

# SSHAC Level 2 Site Response Project

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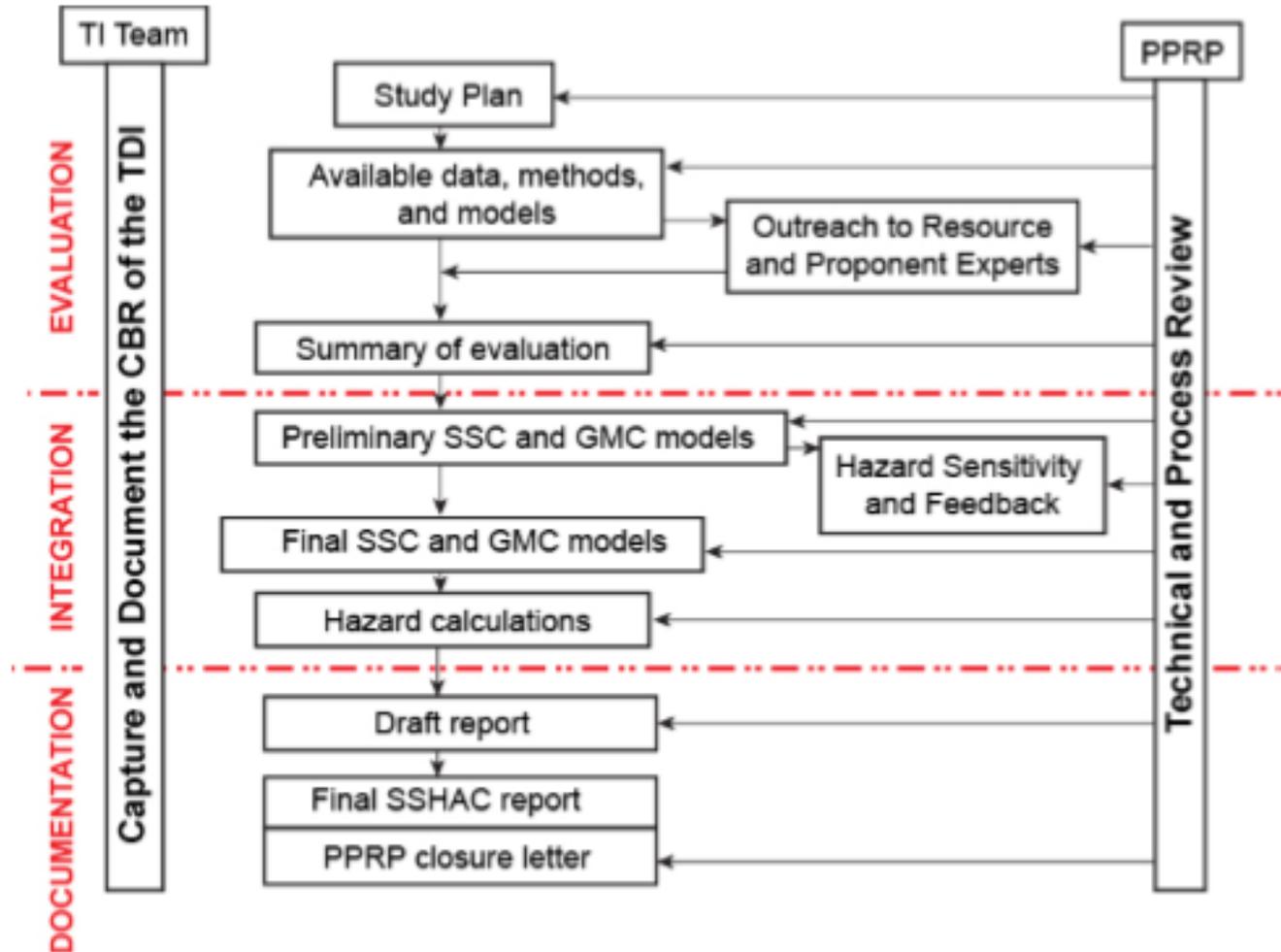
# Overview

- Project Purpose and Plan
- Study Sites
- Site Response Analysis Approach
- Site Response Logic Trees
- Implementation of Site Response Results

# Project Purpose

- Perform pilot study implementing site response within a SSHAC process at two example sites
  - Demonstrate characterization of site term (site response) epistemic uncertainty
  - Address methods to differentiate between epistemic uncertainty and aleatory variability for site response
  - Evaluate alternative approaches for incorporating site response results into the PSHA
- Downstream applications
  - SSI
  - PRA

# SSHAC Level 2 PSHA Study

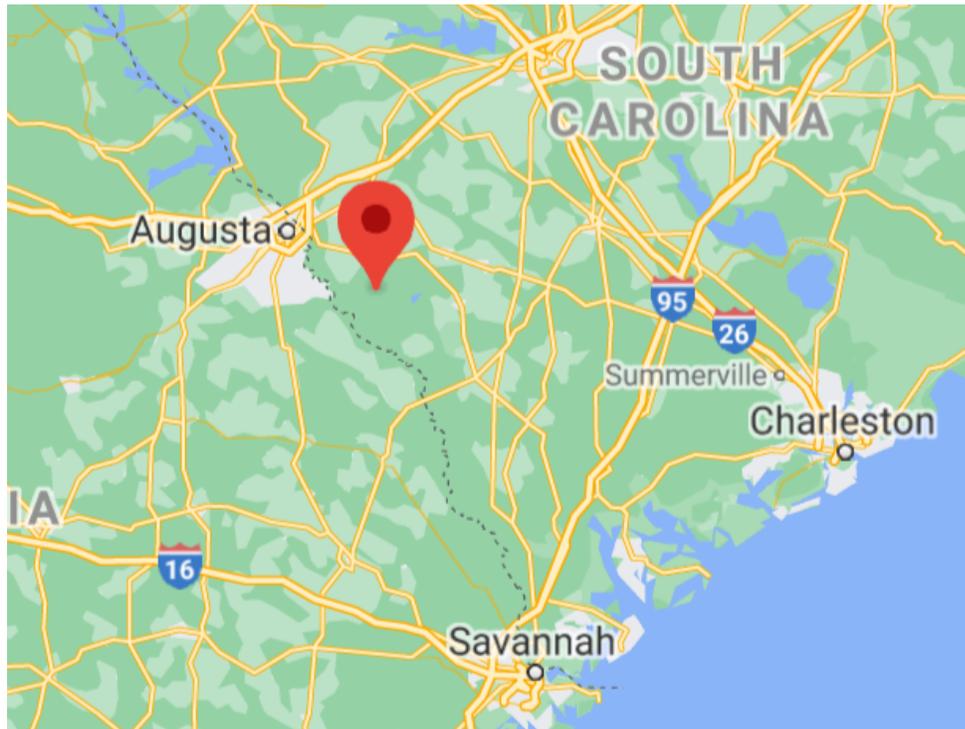


# Project Plan

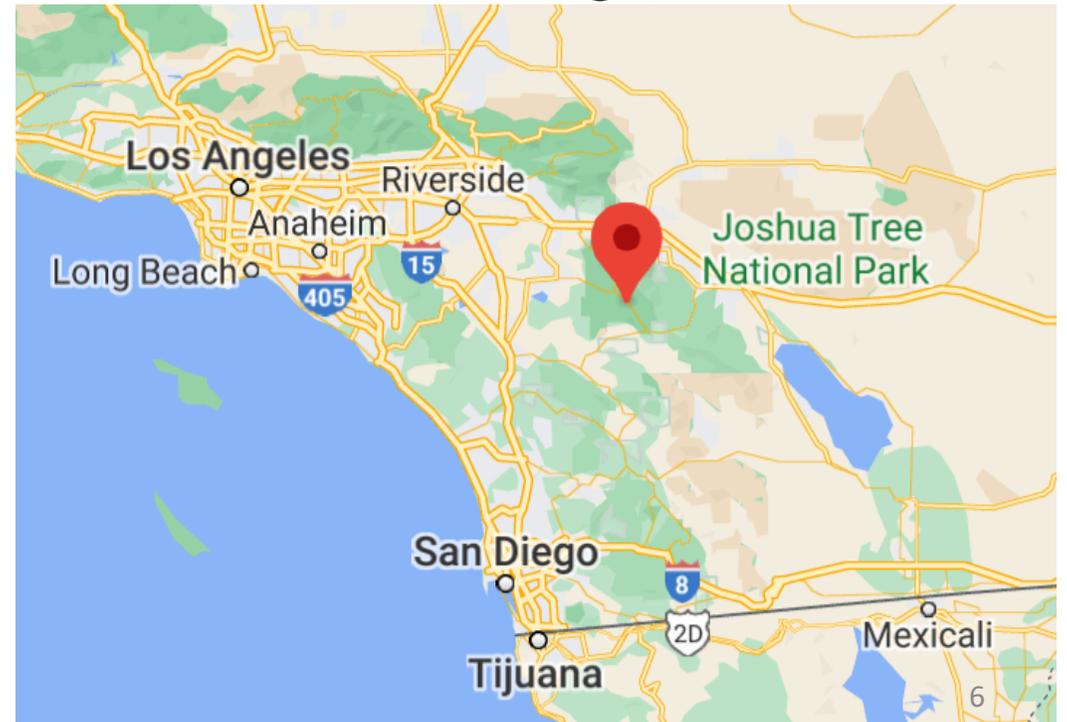
- Public Workshop, January 2020
  - Input from technical experts
- Interviews with technical experts, March 2020
- Technical Integration Team Meetings, January 2020 – Present
  - Sensitivity studies
  - Developing logic tree
  - Hazard evaluation
- Draft Project Report, December 2021
- PPRP Comments – January 2021
- Final Report – March 2021

