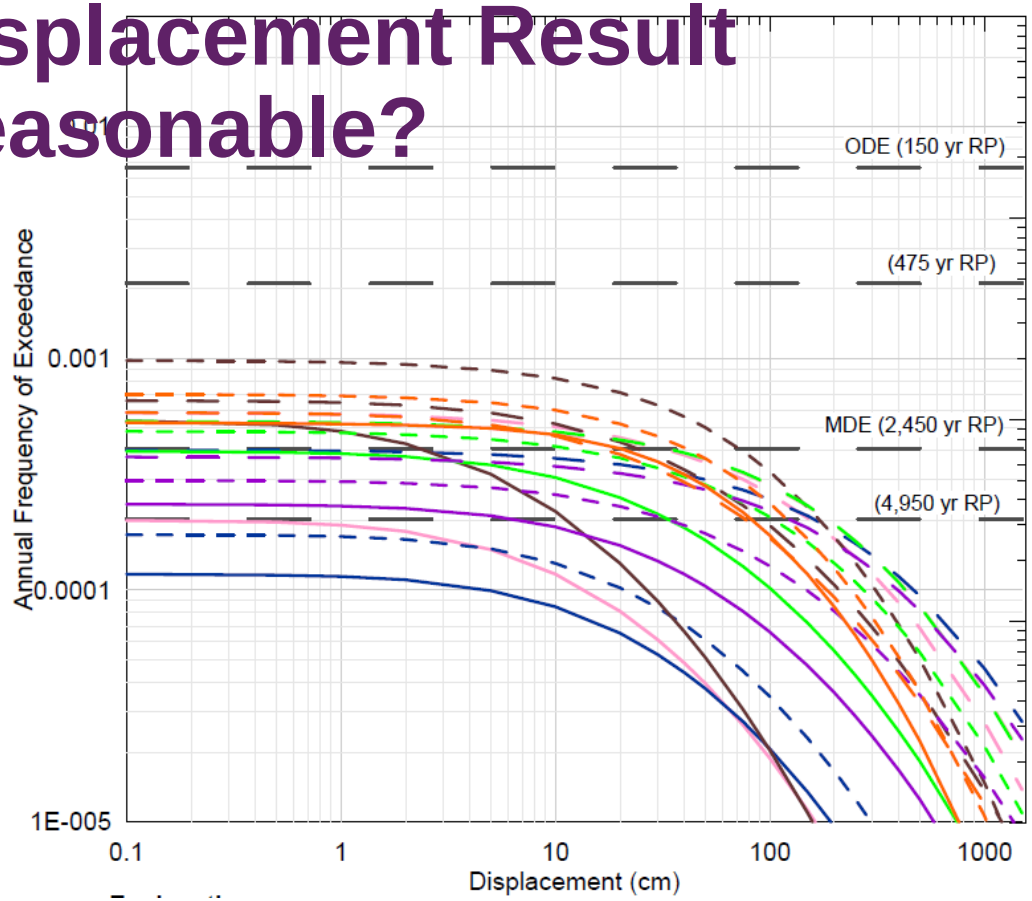
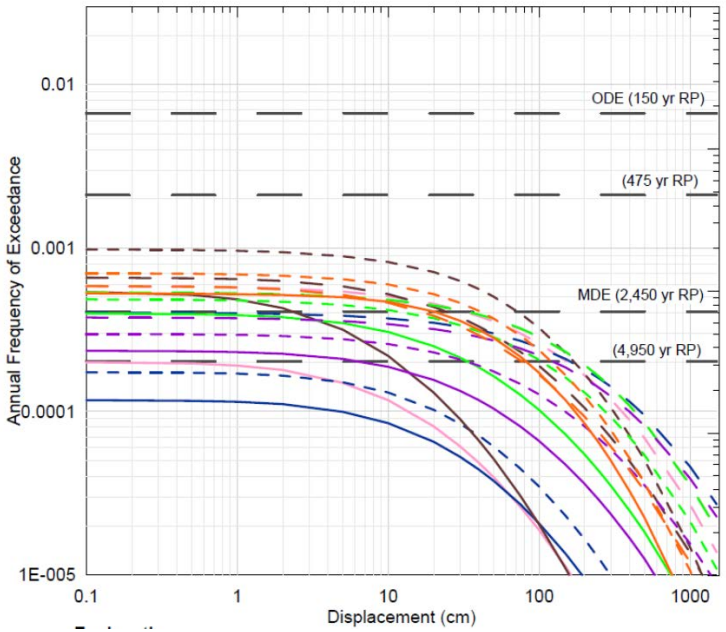
Application or Mis-Application of PFDHA. What Relationships are Appropriate and Is the Displacement Result Reasonable?



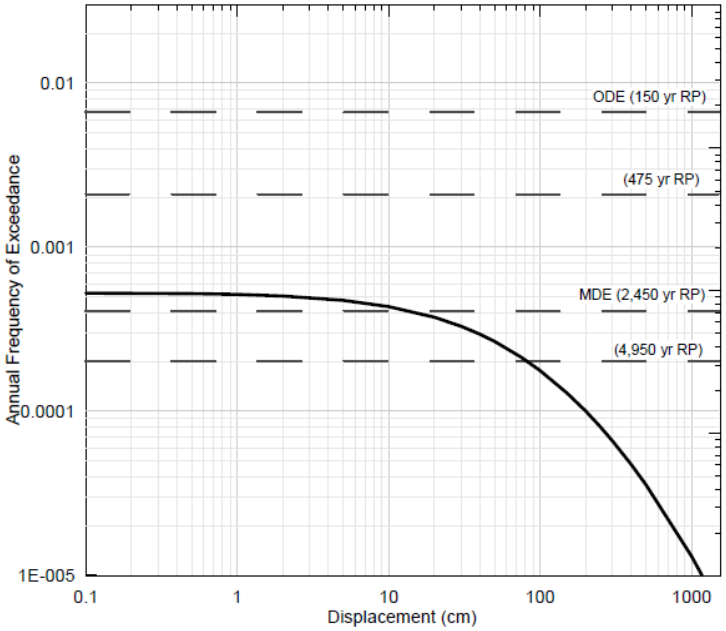
Donald Wells
December 9, 2016

Outline

What the Modeler may Consider



What the Client Needs



Outline

Sensitivity of PFDHA Results to

- Rupture Models and
- PFDHA Components

Outline

Sensitivity of PFDHA Results to

- Rupture Models and
- PFDHA Components

1. Input/Assumptions, and PFDHA Components
2. Examples for Probability of Surface Rupture
3. Example for Simple Rupture Scenario
4. Example for Complex Rupture Scenarios
5. What should we do?

Preparing and Implementing PFDHA

Assumptions and Information

- Site location on fault trace – uncertainty in fault location not considered
- Data for fault length, downdip geometry, and recurrence (slip rate)
- Selection of fault segments and rupture segments (Effect on Results)

Components of PFDHA

Given site location along a fault, and models for extent and frequency of ruptures

Probability Rupture Extends to Surface

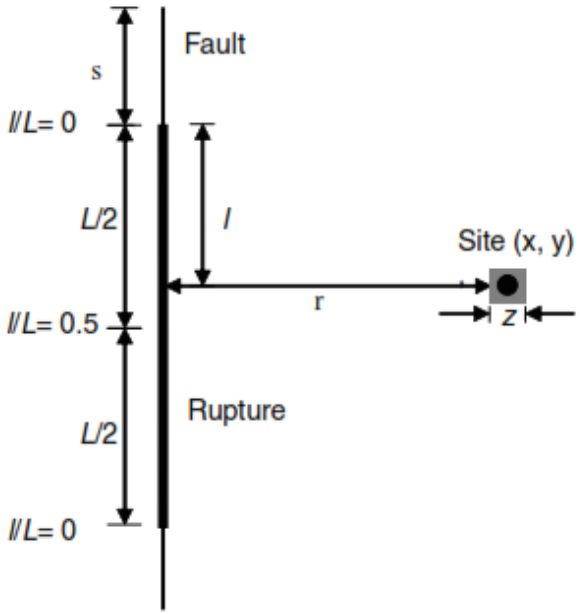
- Logistic Regression or Geometry Approach

