Using SPARC to Extract Risk Insights from Performance Assessments for HLW Repositories

Tina Ghosh, U.S. NRC
Co-author: George Apostolakis, MIT
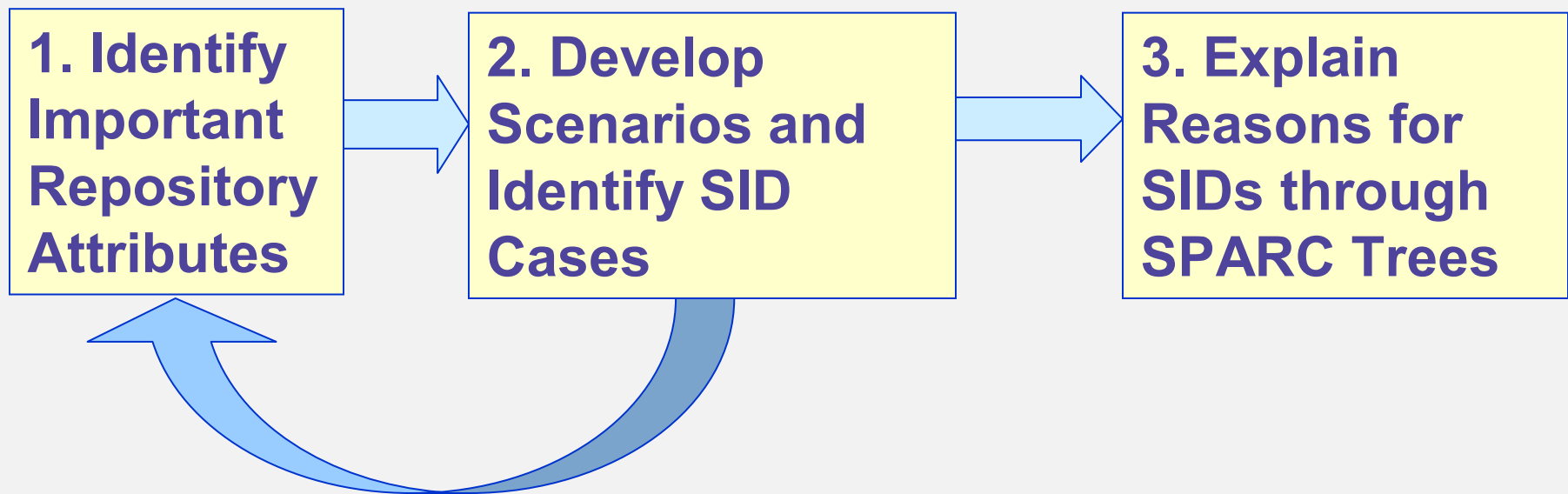**PSAM 8 Conference**
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Issues

- **Numerous uncertainties are present in Performance Assessments (PAs) for high-level nuclear waste (HLW) repositories**

- **People nonetheless have to make decisions about HLW repositories, such as choosing the design and prioritizing research, and make a convincing safety case to society**

- **Information about risk is an important component of the decisions and safety case**
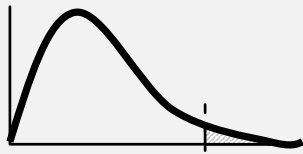
SPARC Approach

- This presentation discusses the Strategic Partitioning of Assumption-Ranges and Consequences (SPARC) method for extracting risk information from PAs.

- The SPARC method constructs scenarios of risk, defined in terms of the *specific assumption ranges* that can produce substantially-increased doses to future generations.

- The goal is to find the model-parameter sample domain where substantially-increased dose (SID) is possible

- The results should help explain *how* the repository may produce SIDs; the goal is similar to the event-trees/fault-trees in reactor PRAs that show specifically how the undesired consequence (e.g., core damage) may occur

- One purpose is to build confidence by confirming that these SID scenarios are indeed highly unlikely
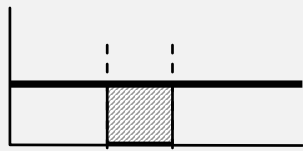
Strategic Partitioning of Assumption Ranges and Consequences (SPARC)

