

# External Flooding PRA Guidance

Marko Randelovic - Principal Technical Leader, EPRI  
Ray Schneider, Fellow Engineer, Westinghouse

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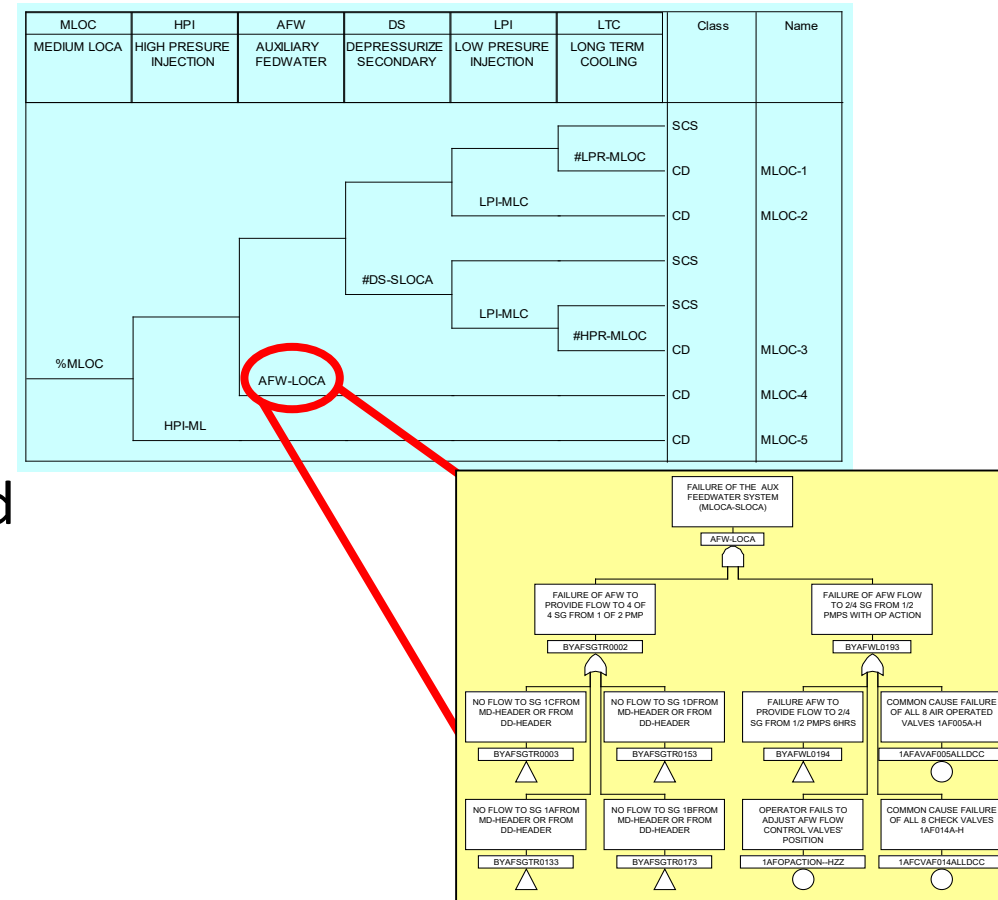


# Background

- Past EPRI projects have provided guidance supporting implementation of the ASME/ANS PRA Standard to assess risks of internal and external hazards. EPRI projects in the internal and external flooding area include:
  - Development of screening methodology for the external hazards
  - Development of external flood walkdown guidance
  - Development of the methodologies for variety of the flood hazard curves
  - Development of the 3D modeling technique for internal flooding
- The current project expands the external flood PRA effort by integrating available information on external flood modeling to develop a practical methodology for the development of the external flooding PRAs

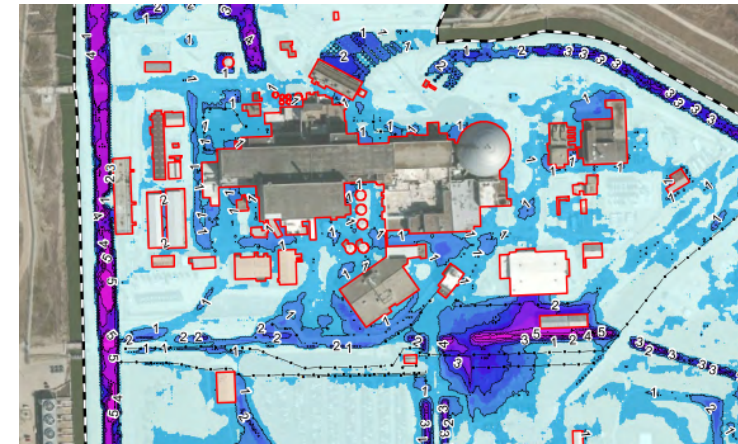
# External Flood Guidance for Probabilistic Risk Assessment

