ANS-2.8: Probabilistic Evaluation of External Flood Hazards for Nuclear Facilities

Working Group Status

4th PFHA Workshop May 02, 2019

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Topics

- Background
- Objective/Scope
- Layout of the Standard
- Present status
- Questions

Background

- ANSI / ANS-2.8 1992 "Determining design basis flooding at Nuclear Power sites"
  - Intent to establish a methodology for a design basis flood hazard with "virtually no risk of exceedance" (e.g probable maximum Floods (PMFs), Probable maximum Hurricanes (PMH), etc.) .
  - Standard covered external flooding hazard with the exception of tsunami
  - Design Basis Flood based on a deterministic process with assumptions intended to produce low probability flood hazard elevations
  - Appendix B (estimated expected frequencies of recommended combinations)
  - Standard withdrawn in 2002 and not subsequently updated
- ANSI/ANS-2.8-XXXX being developed to fill an important gap in standard
  - Standard to reflect lessons learned from nuclear site flooding events from 1992
    - Insights from Katrina, record floods in mid-west, combined flood events at European coastal site and Fukushima
  - Establish hazard based on a probabilistic/statistical approaches
    - Reflect State of the art enhancements in technology in computation methods and capabilities in fluid dynamics/hydrology
    - Extend application to all nuclear facilities
  - Consider Tsunami
  - Integrate consideration of "climate change"

Objective

- **Upgrade ANSI/ANS Standard for determining external flood hazards**
- **Establish a probabilistic framework for modeling external flood hazard parameters considering the aleatory variability uncertainties associated with natural phenomena and epistemic uncertainties in estimating the frequency of occurrence and magnitude of hazards**
- **Hazard characterized by site-wide Water Surface Level (WSL), Wind – Wave Runup, water flowrates**
- **Consider present state-of-knowledge using scientific and engineering modeling capabilities to describe the hazard.**

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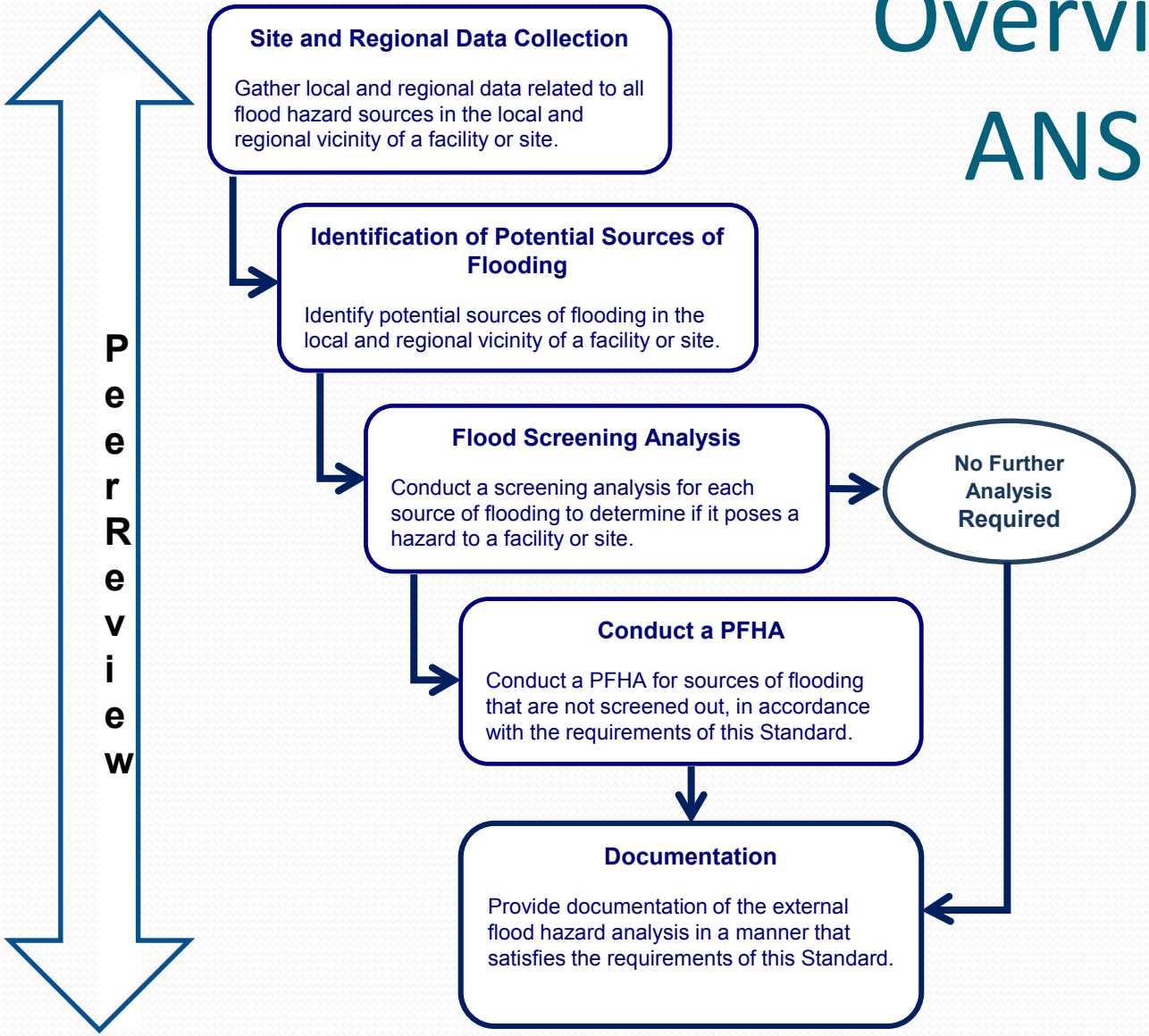
Scope of ANS2.8