1. Identify Important Repository Attributes → **2. Develop Scenarios and Identify SID Cases** → **3. Explain Reasons for SIDs through SPARC Trees**
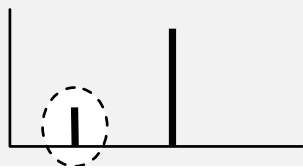
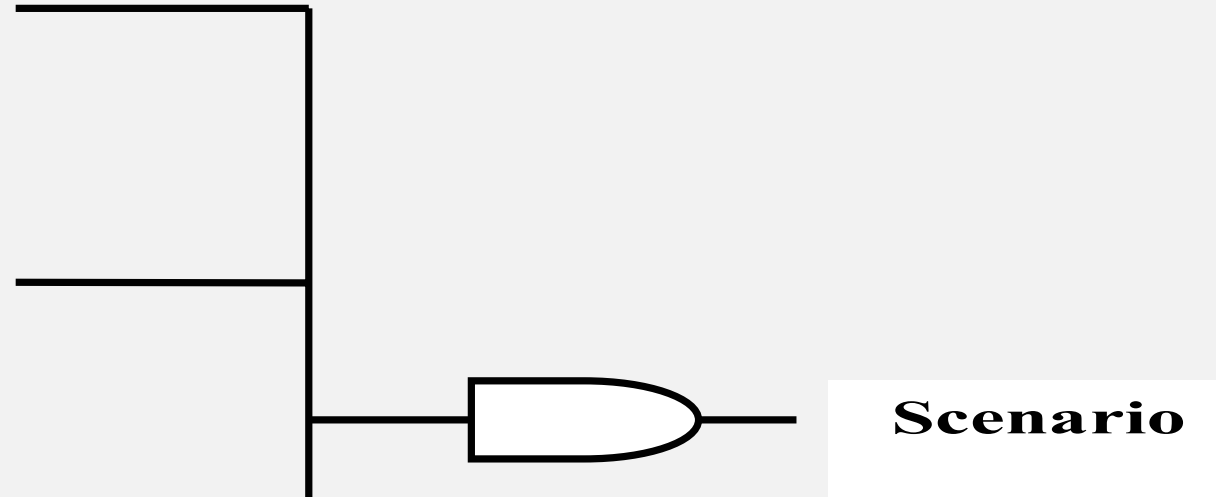# Definition of Scenarios