Probability Rupture Extends to Site

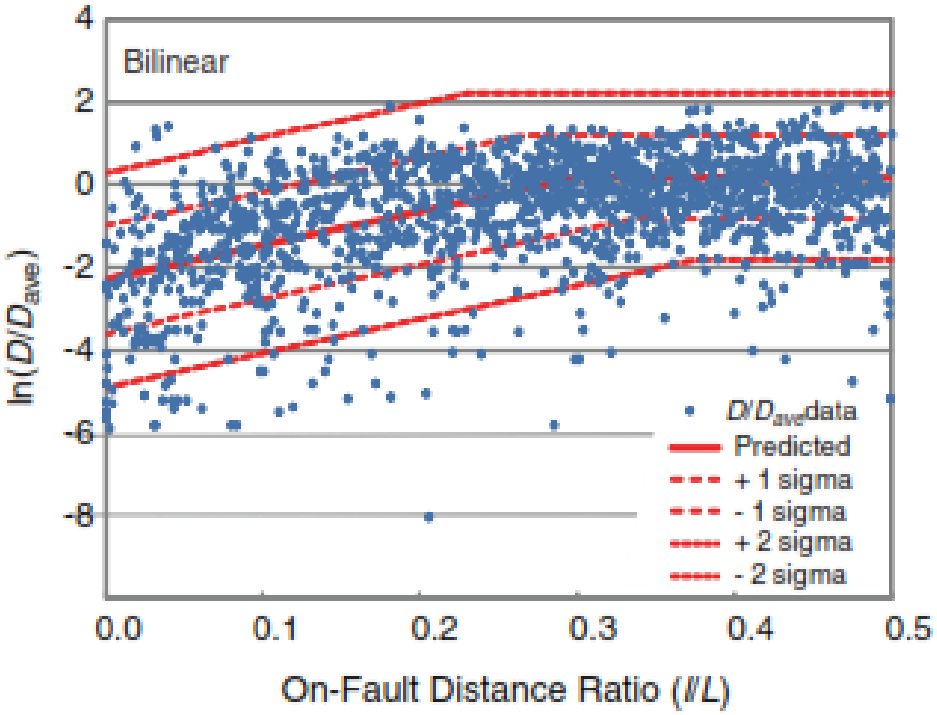
- Stepping function along trace, percentage of rupture that reach the site

Components of PFDHA

Geometry for Site Location



Model for Slip Distribution

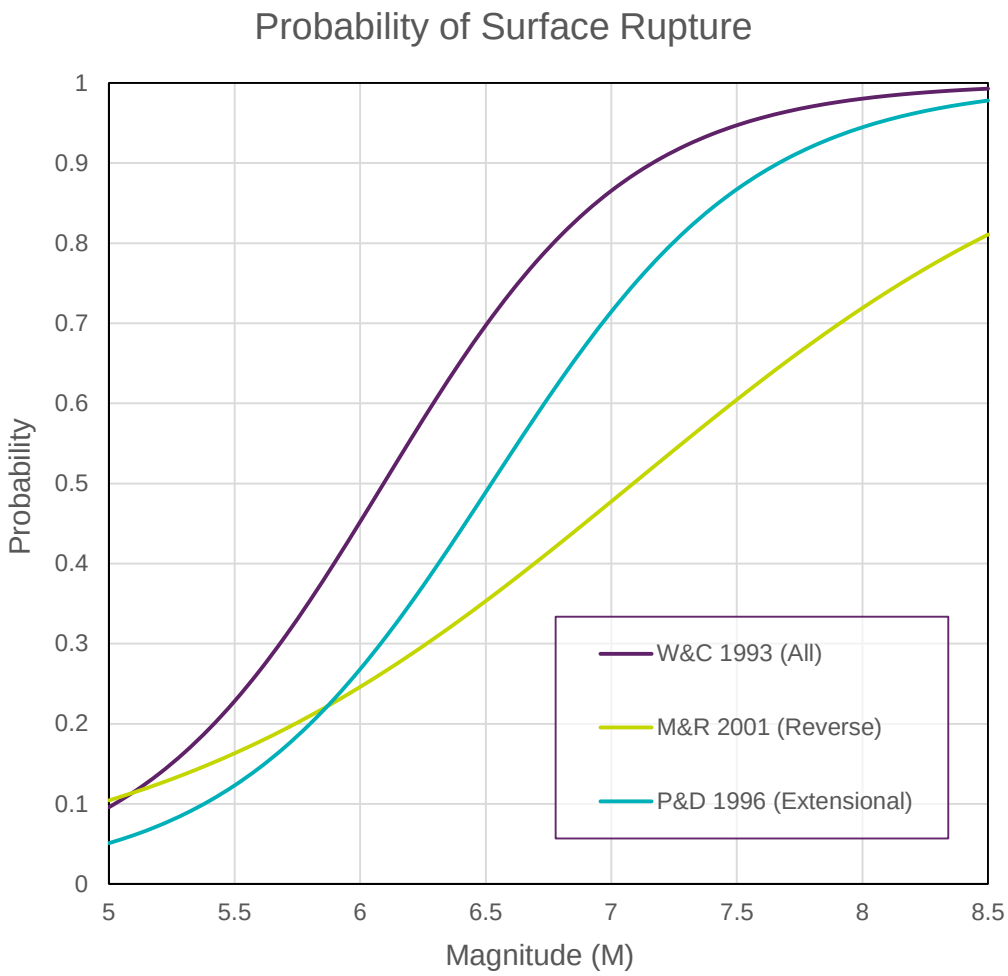


Probability of Surface Rupture

Two Approaches (Youngs et al, 2003)

- Logistic Regression –
  - Based on occurrence of surface rupture for historical earthquakes
- Geometry Approach –
  - Based on rupture aspect ratio and focal depth distribution for local region

PSR – Logistic Regression



PSR – Geometry Approach

Focal Depth Distribution

CIT Zones PR-D17 Focal Depth Distribution

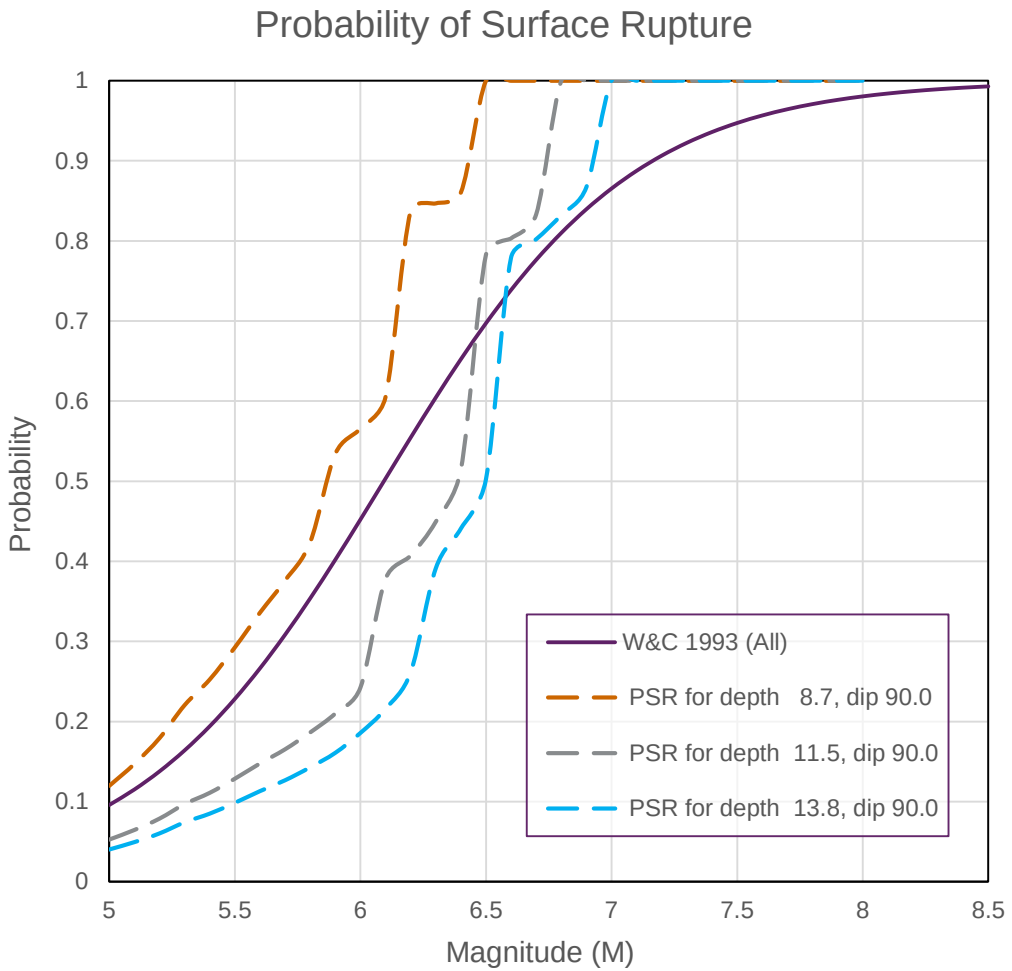
16 D	Frac	N
1	0.014	1
2	0.041	1
3	0.041	1
4	0.027	1
5	0.014	1
6	0.014	3
7	0.027	7
8	0.095	5
9	0.108	4
10	0.12	2
11	0.12	1
12	0.108	2
13	0.081	1
14	0.068	1
15	0.068	1
16	0.054	1

