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

Advanced Reactor Stakeholder Public Meeting

August 28, 2025

Bridge line: 301-576-2978

Conference ID: 446 637 854#

Advanced Reactor Program

U.S.NRC
United States Nuclear Regulatory Commission
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Time	Topic	Speaker
10:00 - 10:15 am	Opening Remarks	NRC
10:15 - 10:45 am	Driving Regulatory Decisions Through More Effective Communications	NRC
10:45 - 11:15 am	Risk Assessment Acceptability	NRC
11:15 - 12:00 pm	Senior Seismic Hazard Analysis Level 1 Study	NRC
12:00 - 1:00 pm	Lunch Break	
1:00 - 1:30 pm	eVinci PRA Peer Review Lessons Learned	NEI
1:30 - 2:00 pm	Approach for the Assessment of Low Frequency External Events	ANL
2:00 - 2:30 pm	Public Comment, Adjourn	NRC

Opening Remarks

Advanced Reactor Program Highlights

Updates and Recent Accomplishments:

- 5/9 - Submitted SECY paper on the status of advanced reactor activities
- 5/29 - Issued NuScale standard design approval (22 months from the application acceptance in July 2023)
- 6/18 - Submitted SECY paper on microreactor licensing/deployment considerations for NOAK licensing
- 7/14 – 7/18 - Held public forum with the nuclear industry and other stakeholders to discuss the NRC’s rulemaking to address licensing requirements for microreactors and other low consequence reactors
- 8/6 - Public meeting to discuss proposed training program considerations for Advanced and microreactors
- 8/26 - Public meeting to discuss draft Advanced Reactor Construction Oversight Program (ARCOP) Inspection Manual Chapters

Driving Regulatory Decisions Through More Effective Communications

Key Messages

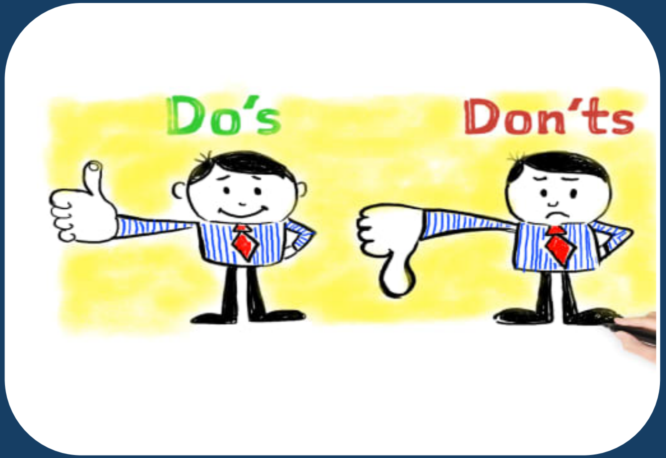
- Central to accomplishing the NRC mission is open, proactive, and timely communication between NRC staff and regulated entities
- OEDO Procedure-0235, "Driving Regulatory Decisions Through More Effective Communications," issued on 7/2/25 (ML25167A039)
  - Provides guidance to facilitate a mindset shift in how the NRC staff communicates with regulated entities to achieve more efficient and reliable regulatory activities
  - Identifies best practices to facilitate efficient resolution of issues while maintaining transparency
  - Responds to stakeholder feedback for more open communication

Objectives

- Serve as a resource for NRC staff, providing strategies and practices for regulatory engagements
- Facilitate timely and efficient resolution of regulatory activities while maintaining independence and transparency
- Provide clearly documented expectations and guidance to NRC staff to support timely updating of agency procedures

Important Tenets of the Procedure

Effective Communications versus Consulting



Dos and Don'ts

Examples

Effective NRC staff Communication

- Discuss Options to Resolve Regulatory Issues
- Clearly Identify and Describe Gaps
- Explain Processes and Requirements

NRC Staff Consulting

- Direct Implementation of a Specific Option
- Provide Competitive Advantage
- Commit the Agency to a Specific Course of Action

Public / Non-public Meetings

- Non-public forums can be used when appropriate
  - Create publicly available records of the interaction
- Information discussed in non-public forums that go beyond clarification and logistics that is not already publicly available must be made public
- Balance openness and transparency with the need for efficient and effective regulation
- All information material to a regulatory decision must be docketed
- Follow requirements for protection of classified, safeguards, and proprietary information

NRC Staff Dos and Don'ts

Do

- Describe the specific regulatory issue and its safety significance
- Provide an accurate, clear and concise technical or regulatory basis by referring to the applicable regulatory standard, acceptance criteria, and relevant guidance documents
- Identify and discuss possible options and alternatives for licensees, applicants, or vendors to consider, including pointing to past precedents or NRC regulatory guides (without making commitments)

Don't

- Simply cite the regulatory requirements without describing the issue and its significance
- Simply identify an issue without providing the regulatory basis
- Recommend or direct implementation of a specific solution to resolve a regulatory issue

Questions/Feedback

Risk Assessment Acceptability: Focus on Fundamental Principles

Jeffery Wood, *Senior Reliability and Risk Analyst*
Anders Gilbertson, *Senior Project Manager*
Marty Stutzke, *Senior Technical Advisor for PRA*

Office of Nuclear Reactor Regulation, Division of Advanced Reactors and Non-power Production and Utilization Facilities

August 28, 2025

Outline

- Motivation for This Effort
- Objectives
- Scope and Terminology
- Review of Existing RIDM Framework
- Fundamental Principles of Risk Assessment Acceptability
- Next Steps

Direction to Refocus Staff Approaches

Proposed Part 53 rule: "The staff should not apply consensus [PRA] standards as a strict checklist …" (SRM to SECY-23-0021, ADAMS ML24064A039)

Mission statement update: NRC mission statement update to enable "… efficient and reliable licensing, oversight, and regulation …" (SRM to SECY-24-0083, ADAMS ML25024A040)

ADVANCE Act, Sec. 208: Develop microreactor licensing strategies and guidance for "risk analysis methods, including alternatives to probabilistic risk assessments"

Microreactor considerations to factor fuel load and testing: "The staff should consider whether certain proposed licensing and oversight strategies for microreactors … would be applicable to other types of nuclear reactors …" (SRM to SECY-24-0008, ADAMS ML25168A133)

Executive Order 14300:

- "Establish fixed deadlines for its evaluation and approval of licenses…no more than 18 months for final decision …"
- "Establish a process for high-volume licensing of microreactors and modular reactors.…"

Objectives

- Maintain a ***flexible*** framework that enables determinations of acceptability of risk assessments, including PRAs, to support RIDM and the continuing evolution of advanced reactor regulatory activities.
    - Ensuring that fundamental technical analyses needed to develop a risk assessment are addressed, rather than specific modeling details.
- ***Focus*** on the usability and adequacy of results for ***safety*** decision-making.
- Provide ***efficiency*** to obviate the need to create and maintain multiple guidance documents for various application types.
- ***Enable*** the implementation of novel methods, approaches, data, and analyses with appropriate consideration of their impact on safety decision-making.

Scope and Terms

- Risk assessment acceptability determination
  - Taking a holistic view of risk results that inform safety decisions.
  - Can include *both* **PRA** *and* **non-PRA methods**.
- Risk assessment terms as discussed in *White Paper on RIPB Regulation* (SRM to SECY-98-144, ADAMS ML003753601)
  - ***Risk assessment*** – a systematic method for addressing the risk triplet as it relates to the performance of a particular system to understand likely outcomes, sensitivities, areas of importance, system interactions and areas of uncertainty.
  - ***Risk triplet*** – "What can go wrong?", "How likely is it?", and "What are the consequences?"
  - ***Risk insights*** – Results and findings that come from risk assessments.

Existing RIDM Framework

- Established guidance documents support effective RIDM.

RG 1.174

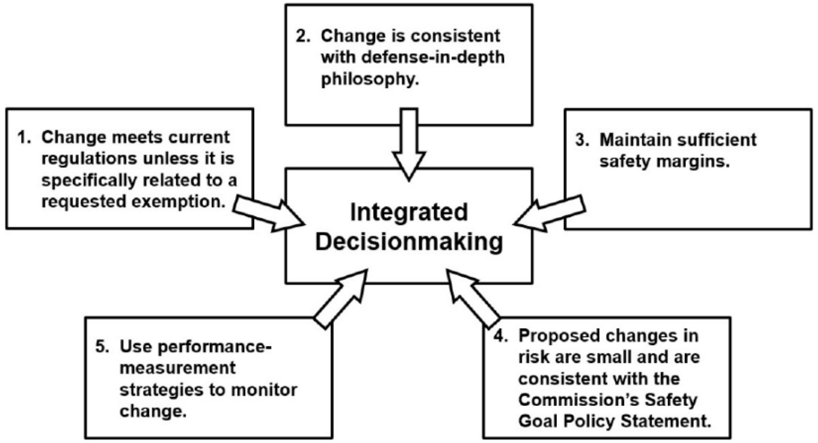


Figure 2. Principles of risk-informed integrated decisionmaking

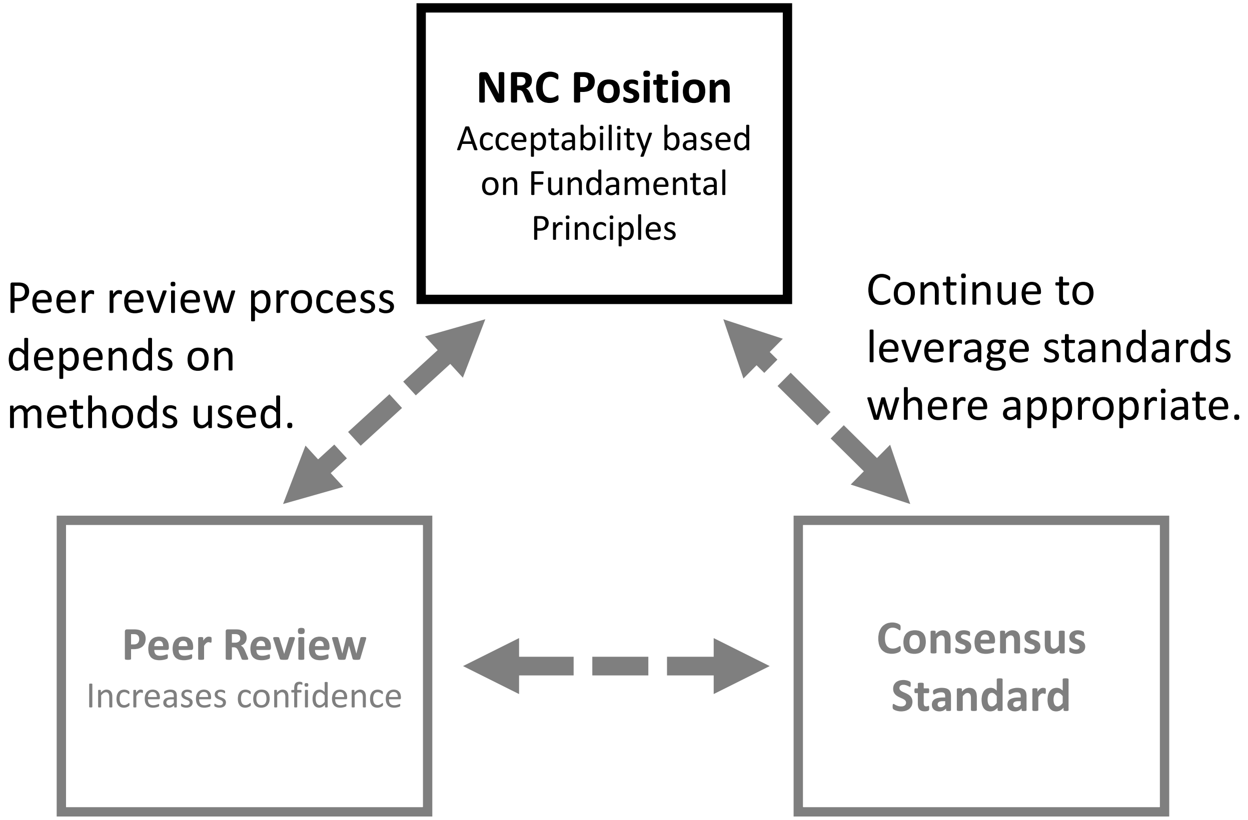
RG 1.200 and RG 1.247 (Trial Use)

Figure 1. NRC general framework for achieving PRA acceptability

- Principles of the RIDM framework can be generalized to apply broadly to risk assessments.

Focused Risk Assessment Acceptability

- This effort to focus on:
  - Fundamental principles of risk assessment acceptability.
  - Good practices established by existing guidance.
  - A range of different methods may be used including well-exercised standard-based approaches or alternative risk methods.
  - Avoiding maintenance of multiple guidance documents.



Risk Assessment Characteristics of an Application

Uses of Risk Assessment

Risk Assessment Scope

Risk Assessment Methods

Application Complexity

Applicant's Independent Review Process
(e.g., use of endorsed standards and processes)

Relation to Overall Safety Significance

Depth of review depends on novelty, complexity, and quality of the application.

Fundamental Principles of Risk Assessment Acceptability Determination

- How is risk assessment used in an application?
  - This can range from a confirmatory approach to a risk-led approach.
- What processes are in place for risk assessment development and use of results?
- Technical acceptability of risk assessment analyses
  - Risk assessment scope
  - Level of detail
  - Use of acceptable methods
  - Representation of plant/site
- Consideration of risk assessment uncertainties in RIDM process

Next Steps

- Communicating internally with staff
- Emphasizing flexibility in the staff's risk assessment acceptability approach with focus on the ability to identify and evaluate risk-significant items
- Continuing to formulate the final outcomes and expectations for this effort

Senior Seismic Hazard Analysis Committee Level 1 Project

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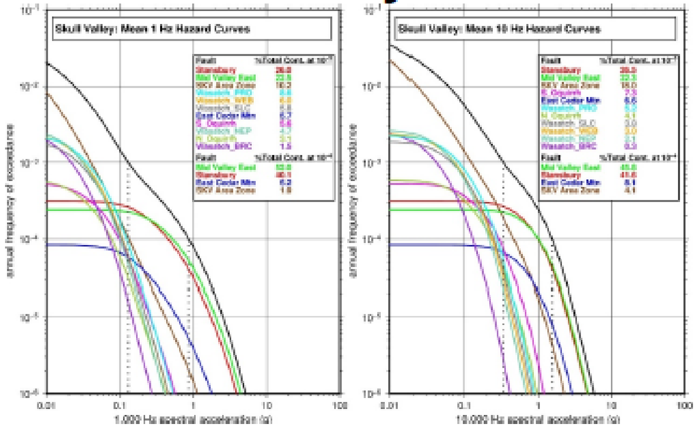
RIL 2025-10