- Provides a structured roadmap for performing an External Flood PRA (XFPRAs) consistent with meeting requirements of the ASME/ANS PRA Standard.
- Includes guidance for:
  - Defining and characterizing the external flood hazard
    - Including estimation of external flood hazard frequencies, severity and associated uncertainties
  - Identifying flood induced failure modes and develop external flood fragility curves for flood significant Systems, Structures, and Components (SSCs).
  - Preparing and quantifying a PRA external flood event tree.



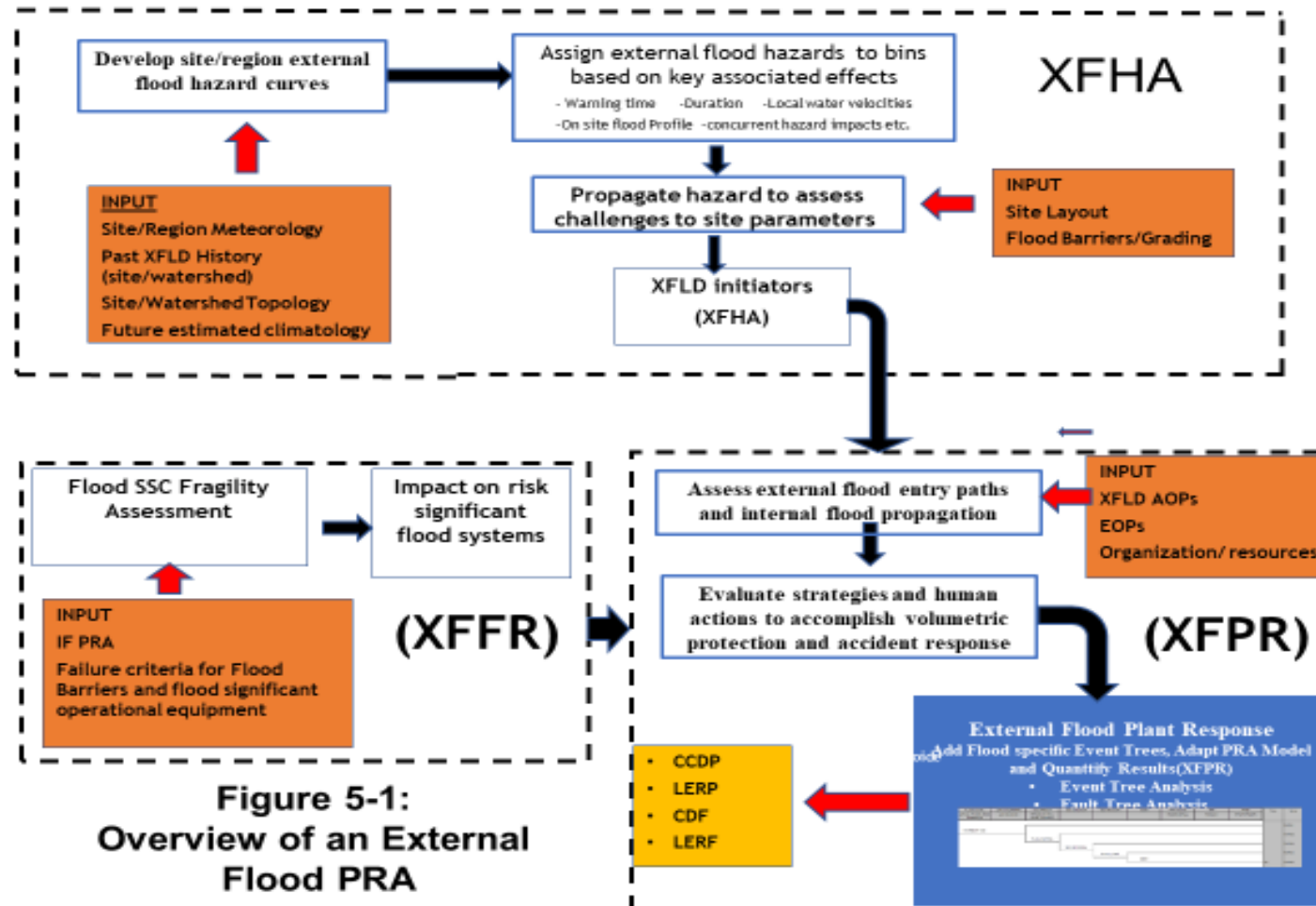
# External Flood Guidance for Probabilistic Risk Assessment

