U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Current Application of Extreme Precipitation Data and Information

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Workshop to Define Needed Extreme Storm Products

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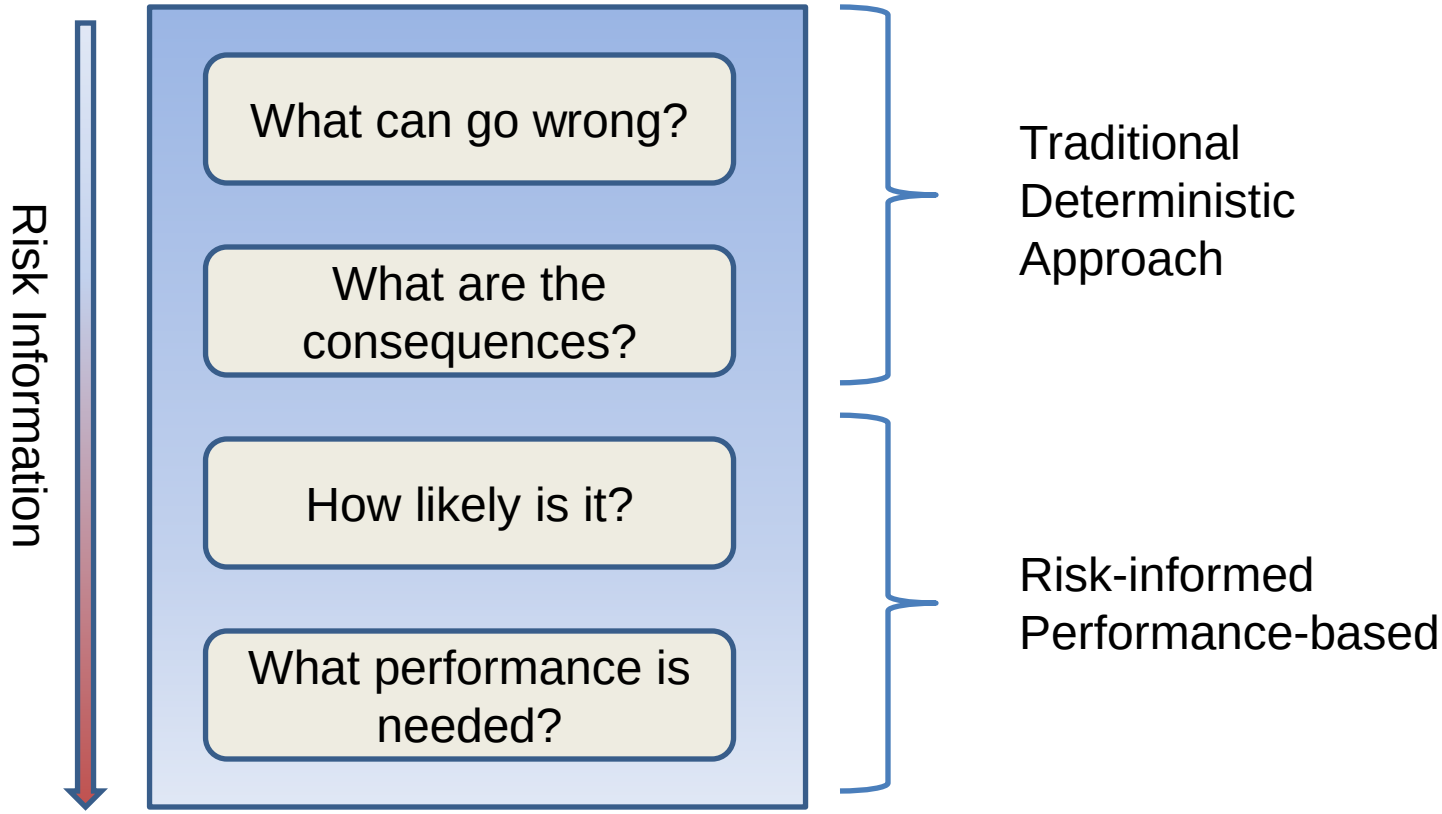
NRC Mission

