

**Selection of Ground Motion Time
Histories Using the CSMIP-PEER
Design Ground Motion Library
(DGML)**

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The DGML Concept

- Develop specific sets of time histories judged suitable for dynamic analyses for defined categories of:
 - Seismic hazard environment – “design earthquake”
 - e.g. Near source, strike-slip **M** 6.5-7, “rock-like” site
 - Structural characteristics
 - e.g. Short period (0.05 to 0.5 sec), long period (0.5 to 5 sec) or broad-band (0.1 to 5 sec)
 - Analysis objective
 - Good representation of “expected” motions with limited set (e.g. 3 time histories)
 - Representation of variability with larger set of time histories

DGML PROJECT TEAM

- **Prime Contractor:**
 - Geomatrix Consultants (Maurice Power, Robert Youngs, Faiz Makdisi, Chih-Cheng Chin)
- **Subcontractors and Consultants:**
 - Simpson Gumpertz & Heger, Inc. (Ronald Hamburger, Ronald Mayes)
 - T.Y. Lin International (Roupen Donikian)
 - Quest Structures (Yusof Ghanaat)
 - Pacific Engineering & Analysis (Walter Silva)
 - URS Corporation (Paul Somerville)
 - Earth Mechanics (Ignatius Po Lam)
 - Professor Allin Cornell, Stanford University
 - Professor Stephen Mahin, University of California, Berkeley

CRITERIA FOR FORMING TIME HISTORY RECORD SETS

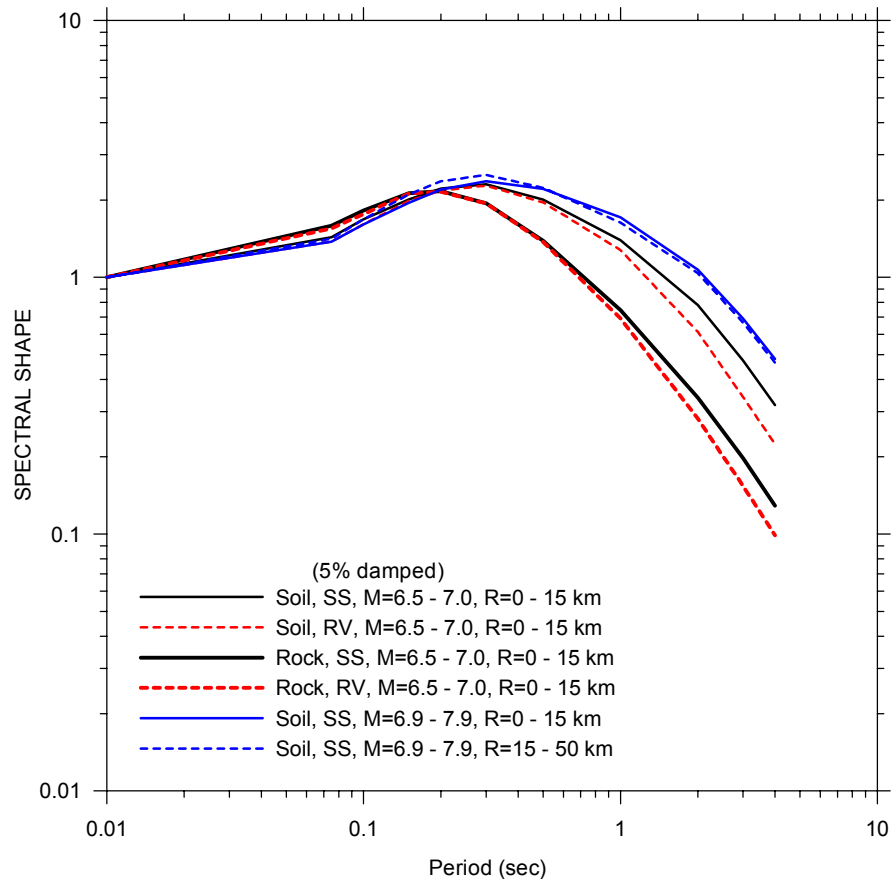
- Starting point is “Design Earthquake”.
 - Deterministic
 - Probabilistic
- Record sets formed for ranges of magnitude (M), distance (R), Mechanism (Mech) and site classifications (S) [M-R-S-Mech bins] that encompass design earthquakes.

(continued)

CRITERIA FOR FORMING TIME HISTORY RECORD SETS

- Two primary criteria:
 - Response spectral shapes of records are representative for M-R-S-Mech bins over defined spectral period ranges for different types of structures [period range sub-bins].
 - Time-domain pulsive characteristics of records are representative of expected ground motion characteristics in near-source record sets.