- Guidance uses baseline internal events and internal flood PRAs as basis for developing relevant flood-induced failures for inclusion in an External Flood PRA.
- Guidance is structured consistent with the ASME/ANS PRA Standard
- Guidance builds upon prior relevant EPRI references for hazard screening and example PFHA studies for representative NPPs
- Where available and appropriate USACE and NRC documents and methods are identified to support both PFHA and fragility assessments



# External Flood PRA Process

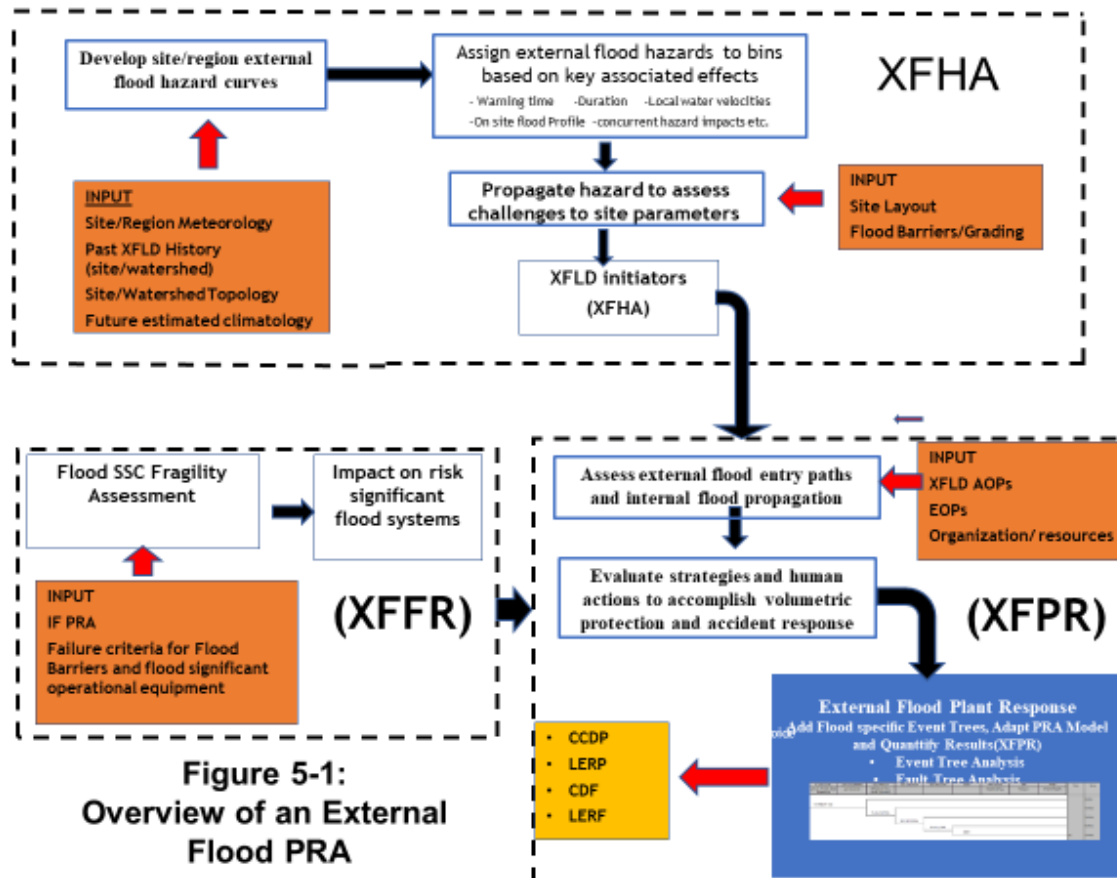
## Information flow through an External Flood PRA





