



# **NRC Probabilistic Flood Hazard Assessment Research Program Update**

***Thomas Aird\*, Joseph Kanney, Elena Yegorova***

Fire and External Hazards Analysis Branch  
Division of Risk Analysis  
Office of Nuclear Regulatory Research

**7<sup>th</sup> Annual PFHA Research Workshop**  
NRC HQ, Rockville, MD  
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# Outline

- Objectives, key challenges, approach
- Phase 1 Overview (Technical Basis)
- Phase 2 Projects (Pilot Studies)
- Thoughts on Phase 3 (Guidance)

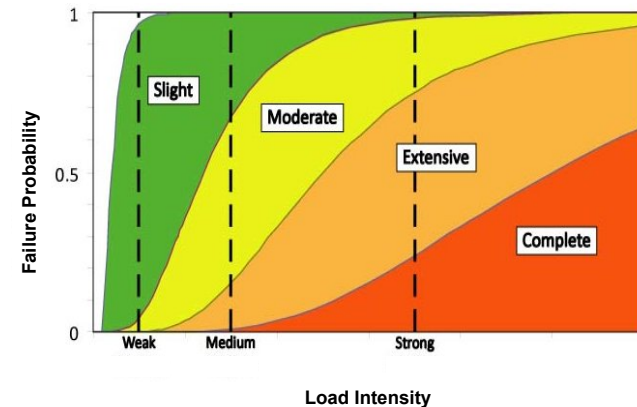
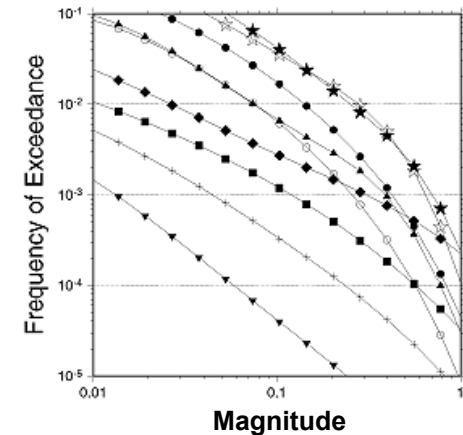


# PFHA Research Objectives

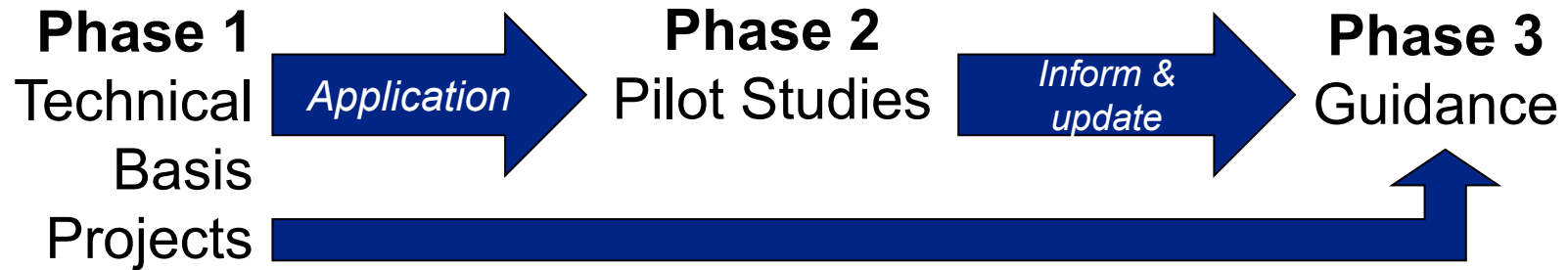
- Develop resources, tools and selected guidance to:
  - Address significant gap in the technical basis for guidance for probabilistic assessment of external hazards
    - Probabilistic: seismic, high winds
    - **Deterministic: flooding**
  - Support risk-informed licensing and oversight activities involving assessment of flooding hazards and potential consequences
    - Licensing and oversight in operating reactor program
    - Design basis flood hazard assessments for new facilities
      - Readiness for licensing of advanced reactors

# Key Challenges

- Hazard Estimation
  - Range of annual exceedance probabilities (AEPs)
    - Moderately rare to extreme floods
  - Multiple flooding mechanisms
    - Coincident and correlated mechanisms
  - Uncertainty characterization and estimation
    - Aleatory (e.g., storm recurrence rates)
    - Epistemic (e.g., model structure, parameters)
- Fragility
  - Information on reliability of flood protection features and procedures is sparse
  - Cliff-edge effects