Documentation Report for Skull Valley SSHAC Level 1 Demonstration Project



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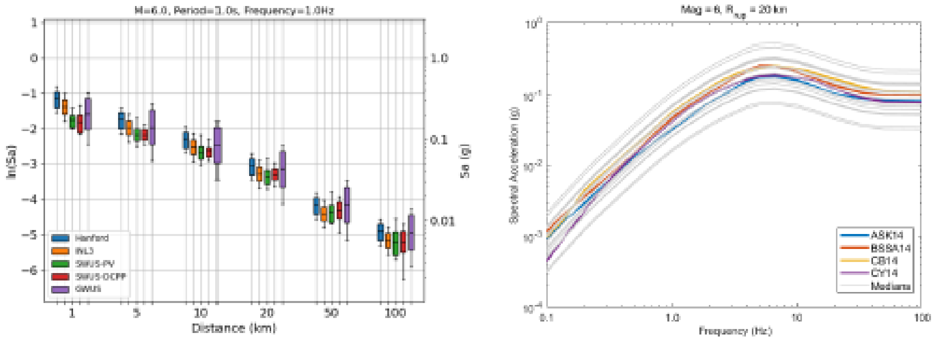
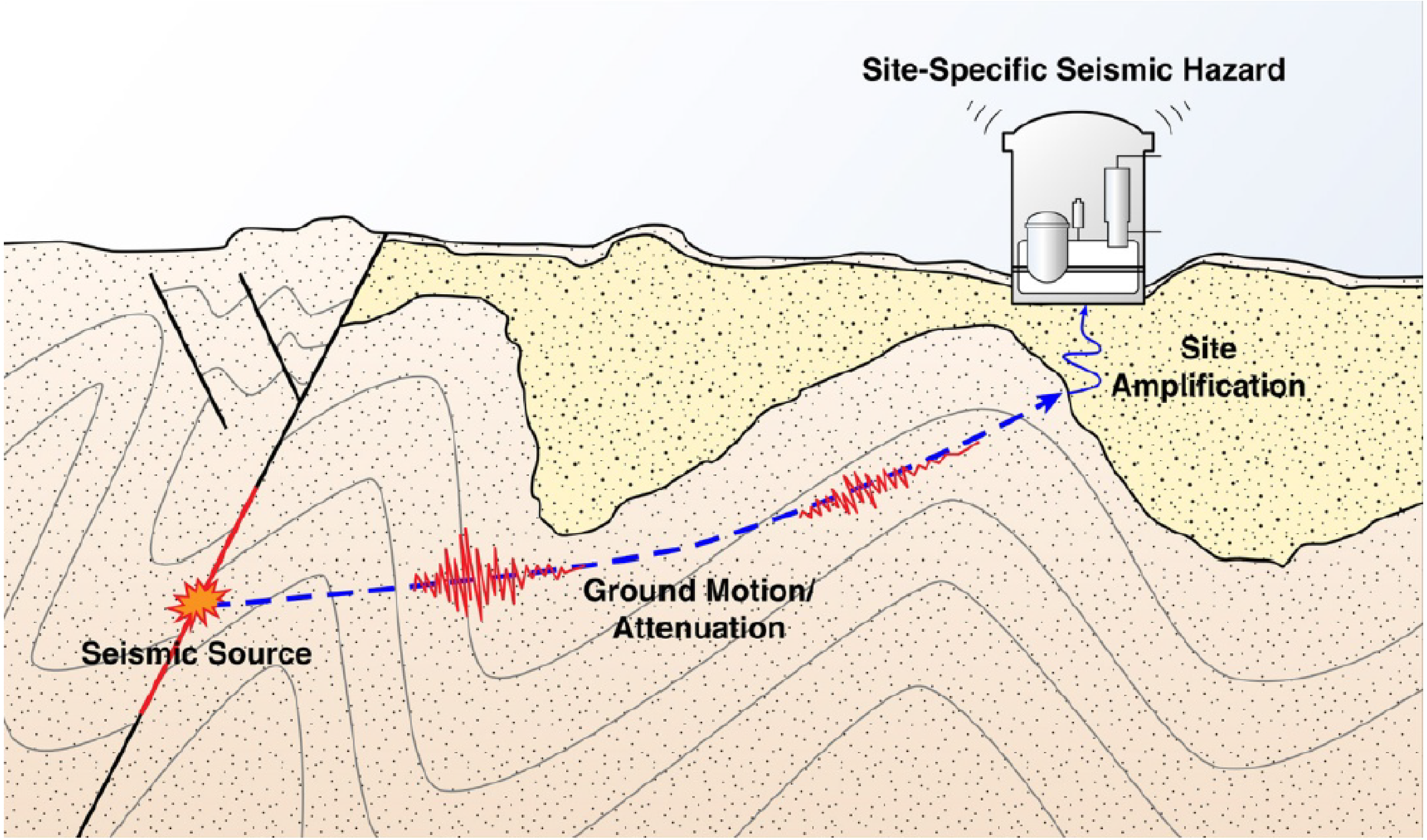
RIL 2025-11

Recommendations Report for SSHAC Level 1 Demonstration Project

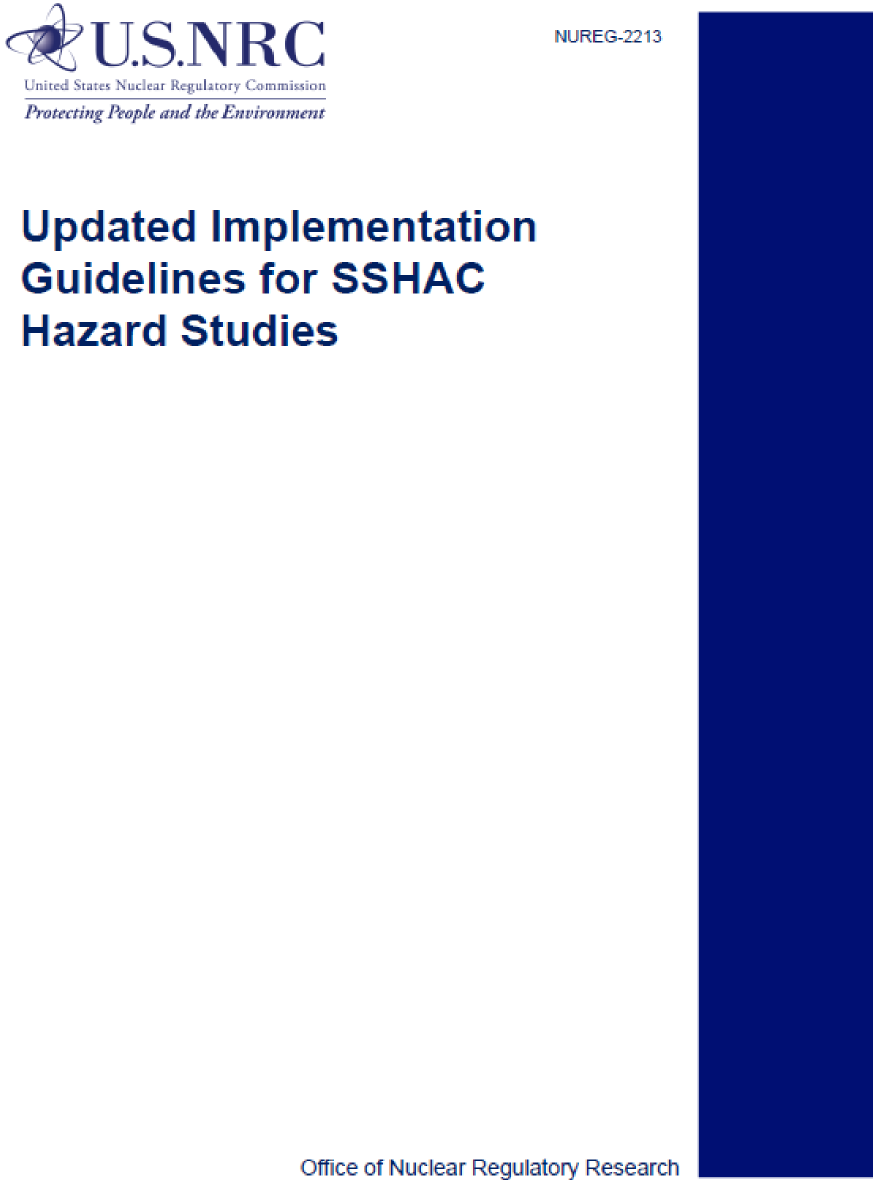


Structural, Geotechnical and Seismic Engineering Branch
Division of Engineering
Office of Research

Seismic Hazard Analysis



Senior Seismic Hazard Analysis Committee (SSHAC)



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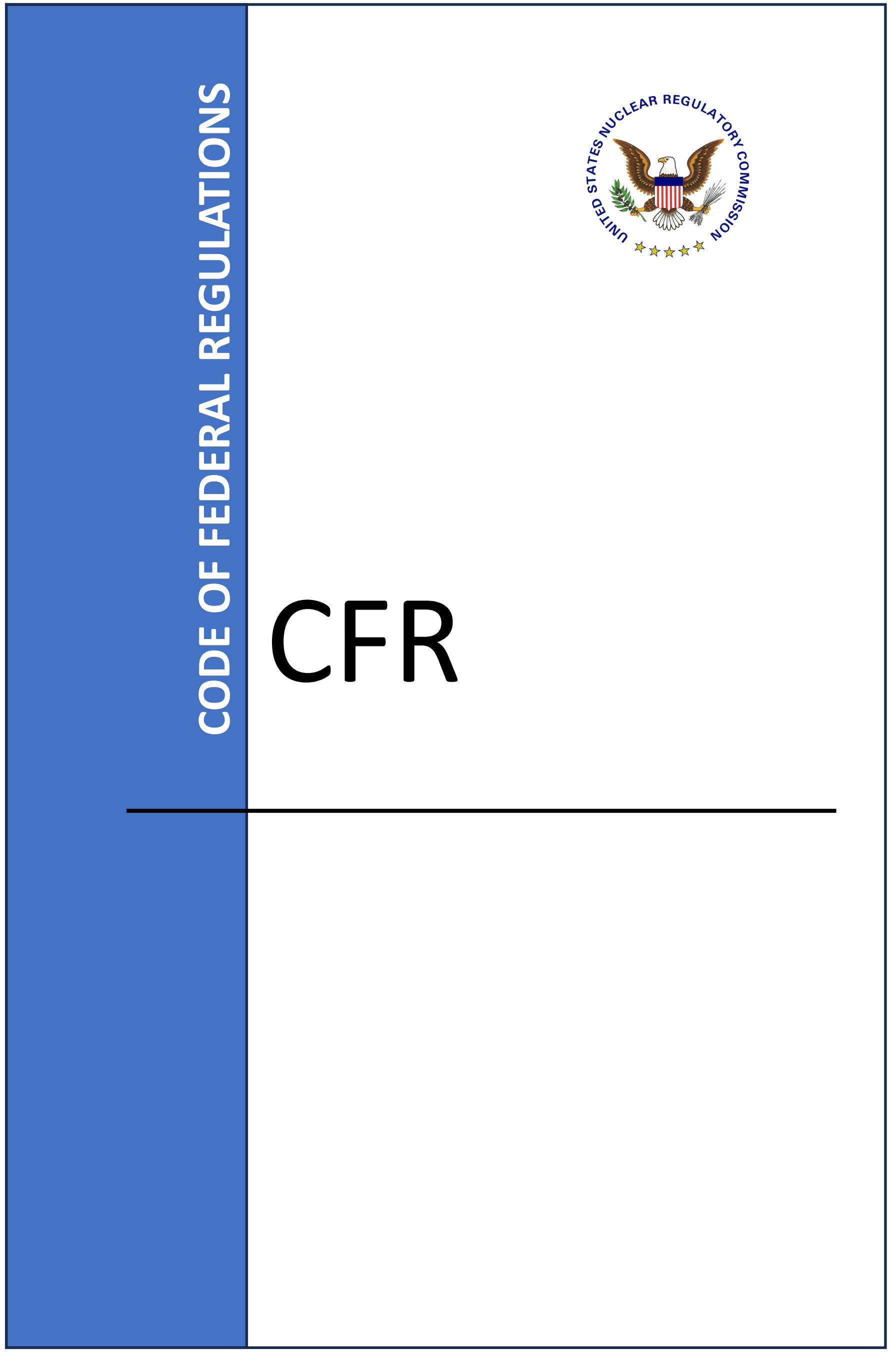
NUREG-2213

Updated Implementation Guidelines for SSHAC Hazard Studies

Office of Nuclear Regulatory Research

- Process for capturing uncertainty in a probabilistic seismic hazard analysis and expert elicitation
- Range of SSHAC Levels
  - Level 1 to Level 4
  - Level of effort in eliciting expert views increases with SSHAC level
- **Recent SSHAC Level 3 studies (Large Light Water Reactors, SDC-5)**
  - **Time: ~2 – 5 years**
  - **Cost: $6,000,000 – 10,000,000**



10 CFR 100.23

- Safe Shutdown Earthquake Ground Motion: considers results of required investigations. **Uncertainties are inherent and must be addressed through appropriate analyses**.
- Geologic, seismological, and engineering characteristics must be investigated in **sufficient scope and detail**.

RG 1.208

- Guidance for developing the Ground Motion Response Spectrum
- Updates in progress for multiple reactor types

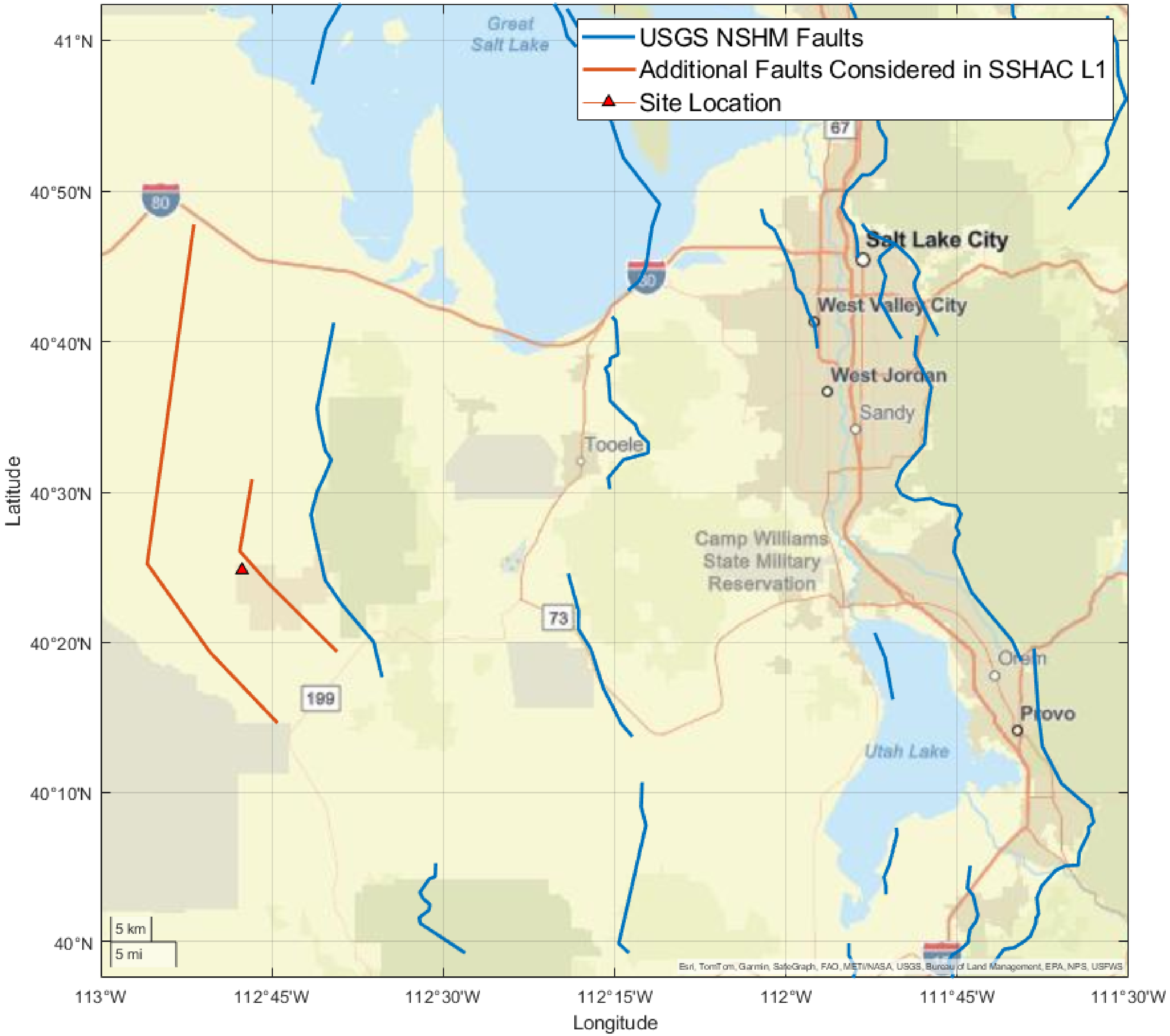
SSHAC Level 1 Project Objectives

- Illustrate how a SSHAC Level 1 study can be used to develop the seismic hazard for some advanced nuclear power plant designs through an example study
  - **SSHAC Level 1 Seismic Hazard Report**
- Identify efficiencies and simplifying approaches for evaluating and incorporating uncertainty
  - **Recommendations Report**

