

RECOMMENDATION 2.1: FLOODING

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC or Commission) is issuing this information request for the following purposes:

- To gather information with respect to Near-Term Task Force (NTTF) Recommendation 2.1, as amended by staff requirements memoranda (SRM) associated with SECY-11-0124 and SECY-11-0137, and the Consolidated Appropriations Act, for 2012 (*Pub Law 112-74*), Section 402, to reevaluate seismic and flooding hazards at operating reactor sites
- To collect information to facilitate NRC's determination if there is a need to update the design basis and systems, structures, and components (SSCs) important to safety to protect against the updated hazards at operating reactor sites
- To collect information to address Generic Issue (GI) 204 regarding flooding of nuclear power plant sites following upstream dam failures

Pursuant to Sections 161.c, 103.b, and 182.a of the Atomic Energy Act of 1954, as amended, and Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), addressees are required to submit a written response to this information request.

BACKGROUND

The SSCs important to safety in operating nuclear power plants are designed either in accordance with, or meet the intent of Appendix A to 10 CFR Part 50, General Design Criteria (GDC) 2. GDC 2 states that SSCs important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability to perform their intended safety functions. The design bases for these SSCs reflect consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases also reflect margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

In response to the accident at the Fukushima Dai-ichi nuclear power plant caused by the March 11, 2011, Tohoku earthquake and subsequent tsunami, the Commission established the NTTF to conduct a systematic review of NRC processes and regulations, and to make recommendations to the Commission for its policy direction. The NTTF developed a set of recommendations that are intended to clarify and strengthen the regulatory framework for protection against natural phenomena. The purpose of this letter is to gather information related to NTTF Recommendation 2.1 for flooding hazards. Recommendation 2.1, as amended by the SRMs associated with SECY-11-0124 and SECY-11-0137, instructs the NRC staff to issue requests for information to licensees pursuant to Sections 161.c, 103.b, and 182.a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). This letter requests licensees and holders of construction permits under 10 CFR Part 50 to reevaluate the flooding hazards at their sites against present-day regulatory guidance and methodologies being used for early site permits and combined license reviews (SECY-11-0124, Staff Recommendations 2 and 4 for

NTTF Recommendation 2.1). This request is consistent with and required by the Consolidated Appropriations Act for 2012 (*Pub Law 112-74*), Section 402.

In developing Recommendation 2.1, the NTTF recognized that, "since the establishment of GDC 2, the NRC's requirements and guidance for protection from seismic events, floods, and other natural phenomena has continued to evolve," and that "as a result, significant differences may exist between plants in the way they protect against design-basis natural phenomena and the safety margin provided."

Since the issuance of GDC 2 in 1971, the NRC has developed new regulations, regulatory guidance, and several regulatory programs aimed at enhancements for previously licensed reactors. A summary of these regulatory programs for enhancements are described in Section 4.1.1 of the NTTF report. From this summary, items of note with regard to flooding include the individual plant examination of external events (IPEEE) program, the new requirement in 10 CFR 100.20 for applications after January 10, 1997, and efforts underway to update Regulatory Guide (RG) 1.59, "Design Basis Floods for Nuclear Power Plants."

Individual Plant Examination of External Events:

On June 28, 1991, the NRC issued Supplement 4 to Generic Letter (GL) 88-20, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML031150485) to request that each licensee identify and report to the NRC all plant-specific vulnerabilities to severe accidents caused by external events. The IPEEE program included the following four supporting objectives:

- (1) Develop an appreciation of severe accident behavior.
- (2) Understand the most likely severe accident sequences that could occur at the licensee's plant under full-power operating conditions.
- (3) Gain a qualitative understanding of the overall likelihood of core damage and fission product releases.
- (4) Reduce, if necessary, the overall likelihood of core damage and radioactive material releases by modifying, where appropriate, hardware and procedures that would help prevent or mitigate severe accidents.

The external events to be considered in the IPEEE were: seismic events; internal fires; high winds, floods, and other external initiating events, including accidents related to transportation or nearby facilities, and plant-unique hazards.

In most cases, licensees used a qualitative progressive-screening approach in lieu of a more quantitative approach to assess the flooding hazard. NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," volumes 1 and 2 issued April, 2002 (ADAMS Accession Nos. ML021270070 and ML021270674) states that "given the substantial uncertainties involved in developing site-specific flood hazard curves, a consideration of possible combinations of multiple effects causing a range of flood levels would have enhanced the robustness of some of the licensee's analyses and lent greater confidence

to their findings.” It should be noted that the term “vulnerability” was not defined in GL 88-20. Instead, GL 88-20 states that licensees should provide a discussion on how vulnerability is defined for each external event evaluated. NUREG-1742 notes that “as a result, the use of the term vulnerability varied widely among the IPEEE submittals...Some licensees avoided the term altogether, other stated that no vulnerabilities existed at their plant without defining the word, and still others provided a definition of vulnerability along with a discussion of their findings.”