Rupture Aspect Ratio

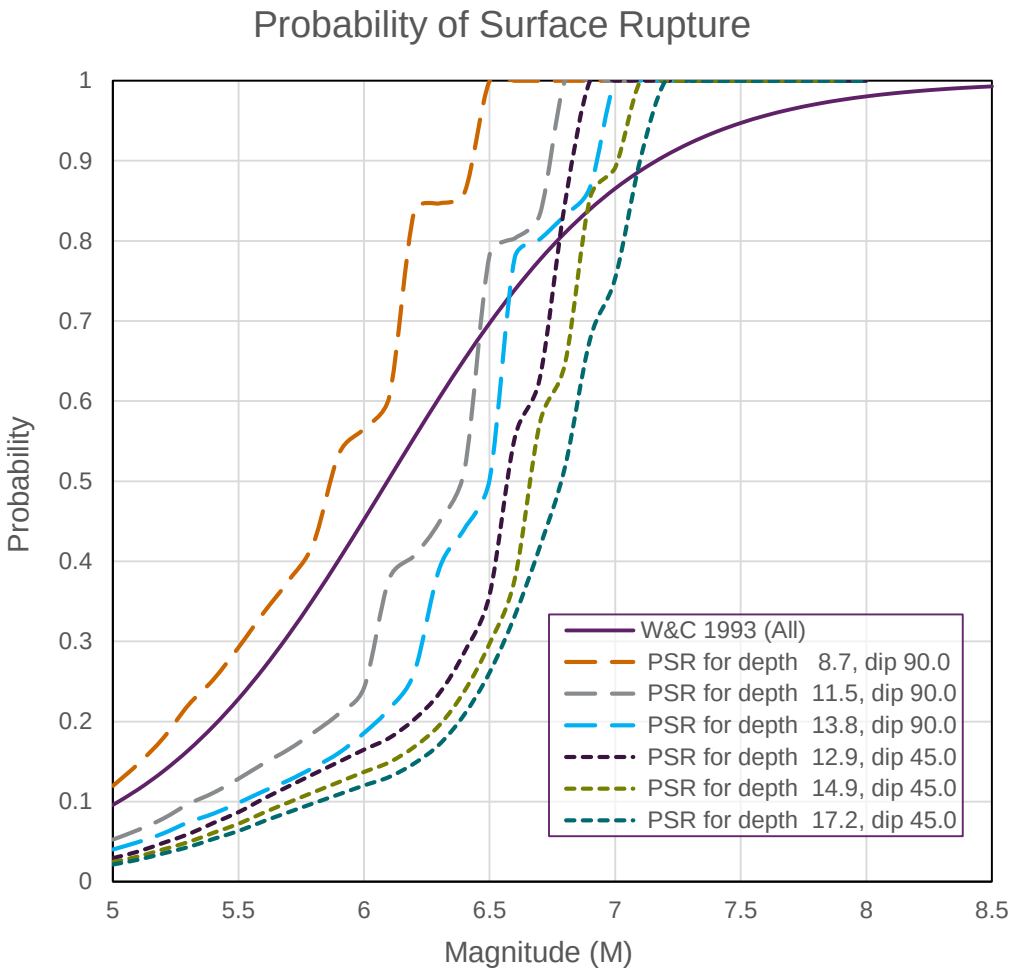
Strike Slip: 2:1 or greater

Reverse/Normal: 1:1

PSR – Geometry Approach – Strike Slip



PSR – Geometry Approach - Oblique Rev. Slip

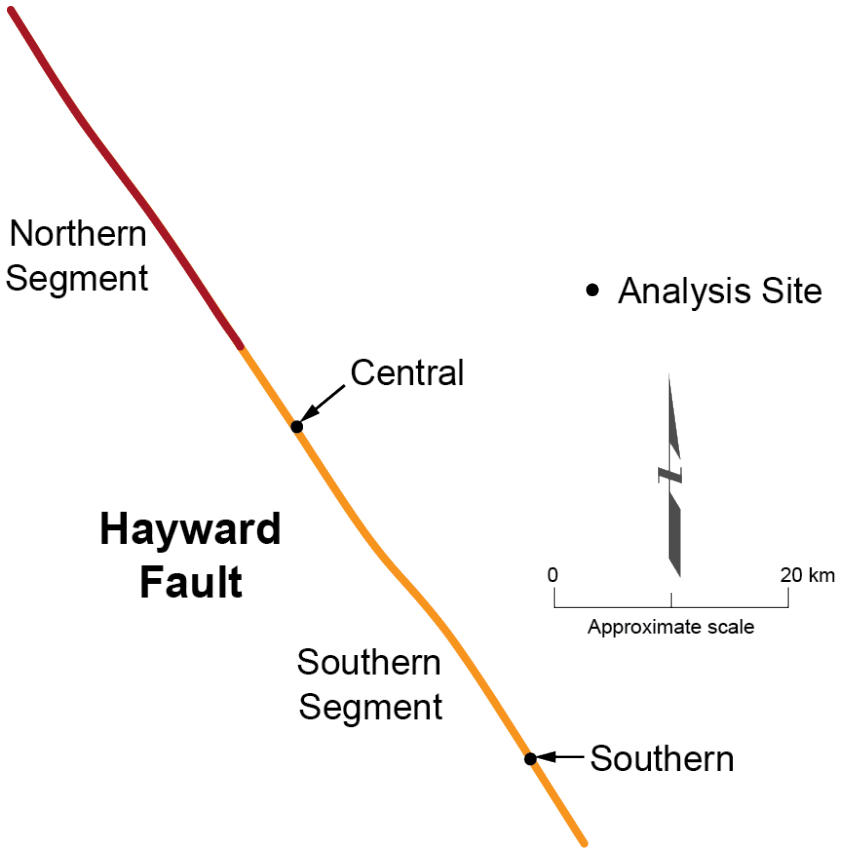


Probability of Surface Rupture

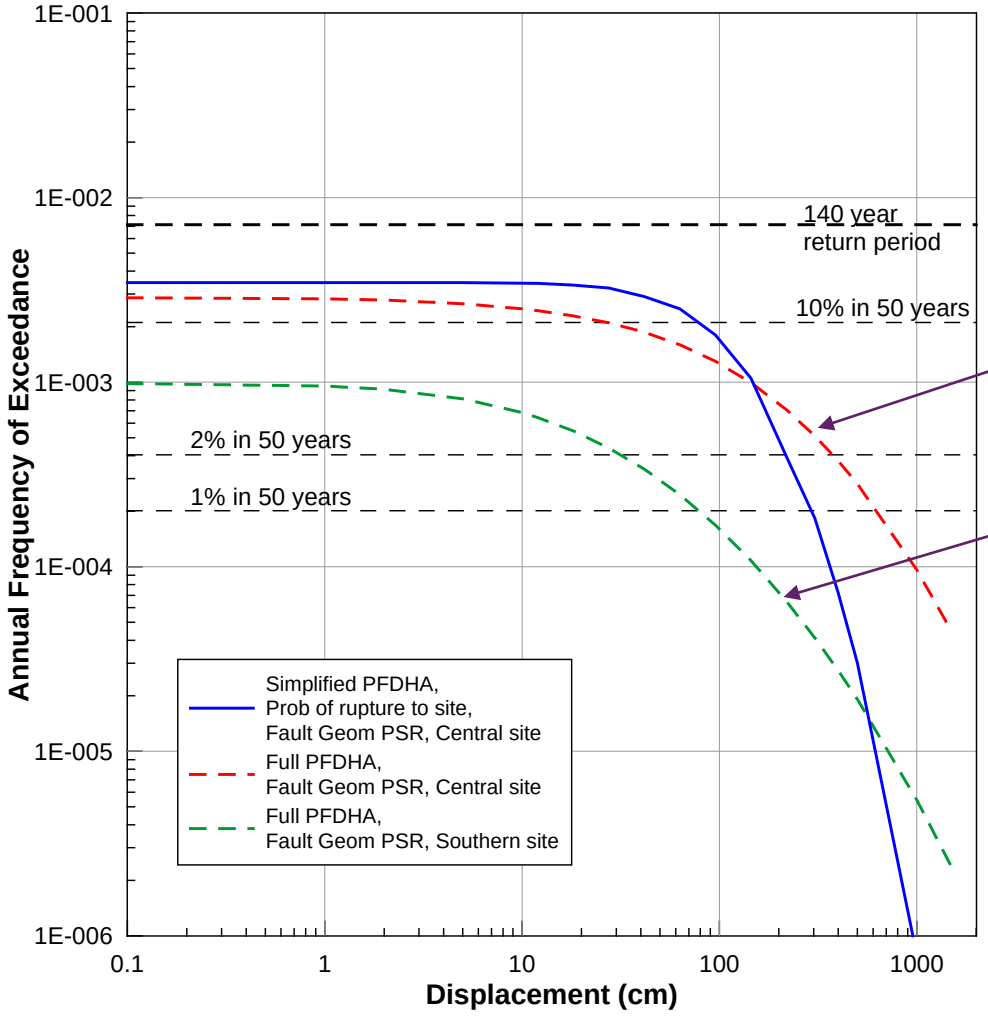
Sensitivity of Results to Function for PSR

- For moderate magnitude earthquakes, the results (Displacement Hazard) are quite sensitive
- For larger magnitude earthquakes, most or all earthquakes rupture to surface and results are not sensitive.