- **Local Intense Precipitation**
- **Riverine flooding**
- **Upstream dam failure**
  - **Hydrologic**
  - **Non-hydrologic (seismic, intrinsic, other)**
- **Hurricane induced storm surge**
- **Seiche (wind and earthquake generated)**
- **Tsunami (seismic and landslide initiated)**

Not in Scope

- Low water
- Dispersion, dilution and travel time of accident release of effluents
- Groundwater
- Channel diversions
- Internal or external flooding from failure of pipes or tanks
- Combined Events assessments
- Hydrodynamic loadings on plant structures associated with flood.
- Standard does not specify:
  - any requirement regarding the acceptability of any particular hazard frequency or hazard profile
  - nor does the Standard provide guidance on the appropriateness of facility flood protection or mitigation systems

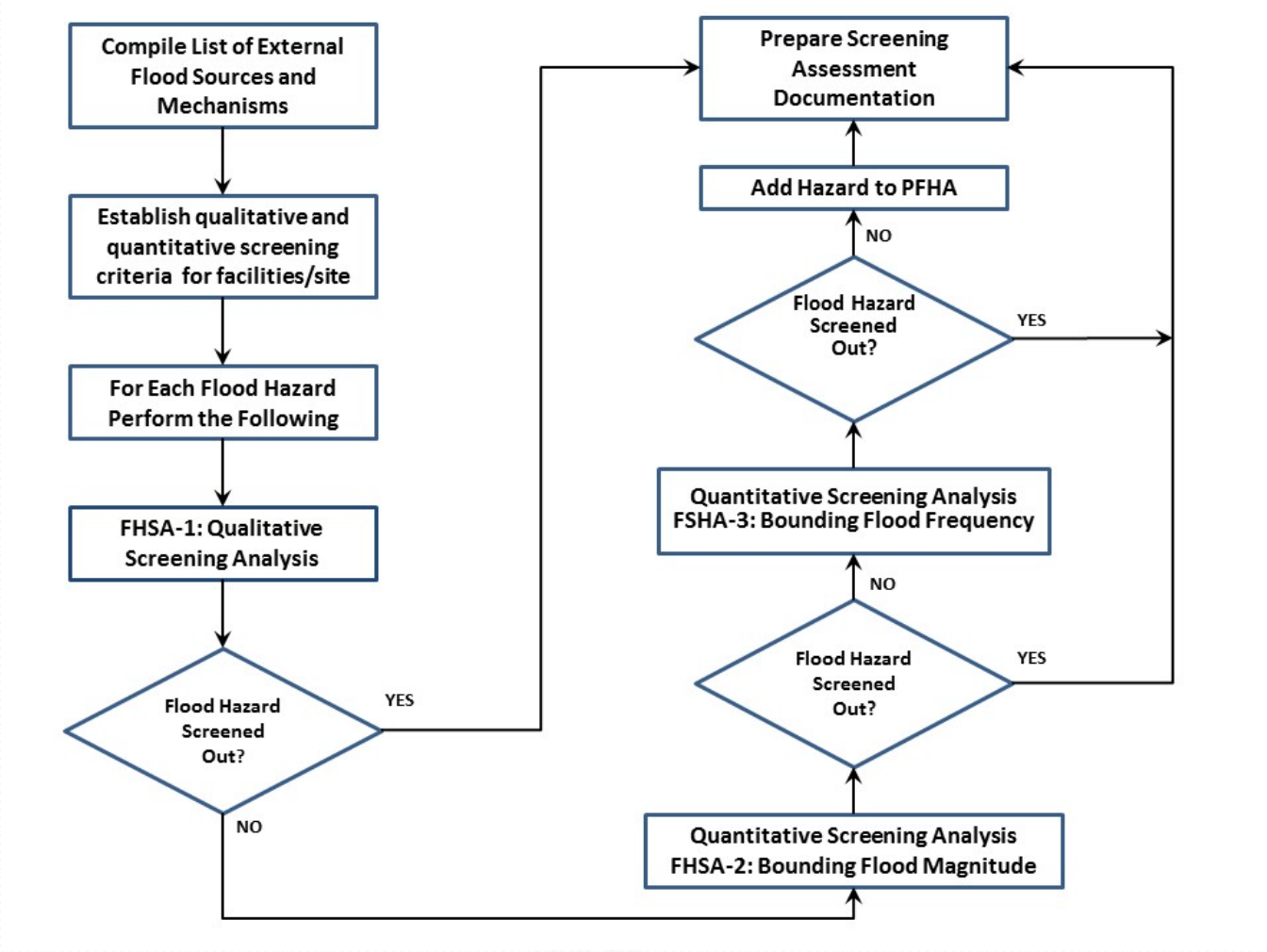
Overview of ANS 2.8



Site and Regional Data Collection and Identification of Potential Sources of Flooding

- Use of consistent datum
- Site and facility description
- Location of main hydrologic features nearby to the facility (streams, rivers, gages etc.) and relevant information regarding the surrounding watershed.
- Location and flood protections of SSCs important to safety
- Site topography and drainage
- Site and regional climatology, meteorology and hydrology (and associated history)

Flood Hazard Screening Analysis



Probabilistic Flood Hazard Analysis

- PFHA performed on all non-screened flood hazards
- Standard provides specific requirements for performing the PFHA
- Overall PFHA process provides for a structured hierarchical approach based on facility risk and hazard complexity

Safety Category per ANS 58.16-2014	Overall Site Flood Hazard Complexity	Recommended PFHA Level
SC-3 (High Consequence)	High	3,4
	Low	3
SC-2 (Intermediate Consequence)	High	3,4
	Low	2
SC-1 (Low Consequence)	High	2
	Low	1

ANS-2.8

Probabilistic Flood Hazard Analysis

Regardless of Level PFHA Process is a hazard evaluation and integration process which includes the following:

- Formation of PFHA team with specific objectives
- Data Collection commensurate with Level of PFHA
- Evaluate and select physically based stochastic models for the assessment of the flood hazard; including consideration of treatment of aleatory variability and epistemic model uncertainty (to the extent warranted by the PFHA Level)
- Integrate models into a probabilistic framework considering sources of uncertainty
- Propagate hazard scenarios to produce a family of site-specific hazard curves

Specific requirements based on meeting high level and subordinate Supporting requirements

