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Managing Water in the West

Seismotectonic and Ground Motion Investigations at Reclamation

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Current Reclamation Practice

- Risk informed decision process, requires an integrated probabilistic approach to hazard/response analyses
- Periodic reviews (CFR) and prioritization is risk-based
- Most studies are for existing dams
- Scope determined by hazard and risk

Current Reclamation Practice

- Probabilistic approach
- Site response data acquired wherever feasible
- If needed, deterministic values can be obtained as a subset of PSHA
- Focus on importance of source characterization (*RATE*) and development of time histories

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Important Issues

- Incorporation of uncertainty, aleatory and epistemic (source and g.m.)
- Important effects in the near-field (directivity, HW/FW, fault normal/parallel, radiation from near surface)
- Site response (multiple scales)
- Lack of data
- Proper incorporation into engineering analyses and decision process
- Nonlinear soil response
- Development of time histories

Source Characterization-Rate

- The 800 pound gorilla of the problem.
- Accurate and unbiased assignment of rate provides the scaling of the problem and ultimately defines importance.

Epistemic or Model Uncertainty

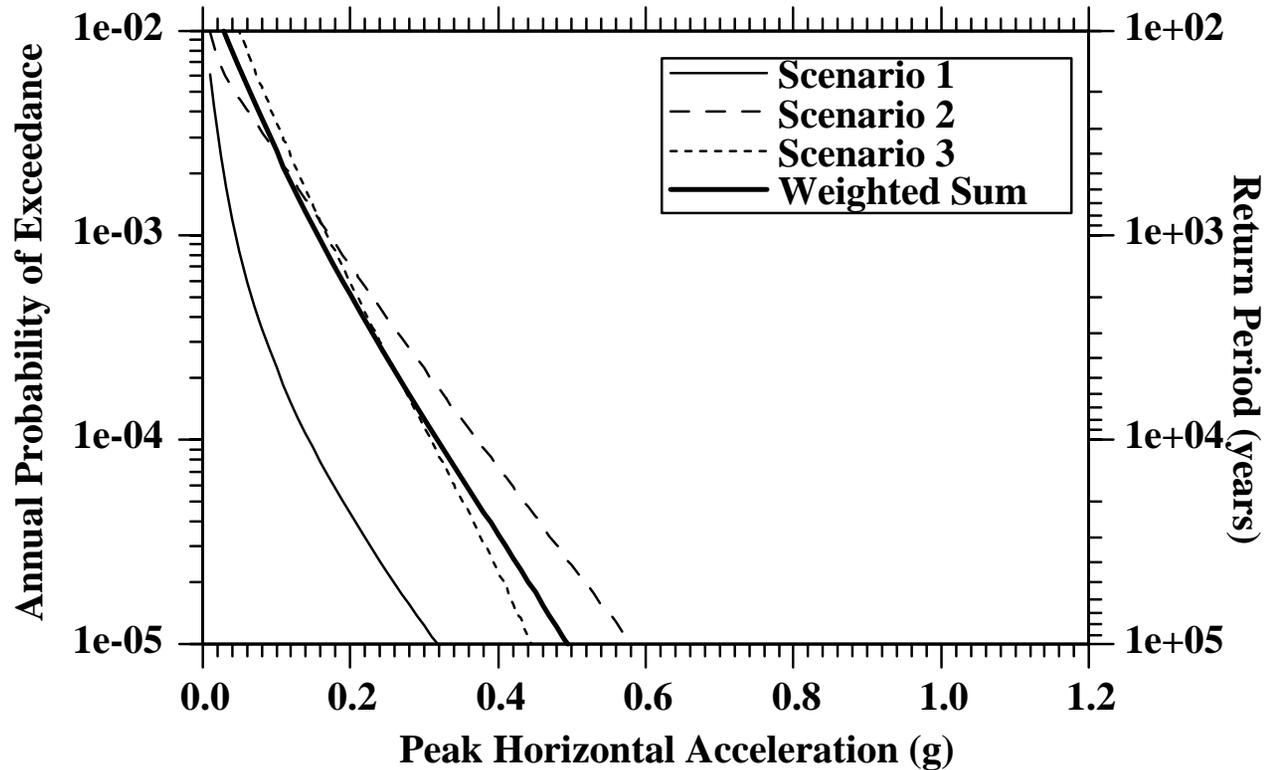
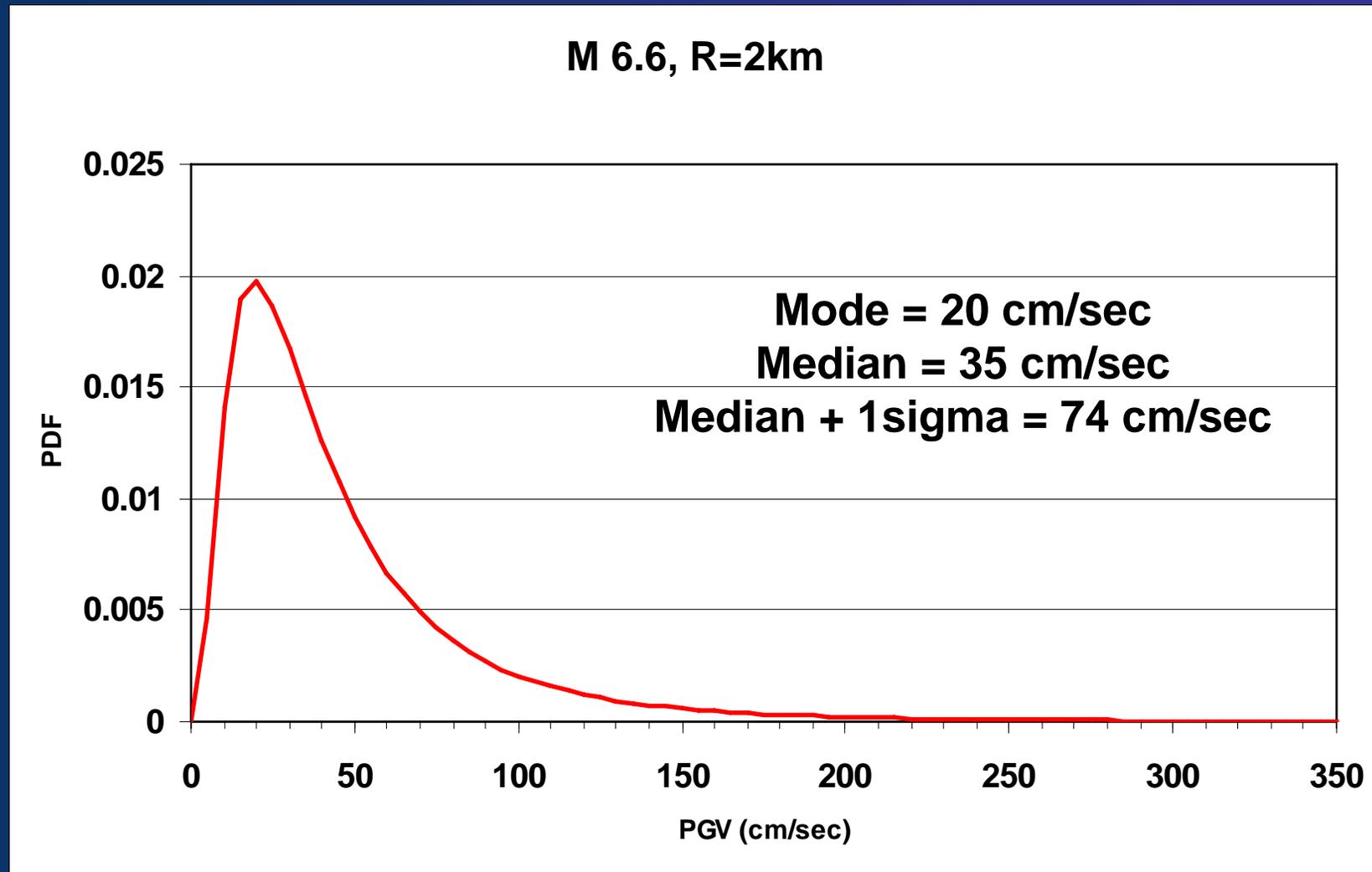
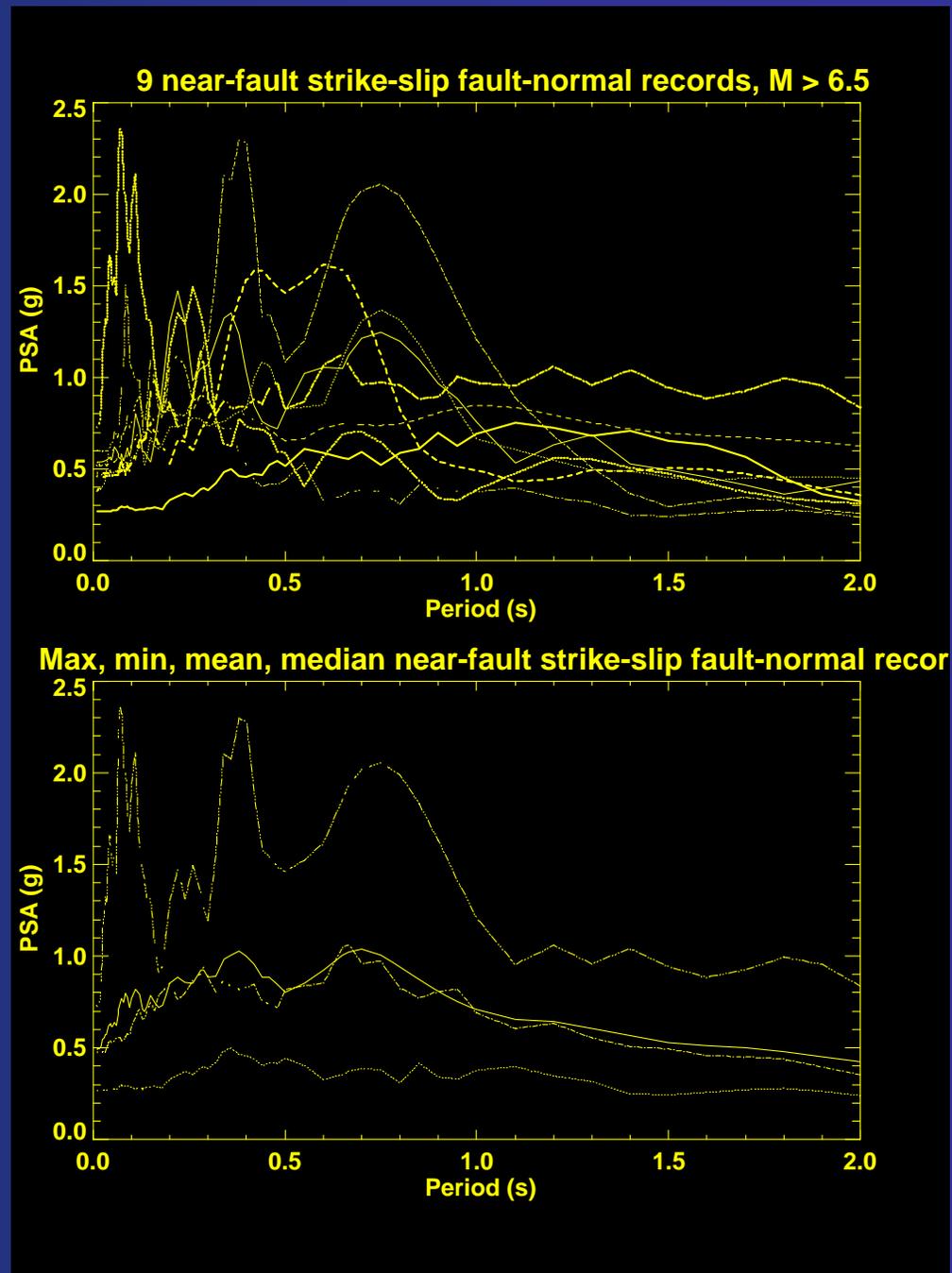