Sensitivity to Site Location/Rupture Scenarios



Sensitivity to Site Location



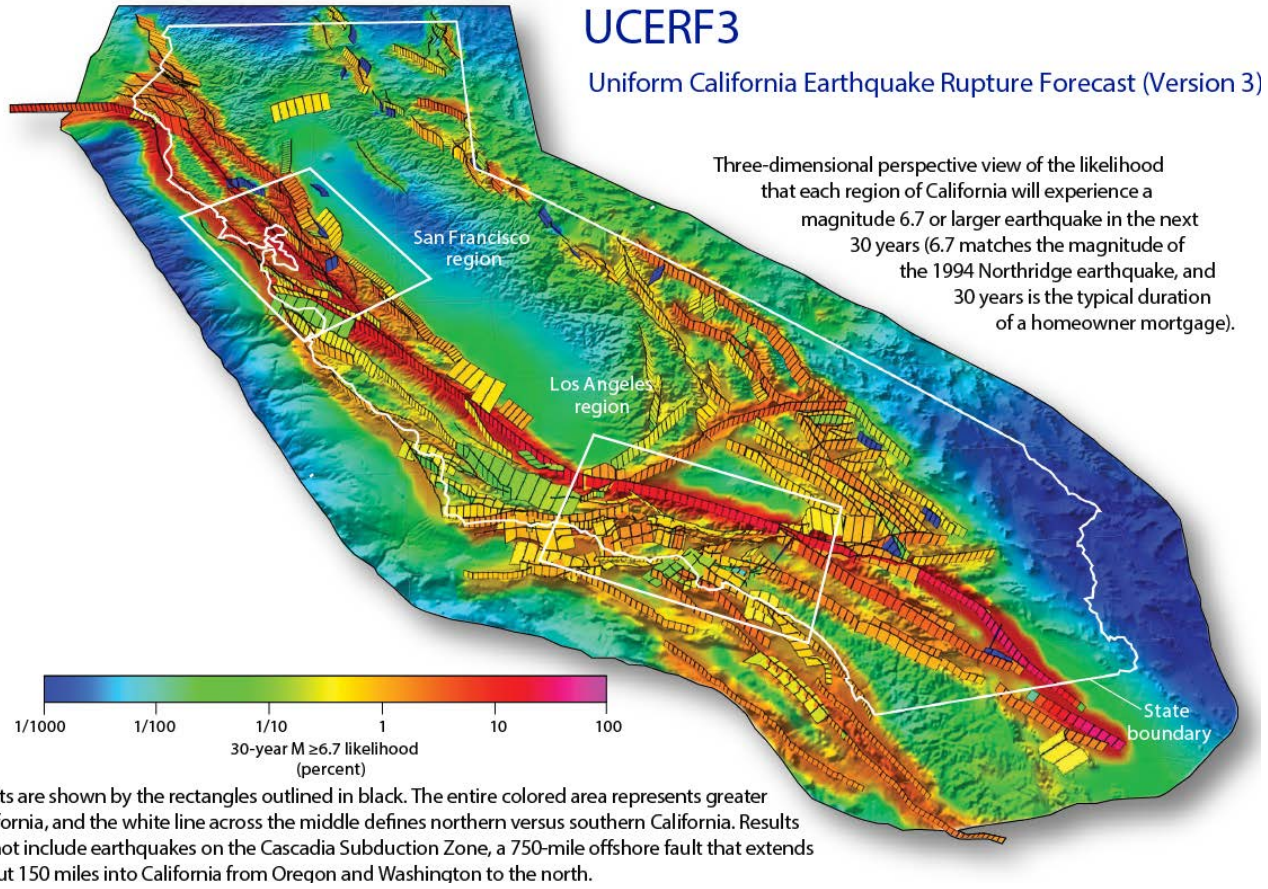
Hayward Fault
PDFHA Example

Central Site

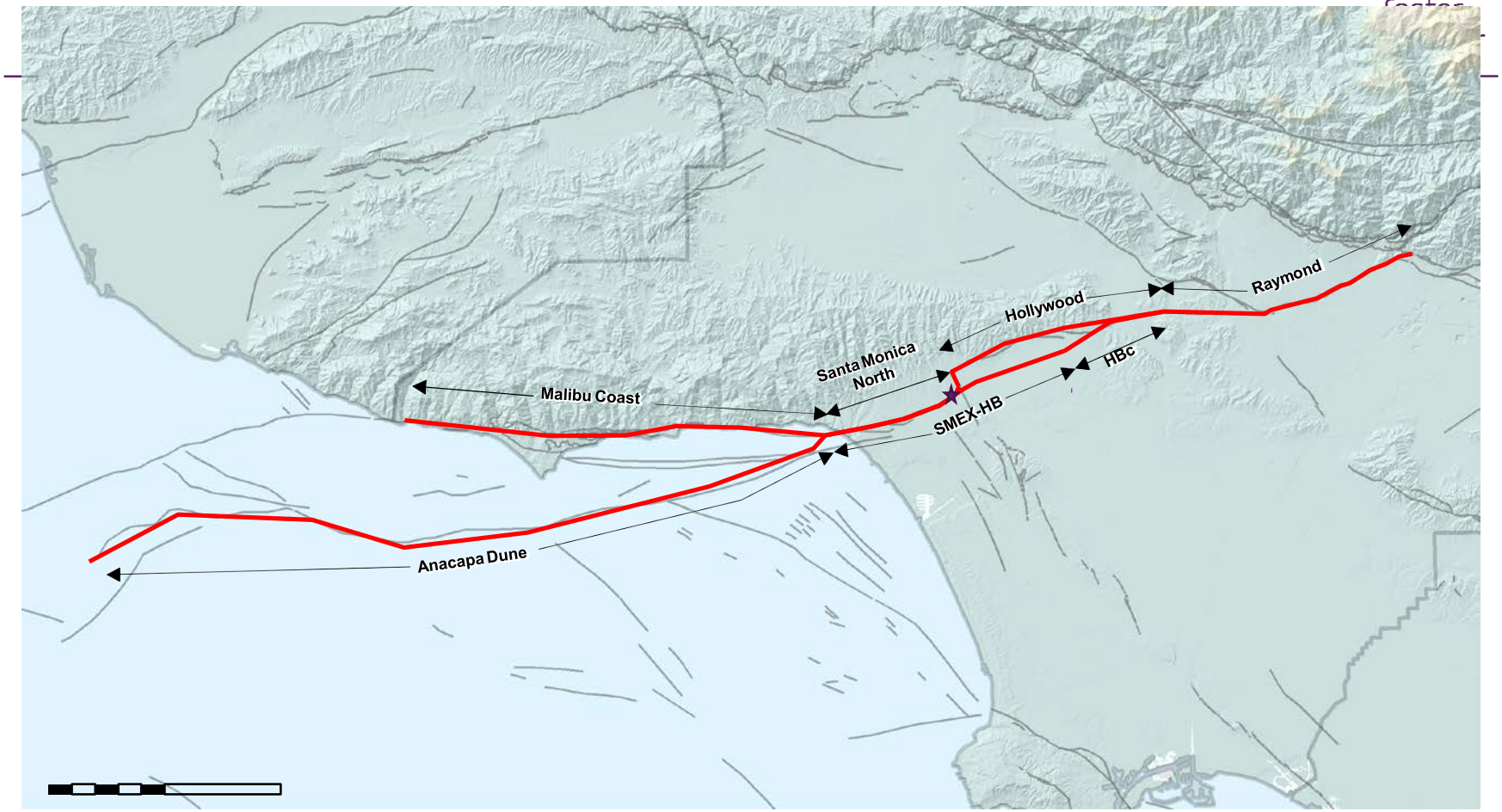
Southern Site

Sensitivity to Site Location

Consider More Comprehensive Suite of Rupture Scenarios



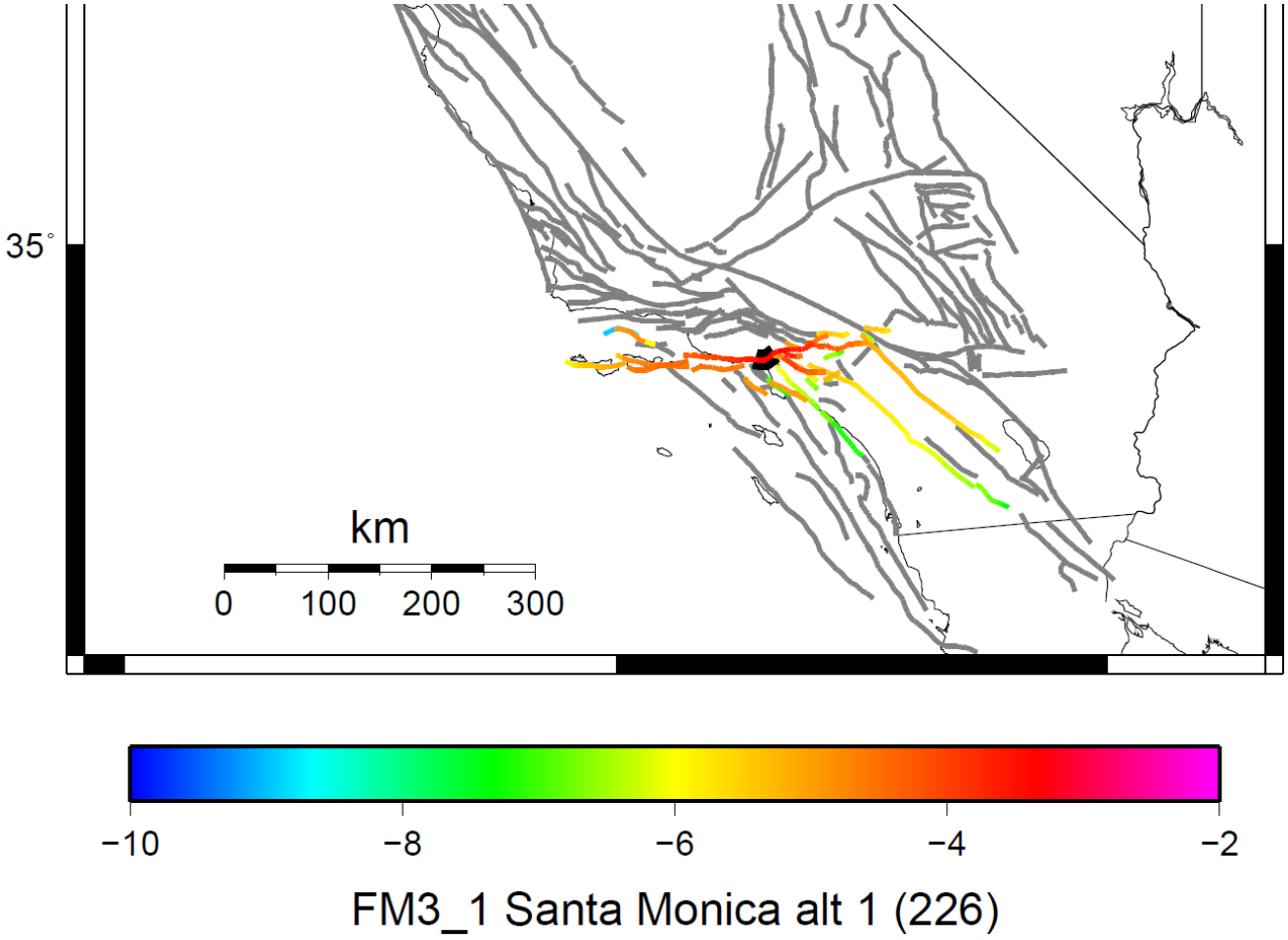
Sensitivity for Rupture Scenarios



Anacapa Dume – Santa Monica – Hollywood Raymond Faults

Sensitivity for Rupture Scenarios

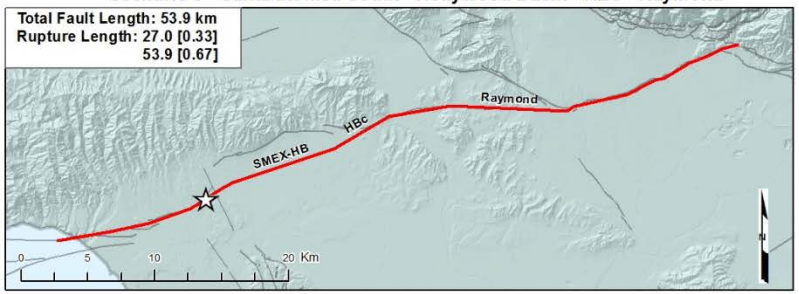
UCERF 3 Fault Participation Rates



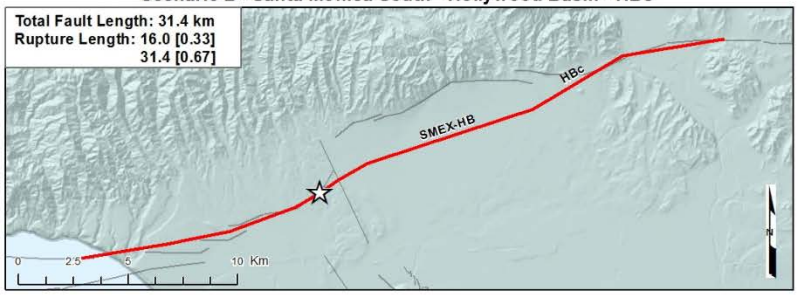
Sensitivity for Rupture Scenarios

Santa Monica Rupture Scenarios

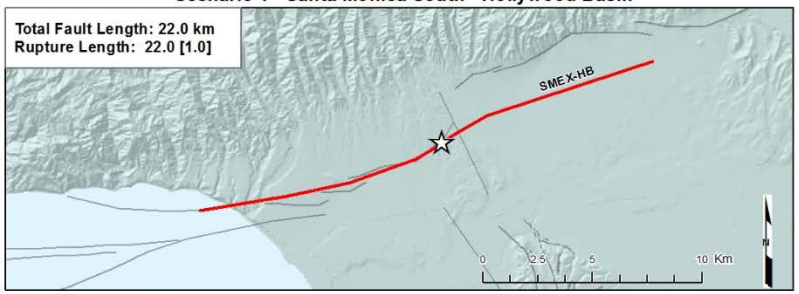
Scenario 3 - Santa Monica South - Hollywood Basin - HBc - Raymond