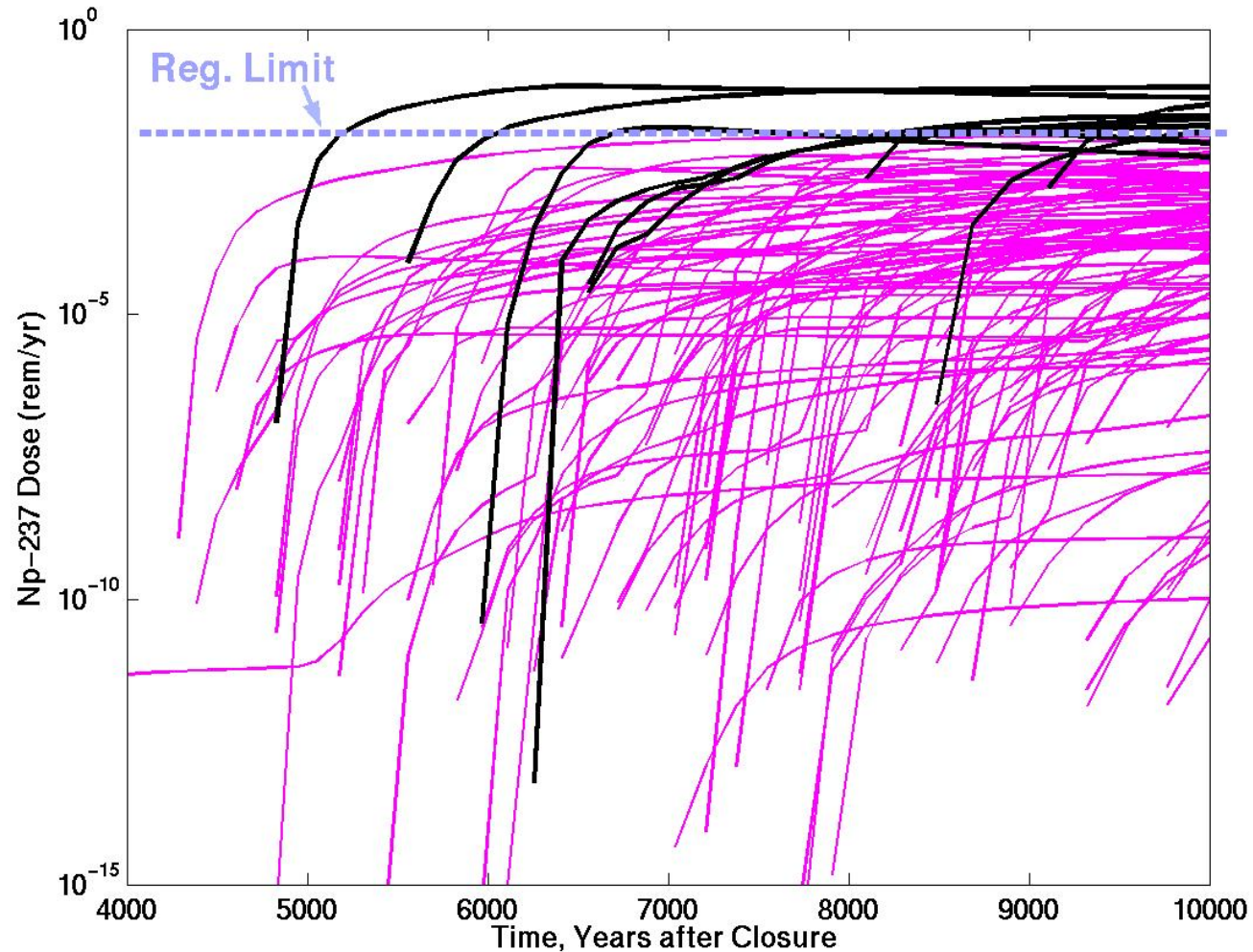Parameter A pdf

Parameter B pdf

Parameter C pdf

Parameter D, sub-model choice pdf

Scenario

Example -- Np-237 Dose to Receptor at 10-km in 10,000 years after Closure for a Potential Repository at Yucca Mountain

Reg. Limit

Np-237 Dose (rem/yr)

Time, Years after Closure

Concept for a Potential Repository at Yucca Mountain

Source: USDOE, 2002 Site Suitability Evaluation

TCw - Tiva Canyon Welded
PTn - Paintbrush Nonwelded
TSw - Topopah Spring Welded
CHn - Calico Hills Nonwelded
CFu - Crater Flat Undifferentiated
GDF - Ghost Dance Fault
ESF- Exploratory Studies Facility