Figure 0-0a: Mean PHA hazard curves for areal source zones, comparison of scenarios 1, 2 and 3, and weighted sum.

Aleatory or Random Variability



- **Directivity**
- **Near-field observations often display strong frequency-dependent directivity pulse.**



Path and Site Response

- Requires information on geological/geophysical properties along path. Primary sources of information are crustal scale research geophysical surveys and oil exploration data
- At site, shallow geophysical measurements (shear wave testing), material descriptions
- Earthquakes recorded at site a great asset

- Basin effects may produce significant variations in motions
- Effects on duration and energy can be very large

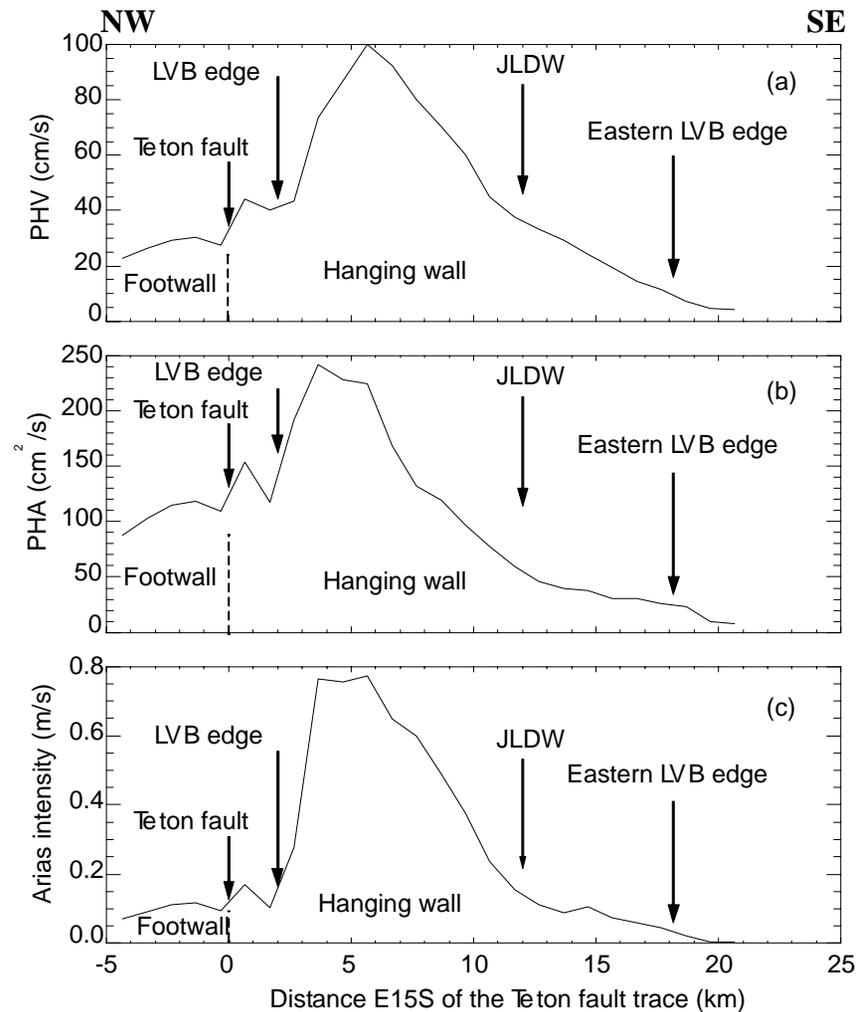


Figure 0-1: Simulated peak motion characteristics for a M 7.1 earthquake on the Teton fault. Long-period (< 1 Hz) peak horizontal velocities (PHV) (a), peak horizontal accelerations (PHA) (b), and Arias Intensities (c) for a profile of sites oriented E15S through the JLDW from a 3D finite-difference simulation of a M 7.1 normal-faulting earthquake on the northern Teton fault segment with a 35°-dip extending to 16 km depth. The hypocenter was located at 15 km depth, 2 km from the south end of the fault segment. The Jackson Lake LVB is located on the hanging wall, 2 km from the surface trace of the Teton fault.

