GUIDANCE FOR PERFORMANCE OF INTEGRATED ASSESSMENT

GUIDANCE FOR PERFORMANCE OF INTEGRATED ASSESSMENT

1. Introduction

The objective of this document is to provide guidance for performance of the Integrated Assessment. The Integrated Assessment evaluates the total plant response to external flood hazards, considering both the protection and mitigation capabilities of the plant. The purpose of the Integrated Assessment is to: (1) evaluate the effectiveness of the current licensing basis, (2) identify plant-specific vulnerabilities, and (3) assess the effectiveness of existing or planned plant systems and procedures in protecting against flood conditions and mitigating consequences for the entire duration of a flooding event.

In general, the types and attributes of flood protection features used at nuclear power plants are diverse due to differences in factors such as: hazard characteristics (e.g., flood mechanisms, flood durations, and debris quantity), site topography and surrounding environment, and other site-specific considerations (e.g., available warning time). As a result, this guidance must be capable of accommodating the unique environments and characteristics of nuclear power plant sites while ensuring that the information gathered as part of the NRC's March 12, 2012 50.54(f) letter provides a sufficient technical basis to determine if any additional regulatory actions are necessary to protect against external flood hazards.

or design bases?

Trigger is still not clear

Recommendation 2.1 of the NTTF is being implemented in two phases. In Phase 1 licensees and construction permit holders will reevaluate the flooding hazard at each site using present-day regulatory guidance and methodologies. If the reevaluated hazard is not bounded by the current licensing basis flood at the site, licensees and construction permit holders are also requested to perform an Integrated Assessment for external flooding. Phase 2 uses the Phase 1 results to determine whether additional regulatory actions are necessary (e.g., update the licensing basis and SSCs important to safety).

This should be clearly defined.

1.1 Integrated Assessment Concept

Figure 1 provides a conceptual illustration of the Integrated Assessment process. The outcomes of the hazard reviews performed under the Near-Term Task Force (NTTF) Recommendation 2.1 flood hazard reevaluations[1] provide input into the Integrated Assessment Process. Upon entry into the Integrated Assessment process, licensees should evaluate the capability of flood protection systems to meet their intended safety functions under the reevaluated hazard.

If the site flood protection can be shown to have high reliability and margin, the licensee should proceed to documentation and justification of results. If site flood protection cannot be shown to have high reliability and margin, licensees should evaluate the plant's ability to maintain key safety functions during a flood in the event that one or more flood protection systems are compromised and unable to perform their intended functions. In the Integrated Assessment, this step of the process is referred to as an evaluation of mitigation capability and strategies. Upon evaluation of the mitigation capability of the plant, the process proceeds to documentation and justification of results.

[1] See Section 2.3 for additional details on the NTTF Recommendation 2.1 hazard reevaluations and the relationship to the Integrated Assessment.

Delete "may"

In lieu of flood protection, some sites may allow water to enter buildings (or other areas housing structures, systems, or components that are important to safety) by procedure or design. If the presence of water in these locations may adversely affect structures, systems, or components that are important to safety, then the Integrated Assessment process should proceed directly into the evaluation of the mitigation capability of the plant. This is represented by the large arrow on the rightmost side of Figure 1.

Additional details on the Integrated Assessment process are provided in subsequent sections of this document.

Clarifying letter needed

1.2 Scope of Integrated Assessment

In accordance with the March 12, 2012 letter, the scope of the Integrated Assessment includes full-power operations and other plant configurations that could be susceptible to damage due to the status of the flood protection features. The scope also includes flood-induced loss of an ultimate heat sink (UHS) water source (e.g., due to failure of a downstream dam) that could be caused by the flood conditions. (The loss of the UHS from causes other than flooding are not included.) The March 12, 2012 50.54(f) letter also requests that the Integrated Assessment address the entire duration of the flood conditions. [#additional text under development]

2. Background

2.1 Actions and Information Requested

design basis vs licensing basis. This paragraph refers to "design basis" which mirrors the 50.54(f) letter. This is the correct term, however elsewhere in the document current licensing basis is used interchangeably

For the sites where the reevaluated flood is not bounded by the current design basis for all flood-causing mechanisms, the March 12, 2012 letter requests that licensees and construction permit holders perform an Integrated Assessment of the plant to identify vulnerabilities and actions to address them. This ISG provides guidance on methods the NRC considers acceptable for performing the Integrated Assessment as requested by the March 12, 2012 50.54(f) letter.

Consistent with the March 12, 2012 letter (Enclosure 2, p. 8-9), licensees and construction permit holders are requested to provide the following as part of the Integrated Assessment report:

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.

This ISG provides guidance on methods considered acceptable to NRC for performing the Integrated Assessment as requested by the March 12, 2012 50.54(f) letter.

2.2 NTTF Recommendation 2.3 Flood Walkdowns

As part of the 50.54(f) letter issued by the NRC on March 12, 2012, licensees were requested to perform flood protection walkdowns to verify that plant features credited in the current licensing basis for protection and mitigation from external flood events are available, functional, and properly maintained. These walkdowns are interim actions to be performed while the longer-term hazard reevaluations and Integrated Assessments are performed. NRC and NEI worked collaboratively to develop guidelines for performing the walkdowns, resulting in NEI 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features" (Ref. (7)), which NRC endorsed on May 31, 2012 (Ref. (1)).

As part of the walkdowns, licensees and construction permit holders will verify that permanent structures, systems, and components (SSC) as well as temporary or portable flood protection and mitigation equipment will perform their intended safety functions as credited in the current licensing basis. Verification activities will ensure that changes to the plant (e.g., security barrier installations and topography changes) do not adversely affect flood protection and mitigation equipment. In addition, the walkdown will verify that procedures needed to install and operate equipment needed for flood protection or mitigation can be performed as credited in the current licensing basis. The walkdown will also verify that the execution of procedures will not be impeded by adverse weather conditions that could be reasonably expected to simultaneously occur with a flood event. As part of the walkdowns, observations of potential deficiencies, as well as observations of flood protection features with small margin and potentially significant safety consequences if lost, will be entered into the licensee's corrective action program.

It is anticipated that the walkdowns will be a valuable source of information that will be useful during the performance of the Integrated Assessment. In particular, the walkdowns will provide information on available physical margin (APM) under the current design basis hazard, the condition of flood protection features, the feasibility of procedures, SSCs that are subjected to flooding, and the potential availability of systems to mitigate flood events. However, it is emphasized that the walkdowns are performed to the current licensing basis. The reevaluated flood hazards performed under Recommendation 2.1 (see Section 2.3) may be associated with higher water surface elevations and different associated effects when compared to the current licensing basis. Therefore, some of the information from the walkdowns may not be directly applicable as part of the Integrated Assessment. It is expected that any additional information related to the impact of the flooding hazard reassessment will be considered as part of the Integrated Assessment, and that this information would be available to effectively consider the flood protection capabilities in light of potential additional flooding impacts to the site (i.e., higher elevations, accessibility issues) that may not have been fully considered during the implementation of Recommendation 2.3 walkdown.

2.3 NTTF Recommendation 2.1 Flood Hazard Reevaluations

NRC's March 12, 2012 50.54(f) letter requests that licensees and construction permit holderss reevaluate 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, seiche, tsunami, and dam failures. It is requested that the reevaluation apply present-day regulatory guidance and methodologies used for early site permit (ESP) and combined license (COL) reviews including current techniques, software, and methods used in present-day standard engineering practice.

For the sites where the reevaluated flood is *not* bounded by the current design basis hazard for all flood mechanisms applicable to the site, licensees and construction permit holderss are requested to submit an interim action plan with the hazard report that documents actions planned or taken to address the reevaluated hazard. Subsequently, licensees and construction permit holderss are also asked to perform an Integrated Assessment. In light of the reevaluated hazard, the Integrated Assessment will evaluate the effectiveness of the current licensing basis (i.e., flood protection and mitigation systems), identify plant-specific vulnerabilities, and assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating the effects of the reevaluated hazard for the entire duration of the flood event.

only discusses protection with no recognition of mitigation as part of the IA

3. Framework of Integrated Assessment

This Integrated Assessment guidance utilizes a graded approach so that the type of analysis performed for a plant is commensurate with the site characteristics. In particular, for a given plant, the types of assessments and methodologies considered appropriate for performing the Integrated Assessment vary based on two key factors:

1. the relationship between the re-evaluated flood hazard (including flood height and associated effects) and the existing flood protection at the plant,
2. the type(s) of flood protection utilized at the plant

Under the graded approach, it may be appropriate to perform conventional, engineering evaluations of individual flood protection features at some plants while application of PRA techniques[2] (e.g., system logic models) may be appropriate for other sites. Figure 2 provides a conceptual illustration of the graded approach. The figure demonstrates that the type of evaluation appropriate for performing the Integrated Assessment depends on the relationship between the revaluated hazard and the existing flood protection as well as the type of flood protection utilized at the site. The inherent reliability of flood protection features may differ substantially from plant-to-plant, and, as illustrated by the *x*-axis in Figure 2, the Integrated Assessment process described herein accounts for the differences in characteristics of flood protection. The *y*-axis in Figure 2 is a function of the reevaluated flood hazard in comparison to the existing flood protection. Moving upward on the *y*-axis in Figure 1 represents the increasing utility associated with the use of PRA-type techniques as the available margin under the reevaluated hazard becomes small or negative (i.e., the site flood protection is not able to accommodate the reevaluated flood elevation or associated effects for the flood event duration).

is this information required by the 50.54(f0 letter?

3.1 Integrated Assessment process

The Integrated Assessment is intended to identify site-specific vulnerabilities and provide other important insights, including evaluation of available margin, defense-in-depth, and cliff-edge effects (see Section 8). As described above, the Integrated Assessment is based on a graded approach to ensure the assessment performed is appropriate for the unique characteristics of a given site. Depending on site characteristics, the graded approach supports assessments ranging from engineering evaluations of individual flood protection features to evaluations based on PRA-techniques (e.g., system logic models and risk-

---

[2] This guide describes the use of PRA-techniques, however the approaches described in this document are not intended to be compliant with guidance provided in Ref. (14).

insights). The Integrated Assessment process consists of up to five possible steps, depending on site characteristics:

1. assembly of a peer review team
2. determination of controlling flood parameters
3. evaluation of flood protection systems (if applicable)
4. evaluation of mitigation capability (if appropriate)
5. documentation of results

not always necessary if there are no "unique" aspects of the IA

The Integrated Assessment process is illustrated by the flowchart in Figure 3 and described below.

The first step of the Integrated Assessment process involves assembly of a participatory peer review team. Section 4 and Appendix B provide additional details on the peer review and composition of the peer review team.

The second step in the Integrated Assessment process involves determination of the flood parameter scenario(s) that should be considered based on the results produced as part of the NTTF Recommendation 2.1 flood hazard reevaluations (represented by box 2 in Figure 3). Section 5 provides additional guidance on determining the flood parameter scenario(s) that should be considered as part of the Integrated Assessment.

