and to Key SSCs may have been already evaluated as part of the MSA. If the mechanism is characterized the same in the FIAP as in the MSA, the licensee could utilize and rely on the same information to complete this step in the process. If the mechanism is characterized differently, the MSA should be evaluated further to determine if the information is appropriate to use.

6.3.2 Determination Available Physical Margin (APM)

Flood protection consists of passive (including temporary) or active protection features to prevent the entry or control accumulation of water into areas containing Key SSCs that support KSFs. This includes associated effects from flooding.

Sites may use different flood protection features to protect against each flood mechanism. For each flood mechanism that is not bounded (including associated effects), the specific set of flood protection features should be evaluated. Specifically, a determination should be made of the APM for flood protection features required to protect Key SSCs. The APM is one of the inputs used to evaluate effectiveness of the flood protection. Guidance on how to determine APM is contained in Appendix B.

6.4 Determination of Appropriate Process Path

Once the initial steps of the FIAP are completed, the licensee should evaluate which path is most appropriate for each flood mechanism.

Path	**Description**

Path	Description
Path 1	This path should be pursued if it can be demonstrated that all the flood mechanism parameters are bounded by the site's design/licensing basis. It is not necessary to evaluate any flood response strategies for this path.
Path 2	This path should be pursued if available physical margin can be justified to be adequate to protect Key SSCs. This evaluation will need to verify the reliability of the flood protection features as well as the dependability of the site response necessary to ensure success.
Path 3	This path should be pursued if Local Intense Precipitation is an unbounded flood mechanism. The licensee should describe a feasible response strategy using guidance from NEI 12-06. This evaluation should utilize any and all relevant information from the site's MSA, if it determined to be appropriate. Credited strategies can be those used for either or both the protection of and/or mitigation to maintain KSFs.
Path 4	This path should be pursued for a flood mechanism (other than LIP), if the licensee cannot demonstrate that APM is adequate, credited protection features are reliable, or the site response for protection is dependable. This path demonstrates an effective mitigation strategy which utilizes SSCs, mitigation equipment and manual actions that are used to maintain or restore KSFs.
Path 5	Similar to Path 4, this path should be pursued for a flood mechanism (other than LIP), if the licensee cannot demonstrate that available physical margin is adequate, credited protection features are reliable, or the site response is dependable. Path 5 is appropriate for a mechanism where an effective mitigation strategy cannot be demonstrated for the most bounding flood parameters and a blend of strategies is determined to be most appropriate. This evaluation includes defining multiple scenarios for the flood mechanism and demonstrating an adequate response strategy for each scenario.

7 FOCUSED EVALUATION PROCESS (PATH 1-3)

7.1 Path 1: Demonstrate Flood Mechanism is Bounded (Box 2a-2b-2c)

The objective of Path 1 is to offer licensees an option to revisit assumptions, inputs and methods (AIMs), using industry-wide lessons-learned, and establish a set of flood parameters that is more realistic, yet still bounding. Path 1 is intended to show that each applicable flood-causing mechanism is completely bounded by the design/licensing basis.

Completing the FIAP for a flood mechanism through Path 1 requires that the licensee demonstrate that the refined flood parameters (flood level, associated effects, and duration parameters) are bounded by the plant's design/licensing basis. Note that a bounding set of reevaluated flood parameters, instead of parameters for individual flood-causing mechanisms, can be used in making the flood comparison. See below for additional guidance for each parameter.

		Flood Mechanism Parameters	Description
Flood Level and Associated Effects	1	Max Stillwater Elevation	Provide the appropriate units and datum
	2	Max Wave Run-up Elevation	Provide the appropriate units and datum
	3	Max Hydrodynamic/Debris Loading	Discuss the loads on flood barriers caused by flowing water and associated debris
	4	Effects of Sediment Deposition/Erosion	Discuss velocity and scour results and provide comparisons with CDB, permissible velocities, presence of scour resistant material, etc.
	5	Other Associated Effects	Discuss any other significant detrimental effects associated with the flood mechanism, such as soil deposition
	6	Concurrent Site Conditions	Discuss conditions that could exist concurrent with this flood-causing mechanism (e.g. high winds, ice formation, etc.)

		Flood Mechanism Parameters	Description
	7	Effects on Ground Water	If and how this flood-causing mechanism could cause a surcharge to groundwater, considering flood duration and soil conditions.
Flood Event Duration	**8**	Warning Time	Discuss warning time; may include information from relevant forecasting methods (e.g., products from local, regional, or national weather forecasting centers) and ascension time of the flood hydrograph to a point (e.g. intermediate water surface elevations) triggering entry into flood procedures and actions by plant personnel. Reference NEI 15-05 for LIP.
	9	Period of Site Preparation	Discuss period of site preparation (after entry into flood procedures and before flood waters reach site grade)
	10	Period of Inundation	Discuss period of inundation, when flood waters are above site or plant grade
	11	Period of Recession	Discuss period of recession, when flood waters completely recede from site and plant continues to be in a safe and stable state that can be maintained indefinitely. Also discuss the timing of loss and restoration of site access if the site is not accessible due to flooding for some period during the reevaluated flood.

		Flood Mechanism Parameters	Description
Other	**12**	Plant Mode of Operation	Additional notes regarding plant mode of operations
	13	Other Factors	Discuss other plant-specific factors

Clarification notes should be provided, as needed, to explain why a particular parameter is judged not to affect the site and further explain the bounded/non-bounded determination.

7.2 Path 2: Demonstrate Effective Flood Protection (Box 5-6)

Completing the FIAP for a mechanism through Path 2 involves demonstrating that the flood protection strategy will ensure Key SSCs identified in Section 6.3.1 are available to maintain KSFs. The Path 2 process evaluates the effectiveness of the flood protection strategy that prevents the entry or controls accumulation of water into areas containing Key SSCs. Flood protection at the site can include both passive and active flood protection. This assessment is an extension of the initial evaluation of APM in Section 6.3.2 (Box 4) and includes a detailed evaluation of the flood protection features as well as any human actions associated with installation and execution of the flood protection strategy. Effective protection includes demonstrating:

Demonstration Step	Description	Applicable Sections
Available physical margin is adequate	APM is evaluated for each flood protection feature. In general, the APM for a flood feature is the difference between the flood parameter(s) expected to result in failure and the corresponding reevaluated flood parameter(s). The threshold for what constitutes "Adequate APM" for specific flood mechanism(s) is can be established using one or more methods as described in Appendix B.	Appendix B
Passive and/or active flood protection features are reliable	Determine if the identified flood protection features are reliable, as described in Appendix B to prevent flood waters from reaching the Key SSCs in quantities that could cause their failure. This includes showing that the flood protection feature will continue to perform its function through the duration of the flood event.	Appendix B

Demonstration Step	Description	Applicable Sections
Flood protection response is dependable	The site response associated with installation and execution of the flood protection strategy should be evaluated for dependability, as described in Appendix C.	Appendix C

7.3 Path 3: Demonstrate a Feasible Response to LIP (Box 7-8)

Completion of the FIAP through Path 3 is limited to sites where Local Intense Precipitation (LIP) is an unbounded flood mechanism. In COMSECY-15-0019, NRC stated that "Licensees with LIP hazards exceeding their current design-basis flood will not be required to complete a revised integrated assessment. These licensees will instead assess the impact of the LIP hazard on their sites and then evaluate and implement any necessary programmatic, procedural or plant modifications to address this hazard exceedance."

The objective of the Path 3 process is to demonstrate a feasible response to LIP. The process is intended to utilize NEI 12-06 Rev. 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," where a process for determining the feasibility of carrying out a response strategy has already been implemented for FLEX strategies. Appendix G of NEI 12-06 provides a specific evaluation of a feasible response to flooding mechanisms and this process is appropriate to follow in a Path 3 evaluation. In general, sites with an unbounded LIP flooding mechanism have followed this evaluation process to complete their MSA. If the LIP mechanism is characterized the same in the FIAP as in the MSA, the licensee should utilize and rely on the same information to complete the Path 3 process. If the LIP mechanism is characterized differently, the information in the MSA should be further evaluated to ensure that the strategies are appropriate to use in the Path 3 process.

8 FULL SCOPE INTEGRATED ASSESSMENT PROCESS (PATH 4-5)

8.1 Path 4: Demonstrate Effective Mitigation (Box 9-10)

Path 4 is entered when an unbounded flood mechanism other than LIP is not resolved through the implementation of flood protection features alone. The objective of the Path 4 is to define the strategy for maintaining KSFs for the unbounded flood mechanism being evaluated and assess its effectiveness by demonstrating that:

Demonstration Step	Description	Applicable Appendices
Mitigation Equipment is Reliable	Determine if the identified flood mitigation equipment is reliable as described in Appendix B. This includes equipment in the strategy to restore or maintain KSFs.	Appendix B
Flood mitigation response is dependable	The site response associated with installation and execution of the flood mitigation strategy should be evaluated for dependability, as described in Appendix C.	Appendix C

For Path 4, the licensee should identify which, if not all, of the KSFs are necessary to be maintained for the strategy being assessed. For example, some strategies would not require containment integrity to be maintained. A justification should be provided for any KSFs that are determined to be unnecessary to maintain. KSFs may be mitigated using installed plant equipment or temporary equipment. All existing equipment necessary for the strategy to be successful should be evaluated. If the plant is planning to procure any required equipment or make any modifications to support the strategy, a clear description of these plans should be provided. This includes a clear distinction between existing flooding mitigation credited by the site and the new planned modifications/additions. Guidance for performing reliability assessments of equipment required to maintain or restore KSFs is discussed in Appendix B.