Near-surface spectral amplification

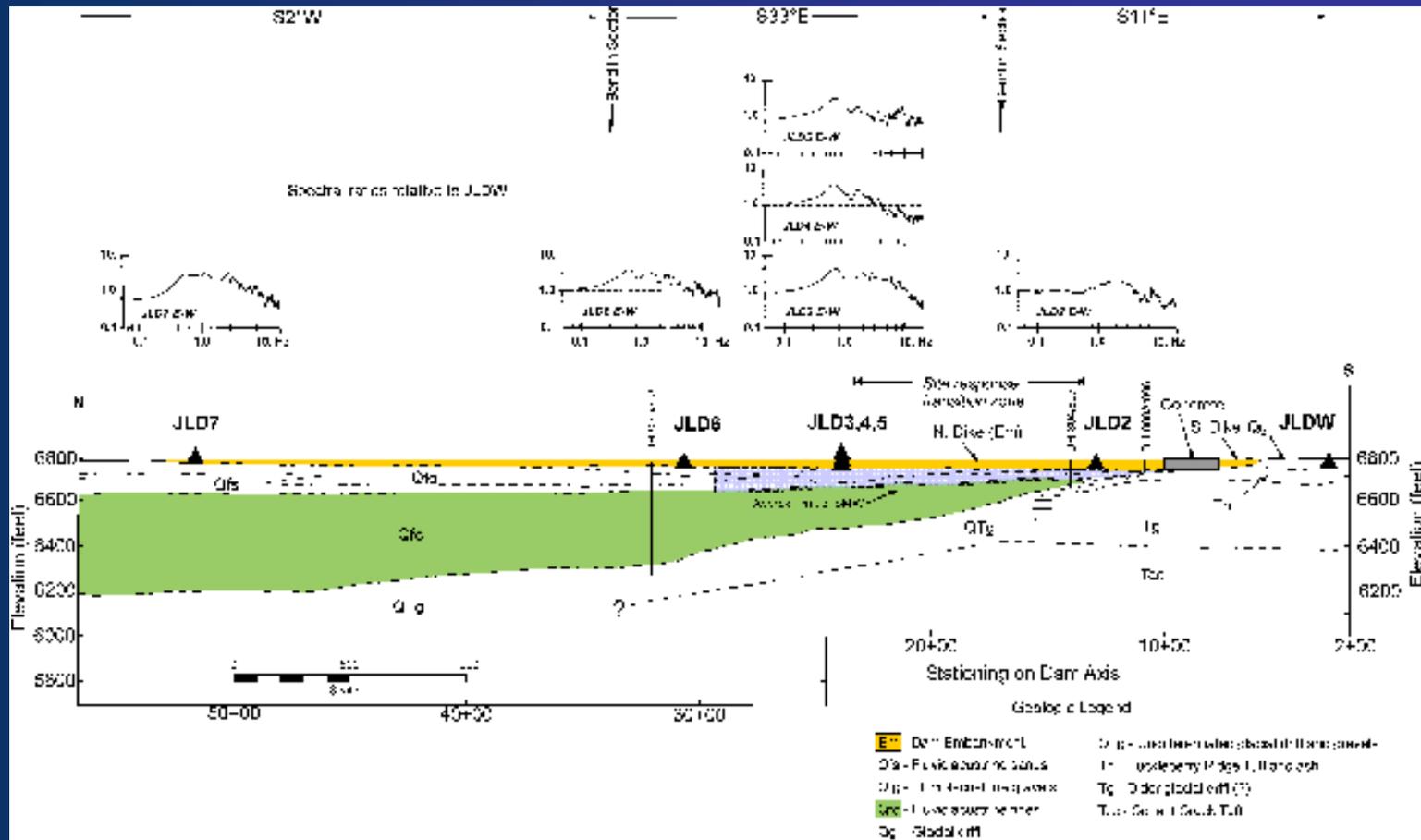
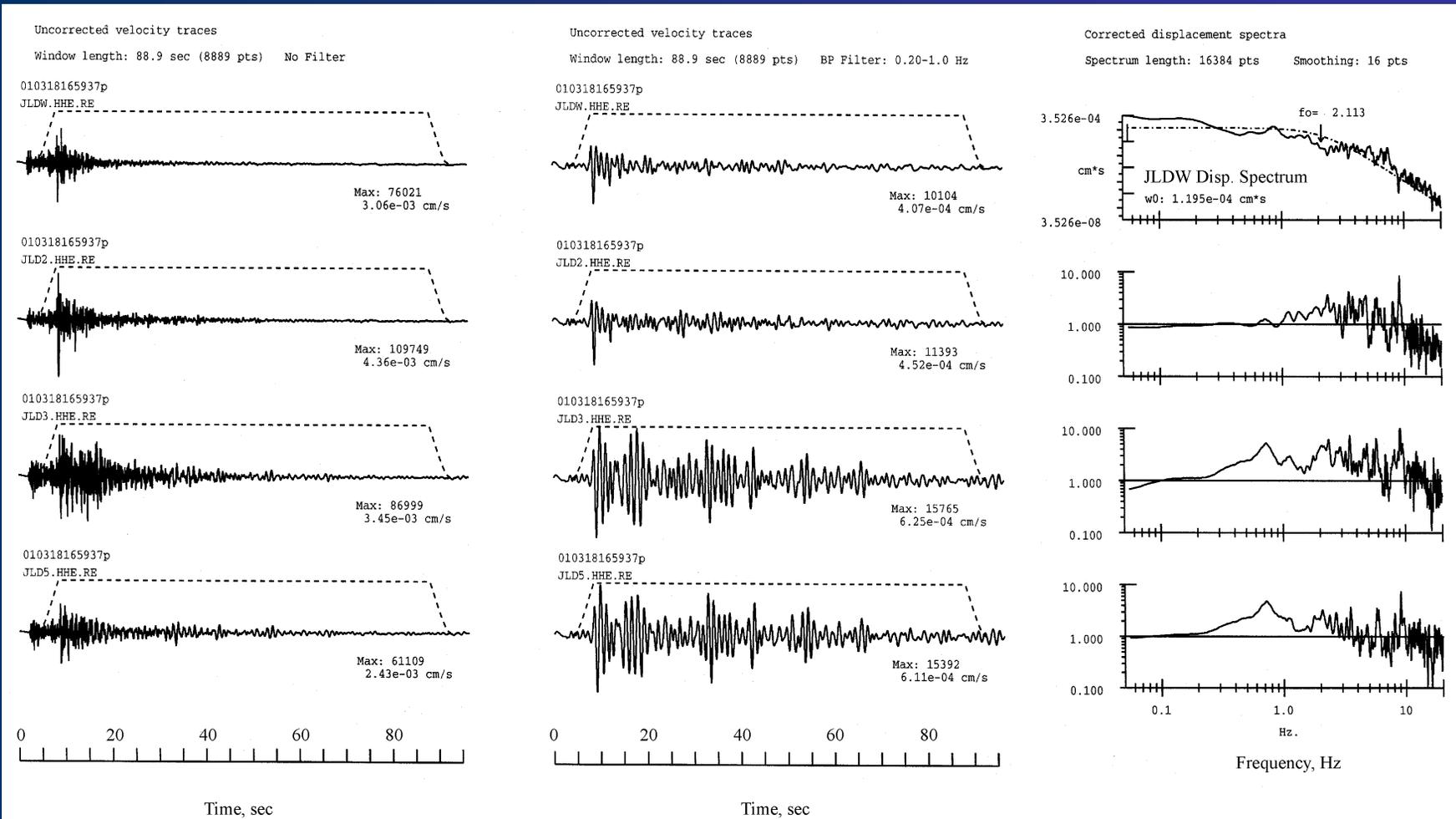


Figure 0-1: Jackson Lake Dam section showing locations of site response seismometers JLDW-JLD7. Average spectral ratios relative to JLDW measured from weak-motion data are also shown (east-west component). JLD3 through JLD7 exhibit amplification for frequencies between 0.2 and 1.0 Hz, whereas JLD2 does not. Transition between JLD2 and JLD3 response may occur as soon as DH-804/805 (stn. 14+00) since Qfs/Qfg shear-wave velocities measured there are much lower than measured at DH-800A/806, but are similar to shear velocities measured at DH-807/808. See Section 1.3.1 for additional discussion of site geology

Local Basin Response



(A) Unfiltered velocity (East-West)

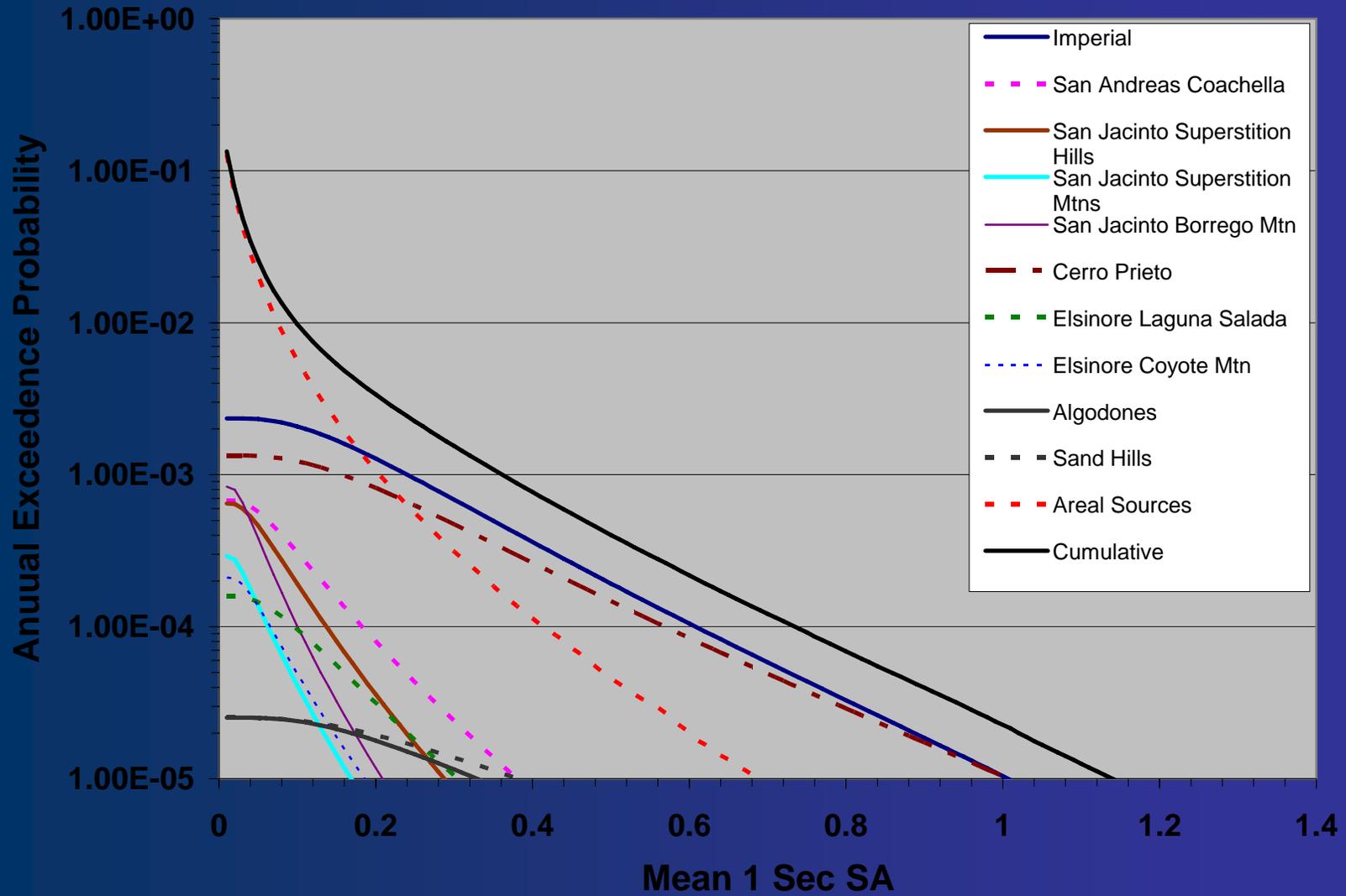
(B) Filtered velocity: 0.2 - 1.0 Hz

(C) Spectral ratio (rel. to JLDW)

Definition of Scenario Earthquakes

- Based on deaggregation of the hazard at a specified APE (often more than one) and ground motion period(s).
- For each APE specify controlling magnitude (M), source-site distance (R), and perhaps epsilon (ϵ).
- Complex dams (those with both concrete and earth sections) can/will have different response characteristics and perhaps different site responses.