New Requirements for Evaluation of Dam Hazards in 10 CFR 100.20:

The staff established a new requirement in 10 CFR 100.20, “Factors to be Considered when Evaluating Sites,” in 1996. The requirement in 10 CFR 100.20(b) states that for applications submitted on or after January 10, 1997, the nature and proximity of man-related hazards must be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards, and whether the risk of other hazards is very low. A parenthetical statement in the new regulation specifically identifies dams as hazards to be evaluated at a plant site.

Tsunami and Regulatory Guide 1.59 Updates:

Following the Sumatra earthquake and its accompanying tsunami in December 2004, the NRC staff initiated a study to examine tsunami hazards at power plant sites. Study results are documented in NUREG/CR-6966, “Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America,” which was published in March 2009. As the NTTF report notes, “while tsunami hazards are not expected to be the limiting flood hazard for operating plants sited on the Atlantic Ocean and the Gulf of Mexico, plants in these coastal regions do not currently include an analysis of tsunami hazards in their licensing basis.”

Regulatory Guide 1.59, “Design Basis Floods for Nuclear Power Plants,” was originally issued in 1973. The most recent version is Revision 2, published in 1977, including an errata dated July 1980, and a substitution of methods presented in Appendix A (ADAMS Accession No. ML003740388). NRC staff is in the process of updating RG 1.59 to address advances in flooding analysis in the 35 years since Revision 2 was published. Although the update to RG 1.59 update is not complete, NUREG/CR7046, “Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America,” was published in November 2011. This report documents present-day methodologies used by the NRC to review early site permits (ESPs) and combined license (COL) applications.

GI-204: Flooding of Nuclear Power Plant Sites following Upstream Dam Failures:

Page 28 of the NTTF report states that, “In August 2010, the NRC initiated a proposed GI regarding flooding of nuclear power plant sites following upstream dam failures.” The NRC staff approved this generic issue as GI-204 on February 29, 2012. The staff notes that the flood hazard information gathered by this 10 CFR 50.54(f) request will be applicable to the resolution of GI-204.

APPLICABLE REGULATORY REQUIREMENTS

- 10 CFR 50.34(a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4)
- 10 CFR 50.54, “Conditions of Licenses”
- Appendix A, “General Design Criteria for Nuclear Power Plants,” to 10 CFR Part 50, GDC 2, “Design Bases for Protection against Natural Phenomena”
- Appendix A, “Seismic and Geologic Siting Criteria for Nuclear Power Plants,” to 10 CFR Part 100
- Subpart B, “Evaluation Factors for Stationary Power Reactors Site Applications On or After January 10, 1997,” to 10 CFR Part 100

In GDC 2 it states that SSCs important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to reflect sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for applications on or after January 10, 1997) states, in part, that the physical characteristics of the site, including hydrology, must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site (10 CFR 100.21(d)). Factors to be considered when evaluating sites includes the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.20(c)).

DISCUSSION

The NTF recommended that the Commission direct several actions to ensure adequate protection from natural phenomena, consistent with the current state of knowledge and analytical methods. These actions should be undertaken to prevent fuel damage and to ensure containment and spent fuel pool integrity. In particular, Recommendation 2.1 states, “Order licensees to reevaluate the seismic and flooding hazards at their sites against current NRC requirements and guidance, and if necessary, update the design basis and SSCs important to safety to protect against the updated hazards.”

Staff assessment of Recommendation 2.1 is discussed in SECY-11-0124. Staff noted that the assumptions and factors that were considered in flood protection at operating plants vary. In some cases, the design bases did not consider the effects from local-intense precipitation and related site drainage. In other cases, the probable maximum flood is calculated differently at units co-located at the same site, depending on the time of licensing, resulting in different

design-basis flood protection. The NTTF and the staff noted that some plants rely on operator actions and temporary flood mitigation measures such as sandbagging, temporary flood walls and barriers, and portable equipment to perform safety functions. For several sites, the staff noted that not all appropriate flooding hazards are documented in the updated final safety analysis report. The NTTF and the staff also noted that flooding risks are of concern because of a “cliff-edge” effect, in that the safety consequences of a flooding event may increase sharply with a small increase in the flooding level. Therefore, the staff concluded that all licensees should confirm that SSCs important to safety are adequately protected from flooding hazards.