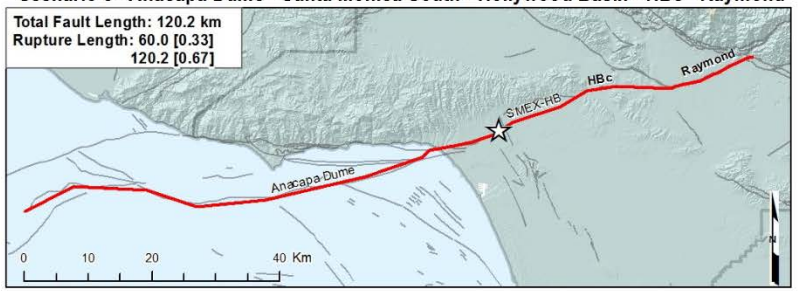
Scenario 2 - Santa Monica South - Hollywood Basin - HBc



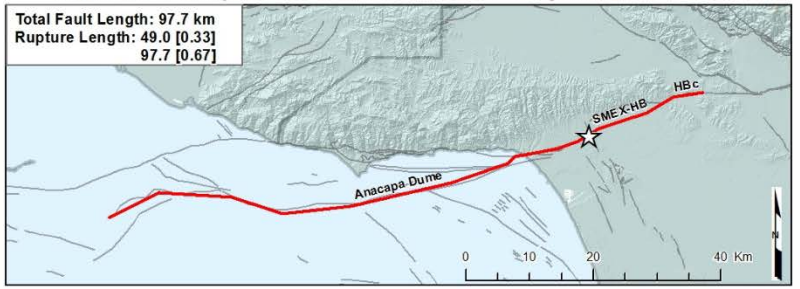
Scenario 1 - Santa Monica South - Hollywood Basin



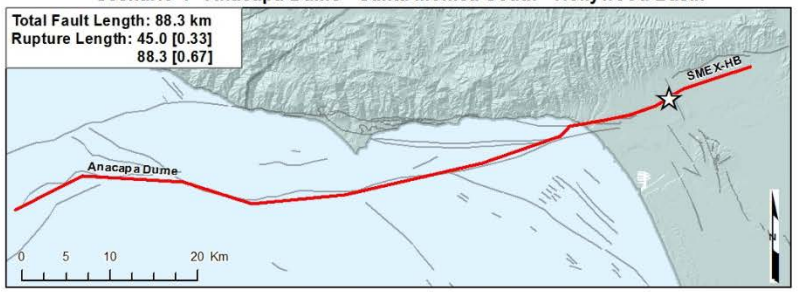
Scenario 6 - Anacapa Dume - Santa Monica South - Hollywood Basin - HBc - Raymond



Scenario 5 - Anacapa Dume - Santa Monica South - Hollywood Basin - HBc



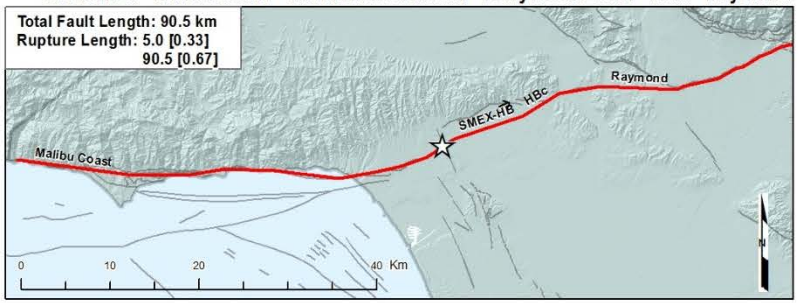
Scenario 4 - Anacapa Dume - Santa Monica South - Hollywood Basin



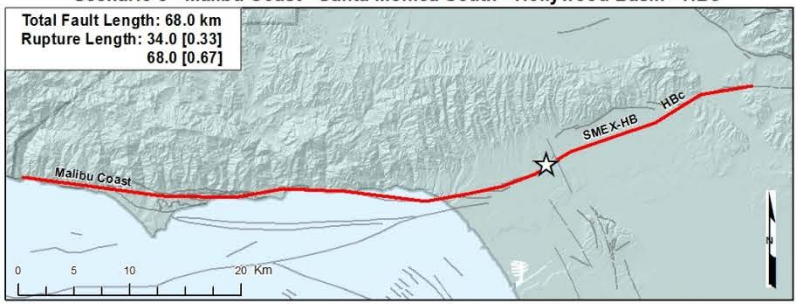
Sensitivity for Rupture Scenarios

Santa Monica Rupture Scenarios

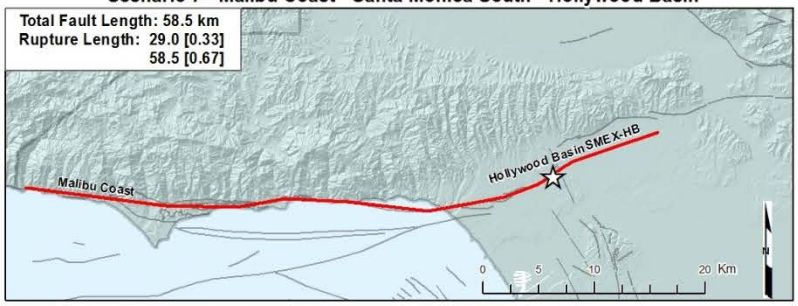
Scenario 9 - Malibu Coast - Santa Monica South - Hollywood Basin - HBc - Raymond