The next step of this evaluation is to demonstrate that the overall response strategy used to support the implementation and execution of the mitigation equipment is dependable. Guidance for evaluating associated human actions and assessing overall mitigating strategy is discussed in Appendix C.

The Path 4 evaluation should include the following key elements:

- A detailed description of the strategy and required equipment and/or actions

- A timeline showing necessary manual actions, including cues, key indications, and notifications the plant will rely on to implement actions/strategies.
- An evaluation of the reliability of active components (consistent with the guidance in Appendix B). The evaluation should identify the equipment required for mitigation and should include consideration of applicable associated effects. Reliability of active components should consider the duration of the event, expected availability of the equipment, availability of consumables, means for replenishment of consumables (if needed) and ability of passive SSCs to function under external flood conditions.
- An evaluation of manual actions demonstrating the overall mitigation strategy is dependable. This evaluation is to be performed consistent with the guidance in Appendix C.

The Path 4 evaluation is complete when it is demonstrated that the strategy used to mitigate the external flood mechanism is dependable and the equipment used to maintain or restore the KSFs are reliable.

8.2 Path 5: Scenario Based Approach (Box 11-12)

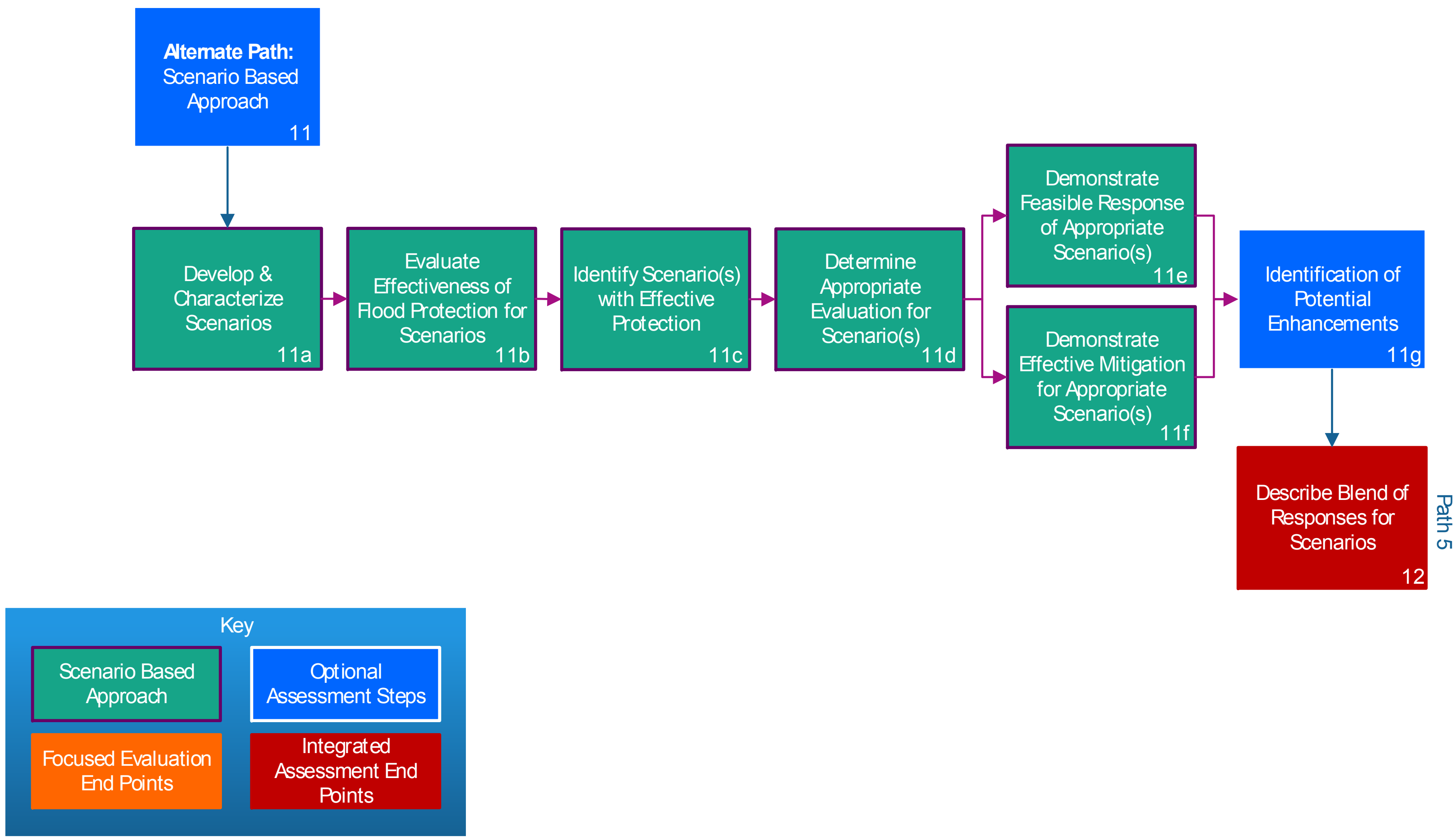
8.2.1 Objective

The objective of Path 5 in the FIAP is to more fully characterize the flood mechanism and determine the appropriate level of evaluation for the response. Given the extreme nature of beyond-design-basis flood mechanisms, it is important to understand the mechanism and have an understanding of the likelihood of the flood scenario occurring. The overall goal of this evaluation is to demonstrate that scenarios with consequential flooding and higher frequencies of occurrence have an effective flood strategy. For scenarios with lower frequencies, the goal is to demonstrate that a feasible response strategy is available to mitigate the effects of extreme flood conditions.

This evaluation will be accomplished by performing the following steps:

- Develop Flood Scenarios for a mechanism
- Identify Scenarios with Effective Protection
- Determine Appropriate Level of Evaluation for Remaining Scenarios
- Describe Effective Mitigation or a Feasible Flood Response Strategy for each Scenario
- Identify Potential Enhancements

The FIAP Path 5 evaluation is intended to give the analyst a process to demonstrate the appropriate level of adequacy of flood response strategies based on the magnitude and frequency of occurrence of the associated flood scenario. This evaluation will also allow the analyst to identify potential changes that may be additional opportunities to enhance the strategies.


Alternate Path: Scenario Based Approach
11
Develop & Characterize Scenarios
11a
Evaluate Effectiveness of Flood Protection for Scenarios
11b
Identify Scenario(s) with Effective Protection
11c
Determine Appropriate Evaluation for Scenario(s)
11d
Demonstrate Feasible Response of Appropriate Scenario(s)
11e
Demonstrate Effective Mitigation for Appropriate Scenario(s)
11f
Identification of Potential Enhancements
11g
Describe Blend of Responses for Scenarios
12
Path 5
Key
Scenario Based Approach
Optional Assessment Steps
Focused Evaluation End Points
Integrated Assessment End Points

8.2.2 Develop and Characterize Scenarios (Box 11a)

The development and characterization of flood scenarios is the first step in the Path 5 evaluation and the foundation of the analysis. This step is necessary to understand and characterize the flood mechanism at the site. Creating and defining flood scenarios is a site specific process that is dependent on a site's configuration and the nature of the specific flood mechanism. This section will provide guidance on developing scenarios that facilitate the determination of the appropriate level of evaluation for the flood response strategy.

The following considerations should be made when defining flood scenarios for this evaluation:

- Elevations where flood levels could enter plant locations with Key SSCs
- Elevations where the plant is expected to be impacted such that actions become infeasible to maintain KSFs
- Height of flood protection features
- Elevation where mitigation is no longer feasible
- Mechanism specific characteristics (e.g. dam breach parameters)
- Other relevant plant information

The critical water surface elevations (WSEs) determined should be used to define the boundaries of the flood scenarios. Engineering judgement and consideration of various flooding parameters may be necessary to define the most appropriate scenarios; however, the goal is to best describe critical elevations that will be used to further evaluate the impact to the plant.

For example, if a site is situated with ground elevation at 100 ft, a maximum still water elevation of 110 ft from the PMF and a flood barrier height of 105 ft, then it may be most appropriate to create two scenarios. The first scenario would include the flood height up to the top of the barrier (105 ft) and a second scenario up to the max still water elevation. If the site included a transformer for offsite power or emergency diesel generators at 107 ft, then a third scenario could be created. This could result in the following scenarios:

Scenario	WSE (ft)
Scenario 1	105
Scenario 2	107
Scenario 3	110

Each of these scenarios should be characterized using the flood parameters and guidance described in Section 6.2. Additionally, frequency of the flooding event should not be a consideration during this step. The scenarios should be developed based on the flood impact to the site in order to fully capture all of the scenarios that may need to be considered.

8.2.3 Identify Scenarios with Effective Flood Protection (Box 11b-11c)

The next step in the Path 5 evaluation is to identify those scenarios with effective flood protection. It is necessary to utilize the same approach as in Path 2 (Section 6.4) to demonstrate that the flood protection is effective and will protect the Key SSCs. This assessment includes an evaluation of the physical protection features as well as any human actions associated with installation and execution of the flood protection strategy. Effective protection includes demonstrating:

Demonstration Step	**Description**	**Applicable Sections**
Available physical margin is adequate	APM is evaluated for each flood protection barrier. In general, the APM for a flood feature is the difference between the flood parameter(s) expected to result in failure and the corresponding reevaluated flood parameter(s). The threshold for what constitutes "Adequate APM" for specific flood mechanism(s) is can be established using one or more methods as described in Appendix B.	Appendix B
Passive and/or active flood protection features are reliable	Determine if the identified flood protection features are reliable, as described in Appendix B to prevent flood waters from reaching the Key SSCs in quantities that could cause their failure. This includes showing that the flood protection feature will continue to perform its function through the duration of the flood event.	Appendix B
Flood protection response is dependable	The site response associated with installation and execution of the flood protection strategy should be evaluated for dependability, as described in Appendix C.	Appendix C

Using the same example as in the section above, Scenario 1 would be considered for demonstration of effective protection. After completing the evaluation in Section 6.4 for the flood protection features relied upon for water surface elevation (WSE) up to 105 ft., it should be documented that the protection is effective for this scenario. A different evaluation process for the remaining two scenarios will be included in the remaining steps of this evaluation.