AAC 1



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Selection of Time Histories

- Proper selection and modification of time histories for use in engineering analyses is very important.
- Increasing use of non-linear engineering analyses increases the importance of this step.
- Often one of the largest sources of uncertainty in the process.

Spectral Modification

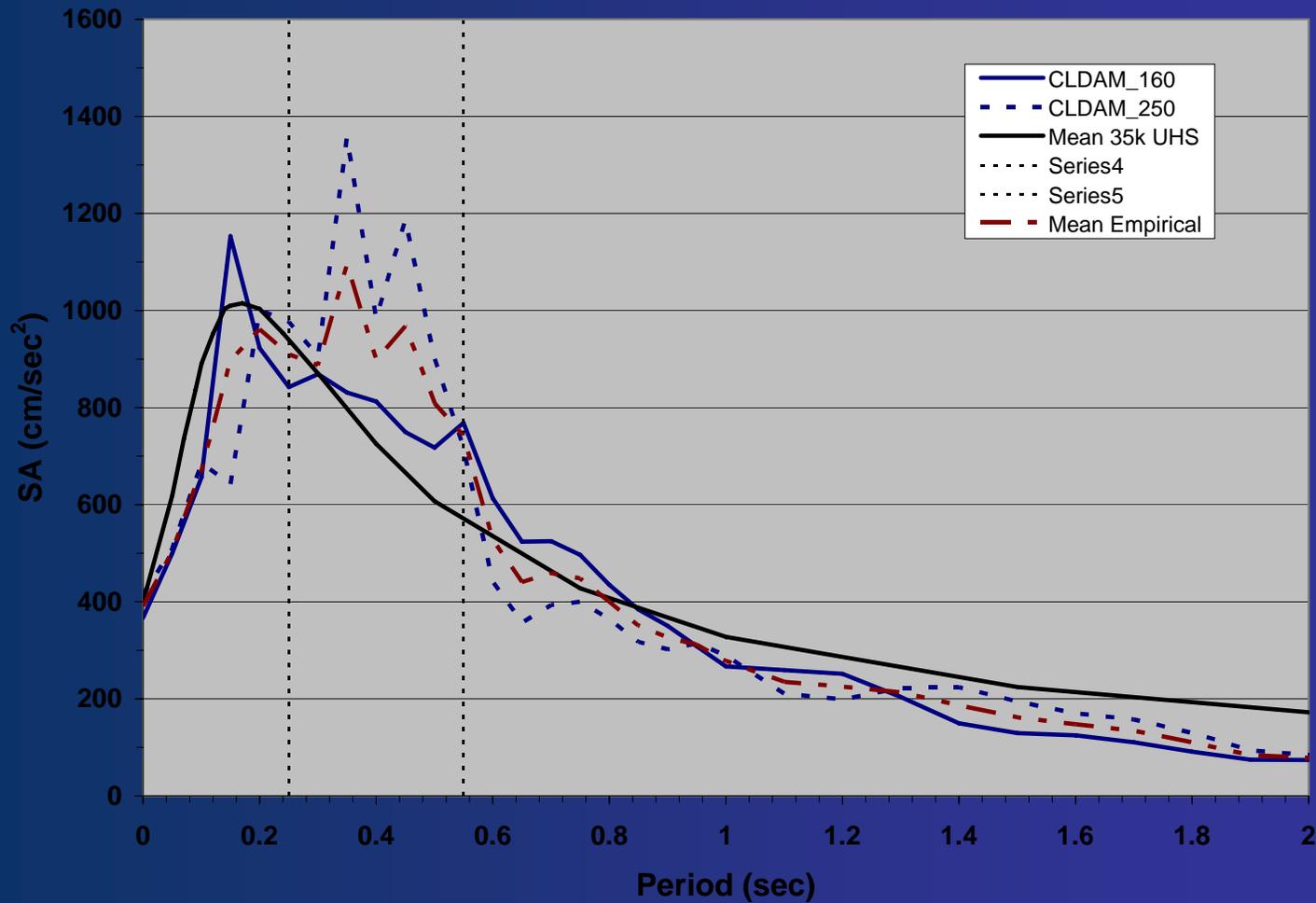
- Use the UHS for a specific APE as the target. This is always a smooth spectra (each spectral period is the ensemble average of the empirical data in the M,R bin).
- Real records are not smooth, have peaks and troughs. Ideally, we try to have several records which incorporate this behavior, whose ensemble average ~equals the UHS in the frequency band of interest.

Spectral Modification

- Prefer to minimize scaling.
- We are at least somewhat interested in variability (not just average) response.
- When selecting records for low APE, need to consider high epsilon records.
- To avoid bias, avoid scaling “troughs” to target-rely on average spectral response.
- Weak spectral modification usually needed.
- Significant judgment and experience required.

UHS-Empirical Fit

Spectra 35k



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Definition of Ground Motion Metric

- Strong integration between ground motion and structural analysis team required
- PHA, PHV, Sa, Sa over a period range, duration, AI, joint distribution, vector valued measures?
- Metric may change between existing structure and modified structure.

Areal Source Zones: Southern Cascades & Transition Zone

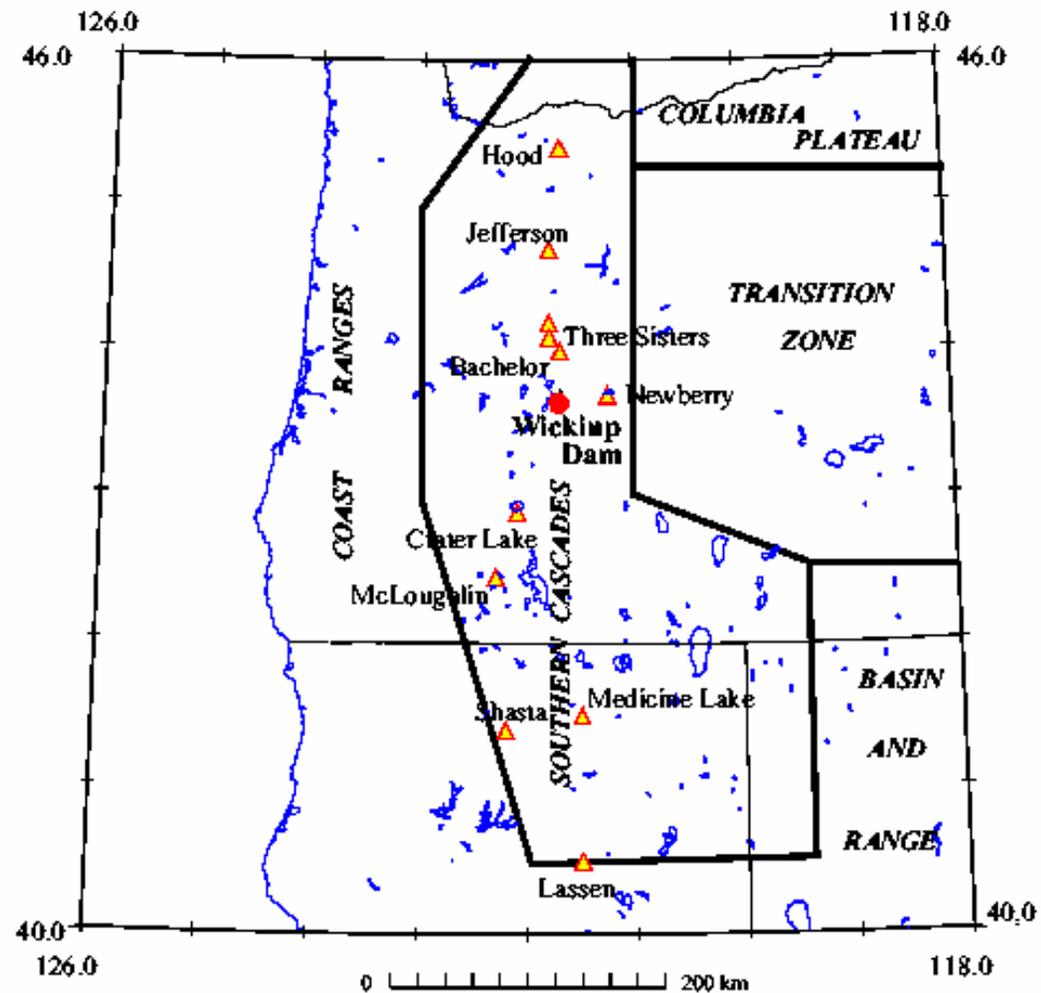


Figure 0-1. Generalized tectonic provinces of western Oregon. Volcanoes of the southern Cascades indicated by triangles, Wickiup Dam by solid circle. Boundaries used for areal source zones indi-

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1-sec SA Contribution by Source