Box 3 of Figure 3 represents a decision point. If a site has flood protection to prevent the entry of water into buildings or other areas containing SSCs that are important to safety, the process proceeds to Step 3, which involves an evaluation of the effectiveness of the flood protection system at the site. Section 6 provides additional guidance on the evaluation of flood protection. Conversely, if a site allows water to enter buildings or other areas with SSCs that are important to safety (by procedure or design) with potential effects on those SSCs, the Integrated Assessment process skips Step 3 and proceeds directly to Step 4. Step 4 involves the evaluation of the capability of the plant to maintain key safety functions during a flood event.

need to define

Following the performance of the flood protection evaluation (Step 3), there is another decision point, as shown by Box 5 of Figure 3. If the on-site flood protection demonstrates high reliability and margin, the Integrated Assessment process proceeds directly to Step 5 (documentation of results). However, if the on-site flood protection cannot be shown to have high reliability and margin, the process proceeds to Step 4 and the capability of the plant to mitigate a loss of one or more flood protection systems by maintaining key safety functions is evaluated (represented by box 6 in Figure 3). Section 7 provides additional information on evaluating the capability of a plant to mitigate the loss of one more flood protection systems. Section 8 provides guidance on docume

3.2 Key assumptions

The following subsections provide in
Integrated Assessment.

3.2.1 Use of available resources for

The first paragraph cites having sufficient technical basis for use of non-safety SSCs. This paragraph is not clear as to whether it relates to our current licensing basis or future plans for mitigation. Will Sections 6 and 7 satisfy having sufficient technical basis. Should FLEX also be included in this paragraph as an acceptable mitigation method?

The Integrated Assessment evaluates the current licensing basis protection and mitigation capability of plants in response to the reevaluated flood hazards as well as additional in-place or planned resources. In assessing the protection and mitigation capability of a plant, credit can be taken for all available resources (onsite and offsite) as well as the use of systems, equipment, and personnel in nontraditional ways. Temporary protection and mitigation measures as well as non-safety related SSCs can also be credited with sufficient technical bases. In crediting use of systems, equipment, and personnel in non-traditional ways, non-safety related SSCs, temporary mitigation and protection features, or similar resources, the Integrated Assessment should account for the potentially reduced reliability of such resources relative to permanent, safety-related equipment (Ref.(2)). Moreover, if credit is taken for these resources, the licensee or construction permit holder should justify that the resources will be available and functional when required for the flood event duration. Justification should consider the time required to acquire these resources and place them in service. Sections 6 and 7 provide guidance on evaluation of flood protection and mitigation capability.

3.2.2 Modes of operation and concurrent conditions

As described in Section 1.2, the scope of the Integrated Assessment includes full power operations and other plant configurations that could be susceptible due to the status of the flood protection features. The Integrated Assessment should evaluate the effectiveness of flood protection and mitigation capability of the plant for the mode(s) of operation that the plant will be in for the entire flood event duration.[3] In addition, the Integrated Assessment should describe the expected total plant response under other modes of operation, including a discussion of controls that are in place in the event that a flood occurs during any of these modes (e.g., during refueling). The Integrated Assessment should also consider whether specific vulnerabilities may arise during modes of operation other than full-power (e.g., conditions where flood protection features may be bypassed or defeated for maintenance or refueling activities).

Finally, the Integrated Assessment should consider concurrent plant conditions, including adverse weather that could reasonably be expected to simultaneously occur with an external flood event[4] as well as equipment that may be directly affected by the flood event (e.g., loss of the switchyard due to inundation).

This sentence does not belong in the paragraph because the paragraph is discussing flood fequentcies...

3.2.3 Flood frequencies

Due to the limitations of the current state of practice in hydrology, widely-accepted and well-established methodologies are not available to assign initiating event frequencies for most flood mechanisms using probabilistic flood hazard assessment for floods as severe as those specified in the design basis hazards for nuclear power plants (Ref. (3)). Because of these limitations, the Integrated Assessment does not require the computation of initiating flood-hazard frequencies and guidance to compute these frequencies is not provided in this ISG. Furthermore, it is not acceptable to use initiating event frequencies to screen-out flood events in lieu of evaluation of flood protection features at the site. However, within the Integrated Assessment, flood event frequency is acceptable for use as part of a PRA to evaluate mitigation strategies. As discussed in this ISG, mitigation strategies should be evaluated if flood protection features fail during the duration of the flood event.

---

[3] See Section 8 for definition of flood event duration.

[4] Ref. (13) provides guidance on combined events that should be considered as part of the Integrated Assessment. As part of the Recommendation 2.1 hazard reevaluations (see Section 2.3), Ref. (13) should have been used in establishing the combined events applicable to a site.

I thought the peer review was going to concentrate on unique aspects, see general comments

4. Peer review

An independent peer review is an important element of ensuring technical adequacy. The technical adequacy of the Integrated Assessment is measured in terms of the appropriateness with respect to scope, level of detail, methodologies employed, and plant representation, which should be consistent with this guidance and commensurate with the site-specific hazard and inherent flood protection reliability. The licensee's Integrated Assessment submittal should discuss measures used to ensure technical adequacy, including documentation of peer review. Appendix B provides additional details on peer review for the Integrated Assessment.

is "mechanism" an event (e.g., river flooding) or an aspect of an event (e.g.; debris loading)?

5.1 Identification of applicable flood mechanisms and plant conditions

The hazard reevaluations performed under Recommendation 2.1 (see Section 2.3) identify the external flood mechanisms applicable to a site. Prior to performing the Integrated Assessment, the flood height and associated effects[5] for all applicable flood mechanisms from the hazard review should be collected or reviewed for use in the Integrated Assessment.

In addition, for each flood mechanism, the following information should be collected for use in the Integrated Assessment:[6]

- the expected plant mode(s) during the flood event duration
- available instrumentation and communication mechanisms associated with each flood mechanism, if applicable (e.g. river forecasts, dam condition reports, river gauges)
- the availability of and access to onsite and offsite resources and consumables
- accessibility considerations to/from and around the site that may impact protective and mitigating actions
- effect of flood conditions on the availability of the UHS

5.2 Identification of controlling flood parameters

The flood parameters considered as part of the Integrated Assessment for a plant are based on the Recommendation 2.1 hazard reevaluations (see Section 2.3). Flood hazards do not need to be considered individually as part of the Integrated Assessment. Instead, the Integrated Assessment should be performed for a set(s) of flood parameters defined based on the results of the Recommendation 2.1 hazard reevaluations (see Section 5.1). This set of parameters is referred to as a flood parameter scenario(s)[7] in this ISG.

The flood parameters that should be defined in a flood parameter scenario and considered as part of the Integrated Assessment include:

need to define "hazard', "mechanism" and "associated effects"

[5] See Section 8 for definition of flood height and associated effects.
[6] This information may be available, in part, from the Recommendation 2.3 walkdown report or licensee walkdown records (see Section 2)
[7] See definition of flood parameter scenario in Section 8.

- flood height and associated effects[8]
- 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

In some cases, there is one controlling flood hazard for a site. In this case, the flood parameter scenario should be defined based on this controlling flood hazard. However, at some sites, due the diversity of flood hazards to which the site is exposed, it may be necessary to define multiple flood parameter scenarios to capture the different plant effects from the diverse flood parameters associated with applicable hazards. In addition, sites may utilize different flood protection systems to protect against or mitigate different flood hazards. In such instances, the Integrated Assessment should define multiple flood parameter scenarios.

If appropriate, instead of considering multiple flood parameter scenarios as part of the Integrated Assessment, it is acceptable to develop an enveloping scenario (e.g., the maximum water surface elevation and inundation duration with the minimum warning time generated from different hazard scenarios). For simplicity, these flood parameters may be combined to generate a single bounding scenario of flood parameters for use in the Integrated Assessment.

6. Evaluation of effectiveness of flood protection

As part of the Integrated Assessment, an evaluation should be performed of the capability of the site flood protection to protect SSCs important to safety from flood height and associated effects for each flood parameter scenario.

There are vast differences from plant to plant with regard to the flood protection features[9] used. Site flood protection may include incorporated, exterior, and temporary features with passive and active functions credited to protect against the effects of external floods. In addition to physical barriers, flood protection at nuclear power plants may involve a variety of operator manual actions. These operator manual actions may be associated with installation of features (e.g., floodgates, portable panels, placement of portable pumps in service), construction of barriers (e.g., sandbag barriers), and other actions.

6.1 Procedure overview

An acceptable procedure to evaluate flood protection is illustrated by the flowchart in Figure 4. The evaluation begins be defining the flood protection systems to be evaluated as part of the Integrated Assessment.[10] Next, a flood parameter scenario and flood protection system are selected for evaluation. An evaluation is then performed of the selected flood protection system under the flood parameter scenario. The type of methodology considered

[8] See definition of flood height and associated effects in Section 8.

[10] Section 8 defines the term flood protection system. A site may have multiple and diverse flood protection systems. For example, a site may be protected by a levee around the entire site as well as incorporated barriers at the structure/environment interface for each individual building. The site levee would constitute one flood protection system while a set of barriers that protects an individual building, which can be isolated from other buildings (either through separation by location or flood protection features), would comprise a separate flood protection system.

appropriate for evaluating a flood protection system is based on the types of flood protection features employed in the flood protection system. The flood protection evaluation should assess the performance of the flood protection at both the feature- and system-levels. Additional information on the evaluation of flood protection is provided in Sections 6.2 and 6.3 as well as Appendix A.

If it can be shown that the flood protection can accommodate the flood parameter scenario with high reliability and margin (box 5) based on available performance criteria (see Section 6.2) or quantification of flood protection reliability, then the integrity of the system is documented and justified (box 6) and the evaluation is repeated for the next flood protection system. Conversely, if the flood protection system is not able to accommodate the flood parameter scenario with high reliability and margin, and modifications will not be made (box 7), the credible failure modes and vulnerabilities should be documented along with the direct consequences (e.g., inundation of a room) of each failure mode and vulnerability. The analysis is then repeated for the next flood protection system. If modifications to the flood protection system are in-place or planned (box 7), the modified flood protection system should be defined (box 8) and the evaluation repeated for the modified flood protection system.

6.2 Performance criteria

6.2.1 Exterior and incorporated flood protection features

should be "and / or" - depends on the performance criteria

Flood protection systems comprised of exterior and incorporated features that are permanent and passive should be evaluated against qualitative and quantitative performance criteria to demonstrate high reliability and margin. The evaluation of a flood protection system with these characteristics should:

- provide an understanding of potential failure modes of the flood protection system
- demonstrate the soundness of the individual features comprising the flood protection system under the loads (i.e., flood height and associated effects) due to a flood parameter scenario(s) and confirm that the features are:
  - in satisfactory condition
  - structurally adequate based on quantitative engineering evaluations
- compare the performance of the individual features of the flood protection system against appropriate, present-day design codes and standards (e.g., ##Add reference) to determine whether the feature(s) conforms to best practices and is sufficiently robust (e.g., demonstrates an appropriate factor of safety)
- provide confidence in the reliability of the flood protection system through qualitative assessment of operational requirements such as surveillance, inspection, design control, maintenance, and testing
- include sensitivity studies if there is uncertainty about the construction or characteristics of a flood protection feature or system

are these the criteria for "high reliability and margin"? Needs to be clear.

Probabilistic evaluation of the fragility of exterior and incorporated features under a flood parameter scenario(s) is also acceptable.

If exterior or incorporated features that are permanent and passive work in conjunction with active components (e.g., pump station, sump pump to handle minor leakage, flood doors) or operator manual actions (e.g., actions associated with closure of flood doors), a more

clarify - there is always uncertainty

Need to describe how this is determined. See industry comments.

extensive evaluation is appropriate. In addition to the considerations described above, the evaluation should:

use "qualify" - see industry comments on section A.1.2

App C attributes are sufficent

- quantify the reliability of the active features based on operating experience and other available data or information
- evaluate the feasibility and reliability of credited operator actions (e.g., barrier installation or closure a flood doors) using human reliability analysis (HRA) concepts and approaches as described in Appendix C[11]
- evaluate the flood protection system as a whole

Additional information on the evaluation of individual features of a flood protection system is provided in Section A.1 of Appendix A. Guidance on the evaluation of a flood protection system as a whole is provided in Section A.2 of Appendix A.