8.2.4 Determine Appropriate Evaluation for Scenarios (Box 11d)

This step in the FIAP Path 5 evaluation focuses on determining the most appropriate level of evaluation for scenarios without effective protection. This is accomplished by characterizing the scenarios by their frequency of occurrence. Scenarios estimated with a high frequency of occurrence and without effective protection should demonstrate a dependable flood response strategy, whereas, for scenarios with a low frequency of occurrence and without effective protection, a feasible flood response strategy is acceptable. Scenarios that demonstrated effective flood protection should document the estimated frequency of occurrence and will not be evaluated further in the FIAP as the KSFs will be considered adequately protected for those scenarios.

A full probabilistic flood hazard assessment (PFHA) is not necessary for this evaluation. Instead, the frequency of each specific scenario should be estimated as the frequency of a flood reaching or exceeding the WSE defined for that scenario. The focus should be on addressing flood scenarios in the $1x10^{-3}$/yr to $1x10^{-4}$/yr regime of frequency where it is necessary to demonstrate the site has an effective flood strategy, as discussed in the SRM of COMSECY-15-0019.

The limiting set of flood scenario parameters should be determined and used to assign the estimated frequency. Typically the first scenario is equal to the frequency of the event that will produce the minimum WSE that may fail Key SSCs. Note that certain flood causing mechanisms (e.g. dam failures or rivers floods) could have two elevation frequency curves. For example, one with still water only and another accounting for wind-wave run up. For these mechanisms, the more limiting case should be identified to be used in this evaluation.

Using the example created in the section above, the resulting scenario frequencies could be calculated with the following results after determining that the still water elevation is representative:

Scenario	WSE (ft)	Scenario Frequency (1/yr)	Evaluation of Response Strategy
Scenario 1	105	1.00E-4	Effective Protection
Scenario 2	107	5.67E-5	Feasible Response
Scenario 3	110	1.08E-5	Feasible Response

The impacts and frequency of the scenarios are then used to inform the remaining evaluation and more specifically to determine the appropriate level of evaluation of the response strategy for the scenarios without effective protection. As another example, the resulting scenario frequencies could be calculated as such:

Scenario	WSE (ft)	Scenario Frequency (1/yr)	Response Strategy to be Demonstrated
Scenario 1	105	7.38E-3	Effective Protection
Scenario 2	107	1.00E-4	Effective Mitigation
Scenario 3	110	1.08E-5	Feasible Response

8.2.5 Feasible Response of Appropriate Scenarios (Box 11e)

The objective of this evaluation is to demonstrate a feasible response to the scenarios identified in Section 8.2.4. The process, similar to the Path 3 evaluation, is intended to utilize NEI 12-06 Rev. 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," where a process for determining the feasibility of carrying out a response strategy has already been implemented for FLEX strategies. Appendix G of NEI 12-06 provides a specific evaluation of a feasible response to flooding mechanisms which is appropriate to follow for this evaluation. In general, sites with unbounded flooding mechanisms have followed this evaluation process to complete their Mitigating Strategies Assessment (MSA). If the flood mechanism is characterized the same in the MSA as the scenario defined in Section 8.2.2, the same information can be relied upon to complete this process. If the mechanism is characterized differently, the information in the MSA should first be evaluated to ensure that the strategies are appropriate to use in the evaluation of these scenarios.

8.2.6 Effective Mitigation of Appropriate Scenarios (Box 11f)

The objective of the evaluation is to demonstrate that an effective mitigation strategy exists for maintaining KSFs for the appropriate scenarios. Assessing the effectiveness of the mitigation strategy includes demonstrating that:

Demonstration Step	Description	Applicable Appendices
Mitigation Equipment is Reliable	Determine if the identified flood mitigation equipment is reliable as described in Appendix B. This includes equipment in the strategy to restore or maintain KSFs.	Appendix B
Flood mitigation response is dependable	The site response associated with installation and execution of the flood mitigation strategy should be evaluated for dependability, as described in Appendix C.	Appendix C

This evaluation follows the same process detailed for Path 4 and Section 8.1 should be used to demonstrate effective mitigation for the appropriate scenarios.

8.2.7 Identification of Potential Enhancements (Box 11g)

Following the evaluation of the flood response strategy, changes can be considered to enhance the strategy. This step is an optional step and should only be performed if improvements are considered warranted. These potential improvements are site and strategy specific. They may include some of the following examples:

- Procedural changes to clarify entry, command and control and/or flood action guidance
- Pre-staging pumps and/or other equipment
- Temporary protection enhancements
- Permanently staging barriers or modify to enhance reliability
- Revising a strategy to include confirmatory actions

The improvements should be documented along with the potential benefit of modifying the strategy (e.g. additional protected equipment, increased dependability of barrier/mitigation installation, and/or clarity of procedure). These potential improvements can be evaluated against the scenario frequencies developed in Section 8.2.4 to determine if they are beneficial to implement.

APPENDIX A: REDUCTION OF CONSERVATISMS

A.1 Characterization of Conservatisms

Most of the aspects of the flood hazard reevaluations were developed using deterministic methods and, as such, the conservatisms too are deterministic. There are also conservatisms in the probabilistic approaches such as the ones used in the "Combined Effects" flood-causing mechanism and the Joint Probability Method (JPM) for hurricane storm surge. Both probabilistic and deterministic conservatisms will be addressed in this appendix. Conservatisms can be differentiated into two types:

A. Conservatism in defining a flood scenario (dealing with how the standards are written, interpreted, and/or applied); or

B. Conservatism in assumptions, inputs, and methods (AIMs) used to simulate the system response.

A.2 Identify Flood Mechanisms with Conservatisms

The table below provides a catalog of potential conservatisms for the flood-causing mechanisms listed in the March 2012 50.54(f) letter, along with combined-effect floods and key associated effects. The table may not be exhaustive but provides a detailed representation of conservative AIMs that have or may have been used in the flood hazard reevaluations.

An appropriate basis should be developed to demonstrate that particular AIMs are key to yielding unrealistic results and that reductions would be more realistic, yet still bounding. Considerations in developing this basis may include:

- Comparisons to observed data (e.g. models consistently over-predict calibration/validation flood discharges and/or elevations)
- Knowledge of physical limitations (e.g. assuming zero constant loss rates of runoff in non-cohesive soil with a deep water table, maximum precipitable water in the atmosphere, etc.)
- Combinations of parameters or events that can be qualitatively shown to have an extremely low joint probability (e.g. simultaneous seismic and large precipitation-induced flood events, perpendicular track direction combined with maximum forward speed of a Atlantic hurricane, etc.).

Part of the basis for reducing conservatisms may need to include an assessment of uncertainty and potential error through more rigorous calibration and/or sensitivity evaluation. In general, it is recommended that some key parameter sensitivities may have to be further assessed when the models:

1. Have not been (or cannot be) calibrated to more accurately define potential error; or
2. Are not already unrealistically conservative.

Where appropriate, reducing conservatisms may also need to be accompanied with additional actions to make the revised assumption valid (e.g. enhanced procedures to maintain storm drains and inlets if crediting unblocked conditions for LIP).

Table A-1 – Conservatisms for Individual Flood-Causing Mechanisms

Flood-Causing Mechanism	Example Conservative Assumptions
Local Intense Precipitation	• HMR-52 1-hour, 1-sq-mi rainfall depths (versus site-specific). (A) • Potential Site-Specific PMP conservatisms (A): - There is maximum moisture in the atmosphere for the storm location and the month of occurrence. - Single station observations of extreme precipitation, coupled with theoretical methods for moisture maximization, transposition, and envelopment, are used. • Nesting a 1-hour, 1-sq-mi rainfall into a longer duration PMP event for drainage areas of less than 1 square mile. (A) • Zero or minimal runoff losses. (B) • Coincidental flooding along boundary (high boundary conditions). (B) • Use of 1-D modeling software (i.e., HEC-RAS), which may not accurately represent flow patterns, including bypass or diverted flow. (B) • Drainage systems (inlets, pipes, culverts, channels, etc.) fully or partially blocked. (B) • Credit not taken for vehicle or security barriers blocking, diverting, and/or passing runoff from off-site areas (may or may not be a conservatism, depending on how the barriers are situated relative to the flow patterns). (B) • Not accounting for storage and attenuation on roofs due to parapets. (B)