M-R-S-Mech Bins Based on Difference in Spectral Shape



- Define average spectra and spectral shape using empirical models
- Set bins to capture differences
 - M 5-5.9, 6-6.5, 6.5-7, 6.9+
 - R 0-15, 15-50, >50 for large magnitudes
 - Strike-slip and reverse (rake >30°)
 - Soil versus rock dividing line $V_{s30} = 450$ m/sec

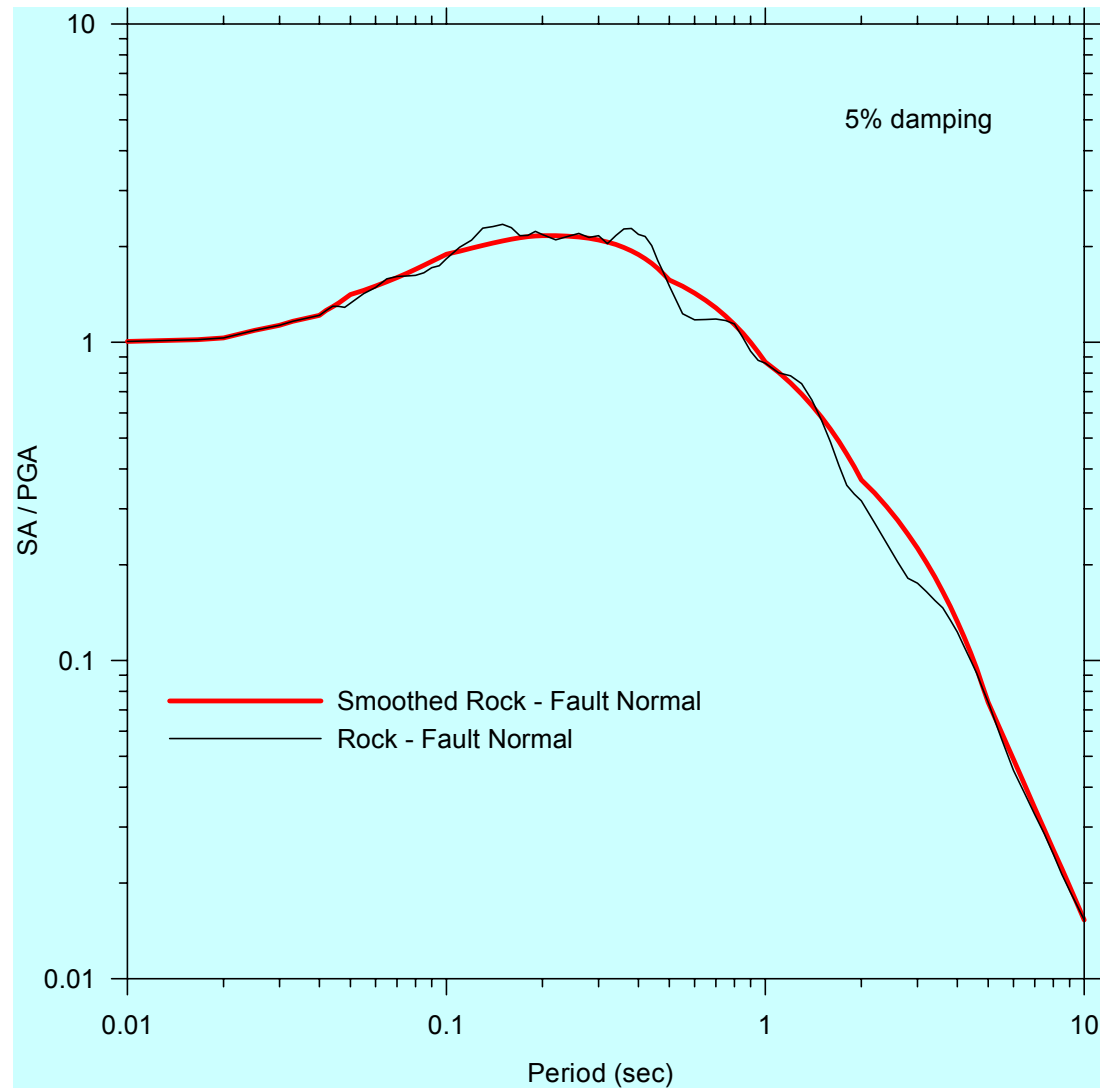
PRELIMINARY PERIOD RANGE SUB-BINS (seconds)