In the SRM to SECY-11-0124 the Commission approved the staff’s proposed actions, which were to implement the NTTF recommendations as described in the SECY without delay. With regard to reevaluating flooding hazards, staff’s approved actions are to:

1. Initiate stakeholder interactions to discuss application of present-day regulatory guidance and methodologies being used for ESP and COL reviews to the reevaluation of flooding hazards at operating reactors.
2. Develop and issue a request for information to licensees pursuant to 10 CFR 50.54(f) to:
 - a. reevaluate site-specific flooding hazards using the methodology discussed in Item 1 above, and
 - b. identify actions that have been taken or are planned to address plant-specific vulnerabilities associated with the updated flooding hazards.

The SRM to SECY-11-0124 also directed the NRC staff to do the following:

- For Recommendation 2.1, when the staff issues the requests for information to licensees pursuant to 10 CFR 50.54(f) to identify actions that have been taken or are planned to address plant-specific vulnerabilities associated with the reevaluation of seismic and flooding hazards, the staff should explain the meaning of “vulnerability.”
- The staff should inform the Commission, either through an Information Paper or briefing of the Commissioners’ Assistants, when it has developed the technical bases and acceptance criteria for implementing Recommendation 2.1, 2.3, and 9.3.

Additionally, the Consolidated Appropriations Act, for 2012 (*Pub Law 112-74*), Section 402, directs the NRC to “require reactor licensees to reevaluate the seismic, tsunami, flooding, and other external hazards at their sites against current applicable Commission requirements and guidance for such licensees as expeditiously as possible, and thereafter, when appropriate, as determined by the Commission, and require each licensee to respond to the Commission that the design basis for each reactor meets the requirements of its license, current applicable Commission requirements and guidance for such license.” These other external hazards can include meteorological and other natural phenomena that could reduce or limit the capacity of safety-related cooling water supplies. These other external hazards will be addressed separately from this information request.

Following the Commission's direction to implement the staff's proposed actions without delay, the NRC staff will implement Recommendation 2.1 in two phases, as follows:

- Phase 1: Issue 10 CFR 50.54(f) letters to all licensees to reevaluate the seismic and flooding hazards at their sites against present-day regulatory guidance and methodologies used for ESP and COL reviews.
- Phase 2: If necessary, and based upon the results of Phase 1, determine whether additional regulatory actions are necessary (e.g., update the design basis and SSCs important to safety) to protect against the updated hazards

This information request addresses only Phase 1; Phase 2 will be conducted after receiving responses to this request.

The NRC staff will interact with industry and stakeholders to develop approaches that can be applied in a uniform and consistent manner across the different sites and plant conditions. This type of an integrated approach will allow the NRC and industry time to assess the significance of any new information related to the hazard evaluation in a systematic manner. This approach is also consistent with Commission direction to initiate stakeholder interactions. As such, responses to this request for information are expected in stages, as outlined in the Required Response section.

Because of the experience gained by both the NRC and the industry in preparing and reviewing numerous ESPs and COLs, present-day methodologies associated with evaluating flooding hazards at plant sites are well documented. It is anticipated that some interactions will be required with the industry and other stakeholders on particulars associated with implementing these methodologies for the existing plants (e.g., certain data collection activities are likely to be needed). However, the timeframe outlined in the requested response section takes this into account. General steps to develop the flooding hazard evaluation are discussed under the requested actions section below, and detailed steps are provided in Attachment 1.

Information related to the identification of actions that will be taken or planned to be taken to address plant-specific vulnerabilities will inform staff's development of "acceptance criteria" necessary to conduct Phase 2, or to address other regulatory actions as necessary. The approaches and methodology used to develop this information requires multiple interactions between the NRC staff, industry, and other stakeholders. The timeframe discussed in the requested response section explicitly recognizes this aspect.

REQUESTED ACTIONS

Addressees are 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, tsunamis, and dam failures. It is requested that the reevaluation apply present-day regulatory guidance and methodologies being used for ESP and COL reviews including current techniques, software, and methods used in present-day standard engineering practice to develop the flood hazard. The requested information will be gathered in

Phase 1 of the NRC staff's two phase process to implement Recommendation 2.1, and will be used to identify potential vulnerabilities¹.

For the sites where the reevaluated flood exceeds the design basis, addressees are requested to submit an interim action plan that documents actions planned or taken to address the reevaluated hazard with the hazard evaluation.

Subsequently, addressees should perform an integrated assessment of the plant to identify vulnerabilities and actions to address them. The scope of the integrated assessment report will include full power operations and other plant configurations that could be susceptible due to the status of the flood protection features. The scope also includes those features of the ultimate heat sinks (UHS) that could be adversely affected by the flood conditions and lead to degradation of the flood protection (the loss of UHS from non-flood associated causes are not included). It is also requested that the integrated assessment address the entire duration of the flood conditions.