# Study Sites

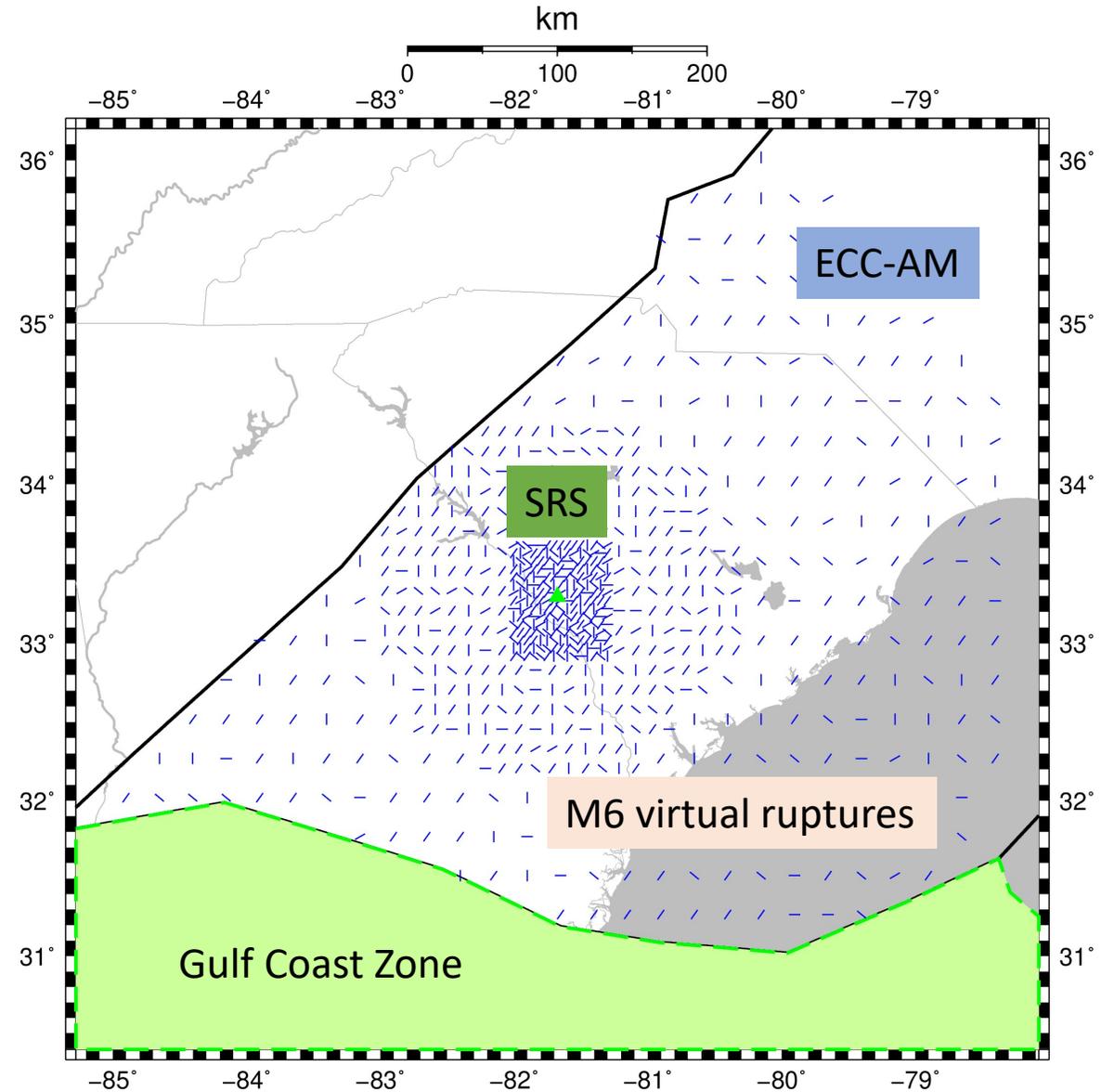
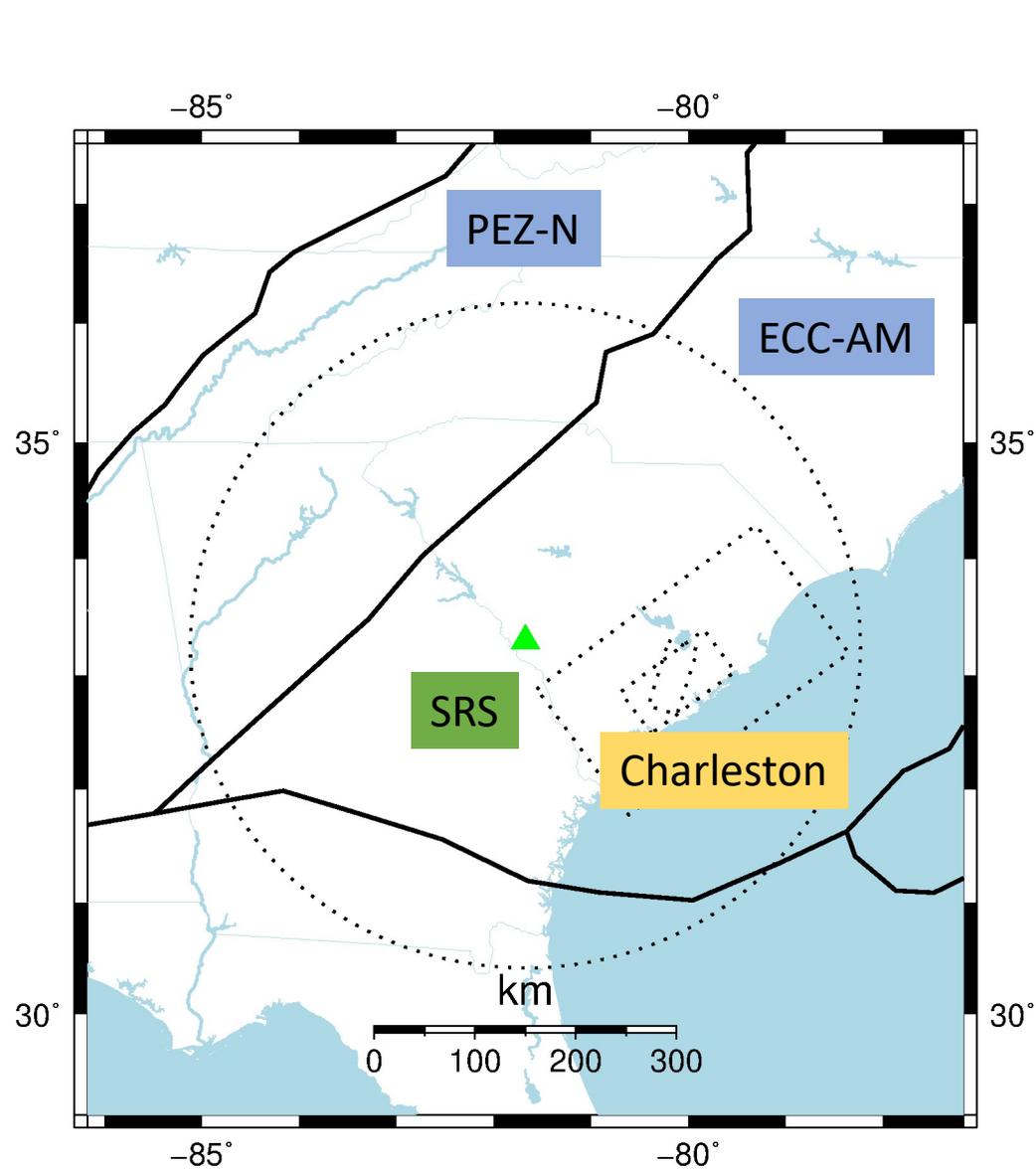
- Savannah River Site
  - Eastern US site
  - Detailed site characterization