0.05 – 0.5

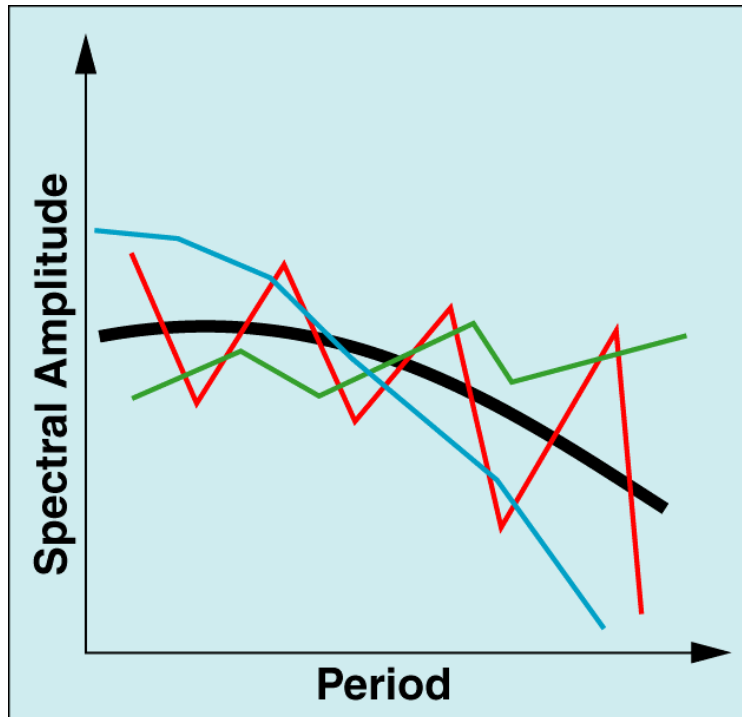
0.5 – 5.0

0.1 – 5.0

Characterize Consistence of Response Spectrum for Individual Record with “Target” Over Spectral Period Range of Interest