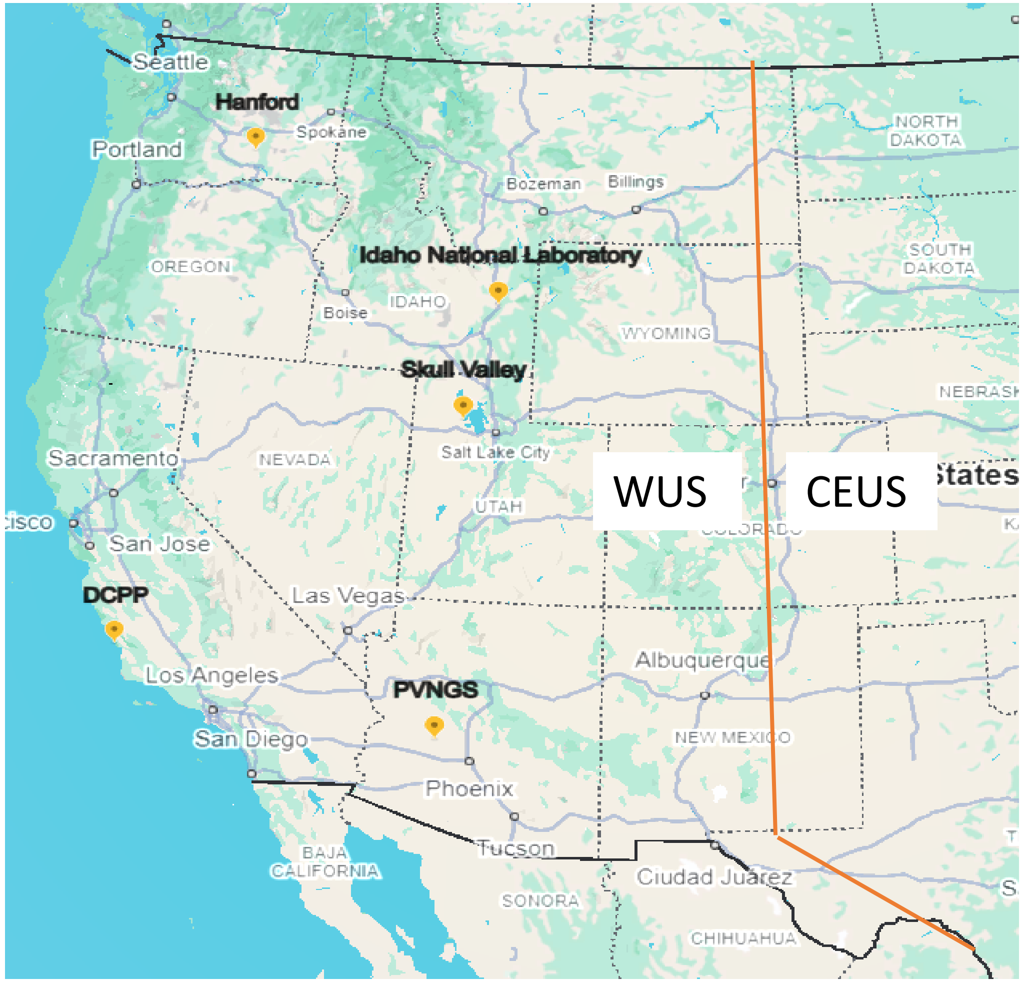
SSHAC Team

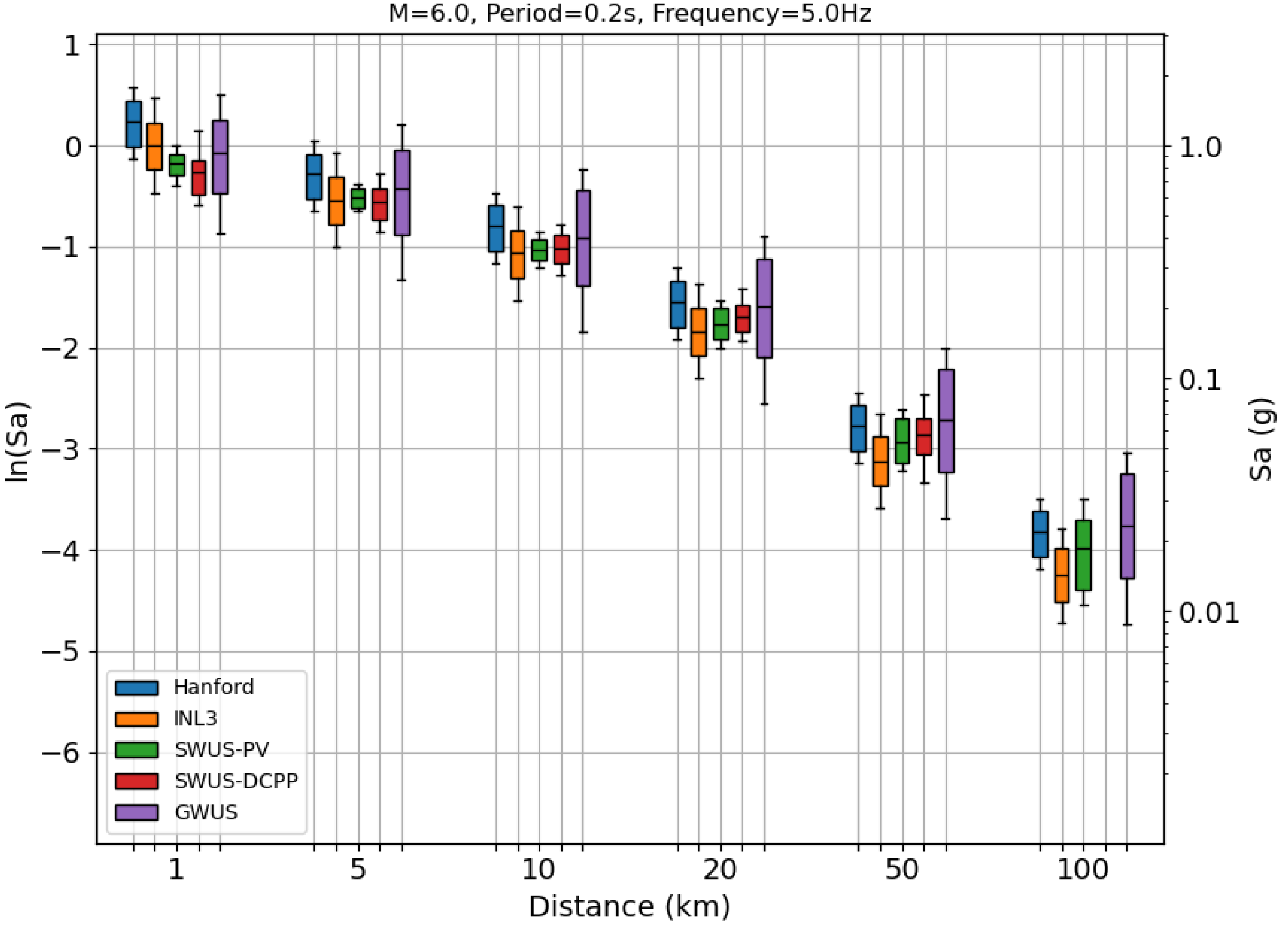
- Technical Integration Team
  - John Stamatakos (SwRI)
  - Adrian Rodriguez-Marek (SwRI Consultant, Virginia Tech)
  - Cliff Munson (NRC)
  - Thomas Weaver (NRC)
  - Ryan Payne (NRC)
- Hazard Analysis Team
  - Scott Stovall (NRC)
  - Kristin Ulmer (SwRI)
- Participatory Peer Review Panel
  - Jon Ake (Consultant to SwRI)
  - Gabriel Torro (Consultant to SwRI, Lettis Consultants International, Inc.)

Seismic Source Characterization for Skull Valley SSHAC L1



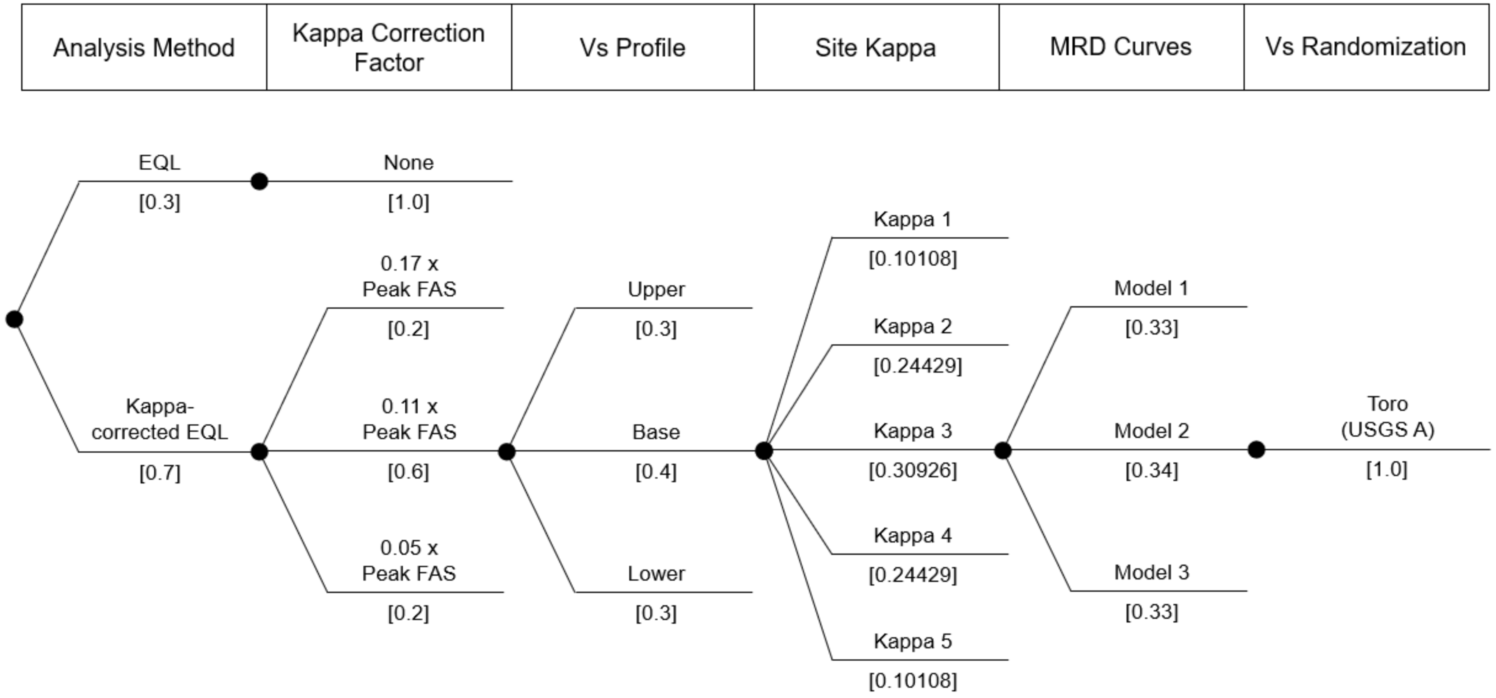
Ground Motion Model for Skull Valley SSHAC L1



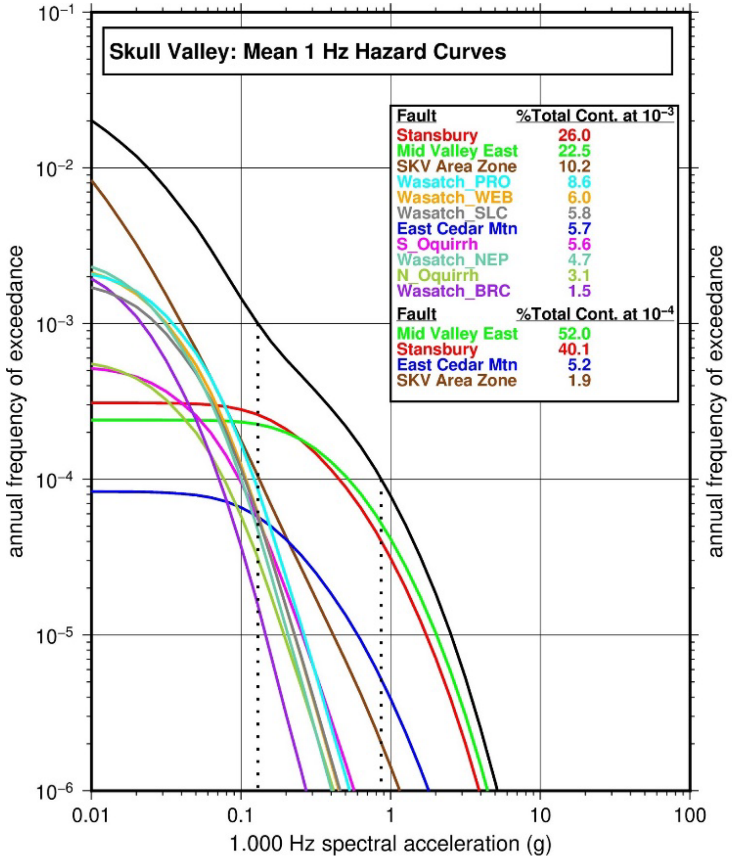


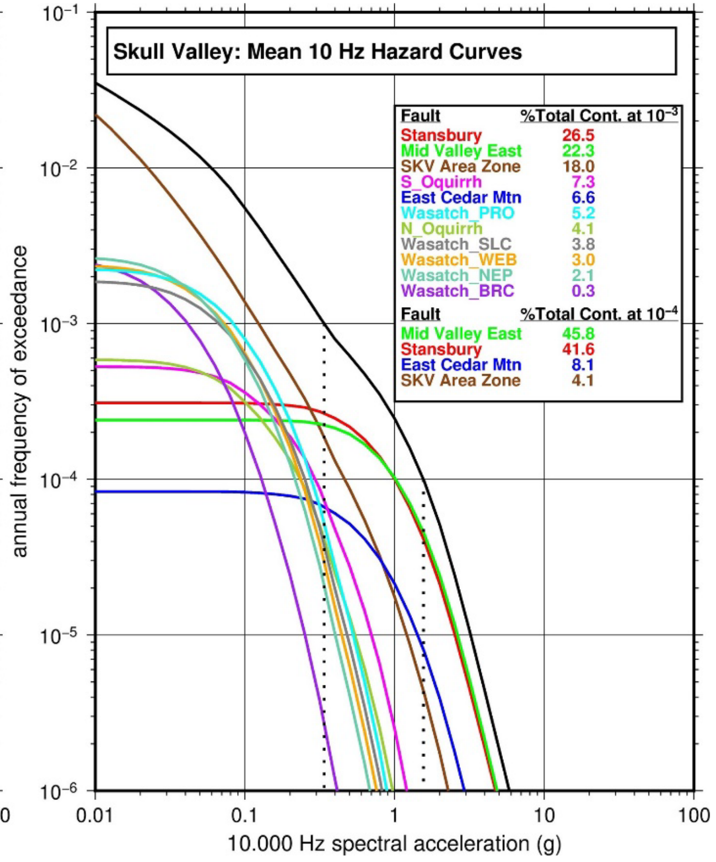
Site Response for Skull Valley SSHAC L1

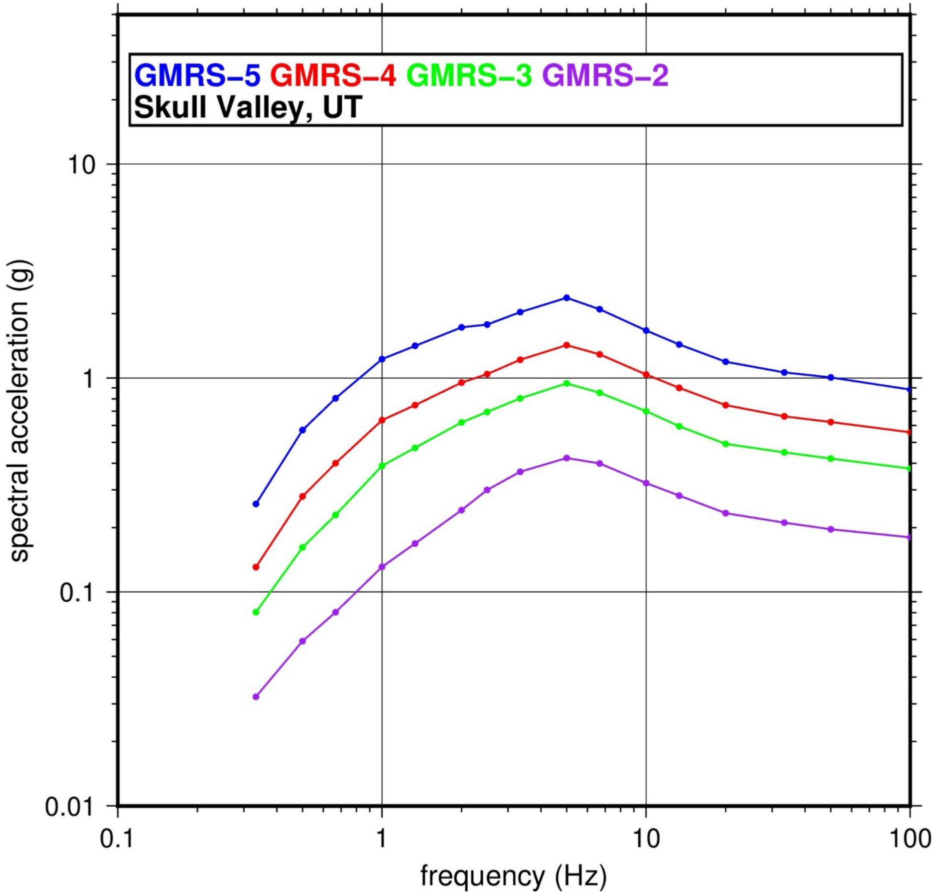
- Site specific geotechnical and geophysical explorations
- Made use of SSHAC Level 2 study (RIL 2021-15) to inform site response logic to appropriately capture uncertainties



Hazard Results for Skull Valley SSHAC L1







SSHAC Process Improvements

1. Examine and utilize **existing geological, geophysical, and geotechnical data**.
2. Use generic ground motion model (e.g. GWUS for WUS and NGA-East for CEUS).
3. **Focus on the contributions to hazard at levels consistent with what is expected for small advanced reactor seismic designs** and seismic risk analyses (e.g., SDC-2 to SDC-4).
4. **Embed the Hazard Analysis Team within the TI Team** to continually develop hazard insights throughout the project.
5. **Take advantage of the experiences and lessons learned from recent SSHAC studies,** especially those developed for sites in the WUS.
6. **Obtain continual feedback from members of the PPRP.** For example, PPRP attends weekly team meetings as well as the more formal presentations made to the PPRP to ensure SSHAC objective of capturing the uncertainty is met in an efficient manner.