- Garner Valley Geotechnical Array
  - Western US site
  - Measured ground motions
    - Kappa and site term
  - Surface wave testing



# Savannah River Site – CEUS Sources with NGA-East GMM



# Garner Valley Site – San Jacinto Fault with SWUS GMM

## San Jacinto Fault Zone

Length: about 244 km

Predominantly Right Lateral Slip

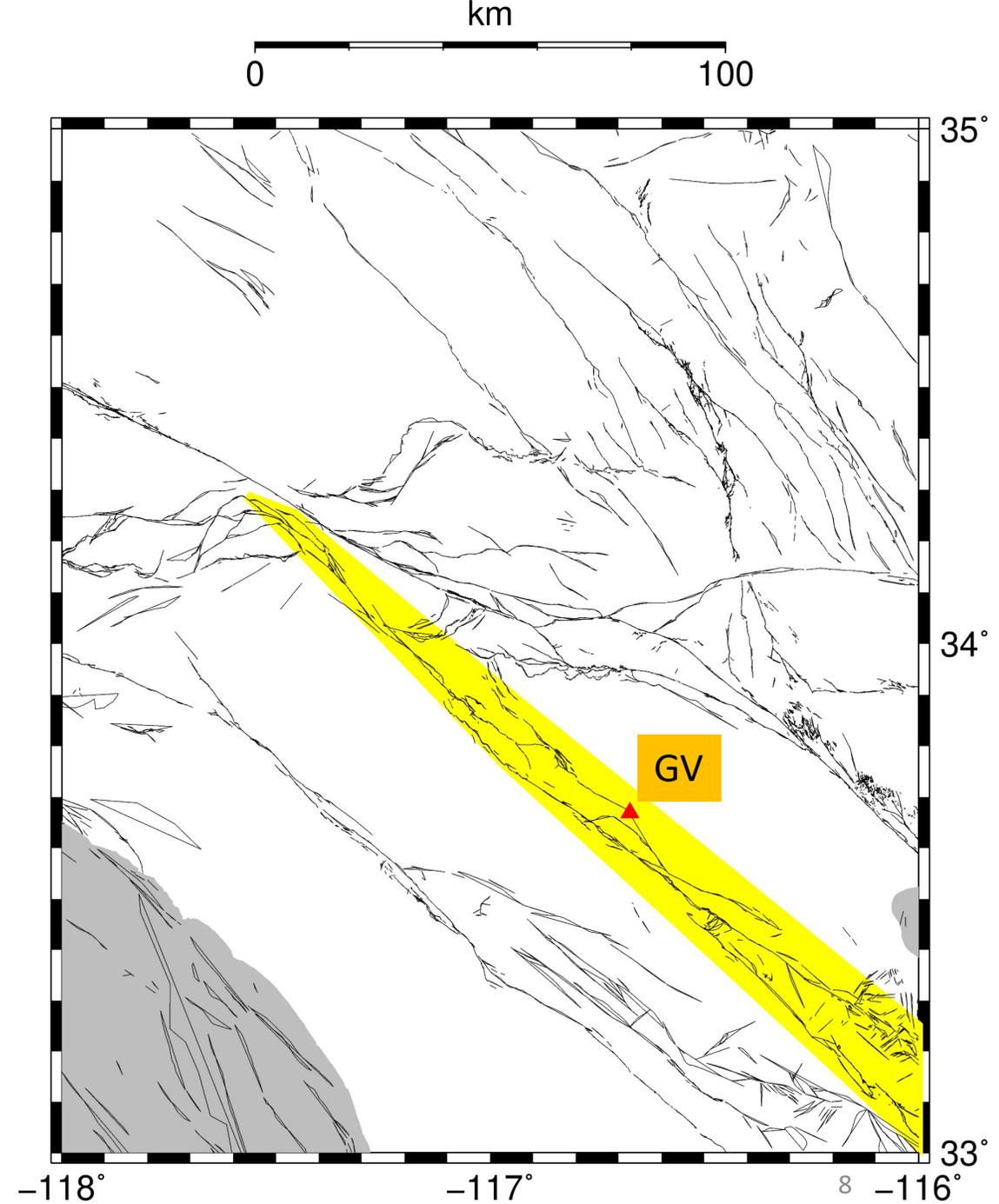
Overall Slip Rate about 10-12 mm/yr

## SWUS GMM

17 spectral periods and up to 31 median models

Reference  $V_{s30} = 760$  m/sec