6.2.2 Temporary flood protection features

If temporary protective measures are utilized as part of a flood protection system, the evaluation should consider the complete flood protection system including incorporated, exterior, and temporary features with passive and active functions. The flood protection evaluation should:

- provide an understanding of potential failure modes of the flood protection system
- demonstrate the soundness of the individual features comprising the flood protection system under the loads (i.e., flood height and associated effects) due to a flood parameter scenario(s) and confirm that the features are:
  - in satisfactory condition
  - structurally adequate based on quantitative engineering evaluations
- compare the performance, characteristics, and configuration of the flood protection feature(s) against appropriate, present-day design codes and standards (e.g., ##Add reference) to determine whether the feature(s) conforms to best practices and is sufficiently robust (e.g., demonstrates an appropriate factor of safety)
- perform qualitative assessment of operational requirements such as surveillance, inspection, design control, maintenance, and testing
- include sensitivity studies if there is uncertainty about the construction or characteristics of a flood protection feature or system
- quantify the reliability of the active features based on operating experience and other available data or information
- evaluate the feasibility and reliability credited operator actions (including construction, installation, or other actions) using HRA concepts and approaches, as described in Appendix C
- evaluate the flood protection system as a whole

Additional guidance on evaluating flood protection at the feature- and system-levels is provided in Appendix A.

---

[11] [#text under development] At the time of publication of this ISG, HRA methodologies have not been extensively used specifically for evaluation of procedures associated human actions during the flood event duration. However, HRA approaches and concepts can be used to evaluate whether and operator manual action is feasible and reliable such that it may be relied upon during a severe flood event.

6.3 Justification of flood protection performance

If, based on the flood protection evaluation, a flood protection system is deemed capable of withstanding the flood height and associated effects for a flood parameter scenario, the Integrated Assessment should justify this conclusion. The Integrated Assessment should also demonstrate that the flood protection system integrity is maintained with high reliability and margin under the flood parameter scenario(s) based on comparison against appropriate performance criteria or quantification of feature or system reliability. In addition, the limiting margin associated with the flood protection system as well as the margin associated with individual flood protection features should be identified.

Margin should be characterized with respect to physical barrier dimensions,[12] structural capacity, and time and staffing associated with performance of operator manual actions. Demonstration of the aforementioned items requires an understanding of the capability of flood protection systems for a range of flood heights and associated effects (including reasonable variation in warning time and flood event duration). Physical margin and structural capacity can be demonstrated by increasing the flood elevation (while accounting for associated effects) and showing the elevation beyond which the system is no longer capable of reliably performing its intended function. The effect of bounding conservatisms considered as part of the NTTF Recommendation 2.1 hazard reevaluation may be credited (if justified) when evaluating the margin available under a flood parameter scenario.

The Integrated Assessment should identify any flood protection features or systems that are unable to accommodate the flood height and associated effects for a flood parameter scenario(s) with high reliability and margin. Any flood protection feature or system determined not to be capable of performing its intended safety function under the reevaluated hazard should be documented as a vulnerability (see Section 8) for all susceptible plant configurations. In addition, if a flood protection feature or system is not able to accommodate a flood parameter scenario, the flood protection evaluation should determine at what flood height and under what associated effects, the flood protection feature or system is able to accommodate a flood with high reliability and margin. If modifications are proposed to address vulnerabilities, improve margin, or otherwise improve the effectiveness of site flood protection, the Integrated Assessment should justify that the modified flood protection has high reliability and margin through comparison against established performance criteria or quantification of reliability (as appropriate).

7. Evaluation of plant mitigation capability

Plant mitigation capability refers to the capability of the plant to maintain key safety functions[13] in the event that a flood protection system(s) fails.

---

[12] Margin with respect to physical barrier dimensions is analogous to the concept of available physical margin defined under the NTTF Recommendation 2.3 flood walkdowns (see Ref. (7)). However, available physical margin was computed as part of the NTTF Recommendation 2.3 flood walkdowns with respect to the current licensing basis flood protection height. In the context of the Integrated Assessment, margin with respect to physical barriers in defined with respect to the reevaluated hazard (including flood height and associated effects).

[13] See Section 8 for definition of key safety functions.

An evaluation of plant mitigation capability is appropriate for sites that have not demonstrated that flood protection systems have high reliability and margin. Plant mitigation capability should be evaluated for credible flood protection failure modes, including concurrent failures, identified based on the evaluation described in Section 6. For each scenario involving the compromise of flood protection under a flood parameter scenario, the mitigation capability of the plant should be evaluated for the entire flood event duration considering all available resources.

In addition, as described in Section 3.1, sites that allow water to enter buildings or other areas with SSCs important to safety by procedure or design (and resulting in the potential compromise of those SSCs) should evaluate mitigation capability.

7.1 Procedure Overview

The mitigation capability of a plant may be demonstrated using one of three potential methods, depending on site characteristics and information needed for decisions:

- scenario-based evaluation
- margins-type evaluation
- full PRA

A margins-type evaluation and full PRA are acceptable for evaluating plant mitigation capability at all sites. A scenario-based evaluation is only acceptable for evaluating the mitigation capability of plants for which (1) the plant systems affected by flood protection failure are not associated with complex interactions and interdependencies, and (2) any credited mitigation actions are not associated with significant reliance on operator manual actions.

is this OK? interpreting "complex" and "significant" could prove to be problematic. See industry recommended words.

The scenario based approach may be what you need when you use operator manual actions since there are not well established PRA approaches for evaluating HRA

7.2 Scenario-based evaluation of mitigation capability

[#text under development]

Figure 5 provides a flowchart depicting the process for a scenario-based evaluation of mitigation capability. The evaluation begins be defining the scenario to be evaluated, which consists of specifying (boxes 1-4 of Figure 5):

- the flood parameter scenario
- the credible flood protection failure mode(s)[14]
- the direct consequences of flood protection failure (e.g., inundation of a room)
- the plant conditions (e.g., identification of whether offsite power is available) and equipment affected by the consequences of flood protection failure

Typically, failure of equipment will be due to inundation. However, associated flood effects (e.g., debris, dynamic loads) also adversely affect equipment and should be considered. If appropriate, failure probabilities of the available equipment may be defined as a function of the flood height and associated effects.

[14] Credible failure modes of flood protection systems for a given flood parameter scenario are identified as part of the evaluation of flood protection systems (see Section 6 and Appendix A). Concurrent failures of multiple flood protection systems (along with associated consequences) should be considered if a flood parameter scenario could adversely affect multiple flood protection systems.

Use a different term. CCDP and high confidence imply a quantitative approach. See industry comment.

Once the scenario has been defined, the key safety functions that must be maintained are defined (box 5) and equipment available for use in maintaining key safety functions (box 6) then specified. The evaluation of plant capability to maintain key safety functions using available resources (box 7) should demonstrate that there is high confidence that the conditional core damage probability (CCDP) is low (i.e., less than 10^{-2} [#numerical criteria to be discussed]). If high confidence in low CCDP cannot be demonstrated, then a scenario-based evaluation is not sufficient and a margins-type evaluation or PRA is necessary.

The evaluation should be repeated until all flood protection failure modes and flood parameter scenarios have been evaluated (as directed by boxes 10 and 11 of Figure 5). If modifications to the plant are proposed, the effectiveness of the modification on plant mitigation capability should be evaluated as described above.

7.3 Margins-type evaluation of mitigation capability

[#text under development]

Figure 6 illustrates the margins-based method for the evaluation of plant mitigation capability. The margins-based mitigation evaluation begins with selection of a flood parameter scenario and credible flood protection failure mode(s) based on the flood parameter scenario under consideration. Credible failure modes of flood protection systems for a given flood parameter scenario are identified as part of the evaluation of flood protection systems (see Section 6). Concurrent failures of multiple flood protection systems (along with associated consequences) should be considered if a flood parameter scenario could adversely affect multiple flood protection systems.

For each credible failure mode(s), the direct consequences (e.g., inundation of a room) from the flood protection system failure (box 3) should be defined along with the equipment that could be adversely affected by the direct consequences of flood protection failure (e.g., failure of equipment due to submersion) (box 4). Typically, flood-caused failure of equipment will be due to inundation. However, associated flood effects (e.g., debris, dynamic loads) may adversely affect equipment and should be considered. If appropriate, failure probabilities of the available equipment may be defined as a function of the flood height and associated effects.

Plant conditions should also be defined (box 5) including the availability of offsite power and ##. Once the plant conditions have been specified along with affected equipment, the plant systems models[15] should be updated to reflect the current plant state and available equipment. Given the equipment affected by the flood protection system failure and associated consequences, the CCDP and conditional large early release probability (CLERP) should be calculated using plant system models. The evaluation of mitigation

[15] The internal events PRA model, with appropriate modifications, can be used to model plant systems. Basic failure events are added to the internal events PRA model to modify it for use in evaluating the mitigation capability of the plant during a flood event. Alternatively, it may be acceptable to develop a system models specifically intended to compute CCDP and CLERP under the flood parameter scenario and flood protection failure mode(s) being analyzed rather than adapting the existing internal events PRA model. If such a model is developed, it should be consistent with the internal events systems model with respect to plant response and cause-effect relationships of failures. Failures from non-flood caused events may be screened out of the model if the contributions to the results are demonstrably very small.

implication is that licensee will have to determine an acceptable CCDP and CLERP. What is the criteria for acceptability? See industry comments.

capability should be repeated until all flood prote
scenarios have been evaluated.

If modifications to the plant are proposed, the effectiveness of the modification on plant mitigation capability should be evaluated as described above.

7.4 PRA-based evaluation of mitigation capability

Based on current state of the art, this approach is not usable

If a PRA-based evaluation is used to assess the mitigation capability of a plant, the evaluation should be consistent with guidance contained in Section 8 of Ref. (4) as well as Ref. (5). However, it is noted that Section 8 of Ref. (4) establishes technical requirements when a reactor is at power. As part of the Integrated Assessment, it is necessary to consider mitigation capability during other modes of operation. [#additional exceptions and qualifications to be added, as appropriate]

If modifications to the plant are proposed, the effectiveness of the modification on plant mitigation capability should be evaluated as described above.

8. Documentation

The Integrated Assessment Report should provide the following (Ref. (1), Encl. 2, p. 8-9):

a) *Description of the integrated procedure used to evaluate integrity of the plant for the entire duration of flood conditions at the site.*

- Describe the methodologies used to demonstrate the effectiveness of:
  a. flood protection features and systems
  b. mitigation strategies
- Describe any plant system models, including modifications made to existing internal event model(s) for the evaluation of the plant's flood protection and mitigation capability

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.*

Controlling Flood Mechanism(s)

- Discuss the applicable flood mechanism(s) and the flood parameter scenario(s), including flood height and associated effects
- Discuss the site conditions during the entire flood event duration, including:
  - the plant mode(s), including the duration expected to remain in each mode
  - available instrumentation and communication mechanisms
  - the availability of and access to onsite and offsite resources and consumables (e.g., diesel fuel)
  - accessibility considerations to/from and around the site that may impact protective and mitigating actions (e.g., scaffolding)
  - conditions of ability of the UHS
  - structures and systems important to safety affected by the flood parameter scenario

Evaluation of Flood Protection

is this information required by the 50.54(f) letter?