Drawing Not To Scale
NFR_0100d.ai
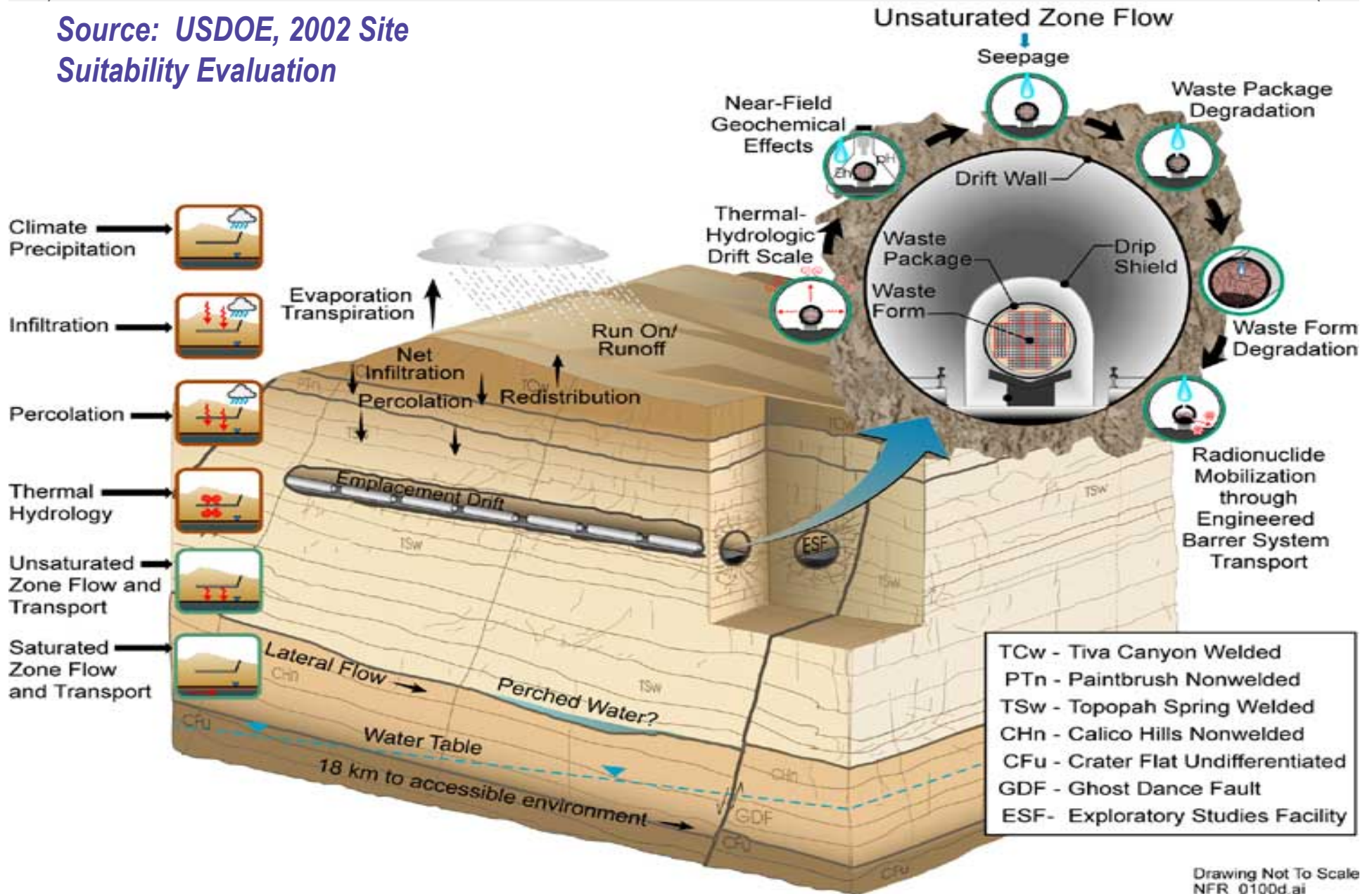
Steps 1. and 2. Explain SIDs Using Important Repository Attributes

Percentiles sampled for six key uncertain parameters in the TPA 4.1j code

**(0.1% and 99.9% bounds of distribution shown in parentheses)**

Np-237 Dose (mrem/yr)	Rain Infiltra-tion (4-13 mm/yr)	WP Flow Factor $(3.15 \times 10^{-2} - 1.05 \times 10^3$	Sub-Area Wet% $(0 - 1)$	Initial Fraction WP Defects $(10^{-4} - 10^{-2})$	Np-237 Solubility $(1.2 \times 10^{-3} - 0.24$ kg/m^3)	SF Dissolution Term $(1.2 \times 10^3 - 1.2 \times 10^6$ mg/m^{2}d)
101	19%	99%	36%	98%	97%	90%
97	8%	97%	43%	80%	96%	94%
48	97%	95%	99%	69%	56%	38%
30	35%	94%	94%	96%	89%	45%

Building a Class of SIDs Scenarios

- The challenge: what if the WP Flow Factor, Np Solubility, and % Initial WP Defects were above their 95th percentiles simultaneously?

- Action: Sample entire range of all other parameters

- Results: ~36% of realizations produced SIDs while ~64% did not (for LHS size 50)

- What "saved" us 64% of the time, even for this extreme challenge scenario?

