JAPAN LESSONS-LEARNED DIVISION

JLD-ISG-2016-01

Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluation;

Focused Evaluation and Integrated Assessment

Interim Staff Guidance
Draft Revision 0

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ADAMS Accession Nos.: Pkg ML16096A301**: Draft ISG:** ML16090A140:
FRN ML16096A314 *Concurrence via e-mail

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INTERIM STAFF GUIDANCE
JAPAN LESSONS-LEARNED DIVISION
GUIDANCE FOR ACTIVITIES RELATED TO NEAR-TERM TASK FORCE RECOMMENDATION 2.1, FLOODING HAZARD REEVALUATION; FOCUSED EVALUATION AND INTEGRATED ASSESSMENT
JLD-ISG-2016-01

PURPOSE

This interim staff guidance (ISG) is being issued to describe to stakeholders methods acceptable to the staff of the U.S. Nuclear Regulatory Commission (NRC) for satisfying the requested integrated assessment for external flooding described in the NRC's March 12, 2012, request for information (Reference 1), issued pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54, "Conditions of Licenses," (hereafter referred to as the 50.54(f) letter) regarding Recommendation 2.1 of the enclosure to SECY-11-0093, "Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident" (Reference 2), as modified by COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," (Reference 3), its related staff requirements memorandum (SRM) (Reference 4), COMSECY-15-0019, "Closure Plan for the Reevaluation of Flooding Hazards for Operating Nuclear Power Plants," (Reference 5) and its associated SRM (Reference 5). Among other actions, the March 12, 2012, letter requested that respondents reevaluate flood hazards at each site and compare the reevaluated hazard to the design-basis at the site for each flood mechanism. Addressees were requested to perform an integrated assessment if the design-basis flood hazard does not bound the reevaluated flood hazard for all mechanisms.

This ISG will assist operating power reactor respondents and holders of construction permits under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," with performance of the focused evaluations and revised integrated assessments. This guidance is not intended for use in design-basis applications or in regulatory activities beyond the scope of performing the integrated assessment.

BACKGROUND

Following the events at the Fukushima Dai-ichi nuclear power plant, the NRC established a senior-level agency task force referred to as the Near-Term Task Force (NTTF). The NTTF conducted a systematic and methodical review of the NRC regulations and processes and determined if the agency should make additional improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a comprehensive set of recommendations, documented in the enclosure to SECY-11-0093 (Reference 2). These recommendations were enhanced by the NRC staff following interactions with stakeholders. Documentation of the NRC staff's efforts is contained in SECY-11-0124, "Recommended Actions To Be Taken without Delay from the Near-Term Task Force Report," dated September 9, 2011 (Reference 7), and SECY-11-0137, "Prioritization of Recommended Actions To Be Taken in Response to Fukushima Lessons Learned," dated October 3, 2011 (Reference 8).

As directed by the SRM for the enclosure to SECY-11-0093 (Reference 9), the NRC staff reviewed the NTTF recommendations within the context of the NRC's existing regulatory framework and considered the various regulatory vehicles available to the NRC to implement the recommendations. SECY-11-0124 and SECY-11-0137 established the staff's prioritization of the recommendations based upon the potential safety enhancements.

As part of the SRM for SECY-11-0124, dated October 18, 2011 (Reference 10), the Commission approved the staff's proposed actions, including the development of three information requests under 10 CFR 50.54(f). The information collected would be used to support the NRC staff's evaluation of whether available or planned measures provide effective protection and mitigation or if further regulatory action should be pursued in the areas of seismic and flooding design, and emergency preparedness.

In addition to Commission direction, the Consolidated Appropriations Act, Public Law 112-074, was signed into law on December 23, 2011, which contains the Energy and Water Development Appropriations Act, 2012. Section 402 of the law requires a reevaluation of licensees' design-basis for external hazards.

In response to Commission and Congressional direction, the NRC issued a request for information to all power reactor licensees and holders of construction permits under 10 CFR Part 50 on March 12, 2012 (Reference 1).

In SRM COMSECY-15-0019, the Commission approved the staff's plans to implement a graded approach for determining the need for, and prioritization and scope of, plant-specific integrated assessments so that they are focused on those plants where there is the greatest opportunity for additional safety enhancements. As discussed in COMSECY-15-0019, the majority of sites with flooding hazards exceeding the design-basis flood will screen out from the integrated assessments and licensees will instead provide focused evaluations to ensure appropriate actions are taken and that these actions are effective and reasonable.