- Describe the overall flood protection system(s)
- Provide a technical justification for assumptions, including failure modes, used to demonstrate the effectiveness of flood protection features.
- Provide an evaluation of the operator manual actions associated with the flood protection system(s) including sensitivity studies, if appropriate.
- Provide a discussion on defense-in-depth considerations that are maintained under each flood parameter scenario
- Discuss any additional margin beyond the postulated scenarios for the flood protection system(s). Margin should be characterized with respect to physical barrier dimensions, structural capacity, and time and staffing associated with performance of operator manual actions.

is this information required by the 50.54(f) letter?

Evaluation of Mitigation Capability

- Describe the equipment and operator manual actions, if applicable, associated with the mitigation capability of the plant
- Describe the performance criteria used to evaluate the mitigation capability of the plant
- Provide an evaluation, including sensitivity studies if appropriate, regarding the effectiveness of the total mitigation capability
- Provide a discussion on defense-in-depth considerations that are maintained under each flood parameter scenario
- Discuss any additional margin beyond the postulated scenarios for the mitigation capability of the plant. Margin should be characterized with respect to physical barrier dimensions, structural capacity, and time and staffing associated with performance of operator manual actions.

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.

- Describe any flood protection or mitigation capabilities discussed in item (b) above that are credited in the plant's current licensing basis but were modified during the course of the hazard reevaluation or Integrated Assessment. The description should include specific features and their functions.
- Describe any flood protection or mitigation capabilities discussed in item (b) above that are not credited in the plant's current licensing basis. The description should include specific features and their functions.
- Describe any flood protection or mitigation capabilities discussed in item (b) above that are planned and have not yet been installed. The description should include specific features and their functions.

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

- Describe any vulnerabilities identified during the review, including the key safety functions that may have been be affected
- Describe any actions that have been taken to address these plant-specific vulnerabilities.
- Separately, describe any actions that are planned to address these plant-specific vulnerabilities.

9. Terms and definitions

Active (flood protection) feature: [#definition under development] Incorporated, exterior, or temporary flood protection features that require the change of state of a component in order to perform as intended. Examples include sump pumps, portable pumps, isolation and check valves, flood detection (e.g., level switches), and flood doors (e.g., watertight doors).

Available Physical Margin (APM): The term available physical margin describes the flood margin available for applicable flood protection features at a site (not all flood protection features have APMs). The APM for each applicable flood protection feature is the difference between licensing basis flood protection height and the flood height at which water could affect an SSC important to safety. Determination of APM for local intense precipitation may not be possible (Additional details are provided in Section 3.13 of the flooding design basis walkdown guidance, NEI 12-07, Ref. (1).). [#definition may be expanded based on recent discussions related to APM]

Cliff-edge effect: An elevation at which safety consequences of a flood event may increase sharply with a small increase in the flood height and associated effects.

Critical elevation: The elevation at which a piece or group of equipment will fail to function, or a transient will be induced, due to flood height and associated effects.

Current Licensing Basis (CLB): As defined by 10 CFR 54.3, the current licensing basis is 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, including all modifications and additions to such commitments over the life of the facility operating license. It also includes the plant-specific design basis information, defined by 10 CFR 50.2, as documented in the most recent UFSAR as required by 10 CFR 50.71. The set of NRC requirements applicable to a specified plant CLB includes:

- NRC regulations in 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 54, 55, 70, 72, 73 and 100 and appendices thereto
- Commission Orders
- License Conditions
- Exemptions
- Technical Specifications
- Plant-Specific design basis information defined in 10 CFR 50.2 and documented in the most recent UFSAR (as required by 10 CFR 50.71)
- Licensee Commitments remaining in effect that were made in docketed licensing correspondence (such as licensee responses to NRC bulletins, License Event Reports, Generic Letters and Enforcement Actions)
- Licensee Commitments documented in NRC safety evaluations

Design bases: As defined by 10 CFR 50.2, the design bases are information that identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be (1) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (2) requirements derived from analysis (based on calculation and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals.

Event tree: A logic diagram that begins with an initiating event or condition and progresses through a series of branches that represent expected system or operator performance that either succeeds or fails and arrives at either a successful or failed end state (Ref. (4)).

Exterior (flood protection) feature: Engineered passive or active flood protection feature external to the immediate plant area and credited to protect safety-related SSCs from inundation and static/dynamic effects of external floods. Examples include levees, dikes, floodwalls, flap gates, sluice gates, duckbill valves and pump stations (Ref. (7)).

Failure modes and effects analysis (FMEA): A process for identifying failure modes of specific components and evaluating their effects on other components, subsystems, and systems (Ref. (4)).

Fault tree: A deductive logic diagram that depicts how a particular undesired event can occur as a logical combination of other undesired events (Ref. (4)).

Feasible action: An action that is analyzed and demonstrated as being able to be performed within an available time to avoid a defined undesirable outcome. As compared to a reliable action (see definition), an action is considered feasible if it is shown that it is possible to be performed within the available time (considering relevant uncertainties in estimating the time available); but it does not necessarily demonstrate that the action is reliable. For instance, performing an action successfully one time out of three attempts within the available time shows that the action is *feasible*, but not necessarily reliable (Ref. (8)).

Flood event duration: The length of time in which the flood event affects the site, beginning with notification of an impending flood (e.g., a flood forecast or notification of dam failure), including preparation for the flood and period of inundation, and ending when water has receded from the site and the plant has reached a stable state [#definition under development]. Figure 7 provides an illustration of flood event duration.

as defined by the plant's licensing basis (i.e., hot or cold shutdown)

Flood height and associated effects: Maximum stillwater surface elevation plus factors such as:

- wind waves and run-up effects
- hydrodynamic loading, including debris
- effects due to sediment deposition and erosion
- concurrent site conditions, including adverse weather conditions
- other pertinent factors

Flood parameter scenario(s): A set(s) of flood parameters that should be considered as part of the Integrated Assessment. (see Section 5.2 for additional details).

Flood protection feature: An individual incorporated, exterior ~~and~~ or temporary structure, system, component (e.g., barrier), or associated procedure that protects safety-related SSCs against the effects of external floods, including flood height and associated effects.

Flood protection system: In the context of the Integrated Assessment, a flood protection system is a set of flood protection features that are intended to protect a specific SSC or group of SSCs (e.g., features used to protect the intake structure) or the entire plant (e.g., a levee around an entire site) and that are primarily separate and independent from the flood protection features used to protect other SSCs. See Appendix A, Section # for additional discussion.

Human reliability analysis (HRA): A structured approach used to identify potential human failure events and to systematically estimate the probability of those events using data, models, or expert judgment (Ref. (4)). In the context of the Integrated Assessment, HRA approaches and concepts are used to evaluate whether operator manual actions are feasible and reliable.

Incorporated (flood protection) feature: 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. Examples include pumps, seals, valves, gates, etc. that are permanently incorporated into a plant structure (Ref. (7)).

Key safety functions: The minimum set of safety functions that must be maintained to prevent core damage and large early release. These include reactivity control, reactor pressure control, reactor coolant inventory control, decay heat removal, and containment integrity in appropriate combinations to prevent core damage and large early release. (Ref. (4)).

Mitigation capability: In the context of the Integrated Assessment, mitigation capability refers to the capability of the plant to maintain key safety functions in the event that a flood protection system(s) fails.

Operator manual action (for flooding): Proceduralized activity carried out by plant personnel outside of the control room to prepare for or respond to an external flood event.

Passive (flood protection) feature: [#definition under development] Incorporated, exterior, or temporary flood protection features that do *not* require the change of state of a component in order to perform as intended. Examples include dikes, berms, sumps, drains, basins, yard drainage systems, walls, removable wall and roof panels, floors, structures, penetration seals, temporary water tight barriers, barriers exterior to the immediate plant area that are under licensee control, and cork seals.

Performance criteria (for flood protection): [#definition under development] In the context of the Integrated Assessment, performance criteria refer to criteria or standards that are used, in part, to demonstrate that a flood protection feature has high reliability and margin

Plant-specific vulnerability: As defined in Ref. (6), 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 safety functions."

Reasonable simulation: a walk-through of a procedure or activity to verify the procedure or activity can be executed as specified/written. This simulation requires verification that:

- all resources needed to complete the actions will be available. (Note that staffing assumptions must be consistent with site access assumptions in emergency planning procedures.)
- any credited time dependent activities can be completed in the time required considering the time required for detection, recognition and communication to initiate action for the applicable flood hazard.
- specified equipment/tools are properly staged and in good working condition.
- connection/installation points are accessible.

- the execution of the activity will not be impeded by the event it is intended to mitigate or prevent (for example, access to the site and movement around it can be accomplished during the flood).
- the execution of the activity will not be impeded by other adverse conditions that could reasonably be expected to simultaneously (Ref. (7))

Reliable action: A feasible action that is analyzed and demonstrated as being dependably repeatable within an available time, so as to avoid a defined adverse consequence, while considering varying conditions that could affect the available time and/or the time to perform the action. As compared to an action that is only feasible (see definition), an action is considered to be reliable as well if it is shown that it can be dependably and repeatably performed within the available time, by different crews, under somewhat varying conditions that typify uncertainties in the available time and the time to perform the action, with a high success rate. All reliable actions need to be feasible, but not all feasible actions will be reliable (Ref. (8)).

Temporary (flood protection) feature: Passive or active flood protection feature within the immediate plant area that protects safety-related SSCs from inundation and static/dynamic effects of external flooding and is temporary in nature (i.e., they must be installed prior to the advent of the design basis external flood). Examples include portable pumps, sandbags, plastic sheeting, and portable panels (Ref. (7)).

Total plant response: The total plant response is the capability of the plant to (1) protect against flood events (considering diverse flood protection features) and (2) mitigate consequences, if the flood protection system is compromised, by maintaining key safety functions using all credited resources.

Variety of site conditions: The site conditions considered in the Integrated Assessment should be all modes of operation (e.g., full power operations, startup, shutdown, and refueling) and adverse weather conditions that could reasonably be expected to occur concurrent with a flood event.

Vulnerability: See definition for *plant-specific vulnerability*.

[#terms to be added or modified, as appropriate]

[#list of acronyms to be added]

