Use of Flooding Hazard Information in Risk-Informed Decisionmaking

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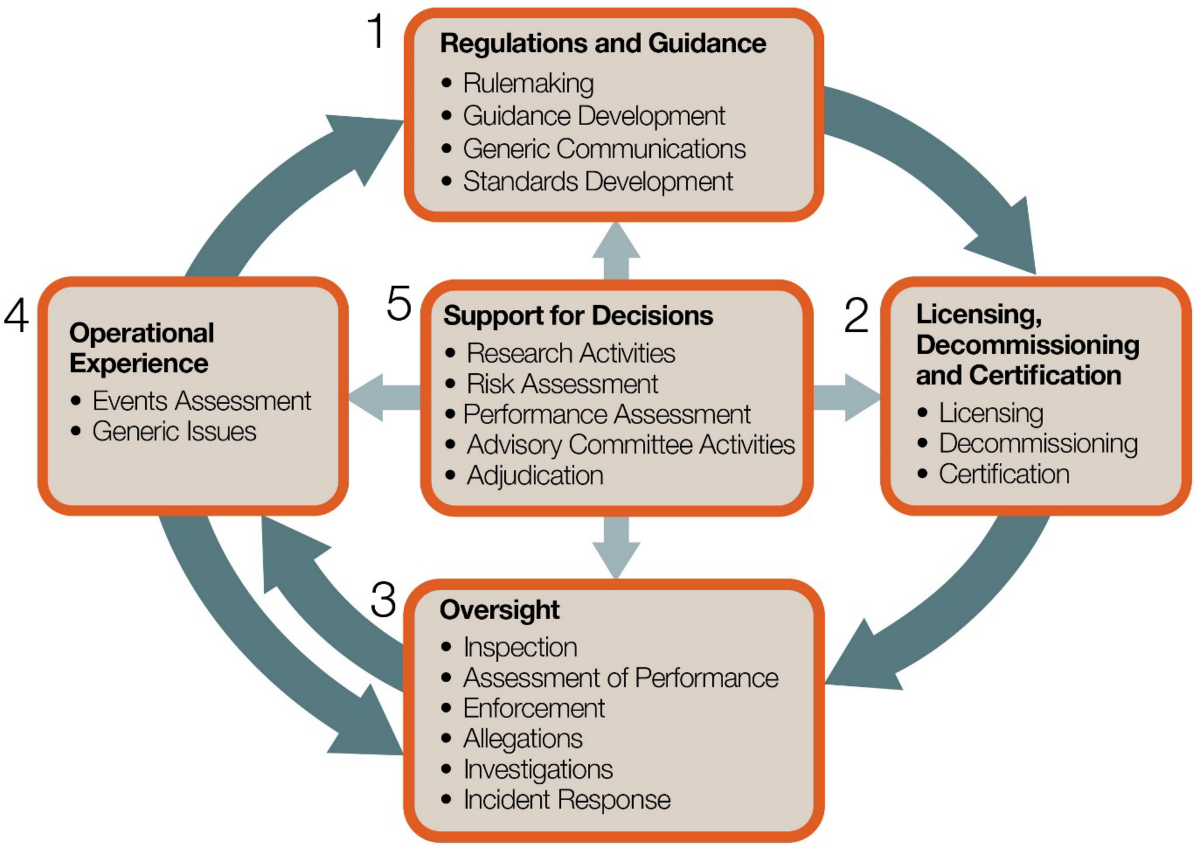
Background:
NRC Regulations Overview

- Designed to withstand effects of natural phenomena, such as floods (10 CFR 50 Appendix A)
  - Appropriate consideration of most severe of the natural phenomena that have been historically reported. With sufficient margin for limited accuracy, quantity, and period of time for accumulated_historical data
  - Reflect the importance of the safety functions to be performed
- Current Nuclear Regulatory Commission guidance references deterministic methods for hazard evaluation
  - Reliance on concept of "probable maximum" scenarios