REQUESTED INFORMATION

The NRC staff requests that each addressee provide the following information. Attachment 1 provides additional information regarding present-day methodologies and guidance used by the NRC staff performing ESP and COL reviews. The attachment also provides a stepwise approach for assessing the flood hazard that should be applied to evaluate the potential hazard from flood causing mechanisms at each licensed reactor site.

1. Hazard Reevaluation Report

Perform a flood hazard reevaluation. Provide a final report documenting results, as well as pertinent site information and detailed analysis. The final report should contain the following:

- a. Site information related to the flood hazard. Relevant SSCs important to safety and the UHS are included in the scope of this reevaluation, and pertinent data concerning these SSCs should be included. Other relevant site data includes the following:
 - i. detailed site information (both designed and as-built), including present-day site layout, elevation of pertinent SSCs important to safety, site topography, as well as pertinent spatial and temporal data sets
 - ii. current design basis flood elevations for all flood causing mechanisms
 - iii. flood-related changes to the licensing basis and any flood protection changes (including mitigation) since license issuance
 - iv. changes to the watershed and local area since license issuance

¹ A definition of vulnerability in the context of this enclosure is as follows: Plant-specific vulnerabilities are those features important to safety that when subject to an increased demand due to the newly calculated hazard evaluation have not been shown to be capable of performing their intended functions.

- v. current licensing basis flood protection and pertinent flood mitigation features at the site
 - vi. additional site details, as necessary, to assess the flood hazard (i.e., bathymetry, walkdown results, etc.)
- b. Evaluation of the flood hazard for each flood causing mechanism, based on present-day methodologies and regulatory guidance. Provide an analysis of each flood causing mechanism that may impact the site including local intense precipitation and site drainage, flooding in streams and rivers, dam breaches and failures, storm surge and seiche, tsunamis, channel migration or diversion, and combined effects. Mechanisms that are not applicable at the site may be screened-out; however, a justification should be provided. Provide a basis for inputs and assumptions, methodologies and models used including input and output files, and other pertinent data.
 - c. Comparison of current and reevaluated flood causing mechanisms at the site. Provide an assessment of the current design basis flood elevation to the reevaluated flood elevation for each flood causing mechanism. Include how the findings from Enclosure 4 of this letter (i.e., Recommendation 2.3 flooding walkdowns) support this determination. If the current design basis flood bounds the reevaluated hazard for all flood causing mechanisms, include how this finding was determined.
 - d. Interim evaluation and actions taken or planned to address any higher flooding hazards relative to the design basis, prior to completion of the integrated assessment described below, if necessary.
 - e. Additional actions beyond Requested Information item 1.d taken or planned to address flooding hazards, if any.

2. Integrated Assessment Report

For the plants where the current design basis floods do not bound the reevaluated hazard for all flood causing mechanisms, provide the following:

- a. Description of the integrated procedure used to evaluate integrity of the plant for the entire duration of flood conditions at the site.
- b. Results of the plant evaluations describing the controlling flood mechanisms and its effects, and how the available or planned measures will provide effective protection and mitigation. Discuss whether there is margin beyond the postulated scenarios.
- c. Description of any additional protection and/or mitigation features that were installed or are planned, including those installed during course of reevaluating

the hazard. The description should include the specific features and their functions.

- d. identify other actions that have been taken or are planned to address plant-specific vulnerabilities.

REQUIRED RESPONSE

Within approximately 60 days of the date of this information request, NRC staff will determine the priority for each reactor site to complete the hazard reevaluation report. The site priority will determine the submittal date for addressees to provide written responses to Requested Information item 1 (Hazard Reevaluation Report).

In accordance with Sections 161.c, 103.b, and 182.a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f), an addressee must respond as described below.

1. Within 60 days of the date of the NRC's issuance of guidance on implementation details of the Integrated Assessment Report, including criteria for identifying vulnerabilities, submit an approach for developing an Integrated Assessment Report including criteria for identifying vulnerabilities².
2. In accordance with the NRC's prioritization plan, within 1- to 3-years from the date of this information request, submit the Hazard Reevaluation Report. Include the interim action plan requested in item 1.d, if appropriate.
3. Within 2 years following submittal of the Hazard Reevaluation Report to the NRC, any addressee who is requested to complete an Integrated Assessment should submit written responses to Requested Information item 2.

If an addressee cannot meet the requested response date, the addressee must provide a response within 90 days of the date of this information request and describe the alternative course of action that it proposes to take, including the basis of the acceptability of the proposed alternative course of action and estimated completion dates.

The prioritization described above will be based on information from COL and ESP applications, updated hazard levels if new information exists, and site-specific circumstances. This prioritization scheme is intended to use both the NRC and industry resources most effectively.