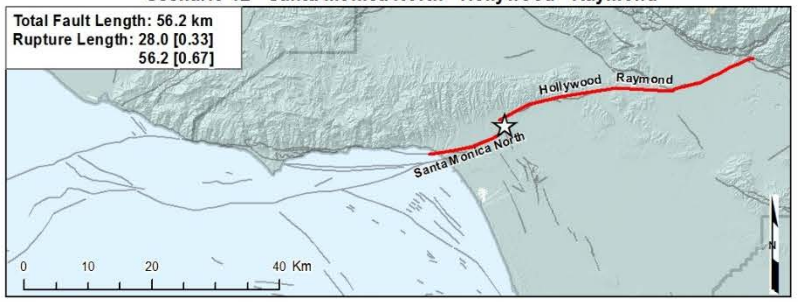
Scenario 8 - Malibu Coast - Santa Monica South - Hollywood Basin - HBc



Scenario 7 - Malibu Coast - Santa Monica South - Hollywood Basin

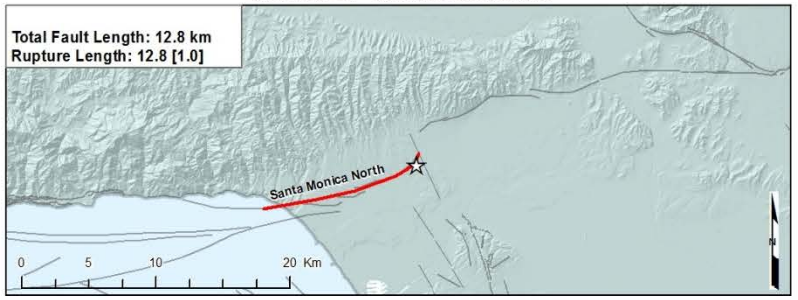


Scenario 12 - Santa Monica North - Hollywood - Raymond



Scenario 11 - Santa Monica North - Hollywood

Scenario 10 - Santa Monica North

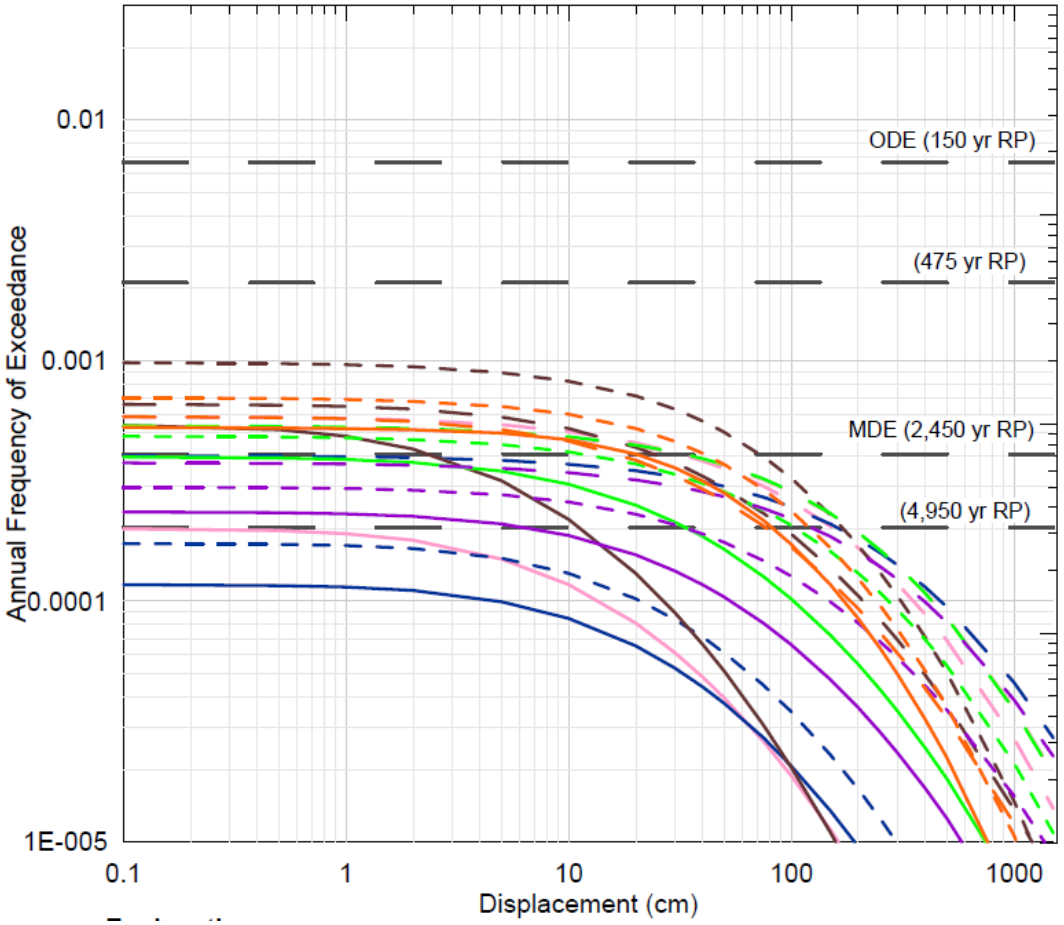


Sensitivity for Rupture Scenarios

PFDHA performed using 18 rupture scenarios that represent a reasonable selection from the UCERF models

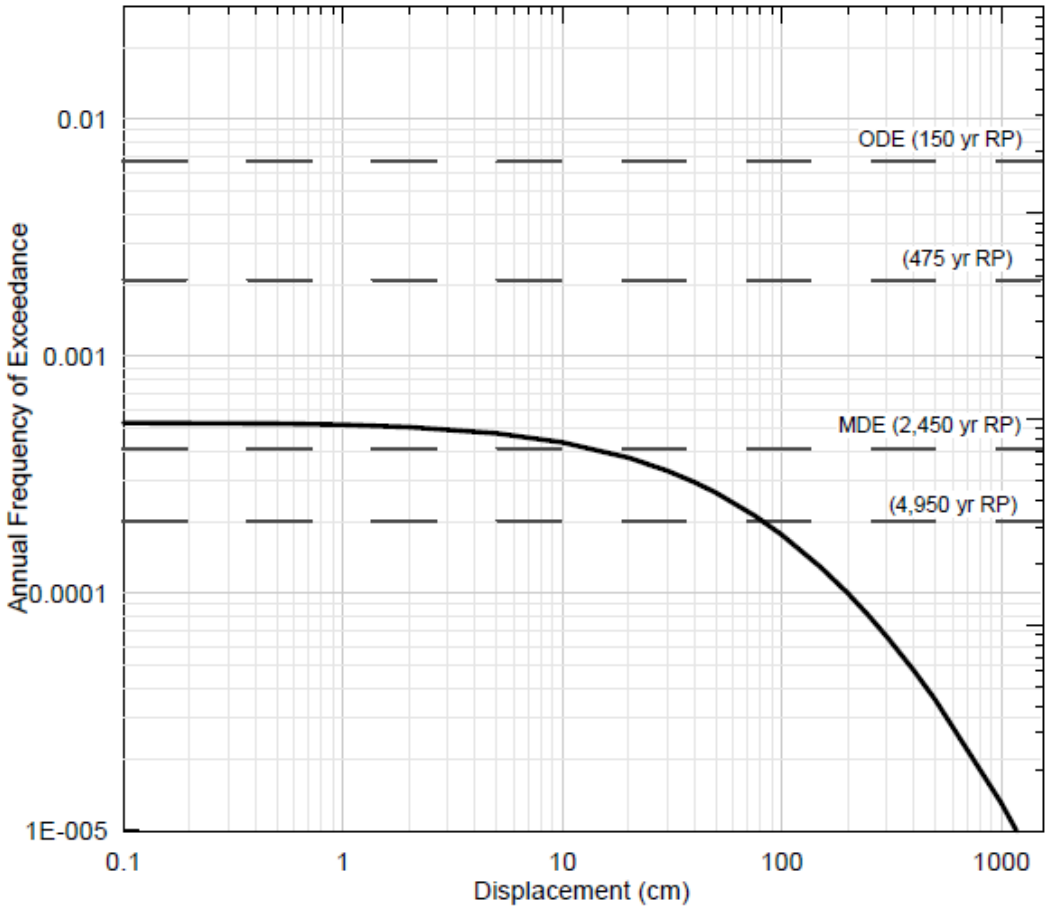
Models based on average parameters defined in UCERF3 for UCERF2 model faults, and using minimum, average, and maximum solution slip rates