Expected Improvement in Efficiency

- Recent SSHAC Level 3 studies
  - Time: ~2 - 5 years
  - Cost: $6,000,000 – 10,000,000
- Anticipated SSHAC Level 1 Effort
  - Time: ~ 0.5 – 0.75 years (6 – 9 months)
  - Cost: ~$750,000 - $1,000,000

Conclusions and Recommendations

- A site-specific study based on geological, geophysical, and geotechnical investigations and analyses is important to capture uncertainty in data and methods used to develop the GMRS
- SSHAC Level 1 study can be completed efficiently and at a cost commensurate with the risk profile and seismic design categories of new and advanced reactors while meeting guidance in RG 1.208 and requirements of 10 CFR 100.23
- SSHAC Process Improvements
  - Active participation with the PPRP
  - Embedded Hazard Analysis Team (HAT) within the TI Team
  - Continually examine hazard sensitivities and focus on those aspects of the models that contribute most to hazard
  - Use generic ground motion models (e.g. GWUS for WUS and NGA-East for CEUS)
  - Rely primarily on existing data, models, and methods from available sources
  - Take advantage of experiences and lessons learned from prior SSHAC studies

Lunch Break

Meeting will resume at 1:00 PM ET

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Peer Review Lessons Learned

Jon Facemire
August 28, 2025

Overview

- Timeline
- Lessons learned for developers considering a peer review
- Lessons learned for nLWR Standard development
- Lessons learned for RG 1.247
- Lessons learned for NEI 20-09 (Peer Review Process)

Timeline

- April 7-11, 2025: First non-LWR PRA Peer Review using Trial Use RG 1.247 completed for eVinci™ microreactor test article at INL's DOME
- June 27, 2025: NEI letter sent to Joint Committee on Nuclear Risk Management (JCNRM) suggesting updates to RA-S-1.4-2021
- July 29, 2025: NEI letter sent to NRC providing suggested changes to Trial Use RG 1.247 including a revision 2 to NEI 20-09

Lessons for Developers

- Choosing PRA scope & Peer Review scope is critical!
    - PRA objectives for meeting PRA Standard may be different from licensing objectives or project objectives
    - Depending on design maturity, consideration of hazards, modes and sources might be necessary for licensing purposes but can complicate meeting the supporting requirements of the standard.
    - RG 1.253 describes how DBHLs assessed deterministically and lower modes assessed via bounding analyses can be acceptable for PSARs
- Many SRs are assessed based on the scope of the PRA
- POS in particular causes many SRs in ESQ, IE, DA and other elements to not be met if lower modes are not modeled realistically.
- Hazards are often the most risk-significant sequences so inclusion could cause not mets in ESQ and RI.
- NEI 20-09 updated to provide clarity on Peer Review vs PRA scope.

Lessons for Developers

- Configuration Control programs are essential for maintaining the interface between design and analysis and can facilitate reviews. CC should provide clarity on when a PRA is an upgrade; Increasing scope (modes, sources, multiunit and Hazards) would be an upgrade.
  - There are conditionals in the standard which might change the way SRs would be met (Procedures, HRA credit, Risk-significance)
  - Example is ES-B6: ENSURE that the level of detail in delineating the dependencies is consistent with the level of detail of the design information and procedural guidance available sufficient to identify potential risk-significant contributors. If dependency information is missing in the supporting design information, IDENTIFY assumptions regarding dependence and independence among SSCs, barriers, and operator actions.

PRA Upgrade Criteria

- Increasing scope (hazards, sources, plant operating states, multiunit, SRs not previously assessed)
- Pre-Operational vs Operational vs Op data collected
  - DA-C3: "For operating plants, COLLECT plant-specific data for the basic event/parameter grouping…"
- Operations Philosophy vs Procedures
  - SC-A9: "ENSURE that the bases for the success criteria are consistent with the features, available procedures, and design and/or operating philosophy of the plant."
- No Risk-Significance vs Risk-Significance
  - ESQ-A9 CC-II: "USE realistic parameter estimates to characterize event sequence phenomena for risk-significant event sequence families. USE conservative or a combination of conservative and realistic estimates for non-risk-significant event sequence families."
- HRA credited vs not – note that other SRs require some HRA e.g. IE-A14
- Operating fleet guidance is available in PWROG-20037-NP, NEI considering developing a non-LWR supplement

Lessons for Standards Development

- There is opportunity for simplification & consolidation! Many linked F&Os identified.
- More needs to be done to ensure SRs can be met for PRAs that are limited scope or for microreactor deployment models
- POS-A1 CC-II: “IDENTIFY a representative set of plant evolutions to be analyzed, including refueling outages, other controlled shutdowns, and forced outages.” cannot be met for microreactor deployment models that refuel offsite.
- ESQ-A5 has language for POS and hazards “within the scope of the PRA” while other SRs don’t: ESQ-A2, ESQ-C12(c), ESQ-F1.
  - Some reference HRA which may not be credited for some designs
- Some SRs refer to applications which is not appropriate
  - RI-A1: “For the purpose of Risk Integration, DEFINE the consequence measure(s) necessary to support the intended applications of the PRA (e.g., person-rem, early fatalities, latent health effects, site boundary doses, quantity of radioactive material released).” also RCRE-B1

Lessons for Standards Development

- Realistic vs Conservative treatment needs to be addressed consistently

Index No. SC-B	Capability Category I	Capability Category II
SC-B1	DEFINE success criteria by using generic analyses that are applicable to the type of reactor and plant design. See Note SC-N-6	DEFINE the realistic success criteria to mitigate the risk-significant event sequences based on applicable generic and plant- or design-specific analyses. For non-risk-significant event sequences, ENSURE the requirement of Capability Category I (CC-I) is met. See Note SC-N-6
SC-B7	SELECT a conservative method for evaluating effectiveness of each radionuclide transport barrier consistent with the definition of loads and capacities in Requirement SC-B6.	SELECT a realistic method for evaluating effectiveness of each radionuclide transport barrier. INCLUDE an assessment of the uncertainties in the event sequence-specific loading conditions of each radionuclide transport barrier and radionuclide transport barrier capacity to withstand the loads consistent with the definition of loads and capacities in Requirement SC-B6.

Lessons for Standards Development

- SRs related to barrier failure are problematic for TRISO fuel

SC-B6	DEFINE the thermal-mechanical loads or other relevant physical attributes of the event sequence-specific challenges to radionuclide transport barrier integrity. IDENTIFY the relevant parameters that are needed to define the capability of each radionuclide transport barrier to withstand these challenges. See Note SC-N-11

- One solution is to directly modeled TRISO in MS without setting an explicit criteria.

Lessons for RG 1.247

- NRC Qualification on RI-A4 & RI-A5 are inappropriate. Similar to comments to Standard committee on RI-A1 and RCRE-B1. Peer Reviews are for the PRA against the standard, not for a specific application
- NRC should consider the NEI letter to JCNRM for potential qualifications to address issues with the standard.
- Guidance on specific applications should be worked into the specific application guidance.
- NEI 20-09 Updated as discussed on the next slide

Lessons for NEI 20-09

- Revision 2 of NEI 20-09 addresses
  - How a Peer Review team should consider supporting requirements when the PRA scope is different from the scope of the Peer Review.
  - Considerations for determining Peer Review scope early in the design phase, informed by RG 1.253.
  - Clarification that not every PRA Peer Review requires review of Configuration Control.
- Future revisions may address upgrade guidance for nLWRs, see developer slides.

APPROACH FOR THE ASSESSMENT OF LOW FREQUENCY EXTERNAL EVENTS

DAVE GRABASKAS
Manager, Licensing and Risk Assessments Group
Argonne National Laboratory

- Background
- Approach
- Example
- Basis
- Next Steps

Background

Approach

Example

Basis

Next Steps

BACKGROUND: PROJECT

- **Objective**
  - Demonstration of the ***regulatory acceptability*** of a plant design regarding external hazards when using a risk-informed, performance-based (RIPB) licensing approach

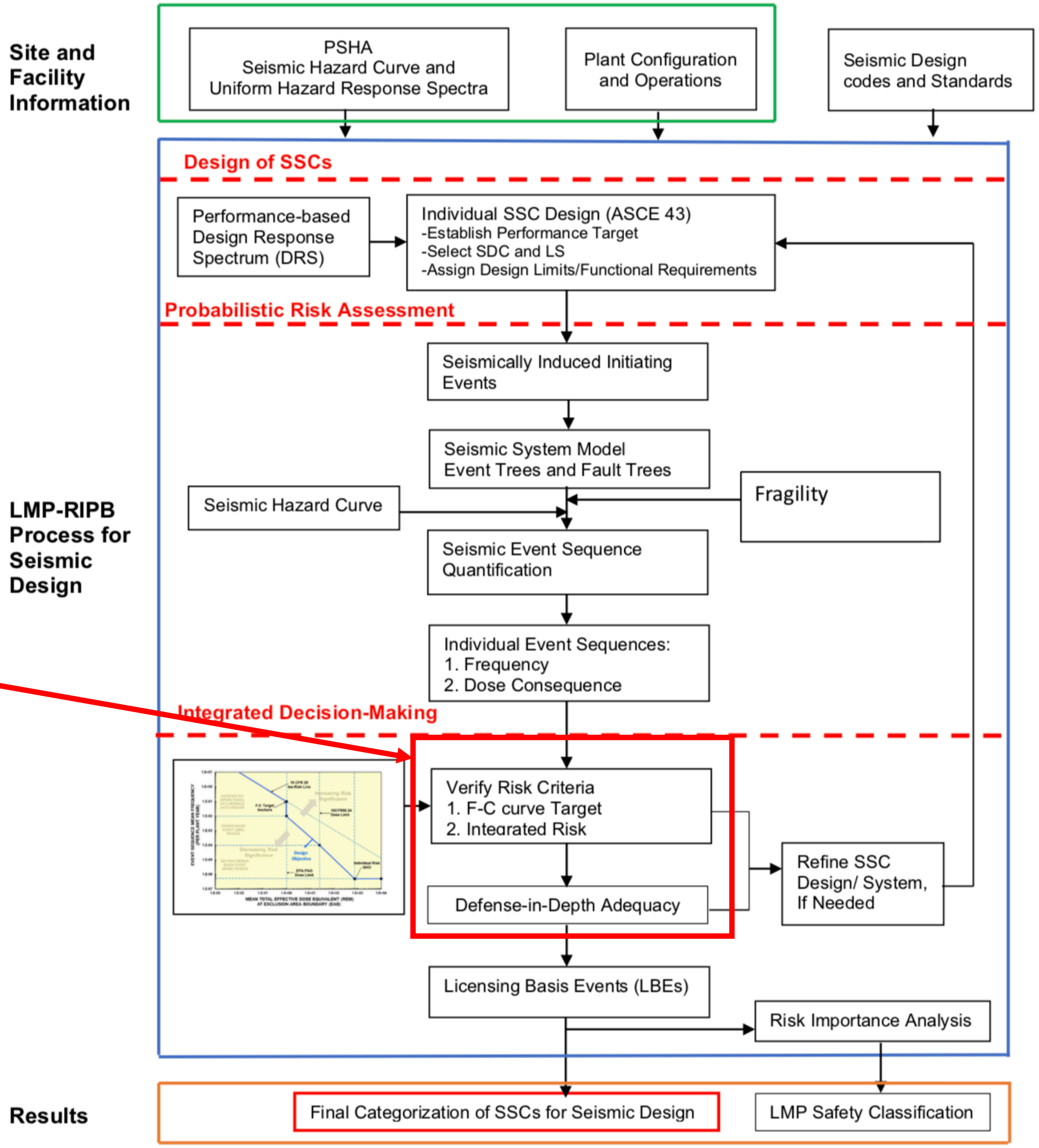
- **Focus**
  - Seismic hazard, given general importance for advanced reactor applicants
  - Targeting alignment with 10 CFR Part 53, given RIPB structure and associated NRC RIPB seismic design guidance (RIL 2021-04, draft DG-1410/RG 1.251)

- **Sponsor**
  - DOE:NE Advanced Reactor Demonstration Program, Regulatory Development – Regulatory Framework Modernization Area
  - Significant contributions from many members of industry and seismic community

BACKGROUND: PROJECT

- **Context**
  - There are many ongoing efforts regarding RIPB design, addressing different aspects of seismic design and analysis
  - Current project focused on demonstrating satisfaction of Part 53 safety criteria

RIL-2021-04



BACKGROUND: PART 53 SAFETY CRITERIA (SIMPLIFIED)

- **§ 53.260: Normal Operations**
  - 10 CFR Part 20, 100 mrem per year

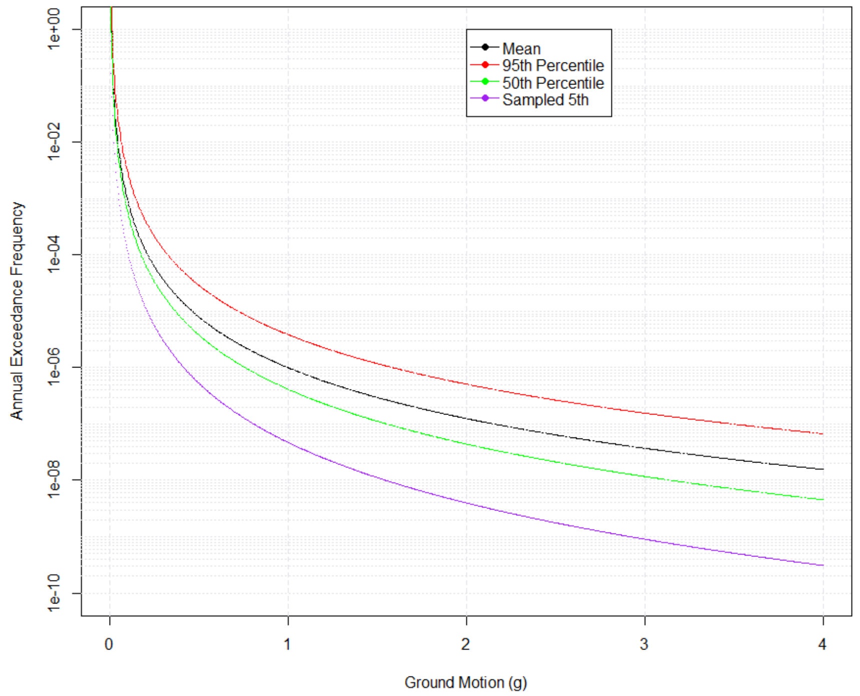
- **§ 53.210: Design Basis Accident (DBAs)**
  - Criteria essentially identical to Part 50, 25 rem TEDE