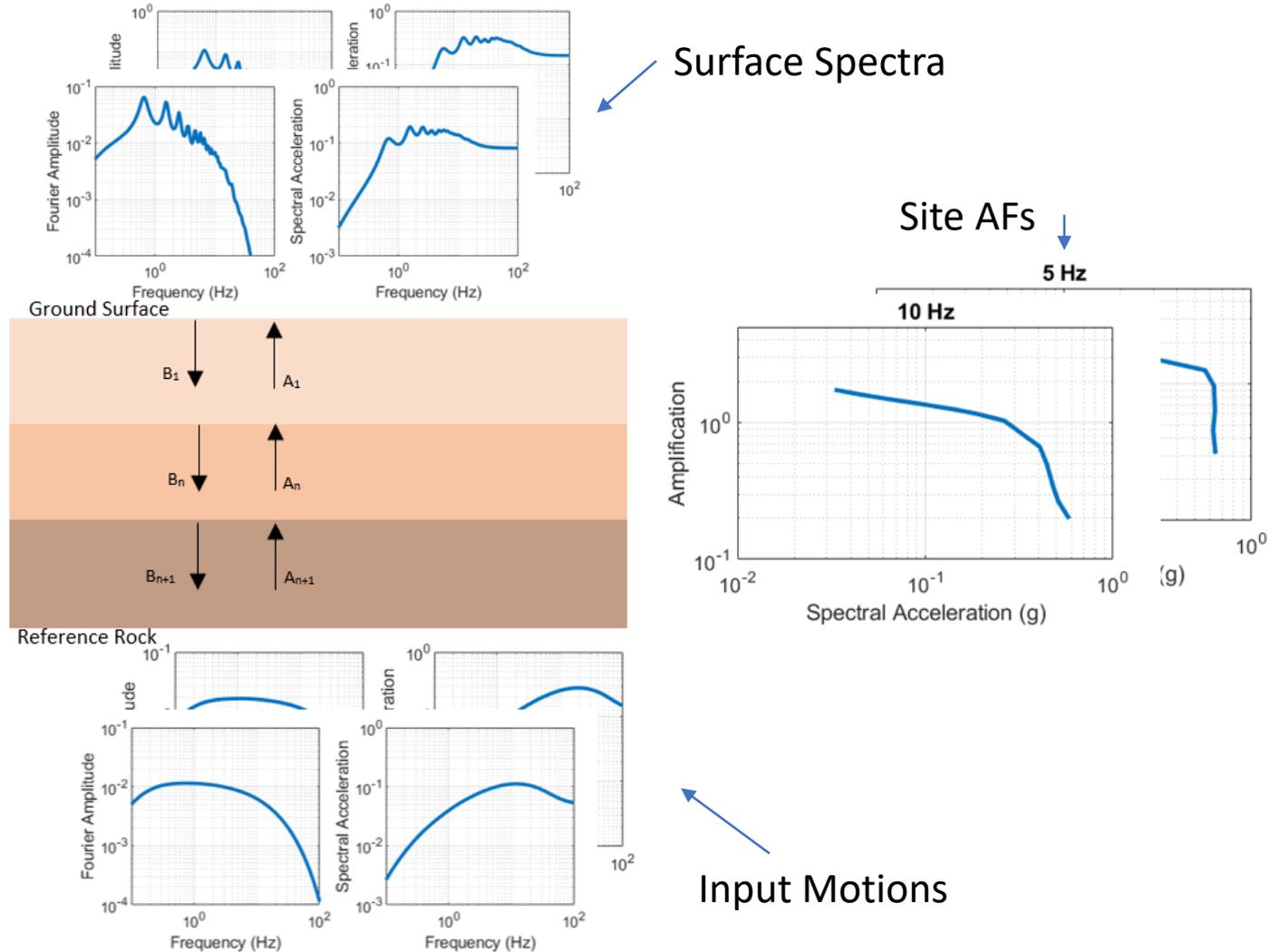
Reference  $\kappa_0 = 40$  msec



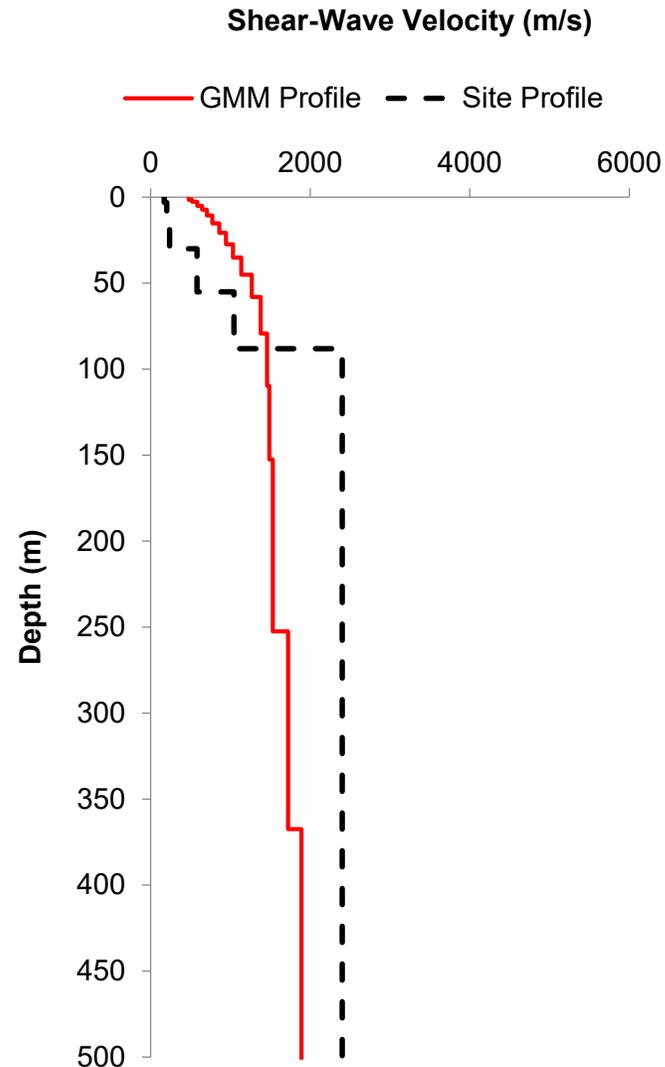
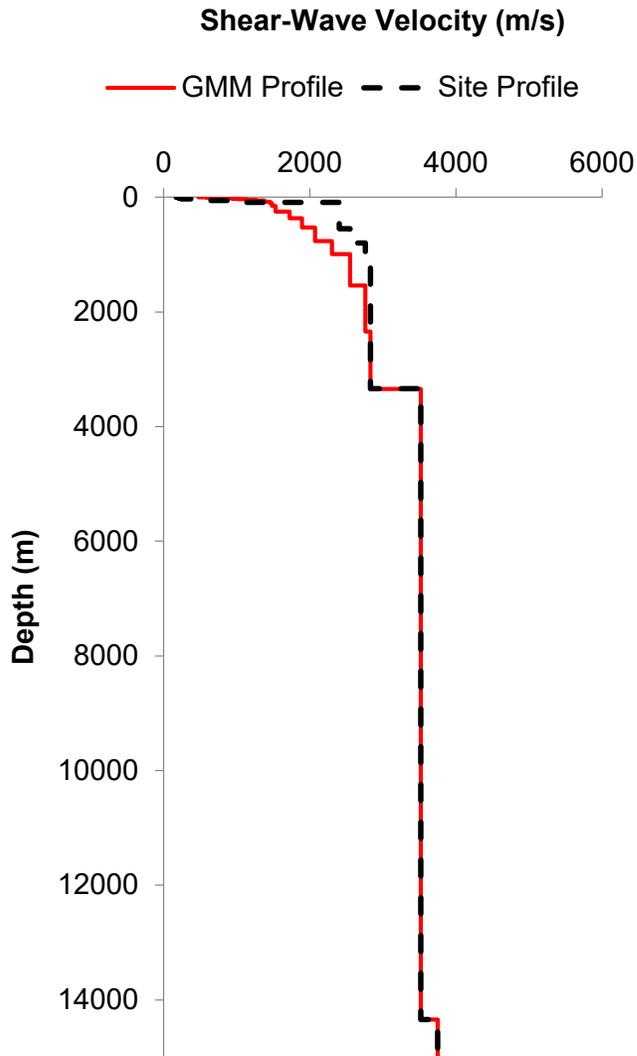
# Equivalent Linear Analysis

## Savannah River Site Response Approach

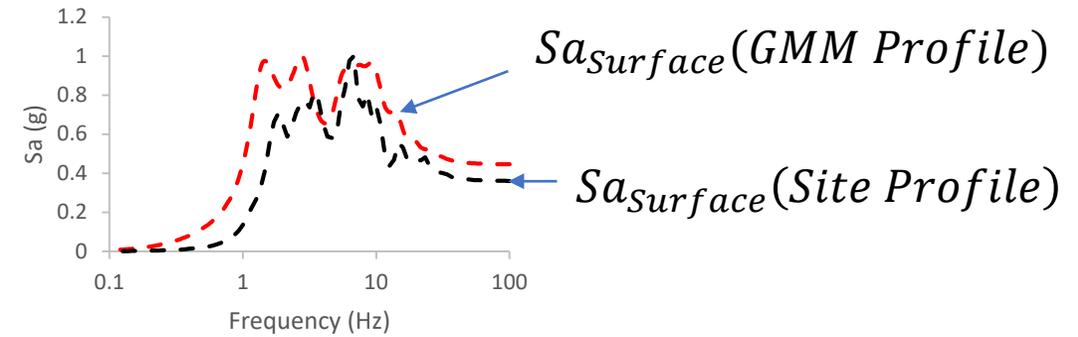
- Point source model used to develop input at reference rock ( $V_s = 3000$  m/s)
- Equivalent linear, RVT
  - One branch will kappa correct surface motion
- Non-linear analyses to inform amplification epistemic uncertainty