Flood-Causing Mechanism	Example Conservative Assumptions
Flooding in Streams and Rivers	● HMR-51 rainfall depths (versus site-specific). (A) ● Using HMR-52 spatial rainfall distributions for drainage areas greater than 20,000 sq miles; depending on how this was done, it may be a conservative distribution. For larger watersheds, the use of a moving storm, extrapolating the HMR-52 distribution, or developing a site-specific distribution may be more realistic and appropriate. See above for potential site-specific PMP conservatisms. (A) ● Use of NRCS Runoff Curve Number (RCN) method, particularly for the all-season scenario with the antecedent storm, whereby the continuous losses approach zero for the main storm. (B) ● Zero constant losses, particularly for the rain-on-snow scenarios (when using the initial/constant loss method). (B)* ● Not accounting for soil infiltration recovery following the antecedent storm. (B) ● Generically incorporating non-linearity adjustments to the Unit Hydrograph per the NUREG/CR-7046, Appendix I, Section I.2. (B) ● Ignoring much of the floodplain storage in river reach routing; not using unsteady flow modeling for the main stems. (B) ● Assuming high Manning n-values in the hydraulic model and not accounting for reductions in n-values at high flow depths. (B) ● High starting water surface elevations in 1D model (and having the upstream and downstream boundary close to the site). (B) ● Not using a 2D model when flow is splitting or being diverted upstream of the site. (B) ● Conservative assumptions regarding ineffective flow areas. (B) ● Conservative assumptions regarding expansion and contraction loss coefficients, particularly in an unsteady-flow model where these losses (away from constrictions) can be set to zero. (B) ● Using the 3-day dry period between antecedent storm and the main storm (ANS-2.8 allows for 3-5 day range if justification is provided). (A) ● Ignoring tributary storage by not modeling tributaries to main stems as reaches or at least as storage areas. (B)

Flood-Causing Mechanism	Example Conservative Assumptions
Dam Breaches and Failures	● Assuming all dams fail during a PMF, particularly given that much of the dam-specific watersheds will not experience a PMF-type flood during the larger watershed's PMF. (A) ● Assuming critical dams fail; per the ISG, justification is required to show that dam failure is not credible. ● Using rainfall-runoff models (e.g., HEC-HMS), and associated simplified routing methods, in lieu of 1D unsteady-flow or 2D models to develop and route dam breach flood waves. (B) ● Not using more realistic breach parameters, particularly assuming short breach formation times, particularly for rock-filled and earthen dams. (B) ● Inconsequential dams – the definition of inconsequential dams per the ISG could not be directly correlated to the state hazard classification, resulting in conservatively not excluding potentially inconsequential dams. (A) ● Clustering dams into hypothetical dams. Alternatives include modeling more dams individually and/or use synthetic breach parameters (e.g. longer breach formation times to simulate range of breach wave travel times, etc.) to simulate multiple small dams failing with hydrographs combining at different times. (B) ● Accounting for cumulative volume from non-critical dams. (B) ● Assuming "top of active storage" (full pool or maximum normal pool) for starting water surface elevations at the dam. (A) ● Assuming all gates are closed to maximize head on the dam before a breach. (A) ● Triggering failures such that the peak outflow timing from multiple dam failures coincide. (A) ● Set timing of the seismic event such that peak flow from failure of critical upstream dams coincides with the 500-year or ½ PMF peak flow. (A) ● Automatically assuming dams in series fail due to cascading effects. (A)

Flood-Causing Mechanism	Example Conservative Assumptions
Storm Surge	• PMH (Coast) - Conservative PMH parameter bounds as a result of use of National Weather Service reference document NWS-23, including the limited historical data, use of techniques such as extrapolation, curve-fitting and smoothing; the lack of parameter correlation (e.g. storm track and intensity); and steady state tracks with no pre-landfall or post-landfall intensity change (decay). The conservatism associated with NWS 23 is significant within the U.S. Northeast and Mid-Atlantic coast regions, but not the southern regions (Florida and the Gulf of Mexico). (A) • PMH (Inland and Great Lakes) - Conservative assumptions that result of use of ANS-2.8 guidance for central pressure of 950 mb, a maximum wind speed of 100 mph, a translational speed as low as 40 mph (usually corresponding to the lower bound of recorded storm speeds), and windfield development. (A) • Moving Squall Line (Great Lakes) - Conservative assumptions of pressure jump of 8 mb within a 10-nm width of the squall lines and wind speed for probable maximum meteorological conditions. (B) • Simple numerical models with a relatively coarse grid can produce different results than those developed using more advanced, complex numerical models which have highly resolved digital elevation and bathymetric data and usually require more detailed input parameters. Depending on site location and hydrologic setting, some hydrodynamic models (such as SLOSH) tend to over-predict flood elevations at certain locations. The use of coupled surge and wave models will also result in more realistic representation of flooding as compared to individual (uncoupled) models. (B)
Seiche	• Not known to be a prevalent flood-causing mechanism at nuclear plants.
Tsunami	• Conservative, empirical assumptions about flow velocities due to tsunami waves (versus velocities developed based on numerical model simulation).
Ice Induced Flooding	• Not known to be a prevalent flood-causing mechanism at nuclear plants.

Flood-Causing Mechanism	Example Conservative Assumptions
Channel Migration or Diversion	• Not known to be a prevalent flood-causing mechanism at nuclear plants.

Table A-2 – Conservatisms in Defining Combined-Effect Floods

Flood-Causing Mechanism	Example Conservative Assumptions
Combined Effects for Precipitation Events and Seismic Dam Failure (NUREG/CR-7046, Sections H.1 and H.2)	• Using combinations that can be shown to have a joint probability lower than 10-6. Some examples are discussed below. (A) - Seismic event causing catastrophic dam failure coincident to the peak of a 500-year (or ½ PMF) flood, two independent and non-correlated events. E.g., 1/10,000-year exceedance frequency (p = $1x10^{-4}$) seismic event occurring during a 1/500-year (p = $2x10^{-3}$) exceedance frequency flood, even conservatively assuming the peak of the flood lasts 1 month (p = 1/12 = $8.3x10^{-2}$), which is likely unrealistic, would produce a 1/59,000,000-year joint exceedance frequency (p = 0.0001 x 0.002 x 0.083 = 1.7×10^{-8}) (A) - 500-year or ½ PMF antecedent to an all-season PMF, occurring almost coincidentally (within 5 days or so). Conservatively assuming the PMP has a 1/10,000-year exceedance frequency (p = 10^{-4}) and the antecedent storm occurs in the same month as the PMP, the joint exceedance frequency would be the same as above (1/59,000,000-year or p = 1.7×10^{-8}) (A) - For the rain-on-snow events, having the worst-case combinations of rainfall, snowpack, temperature, and wind-speed would seem to produce joint exceedance frequencies well below 1/1,000,000-year (p = 10^{-6}). (A)
Combined Effects for Storm Surge (NUREG/CR-7046, Sections H.3 and H.4)	• Antecedent Water Level o For coastal areas, use of the 10-percent exceedance high tide, coincident with the PMSS,

Flood-Causing Mechanism	Example Conservative Assumptions
	which by itself is an infrequent event. (A) o For Great Lakes, use of the maximum controlled water level or 100-yr recurrence monthly average high water, coincident with the PMSS. (A) o Sea level rise assumptions (dependent on proposed facility life). (A) • Coincident River Flow - Conservative application of the peak flow rate of the 25-year river flood coincident with the PMSS, with little to no consideration of watershed size/orientation, watershed runoff response, PMH parameter-precipitation correlation, dependent versus independent river and storm surge, and/or river flow-surge phasing differential. (A)

Table A-3 – Conservatisms in Key Associated Effects

Flood-Causing Mechanism	Example Conservative Assumptions
Wind-Wave Action	• Application of the maximum wind speed at the most critical direction for wave parameter calculation due to lack of specific guidance (i.e., decoupling wave and surge versus coupled conditions for individual storm tracks). (B) • Empirical formulas used to calculate wave heights. For instance, assumptions of depth-limited wave heights (i.e., 78 percent of the stillwater depth, with 70 percent of the wave height above the stillwater elevation). (B) • Over-prediction of wave setup due to use of simple empirical equations, compared to the more advanced numerical simulations such as STWAVE or SWAN modeling. (B) • Wave run-up usually overestimated by calculating a reflected wave against a vertical wall using 120 percent of the stillwater depth. (B) • Overtopping rate over-estimated by using conservative stillwater level, wave setup and run-up elevations. (B) • No consideration (i.e., through use of numerical models) of the effects of wave transformation (e.g., refraction and reflection). (B)

Flood-Causing Mechanism	Example Conservative Assumptions
	• Not using advanced numerical models (e.g., Boussinesq type) that provide a better representation of wave propagation over topographic features and structures. (B) • Conservative, empirical assumptions about flow velocities due to surge and waves (versus velocities developed based on numerical model simulation). (B)
Hydrodynamic and Debris Loads	• Using unrealistic debris weights and types, given the upstream watershed conditions. (B) • Using unrealistic debris velocities, given that most sites are located in low-velocity overbank areas. (B) • Not accounting for inertia in forcing certain debris (e.g. barges) to bypass the site. (B) • Not accounting for the shielding effect of structures or localized ineffective flow areas in hydrodynamic and debris load calculations. (B)

A.3 Appendix A References

A1. American Nuclear Society (ANS). 1992. American National Standard for Determining Design Basis Flooding at Power Reactor Sites. Prepared by the American Nuclear Society Standards Committee Working Group ANS-2.8, La Grange Park, Illinois.

A2. American Society of Civil Engineers (2010). Minimum Design Loads for Buildings and Other Structures. ASCE/SEI Standard 7-10.

A3. Federal Emergency Management Agency (2012). Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures – Chapter 4: Determination of Hazards. FEMA P-259. Third Edition.

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A6. U.S. Army Corps of Engineers, Hydrologic Modeling System, HEC-HMS, Technical Reference Manual, CPD-74B, Hydrologic Engineering Center, Davis, CA. March 2000.

A7. U.S. Army Corps of Engineers, Hydrologic Modeling System HEC-HMS. User's Manual. Version 3.5. Hydrologic Engineering Center, Davis, CA. August 2010.