Sensitivity for Rupture Scenarios



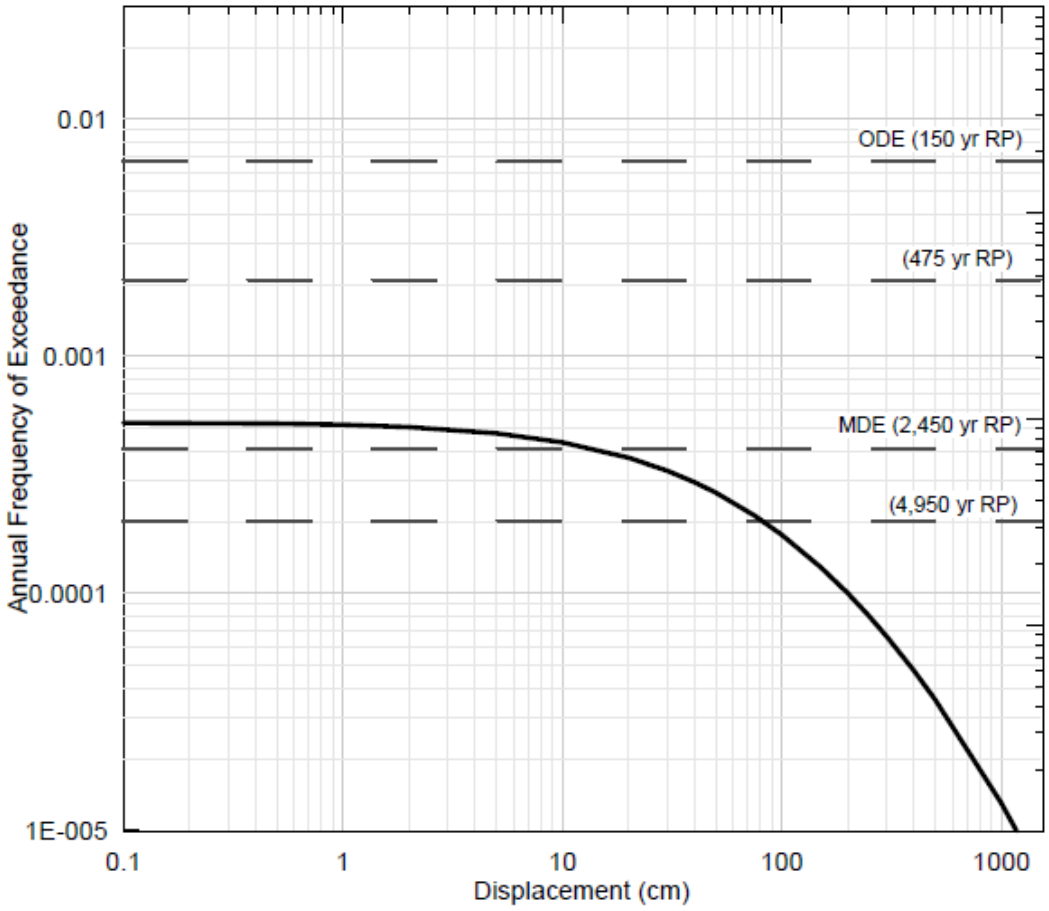
Displacement Curves for Individual Model Show a Wide Range of AFE

Sensitivity for Rupture Scenarios



Mean Hazard Curve Developed from Weighting of Individual Rupture Models

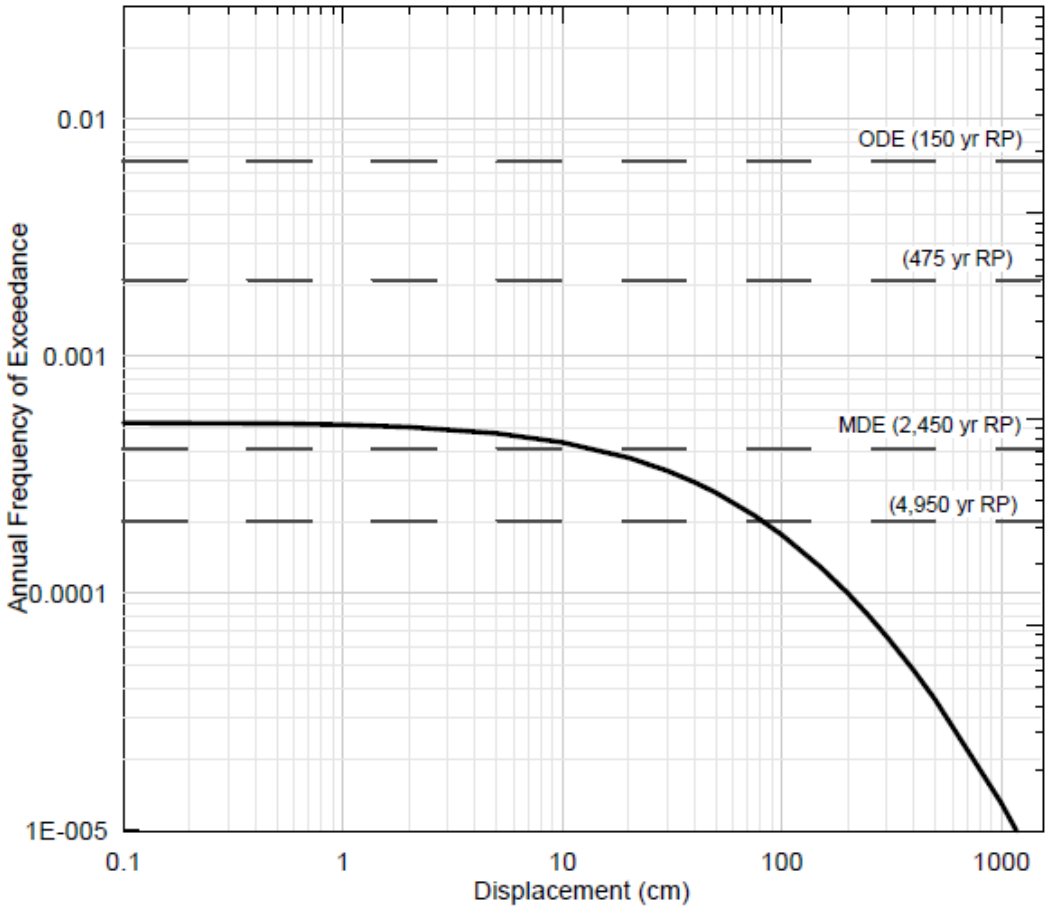
Sensitivity for Rupture Scenarios



How were the rupture scenarios weighted?

How do we know if the results are reasonable?

Sensitivity for Rupture Scenarios



Weighting for individual models often is based on expert judgement.

And, given the wide range of AFE for individual scenarios, the results are sensitive to the weighting scheme.