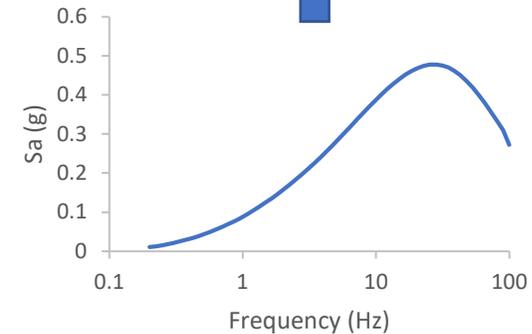
# Garner Valley Site Response Approach



$$Amp = \frac{S a_{surface}(Site Profile)}{S a_{surface}(GMM Profile)}$$

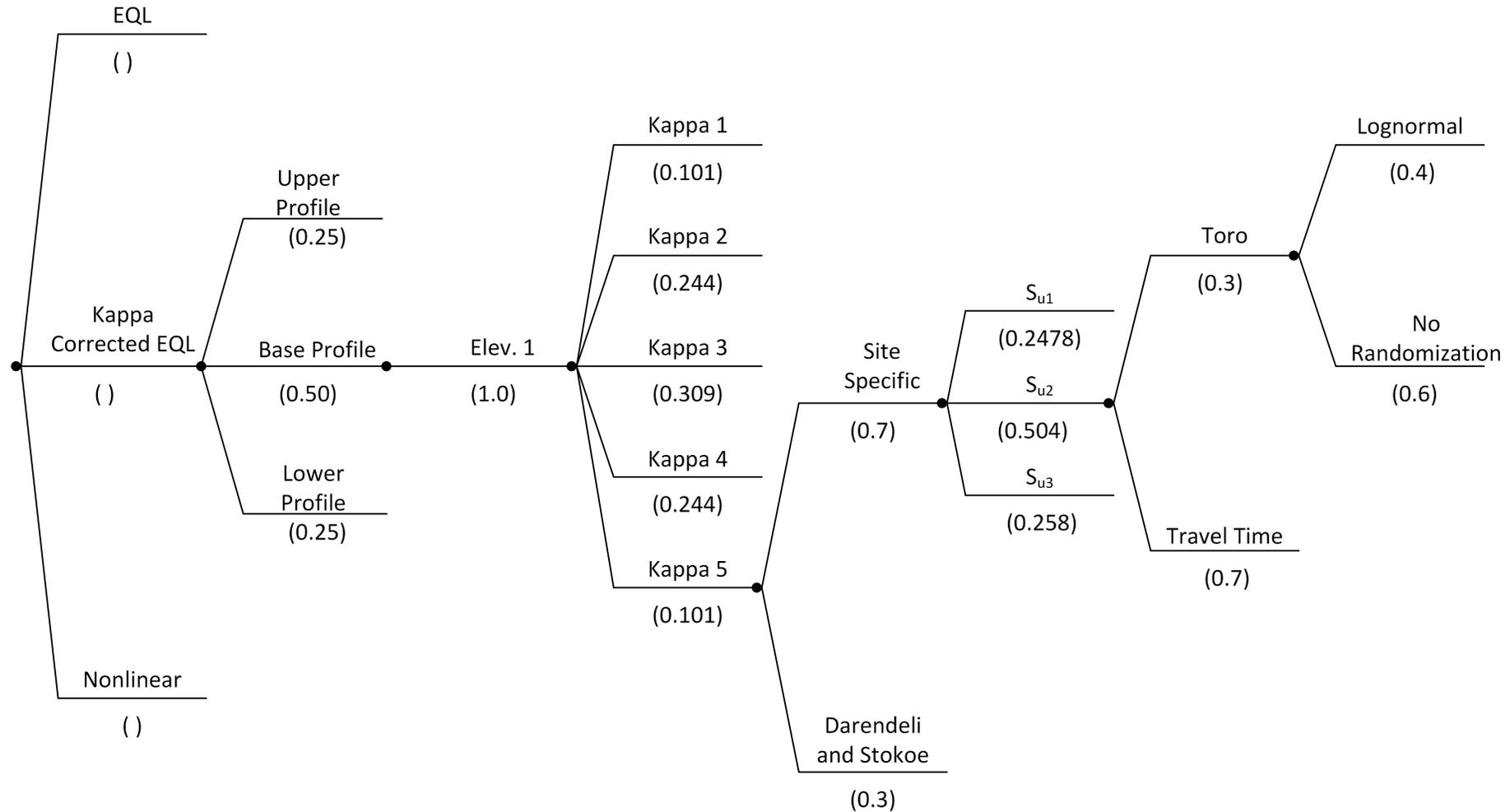


Site and GMM Profile



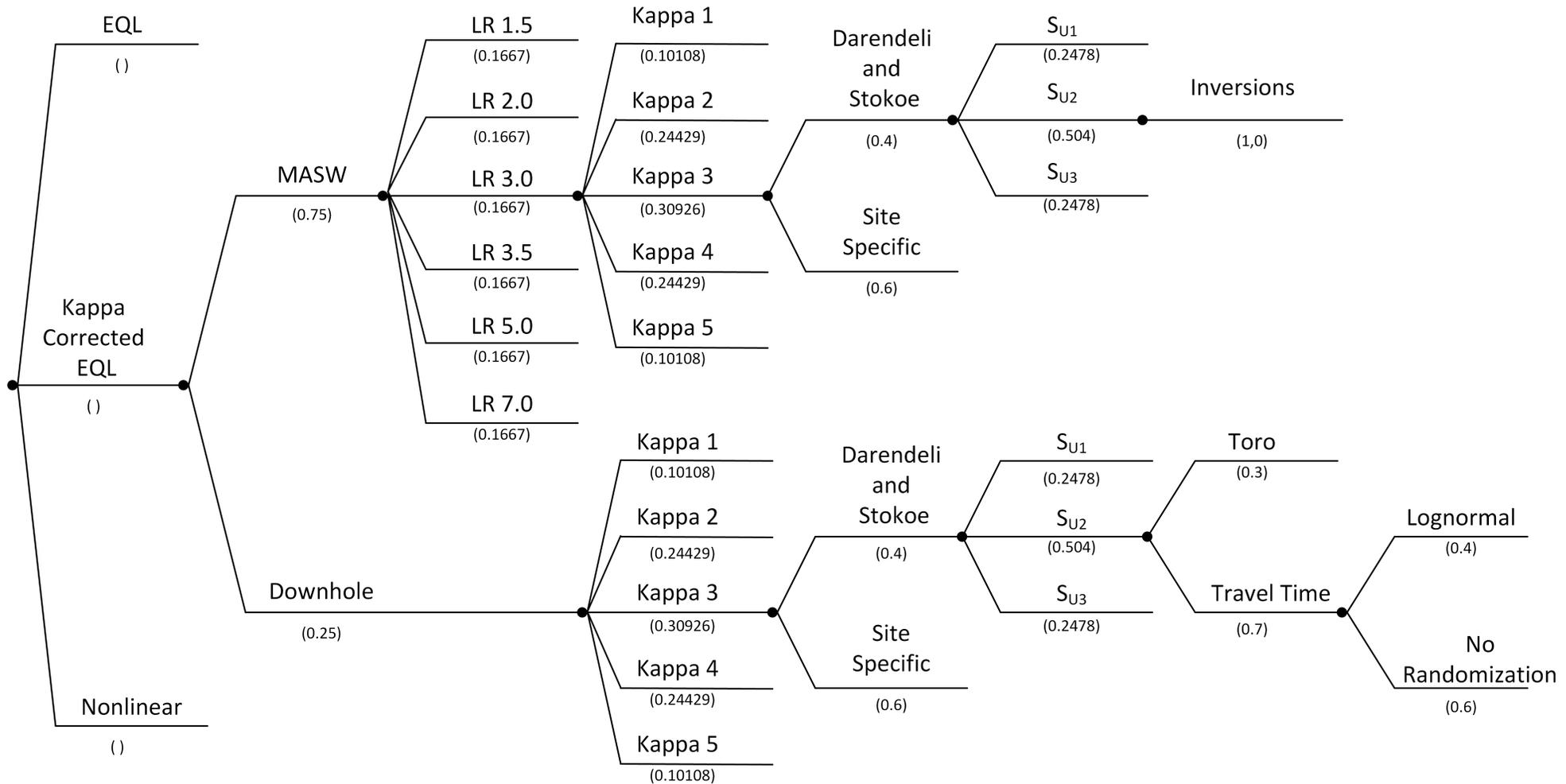
# Savannah River Logic Tree

Analysis Method	Vs Profile	Reference Rock Elevation	Site Kappa	MRD Curves	Shear Strength	Vs Randomization	Layer Thickness Randomization