The NRC held a series of public meetings to gather stakeholder input as an aid to developing the guidance for this approach. On March 9, 2016, the Nuclear Energy Institute (NEI) submitted NEI 16-05, Revision A, "External Flooding Assessment Guidelines," (Reference 11) in support of this effort. NEI subsequently submitted NEI 16-05, Revision B (Reference 12) to support further discussion in a public meeting on April 8, 2016. NEI submitted a final version of NEI 16-05 on April 12, 2016. This ISG endorses NEI 16-05, Revision 0 (Reference 13), with clarifications as described in the attachment.

RATIONALE

1. On March 12, 2012, the NRC issued a request for information to all power reactor licensees and holders of construction permits under 10 CFR Part 50. The request was issued in accordance with the provisions of Sections 161.c, 103.b, and 182.a of the Atomic Energy Act of 1954, as amended (the Act), and NRC regulation in 10 CFR, Part 50, Paragraph 50.54(f). Pursuant to these provisions of the Act or this regulation, respondents were required to provide information to enable the staff to determine whether a nuclear plant license should be modified, suspended, or revoked. The request for information includes a request that respondents reevaluate

flooding hazards at nuclear power plant sites using updated flooding hazard information and present-day regulatory guidance and methodologies. The 50.54(f) letter also requests the comparison of the reevaluated hazard to the design-basis at the site for each potential flood mechanism. If the reevaluated flood hazard at a site is not bounded by the current design-basis, respondents were requested to perform an integrated assessment to evaluate the total plant response to the flood hazard, considering multiple and diverse capabilities such as physical barriers, temporary protective measures, and operational procedures.

2. As described in COMSECY-15-0019, a focused evaluation process will be used by the NRC staff to screen out licensees from need for an integrated assessment based on a graded, risk-informed, and performance-based approach. COMSECY-15-0019 and the related SRM informed the development of guidance in NEI 16-05 and the screening process for improving realism in the flooding hazards and addressing focused evaluations for plants with available physical margin and plants affected by local intense precipitation (LIP). As described in COMSECY-15-0019, Phase 2 decisionmaking will only be applicable to plants performing a revised integrated assessment because licensees for "screened-out" sites will address the reevaluated flooding hazards through existing capabilities or regulatory commitments associated with enhanced capabilities.

APPLICABILITY

This ISG will be implemented on the day following its approval. It will remain in effect until it has been superseded or withdrawn.

PROPOSED GUIDANCE

This ISG is applicable to holders of operating power reactor licenses from whom an integrated assessment is requested in the March 12, 2012 request for information (i.e., sites for which the current design-basis flood hazard does not bound the reevaluated hazard for all potential flood mechanisms).

IMPLEMENTATION

Except in those cases in which a licensee proposes an acceptable alternative method for performing the integrated assessment, the NRC staff will use the methods described in this ISG to evaluate the results of the integrated assessment.

BACKFITTING DISCUSSION

This ISG does not constitute backfitting as defined in 10 CFR 50.109 (the Backfit Rule) and is not otherwise inconsistent with the issue finality provision in 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," of 10 CFR. This ISG provides guidance on an acceptable method for responding to a portion of an information request issued pursuant to 10 CFR 50.54(f). Neither the information request nor the ISG requires the modification or addition to systems, structures, or components, or design of a facility.

Licensees may voluntarily use the guidance in JLD-ISG-2016-01 to comply with the request for information.

The information received in response to this information request may be used in the basis for a backfit at a later date. In that case, the appropriate backfit review process would be followed at that time.

FINAL RESOLUTION

The contents of this ISG, or a portion thereof, may subsequently be incorporated into other guidance documents, as appropriate.

ENCLOSURES:

1. Guidance for Closure of Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluation, through the Focused Evaluation Process.

2. Probabilistic Flood Hazard Assessment for Phase 2 Decisionmaking.

REFERENCES

1. 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, Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340.

2. 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.

3. U.S. Nuclear Regulatory Commission, “Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards,” COMSECY-14-0037, November 21, 2014, ADAMS Accession No. ML14238A616.

4. 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,” SRM-COMSECY-14-0037, March 30, 2015, ADAMS Accession No. ML15089A236.

5. U.S. Nuclear Regulatory Commission, “Closure Plan for the Reevaluation of Flooding Hazards for Operating Nuclear Power Plants,” COMSECY-15-0019, June 30, 2015, ADAMS Accession No. ML15153A105.