10. Figures

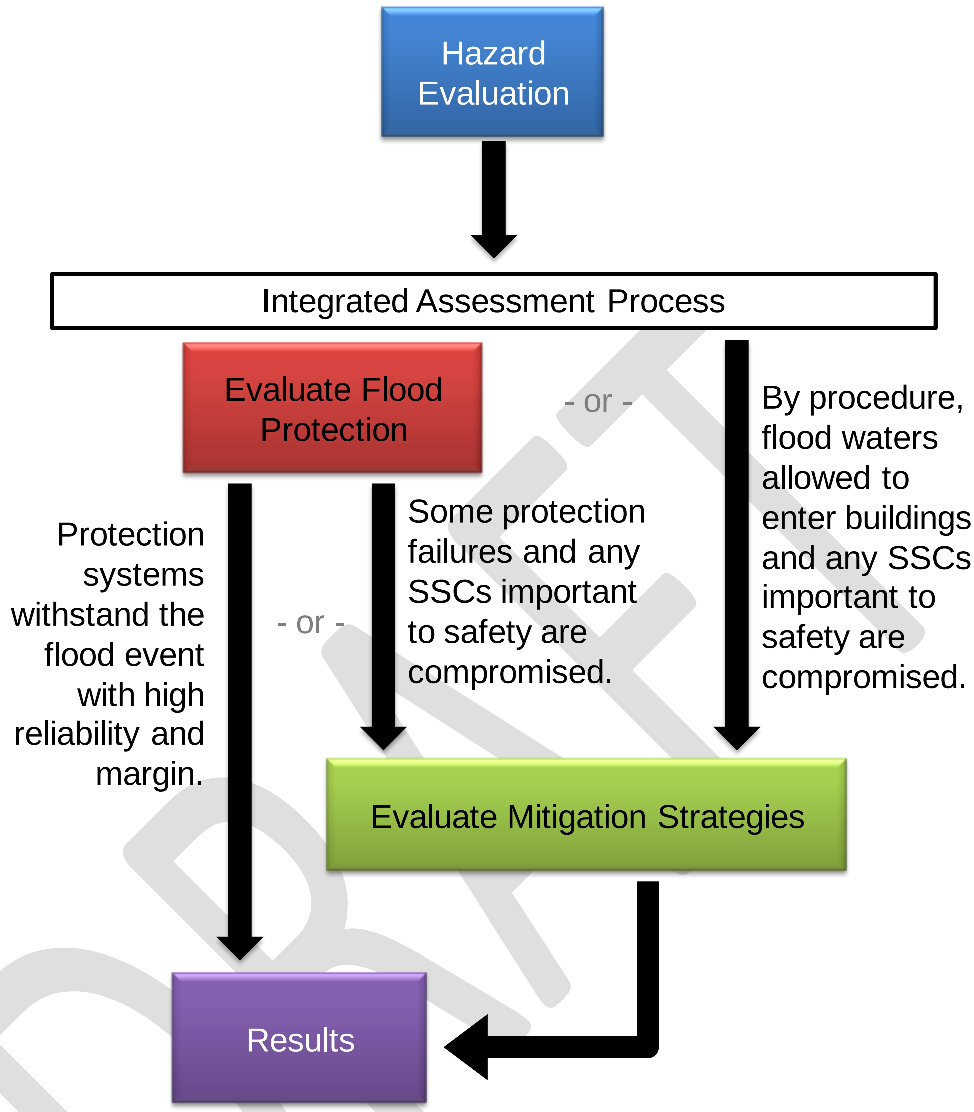
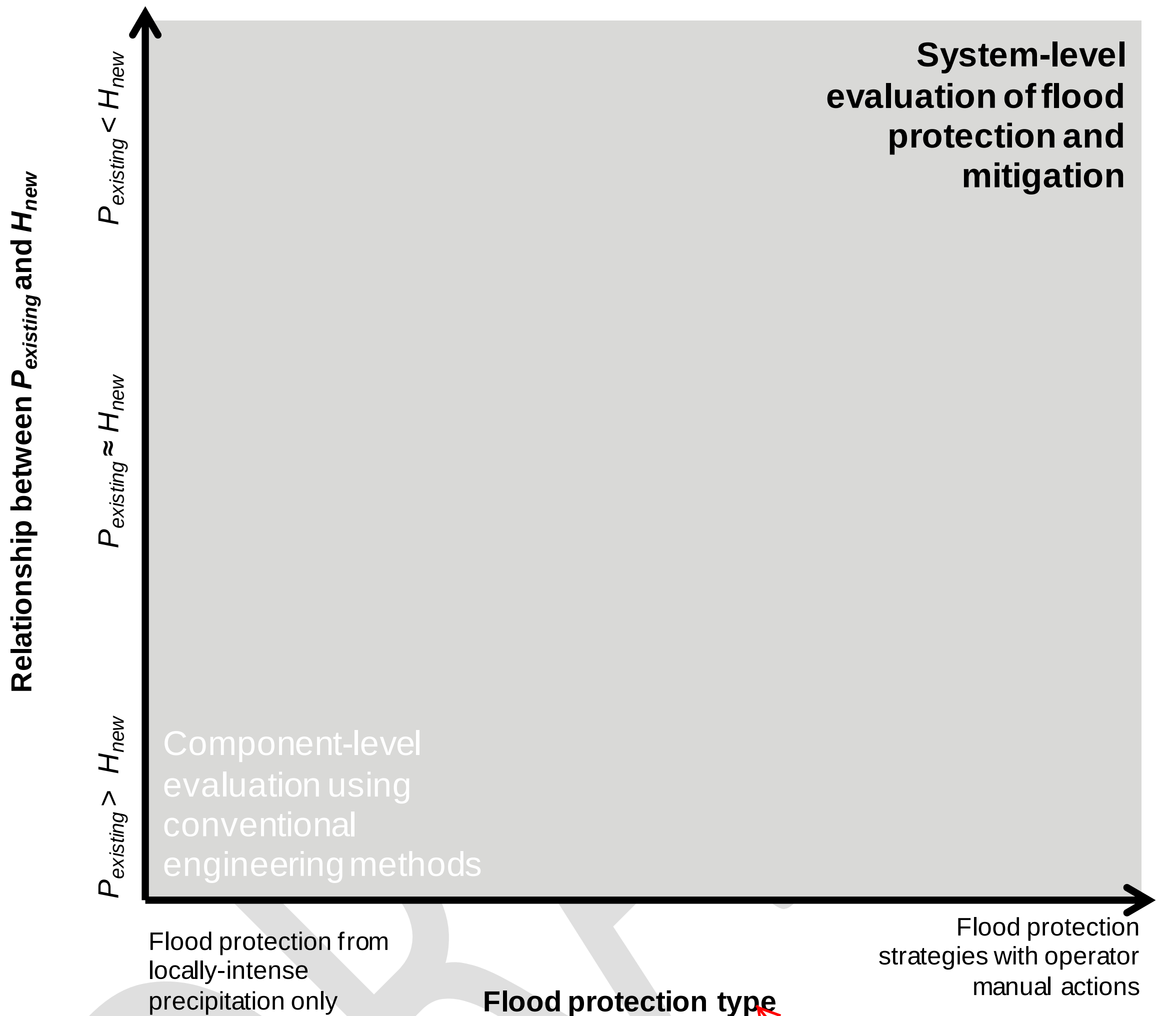


Figure 1: Conceptual illustration of Integrated Assessment process



***$P_{existing}$* = existing flood protection**

***H_{new}* = reevaluated hazard**

Figure 2: Illustration of graded approach

It is difficult to interpret this chart in a meaningful way. Document words and flow charts make this chart unecessary. Suggest deleting.