The required written response should be addressed to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, 11555 Rockville Pike, Rockville, MD 20852, under oath or affirmation under the provisions of Sections 161.c, 103.b, and 182.a of the Atomic

² The NRC staff will develop the implementation details of the Integrated Assessment Report, including criteria for identifying vulnerabilities. This information is scheduled to be developed by November 30, 2012 and the NRC staff will interact with stakeholders, as appropriate during this process.

Energy Act of 1954, as amended, and 10 CFR 50.54(f). In addition, addressees should submit a copy of the response to the appropriate regional administrator.

Attachment 1 to Recommendation 2.1: Flooding Enclosure 2

PROCEDURE

The steps shown in Figure 1 of this attachment represent an acceptable approach to perform the reevaluation of the flood hazard and integrated assessment. The flood hazard reevaluation should address all flood causing mechanisms that are pertinent to the site based on the geographic location and interface of the plant with the hydrosphere. The reason for omitting any of these flood causing mechanisms should be clearly discussed in the final report. A discussion of typical flood causing mechanisms is included below. Many types of flood causing mechanisms are included in that discussion, but it is important to note that each site should address unique characteristics and any additional flood causing mechanisms identified.

Step 1:

All licensees should review information concerning the current flooding hazard against that for which the plant is designed. This information will be used in the following steps for reevaluation of the flood hazard. Pertinent information includes, but is not limited to, the following:

- Current design basis flood hazard
- Flood elevations and other effects considered in the flood protection³ for all flood causing mechanisms.
- Changes in licensing basis since initial licensing including site drainage characteristic and modification, watershed changes, new dam construction, revision of dam operations
- New information pertinent to the hydrologic characteristics including changes to dam operation, new flood studies and changes to meteorological basis (e.g., maximum precipitation studies)
- Pertinent information from site-related or watershed-related studies
- Site changes since issuance of the operating license (new barriers, openings, revised drainage systems, new structures, etc.)
- Flood protection mechanisms and identifying characteristics (e.g., structures and procedures)
- Pertinent features identified in site walkdowns

Step 2:

Reevaluate the flood hazard based on present day regulatory guidance and methodologies for each flood causing mechanism. Using any new site-related information and site details identified in Step 1, evaluate all possible flood causing mechanisms. Documentation of all methodologies should be discussed. This step of the process reiterates the current hierarchical hazard assessment (HHA) used by U.S. Nuclear Regulatory Commission (NRC) staff. The HHA is described as a progressively refined, stepwise estimation of the site-specific hazards that evaluates the safety of the site with the most conservative plausible assumptions consistent with available data.

³ Examples of other effects include dynamic wave effects, scouring, and debris transportation

- (a) Select one flood causing mechanism to be reanalyzed
- (b) Develop a conservative estimate of the site related parameters using simplifying assumptions for a flood causing mechanism and perform the reevaluation.
- (c) Determine if the reevaluated flood hazard elevation (from Step 2b) is higher than the original design flood elevation for the selected flood causing mechanism. If not, use this flood elevation for this causal mechanism in Step 3.
- (d) Determine if the site-related parameters can be further refined. If yes, perform reevaluation (repeat step 2c). If no, use this flood elevation for this causal mechanism in Step 3.
- (e) Determine if all flood causing mechanisms have been addressed. If yes, continue to Step 3. If no, select another flood causing mechanism (Step 2a).

Step 3:

For each flood causing mechanism, compare the final flood elevations from the hazard reevaluation against the current design basis flood elevations. Using this comparison, determine whether the design basis flood bounds each reevaluated hazard from Step 2. If it is determined that the current design basis flood bounds all of the reevaluated hazards, proceed to Step 4. If not all of the reevaluated hazards are bounded by the current design basis flood, proceed to Step 6 for additional analysis.

Step 4:

Submit a report in accordance with Requested Information item 1, Hazard Reevaluation Report. It is anticipated that activities associated with the NTTF Recommendation 2.3 are completed and form a partial basis for the information requested.

Step 5:

No further action is required. This step demonstrates termination of the process for resolution of NTTF Recommendation 2.1.

Step 6: Submit a report in accordance with the Requested Information item 1, Hazard Reevaluation Report, including any relevant information from the results of plant walkdown activities related to NTTF Recommendation 2.3. Also, provide plans for conducting further analysis (steps 7 through 9) and submitting the final report identified in Requested Information item 2.

Step 7:

For the flood causing mechanisms that were not bounded, or for a controlling flood causing mechanism, perform an integrated assessment using the procedures developed in interactions with the NRC staff. The purpose of the integrated assessment is to determine the effectiveness of the existing design basis and any other planned or installed features for the protection and mitigation of flood conditions for the entire duration of the flood.