# External Flood PRA Process

## Information flow through an External Flood PRA



## External Flood Hazard Analysis (XFHA)

- Interface with PFHAs
- PFHA provides event frequencies, uncertainties and may be disaggregated into specific event classes
- PFHA results are parsed into representative scenarios and characterized with features important for risk assessment
  - Event warning time
  - Event duration
  - Site-wide water levels and velocities
  - Any relevant coexistent / concurrent conditions that may affect plant challenge/response

# External Flood PRA Process

## Information flow through an External Flood PRA

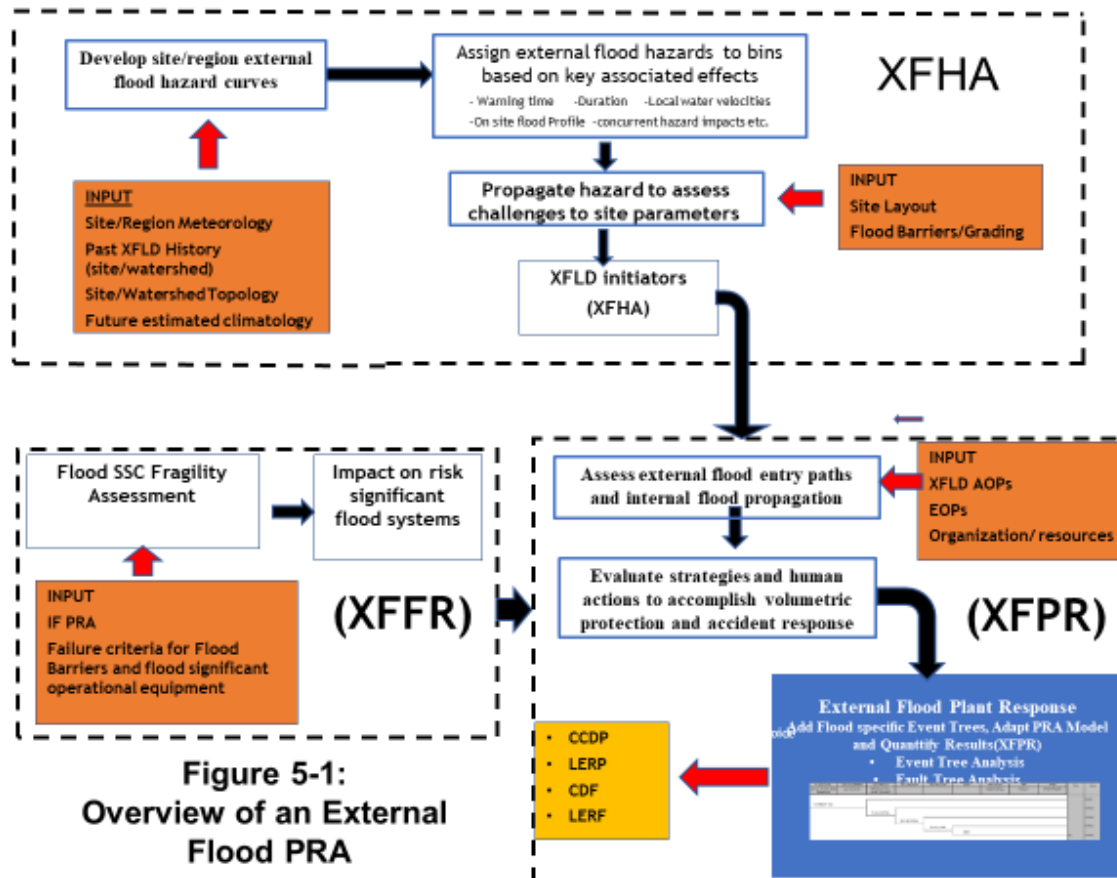


Figure 5-1:  
Overview of an External  
Flood PRA

## External Flood Fragility Response Analysis (XFFR)

- Includes guidance for development of hazard specific loadings for fragility representation for:
  - Integrity / effectiveness of permanent and temporary flood barriers,
  - Flood penetration seals leakage/ dislodgement
  - Equipment wetting/submergence of flood significant components (FSCs)
  - Consideration of potential effects of coexistent/concurrent hazards