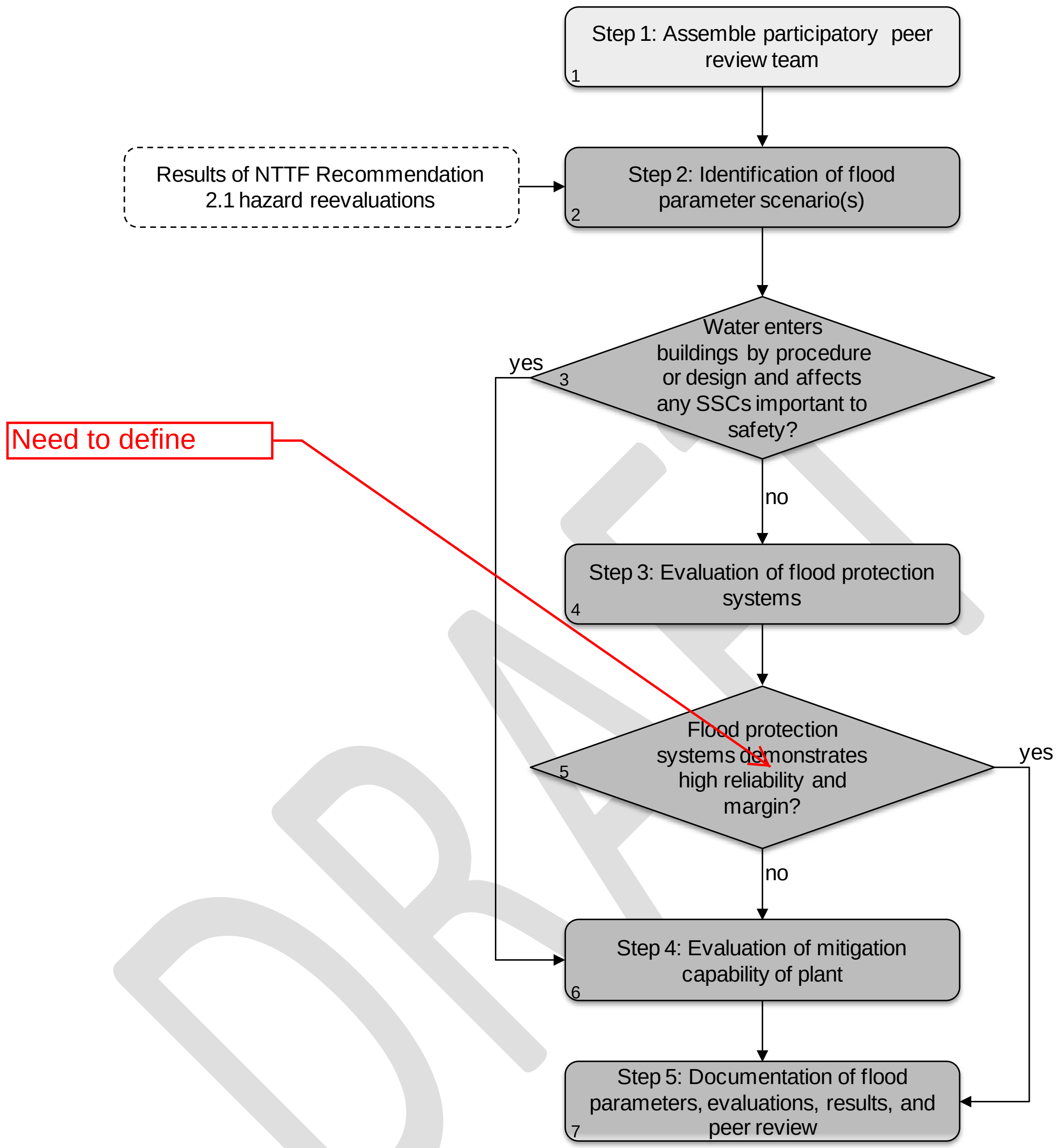


Figure 3: Integrated Assessment process flowchart

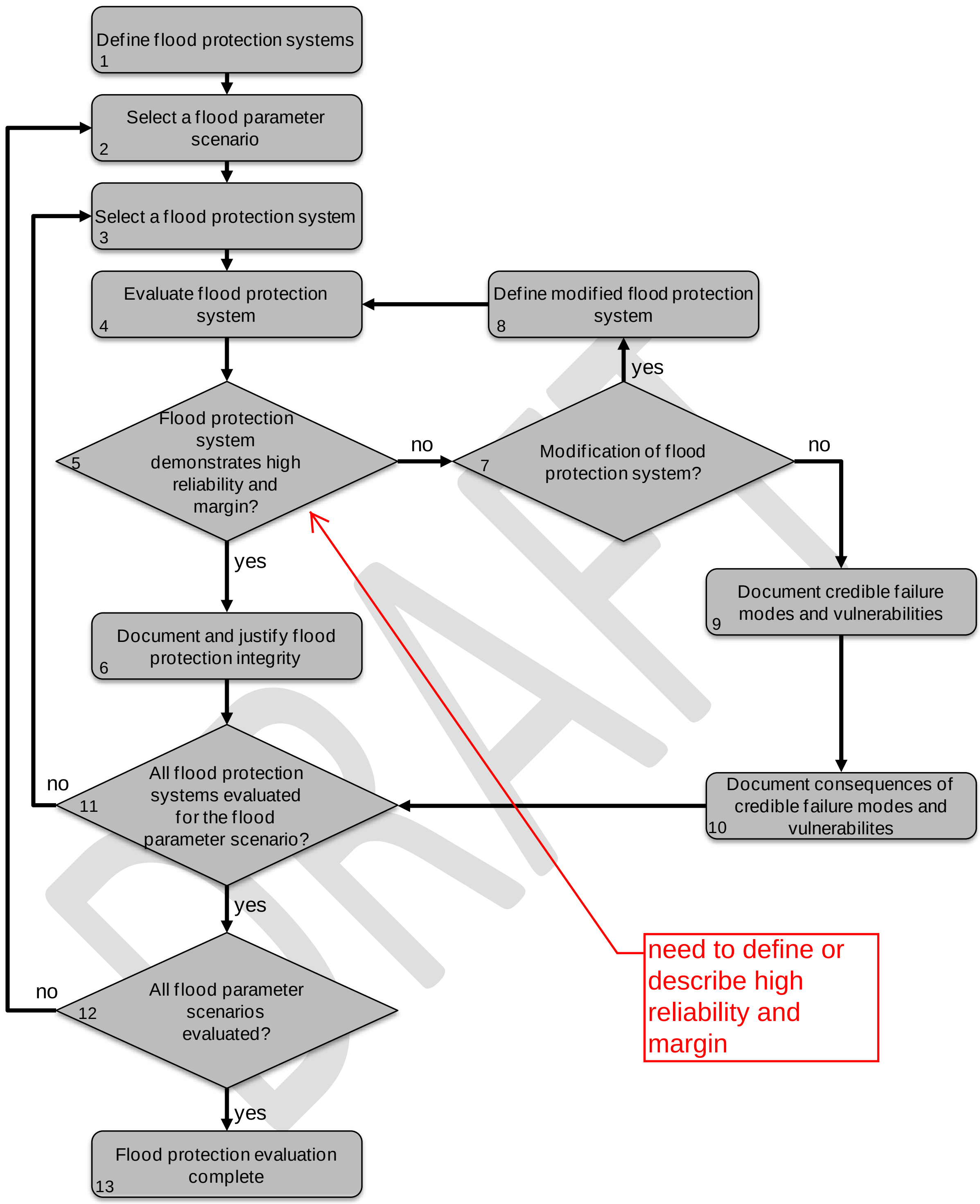


Figure 4: Flood protection evaluation procedure flowchart

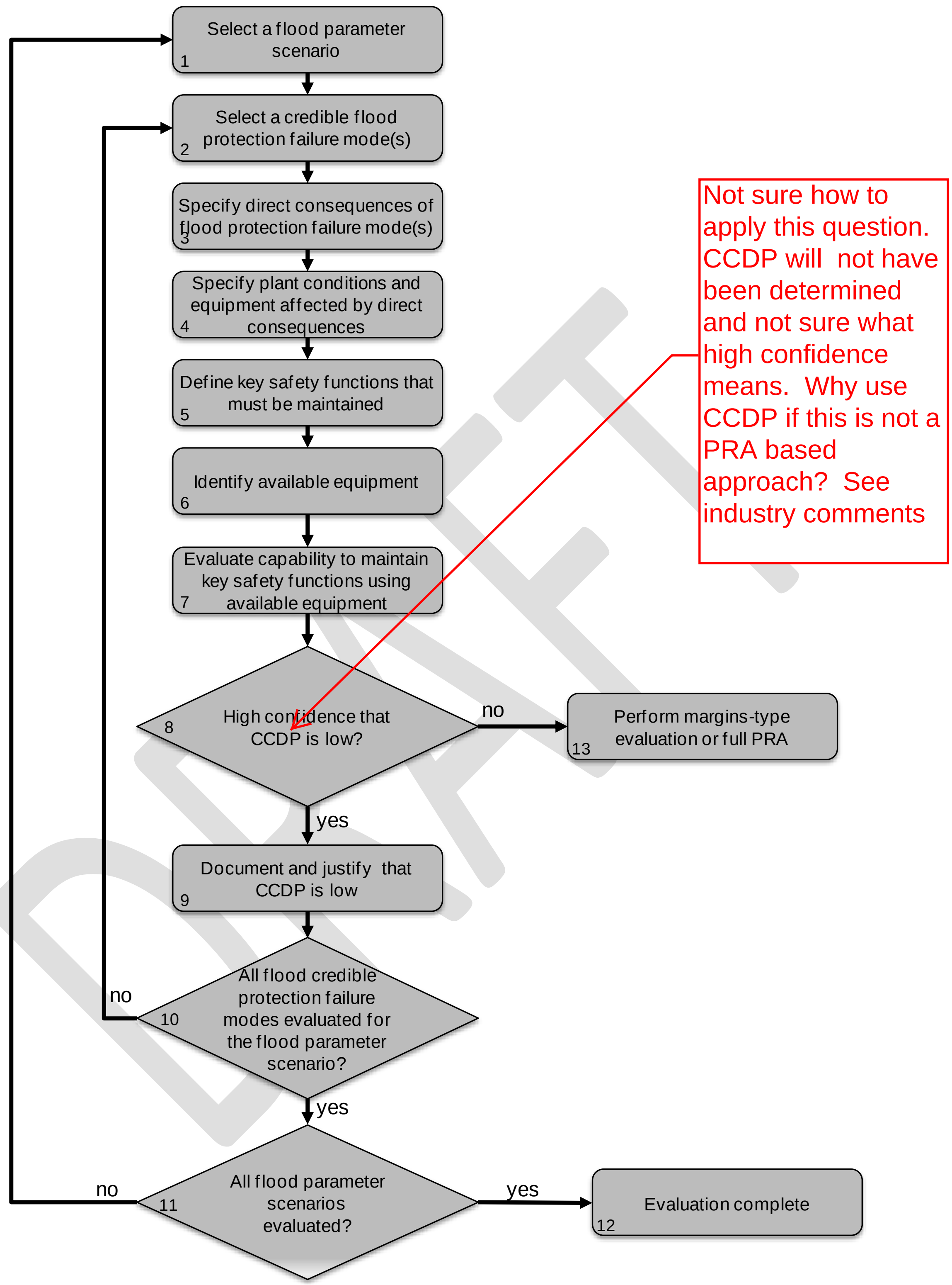


Figure 5: Scenario-based mitigation evaluation flowchart [#figure under development]

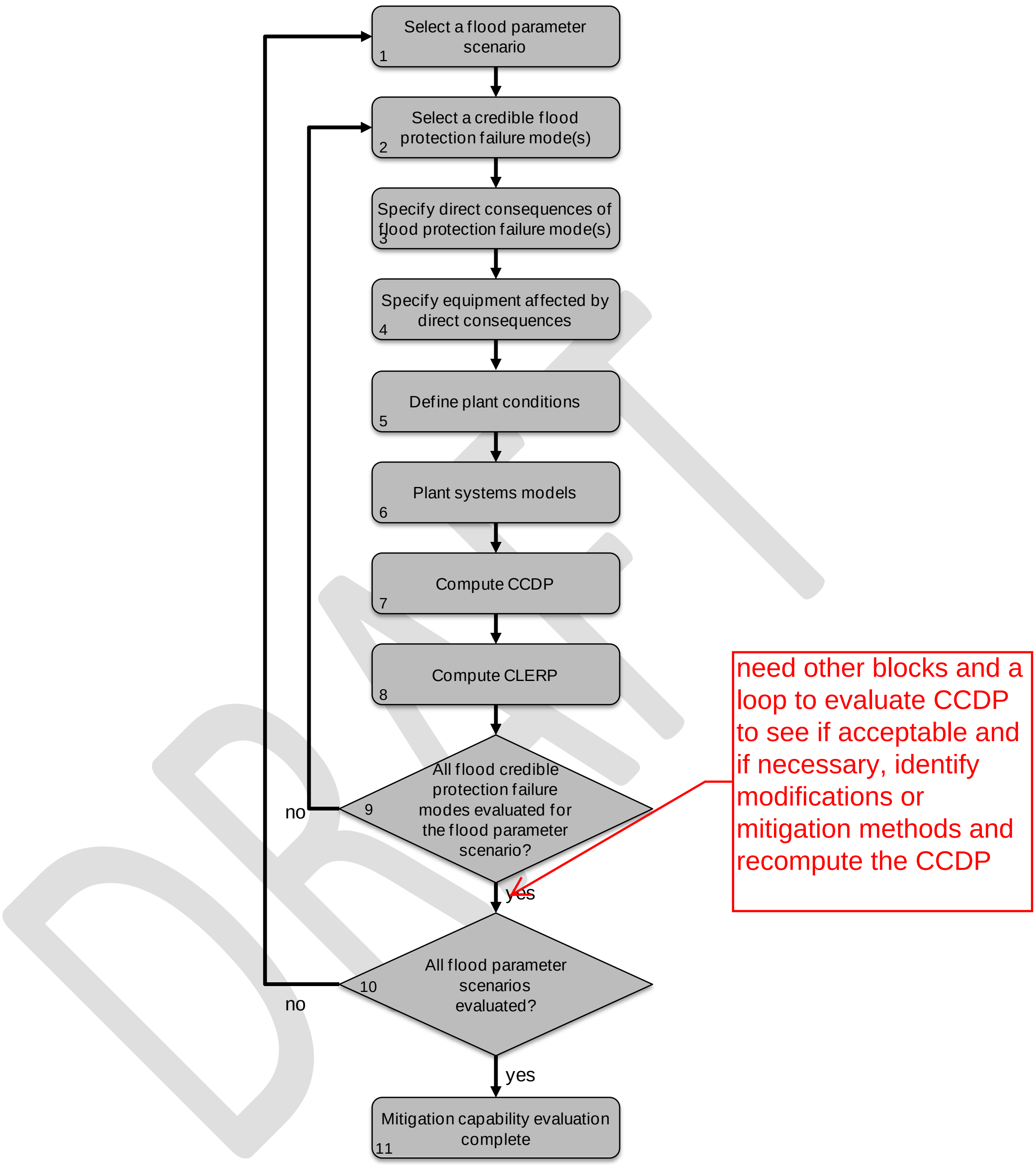


Figure 6: Margins-based mitigation evaluation flowchart [#figure under development]

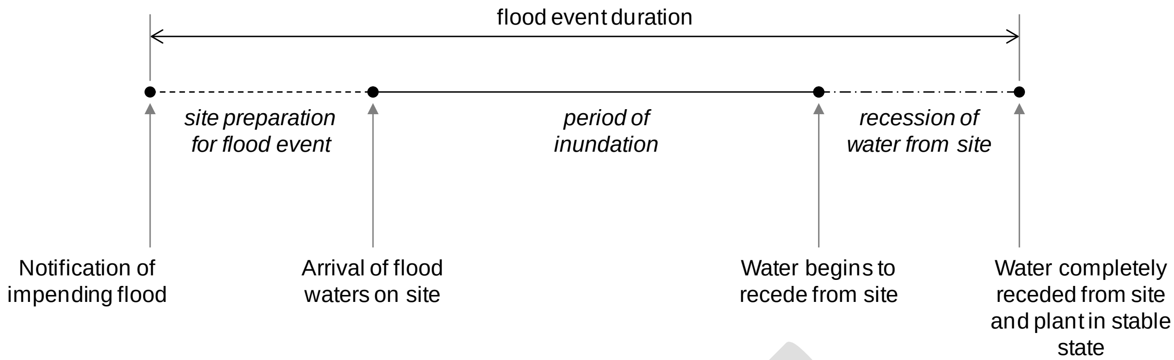


Figure 7: Illustration of flood event duration

11. References [#incomplete and unformatted]

1. USNRC. *#INSERT Reference to NRC endorsement letter of NEI 12-07.*

2. —. *#INSERT Reference to STAFF REQUIREMENTS – SECY-12-0025.*

3. —. *#INSERT Reference to NUREG/CR-7046 .*

4. ANS. *#INSERT Reference to ANS PRA document.*

5. USNRC. *#INSERT Reference to Regulatory Guide 1.200, "AN APPROACH FOR DETERMINING THE TECHNICAL ADEQUACY OF PROBABILISTIC RISK ASSESSMENT RESULTS FOR RISK-INFORMED ACTIVITIES".*

6. —. *#INSERT Reference to NRC 50.54(f) letter.* ML #.