- **§ 53.220: Licensing Basis Events (LBEs) other than DBAs**
  - Applicant proposed “comprehensive risk metrics that satisfy associated risk performance objectives that are acceptable to the NRC and provide an appropriate level of safety"

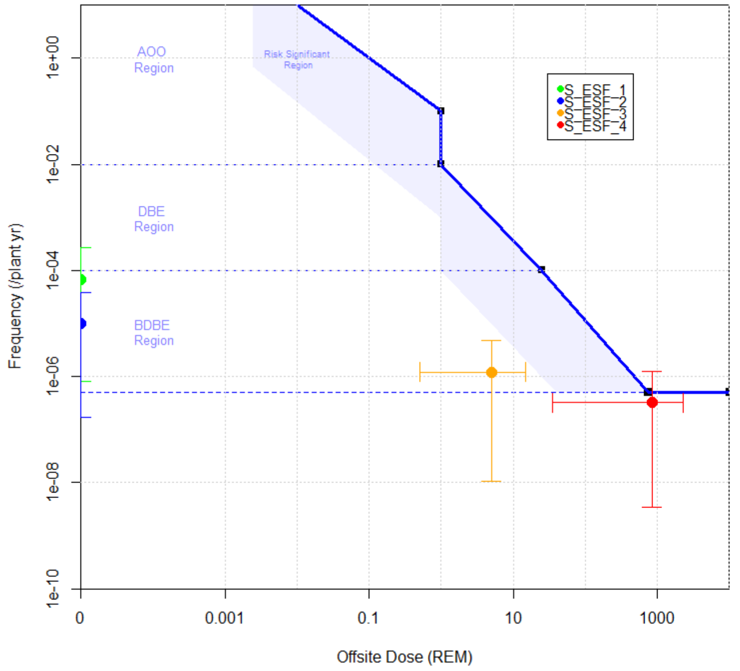
- **Subject to change…**

BACKGROUND: CHALLENGES

- **Frequency**
  - Due to lack of data on rare events, the seismic hazard curves use extrapolations in low frequency range with large uncertainties
  - Uncertainty is essentially irreducible



- **Consequence**
  - Uncertainty regarding how gross SSC failures occur during severe seismic events
  - Large uncertainty in associated source term analysis
  - Uncertainty regarding population response and the effectiveness of protective actions (sheltering, evacuation, etc.)



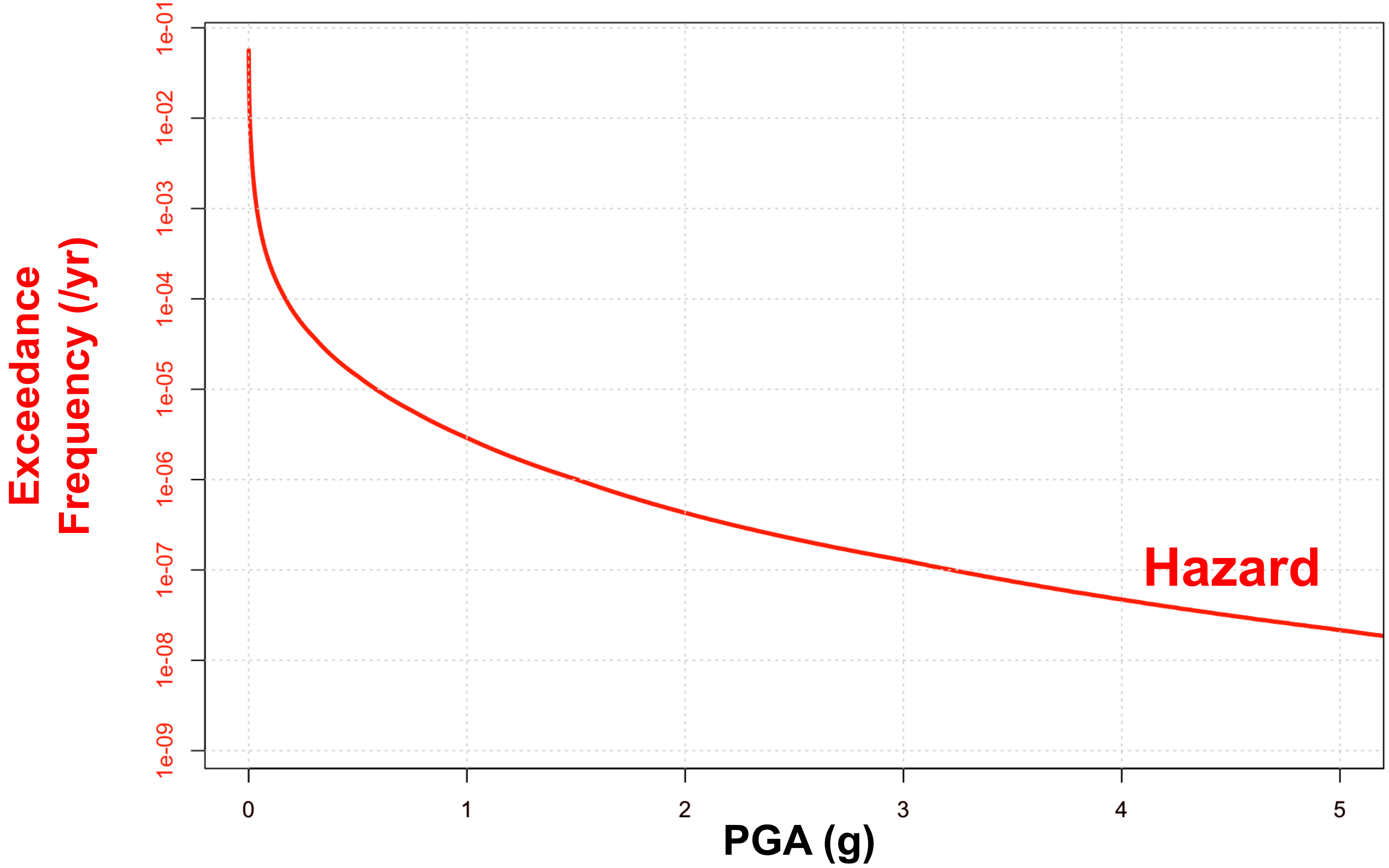
Background

Approach

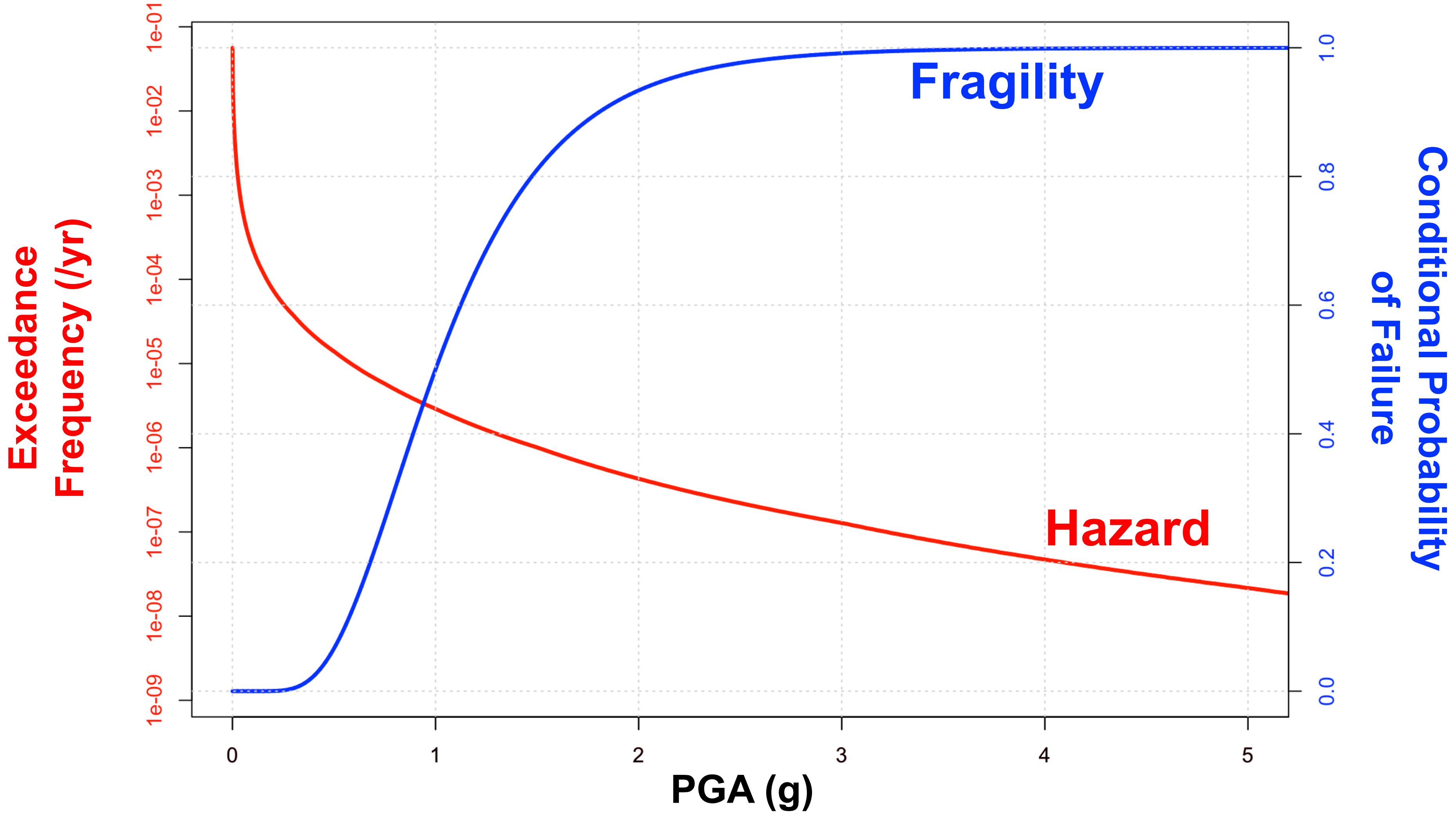
Example

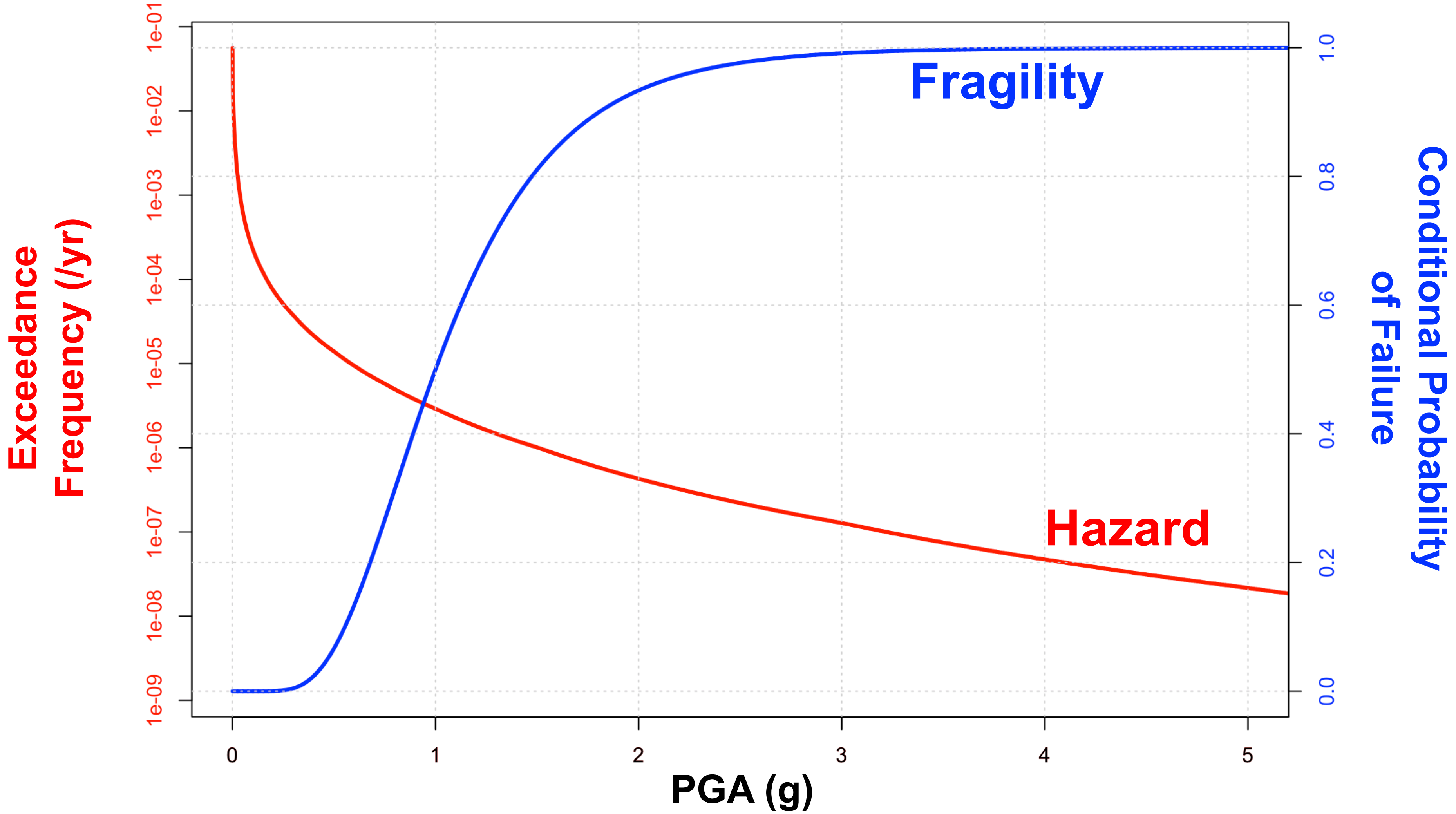
Basis

Next Steps

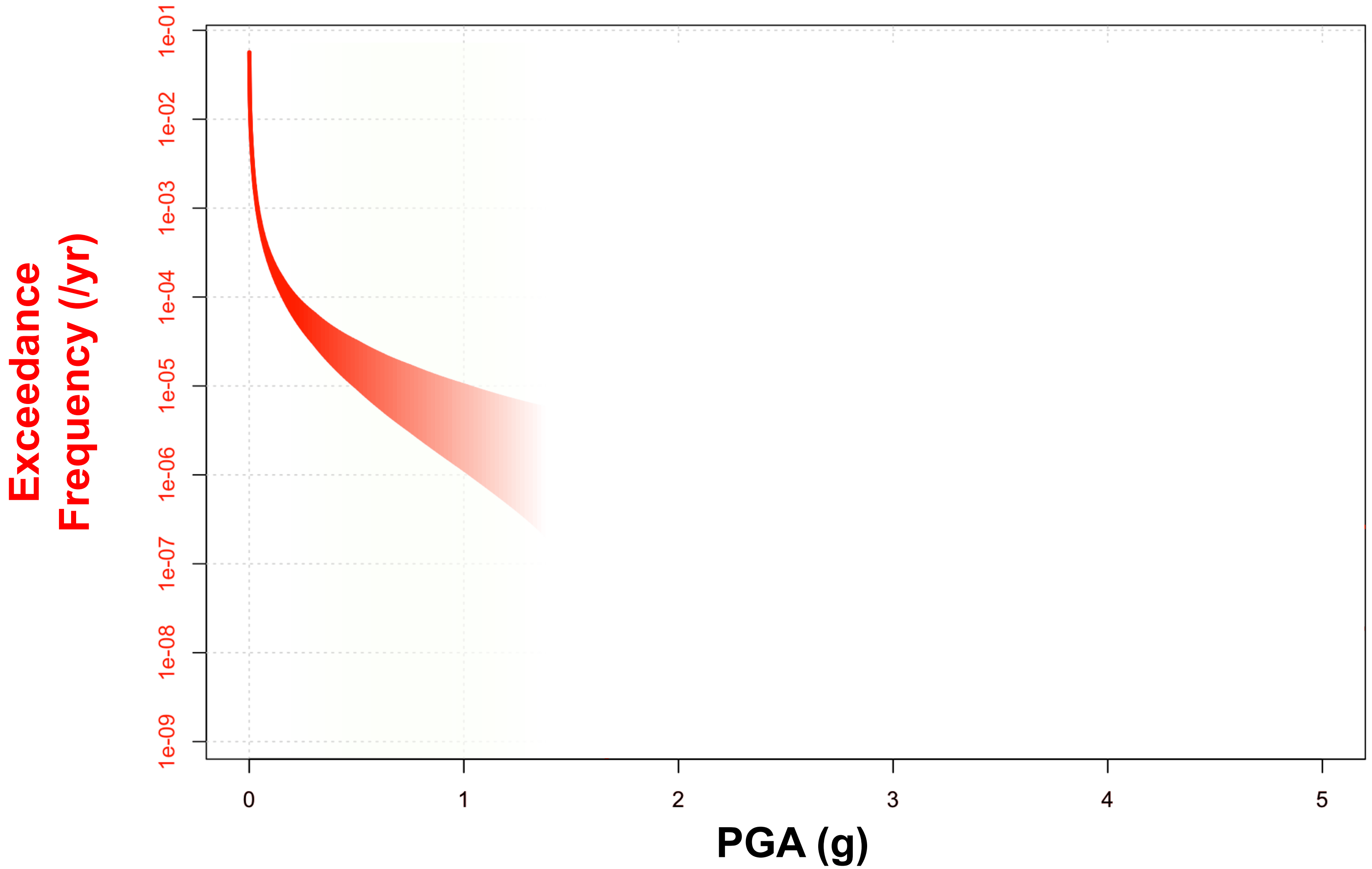


Exceedance Frequency (/yr)
1e-01
1e-02
1e-03
1e-04
1e-05
1e-06
1e-07
1e-08
1e-09
0
1
2
3
4
5
PGA (g)
Hazard