Step 8:

Identify vulnerabilities, if any, as a result of the assessment conducted in Step 7. Also, identify any planned actions or actions that were already taken to address these vulnerabilities.

Step 9:

Submit a report in accordance with the Requested Information item 2. Include a brief summary of the flood causing mechanisms and the associated parameters that were used in the assessment.

Step 10:

The information provided in Step 9 will be evaluated by the NRC in Phase 2 to consider any additional regulatory actions.

FLOOD CAUSING MECHANISMS

The NRC regulations require that structure, systems and components (SSCs) important to safety of a nuclear power plant are adequately protected from the adverse effects of flooding. The NRC staff discusses the approach for determining the flood hazard for new reactors in its current guidance documents, NUREG-0800 and NUREG/CR-7046.

As part of analyzing the flood hazard, it is important to list all plausible flood causing mechanisms that are capable of generating a severe flood at the site and to recognize that several scenarios of a particular flood causing mechanism can affect the site. For example, extreme precipitation can cause flooding in adjacent rivers, near-by tributaries, and on-site drainage facilities. Similarly, flood causing mechanisms that are not plausible at a particular site may also be ruled out. Present day NRC staff guidance applies the HHA (see NUREG/CR-7046) to each pertinent flood causing mechanism at a site.

The following is a list of flood causing mechanisms that should be addressed in a flood hazard analysis. Site specific characteristics may warrant review of other mechanisms in addition to those listed here.

1. Local Intense Precipitation

Local intense precipitation is a measure of the extreme precipitation at a given location. Generally, local intense precipitation values are developed using methods called Probable Maximum Precipitation (PMP) based on the methods developed by the federal government and published in hydrometeorological reports (HMR) by the National Weather Service. For extreme precipitation, localized precipitation values are developed using methods in HMR 52 (eastern areas of the United States (U.S.)) as well as regionalized reports within the HMR publication series.

The elevation of the site is not relevant for mitigation of flooding from local intense precipitation. The runoff carrying capacity of the site grading design and the performance of any active or passive drainage systems would determine the depth and velocity of surface runoff at the site. Typically, any active drainage system should be considered non-functional at the time of local intense precipitation event. Generally, runoff losses should be ignored during the local intense precipitation event to maximize the runoff. Hydraulic parameters that affect the depth and velocity of flow should be chosen carefully and should be consistent with values used in standard engineering practice.

2. Flooding in Streams and Rivers

The probable maximum flood (PMF) in rivers and streams adjoining the site should be determined by applying the PMP to the drainage basin in which the site is located. The PMF is based on a translation of PMP rainfall on a watershed to flood flow. The estimation of PMP for regional areas within the U.S. is based on HMRs and the appropriate regional report should be used to develop the PMP for a given site and watershed. The PMP is a deterministic estimate of the theoretical maximum depth of precipitation that can occur at a time of year of a specified area. A rainfall-to-runoff transformation function, as well as runoff characteristics, based on the topographic and drainage system network characteristics and watershed properties are needed to appropriately develop the PMF hydrograph. The PMF hydrograph is a time history of the discharge and serves as the input parameter for other hydraulic models which develop the flow characteristics including flood flow and elevation. The U.S. Army Corps of Engineers hydrologic and hydraulic methods are widely accepted in engineering practice. However, unique characteristics or preference of the analysis may dictate use of other models. Appropriate justification for selection of methods, data and models would depend on site-specific circumstances.

3. Dam Breaches and Failures

Flood waves resulting from the breach of upstream dams, including domino-type or cascading dam failures should be evaluated for the site. Water storage and water control structures (such as onsite cooling or auxiliary water reservoirs and onsite levees) that may be located at or above SSCs important to safety should also be evaluated. Additional effects for earthen embankments, such as sediment, should also be considered. Models and methods used to evaluate the dam failure and the resulting effects should be applicable to the type of failure mechanism and should be appropriately justified. Recent analyses completed by State and Federal agencies with appropriate jurisdiction for dams within the watershed may be used.

4. Storm Surge

Storm surge is the rise of offshore water elevation caused principally by the shear force of the hurricane or tropical depression winds acting on the water surface. Technical reports, from the National Oceanic and Atmospheric Administration (NOAA), provide guidance on developing wind fields for a probable maximum hurricane. The wind field parameter is input to coastal hydrodynamics simulation model that predict water surface rise based on the shear forces imparted by the wind. However, appropriate justification for selection of methods, data, and models depends on site-specific circumstances.

5. Seiche

A seiche is an oscillation of the water surface in an enclosed or semi-enclosed water body initiated by an external cause. If a seiche is determined to be possible at the site, then appropriate numerical modeling may be needed. For bays and lakes with irregular geometries and variable bathymetries, numerical longwave hydrodynamics modeling may be the only viable technique to determine hazard.