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A9. U.S. Nuclear Regulatory Commission (NRC). 2007. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition – Site Characteristics and Site Parameters (Chapter 2)," March 2007.

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A13. U.S. Nuclear Regulatory Commission (NRC). 2013. JLD-ISG-2013-06, Guidance for Performing Tsunami, Surge, or Seiche Hazard Assessment. Revision 0. January 2013.

A14. U.S. Nuclear Regulatory Commission (NRC). 2012. NUREG/CR-7134, The Estimation of Very-Low Probability Hurricane Storm Surges for Design and Licensing of Nuclear Power Plants in Coastal Areas. October 2012.

A15. U.S. Nuclear Regulatory Commission (NRC). 1977. Design Basis Flood for Nuclear Power Plants. Regulatory Guide 1.59, Rev. 2, Washington, D.C.

APPENDIX B: EVALUATION OF PASSIVE & ACTIVE COMPONENTS

The objective of this appendix is to provide guidance for the evaluation of flood protection features. Flood protection features may be incorporated or temporary and may be passive or active. The evaluation determines the attributes of a flood protection feature, and compares the impacts of the reevaluated flood hazard to the existing design to determine if the flood protection feature is reliable.

B.1 Determination of Adequate Available Physical Margin

As discussed in Section 7.2, demonstrating "adequacy" of available physical margin is part of demonstrating "effective" flood protection. Demonstrating adequacy is approached differently for two types of features:

1) Features engineered in the design/licensing basis as having a flood protection function
2) Features engineered for a purpose other than flood protection in the design/licensing basis but are now being credited in the Integrated Assessment with this function when subject to the reevaluated flood hazard. Examples may include exterior doors or walls with protecting against a new LIP flood, security or vehicle barriers credited with dissipating wind-generated waves, etc.

In general, the APM for a flood feature is the difference between the flood parameter(s) expected to result in failure and the corresponding reevaluated flood parameter(s). The approach to developing "failure" parameters differs for a Type 1 and Type 2 feature (defined above).

For a Type 1 feature, failure parameters can be developed from design basis information and use of engineering codes and standards as well as factors-of-safety. Engineering judgement may be required to interpret design basis information and calculations in developing parameters that would likely lead to failure of a feature. For a Type 2 feature, failure parameters may need to be developed through additional engineering evaluations discussed in Section B.2. Certain flood features may not lend themselves for a specific quantitative value but may need to be supported by qualitative analysis.

The threshold for what constitutes "Adequate APM" for specific flood mechanism(s) can be established using one or more of the following methods:

- Negligible or zero APM can be justified as acceptable if the use of conservative inputs, assumptions, and/or methods in the flood hazard reevaluation can be established.
- Sensitivity analyses performed for key input parameters based on an acceptable upper and lower limit of the parameter.

- Potential error in a particular output parameter (e.g. peak flood elevation) can be estimated from observed, model calibration data and used to quantify adequate APM.
- Other government standards can be used to justify what constitutes "adequate APM". Two examples are below:

    - The flood hazard reevaluation for river flooding was often developed using the USACE HEC-RAS, the same program frequently used for FEMA Flood Insurance Studies. National Flood Insurance Program (NFIP) regulations for mapping areas protected by levee systems is provided in 44 CFR 65.10. The minimum freeboard (e.g. margin) requirement, specified in 44 CFR 65.10(b)(1)(i) to account for uncertainty in the estimated flood level, is 3 feet overall and 4 feet within 100 feet on either side of a flow constriction (e.g. bridge). The absolute minimum is 2 feet with proper justification and supporting uncertainty analysis. This FEMA standard can be used to define "adequate APM" for the river flood as 2.5 feet.

    - The procedure for estimating error associated with the water surface profile is referenced in Chapter 5, Table 5-2 of the USACE Engineering Manual (EM) 1110-2-1619, Engineering and Design, Risk Based Analysis for Flood Damage Reduction Studies. The USACE Hydrologic Engineering Center (HEC) and Waterways Experiment Station (WES) researched error in water surface profiles obtained when using a gradually varied flow model (such as HEC-RAS). The USACE published the standard deviation of the normally distributed errors in the estimated stages are based on topographic information and confidence in estimated Manning's n value as shown in Table B-1 taken from EM 1619.

Table B-1: Minimum Standard Deviation of Error in Stage

	Standard deviation (in feet)	
Manning's n Value Reliability	**Cross Section Based on Field Survey or Aerial Spot Elevation**	**Cross Section Based on Topographic Map with 2-5' Contours**
Good	0.3	0.6
Fair	0.7	0.9
Poor	1.3	1.5

[1]Where good reliability of Manning's n value equates to excellent to very good model adjustment/validation to stream gauge, a set of high water marks in the project effective size range, and other data. Fair reliability relates to fair to good model adjustment/ validation for which some, but limited, high-water mark data are available. Poor reliability equates to poor model adjustment/validation or essentially no data for model adjustment/validation.

B.2 Evaluation of Flood Features

The sections below provide attributes and considerations for specific flood features that are credited as part of the flood response strategy. For existing flood barriers that are being credited for higher flood levels, the purpose of this evaluation is to identify the specific flood parameters that exceed the current design and verify that the barrier will provide flooding protection. This evaluation does not require an analysis to reconstitute all aspects of the original barrier design. If the documentation for the existing barrier is incomplete (e.g. concrete psi rating or testing data) but there are similar structures or features at the site, engineering judgment can be applied to provide realistic but conservative assumptions for the evaluation. The evaluation of a new flood feature not originally designed for flood protection should include codes and standards relevant to that barrier as well as any operational requirements. In addition to determining the robustness of a new flood protection feature, the evaluation should identify the critical or maximum values that individually or in combination could exceed the capacity of the flood protection feature or component and impact the key safety function.

B.2.1 Permanent, Passive, Exterior and Incorporated Features

B.2.1.1 Earthen Embankments (Earth Dams, Levees, and Dikes)

Earthen dikes and embankments come in a variety of configurations. There are differences in design and construction details between earthen dams, levees, and dikes. However, since earthen dams, levees, and dikes are subsets of an "earthen embankment," this appendix will use that term. If an existing dike or embankment was designed with freeboard to provide margin and the flooding from the FHRR occurs within the existing freeboard, then the freeboard can be credited and the evaluation would focus on any new impacts not considered in the original design such as scour or wave action. If the earthen embankment was not designed and constructed as a flood barrier (e.g. a roadway embankment), this section provides points of considerations for evaluating earthen embankments, including the following:

- potential failure modes of earthen dams
- considerations that should be evaluated to determine whether appropriate factors are considered in the embankment design
- material characterization
- maintenance and inspection

Potential failure modes of earthen embankments that should be considered for applicability include the following:

- seepage, internal erosion and piping

- erosion-induced breaching
- shear failure
- surface sloughing
- excessive deformation
- seismically induced liquefaction
- other type of slope movement

The foundation and subsurface design of an embankment, levee, or berm should be evaluated to determine whether the following factors are appropriately considered in its design:

- foundation stability
- positive control of seepage
- minimum adverse deformation via good contact between flood protection structure and foundation
- use of cut off walls and drainage systems to control seepage paths through foundation

The stability of embankments should be evaluated utilizing pertinent geologic information and in situ engineering properties of soil and rock materials. The geologic information and site characteristics that should be considered include the following:

- groundwater and seepage conditions
- lithology, stratigraphy, and geologic details disclosed by borings and geologic interpretations
- maximum past overburden at the site as deduced from geological evidence
- structure, including bedding, folding, and faulting
- alteration of materials by faulting
- joints and joint systems
- weathering
- cementation
- slickensides
- field evidence relating to slides, earthquake activity, movement along existing faults, and tension jointing

The materials used in construction of the embankment should be evaluated to determine whether the following factors are appropriately considered in its design:

- use of filter materials to preclude migration of soil materials through the embankment and foundation
- erosion control against surface runoff, wave action, hydrodynamic forces, and debris

In evaluating engineering properties of soil and rock materials used in construction of the embankment, the licensee should consider the following:

- possible variation in natural deposits or borrow materials
- natural water contents of the materials
- climatic conditions
- possible variations in rate and methods of fill placement
- variations in placement water contents and compacted densities that must be expected with normal control of fill construction

The maintenance and inspection regime of the embankment should be evaluated to assess whether the following is true:

- the embankment is inspected at regular intervals
- written procedures are in place for proper maintenance
- personnel responsible for inspecting the structure have been trained in inspection techniques, implementing preventative and compensatory measures, and correcting or repairing deterioration
- suitable instrumentation is used to obtain information on the performance and condition of the structure.

B.2.1.2 Floodwalls

If an existing floodwall was designed with freeboard and the flooding from the FHRR occurs within the existing freeboard, then the freeboard can be credited and the evaluation would focus on any new impacts not considered in the original design (e.g new or different dynamic loading, debris impacts, etc.).

If the walls being credited were not designed and constructed as flood barriers, this section provides points of considerations for evaluating floodwalls, including the following:

A retaining wall is any wall that retains material to maintain a change in elevation, whereas the principal function of a floodwall is to prevent flooding (inundation) of adjacent land. A floodwall is subject to water force on one side, which is usually greater than any resisting earth force on the opposite side. A wall may be a retaining wall for one loading condition and a floodwall for another loading condition. The flood loading (e.g., surge tide, river flood) may be from the same or the opposite direction as the higher earth elevation.

For inverted T-type floodwalls, the crossbar of the T serves as a base and the stem serves as the water barrier. In evaluating T-type floodwalls, potential failure modes for T-walls that should be considered include the following:

- seepage
- wall stability

Planning and design procedure considerations for floodwall projects are described in References B1 and B2.