# Phased Research Approach



- Phase 1 – Technical Basis Research - Complete
  - *Climate and precipitation*
  - *Mechanistic, statistical and probabilistic modeling of flooding processes*
  - *Reliability of flood protection features and procedures*
  - *Modeling Frameworks*
  - *Natural Hazard Information Digest (NHID)*
- Phase 2 – Pilot Studies - In Progress
  - *Local Intense Precipitation (LIP) Flooding*
  - *Riverine Flooding - Complete*
  - *Coastal Flooding*
- Phase 3 – Develop Guidance - In Progress

# **Phase 1 Technical Basis Research**

- **Climate**
  - *Historical trends and future projections for U.S. regions*
- **Mechanistic, statistical and probabilistic modeling of flooding processes**
  - *Extreme precipitation*
  - *Riverine flooding*
  - *Coastal flooding*
- **Methods for Estimating Joint Probabilities of Coincident and Correlated Flooding Mechanisms**
  - *Riverine flooding*
  - *Coastal flooding*
- **Reliability of flood protection features and procedures**
  - *Flood barriers (seals, etc.)*
  - *Environmental effects on manual actions*
- **Modeling Frameworks**
  - *Structured hazard assessment committee process for flooding (SHAC-F)*
  - *Dynamic analysis of flooding events*
  - *USACE HEC-WAT*
- **Natural hazards information digest (for internal NRC staff use)**
  - *Collect and organize natural hazard information for operating reactors*

*For more details on Phase 1 completion see Digital Exhibit #11 at the 34<sup>th</sup> Annual Regulatory Information Conference (RIC), March 8-10, 2022:*

<https://www.nrc.gov/public-involve/conference-symposia/ric/index.html>

## Phase 2: Pilot Studies

**Objective: Synthesize results from technical basis research**

- Multiple flooding mechanism contribution to hazard curves
- Quantify key aleatory variabilities and epistemic uncertainties

- **LIP Flooding PFHA Pilot**

- PNNL
- *In Progress; completion expected in March 2022*



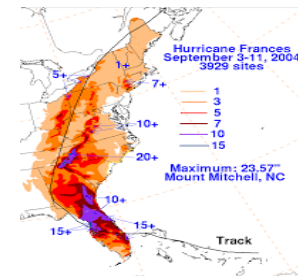
- **Riverine Flooding PFHA Pilot**

- USACE/HEC
- *Completed in January 2022*



- **Coastal Flooding Pilot PFHA Pilot**

- USACE/ERDC/CHL
- *In Progress; completion expected in June 2022*





## Phase 2: LIP Pilot Study

- **Objectives**
  - *Inform guidance development for probabilistic assessment of site-scale flooding hazards due to local intense precipitation*
  - *Synthesize results from technical basis research*
  - *Incorporate site-scale features (curbs, buildings, drains)*
- **Key elements**
  - *Point rainfall (aleatory variability) based on NOAA Atlas 14*
  - *Sensitivity study to identify key epistemic uncertainties wrt site features*
  - *Propagation of uncertainties to construct hazard curve families for selected flood hazard metrics (e.g., depth, velocity, duration)*
  - *Monte Carlo simulation with stratified sampling*
- **More detailed information:**
  - *Presentation 2A-5 (Wednesday at 12:00)*



## Phase 2: Riverine Pilot Study

- **Objectives**

- *Inform guidance development for probabilistic assessment of riverine flooding hazards*
- *Synthesize results from technical basis research*
- *Incorporate multiple flooding mechanism contributions to hazard curves*

- **Key elements**

- *Stochastic rainfall model (aleatory variability)*
- *Epistemic uncertainties in hydrologic (runoff and routing), reservoir, and hydraulic models*
- *Multiple dam failure scenarios*
- *Propagation of uncertainties to construct hazard curve families for selected flood hazard metrics (e.g., elevation, velocity, duration)*
- *Monte Carlo simulation approach using HEC-WAT*

- **More detailed information:**

- *Presentation 2B-4 (Wednesday at 15:20)*
- *Posters 3A-4 and 3A-5 (Thursday at 10:00)*