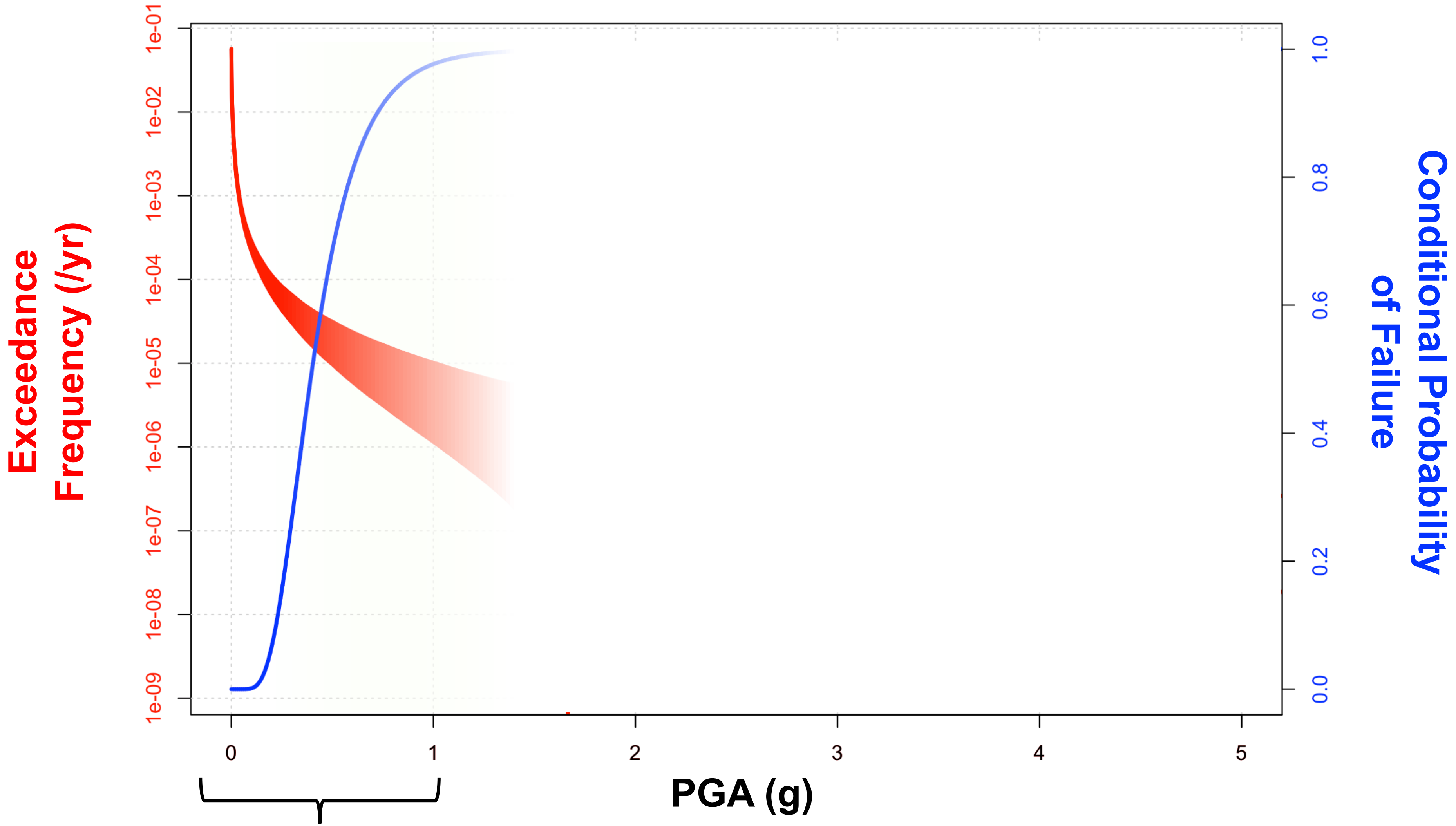

Fragility
Hazard
Exceedance Frequency (/yr)
Conditional Probability of Failure
PGA (g)
1e-01
1e-02
1e-03
1e-04
1e-05
1e-06
1e-07
1e-08
1e-09
0.0
0.2
0.4
0.6
0.8
1.0
0
1
2
3
4
5



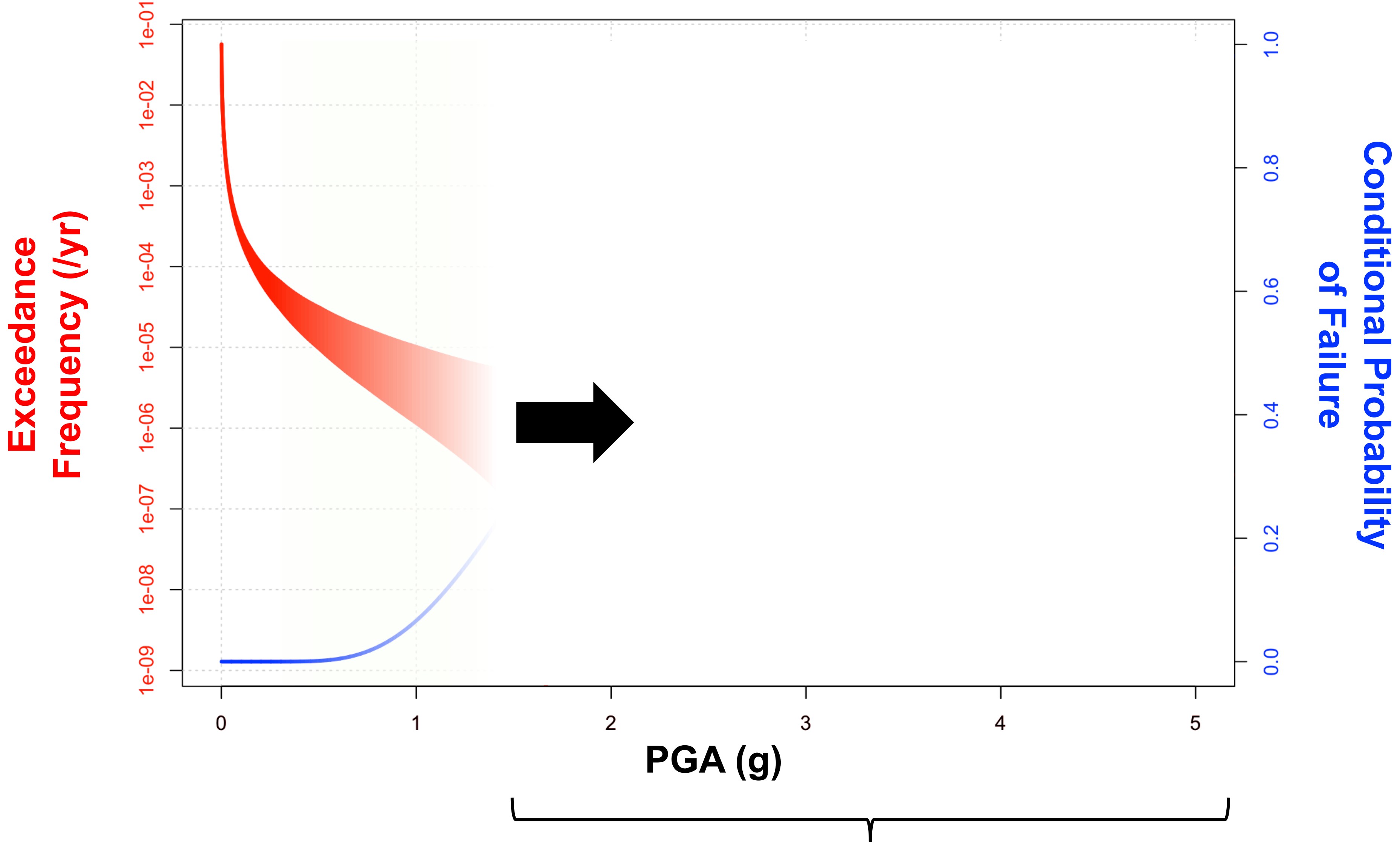
If we had perfect (or at least reasonable) knowledge, we would simply compute the convolution of the hazard and fragility curves and compare the resulting failure frequency to a designated criterion



In reality, the hazard curve is highly uncertainty at lower frequencies, with extrapolations based on the higher frequency data

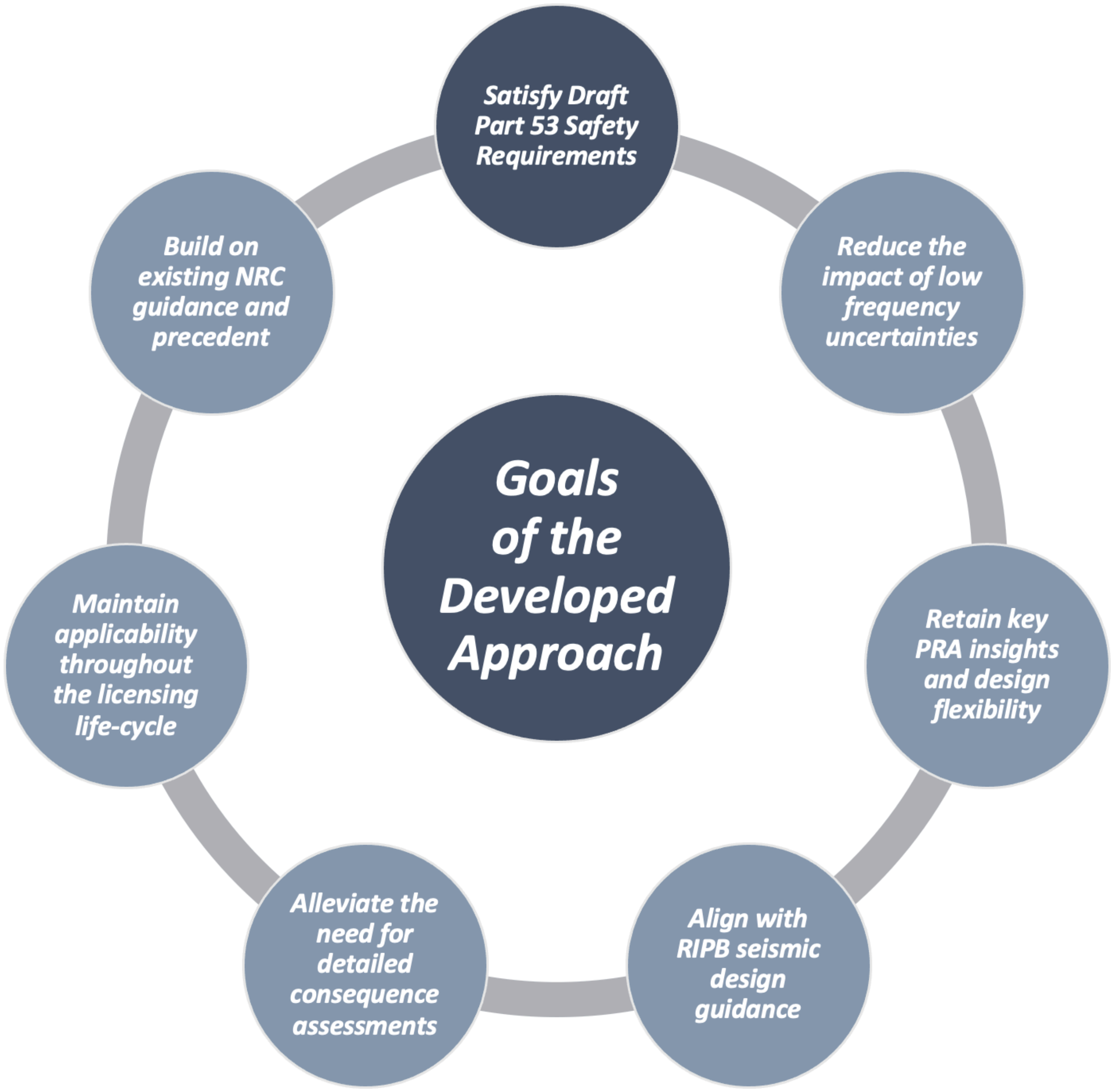


In this frequency range, the level of confidence in the data supports the validity of the convolution



In this region, convolution is challenging, given our limited knowledge. We are essentially constrained to proving that we are “far enough” to the right, with some amount of confidence