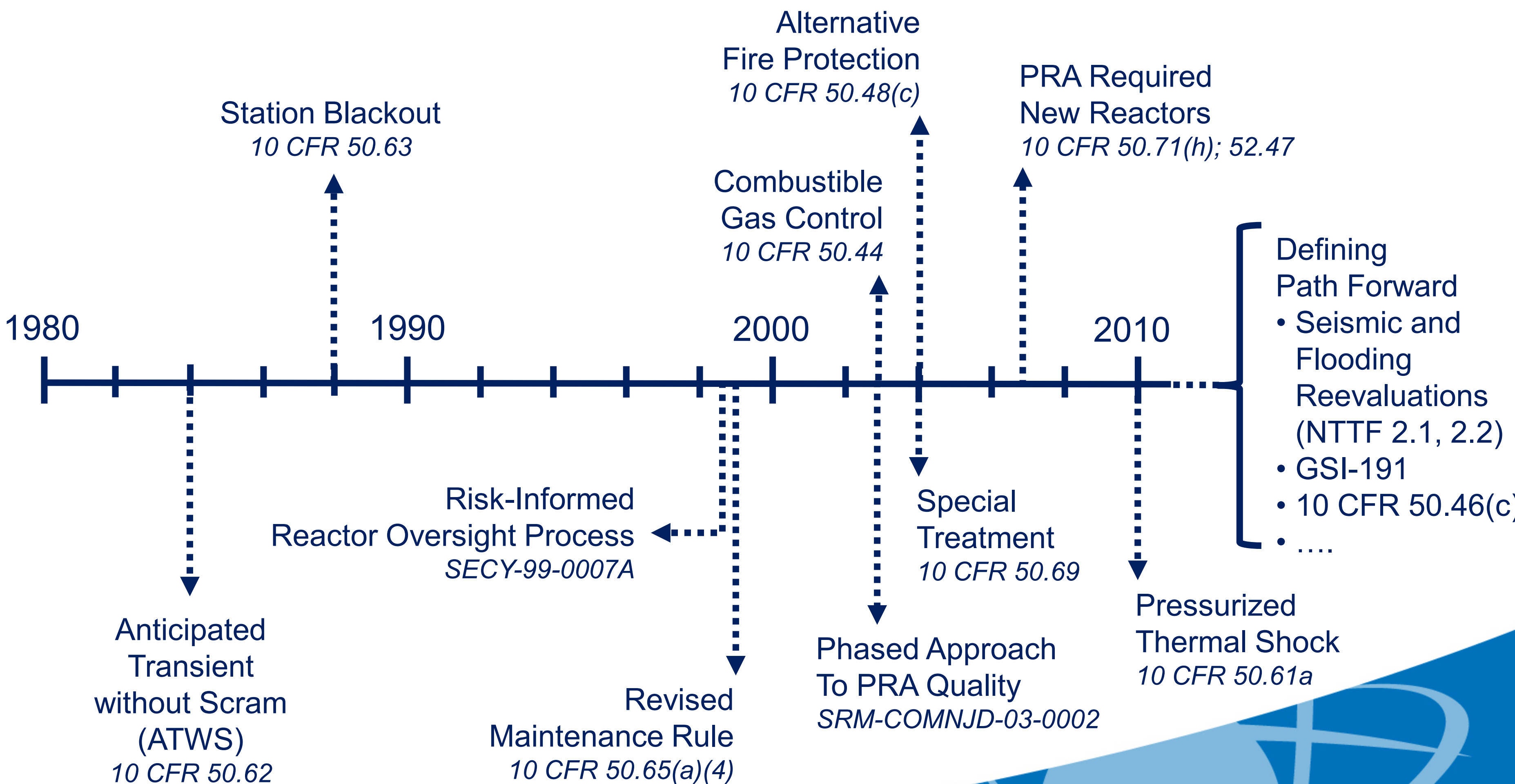
Background: Risk Measures and PRA Policy

- Safety Goals for the Operations of Nuclear Power Plants Policy Statement (51 FR 30028; August 21, 1986) established goals that broadly define an acceptable level of radiological risk.
- Probabilistic Risk Assessment (PRA) Policy Statement (60 FR 42622; August 16, 1995) formalized the Commission's commitment to risk-informed regulation through the expanded use of PRA.
  - *The use of PRA technology should be increased in all regulatory matters to the extent supported by the state of the art in PRA methods and data, and in a manner that complements the NRC's deterministic approach and supports the NRC's traditional defense-in-depth philosophy.*