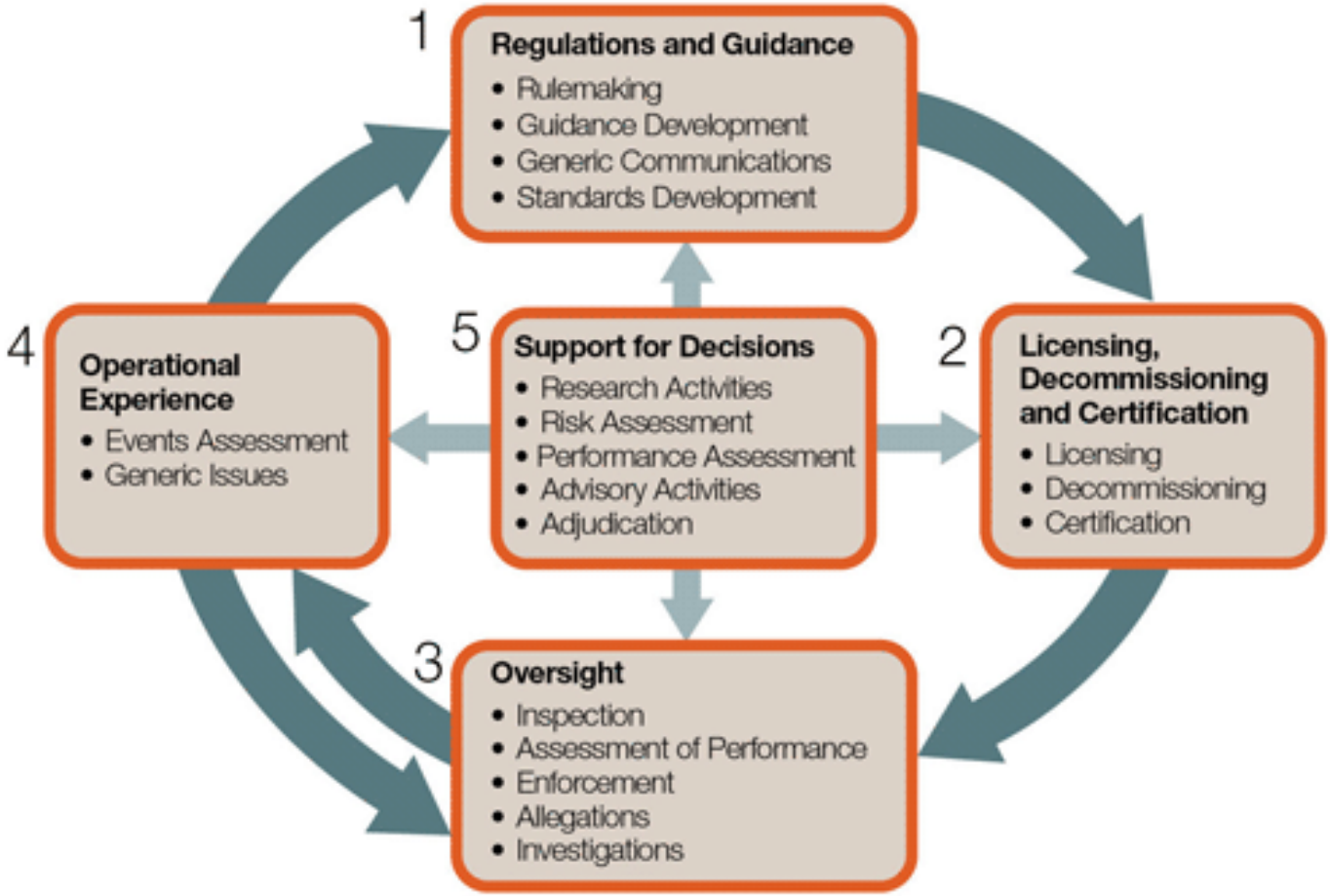
- The NRC licenses and regulates the Nation's civilian use of radioactive materials to protect public health and safety, promote the common defense and security, and protect the environment.
  - Reactors - Commercial reactors for generating electric power and research and test reactors used for research, testing, and training
  - Materials - Uses of nuclear materials in medical, industrial, and academic settings and facilities that produce nuclear fuel
  - Waste - Transportation, storage, and disposal of nuclear materials and waste, and decommissioning of nuclear facilities from service

NRC Regulatory Approach

Our Goal: Risk-informed and performance-based regulation



How NRC Regulates



*Regulation: Design bases for protection against natural phenomena**

- Structures, systems, and components (SSCs) important to safety shall be designed to withstand the effects of natural phenomena* without loss of capability to perform their safety functions
- The design bases for these SSCs shall reflect:
  - Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated
  - Appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena
  - The importance of the safety functions to be performed

*earthquakes, tornadoes, hurricanes, **floods**, tsunami, seiches, etc.

Supplements to Regulations

- Industry Standards
  - Professional societies and standards organizations
- NRC Regulatory Guidance (RG)
  - Describe methods acceptable to NRC Staff
- NRC Standard Review Plans (SRP)
  - Describe how NRC Staff will review license applications, amendments, etc.
- NRC NUREG Reports
  - Technical basis used to develop guidance/standards
  - Developed by NRC Staff
  - Contract technical support
    - DOE National Laboratories
    - Other Federal Agencies
    - Private Industry Consultants

Agency Methods & Needs

- Types of facilities/sites for which extreme precipitation estimates are needed to support flood hazard assessments is varied:
  - nuclear power plant sites and designs
  - fuel cycle facilities
  - interim spent fuel storage facilities
  - nuclear waste repositories
  - watersheds in which nuclear facilities are located
  - reservoirs and dams upstream of nuclear facilities
  - tailings dams

Agency Methods & Needs (Cont.)