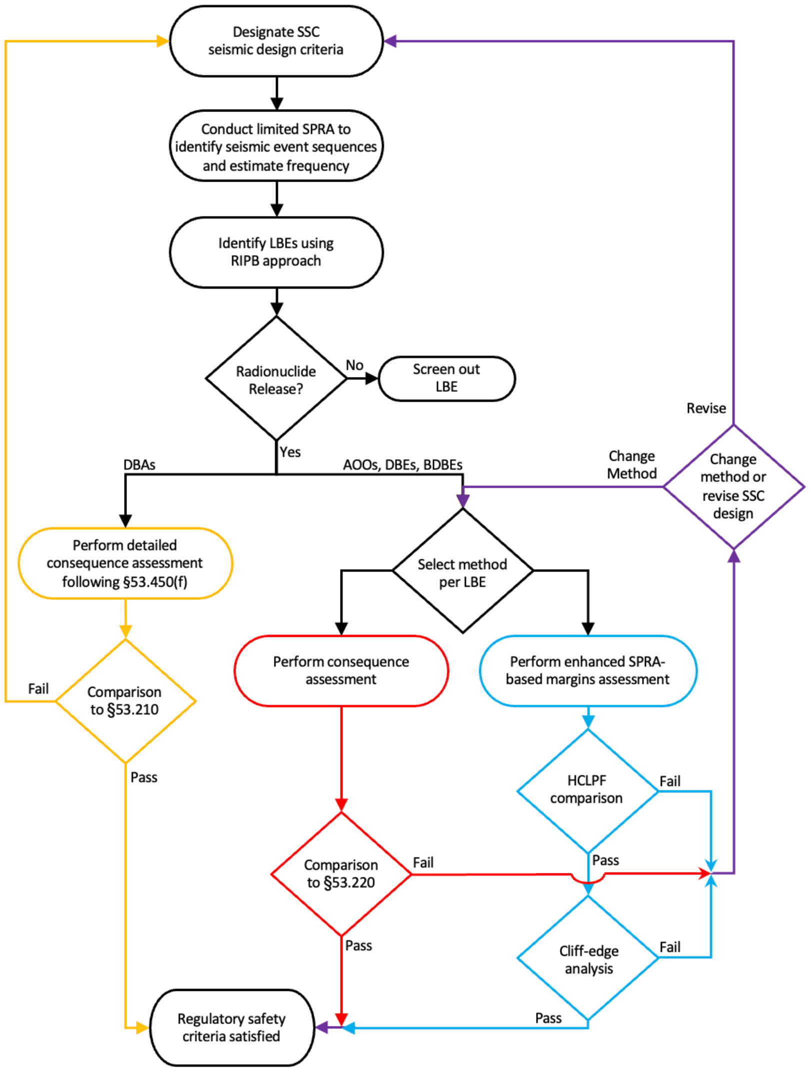
REVISED APPROACH: GOALS



DEVELOPED APPROACH

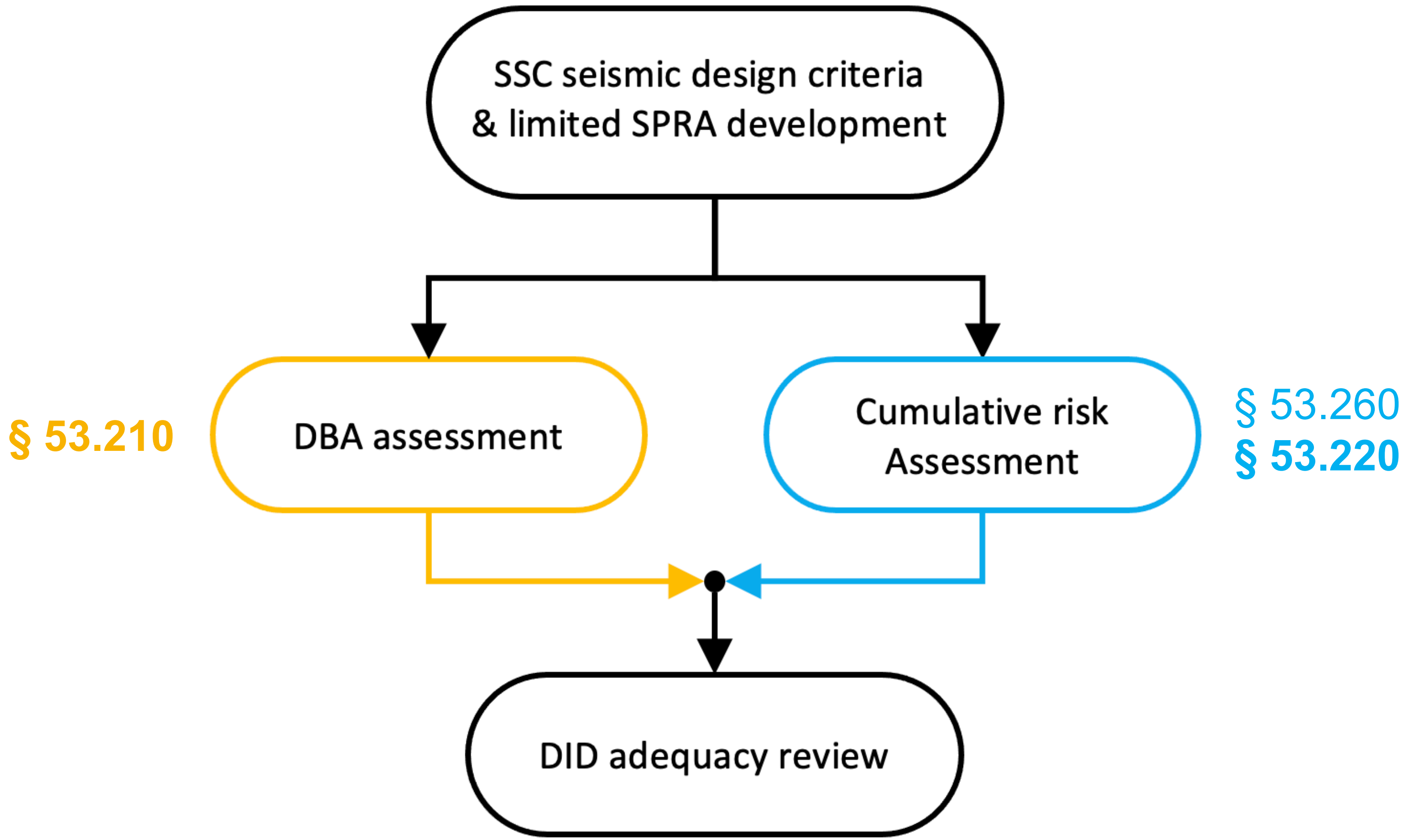
- **Initial Version**
  - An initial version of the approach was developed in 2023 and shared with industry and NRC for informal review
  - Utilized a margins-based approach partially derived from PRA-based seismic margins analyses under Part 52

- **Feedback**
  - Interest in simplified margins-based approach
  - Questions regarding margins criteria of 1.67 x GMRS
  - Clarification of linkage between margin and risk metrics
  - How to address **cumulative risk**?



REVISED APPROACH

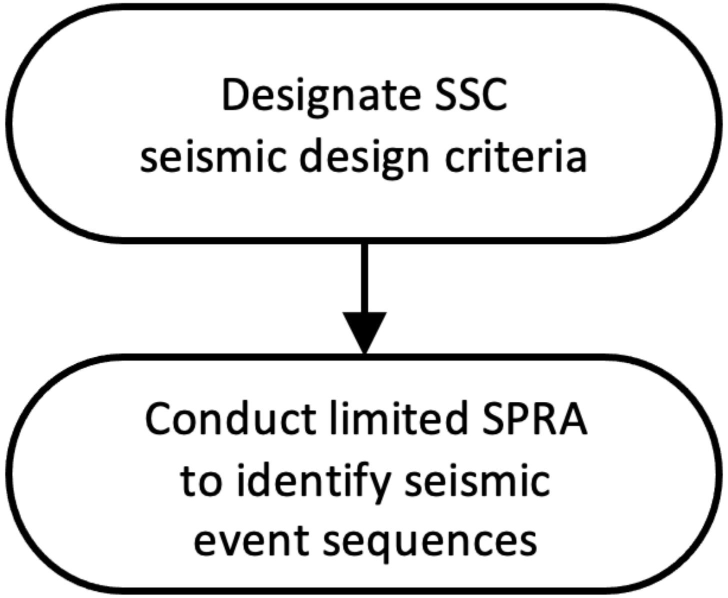
REVISED APPROACH: OVERVIEW



REVISED APPROACH: SSC DESIGN & SPRA

- **SSC Seismic Design Criteria**
  - Using ASCE 43 or other methods
  - Likely an iterative process based on results of later steps

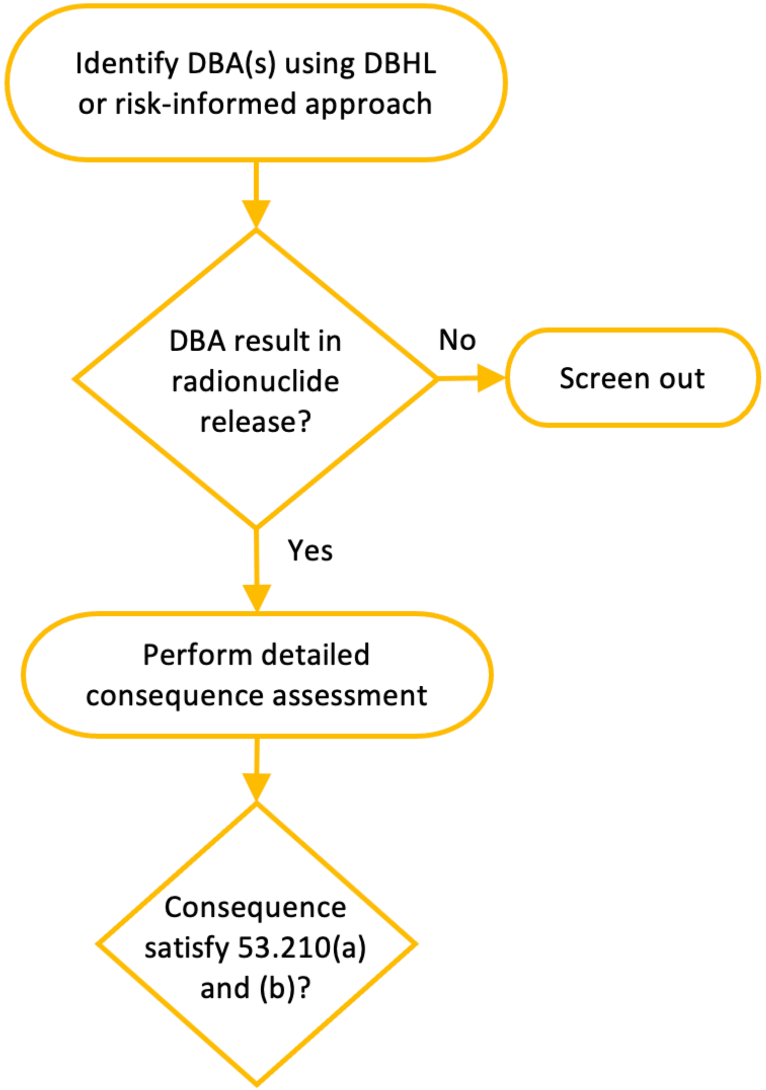
- **Limited SPRA Development**
  - Construct a seismic-PRA (SPRA) with a focus on identifying seismically-induced event sequences
  - Frequency and consequence quantification not necessary
    - Determination of which event sequences result in radionuclide release is required
  - Process informed by seismic element of NLWR PRA standard, though not all requirements apply



REVISED APPROACH: DBAs

- **DBA Identification**
  - Seismic DBAs can be specified using either:
    - DBHL approach, such as RG 1.208
    - RIPB approach, such as LMP
      - LMP approach would require identification of design basis events (DBEs) in previous step

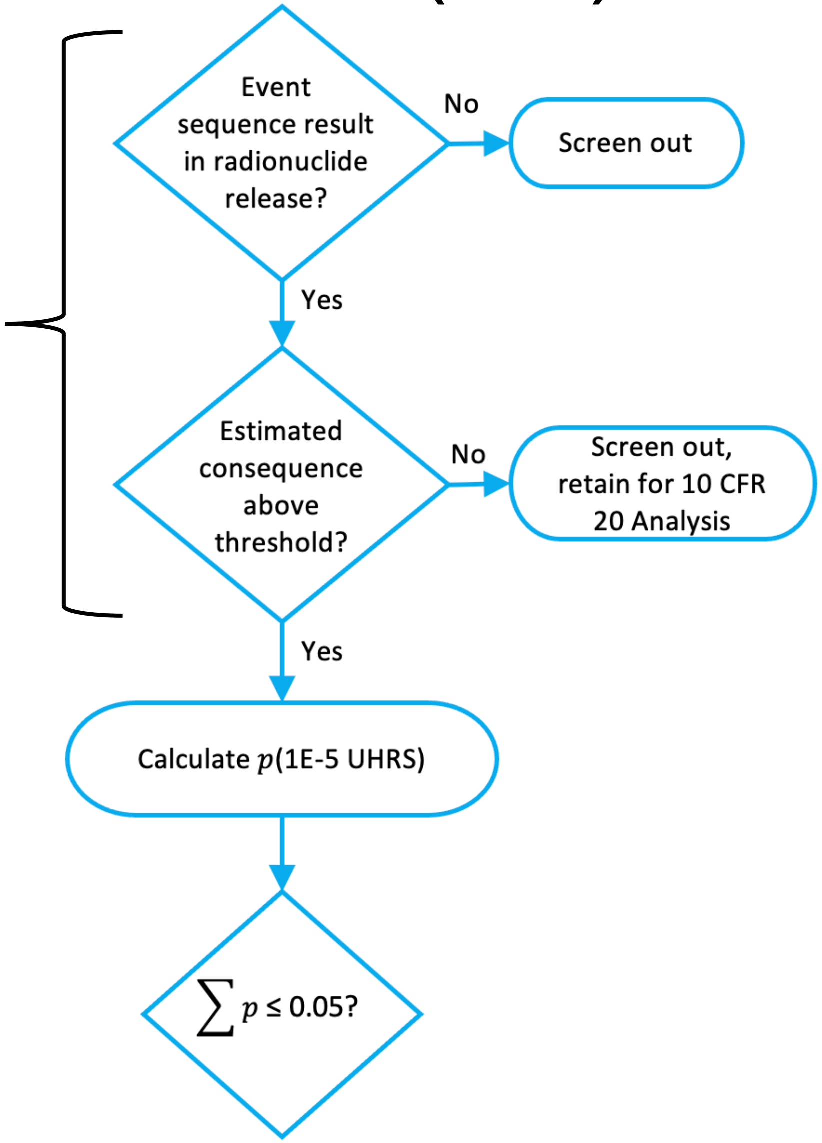
- **Consequence Analysis**
  - For those DBAs that result in radionuclide release, a source term and dispersion analysis is conducted
  - Results compared to § 53.210 criteria
    - If above criteria, the SSC seismic design criteria (or other design choices) must be revised



REVISED APPROACH: CUMULATIVE RISK (1/2)

- **Event Sequence[1] Selection**
  - Utilizes event sequences from the limited SPRA
  - Those that do not result in radionuclide release are screened from the cumulative risk assessment

- **Consequence Screening**
  - Event sequences with an estimated consequence below **25 rem** TEDE are screened
    - Justification for 25 rem discussed in later slides
    - Screened event sequences are retained for Part 20 analysis
  - Detailed source term/dispersion assessment not needed, screening can be performed based on qualitative basis

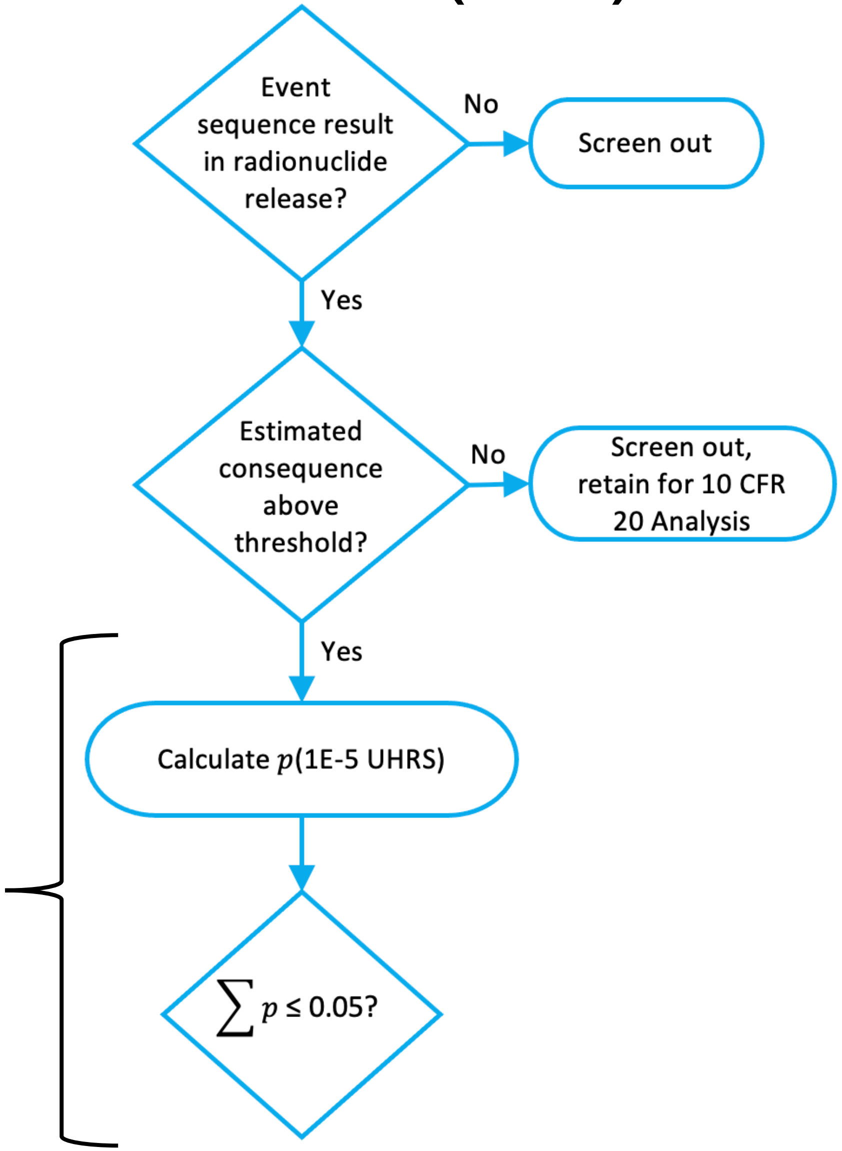


[1] May be event sequence families or LBEs

REVISED APPROACH: CUMULATIVE RISK (2/2)