6. U.S. Nuclear Regulatory Commission, “Staff Requirements – COMSECY 15-0019 - Closure Plan for the Reevaluation of Flooding Hazards for Operating Nuclear Power Plants,” SRM-COMSECY-15-0019, ADAMS Accession No. ML15209A682.

7. 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.

8. 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.

9. 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.

10. 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.

11. Nuclear Energy Institute, NEI 16-05, Revision A, “External Flooding Assessment Guidelines,” June 2016 (sic), ADAMS Accession No. ML16074A263.

12. Nuclear Energy Institute, NEI 16-05, Revision B, “External Flooding Assessment Guidelines,” April 2016, ADAMS Accession No. ML16104A019.

13. Nuclear Energy Institute, NEI 16-05, Revision 0, “External Flooding Integrated Assessment Guidelines,” April 2016, ADAMS Accession No. ML16105A327.

14. U.S. Nuclear Regulatory Commission, Directive Handbook 8.4, “Management of Facility-Specific Backfitting and Information Collection,” DH 8.4, October 9, 2013, ADAMS Accession No. ML12059A460.

15. U.S. Nuclear Regulatory Commission, “Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission,” NUREG/BR-0058, Revision 4, September 2004.

16. U.S. Nuclear Regulatory Commission, “Regulatory Analysis Technical Handbook,” NUREG/BR-0184, January 1997.

17. U.S. Nuclear Regulatory Commission, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 2.4.2, “Floods,” Rev. 4, March 2007.

INTERIM STAFF GUIDANCE
JAPAN LESSONS-LEARNED DIVISION
GUIDANCE FOR ACTIVITIES RELATED TO NEAR-TERM TASK FORCE RECOMMENDATION 2.1, FLOODING HAZARD REEVALUATION; FOCUSED EVALUATION AND INTEGRATED ASSESSMENT
JLD-ISG-2016-01

1. Introduction

This interim staff guidance (ISG) provides guidance for the Nuclear Regulatory Commission (NRC) staff review of focused evaluations submitted in response to the NRC's March 12, 2012, request for information regarding flooding hazards. The request was issued pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) (hereafter referred to as the 50.54(f) letter). This ISG endorses, with clarifications, the approach proposed by the Nuclear Energy Institute (NEI) in NEI 16-05, Revision 0, "External Flooding Integrated Assessment Guidelines," Agencywide Documents Access and Management System (ADAMS) Accession No. ML16105A327.

Staff Position: NEI 16-05 provides an acceptable methodology for licensees to perform focused evaluations and integrated assessments of flood mechanisms that exceed the design-basis flood parameters for a facility, subject to the clarifications related to specific sections of NEI 16-05. Licensees may use the methodology of NEI 16-05, with clarifications, upon receipt of the NRC letter providing the flood hazard parameters for use in the Mitigating Strategies Assessments of NEI 12-06, Appendix G.

2. Initial Evaluation Process – Reduction of Unnecessary Conservatism

Section 6.1 of NEI 16-05 discusses concepts a licensee may use as part of an iterative process under the NUREG/CR-7046 hierarchical hazard assessment approach in order to reduce conservatisms inherent in the reevaluation of flooding hazards. Appendix A of NEI 16-05 provides a catalog of select assumptions, inputs, and methods that may introduce conservatisms in the results.

Staff Position: As discussed in NEI 16-05, Section 6.1, licensees seeking to reduce unnecessary conservatisms in the reevaluation of flooding hazards submitted in response to the 50.54(f) letter may do so by refinement of the estimation of their site-specific hazard using the hierarchical hazard assessment (HHA) process of NUREG/CR-7046, as described in the 50.54(f) letter. The output of this process would be a refined, yet still bounding flood hazard. As described in Appendix A, Section A.3, licensees should provide a sound basis for refinements, "demonstrat[e] that reductions are more realistic yet still bounding" and "[err] on the side of conservative [as] the acceptance standard." Appendix A, Tables A-1 through A-3 provide considerations for licensees in identifying potential refinements but, due to the site-specific nature of flooding evaluations, the tables are not endorsed as guidance for evaluation of flood hazards.

For local intense precipitation, NRC staff review of a licensee's proposed reduction of conservatism should consider whether the refinements have been justified by regulatory commitments to implement or maintain procedures or programs."

NRC staff will review hazard reevaluation on a site-specific basis to ensure the hazard refinements are consistent with present-day methods and guidance, including the HHA process.