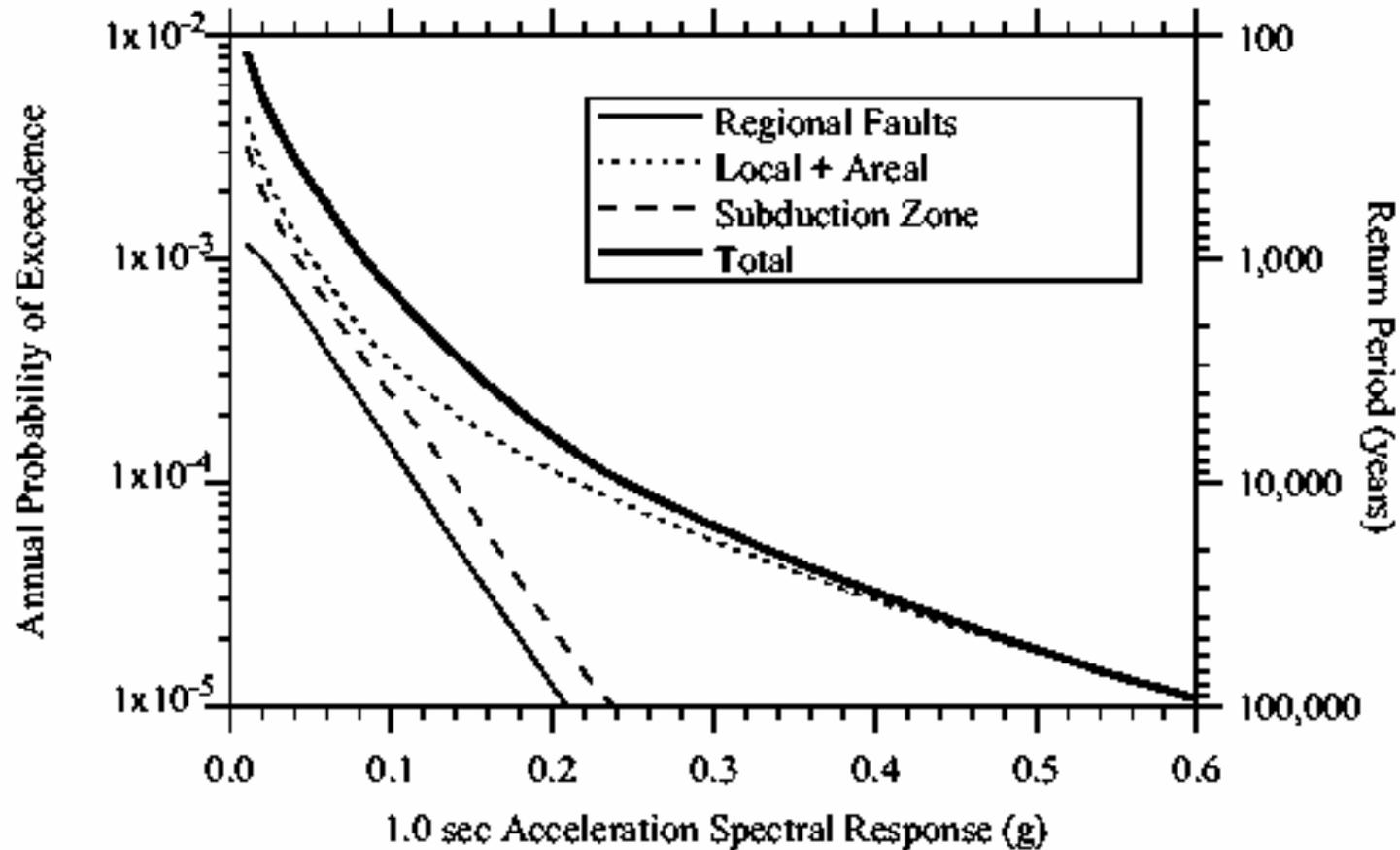
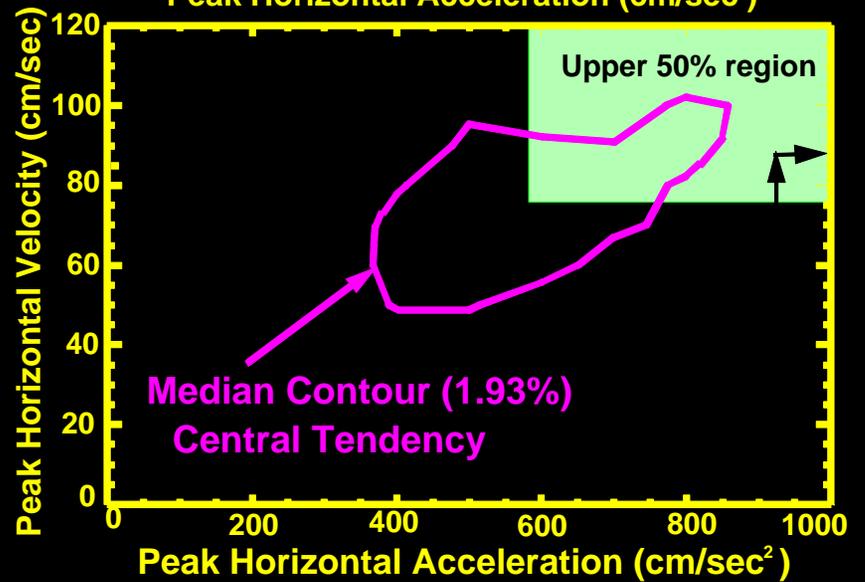
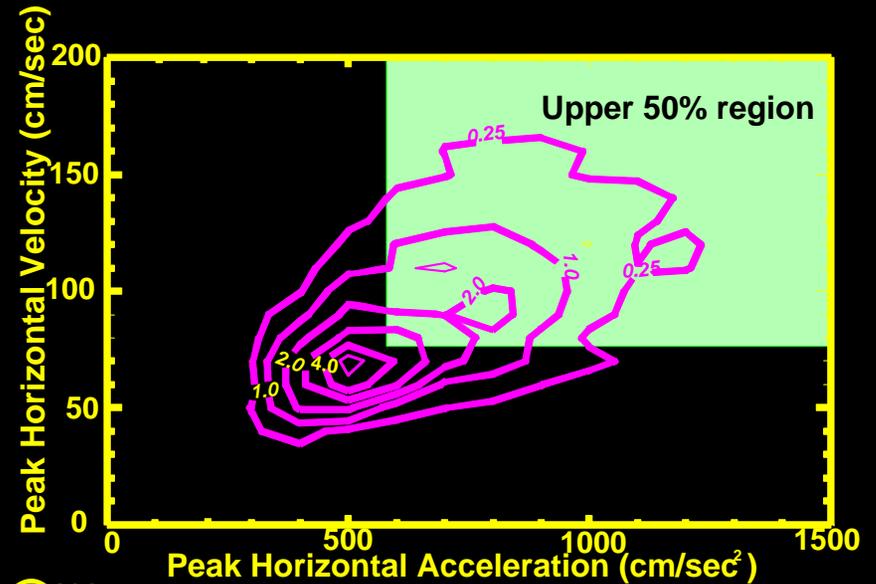


Figure 0-1. Contribution of sources to mean 1 sec spectral hazard. Uncertainty in fault activity, recurrence model, slip rate, and attenuation functions weighted as shown in Figures 4-2 and 4-3.

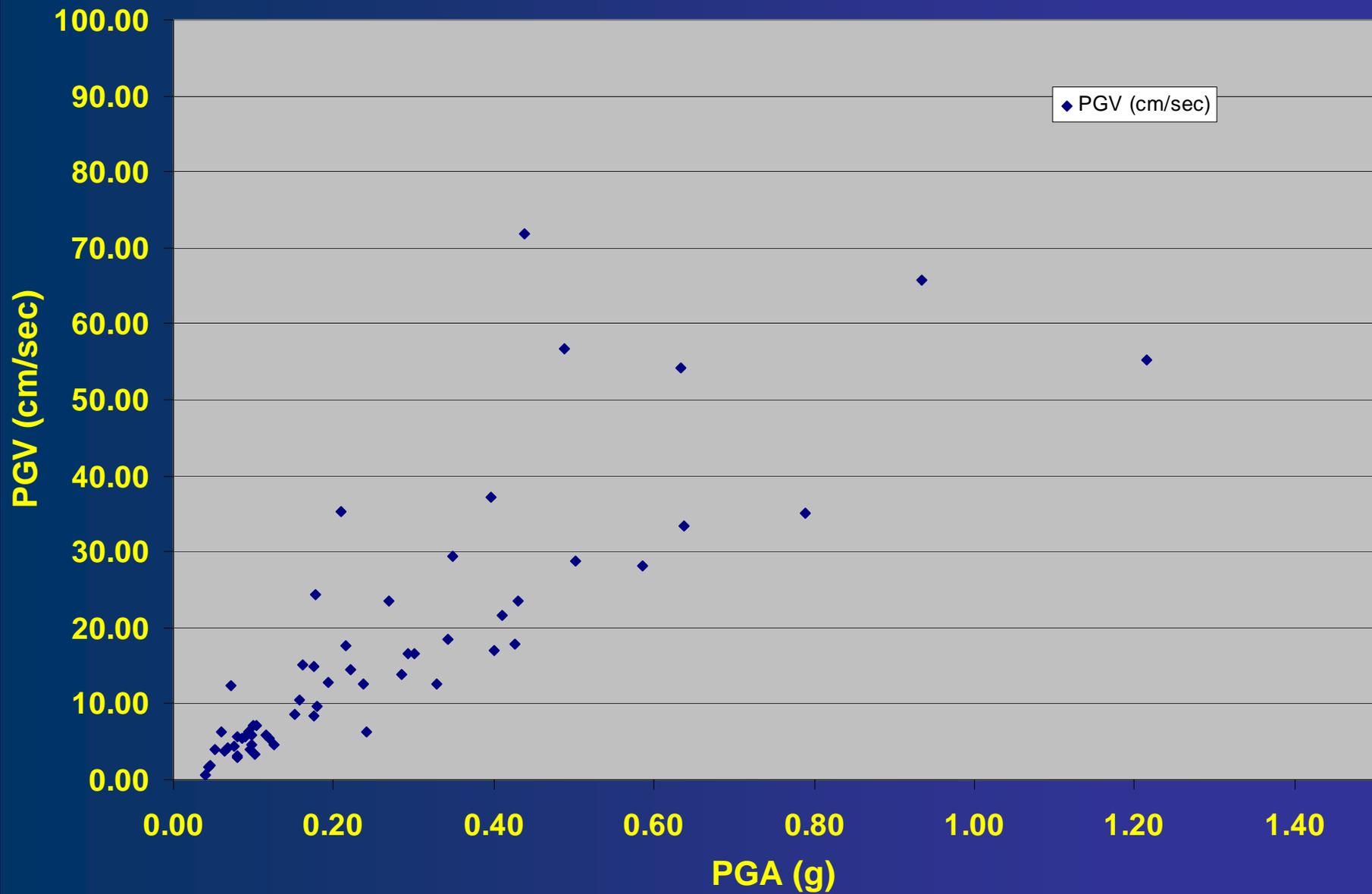
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- Possibility of using joint distributions or vector measures
- Depends on what the mean means.