## Phase 2: Coastal Pilot Study

- **Objectives**

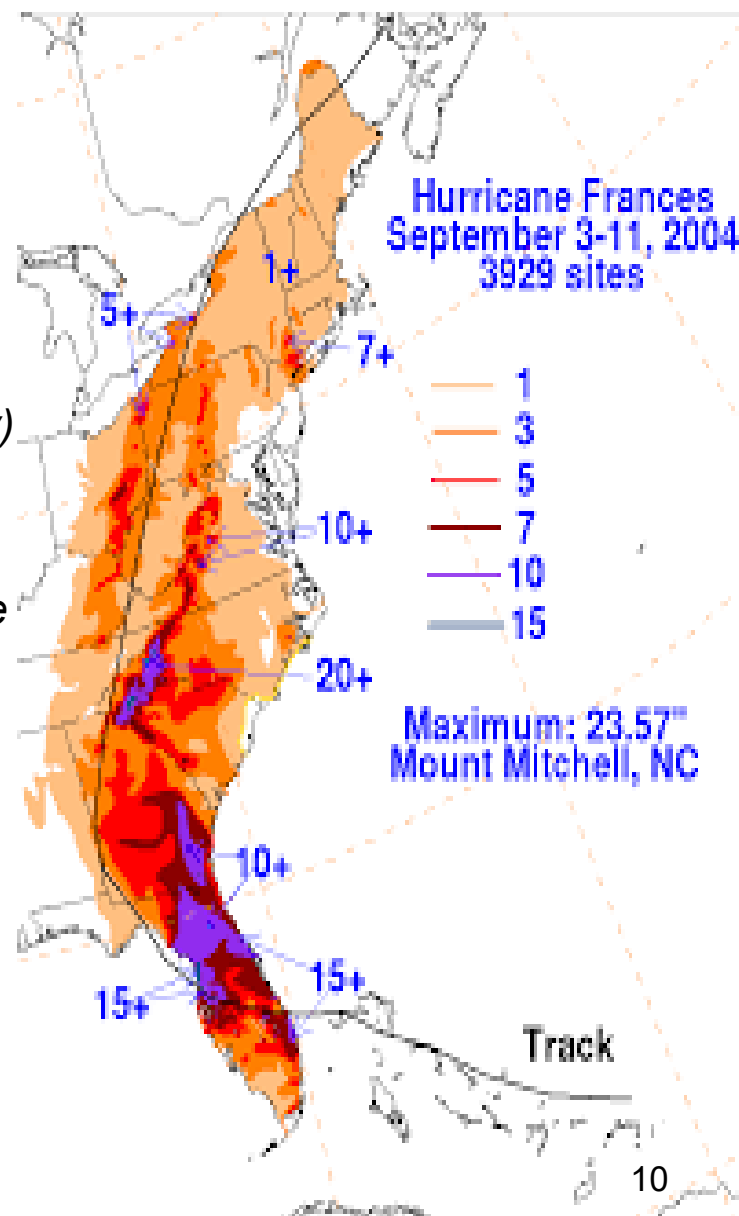
- Inform guidance development for probabilistic assessment of coastal flooding hazards
- Synthesize results from technical basis research
- Incorporate multiple flooding mechanism contributions to hazard curves

- **Key elements**

- Tropical cyclone rainfall model (aleatory variability)
- Epistemic uncertainties in hydrodynamic (surge), hydrologic (runoff and routing), and hydraulic models
- Flooding due to surge and rainfall-induced riverine discharge
- Propagation of uncertainties to construct hazard curve families for selected flood hazard metrics (e.g., elevation, velocity)
- USACE Probabilistic Coastal Hazard Assessment (PCHA) framework

- **More detailed information:**

- Presentation 3B-3 (Thursday at 12:05)



## Phase 3: PFHA Guidance

- **FY 22/FY23: Develop draft guidance based on:**
  - *Technical basis research*
  - *Pilot projects*
  - *User office needs*
  - *Stakeholder & public interests*
- **FY23: Publish draft guidance for public comment**
- **FY23: Finalize guidance based on public comment**



## Past Workshops

- **Proceedings of 1<sup>st</sup>-4<sup>th</sup> Annual NRC PFHA Research Workshops**
  - *NRC Research Information Letter (RIL) 2020-01*
- **Proceedings of 5<sup>th</sup> Annual NRC PFHA Research Workshop**
  - *RIL 2021-01*
- **Proceedings of 6<sup>th</sup> Annual NRC PFHA Research Workshop**
  - *RIL 2022-02*

***NRC Research Information Letters are available at:***

***<https://www.nrc.gov/reading-rm/doc-collections/index.html#ril>***

## Questions?

### Contacts:

[Joseph.Kanney@nrc.gov](mailto:Joseph.Kanney@nrc.gov)

[Thomas.Aird@nrc.gov](mailto:Thomas.Aird@nrc.gov)

[Elena.Yegorova@nrc.gov](mailto:Elena.Yegorova@nrc.gov)