Step 2. Finding Savior Attributes, Using GSA and Scatter Plots

**Non-SID scenarios only**
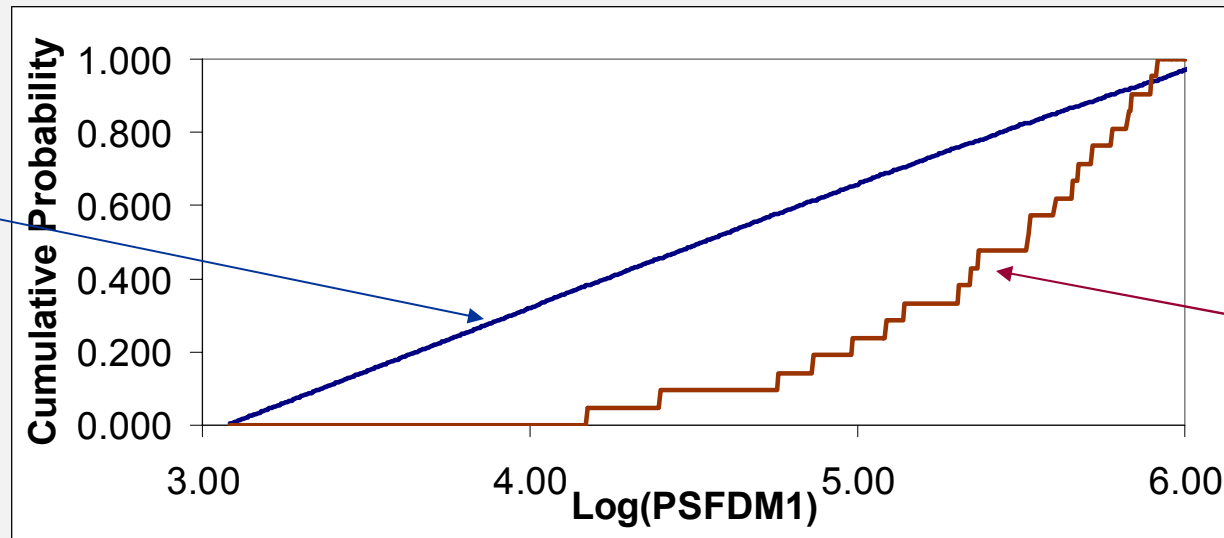
SID scenarios only

- There is a threshold effect. No sampling from 0 to 15,000 mg/m²-day resulted in SID scenarios.

- Each step on the SID CDF represents one sampled value producing SID.