3. Initial Evaluation of Flood Impacts and Protection

Section 6.3.1 of NEI 16-05 provides a method for evaluating the potential impact of flooding under the reevaluated flood parameters on plant conditions. This method includes the identification of key structures, systems and components (SSCs), flood protection features, and critical flood elevations that could impact the key SSCs (i.e., the consequential flood).

Staff Position: NEI 16-05, Section 6.3.1 provides an acceptable method for evaluating the potential impact of flooding under the reevaluated flood parameters on plant conditions.

3.1 Determination of Available Physical Margin

Section 6.3.2 and Appendix B of NEI 16-05 provide a method for determining available physical margin (APM) for passive (including temporary) or active flood protection features.

Staff Position: Section 6.3.2 and Appendix B of NEI 16-05 provide an acceptable method for the determining APM subject to the following clarifications:

1. Section B.2.1.5 to NEI 16-05 relies on the guidance of NEI 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," and NRC letter, "Request for Additional Information [RAI] Associated with Near Term Task Force Recommendation 2.3, Flooding Walkdowns," dated December 23, 2013 (ADAMS Accession No. ML13325A891) for the evaluation of adequacy of plugs and penetration seals. In applying the considerations of the RAI, item 4, licensees should use the reevaluated flooding parameters rather than the current licensing basis flood height.

4. Focused Evaluation Process (Paths 1-3)

Section 7 of NEI 16-05 provides the process for licensees to use in conducting focused evaluations of the various flooding mechanisms.

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

Section 7.1 of NEI 16-05 provides a process for licensees to disposition flood mechanisms for which the flooding parameters are bounded by the design basis flooding parameters of the facility.

Staff Position: Section 7.1 of NEI 16-05 provides an acceptable method for dispositioning flood mechanisms with flooding parameters bounded by the design basis flooding parameters of the facility subject to the following clarification:

1. The second paragraph of Section 7.1 includes the statement that "a bounding set of reevaluated flood parameters, instead of parameters for individual flood-causing mechanisms, can be used in making the flood comparison." Licensees may group sets of flood mechanisms to disposition under Path 1, leaving the remaining flood mechanisms or groups of flood mechanisms to be dispositioned under the other paths of NEI 16-05.

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

Section 7.2 and Appendix B of NEI 16-05 provide a process for licensees to disposition flood mechanisms for which the facility's flood protection is effective. The process of Section 7.2 builds upon that of Section 6.3.2, but may be based on a refined hazard as developed under NEI 16-05, Section 6.1 and staff position in Section 2 of Enclosure 1 of this ISG.

Appendix C of NEI 16-05 provides a method for assessing the manual actions necessary for reliance on the flood protection features where appropriate.

Staff Positions:

1. Section 7.2 and Appendix B of NEI 16-05 provide an acceptable method for the evaluating the effectiveness of flood protection.

2. Appendix C to NEI 16-05 provides an acceptable method for evaluation of the site response. NRC staff reviewing the operator actions associated with flood protection using Appendix C to NEI 16-05 should exercise engineering and operational judgment in assessing the site response.

3. Section B.2.1.5 to NEI 16-05 relies on the guidance of NEI 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," and NRC letter, "Request for Additional Information [RAI] Associated with Near Term Task Force Recommendation 2.3, Flooding Walkdowns," dated December 23, 2013 (ADAMS Accession No. ML13325A891) for the evaluation of adequacy of plugs and penetration seals. In applying the considerations of the RAI, item 4, licensees should use the reevaluated flooding parameters rather than the current licensing basis flood height.

4. In addition to the considerations described in Section B.2.3 for temporary features, licensees should consider operating experience in assessing the reliability of temporary barriers and demonstrating effective protection.

4.3 Path 3: Demonstrate a Feasible Response to Local Intense Precipitation (Box 7-8)

Section 7.3 of NEI 16-05 provides a process for licensees to disposition instances where the LIP flood mechanism is not bounded by the design basis flooding parameters of the facility.

Staff Position: As discussed in COMSECY-15-0019:

> licensees [with LIP hazards exceeding their current design-basis flood should] 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. This assessment includes evaluation and justification for: crediting systems that were assumed clogged during the hazard reevaluations; and considering available warning time and flood protection measures, both permanent and temporary, as well as associated manual actions.

Licensees may use the process described in the NEI White Paper, "Warning Time for Maximum Precipitation Events," dated April 8, 2015 (ADAMS Accession No. ML15104A157), and the related NRC letter dated April 23, 2015 (ADAMS Accession No. ML15110A080), in order to take advantage of warning time for LIP.