6. Tsunami

A tsunami is a series of water waves generated by a rapid, large scale disturbance of a water body due to seismic, landslide or volcanic tsunamigenic sources. An assessment with respect to tsunami can include a stepwise approach addressing: the susceptibility of the site's region subject to tsunami, the susceptibility of the plant site affected by tsunami, and specific hazards of the site posed to safety of the plant by tsunami.

7. Ice Induced Flooding

Ice jams and ice dams can cause flooding by impounding water upstream of a site and subsequently collapsing or downstream of a site impounding and backing up water. There is no method to assess a probable maximum ice jam or ice dam, therefore, historical records are generally accessed to determine the most severe historical event in the vicinity of the site. This method is based on an observed historical observation and reasonable margin should be considered.

8. Channel Migration or Diversion

Flood hazard associated with channel diversion is due to the possible migration either toward the site or away from it. For natural channels adjacent to the site, historical and geomorphic processes should be reviewed for possible tendency to meander. For man-made channels, canals or diversions used for the conveyance of water located at a site, possible failure of these structures should be considered.

9. Combined Effect Flood

For flood hazard associated with combined events, American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.

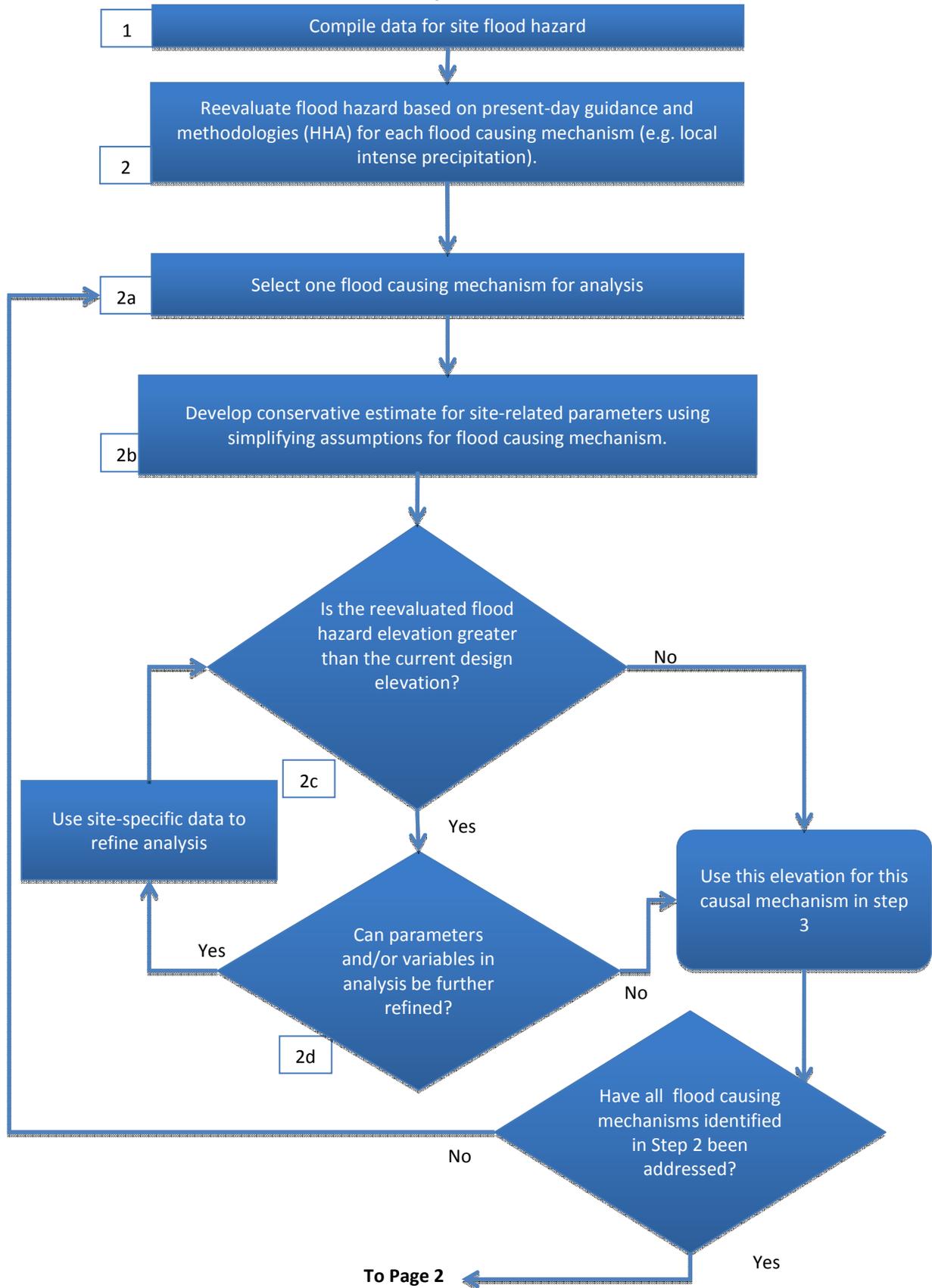


Figure 1. Development of Requested Information and Its Use in Regulatory Analysis. Page 1 of 2