An I-wall is a slender cantilever wall, embedded in the ground or in an embankment that rotates when loaded and is thereby stabilized by reactive lateral earth pressures. The licensee should consider the following potential failure modes of I-walls:

- depth of piling
- deep seated (global failure)
- rotational failure caused by inadequate pile penetration
- seepage

Reference B3 provides information on I-Walls, as they relate to hydrostatic loads, static and dynamic water (wave) loads, seepage and piping, I-wall deflections, and determination of safety factors.

B.2.1.3 Seawalls

Seawalls are onshore structures with the principal function of preventing or alleviating overtopping and flooding of the land and the structures behind them caused by storm surges and waves. The licensee should consider potential failure modes of seawalls, including instability due to erosion of the seabed at the toe of the structure and increase in wave impact, run-up, and overtopping. References (B4-B6) provide additional information on seawalls.

B.2.1.4 Concrete Barriers

If the existing concrete barrier was designed with freeboard and the flooding from the FHRR occurs within the existing freeboard, then the freeboard can be credited and the evaluation would focus on any new impacts not considered in the original design.
In assessing whether other concrete barriers (not designed for flooding) can support flood loads, the licensee should evaluate the foundation and subsurface design of the barrier to determine whether the following factors were appropriately considered in design of the structure:

- static loads from stillwater elevation
- hydrodynamic loading from wave effects and debris
- foundation design and treatment, including good contact between the flood protection structure and foundation
- removal of problem soils

- increasing seepage paths through the foundation by use of deep cut off walls, if necessary

The licensee should evaluate the material properties of the concrete barrier (using available documentation and current condition) to assess whether the following is true:

- there was a competent investigation of material sources
- adequate testing was performed of materials in accordance with accepted standards
- proper proportioning of concrete was performed to improve strength and durability.

The licensee should evaluate the design of the concrete barrier to ensure it is safe against overturning and sliding without exceeding the allowable stress of the foundation and concrete for the loading conditions imposed by the flood and all associated flood effects.

The licensee should evaluate the maintenance and inspection regime of the concrete barrier to assess whether the following is true:

- the barrier is inspected at regular intervals
- written procedures are in place for proper maintenance
- personnel responsible for inspecting flood control structures have been trained in inspection techniques, implementing preventative and compensatory measures, and correcting or repairing deterioration
- suitable instrumentation is being used to obtain information on the performance and condition of the structure (e.g., assessing settlement and tilting of foundations, condition of the concrete including degradation mechanisms, seepage).

An example of attributes for a concrete barrier could be the flood elevation where failure of the barrier is expected to occur. Failure modes can include sliding, overturning, settlement, or erosion/scour.

B.2.1.5 Plugs and Penetrations Seals

For the purposes of evaluating the adequacy of plugs and penetration seals, it is sufficient to use the guidance prepared for the flooding design basis walkdowns performed in response to Near Term Task Force (NTTF) Recommendation 2.3. This guidance is described in NEI 12-07, Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features. Consideration of recent operating experience should be used when applying this guidance.

B.2.1.6 Storm Drainage Systems

If credited, the licensee should evaluate the storm drainage systems to demonstrate they are capable of passing sufficient flow to accommodate the reevaluated flood flow rate while maintaining the flood height not greater than the allowable value. The evaluation should consider all effects associated with the flood (e.g., scour). Performance should be compared against appropriate present-day codes and standards, including Section 2.4.2, Revision 4, "Floods," of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [light-water reactor] Edition" (Ref. A7). Storm drainage systems should also be evaluated to demonstrate that they are in satisfactory condition. Qualitative evaluation of operational requirements, such as surveillance, inspection, design control, procurement, maintenance, and testing is appropriate (e.g., a walkdown procedure should be provided for verifying that the system is clear of debris and objects that could impede flow). If drainage systems are associated with active components, active components should be evaluated using considerations described in Section B.1.2.

B.2.2 Active Features

B.2.2.1 Active Components

Active components that are currently included as part of the sites existing response to flooding (can be for external or internal flooding sources) should be evaluated based on the increased impacts of the flooding from the new FHRR flooding analysis (e.g increased leakage rates, pumping and flow capacity, flood duration, etc.).
New active components not originally intended for flooding response should be evaluated for availability and reliability using:

- operational data
- performance criteria (e.g., see Table B-2)
- consideration of operational requirements:
  - surveillance
  - inspection
  - design control
  - maintenance
  - procurement
  - testing and test control

If applicable, licensees should further use the following to justify the availability and reliability of active components and features:

- incorporation of equipment in plant programs (e.g., whether the component is included in established plant equipment reliability programs or subject to 10 CFR Part 50, Appendix B)
- conformance to consensus standard developed for similar uses, including emergency uses (e.g., standards developed by the National Fire Protection Association for fire protection equipment)

In addition, when information is available, the reliability of active components (e.g., failure to start on demand and failure to run once started) should be quantitatively evaluated and documented based on operating experience, testing, and other available information using traditional probabilistic risk assessment or statistical techniques. In some cases, this information may not be available. In this case, tests or analyses may be appropriate to support quantification of reliability. If information is not available and testing is not feasible, the integrated assessment submittal should:

1) Describe why quantification of equipment reliability is not possible or necessary; and
2) Justify why the equipment can be reasonably credited despite these limitations.

Table B-2: Criteria for Evaluating Active Components

Criteria	Description
Functional characteristics:	1. Equipment is capable of performing its required function (e.g., functional requirements such as pump flow rate, pump discharge pressure are met). 2. Equipment is in satisfactory condition. 3. Functionality of the equipment may be outside the manufacturer's specifications if a documented engineering evaluation justifies that the equipment will be functional when needed during the flood event duration. 4. There is an engineering basis for the functional requirements for the equipment which: a) is auditable and inspectable; b) is consistent with generally accepted engineering principles; c) defines incorporated functional margin; and d) is controlled within the configuration document control system.

Table B-2: Criteria for Evaluating Active Components	
Criteria	**Description**
Operational characteristics	1. Equipment is covered by one of the following: a) existing quality assurance (QA) requirements in Appendix B of 10 CFR Part 50; b) existing fire protection QA programs; or c) a separate program that provides assurance that equipment is tested, maintained, and operated so that it will function as intended and that equipment reliability is achieved. 2. Testing (including surveillances) a) Equipment is initially tested or other reasonable means should be used to verify that its performance conforms to the limiting performance requirements. b) Periodic tests and test frequency are determined based upon equipment type and expected use. Testing is done to verify design requirements and basis are met. The basis is documented and deviations from vendor recommendations and applicable standards should be justified. c) Periodic inspections address storage and standby conditions as well as in-service conditions (if applicable). d) Equipment issues identified through testing are incorporated into the corrective action program and failures are included in the operating history of the component.
	3. Preventive maintenance (including inspections) a) Preventive maintenance (including tasks and task intervals) is determined based upon equipment type and expected use. The basis is documented and deviations from vendor recommendations and applicable standards should be justified. b) Periodic testing addresses storage and standby conditions as well as in-service conditions (if applicable). c) Equipment issues identified through inspections are incorporated into the corrective action program and failures are included in the operating history of the component.

Table B-2: Criteria for Evaluating Active Components

Criteria	Description
Unavailability characteristics	1. The unavailability of equipment should be managed such that loss of capability is minimized. Appropriate and justifiable unavailability time limits are defined as well as remedial actions. A replacement would be for equipment that is expected to be unavailable in excess of this time limit or when a flood event is forecasted. 2. A spare parts strategy supports availability considerations. 3. The unavailability of installed plant equipment is controlled under existing plant processes such as technical specifications.
Equipment storage characteristics	1. Portable equipment is stored and maintained to ensure that it does not degrade while being stored and that it is accessible for maintenance and testing. 2. Credited active equipment is protected from flooding. It is accessible during a flooding event. Alternatively, credited active equipment may be stored in locations that are neither protected from flooding nor accessible during a flood if adequate warning of an impending flood is available and equipment can be relocated prior to inundation. a) Consideration should be given to the transport from the storage area recognizing that flooding can result in obstacles restricting normal pathways for movement. b) Manual actions associated with relocation of equipment should be evaluated as feasible and reliable (see Appendix C to this guidance). 3. A technical basis is developed for equipment storage that provides the inputs, assumptions, and documented basis that the equipment will be protected from flood scenario parameters such that the equipment could be operated in place, if applicable, or moved to its deployment locations. This basis is auditable, consistent with generally accepted engineering principles, and controlled within the configuration document control system.

B.2.2.2 Flood Doors and Hatches

Flood doors and hatches that are currently included as part of the sites existing response to flooding (can be for external or internal flooding sources) should be evaluated based on the increased impacts of the flooding from the new FHRR flooding analysis (e.g increased static head, dynamic loading, debris impacts, flood duration, etc.).

In assessing whether other doors and hatches can provide flooding protection, the following factors should be considered:

- hydrostatic force resistance – flood barriers should conform to the criteria for resisting lateral forces due to hydrostatic pressure from freestanding water
- hydrodynamic force resistance – flood barriers should conform to the criteria for resisting lateral forces due to moving flood waters
- debris impact force resistance – flood barriers should conform to the criteria for resisting debris objects at stated velocities.