Section 7.3 of NEI 16-05 provides an acceptable approach to implement the principles discussed in COMSECY-15-0019 for dispositioning LIP hazards that are not bounded by the design basis flooding parameters of a facility subject to the following clarification:

a. Licensees should assess protection of key SSCs as defined in NEI 16-05 with the considerations described in Section 4.2. Protection should include considerations described in NEI 16-05, Appendix B. If it is not practical to protect key SSCs from the LIP hazards, licensees should attempt to mitigate the impact of the LIP on key SSCs. Demonstration of mitigation capability could include reliance on the mitigating strategies assessment for LIP.

NRC staff reviewing the plant response evaluation for LIP should apply engineering and operational judgment.

5. Full Scope Integrated Assessment Process (Paths 4-5)

Section 8 of NEI 16-05 provides the process for licensees to use in conducting revised integrated assessments of the various flooding mechanisms.

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

Section 8.1 of NEI 16-05 provides one process for licensees to perform a revised integrated assessment of flood mechanisms that are not bounded by the design basis flood hazard of a facility.

Appendix C of NEI 16-05 provides a method for assessing the manual actions necessary for flood mitigation or reliance on the flood protection features where appropriate.

Appendix D of NEI 16-05 provides resources for estimating frequencies of exceedance for flooding mechanisms in the 10^{-3}/year to 10^{-4}/year range.

Staff Position: NEI 16-05, Section 8.1, and Appendix C provide an acceptable method to perform a revised integrated assessment subject to the following clarifications:

1. In addition to the key elements listed in NEI 16-05, the licensee should provide corresponding information to address the critical flood elevations identified for the flood mechanism under consideration under NEI 16-05, Section 6.3.1, and this document, Section 3.

2. NEI 16-05, Appendix C provides an acceptable method for evaluation of the site response. NRC staff reviewing the operator actions associated with Path 4 using Appendix C to NEI 16-05 should exercise engineering and operational judgment in assessing the site response.

3. NEI 16-05, Appendix D provides available methods for estimating frequencies greater than 10^{-4}/year. When applying these methods, the licensees should consider the attributes described in Enclosure 2 of this ISG along with the following clarifications:

   a. Appendix D, Section D.2, compiles selected methods and references related to developing a probabilistic characterization of flooding hazards that have been used primarily in applications not related to nuclear power plants. When applying methods and references provided in Section D.2, licensees should assess the methods and references to:
      - Verify that that references have not been superseded or rescinded due to identified technical inadequacies or shortcomings. Limitations on rescinded references do not apply to documents that have been administratively withdrawn for reasons not related to technically adequacy (e.g., due to administrative schedules associated with Standards).
      - Ensure context and caveats related to the numerical values in Table D-1 (as described in USBR, 2004) and Figure D-1 as well as the methods and references described in Table D-2 are addressed.

   b. To establish the frequency of exceeding a given measure of flood severity, the licensee should aggregate the contributions from a range of potential flooding mechanisms and relevant contributing events and should not limit the assessment to development of frequencies associated with deterministic event combinations (e.g., combinations identified in NUREG/CR-7046) shown in Section D.3.

   Staff will review licensee evaluations on a case-by-case basis to ensure references and methods are applied appropriately and that evaluations have suitable attributes.

4. Information submitted to the NRC should include the frequency of exceedance for the critical flood elevations or (if appropriate) should identify that the frequency of exceedance for the critical flood elevations is estimated to be less than 1E-4/year.

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

Section 8.2 of NEI 16-05 provides another process for licensees to perform a revised integrated assessment of flood mechanisms that are not bounded by the design-basis flood hazard of a facility.

Appendix C of NEI 16-05 provides a method for assessing the manual actions necessary for flood mitigation or reliance on the flood protection features where appropriate.

Appendix D of NEI 16-05 provides resources for estimating frequencies of exceedance for flooding mechanisms in the 10^{-3}/year to 10^{-4}/year range.

Staff Position: NEI 16-05, Section 8.1, and Appendix C provide an acceptable method to perform a revised integrated assessment subject to the following clarifications:

1. Development and characterization of the scenarios under NEI 16-05, Section 8.2.2, should include scenarios for the flooding mechanism under consideration at the critical flood elevations identified under NEI 16-05, Section 6.3.

2. Identification of scenarios with effective flood protection under NEI 16-05, Section 8.2.3, should include the considerations of NEI 16-05, Section 7.2, and Section 4.2 of this ISG.

3. NEI 16-05, Appendix C provides an acceptable method for evaluation of the site response. NRC staff reviewing the operator actions associated with Path 5 using Appendix C to NEI 16-05 should exercise engineering and operational judgment in assessing the site response.