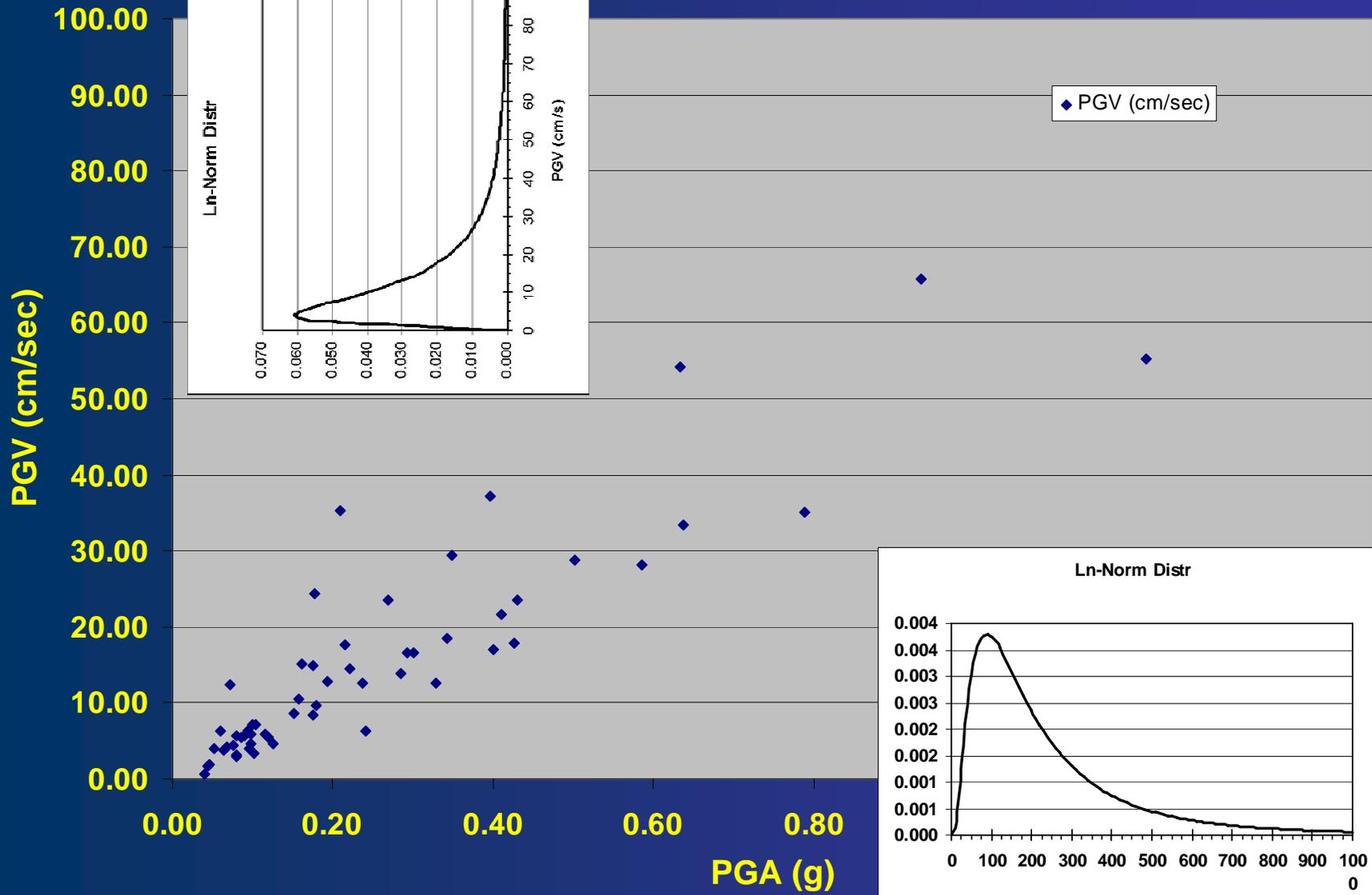
Joint PHA-PHV Occurrences

PGV-PGA firm



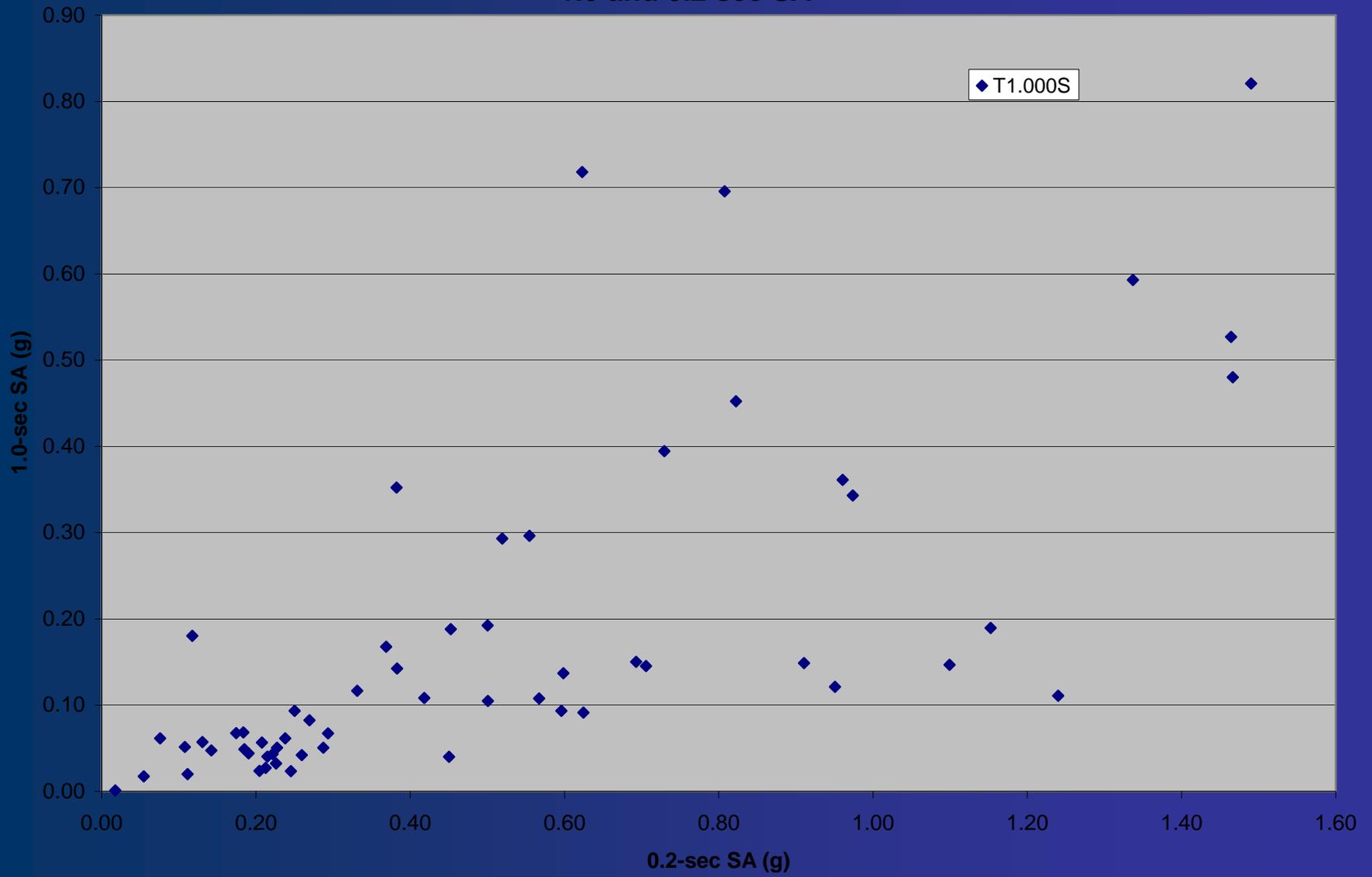
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PGV-PGA firm