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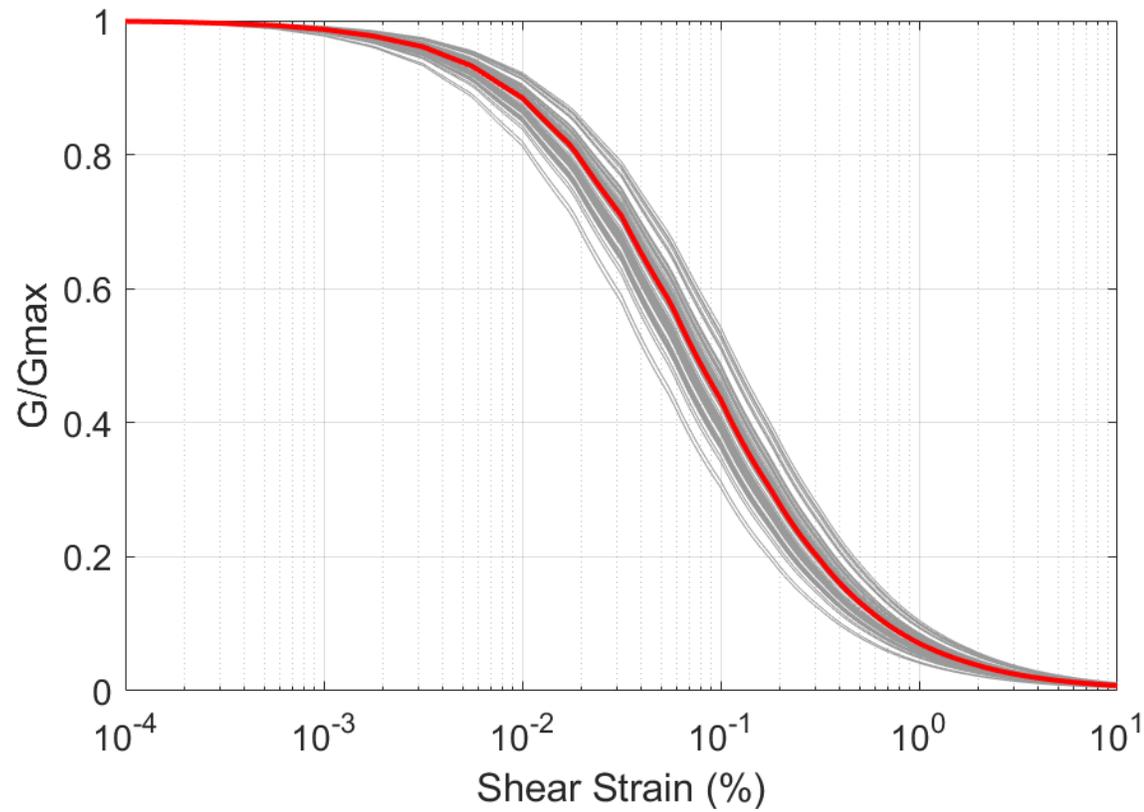
# Garner Valley Logic Tree

Analysis Method	Vs Profile	Layering Ratio	Site Kappa	MRD Curves	Shear Strength	Vs Randomization	Layer Thickness Randomization
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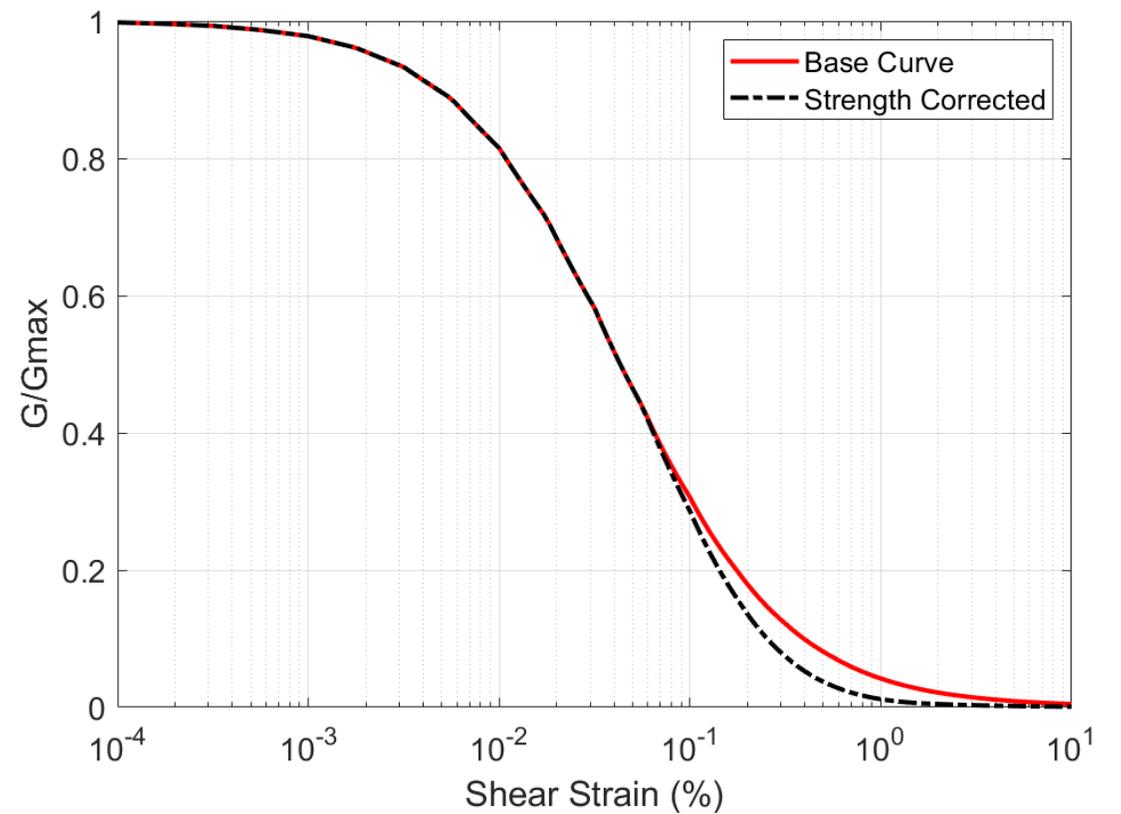


# MRD Curves

## Randomization

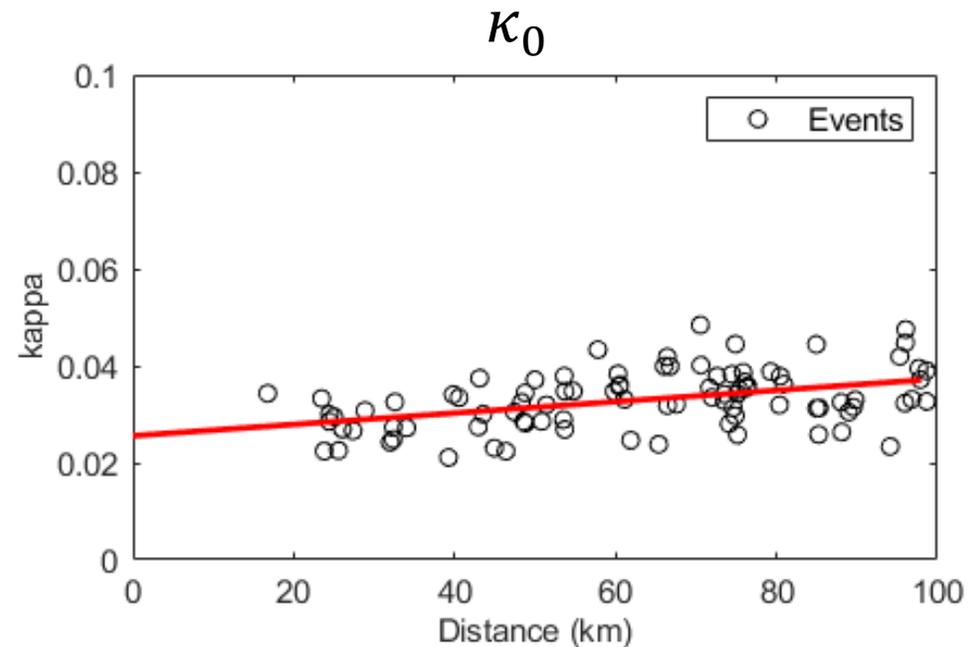
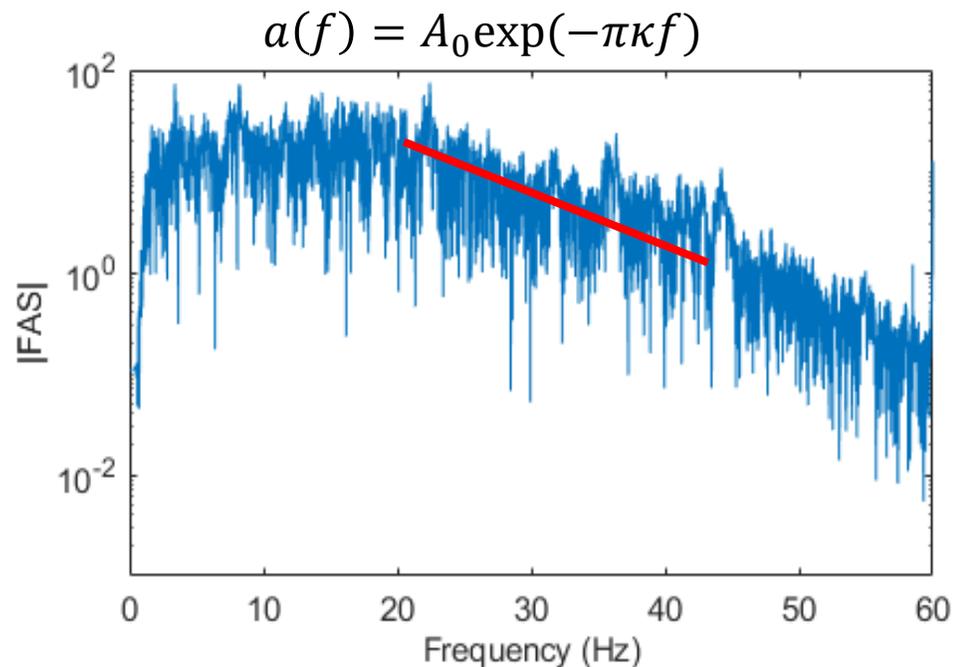