B.2.3 Temporary Features

Standards, codes, and guidance documents (e.g., References B7 and B8) should be consulted to determine whether the configuration of the temporary barrier (e.g., configuration of a sandbag wall) conforms to accepted engineering practices. Justification of feature reliability may require laboratory- or field-testing (e.g., Reference B9), analytical modeling, or demonstrations. If an assessment and evaluation of temporary features reveals deficiencies and shortcomings in their capability to perform adequately as a flood barrier because they do not conform to accepted engineering practice, the implications of the deficiencies should be summarized.
Moreover, it should be demonstrated that temporary features can be moved to the location where needed and installed. The licensee should use Appendix C to this guidance to evaluate manual actions associated with construction or installation of temporary protective measures.

B.2.4 Equipment Necessary to Perform Human Actions

The licensee should use Appendix C to this guidance to evaluate human actions associated with flood protection features.

B.3 Appendix B References

B1. U.S. Army Corps of Engineers, "Engineering and Design - Retaining and Flood Walls," EM 1110-2-2502, 1989.

B2. U.S. Army Corps of Engineers, "Engineering and Design – Waterstops and Other Preformed Joint Materials for Civil Works Structures," EM 1110-2-2102, 1995.

B3. U.S. Army Corps of Engineers, "Design of Sheet Pile Walls," EM 1110-2-2504, 1994. B4. U.S. Army Corps of Engineers, "Engineering and Design-Design of Coastal Revetments, Seawalls and Bulkheads," EM 1110-2-1614, 1995.

B4. U.S. Army Corps of Engineers, "Coastal Engineering Manual-Part VI, Introduction to Coastal Project Element Design," EM 1110-2-1100, 2002.

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APPENDIX C: EVALUATION OF THE SITE RESPONSE

C.1 Objective

The purpose of this Appendix is to provide guidance on evaluating manual actions associated with successfully carrying out an external flood response strategy. The goal of the evaluation is to demonstrate that the manual actions required to implement the flood response strategy are feasible and overall implementation of the strategy is dependable. This guidance is applicable for any flood response strategy that requires manual actions regardless of which path is selected in the IA process.

A dependable response strategy is one which can be implemented successfully by appropriately trained crews in an organized pre-planned manner under the expected environmental conditions. Equipment required for a dependable strategy is maintained and tracked in a controlled manner and is determined to be available and reliable. The crews have been appropriately trained and demonstrate the ability to complete the strategy successfully within the designated time frame with sufficient time margin for the strategy required to implement the actions on critical path. A strategy with limited time margin can be demonstrated dependable with either redundancy, confirmation or compensation measures for incorrect execution for the actions.

External flood response strategies, in general, differ from other response strategies at nuclear power plants. Many of the actions take place outside the main control room, have long lead times and require significant coordination from a large organization. It is therefore prudent that the evaluation not only review individual actions but the strategy as a whole to determine its dependability. This appendix will provide a framework to evaluate individual actions, leveraging pre-established methods developed for other beyond-design-basis mitigation efforts, and demonstrate that the implementation of a flood response strategy is dependable.

C.2 Overall Process of Evaluating a Flood Response Strategy

The overall process for this evaluation should begin with understanding and defining the flood response strategy. This step is required for any path chosen when manual actions are required to carry out a particular strategy. The process will include laying out the key tasks, manual actions and decisions that are required for successful implementation of the flood response strategy. The evaluation then proceeds to ensuring that the following major components are satisfactorily addressed:

- All required procedures are clear and appropriately detailed

- Organizational structure is well understood
- Resources are available
- Reasonable Simulation and Training have been conducted
- Expected environmental factors are addressed
- Time and Time Margin is available

The first step in the analysis is to determine that each individual action is feasible using the validation process in NEI 12-06, App E Ref [X]. In the validation process, a set of performance attributes should be evaluated, a timing estimate is performed and margin is established for the individual actions. The process should be followed and reasonable simulation or walkthroughs should be performed in accordance with the validation level deemed most appropriate for the action. These results will be used as a direct input to the next step which is to evaluate the dependability of the flood response strategy as a whole under the environmental conditions expected during the event.

The purpose of the dependability evaluation is to further demonstrate the adequacy of the overall site response to the event. This begins with establishing dependable procedural triggers, organizational response and defining the critical path for the initiation and execution of the total response strategy. The next step includes a detailed timeline analysis which reviews the TSAs, flood progression, effects on the plant, and accounts for the expected flood specific environmental conditions. A margin assessment is performed for the strategy and strategies with limited margin have the option to include redundancy, confirmation or compensation for incorrect execution and suboptimal performance of TSAs. The demonstration of the flood response strategy as dependable is then documented in conclusion of the IAP.

C.3 Defining Critical Path and Identifying Time Sensitive Actions (TSAs)

During a large external flood event, procedures would implement many strategies to protect the plant and mitigate the effects of the flood. Within these strategies there are actions that must be completed successfully for the strategy to succeed at preserving or restoring the KSFs. The sequence of actions that determine the minimum time needed to complete the strategy is the critical path of the response. Actions on critical path where a failure would lead to the failure of the overall strategy without compensatory measures should be considered the TSAs applicable to flooding that need to be evaluated in the IAP.

Strategies and/or actions aimed at other goals such as preserving economic assets, providing for station security, or assisting with local relief efforts, for this evaluation, are considered only to the extent that they could conflict with or distract from performance of these TSAs. It is not necessary to demonstrate the feasibility or dependability of these strategies in this evaluation.

C.4 Evaluating Feasible Actions

The first step to demonstrating a flood response strategy is dependable is to show that all TSAs required for the strategy are feasible. This guidance intends to utilize NEI 12-06 Rev. 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide - Appendix E, Validation Guidance" Ref. [X]. The process for determining the feasibility of carrying out beyond design basis (BDB) mitigation response strategy actions has already been implemented for FLEX strategies and this guidance is appropriate for evaluating the feasibility of flood response actions as FLEX mitigation actions share very similar characteristics to that of flood response actions and many FLEX strategies already account for external flood hazards.

All actions required for the flood response strategy should be evaluated in accordance with the guidance in Ref [X]. The process describes the fundamental steps to determining that a strategy's actions are feasible to implement within the time available. In general, sites with unbounded flooding mechanisms have followed this evaluation process to complete their Mitigating Strategies Assessment (MSA). The information in the MSA should be evaluated to determine if the same strategies and actions are appropriate to use in the evaluation of these scenarios. If so, the same information from the MSA can be relied upon and used to complete this step of the site response evaluation.

It is important to note that any actions that are critical path require Level A or B validation, regardless of the time frame in which the action is performed. Additional details regarding requirements for validating Level A and Level B actions are contained within Ref [X]. The information gathered from the feasibility assessment should be retained for use during the evaluation for a dependable strategy.

C.5 Evaluating a Dependable Strategy

The process for demonstrating an external flooding strategy is dependable builds upon the validation process presented in Ref. [X]. Where the analysis in the Validation process was focused on demonstrating the individual actions that make up the strategy are feasible, this evaluation assesses the organizational response, the margin in the strategy accounting for the expected environmental factors, and how the strategy is carried out as a whole to conclude the strategy is dependable.

The key elements to evaluating the dependability of a flood response strategy include:

- Establishing unambiguous procedural triggers
- Proceduralized and clear organizational response to a flood

- Developing a detailed flood response timeline
- Accounting for the expected environmental conditions
- Determining time and time margin availability

Though NEI 12-06 addressed these considerations for each individual action to some degree, the following sections provide guidance on the key attributes of the overall site response, including areas that are unique to external flooding response strategies, that should be further addressed in this evaluation.

C.5.1 Procedural Trigger to Initiate Response

A dependable strategy is initiated by an institutionalized, objective trigger that responds to actual or predicted flood conditions or effects.

Triggers to enter the flood response procedure should be unambiguous. They may originate from plant controlled gauges or offsite sources of information, including external organizations responsible for informing the plant staff of a developing or imminent flood challenge.

Examples of dependable triggers to initiate a flood response strategy include:

- Forecast of consequential rainfall as described in Section 5 of NEI 15-05
- River surface reaching a specified elevation as measured on a plant instrument or government-controlled gage
- Government agency forecast of a future specified weather event or flood stage, provided there are requirements to monitor these forecasts and take specific actions based on them
- Workers notifying the control room of water entering the plant at a particular location – but only if the workers are trained to make this report and there are procedurized requirements to monitor for water ingress and report the observation
- Inspect and notify after forecast is received
- Workers observing heavy rainfall and taking self-initiated actions to close building openings – but only if the workers are trained to monitor and determine when rainfall is "heavy", and there are specified requirements to close particular openings

This evaluation should clearly document the procedural cues included in the controlling procedure and include any incremental levels that may be monitored or relied upon to trigger flood response actions. The source of the cue and the anticipated timeframe in which it will be received relative to the flood progression must be known.

C.5.2 Organizational Response to Procedure Initiation

The organization will respond to a flood strategy trigger in one of two ways. If possible, the organization will undertake anticipatory strategies to address a flood prior to it affecting the plant. The organization might also be called upon to implement strategies to address flooding after it affects plant systems, structures, or components.

The controlling procedures for the flood mitigation strategy(ies) should:

- Establish clear responsibility for command and control.
- Prioritize the actions to ensure the identified TSAs have appropriate priority over other actions.
- Clearly define what parts of the plant organization have responsibility for each critical path action.

The workload and priorities for the plant staff to execute flood strategies should be evaluated against the criteria given in NEI 12-01.

C.5.3 Expected Environmental Conditions

The potential impacts to the dependability of an external flood response strategy from the expected environmental conditions should be evaluated in the IAP. This step is included in the validation process for FLEX (Ref. [X]); however, the flood causing mechanisms for this evaluation may be different. The expected environmental conditions should be estimated based on the reevaluated flood hazard information and evaluated for any potential impacts to the human performance of implementing the flood response strategy.