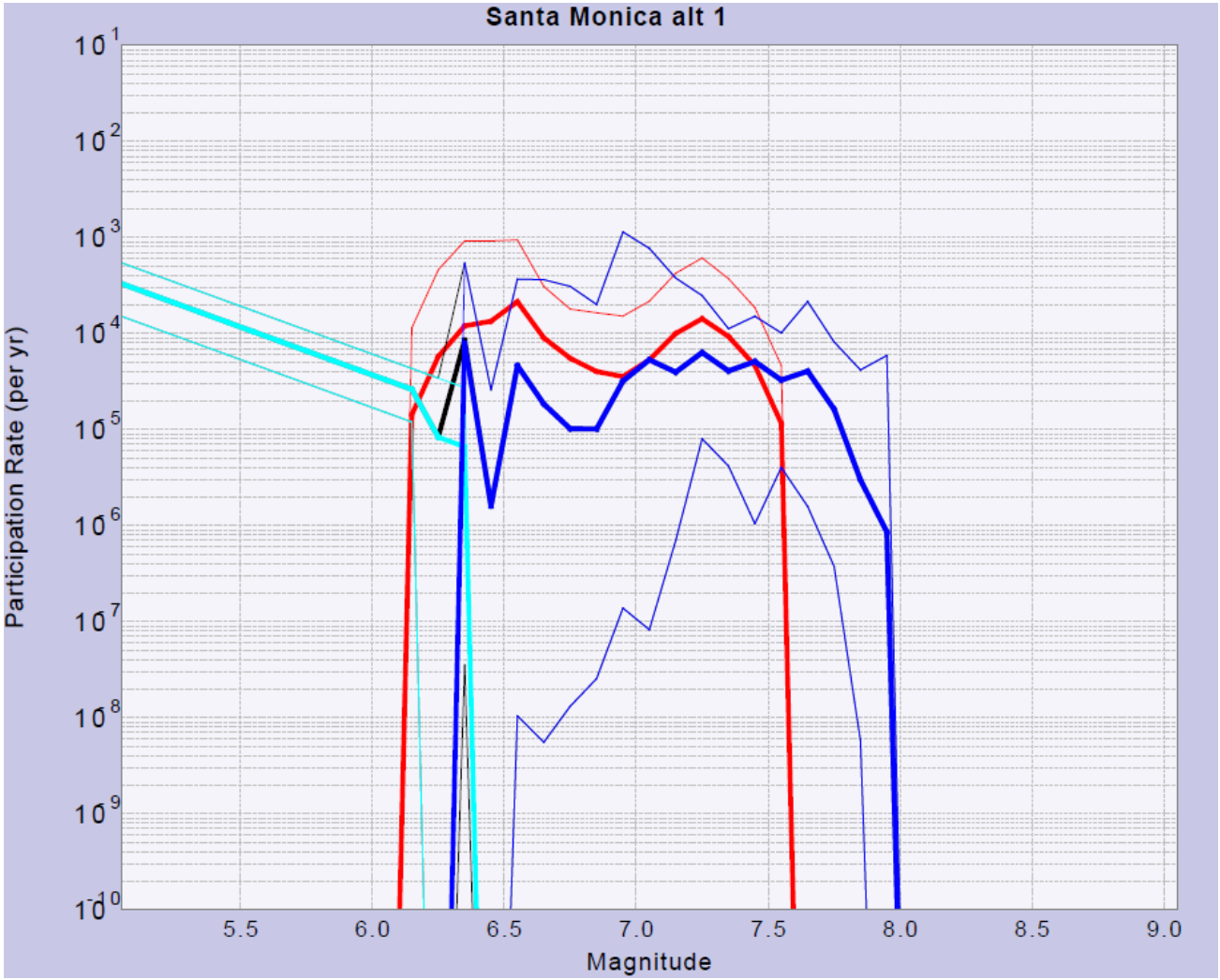
Sensitivity for Rupture Scenarios

Checks on Reasonableness of Results

Compare slip rate implied by hazard curve to slip rate input in model

Compare the magnitude-frequency distribution (MFD) of the weighed rupture scenarios to MFD for the fault

Checks on Reasonableness of Results



UCERF3 MFD Incremental Participation

Improvements in Practice

Test sensitivity of results to model parameters and alternative models.

Many aspects/models for PFDHA are still in early stages of development (models maximum/average displacement, models for slip variability)

Development of rupture models – fixed characteristic ruptures in UCERF2 are not consistent with recent earthquakes;

UCERF3 rupture models represent a wider range of possible ruptures, and are more appropriate as the ends of ruptures are not well known.

Improvements in Practice

Ok, for David, maybe not all those 500 km plus ruptures

Improvements in Practice

Interrogate UCERF 3 Model for detailed results

Slip rate on section underlying the site

More formal consideration of rupture scenarios and solution recurrence rates

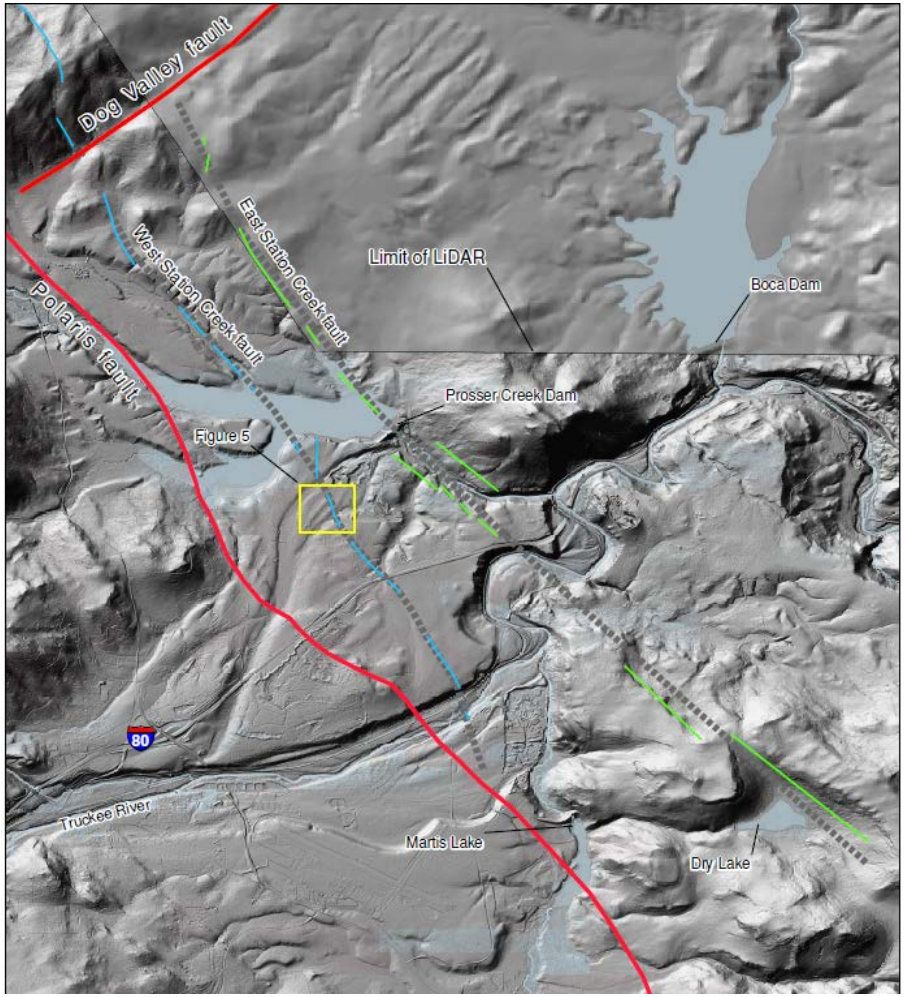
Relative frequency of various ruptures, and frequency of rupture across fault steps (fault to fault/segment to segment)

Wait for Glenn's talk

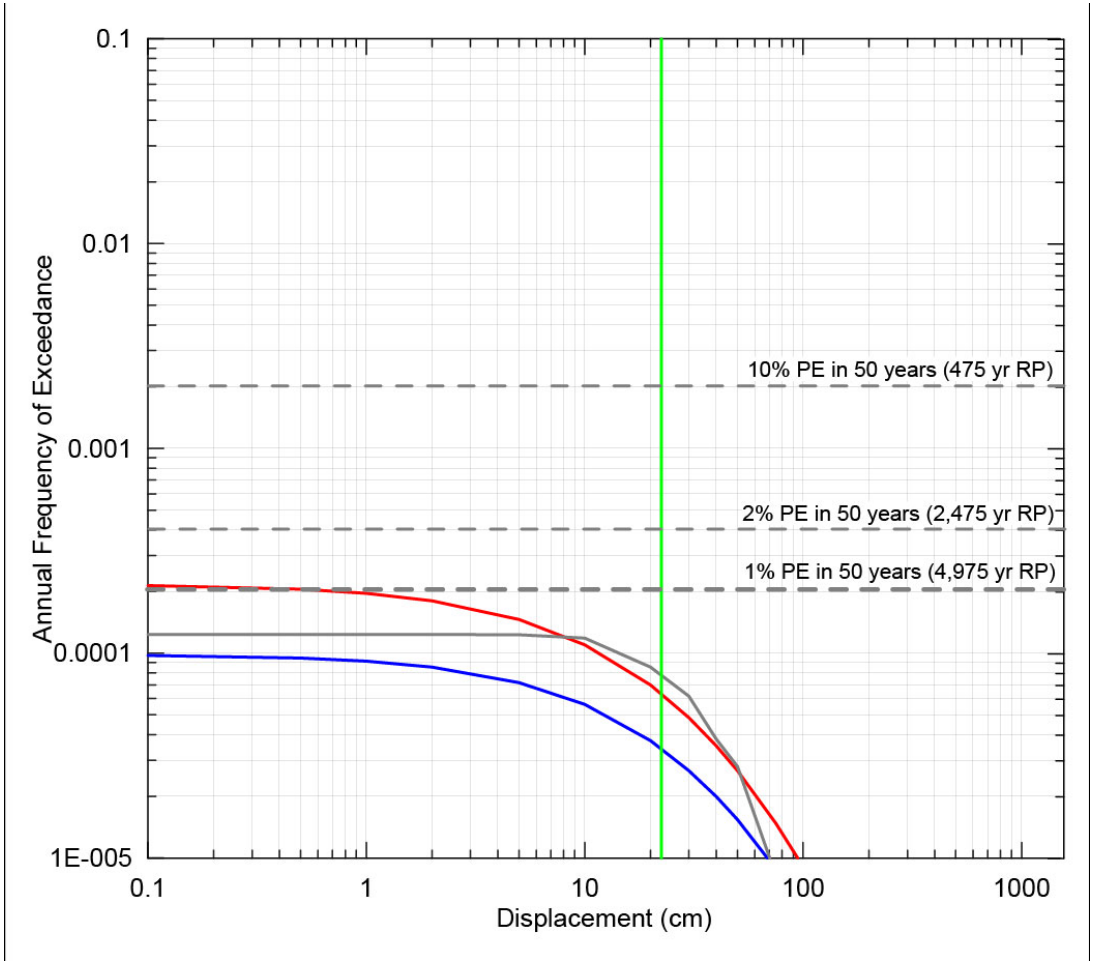
PFDHA

Questions?

Example for Low Displacement Hazard



Example for Low Displacement Hazard



Low slip rate fault,
Subsidiary fault trace
Moderate magnitude
Eqs

Low Displacement
Hazard