7. NEI. *#INSERT Reference to NEI 12-07.* ML12173A215.

8. U.S. Nuclear Regulatory Commission. *Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire.* October 2007. NUREG-1852.

9. Gregory B. Baecher, John T. Christian. *Reliability and Statistics in Geotechnical Engineering.* West Sussex, England : John Wiley & Sons, Ltd., 2003.

10. U.S. Army Corps of Engineers, St. Paul District. *Flood-Fight Handbook - Preparing for a Flood.* 2009. http://www.mvp.usace.army.mil/docs/disaster_response/CEMVP_Flood-Fight_Handbook_2009.pdf.

11. U.S. Army Corps of Engineers. *Sandbag Construction.* http://www.mvp.usace.army.mil/docs/flood_fight2009/5Sandbag_Construction_2009_JRL.pdf.

12. —. Laboratory Testing of Flood Fighting Products. *Coastal and Hydraulics Laboratory.* [Online] [Cited: August 23, 2012.] http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Projects;182.

13. USNRC. *#INSERT Reference to NUREG 1852.*

14. U.S. Nuclear Regulatory Commission. *EPRI/NRC-RES Fire Human Reliability Analysis Guidelines.* July 2012. NUREG-1921.

15. —. *Good Practices for Implementing Human Reliability Analysis (HRA).* April 2005. NUREG-1792.

16. ANSI/ANS. *#INSERT referene to ANS/ANSI 2.8-1992, Determining Design Basis Flooding...*

APPENDIX A: Evaluation of flood protection

[#Text under development]

The goal of this appendix is to provide guidance on the evaluation of flood protection features. Section A.1 provides on guidance on evaluating individual features of a flood protection system. Section A.2 provides guidance on evaluating a complete flood protection system.

A.1 Evaluating individual features of flood protection systems

[#Text under development]

This section provides guidance on evaluating individual features comprising flood protection systems. Section A.1.1 this Appendix provides guidance on the evaluation of exterior and incorporated flood protection features that are passive and permanent. Section A.1.2 provides guidance on the evaluation of active flood protection features. Section A.1.3 provides guidance on the evaluation of temporary protective measures. Section A.1.4 provides guidance on evaluation of operator manual actions.

A.1.1 Evaluation of exterior and incorporated, passive flood protection features

Use of conventional engineering evaluations are generally considered acceptable for demonstrating the capability of exterior and incorporated features that are permanent and passive to perform their intended functions. The following steps should be considered in the flood protection assessment:

as

- analysis of potential failure modes
- evaluation of capacities
- comparison against present-day codes and standards
- evaluation of operational requirements
- sensitivity studies, is appropriate

It is appropriate to systematically consider the potential failure modes when evaluating a permanent, passive flood protection system. Use of PRA techniques (e.g., FMEA) may provide a useful structure for understanding failure modes and sequences. For example, Ref. (9) provides examples of use of PRA techniques in evaluating geotechnical structures.

As described in Section 6.2.1, the evaluation of exterior and incorporated features that are permanent and passive should demonstrate whether the flood protection barrier can withstand the loads associated with a flood parameter scenario(s) and should include a demonstration that the barrier is in satisfactory condition and structurally adequate based on engineering evaluations. The performance of the barrier should be compared against appropriate design codes and standards to determine whether the barrier conforms to best practices and is sufficiently robust (e.g., demonstrates an appropriate factor of safety). Qualitative evaluation of operational requirements such as surveillance, inspection, design control, maintenance, and testing is appropriate to provide confidence in the reliability of a barrier.

In addition, the following sections provide points of consideration in evaluating soil structures (embankment, levees, and berms) and concrete barriers. In evaluating these types of barriers, licensees should refer to the guidance below, referenced documents [#references to be added], and appropriate codes and standards [#insert references] to assess whether in place or planned systems conform to best practices.

A.1.1.1 Soil embankments, levees, and berms

The foundation and subsurface design of an embankment, levee, or berm should be evaluated to determine whether the following factors were 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 materials used in construction of the structure should be evaluated to determine whether the following factors were 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

The maintenance and inspection regime of the embankment, levee, or berm should be evaluated to assess whether:

- the embankment, levee, or berm 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 being used to obtain information on the performance and condition of the structure

A.1.1.2 Concrete barriers

In assessing whether the concrete barrier can support flood loads, the foundation and subsurface design of the barrier should be evaluated to determine whether the following factors were 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 material properties of the concrete barrier should be evaluated to assess whether:

- 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 design of the concrete barrier should be evaluated 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 maintenance and inspection regime of the concrete barrier should be evaluated to assess whether:

- 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

A.1.2 Evaluation of active flood protection features

See recommended approach in industry comments

[#text under development]

A.1.3 Evaluation of temporary barriers

[#text under development]

explain this sentence

As described in Section 6.2.2, temporary barriers should be evaluated to identify potential failure modes and demonstrate whether they are able to withstand the flood height and associated effects due to a flood parameter scenario(s). The evaluation should also consider intermediate water surface elevations that trigger emergency action levels or that are associated with discontinuities in the flood protection system. The performance of the barrier should be compared against appropriate design codes and standards to determine whether the barrier conforms to best practices and is sufficiently robust. Qualitative evaluation of operational requirements such as surveillance, inspection, design control, maintenance, and testing is appropriate In addition, standards, codes, and guidance documents (e.g., Ref. (10) and (11)) should be consulted to determine whether the configuration of the temporary barrier (e.g., configuration of a sandbag wall) conforms to best practices. Operator manual actions associated with construction or installation of temporary protective measures should be evaluated using HRA concepts and approaches based on considerations in Appendix C. Quantitative evaluation of the reliability of active features (based on operating experience or other available data) is appropriate. Quantification of feature reliability may require laboratory or field testing (e.g., Ref. (12)), analytical modeling, or demonstrations.

A.1.4 Evaluation of operator manual actions associated with flood protection features

Operator manual actions associated with flood protection features should be evaluated as described in Appendix C.

A.2 Evaluating flood protection systems

This section describes the evaluation of flood protection systems as a whole. System evaluation should begin with the definition of the flood parameter to which the system is subjected. Next, criteria defining failure of the flood protection system should be defined. In the context of the Integrated Assessment, failure may be defined as loss of barrier integrity, a leakage rate into a room exceeding a specified threshold, or other effects. Failure modes and effects analysis (FMEA) is a common tool for systematically identifying possible failure modes of a SSC and evaluating the effects of the failure on other SSCs. Once failure criteria have been defined, individual flood protection barriers within the flood protection system should be evaluated at the component level under the loads resulting from the flood parameter scenario. Finally, the flood protection system must be evaluated, accounting for interactions and dependencies between components.

The system evaluation should begin with the flood parameter scenario and progress though the sequence of subsequent events that can ultimately lead to end states corresponding to failure (or damage) of the flood protection system and subsequent adverse consequences (e.g., leakage of water past a barrier or inundation of a room). Logic structures, such as event trees, provide a way to represent the various outcomes that can occur as a result of a flood parameter scenario. An event tree starts with the flood parameter and develops sequences based on whether a feature (including an operator manual action) succeed or fail in performing the intended functions. The system level evaluation should account for factors such as:

- the feasibility and reliability of operator manual actions that must be performed to install or construct barriers (e.g., flood gates, sandbag walls), including factors that can influence operator performance, as described in Appendix C
- the duration of the flood event[16]
- the time available to carry out procedures and perform required actions, including consideration of the reliability of communication mechanisms and instrumentation that trigger actions by plant personnel
- the reliability of active components (e.g., pumps that are required to remove water that bypasses flood barriers)
- the effect of flood height and associated flood effects on the performance of barriers
- potential hindrances to movement of personnel and equipment around the site
- the robustness of barriers, particularly temporary barriers

[16] For some hazards, flood conditions could persist for a significant amount of time. Extended inundation on or near the site could present concerns such as site and building access, travel around the site, equipment operating times, and supplies of consumables (Ref. (4)). Flood protection feature limitations based on flood duration should be evaluated. For example, if the duration of the design basis flood is 72 hours and a diesel driven pump is credited with removing water from an area, the total amount of fuel available for the pump and the operating time it represents should be determined and included in the assessment.

APPENDIX B: Peer Review

A participatory peer review is an important element of the Integrated Assessment. The peer review increases confidence and assurance that the results of the Integrated Assessment are reliable and provide a sound basis for regulatory decisions. Additional details about the peer review attributes, team composition, and documentation are provided below.

B.1 Peer review attributes

this does not say that these are the only areas that need to be reviewed

Peer review should include the following attributes:

- The peer review should be a participatory peer review, as opposed to a late-stage review.
- In conducting the peer review, particular attention should be paid to:
  - justifications for use of models or methods that are novel or not consistent with current practice.
  - assumptions and judgments made as part of the Integrated Assessment

Add:
peer reviews need only be performed on "unique" aspects of the IA (such as HRA and PRA). They do not need to be completed for aspects of the IA that are

- Flood protection evaluations and design considerations based on generally recognized codes and standards need not be a focus of the peer review.
- The peer review process should include a review of the following aspects of the Integrated Assessment (if applicable):
  - methodologies and assumptions used in evaluating flood protection or mitigation capability
  - performance criteria used to evaluate flood protection
  - evaluations of the reliability of flood protection features and systems for which generally accepted codes and standards are not available or applicable
  - evaluations of the feasibility and reliability of operator manual actions
  - judgments and assumptions made regarding system response for evaluation of mitigation capability using margins-type and full PRA methods
  - judgments and assumptions made in determining that there is high-confidence that CCDP is low under a scenario-based evaluation of mitigation capability
  - judgments made regarding the reliability of protection or mitigation actions involving the use of equipment, personnel, or other resources in non-traditional ways
  - final Integrated Assessment report
  - [#above items may be modified and additional items may be added, as appropriate]
- Peer reviewers on various technical elements should have the opportunity to interact with each other when performing the reviews.
- The peer review should be conducted as a team for critical items, including evaluation of the following (if applicable): (1) operator manual actions, (2) temporary protective measures, and (3) non-safety-related equipment used for event mitigation.

B.2 Peer review team

The peer review team should be assembled based on the following considerations:

- Peer reviewers should be independent of those who are performing the Integrated Assessment. At least one reviewer should be external to the licensee's organization, this is worse than before, why "strong"?

unless strong justification is provided to demonstrate the independence of reviewers assembled from inside the licensee's organization. [#number of people in team?]

- The peer review team should cover areas of expertise important to the Integrated Assessment. The peer review team members should have combined experience in the areas of systems engineering, flood hazard assessment, flood protection engineering (e.g., structural and geotechnical engineering), human reliability analysis, and application of PRA methodologies.[17]
- Reviewers focusing on the evaluation of flood protection features should have demonstrated experience consistent with the types of flood protection utilized at the site.
- Individuals with experience assessing operator manual actions (e.g., for fire, as described in Ref. (13)) should be included in the peer review team at sites relying on operator manual actions to protect against or mitigate a flood event.
- One of the peer reviewers should be designated as the overall Team Leader. The peer review Team Leader is responsible for the entire peer review process, including completion of the final peer review documentation. The Team Leader is expected to provide oversight related to both the process and technical aspects of the peer review. The Team Leader should also pay attention to potential issues that could occur at the interface between various activities.