Step 2. Finding Savior Attributes -- Single-Parameter Explanations

- **Spent Fuel Dissolution Term (PSFDM1 or SFD) CDF < 0.3**

- **Subarea Wet % (SbArWt% or SAW%) CDF < 0.15**

- **Spent Fuel Wet % (SFWt%, weighted average across all subareas of SF wet %) CDF < 0.1**
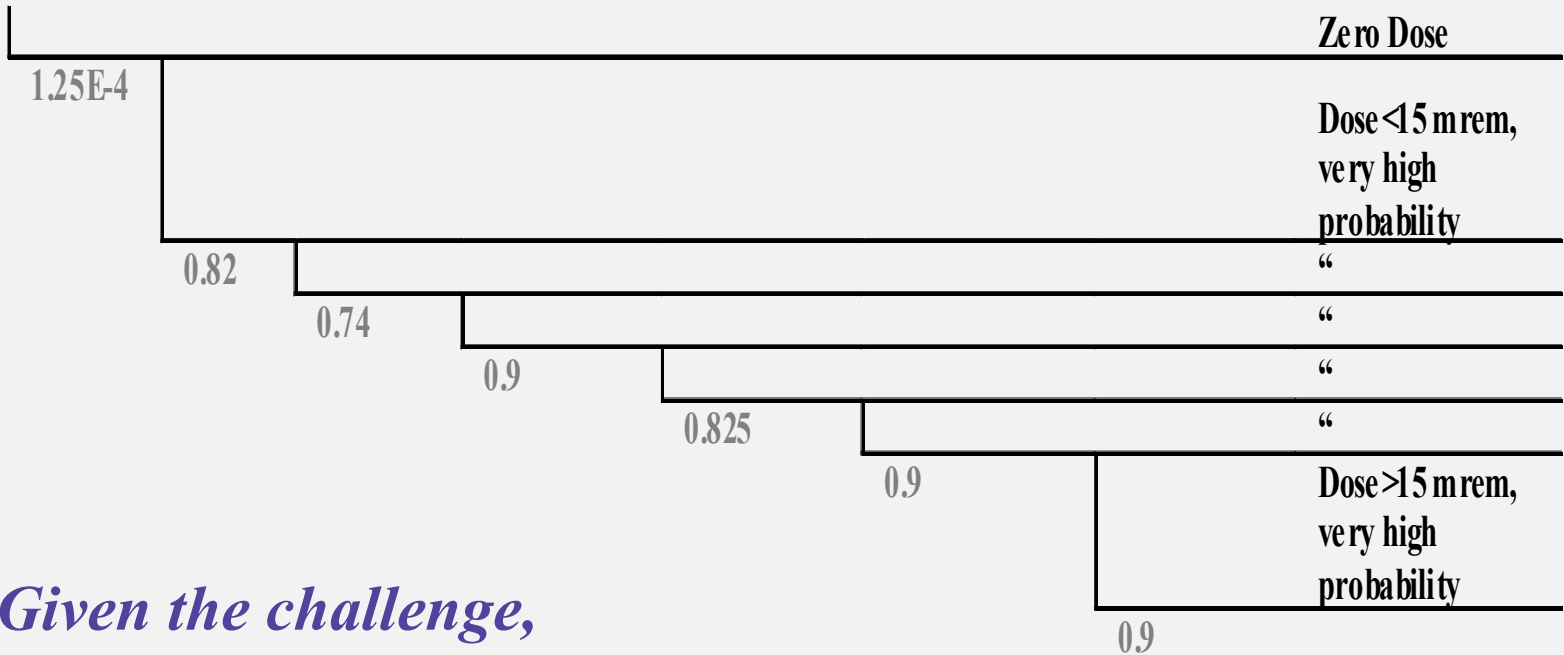
Step 2. Finding Savior Attributes -- SIDs/Successes in SubAreaWet%-Infiltration Space
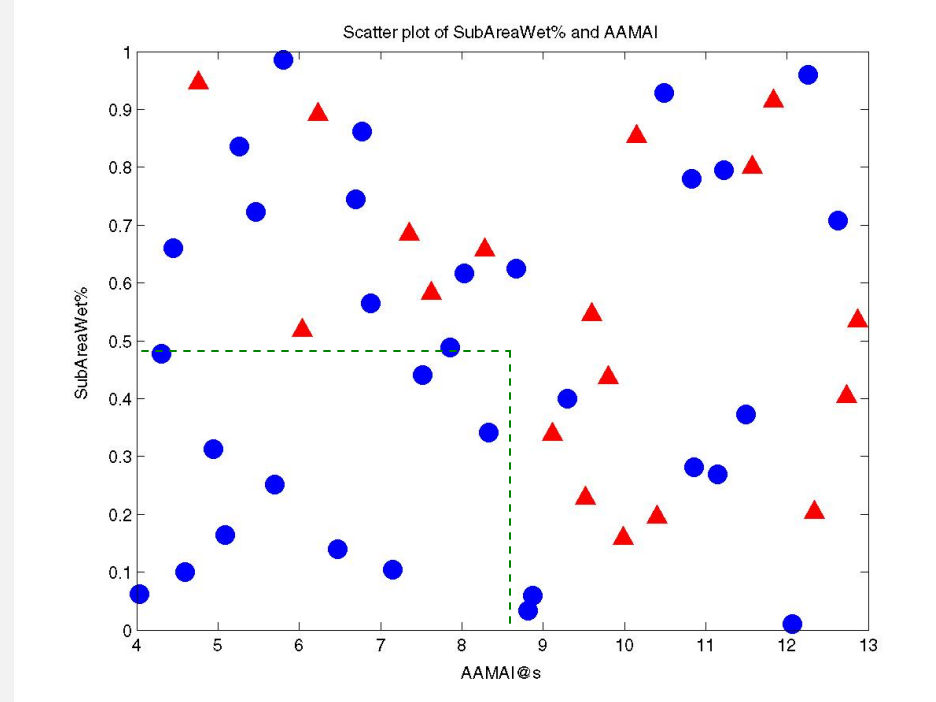
- •While infiltration rate alone does not exhibit a threshold effect on its own, looking at the infiltration rate *and* the subareawet% at the same time *does* exhibit a threshold effect

- •We do not observe SID scenarios in the lower left quadrant

Step 3. Explaining SID Scenarios: SPARC Tree with Probabilities

High WPFF, IWPD, SOL	DSFT > 10^4 yrs	F(SFD) <26%	F(SAW%) <10%	10%< F(SAW%) <45% & Infil<50%	F(FOCTR) <20% & F(Infil)<50%	F(SFWt%) <10%	End State – Consequence
							Zero Dose
1.25E-4							Dose<15 mrem, very high probability
	0.82						"
		0.74					"
			0.9				"
				0.825			"
					0.9		Dose>15 mrem, very high probability
						0.9	

Given the challenge, P(SID) =~0.36 & P(non-SID)=~0.64

Conclusions

SPARC analyses:

- Could extract useful risk information since SPARC trees show specifically *how* SIDs may result or be prevented

- Could help identify important risk contributors

- Could contribute to transparency

- Could contribute to the efficient allocation of resources for future research