- **Event Sequence Probability Assessment**
  - The likelihood of each event sequence is evaluated at the 1E-5 per year UHRS PGA level
  - Probability of event sequence includes both seismically-induced failures and random failure probability

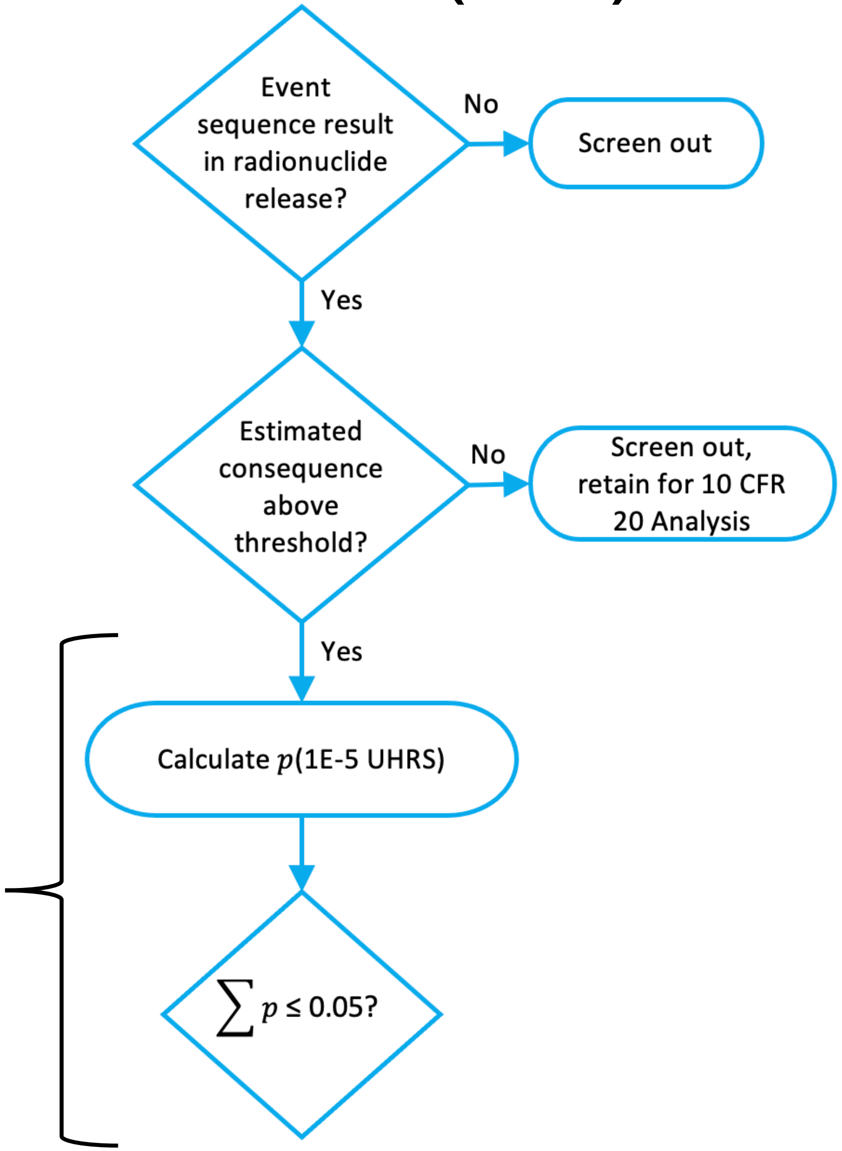
- **Cumulative Probability**
  - The probability of event sequence occurrence is summed and compared to a **criterion of 0.05**
    - If above criteria, the SSC seismic design criteria (or other design choices) must be revised



REVISED APPROACH: CUMULATIVE RISK (2/2)

- **Event Sequence Probability Assessment**
  - The likelihood of each event sequence is evaluated at the 1E-5 per year UHRS PGA level
  - Probability of event sequence includes both seismically-induced failures and random failure probability

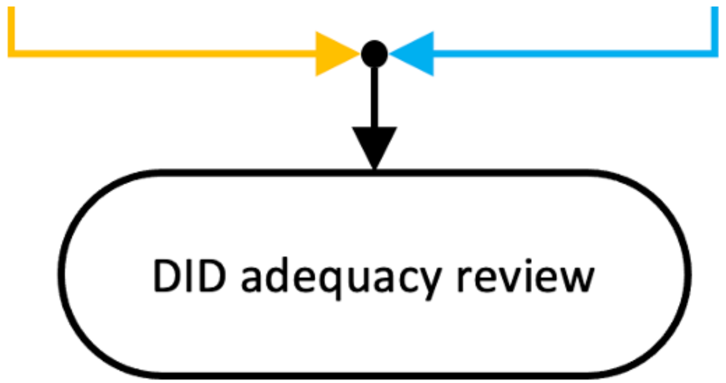
- **Cumulative Probability**
  - The probability of event sequence occurrence is summed and compared to a **criterion of 0.05**
    - If above criteria, the SSC seismic design criteria (or other design choices) must be revised
  - In other words, at a 1 in 100,000 year seismic event, the total probability of an event resulting in ≥ 25 rem is less than 0.05



REVISED APPROACH: DID ADEQUACY REVIEW

- **Integrated Decision-Making Process (IDP)**
  - Aligns with draft DG-1410/RG 1.251
  - For LMP users, can leverage existing IDP

- **Considerations:**
  - Uncertainty related to the modeling results, including uncertainty in inputs, models, completeness, etc.
  - Modeling assumptions, including explicit or implicit conservatisms
  - Identification of key event sequences and SSCs
  - The level of confidence in the performance of key SSCs
  - Cliff-edge events or plant behavior
  - Margin to safety criteria



Background

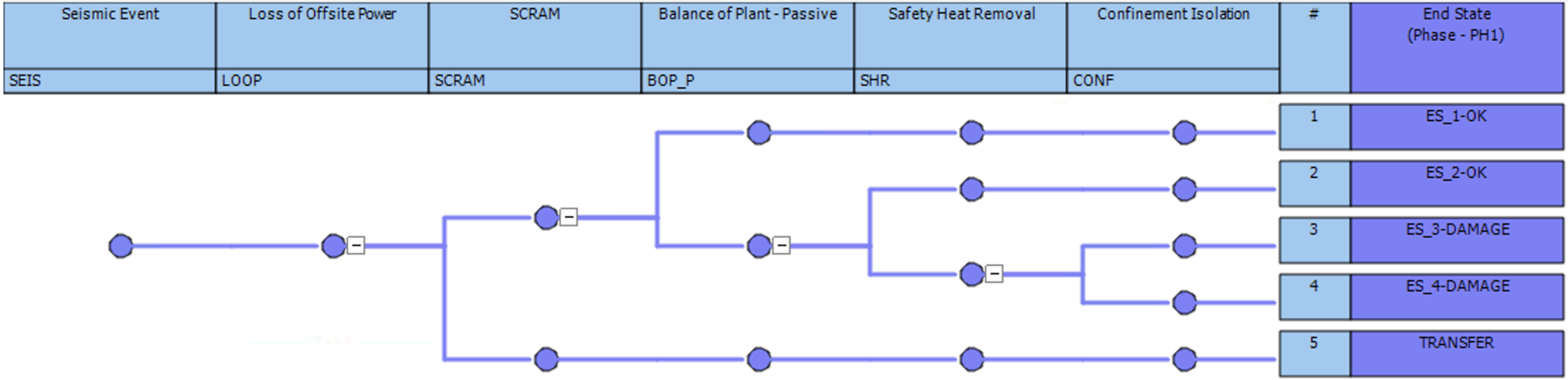
Approach

Example

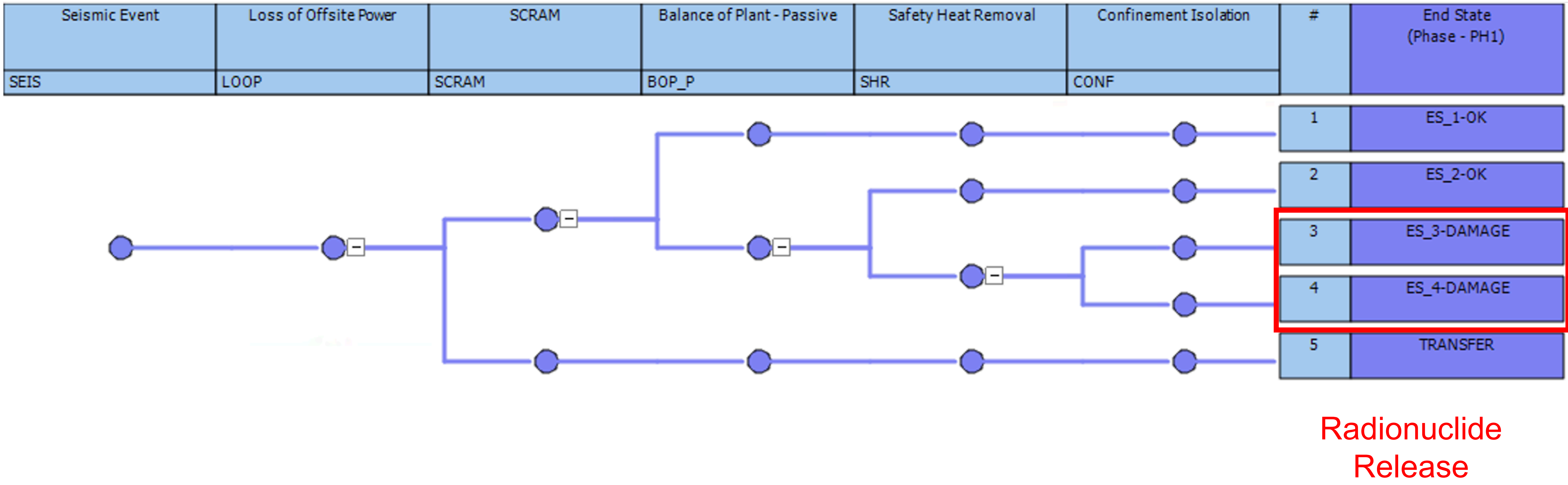
Basis

Next Steps

EXAMPLE: SEISMIC-LOOP



EXAMPLE: SEISMIC-LOOP



EXAMPLE: SEISMIC-LOOP

- **SSC Seismic Design**
  - SSC fragility values based on advanced reactor designs
  - Random failure probabilities estimated

	Seismic			Random Failures	
SSC	Am (g)	β_r	β_u	P	EF
Offsite Power	0.3	0.3	0.3	-	-
SCRAM	3.0	0.3	0.3	1E-6	5
BOP_P	0.5	0.3	0.3	1E-3	5
SHR	1.0	0.3	0.3	1E-5	5
CONF	1.5	0.3	0.3	1E-3	5

- **Limited SPRA**
  - Shown on previous slide. In real case, likely one of multiple event trees

EXAMPLE: SEISMIC-LOOP

- **Cumulative Risk Assessment**
  - Two event sequences (ES_3 and ES_4) with consequence assumed above 25 rem

- **Event Sequence Probability Assessment**
  - The likelihood of ES_3 and ES_4 are evaluated[1] utilizing the 1E-5 per year UHRS PGA
    - CEUS site, 0.464g

$$P_{ES_3} = P_{LOOP} \times (1 - P_{SCRAM}) \times P_{BOP\_P} \times P_{SHR} \times (1 - P_{CONF})$$
$$P_{ES_4} = P_{LOOP} \times (1 - P_{SCRAM}) \times P_{BOP\_P} \times P_{SHR} \times P_{CONF}$$

$P =$ Random failure probability + seismic failure probability at 0.464g

[1] Assumes no correlation between SSCs

EXAMPLE: SEISMIC-LOOP

- **Event Sequence Probability Assessment**

Event Sequence	*p*(1E-5 UHRS)
ES_3	0.0128
ES_4	4.95E-5
Sum	0.0129

- **Cumulative Probability Assessment**
  — Summation of event sequence probabilities < 0.05

- **DID Adequacy Review**
  — Evaluation of uncertainties, SSC importance, etc.
  — Margin for ES_4 particularly important, as it represents a failure of heat removal *and* confinement isolation with larger radionuclide release

Background

Approach

Example

Basis

Next Steps

REVISED APPROACH: BASIS

- **Background**
  - — § 53.220 allows applicants to propose comprehensive risk metrics
  - — The Advanced Reactor Policy Statement sets expectation that ARs will meet the Safety Goal Policy Statement (QHOs). The QHOs are also used as cumulative risk metrics under LMP

- **QHO Surrogates**
  - — In NUREG-1860, the NRC demonstrated that CDF and LERF are suitable surrogates for early fatality and latent cancer risk
  - — Assessment based on *conditional* probabilities
    - Conditional probability of early fatality (CPEF): 0.03 — LERF x CPEF < 5E-7 /yr
    - Conditional probability of latent cancer (CPLF): 4E-3 — CDF x CPLF < 2E-6 /yr

REVISED APPROACH: BASIS

- **Developed Approach:**
  - Using a mean 1E-5 per year seismic event and a total likelihood of less than 0.05 yields:

$$1\text{E-}5\ /\text{yr} \times 0.05 = 5\text{E-}7\ /\text{yr}$$

  - 0.05 is the *conditional* probability of event occurrence, similar to NUREG-1860 approach
  - Additional conservatism as approach assumes CPEF and CPLF = 1

- **Note:**
  - Approach does not prove that a convolution of the hazard curve and event sequence fragilities would yield a value below 5E-7 per year
    - However, it does ensure that the risk contribution is from the portion of the hazard curve that is well below 1E-5 per year, where uncertainty in the hazard estimate is large

REVISED APPROACH: BASIS

- **Precedent:**
  - NRC-endorsed NEI 12-06 utilizes the following metrics to determine if further plant modifications or additional capabilities are needed for beyond design basis seismic:
    - SCDF < 5E-5 /yr
    - SLERF < 5E-6 /yr
  - Part 52 PRA-based seismic margins approach using 1.67 x SSE results in similar value
    - ~5E-5 /yr x 0.01 = 5E-7 /yr

- **Use of 25 rem Threshold**
  - Events with dose below 25 rem are unlikely to make an appreciable contribution to the QHOs, when also considering Part 20 and DBA requirements
    - Additional discussion in report

REVISED APPROACH: OTHER TOPICS

- **Alternative Consequence Thresholds**
  - The approach could be modified to align with other risk metrics proposed under § 53.220, discussed further in report

- **Application to Other External Hazards**
  - Approach could be directly applied to other external hazards
  - Consideration needed for hazards with discontinuous hazard curves (for example, dam failure resulting in a significant increase in external flooding level)

- **Application to Part 50/52**
  - Significant similarities in safety criteria could permit the application of the approach to Part 50 and 52 analyses

- Background
- Approach
- Example
- Basis
- **Next Steps**

REVISED APPROACH: NEXT STEPS

- **Revised Approach:**
  - Addresses project objectives and goals
  - Addresses reviewer feedback
  - Demonstrates satisfaction of draft Part 53 safety criteria

- **Next Steps:**
  - Continued interfacing with other seismic RIPB efforts for coordination
  - Revised report being finalized for NRC submittal and review
  - Given Part 53 timing, also considering application to Part 50/52
  - Worthwhile to discuss best approach for submittal and review

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PUBLIC COMMENTS

United States Nuclear Regulatory Commission
Protecting People and the Environment

CLOSING REMARKS