# External Flood PRA Process

## Information flow through an External Flood PRA

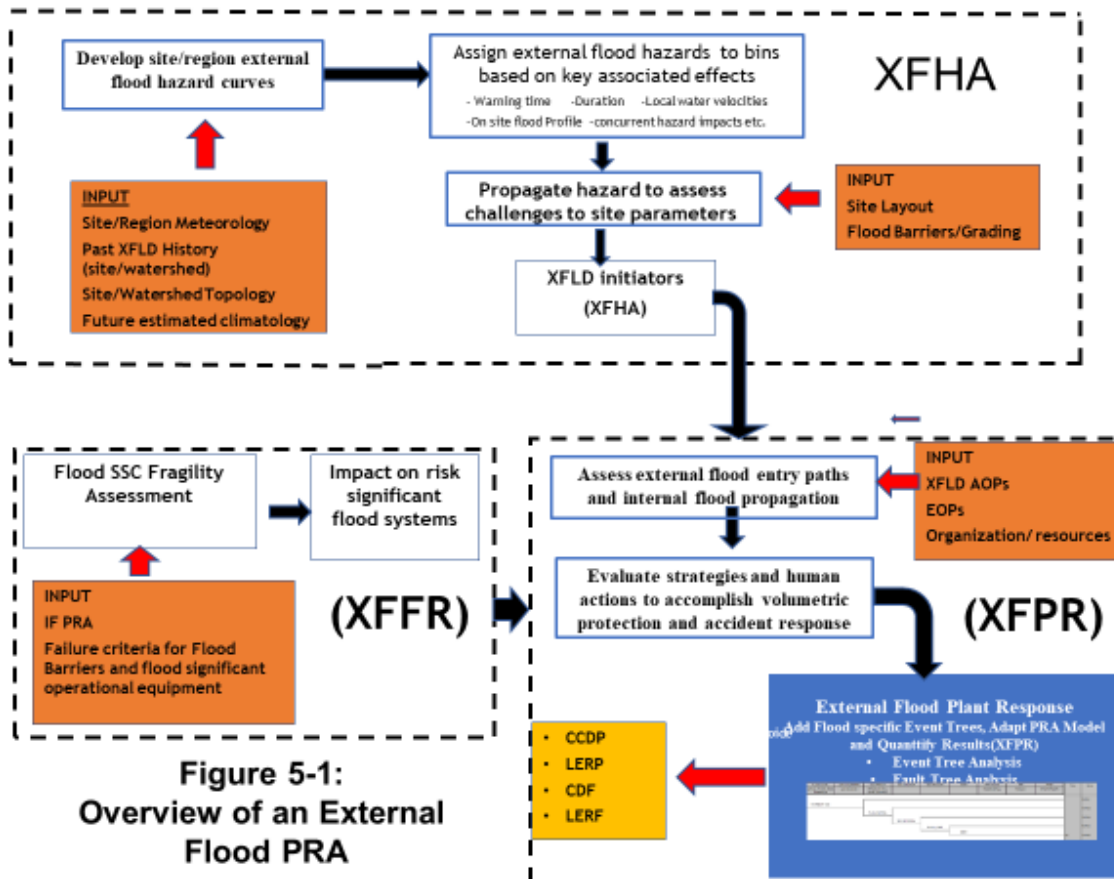


Figure 5-1:  
Overview of an External  
Flood PRA

## External Flood Plant Response Analysis (XFPR)

- Guidance is provided to map flood hazard characteristics and flood related SSC fragilities within the External Flood event tree framework to identify the probability of various core damage hazard end states.
- Specific consideration is given to modeling of
  - Pre-flood preparatory actions
    - Based on warning time and pre-flood site and region conditions
  - Post-flood on-site response as it affects outside activities and external site support
  - External Flood challenges on implementation of FLEX/portable equipment response strategies
- Guidance for quantification and calculation of core damage end states



# Illustrative Examples

- Examples illustrate External Flood PRA models of hypothetical plants for:
  - Local Intense Precipitation
  - Riverine Flood
  - Storm Surge
- Discussion of PFHA methods with reference to example PFHAs for similar hazards for each example
- Illustrative characterization of hazard constituent events
- Examples are presented to guide the analyst through a structured process from PFHA method selection, disaggregation of the hazard curve(s) and hazard characterization through development and quantification of the external flood event tree.

# Illustrative Examples

- Results of example analyses are provided to structure results for presentation of external flood PRA insights.
- Key flood scenarios are identified
- Risk insights are drawn along with discussion of potential for additional mitigation strategies.
- Example hazard illustration concludes with a comparison of the external flood modeling process to the ASME/ANS Supporting Requirements

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