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1.0 and 0.2 sec SA

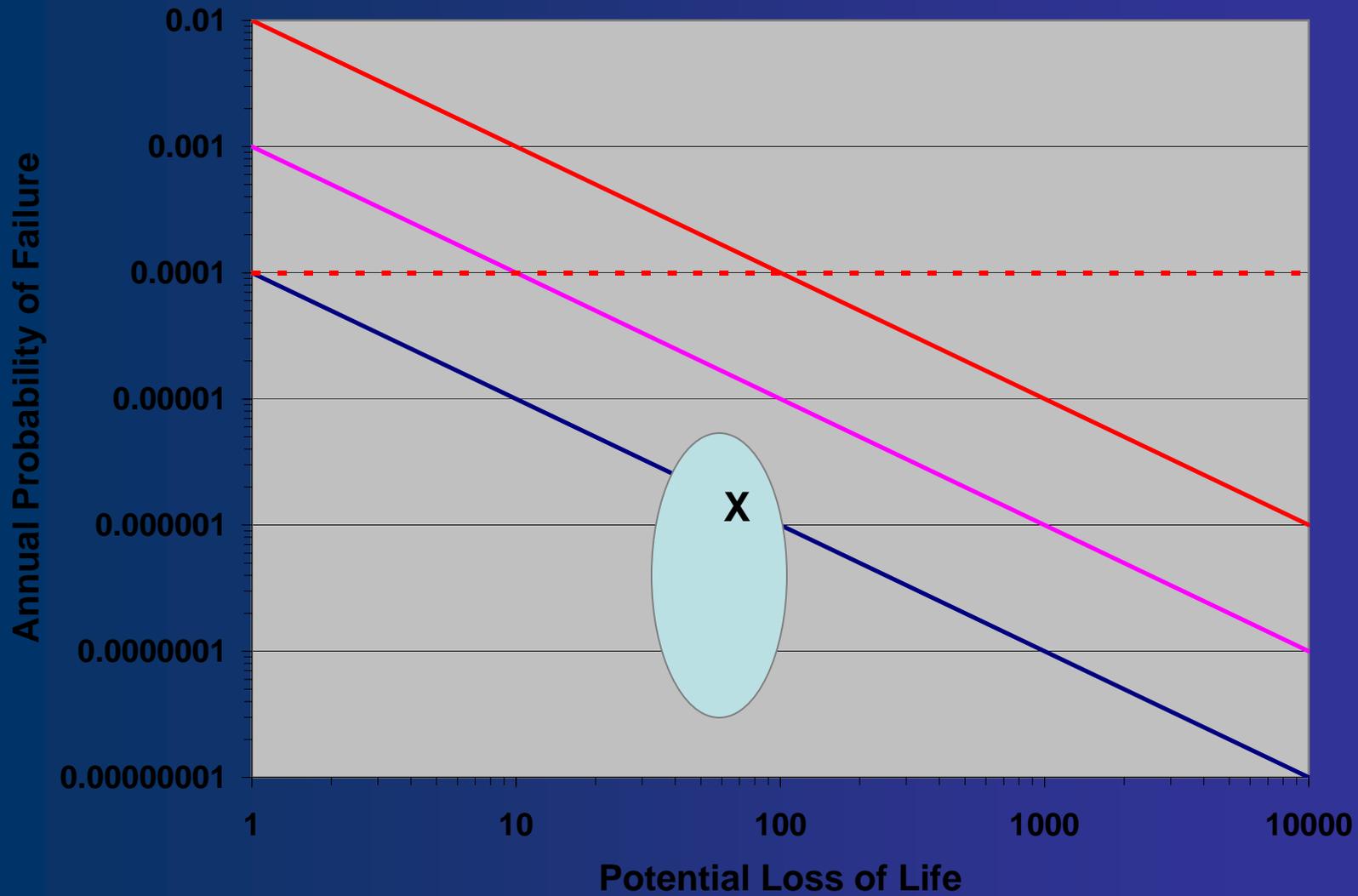


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Integration Issues

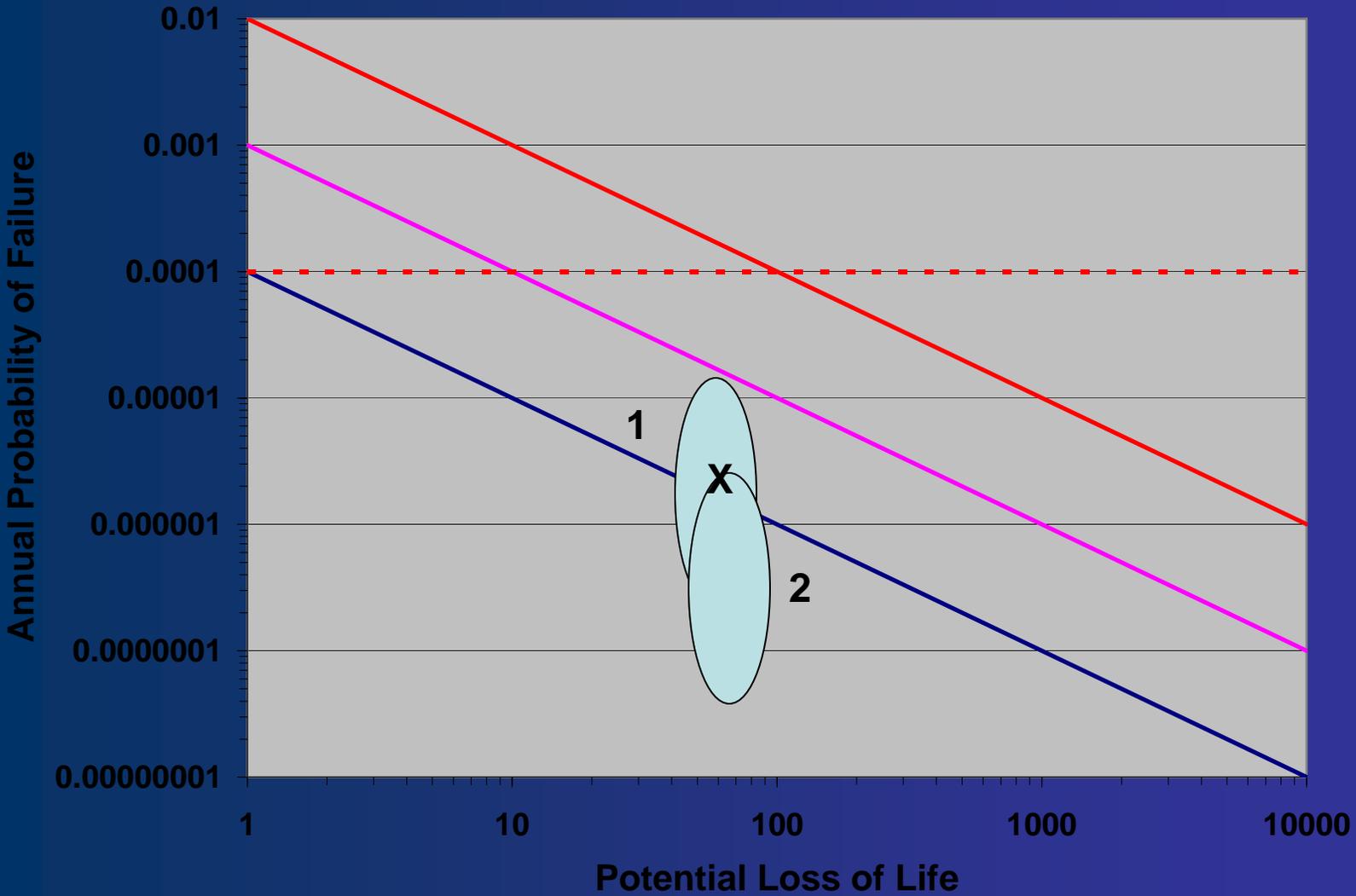
- Generally requires iteration between engineering response team and ground motion development team.
- Modification may lead to a significant change in response properties (the controlling source and/or ground motion metric may change).
- Modification – acceptance criteria.