Use of Risk-Informed Approaches



Risk-Informed Rules & Policies

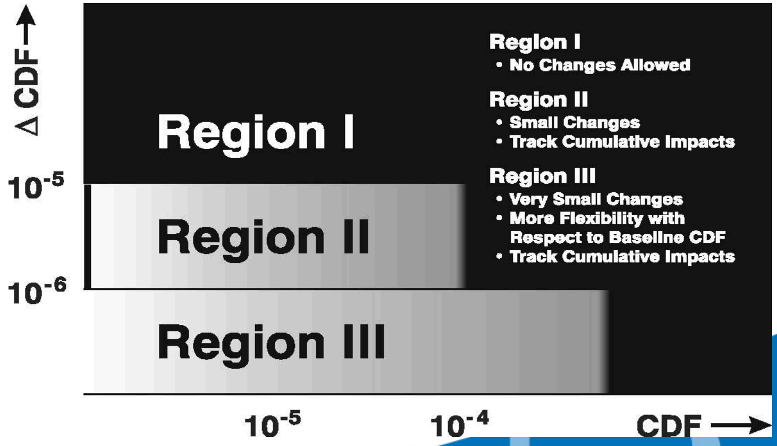


Risk-Informed Licensing Activities

- Regulatory Guide (RG) 1.174 and Standard Review Plan (SRP) 19 provide general guidance for risk-informed licensing basis changes
- Examples of specific guidance:
  - Risk-informed technical specifications (TS) changes: RG 1.177, SRP 16.1
  - Risk-informed inservice inspection (ISI) (piping): RG 1.178, SRP 3.9.8

RG 1.174, Section 2.3.1:

when the risk associated with a <u>particular hazard group</u> would <u>affect the decision</u> being made, it is the Commission's policy that, if a staff-endorsed PRA standard exists for that hazard group, then <u>the risk will be assessed using a PRA that meets that standard</u>



Risk-Informed Oversight

- Reactor Oversight Process (ROP) is the agency's program to inspect, measure, and assess the safety performance of nuclear power plants (NPPs) and to respond to any decline in performance.
- Performance evaluated by analyzing inspection findings resulting from inspection program and performance indicators.
  - Significance Determination Process (SDP) used to support determination of the safety significance of inspection findings (i.e., performance deficiencies)

CHANGE IN CORE DAMAGE FREQUENCY (ΔCDF)

PRA Framework

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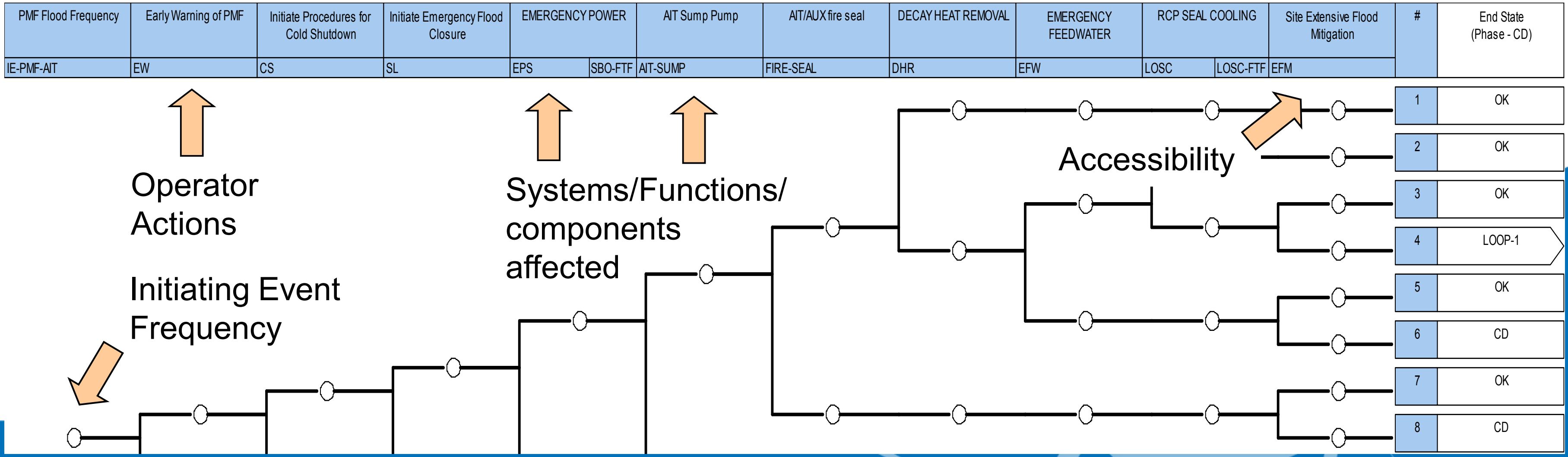
- PRA is a structured, analytical process for identifying potential weaknesses and strengths of a plant design in an integrated fashion
  - provides a framework for explicitly addressing and presenting uncertainties
  - includes all potential accident initiators and mitigation failures (including multiple failures)
  - evaluates responses (physical, automatic and operator response) to perturbations
  - outputs may include core damage frequency, release frequency and radiological consequences
- In using PRA results, sources of uncertainty and assumptions and their impact on results should be understood.