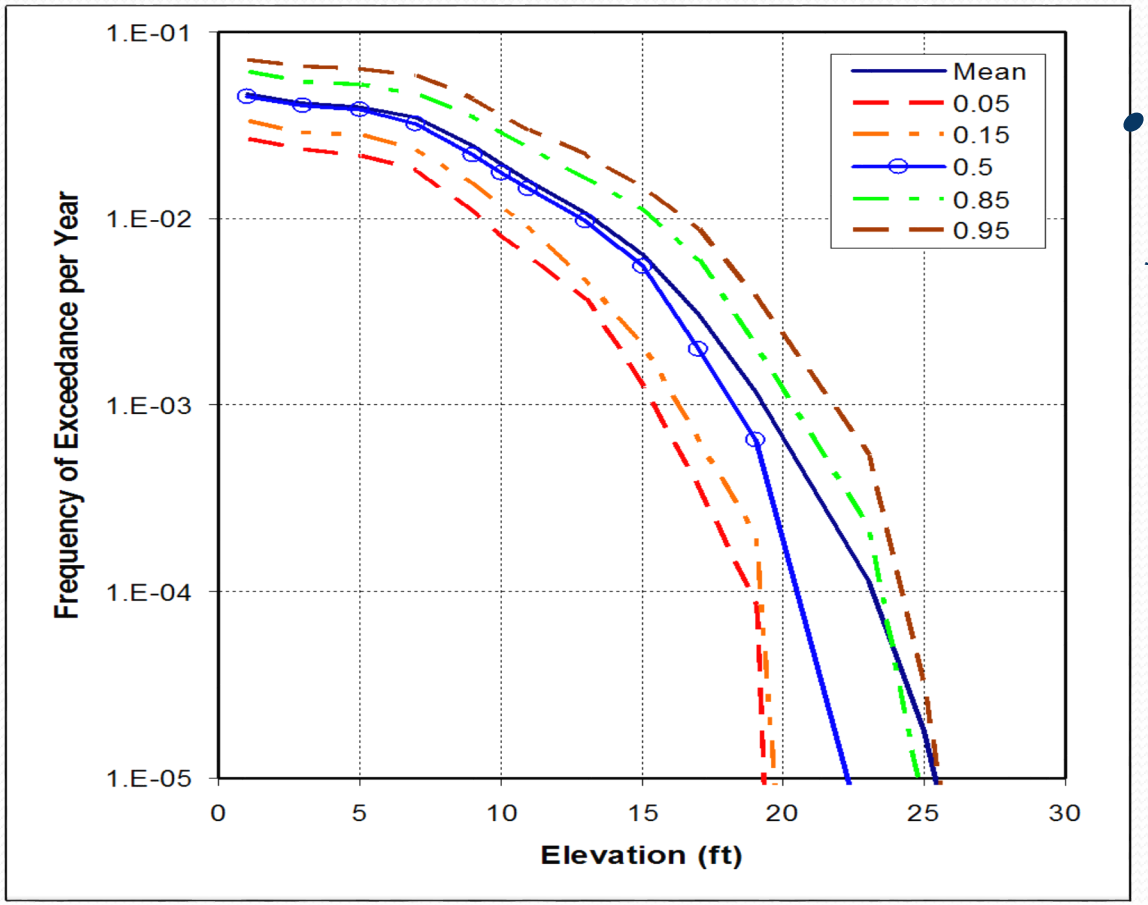
High Level Requirements for Performing a PFHA

No.	Requirement
HLR-PFHA-A	The project organization shall be clearly established including roles and responsibilities of the project participants, shall be identified.
HLR-PFHA-B	The PFHA level of analysis shall be identified and used as the basis for determination of analysis detail.
HLR-PFHA-C	The inputs to the PFHA shall be based on comprehensive up-to-date data.
HLR-PFHA-D	A structured process shall be used for the identification and evaluation of the sources of aleatory and epistemic uncertainty. Where expert elicitation is used, a structured elicitation process shall be implemented.
HLR-PFHA-E	For each flooding source or mechanism (and applicable combinations) an aleatory flood hazard model shall be developed. The aleatory model shall include all elements of the flooding process (meteorological, hydrologic, hydraulic, etc.).
HLR-PFHA-F	For each element of the flooding process, sources of epistemic uncertainty shall be identified, evaluated and modeled using a structured process.
HLR-PFHA-G	The flood hazard shall be characterized in a manner that supports the intended application of the PFHA results.
HLR-PFHA-H	Aleatory and epistemic uncertainties in each step of the hazard analysis shall be propagated and displayed in the final quantification of the flood hazard for each non-screened flooding source and mechanism.
HLR-PFHA-I	A peer review shall be performed whose level of effort is commensurate with the level of the PFHA. (See Section 8)
HLR-PFHA-J	The PFHA shall be documented in a manner that facilitates application of the results, peer review, (and analysis upgrades, where applicable).