- Analysis of flooding hazards submitted for licensing of new facilities is currently almost entirely deterministic.
  - Progressive refinement of conservative assumptions
    - Hierarchical Hazard Assessment (HHA)
  - Concepts such as PMP and PMF are commonly used
  - HMRs used for PMPs
    - Licensees are submitting “site-specific” PMPs
- Research efforts planned to develop probabilistic flood hazard assessment (PFHA) technical basis to support risk-informed design basis flood estimation guidance

Agency Methods & Needs (Cont.)

- Oversight of operating facilities uses more explicitly risk-informed significance determination process (SDP)
  - Used for decision-making in light of new information that comes up after initial licensing.
  - SDP activities have often included attempts to quantify risks due natural hazards such as extreme precipitation and flooding.

What Decisions are Being Made?

- Licensing of proposed projects
  - Suitability of specific sites and the design basis of facilities at those sites.
    - Design basis flood estimates
    - Design loads on structures due to both liquid and solid precipitation.
- Oversight of operating facilities (SDP process)
  - Assigning a significance/severity to identified deficiencies
  - Depending on the severity, orders to modify facilities can be issued and fines can be assessed

What Decisions are Being Made? (Cont.)

- Post-Fukushima Response
  - As part of the agency's response to the Fukushima accident, US NRC has issued a "Request for Information" instructing all operating nuclear power plants to develop and report updated flood risk information for comparison against original licensing information.
  - For sites where flood elevations and associated effects exceed the original licensing basis, licensees are expected to perform an integrated assessment to evaluate their flood protection and mitigation features and procedures
  - The flooding reevaluations and integrated assessments will form the basis for regulatory decisions. The potential decisions range from changes in regulations regarding hazard assessment, protection and mitigation to modification of individual licenses.

What is Used and How?

- New reactor licensing (HHA approach)
  - PMPs from HMRs used to construct extreme flood scenarios within
  - Two typical scenarios (application
    - probable maximum flood (PMF) for stream and river flooding
    - Local intense precipitation (LIP) for evaluation of site drainage
  - PMP values from the HMRs are also used to determine design basis loads on structures due to both liquid and solid precipitation.
- Post-Fukushima Response
  - Licensees' reevaluations use PMP values from the HMRs in some cases and in others, rely on site-specific PMPs.
  - During the review period, some licensees are actively revising protection and mitigation measures that depend in part on the HMR PMP estimates
  - Licensees are interested in using probabilistic methods to support integrated assessments
- SDP activities have also included used of precipitation frequency estimates from NOAA Atlas 14 (or precursors).
    - Focus on estimating the frequency of an initiating event
    - Initiating event frequency is combined with system fragility information to obtain risk insights (often qualitative, not rigorous)

Beneficial to Update?

- Yes, an "update" to the HMRs, and particularly HMR51, which applies to the majority of our sites would be beneficial <u>for our current deterministic methods</u>, **but any update should…..**
- Include a review of potential storm model improvements that could be used to improve estimates.
  - Just plugging new data into an old method without considering adjustments to that method based on decades of experience (since the last update of the HMR 51-52, for example) doesn't seem appropriate.
- Address limitations on basin size, questionable applicability in "stippled" regions affected by orographic effects
- Include more focus on the probabilities associated with PMP estimates (critical component to risk informed decision making)
- Give attention to cool season precipitation (useful for determining design basis snow and ice loads on structures)
- Provide guidance with regard to site-specific PMP values (an increasing regulatory challenge)
- Provide online digital product similar to the NOAA Atlas 14 Precipitation Frequency Data Server

Views on 1994 National Research Council Report

- The strategy appears to have not advanced significantly since the 1994 report!
- Probability-based standards are particularly applicable to high-risk/high-complexity problems faced by U.S. NRC and other regulators.
- One obstacle is the paucity of practitioners for the work related to low probability/high events making the development and evaluation of technically defensible models a challenge.
- Advancements have clearly been made in the use of radar data, the extension of flood frequencies based on paleo-hydrology
  - Process of peer review needed for individual studies remains an issue.

Views on 1994 NRC Report (Cont.)

- National standard for consistency?
  - There is currently lack of consistency regarding both practices and peer review processes between Federal agencies.
  - Consistency in what?
  - How would the consistency apply in light of differing risk tolerances?