4. NEI 16-05, Appendix D provides available methods for estimating frequencies greater than 10^{-4}/year. When applying these methods the licensees should consider the attributes described in Enclosure 2 of this ISG along with the following clarifications:

    a. Appendix D, Section D.2, compiles selected methods and references related to developing a probabilistic characterization of flooding hazards that have been used primarily in applications not related to nuclear power plants. When applying methods and references provided in Section D.2, licensees should assess the methods and references to:
        - Verify that that references have not been superseded or rescinded due to identified technical inadequacies or shortcomings. Limitations on rescinded references do not apply to documents that have been administratively withdrawn for reasons not related to technically adequacy (e.g., due to administrative schedules associated with Standards).
        - Ensure context and caveats related to the numerical values in Table D-1 (as described in USBR, 2004) and Figure D-1 as well as the methods and references described in Table D-2 are addressed.

    b. To establish the frequency of exceeding a given measure of flood severity, the licensee should aggregate the contributions from a range of potential flooding mechanisms and relevant contributing events and should not limit the assessment to

development of frequencies associated with deterministic event combinations (e.g., combinations identified in NUREG/CR-7046) shown in Section D.3

Staff will review licensee evaluations on a case-by-case basis to ensure references and methods are applied appropriately and that evaluations have suitable attributes.

Probabilistic Flood Hazard Assessment for Phase 2 Decisionmaking

1. Introduction

The primary focus of this enclosure is on estimating flooding hazards associated with (approximately mean) frequencies of exceedance of 10^{-3} and 10^{-4}/year to support Phase 2 decisionmaking. The attributes defined in this document are developed with cognizance of the current state of practice and limitations arising from the timelines associated with the post-Fukushima activities. Future guidance related to probabilistic flood hazard assessment (PFHA) and the development of flooding hazard curves may differ.

2. Overview of Probabilistic Flood Hazard Assessment

The PFHA is a systematic assessment of the likelihood that a specified parameter or set of parameters representing flood severity (e.g., flood elevation, flood event duration, and parameters related to associated effects) will be exceeded at a site or in a region based on a site-specific evaluation. The PFHA is typically used to develop a hazard curve, which provides the annual frequency of exceedance for various levels of flood severity. However, for the purposes of this ISG, the focus is on estimating flooding hazards associated with (approximately mean) frequencies of exceedance of 10^{-3} and 10^{-4}/year.

Generally, the key components of a PFHA are:

1. assembly of the analysis team
2. identification of relevant flood-causing mechanisms and plausible combinations
3. selection and use of technically defensible data, models, and methods
4. treatment of uncertainties and quantification of probabilistically-defined hazard
5. documentation of PFHA activities

A peer review provides additional confidence in the results of the licensee's evaluation. The above key components are relevant to a full PFHA as well as an assessment focused on frequencies of exceedance of 10^{-3} and 10^{-4}/year that are relevant to the purposes of this ISG.

3. Consistency with State of Practice to the Extent Appropriate

Probabilistic methods for assessment of flooding hazards are used in applications not related to nuclear power plants (e.g., to develop inundation maps for flood insurance, emergency evacuation plans, coastal protection structures, and design and maintenance of dams and levees). These applications typically do not consider the full range of return periods of relevance to nuclear power plant sites and may focus on portfolio rather than site-specific assessments. Due to the quality and characteristics of available data as well as differing needs of these other applications, when applying methods used in these other applications (including conventional flood frequency analysis), the licensee should account

for site-specific considerations; limitations and shortcomings associated with these methods; and limitations of available data. The licensee should provide a more comprehensive and systematic treatment of uncertainty and larger ranges of parameters than needed for studies focused on shorter return periods or applications not related to nuclear power plants. The licensee should justify and document that the assessment sufficiently addresses limitations, shortcomings, and uncertainties.

4. High-Level Attributes

4.1. Analysts

The analysts performing the assessment should have expertise in the fields of relevance to the flood-causing mechanisms considered (e.g., hydrology, meteorology, oceanography) and the analysts should be capable of representing technical views that are appropriately diverse and complementary.