B.3 Peer review documentation

The peer review process should be clearly documented in the Integrated Assessment report. Documentation of the peer review should be contained in a separate report as part of the in the licensee's Integrated Assessment submittal and should include the following:

- a description of the peer review process
- the names and qualifications of the peer review team members, including the areas reviewed by each participant.
- a discussion of the key findings and a discussion as to how the findings were addressed
- information regarding the disposition of comments made by peer reviewers
- a review of the final Integrated Assessment report
- the conclusions of the peer review

[17] [#Text under development] If certain disciplines are not applicable to the Integrated Assessment, it is not necessary to have peer reviewers with experience in those disciplines (e.g., if protection and mitigation at a site do not require operator manual actions, peer reviewers with experience in HRA may not be necessary). Justification should be provided in the peer review report for any listed discipline not covered as part of the peer review team.

APPENDIX C: Evaluation of operator manual actions

[#additional content for this appendix is under development]

This appendix provides guidance on evaluating operator manual actions associated with flooding based on concepts and approaches used in human reliability analysis (HRA). This appendix is not intended to provide prescriptive guidance on the performance of HRA. Instead, this appendix is intended to provide qualitative "points of consideration" and guidance on using existing HRA concepts and approaches in the context of flooding to evaluate whether operator manual actions are feasible and reliable.[18] Much of this appendix is based on the adaptation of existing guidance related to the evaluation of operator manual actions in response to fire (Refs. (8) and (14)). Thus, in addition to the primarily qualitative considerations described in this Appendix, guidance documents related to the evaluation of operator manual actions for fire provide a valuable resource when evaluating operator manual actions as part of the Integrated Assessment. In addition, general guidance on the application of HRA may also be applicable. For example, while Ref. (15) is developed for HRAs associated with full-power and internal events applications, the document states that "most of the guidance should be useful for other applications (e.g., external events and other operating modes)" (Ref. (15), p. 2-1). While this appendix provides points of consideration for applying existing HRA concepts and approaches to flooding, this appendix is not a comprehensive guide for evaluation of the feasibility and reliability of operator manual actions and considerations beyond those provided here are appropriate.

C.1 Overview

If a flood protection system or mitigation action requires operator manual actions, the Integrated Assessment should evaluate whether operator manual actions are feasible and reliable. Consistent with the definitions provided in Ref. (8) and Section 8 of this ISG, an action is considered feasible if it is analyzed and demonstrated as being able to be performed within an available time so as to avoid a defined undesirable outcome. Reasonable simulation[19] performed as part of the NTTF Recommendation 2.3 walkdowns (see Section 2) may provide useful information for assessing whether an action is feasible. A feasible action that is analyzed and demonstrated as being dependably repeatable within an available time (while considering varying conditions that could affect the available time and/or the time required to perform the action) is considered reliable. All reliable actions need to be feasible, but not all feasible actions will be reliable (Ref. (8)). Determination of whether an action is feasible and reliable should account for the following factors:

- adequacy of available time
- accessibility
- environmental factors
- the functionality, availability, and accessibility of required equipment
- the availability of indications or cues
- communications
- the availability and quality of procedures and training
- available personnel (staffing)

Each of the above factors is further described in the subsequent sections of this Appendix.

---

[18] See Section 8 for definitions of feasible and reliable actions.
[19] See definition in Section 8.

C.2 Adequacy of available time

An important component of establishing whether an operator manual action is feasible involves determination of whether the time available to complete the action exceeds the time required to perform the action. For each operator manual action, the analysis should show that there is adequate time to diagnose, perform, and confirm actions before an undesired consequence occurs. This evaluation includes three key elements:

1) estimation of the time available to perform the manual action
2) estimation of the time required to diagnose the need for action and to implement the action
3) comparison of the times in (1) and (2) above along with appropriate justification for any conclusions

If an action requires more time to diagnose, perform, and confirm than is available, the action is considered infeasible.

To establish whether an action is reliable, it is necessary to consider the uncertainties associated with the time available and the time required to diagnose and execute the required action. Uncertainties are particularly important when there is a small difference between the time available and time required to perform actions. In the context of flooding, potential uncertainties include:

- variations in plant state and concurrent environmental conditions (e.g., adverse weather, hazards to personnel)
- unexpected difficulties encountered by operators (e.g., inundated rooms, locked doors, loss of lighting, communication failures, and underwater hazards)
- factors that cannot be re-created as part of a demonstration (e.g., reasonable simulation performed as part of the NTTF Recommendation 2.3 walkdowns, see Section 2) such as the presence of floodwater on site and stress placed on operators due to the site conditions or concurrent offsite events (e.g., effect of a large flood event on the homes and families of operators)
- obstructions to movement of personnel or resources on site due to floodwaters and associated effects (including adverse weather)
- actions the cannot be "practiced" or demonstrated due to normal plant status, physical limitations (e.g., it is not possible to simulate actual flood waters on site), or other safety considerations
- variations between individuals and crews, including differences in size and strength, cognitive differences, different emotional responses to water or adverse weather conditions, differences in performance "under pressure," and differences in crew characteristics or dynamics
- failure of communication mechanisms (e.g., failure to receive timely notification of an imminent dam failure)

C.3 Accessibility

Actions that must be performed in inundated areas or requiring personnel to travel through inundated areas, should be considered infeasible unless it can be shown that elevated pathways or other means are available to enable movement through the inundated areas and significant hazards to personnel (e.g., electrical hazards due to presence of water or low temperatures) are not present. This criterion is particularly important when evaluating protection or mitigation actions that must be performed after the onset of flood conditions.

Potential uncertainties in accessibility should be considered when evaluating whether an operator manual action is reliable.

C.4 Environmental factors

Environmental conditions may affect an operator's physical or mental performance. As a result, the capability of the operator to perform the required actions may be degraded or precluded by environmental factors. Environmental conditions associated with flood events include:

- adverse weather (e.g., lightning, hail, wind, precipitation)
- temperatures (e.g., 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)
- lighting
- humidity
- radiation
- noise

C.5 Equipment

Equipment necessary to facilitate performance of operator manual actions should be functional, available, and accessible when required. The availability of special equipment required for the performance of protective or mitigative actions should be considered.

In crediting the availability of equipment for use by operators, the following criteria should be considered:

- Equipment should not be damaged or otherwise adversely effected by the flood event (e.g., due to direct inundation, humidity, hydrodynamic forces, or debris) or adverse environmental conditions (see Section C.4).
- Equipment should not be located in an area exposed to the flood (including any associated effects), unless there is strong justification for the continued functionality of the equipment.
- All "needs" of the equipment should be met, including supporting electrical power, cooling, and ventilation.
- Equipment should be easily located and all operator aids should be readily available.
- Physical access and manipulation constraints should be considered in evaluating whether equipment is available for use.
- Operators should have experience using the equipment.

No credit for operator manual actions should be given if equipment is not functional, available, and accessible to operators. The operators should be able to find and reach the equipment and should be able to perform the required actions using the equipment. Therefore, if any of the above criteria are not met, the associated operator manual actions should be considered infeasible.

In evaluating whether operator manual actions are feasible and reliable, consideration should be given to special and portable equipment that may be required to facilitate performance of required actions. Special equipment may include keys to open locked doors (doors may "fail closed" in the event of a loss of power), ladders, and special purpose tools (e.g., equipment required to fill sandbags, portable generators, tools to manipulate equipment manually) and equipment necessary to cope with environmental conditions (e.g., flashlights and protective equipment such as personal floatation devices). Equipment should be easily located and readily available so as not to impede or delay the performance of required actions. Equipment should be controlled and routinely verified. Personnel should be trained to locate and use the required equipment. Any delays associated with acquisition and use of portable equipment should be considered.

C.6 Indications and cues

Indications or cues provide the following functions:

1) enable operators to determine that manual actions are required or appropriate
2) direct or guide personnel performing actions
3) provide feedback to operators

In the context of flooding, indications should be available to provide notification that a flood event is imminent if operator actions are required to provide protection against the flood event. Examples of indications include river forecasts, dam condition reports, and river gauges. Durable agreements should be in place if indications rely on offsite entities to provide notification of an impending flood event. If durable agreements are not in place to ensure communication from offsite entities and the plant does not have independent capability to obtain the same information onsite, any operator manual action initiated by the indication should be considered infeasible. In assessing the reliability of operator manual actions, consideration should be given to the quality of the agreements in place between offsite entities and operators at the nuclear power plant site as well as the potential for the communication mechanisms to fail.

In the context of mitigation actions, indications should be available to alert operators to the failure of flood protection features and presence of water in locations that are intended to be kept dry or otherwise protected from flood effects. For cases in which indications are not available, the evaluation can consider compensatory measures (e.g., local operator observations). Evaluations of adequacy of time should account for the frequency of manual checks in the absence of continuous monitoring. If cues or indications are not available to operators, the mitigation actions should be considered infeasible.

C.7 Communications

Equipment (e.g., two-way radios) may be required to support communication between personnel to ensure the proper performance of manual actions (e.g., to support the performance of sequential actions and to verify procedural steps). Due to the substantial amount of warning that may be present for some flood mechanisms, efficiency of communication may be less important when evaluating the feasibility and reliability of operator manual actions associated with preemptive protective measures. However, mitigation may require actions for which the time available to diagnose, perform, and confirm actions is short. Communications methods should be checked to ensure prevailing conditions do not challenge their effectiveness. Consideration should be given to whether personnel are trained to ensure effective communication and coordination during a flood event.

C.8 Procedures and training

In evaluating the feasibility of an operator manual action, the quality of procedures should be assessed based on its ability to accomplish the following objectives:

- Assist operators in correctly diagnosing an impending flood event (i.e., flood height and associated effects) or the compromise of a flood protection feature
- Identifying the appropriate preventative (or mitigation) actions
- Account for prevailing current conditions, if applicable (e.g., high wind or lightning that makes it difficult for personnel to work outdoors)

Except under special circumstances involving skill-of-the-craft,[20] operator manual actions that are not associated with procedures should be considered infeasible. Written and maintained plant procedures must be available to cover all credited manual actions. Even if procedures are available, actions should be considered infeasible if the associated procedures do not meet the above objectives.

If credit is taken for operator manual actions, personnel performing required actions should have been trained in their individual responsibilities. In evaluating the effectiveness of training on improving the reliability of operator manual actions, the following factors should be considered:

- Operator training should establish familiarity with procedures and required actions including operation of equipment (including special purpose equipment).
- Training should engender operator familiarity with potential adverse conditions arising from a flood event (e.g., dangerous weather).
- Training should prepare operators to handle departure from the expected sequence of events
- Training should provide the opportunity to practice operator response (e.g., construction of barriers using special equipment).

C.9 Staffing

In assessing the feasibility and reliability of an operator manual action, the persons involved in performing the operator manual action should qualified. The feasibility assessment should consider the availability of a sufficient number of trained personnel without collateral duties during a flood event such that the required operator action can be completed as needed. Required staff may be normally onsite or available from offsite, if sufficient warning time is available and the flood event does not inhibit access to the site. Consideration should to given to whether task assignments (or task loads) subject one or more operators to excessive physical or mental stress or if concurrent tasks challenge the ability of the person to perform as required. If there are insufficient qualified staff members to complete the required actions (considering actions that must be performed concurrently), the action should be considered infeasible. In evaluating the reliability of an operator manual action, uncertainties in the number of staff onsite (or that can be “brought in” from offsite) should be considered.

C.10 Documentation

[#text under development]

---

[20] #definition to be added

APPENDIX D: Examples

[#text under development]