Environmental conditions during extreme weather events are site, mechanism and strategy specific. Strategies that employ anticipatory actions may not be impacted by adverse environmental conditions for many hours and have nominal working conditions. Whereas, events that may leave just a few hours before flooding could preclude some activities. These factors need to be considered and treated appropriately in the evaluation.

There are two ways to address the impacts due to environmental conditions: qualitatively and quantitatively. The first step will be to qualitatively analyze the impacts from the expected environmental conditions. Any actions anticipated to be degraded due to these factors should consider compensatory measures to return working conditions to a reasonably nominal state. If compensatory measures are not possible, degraded actions can also be treated quantitatively to determine if the time margin remains adequate with additional time required to complete due to the environmental factors.

The following sections provide guidance on appropriately evaluating the environmental factors on human performance, considerations for compensation measures, and quantitatively accounting for degraded conditions.

C.5.3.1 Qualitative Assessment

A qualitative assessment may be the most appropriate way to address environmental factors when a strategy has adequate warning time and anticipatory actions are completed in advance of the storm. A similar evaluation would be appropriate for a site subject to flooding from upstream precipitation and/or snowmelt where no adverse conditions are predicted before the flood waters arrive. A qualitative assessment may also be appropriate when minimal impacts due to weather are expected or the strategy actions are performed in areas that are protected from the elements.

The following lists considerations that should be reviewed and applicable conditions should be addressed:

- adverse weather (e.g., lightning, hail, wind, precipitation)
- temperatures (e.g., humidity, air and water temperatures, particularly if personnel must enter water)
- conditions hazardous to the health and safety of personnel (e.g., electrical hazards, hazards beneath the water surface, drowning, structural debris)
- lack of lighting
- radiation
- noise
- vibration

The environmental conditions should be evaluated to determine if they pose any adverse conditions that would results in a significant degradation of human performance. Compensatory measures should be considered to return working conditions to a reasonably nominal state or combat the elements for actions that would otherwise be precluded if performed without the measures. Some examples of compensatory measures include:

- Personal Protection Equipment
  - Hearing Protection
  - Gloves
  - Eye Protection
  - Boots/Waders
  - Hardhat
- Additional Lighting
- Water and Wind Resistant Structure
- Procedural guidance to ensure no hazards in the area

Any actions that are still postulated to be performed under degraded conditions that would significantly affect human performance should be evaluated quantitatively in the next section.

C.5.3.2 Quantitative Assessment

Following the qualitative assessment of environmental factors on human performance, it may be necessary to quantitatively assess the impacts due to degraded conditions. There currently is not an industry consensus on how to apply additional time factors to performance of human actions and engineering judgement will be necessary to quantitatively assess the impact to the actions.

Based on the severity of environmental conditions and the nature of the task, additional time should be allotted to the best estimate for time to complete. Time margin can then be assessed against this estimate in the next section to determine if adequate time margin is still available for the flood response strategy. The additional time allotted for the action should be documented and justification should be provided for the basis of selecting any additional factors.

C.5.4 Flood Response Strategy Timeline Analysis

In demonstrating the dependability of a flood response strategy, it is necessary to construct a detailed timeline showing the following items:

- Flood mechanism initiation
- Estimated flood hazard parameters (such as river surface elevation, or ponding elevation of rainfall) as a function of time
- Time of trigger, when plant is cued to respond to the flood (Section C.4.1)
- Manual action timeline of plant flood response strategy focused on the identified TSAs and other actions anticipated to compete for resources
    - Procedural trigger (cue) time
    - Start time
    - Duration of action
- Times when plant impacts (if any) would occur in the absence of any response (e.g. access road becoming impassible, loss of offsite power, or loss of key safety functions)
- Repeatable and/or monitoring actions associated with maintaining a safe stable state

An example timeline is shown in Figure C-1. This timeline may be very similar to the timeline developed for a FLEX mitigation strategy of external flood hazards and should be used for as a base for this evaluation. The analyst must ensure that all elements described in this appendix are included in the evaluation so that flood specific considerations are adequately addressed.

The strategy is considered dependable if the analyst has demonstrated that the identified meet the following criteria.

1. Each TSA is feasible as described in NEI 12-06, App E.
2. The strategy is initiated by a dependable trigger as described in section 10.4.1.
3. The organization can effectively respond to perform the TSA given the environmental conditions, competing tasks, and outside support needs as described in section 10.4.2.
4. The TSAs can be performed as described in the governing procedures for the strategy to be successful with adequate margin. This assessment balances the nature and timing of the tasks against the margin available and supports a conclusion on whether or not the margin is adequate to accommodate the unknown using reasonable judgment.

5. Environmental conditions are satisfactorily addressed and accounted for in the timing or margin analysis.

In the event that adequate time margin is limited or environmental conditions may prove challenging, a strategy can be demonstrated to be dependable, if it includes either redundancy, confirmation or compensation for incorrect execution and suboptimal performance for TSAs. Some specific examples of these actions are:

- Independent verification of component alignments.

- Checking by a separate crew using a checklist to confirm TSAs were completed and properly installed.

- Staging spare sandbags ready to bolster a flood barrier.

- Providing redundant active components in case the primary component fails to perform.

- Establishing two flood barriers in series, so that if the first one fails the second barrier will take over protection.

- Providing shelter or other PPE to combat harsh environmental conditions

ID	Task Names	Dur	Avail
-	DAM BREAK OCCURS		
PF-001	Dam Operator informs Station Personnel of Breach	0.5	21
PF-002	Operators Confirm River Rise	0.5	22
PF-003	Operators being emergency shutdown procedure	6	23
PF-004	Command and control transferred to Site Director	1	16
PF-005	Staffing levels determined and work planned	1	17
XF-001	Test SFMS DG-1&2	2	20
XF-002	Start SFMS DG-1	1	9
XF-003	Test SFMS Well Pumps P-1/2	2	20
XF-004	Stage and align portable pump for RCS make up	4	18
XF-005	Operators Open ADVs and confirm availablility	2	19
XF-006	Block open ADVs to prevent re-closure	2	18
XF-007	Open MSSVs and prevent re-closure	2	15
XF-008	Fully Staff SFMS Facility	1	10
XF-009	Remove power to equipment below max WSE	1	2
XF-010	Open manual valves to align SFMS pumps	1	9
XF-011	Start SFMS well pumps	1	9
XF-012	Start portable pump for RCS make up	1	9
XF-013	RCS heats up to restore SG heat removal	2	6
XF-014	Operators maintain SG level, pressure & temp	Cont.	-
XF-015	Operators refuel SFMS DGs	Cont.	-
XF-016	Restaff + change shifts	Cont.	-

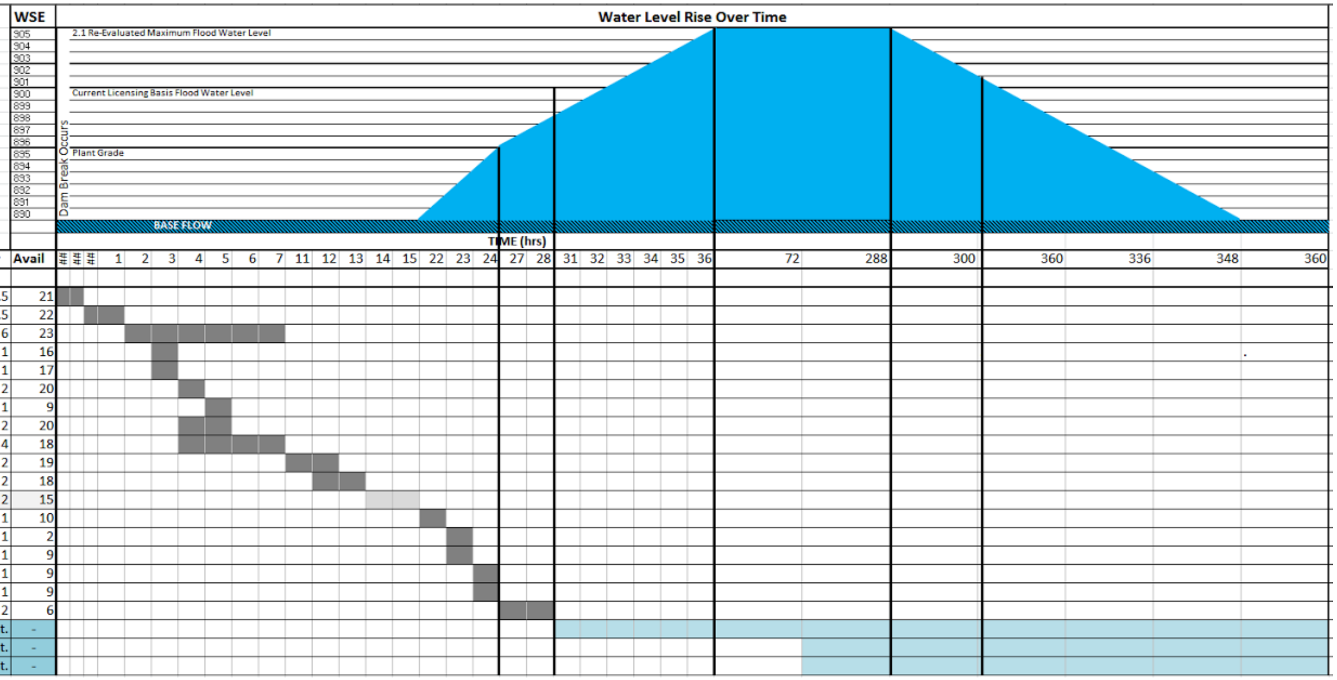

Figure C-1: Flood Response Strategy Timeline