4.2. Identification of Relevant Flood-Causing Mechanisms and Plausible Combinations

As part of a full PFHA, the licensee should capture the contributions to the annual exceedance frequency of a specified parameter (or sets of parameters) representing flood severity from all relevant and significant flood hazard mechanisms affecting the site, including combinations of phenomena. Capturing the contributions from multiple mechanisms may involve development of a composite or multiple flood hazard curves corresponding to multiple mechanisms and scenarios. However, under the March 12, 2012 request for information and for the purposes of this ISG, the analysis may instead focus on a smaller subset of the hazard mechanisms (i.e., those not bounded by the design-basis), which differs from a full external flooding probabilistic risk analysis that would include all relevant mechanisms. Section 5 describes mechanism-specific considerations.

4.3. Selection and Use of Technically Defensible Data, Models, and Methods

The licensee should use models and methods consistent with the existing state of practice for the range of annual exceedance frequencies considered. This will involve use of statistical or probabilistic methods augmented by a realistic mechanistic treatment of hazards. Licensees also may opt to use simplified and bounding approaches or assumptions however it is useful to understand how use of these simplifying and bounding assumptions may affect key insights and conclusions related to Phase 2 decisions. The licensee should justify the models and methods used and the associated level of detail.

The licensee should compile and use up-to-date information for the relevant phenomena consistent with the models and methods selected. Relevant information may include:

- site-specific data augmented by regional, historical, and paleoflood data (as available or applicable) that reflect the current state of knowledge

- recent site hydrologic surveys or survey/walkdowns of the site to establish site topography and identify features that would affect site flow, including site drainage
- regional information and surveys to develop topography and bathymetry (at appropriate spatial scales) and to characterize land use and land cover for use in mechanistic models or for use by experts (as applicable to the mechanism considered)
- information needed to define or represent the uncertainty in data, models, and methods (e.g., information needed to develop probability distributions for relevant model parameters and information regarding potential errors in recorded data)
- information regarding the operation of dams and other river regulation methods (e.g., operating rules, curves, procedures and known future operational plans) and operating history for regulated river systems (if available).
- site procedures and features (e.g., exposed structures, systems, and components; diversion features, drainage features; or a combination thereof) that may affect the flow or accumulation of water on site.

Some of the above information may be available from the FHRR and supporting documents. Otherwise the licensee should collect existing information from alternate sources. The licensee should identify the quality and limitations of available data.

4.4. Treatment of Uncertainties and Quantification of Probabilistically-Defined Hazard

The licensee should characterize the site flood hazard using relevant parameter(s) that represent flood severity (such as flood height), parameters related to associated effects, and flood event duration.[1] Rather than carrying out a PFHA on all relevant parameters, for the purposes of this ISG, the licensee may, as a simplifying assumption, focus on estimating the annual frequencies of exceedance with respect to a single relevant parameter used to represent flood severity (e.g., flood elevation or river discharge) and treat other flood parameters implicitly (e.g., debris loads). The licensee should provide justification that the parameter(s) chosen to represent flood severity are consistent with the parameter(s) needed for subsequent component or plant response analysis. The licensee should account for differences in the severity of flood hazard at different locations at the site, as appropriate.

The licensee should identify important sources of aleatory variability and epistemic uncertainty for each flood mechanism (e.g., using sensitivity studies to identify input parameters that have a significant effect on the output of numerical models). Aleatory variability is typically represented by probability distributions (e.g., distributions on storm or snowmelt parameters) and expressed as a hazard curve. Epistemic uncertainty is typically

[1] "*Associated effects"* may include factors such as wind waves and runup effects; hydrodynamic loading, including debris; sediment deposition; erosion; concurrent site conditions, including adverse weather conditions; and groundwater ingress.

expressed by including various technical interpretations (e.g., alternate data sources, options for filtering data, or alternate functional forms for probability distributions) and developing multiple hazard curves or estimates. Given the timelines associated with post-Fukushima activities, complete treatment of aleatory variability and epistemic uncertainty may not be feasible. Nonetheless, the licensee should consider and assess the impact of important sources of uncertainty qualitatively or quantitatively.

To address some sources of aleatory variability, the licensee may utilize simplifying and bounding assumptions (e.g., fixing parameters at reasonably bounding values rather than accounting for their variability); however, it is useful to understand how use of these simplifying and bounding assumptions affect key insights and conclusions related to Phase 2 decisions. To address important sources of epistemic uncertainties, the licensee should, at a minimum, perform sensitivity studies that consider reasonable changes to key components and assumptions (e.g., alternate functional forms for distribution models) and quantify the effects of changes on estimated hazards. The licensee should document results and justify that the sensitivity studies are adequate to provide a reasonable representation of the effect of important sources of epistemic uncertainty.