Views on FEMA Workshop Report

- Generally all three areas are important
- Considerable advancement has occurred related to both paleo-hydrology and use of NEXRAD data since report was prepared.
- It should also be noted that there are differences in risk tolerances for nuclear facilities compared to dams
  - US NRC is interested in hazard curves that extend significantly beyond the 1 in 10,000 year ARI
  - Simply extrapolating frequencies does not seem appropriate since this ignores potentially significant epistemic uncertainties
- Also, for US NRC's needs associated with high-risk/high-complexity issues, and the trend towards PFHA, greater focus on the peer review is critical.
- The document's focus on risk analysis, rather than risk-informed decision making oversimplifies the challenges that US NRC, and presumably other agencies, face.

2013 NRC PFHA Workshop

- Development of a “global” framework needed to address full hazard
- Focus on extreme rainfall observations/database is necessary but not sufficient.
  - Simply updating the storm catalogue and applying 40-year old methods does not seem like a technically defensible approach
- Regionalized approaches for estimating precipitation frequency exist and are commonly used, although rarely for “PMP-scale” precipitation.
  - It seems reasonable that regionalization would play some role in estimating magnitude and frequency for extreme precipitation.

2013 NRC PFHA Workshop (Con't.)

- Stochastic methods (both event-based and continuous modeling) should be pursued.
  - However, a risk-informed regulatory approach also requires
    - Processes to rigorously evaluate controversial and ambiguous information associated with both data and methodologies.
    - Need to address uncertainty regarding the interpretation and use of such data is equal to the uncertainty of the data itself.
  - Right now, it seems like probabilistic evaluations are performed in rather ad hoc ways.
    - Seems that different individuals are doing PFHA rather differently and there's not much focus on developing an overall framework.
    - This doesn't seem like an appropriate approach to developing a broadly accepted method that reflects the collective community of knowledge.

HMRs

- Used for PMP values and application guidance
  - Local intense precipitation (site-scale flooding)
    - 10^2 mi PMPs
  - PMF for stream and river flooding
  - Design loads on structures
    - 48 hour cool season PMP for snow/ice
- HMR 51, 52 used most often
  - For snow and ice loads on structures, our Standard Review Plan references HMR 49, 53, 55A, 57 and 59
- Other studies
  - Licensees submitting “site specific” studies
- PMP probabilities
  - Licensees have submitted these too

HMRs (Cont.)

- Desired changes if updated
  - Address “stippled areas” in HMR 51
  - Address area limitations
    - Large watersheds (e.g., Missouri, Mississippi rivers)
    - Bridge gap between point estimates and existing 10-sqaure mile estimates
  - Provide precipitation estimates that are more suitable for design snow and ice load calculations in relevant regions
  - An online digital product similar to the NOAA Atlas 14 Precipitation Frequency Data Server
  - Probabilities and confidence intervals associate with estimates

NOAA Atlas 14

- Texas and Northwest?
  - Low to medium importance
- Uses?
  - Initial assessment of the potential impact of precipitation on an area surrounding a licensed facility, such as a nuclear reactor.
  - Any precipitation impact would be coupled with an evaluation of plant response in an integrated system/human probabilistic risk assessment model for follow-up regulatory activities.

NOAA Atlas 14 (Cont.)

- Useful return periods?
  - Full hazard curve, usually in excess of 1000 years (up to and beyond 1,000,000 years) is of interest.
- Extrapolation?
  - In a limited basis and as a risk-informed exercise to evaluate information submitted to the NRC, since multiple licensees have performed such extrapolations on NOAA Atlas 14 and other hydrologic databases, as a way to respond to NRC regulatory activities.
  - NRC is not necessarily interested in pursuing these limited credibility extrapolations, but rather responding to requests to consider risk insights based on submitted information.
  - NRC is aware of the limited technical justification for doing so and therefore uses significant caution in these cases.

NOAA Atlas 14 (Cont.)

- Areal information
  - Yes, needed
  - ARF information from NOAA publications (e.g.TP-40), state and federal drainage manuals, etc.
- Temporal distribution curves are useful
- Seasonal distribution curves are useful

Summary

- NRC currently uses NWS HMRs for safety reviews of proposed sites and designs for commercial nuclear facilities
  - Design basis flood hazard assessments
  - Design basis loads on structures
- NRC currently makes limited use of NOAA Atlas 14 in safety oversight of operating commercial nuclear facilities

Summary (Cont.)

- "Updates" to HMRs would support our current deterministic approach for design basis flood estimates
- "Updates" to HMRs would not support our current risk-informed oversight activities
- Risk information associated with extreme precipitation estimates are needed to better support a risk-informed regulatory approach