## Strength Correction



# Site Kappa

- Savannah River use empirical relationships
- Garner Valley use site recordings



Bayesian Regression	
$\kappa_{0\_1}$	0.10108
$\kappa_{0\_2}$	0.24429
$\kappa_{0\_3}$	0.30926
$\kappa_{0\_4}$	0.24429
$\kappa_{0\_5}$	0.10108

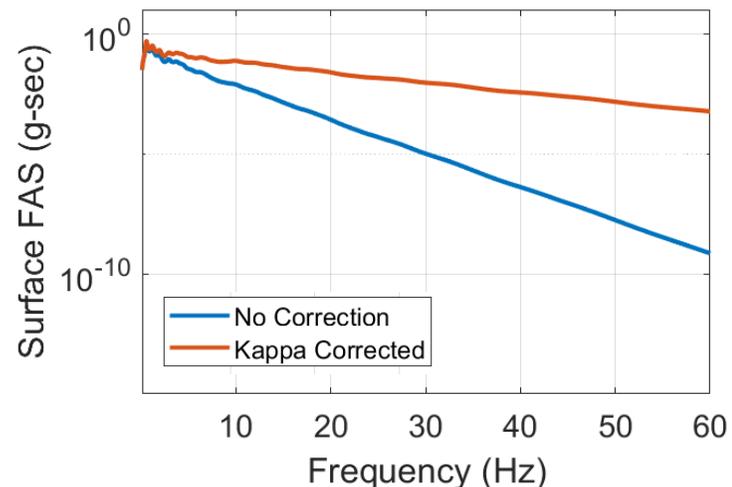
# Kappa Correction of Surface Spectra

- High frequency decay is independent of strain level (Xu and Rathje 2019)
- Target kappa

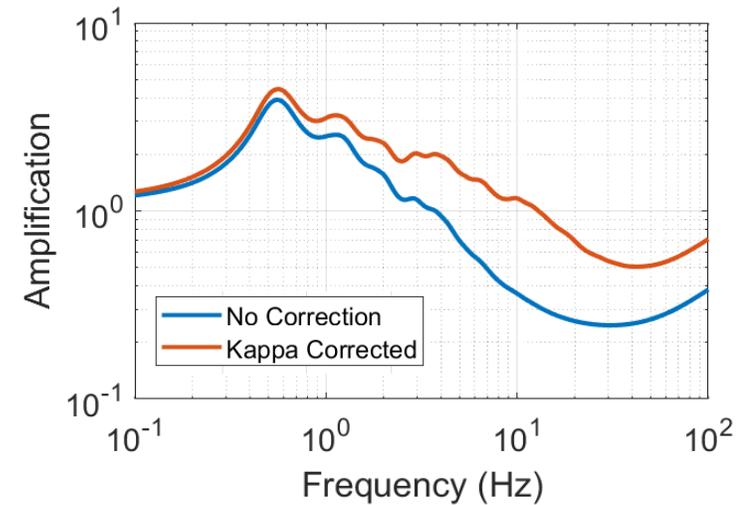
$$\kappa_{target} = \kappa_0 + \kappa_1 \times R$$

- Kappa corrected FAS

$$FAS_{\kappa\_corrected} = FAS_{surface} \cdot e^{(-\pi \cdot [\kappa_{target} - \kappa_{EQL}] \cdot f)}$$