4.5. Documentation

The licensee should document the following information:

- process used to identify relevant external flood hazard mechanisms
- the approach used to perform the PFHA
- the data, models, and methods used
- the basis for including or excluding data, models, and methods in the analysis
- key assumptions
- treatment of uncertainties
- the results of the PFHA
- (if conducted) the results of peer review, including disposition of comments

4.6. Peer Review

Due to the complexity of some flood mechanisms, subjective judgements are necessary in estimating flood frequencies of 10^{-3} and 10^{-4}/year that are relevant to the purposes of this ISG. To increase the efficiency of NRC staff review, an independent[2] peer review is recommended. The peer review should focus on the following key factors:

- the treatment of aleatory variability and epistemic uncertainty
- the treatment of combined events (e.g., storm surge and river flooding; river flooding concurrent with wind events) and the means by which the hazard contributions from the mechanisms are aggregated

[2] An independent peer reviewer has no conflicts of interest that may influence the outcome of the peer review.

- key assumptions
- selection of data, models, and methods, including validations and verifications.

The peer reviewers should have expertise in the fields of relevance to the analysis and the flood-causing mechanisms considered. The peer reviewers should be capable of representing technical views that are appropriately diverse and complementary. For example, in the case of the assessment of storm surge hazard in estuarine environments, fields of relevance include meteorology, (river) hydrology and hydraulics, oceanography, numerical modeling, and probabilistic hazard assessment. The peer review team should generate a formal report and the licensee should document how it dispositioned the peer review findings.

5. Mechanism-Specific Considerations

The following sections identify considerations (typically associated with aleatory variability) that may be relevant to classes of flood mechanisms. The licensee should review the lists provided below and, if appropriate, address the considerations within the assessment. In some cases, licensees have addressed the considerations described below as part of previously performed deterministic assessments. Considerations associated with local intense precipitation (LIP) are not described below because licensees will address LIP using a focused evaluation.

5.1. Riverine Flooding Without Upstream Dams

The following list provides considerations for use in the probabilistic assessment of flooding hazards from riverine flooding.

- flood history of the watershed including local and regional precipitation and river levels
- aleatory variations in storm loading patterns (e.g., precipitation depth, area, and duration as well as spatial and temporal distribution)
- warm and cold season events (e.g., conditions associated with melting of winter snowpack)
- approaches to address uncertainties and limitations of data collection instruments (e.g., site-specific techniques used to quality control data)
- engineered and natural features affecting site flood severity (e.g., permanent and temporary features, downstream impoundments, and adjacent levees)
- basis for:
  - site and watershed initial and boundary conditions
  - site and watershed hydrologic and hydraulic models
  - selection of parameters describing watershed characteristics (e.g. roughness, channel profiles, channel cross-sections, ineffective flow areas)
  - storm characteristics and parameter combinations considered (e.g., duration; area; time intervals; monthly, seasonal, yearly rain patterns; distribution in time and space and associated uncertainties)

5.2. Riverine Flooding With Upstream Dams

The following list provides considerations for use in the probabilistic assessment of flooding hazards from riverine flooding with upstream dams or similar impoundment features (e.g., levees).

- all elements applicable to riverine flooding (Section 5.1)
- dam operating guidelines, operational history (if available) and future operational plans (if any) (e.g., releases and reservoir levels, flood control and release plans, and design and current reservoir capacities)
- dam condition (e.g., condition reports, or other assessments), age, and refurbishments
- type of dam (e.g., dam construction and relevant design characteristics)
- seismic, hydrological, and other failures of onsite and offsite impoundments
- treatment of non-consequential dams
- treatment of downstream dam failure
- uncertainties associated with dam breach parameter estimates and breach modeling
- likely plausible dam failure scenarios with associated uncertainties for each scenario.

5.3. Storm Surge (tropical or extratropical cyclones) and Seiche

The following list provides considerations for use in the probabilistic assessment of flooding hazards from storm surge and seiche.

- basis for resonant frequency estimates, if used
- contribution from tropical and extratropical events
- historical data augmented, as appropriate, by reanalysis or synthetic data sources filtered for the geographic region, including identification of limitations of available data
- numerical wind field and surge models and model uncertainties
- basis for and uncertainties associated with:
  - selection of methodology (e.g., Joint Probability Method or Empirical simulation Technique)
  - filtering of data
  - storm recurrence rate
  - relevant storm parameters and their distributions
  - application of wind, surge, and wave models
  - bathymetry and site topography
  - features affected by surge propagation or characteristics (e.g., seawalls, embankments)