Demonstration Dam



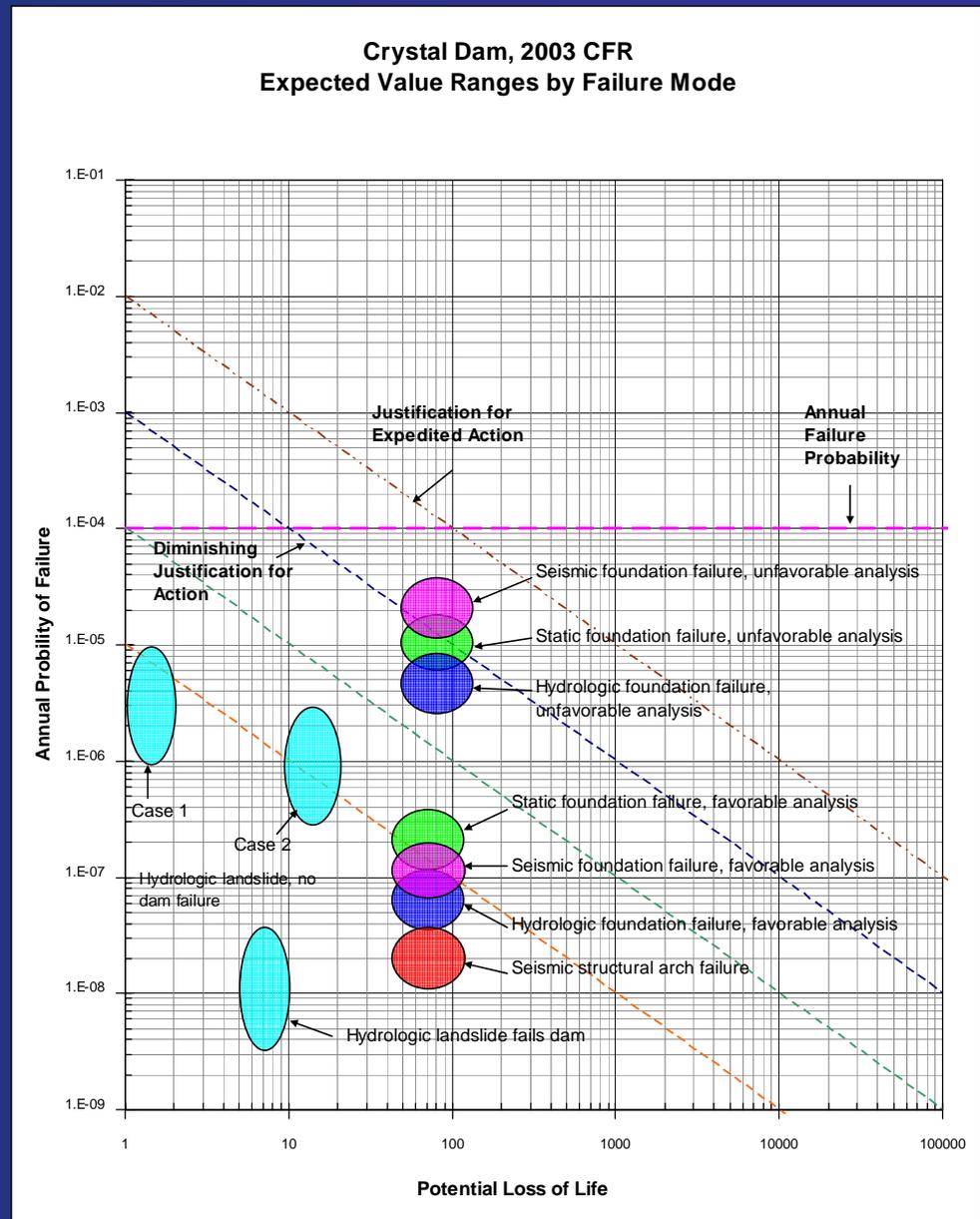
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Demonstration Dam



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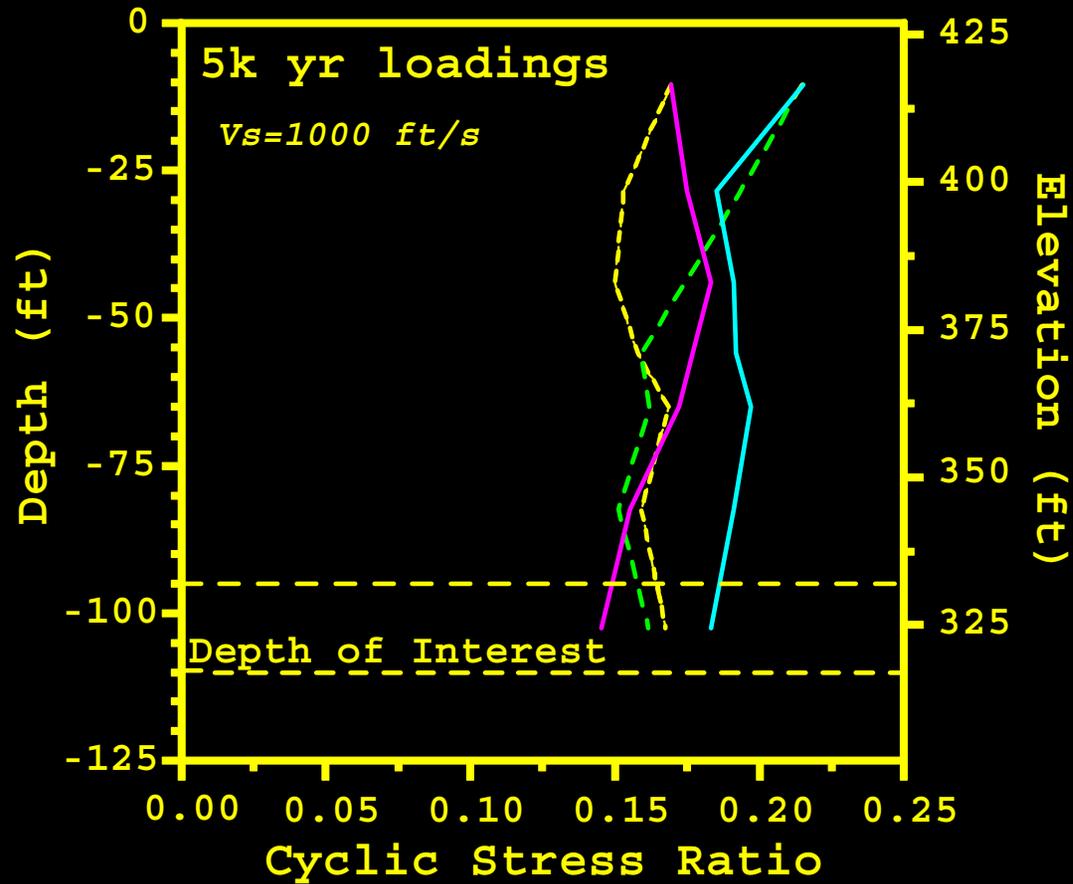
Uncertainty:
lack of
information,
knowledge



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Importance of Time History Selection

CSR vs Depth-Section 2 (CH-92-02)

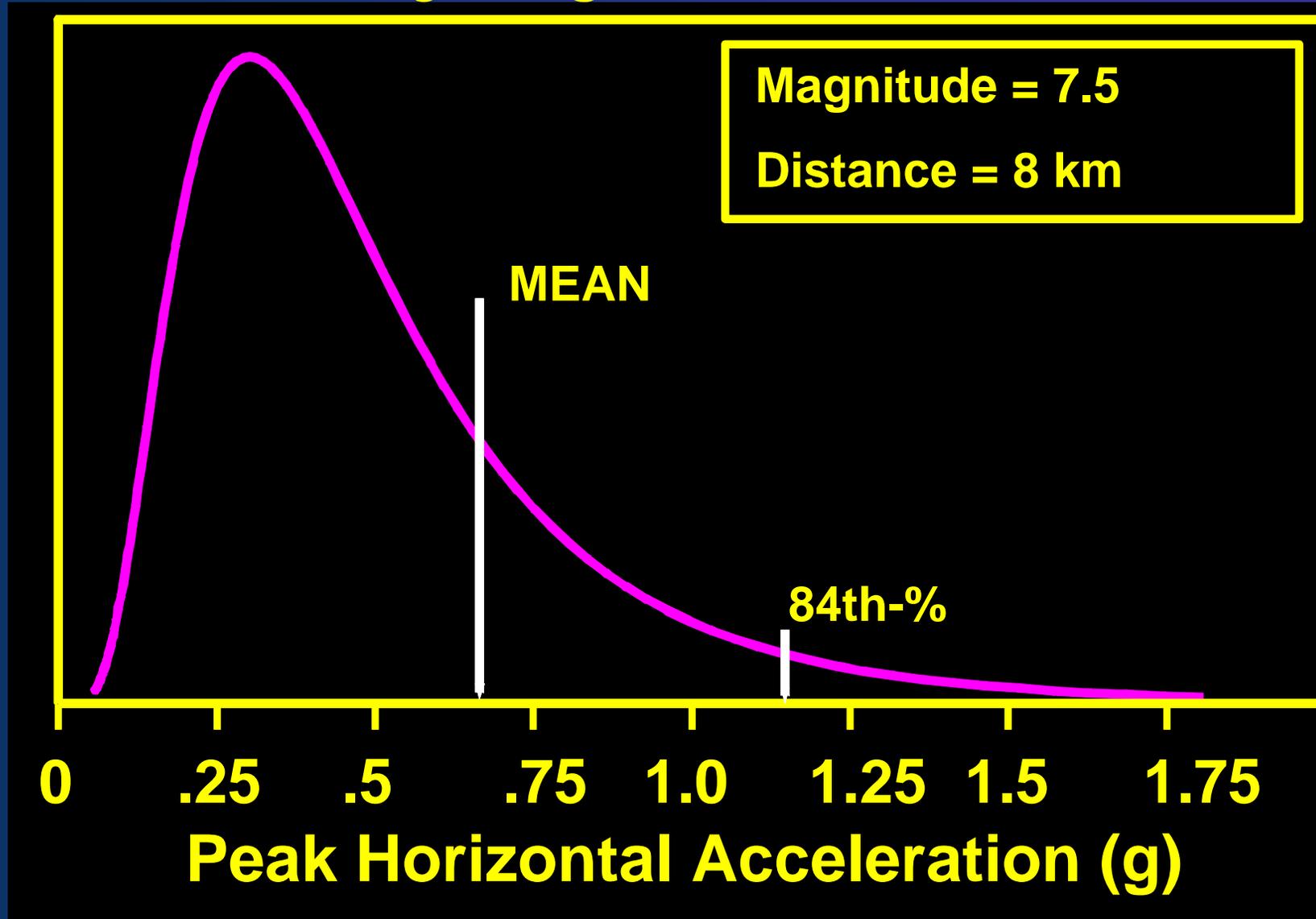


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Liquefaction Analyses

- **Non-linear site response, current state of practice 1D equivalent linear**
- **Fully non-linear and 2D codes becoming available**
- **Significant shortage of good data**

Variability-log normal behavior



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