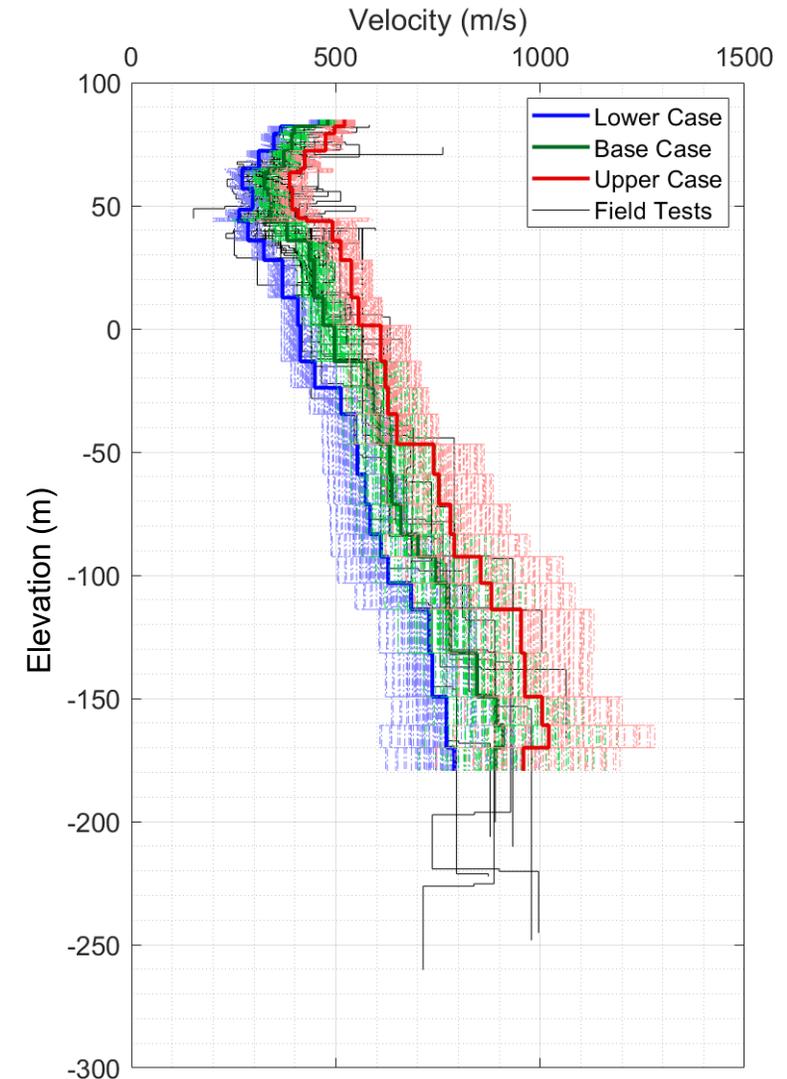


- Kappa corrected amplification

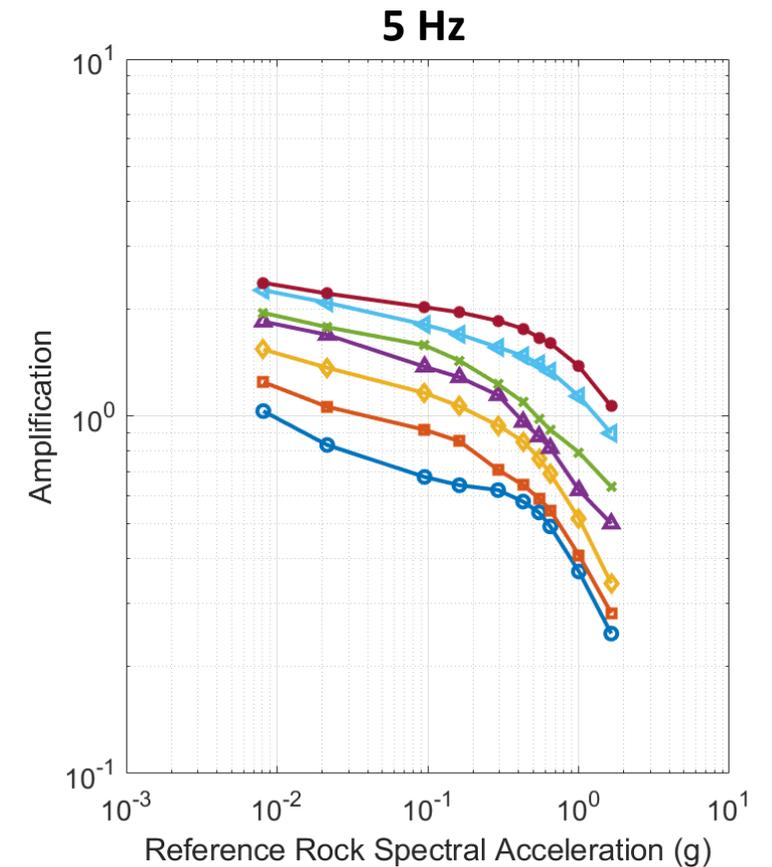
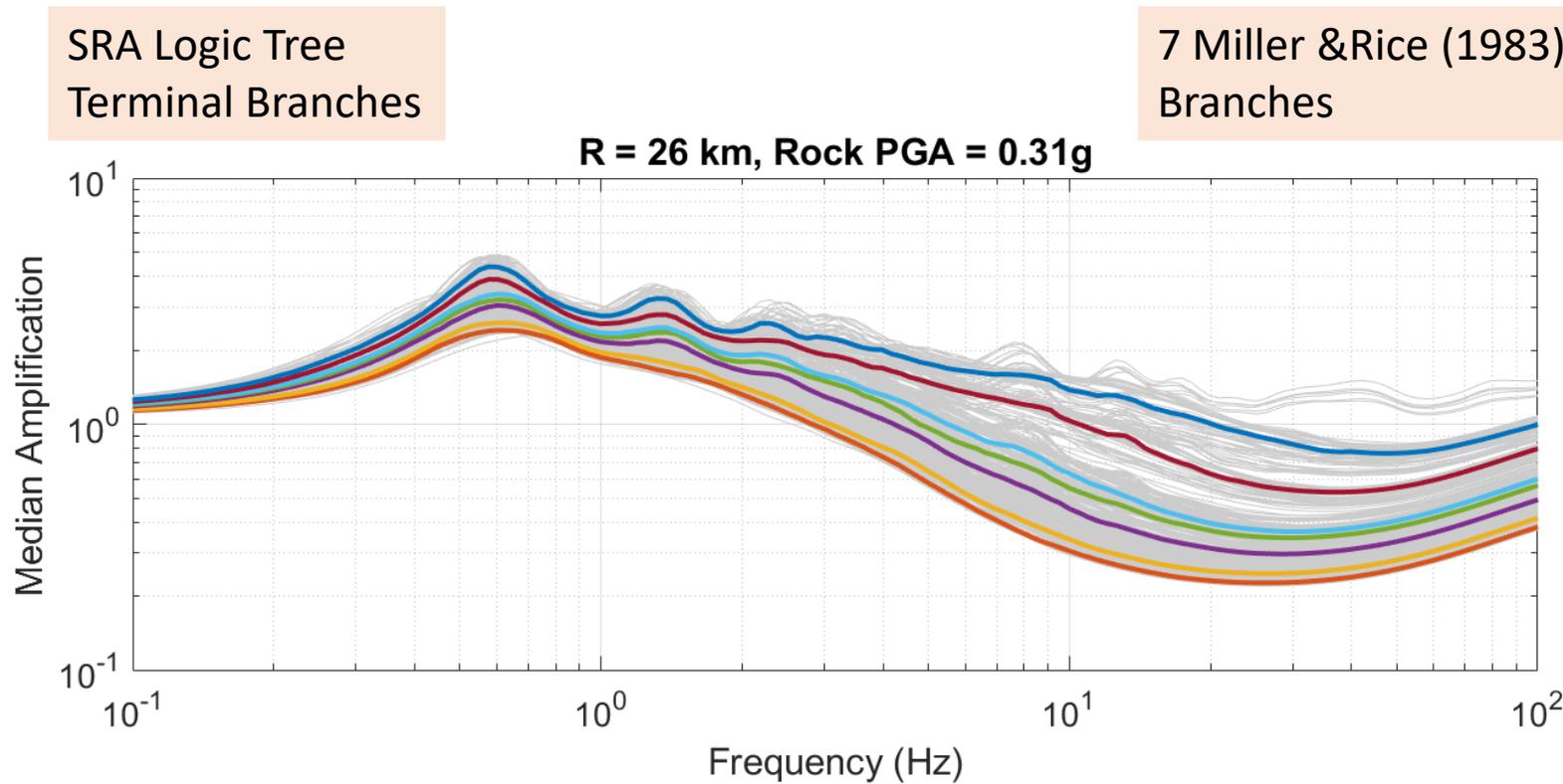


# Travel Time Randomization

- Travel time is lognormally distributed (Passeri et al. 2020)
- Implements Toro (1995) interlayer correlation model
  - Travel time specific model parameters
  - Site class independent

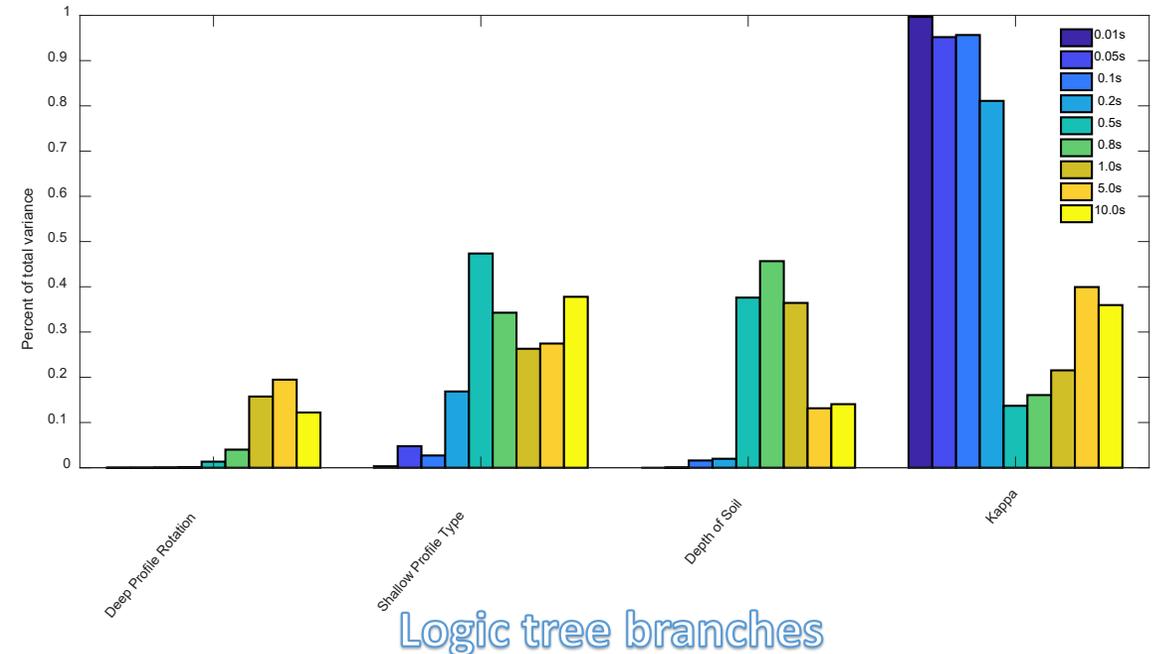


# Implementation of AFs into Hazard Calculation



# Interpretation of Site Response Results

- The AFs computed for each branch of the logic tree can be used to explore contributors to the epistemic uncertainty (Rodriguez-Marek et al. 2020)
  - Variance contribution plots
  - Tornado plots
- Help identify which elements can be further characterized to reduce epistemic uncertainty



Variance contribution plot for a non-identified site, shown only as an example

# Summary

- SSHAC site response pilot study is in progress
- Demonstrates site response approaches for CEUS and WUS sites
- Characterizes site term epistemic uncertainty using logic trees
- Sampling approach used to incorporate AFs into PSHA
  - Approach 3 and 4 will be implemented
- Study to explore handoffs to downstream uses of site response analysis
  - SSI
  - SPRA
- Lessons learned from this study will inform updates to RG 1.208