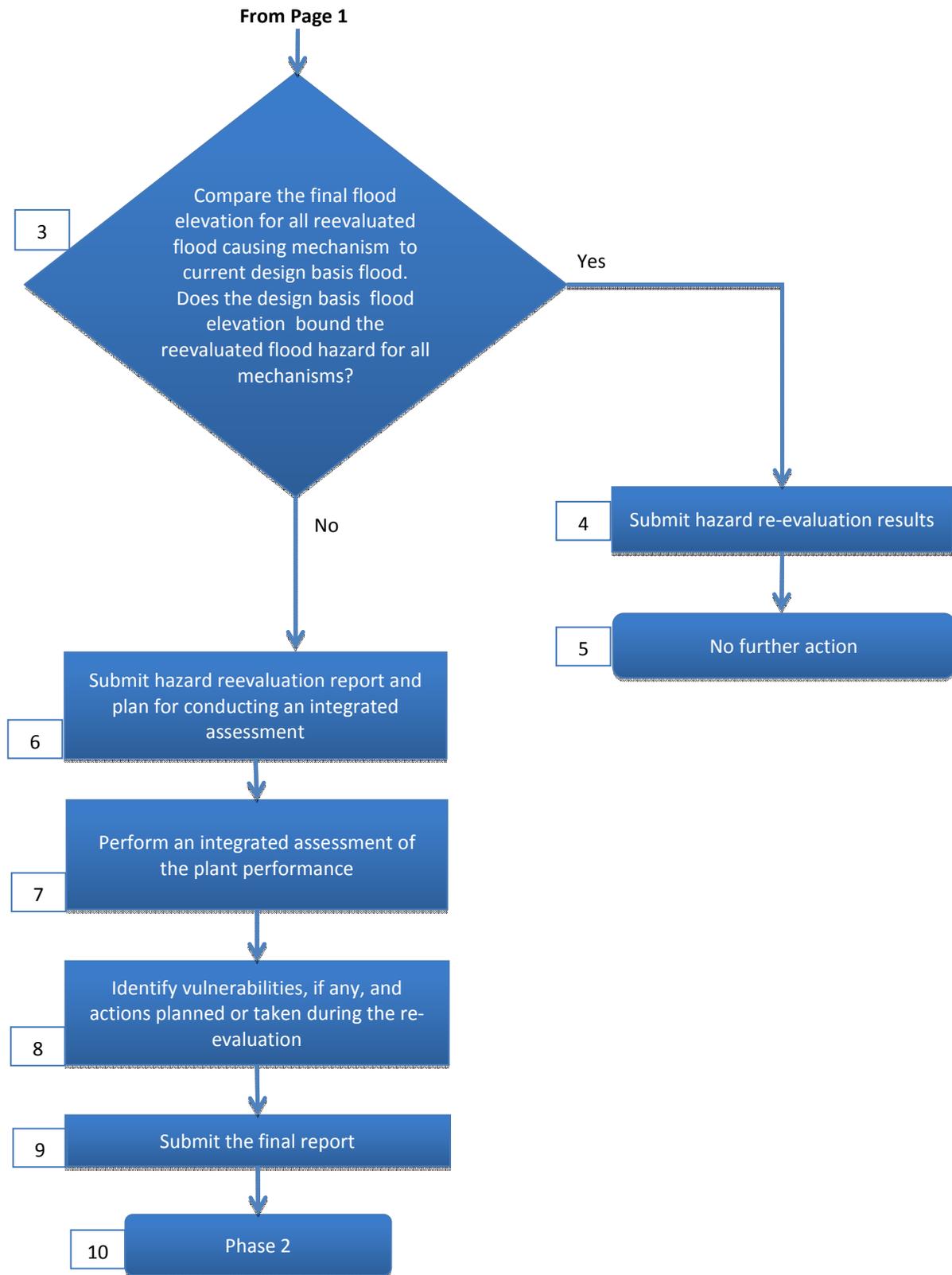


Figure 1. Development of Requested Information and Its Use in Regulatory Analysis. Page 2 of 2

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