Examples of Pre-Fukushima Flooding Risk Evaluations

- PRA studies for specific NPPs in 1980s
- A number of Individual Plant Examination of External Events (IPEEE) submittals in response to Supplement 4 to Generic Letter 88-20 in 1990s
  - External flooding was screened from further analyses in many cases using qualitative analyses
- SDP analyses of performance deficiencies (for example Fort Calhoun in 2010)

Source: OPPD Public Presentation (April 4, 2012)

SDP Analyses Following Fukushima Response

- In light of the effects from the earthquake and tsunami of March 11, 2011, on the NPPs at Fukushima, NRC concluded U.S. NPPs needed to reaffirm their existing ability to resist quakes and flooding.
- On March 2012, NRC requested that all US NPP licensees implement flood protection walkdowns (Recommendation 2.3) to capture any degraded, non-conforming conditions, and cliff-edge effects for flooding
  - Plants completed their walkdowns by November 2012; NRC inspectors have done follow-up inspections and the agency has issued plant-specific assessments of the licensee's walkdown reports.
  - Flooding walkdowns resulted in identification of a number of performance deficiencies associated with external flooding.

Findings Related to External Flooding

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Inadequate Flood Procedures	
2010 - Fort Calhoun inadequate flood procedure	YELLOW
2013 - Watts Bar/Sequoyah inadequate procedures	WHITE
2013 - Watts Bar inadequate procedures/plant realignment	YELLOW
2013 - Dresden inadequate flood procedure	WHITE
2013 - Monticello flood protection plan	YELLOW
2013 - Point Beach inadequate sandbagging protection	WHITE

Degraded or Missing Flood Barriers/Seals	
2004 - Oconee access cover impacting shutdown capability	WHITE
2011 - Brunswick degraded flood barriers	WHITE
2013 - Sequoyah degraded flooding seals	WHITE
2013 - Three Mile Island missing flooding seals	WHITE
2013 - Watts Bar protection of safety-related equipment	GREEN
2014 - Arkansas Nuclear One inadequate flood protection	YELLOW
2014 - Ginna unsealed cable penetrations	WHITE
2014 - St. Lucie unsealed conduits	WHITE
2014 - Brunswick inadequate flood protection	GREEN

substantial safety significance (yellow)
low to moderate safety significance (white)
very low safety significance (green)

Some Insights from Recent SDP Analyses

- Uncertainty associated with flood Frequencies in the range of interest to the NRC is significant. Qualitative insights from plant response and principles of risk-informed decisionmaking should be appropriately considered.
- Full range of hazard curve (containing frequencies of both extreme events and flood elevations below the probable maximum flood) may be needed in some cases for appropriate consideration of impact at various elevations.
- Credit for operator actions as part of human reliability analysis methods for evaluating flood mitigation actions, such as construction of flood protection is a focus area.
- Assumptions about advanced warnings, duration of the events, reliability of components could impact flood mitigation.

NRR Priorities from PFHA User-Need

- Provide guidance/develop methods for extending frequency analysis methods to ranges of interest for NRC applications (in many cases beyond current consensus limits for estimating flood frequencies)
- Provide guidance for consistent application of statistically based flood-frequency estimates at sites where historical or paleoflood information may be available (at-site or from regional information)
  - For future updates to Risk Assessment of Operational Events Handbook (known as RASP Handbook)
- Probabilistic treatment of flood protection structures including temporary barriers

NRR Priorities from PFHA User-Need (Cont.)

- Characterize the impact of environmental factors on operator manual actions associated with flood protection and mitigation (e.g., installation of flooding protection, construction of barriers, etc.) during extreme flooding events.
- To support Recommendation 2.1 regulatory decision-making, identify, to the extent possible, technically-supported approaches currently available for developing estimates of hazards with a frequency of 10^{-3} to 10^{-4} per year (*or proxy*) for certain mechanisms that exceed plant design bases.

Recent Activities

- Revised RASP Handbook to facilitate continued consistency in assessment of external flooding events
  - Sources of Information
  - Credible Extrapolation Ranges
  - Human Reliability Considerations
  - Experience from recent SDP analyses