PFHA: Presentation of Results

Result	Description
Fractile hazard curves	For flood hazard measure (e.g., peak flood elevation), the flood hazard is quantified in terms of fractile hazard curves. Fractiles that are typically reported are the 5, 15, 50, 85 and 95 percentiles.
Mean hazard curves	The arithmetic mean flood hazard curve is computed from the entire uncertainty distribution of the estimated of the frequency of exceedance generated in the PFHA. The mean is the arithmetic mean estimate of the frequency of exceedance.
Intermediate Results	The type of intermediate results that are provided in a PFHA depends on the source of flooding and the type of flood hazards are being evaluated (e.g., riverine flooding, storm surge). The PFHA analyst shall provide intermediate results of the quantification that provide insight to elements of the analysis. For instance, in the case of riverine flooding, hazard curves could be provided for peak river discharge at a selected river cross-section, in addition to flood hazard curves for peak flood elevation at the same location.
Sensitivity Analysis	Results of sensitivity studies shall be provided that show the effect that different models or parameters have on the PFHA aleatory results as well the uncertainty.
Diagnostic Results	Diagnostic methods such as tornado plots and analysis of variance shall be used to demonstrate the effect that uncertain models and parameters have on the uncertainty in the PFHA result.

Example Results of Probabilistic Approach: Riverine Flood



- *Example external flood hazard curve*

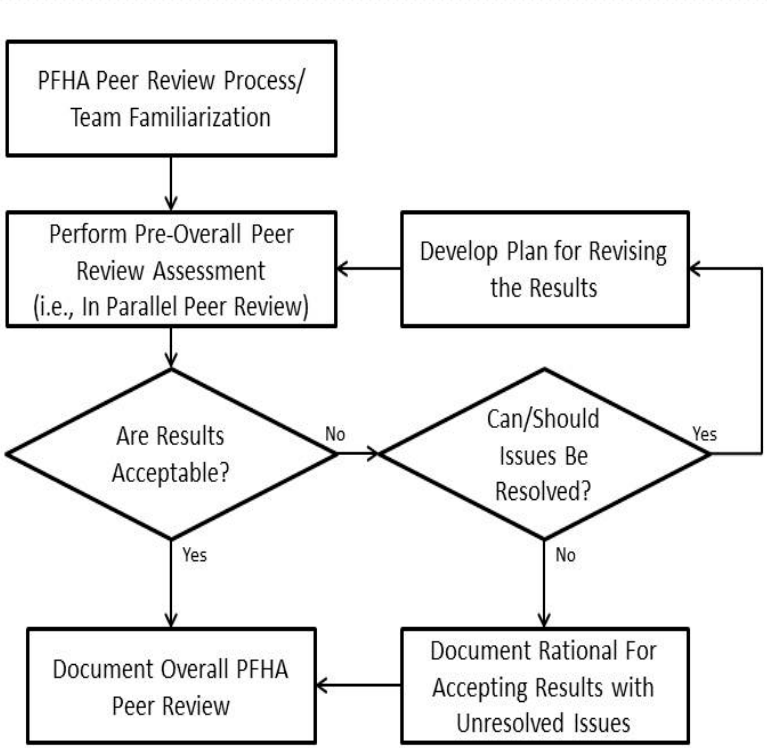
Documentation

- Documentation process is to cover all aspects of the analysis and support peer review.
- Documentation will be commensurate with PFHA Level and facilitate Peer Review and applications of the PFHA

Peer Review

- Peer Review is an integral part of the revised ANS 2.8 Process
- Overall process is modeled after Seismic Peer Review Process (ANS 2.29)
  - Late Stage Peer Review
  - Participatory Peer Review (required for Level 3 / Level 4 PFHA)

Participatory Peer Review Process



Present Status

- Final draft has been released to ANS ESCC (Environmental and Siting Consensus Committee)
- Methods and approaches reflect current industry practice and capabilities

Questions