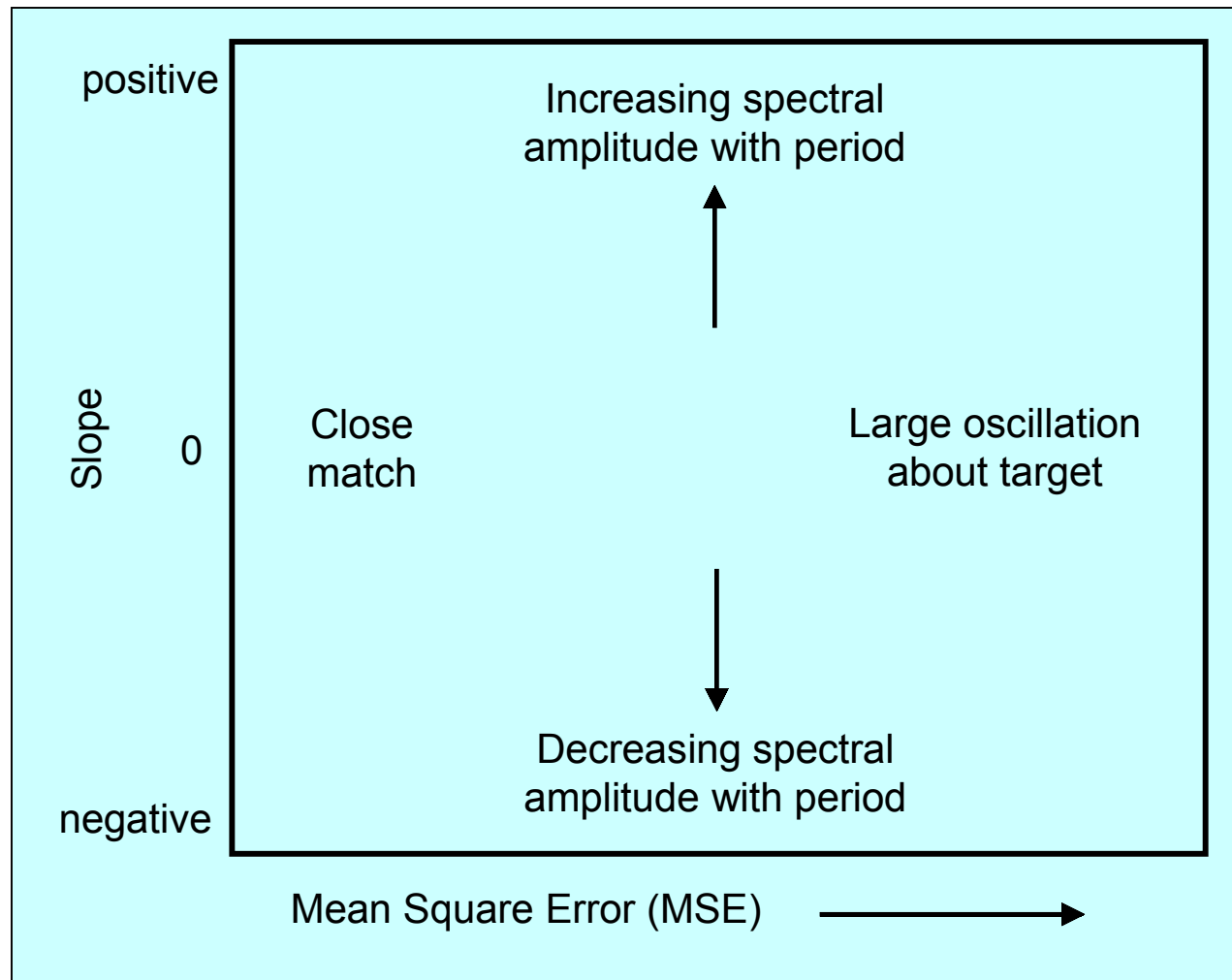


VARIABILITY IN SPECTRAL SHAPE

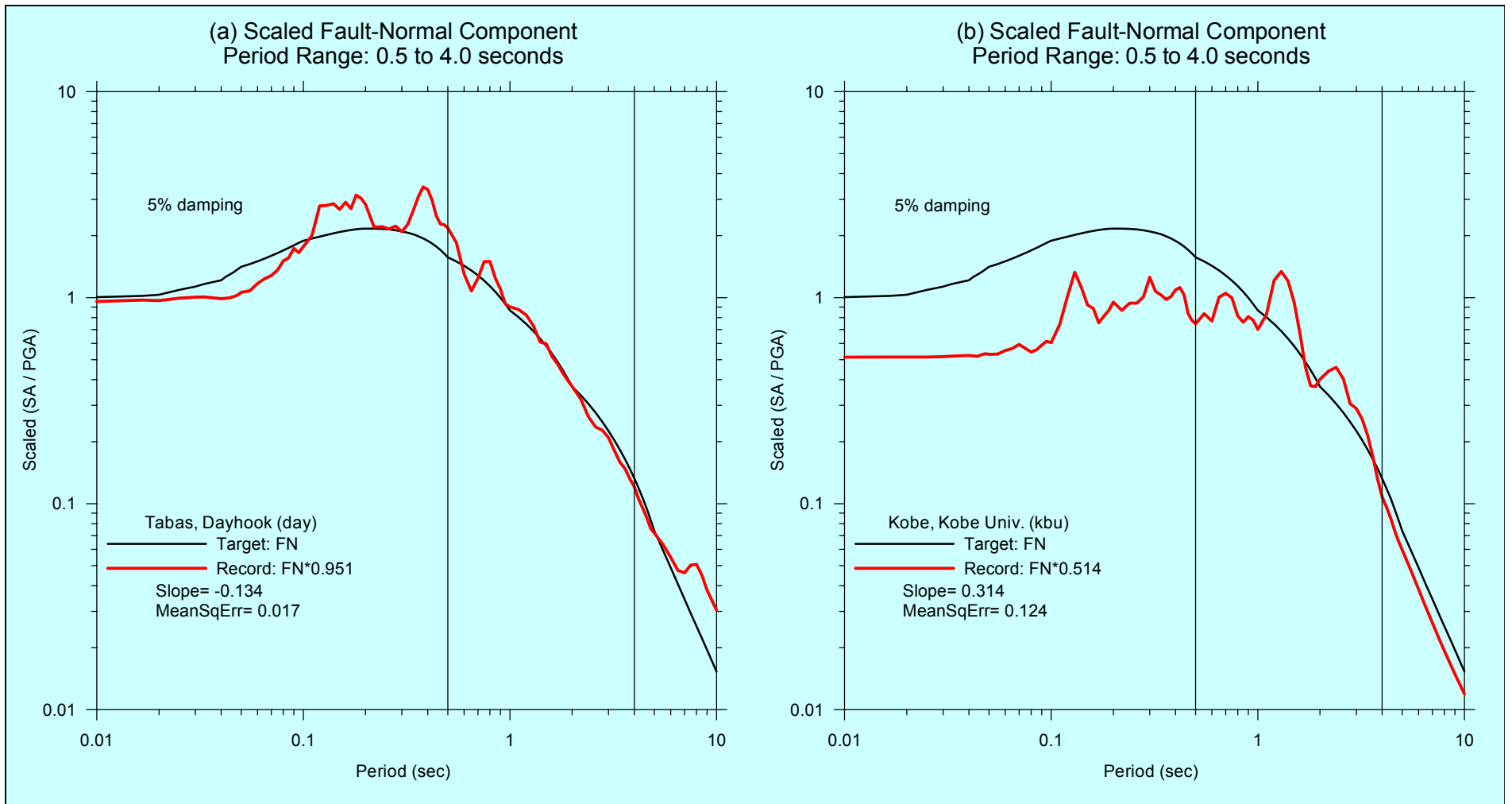


- Spectrum for recording can deviate from target in a number of ways
 - Oscillate about target
 - Cross target with systematic trend to higher or lower amplitudes with increasing period
- Measures of variation of spectral shape of recordings with respect to target
 - Mean square error
 - Slope

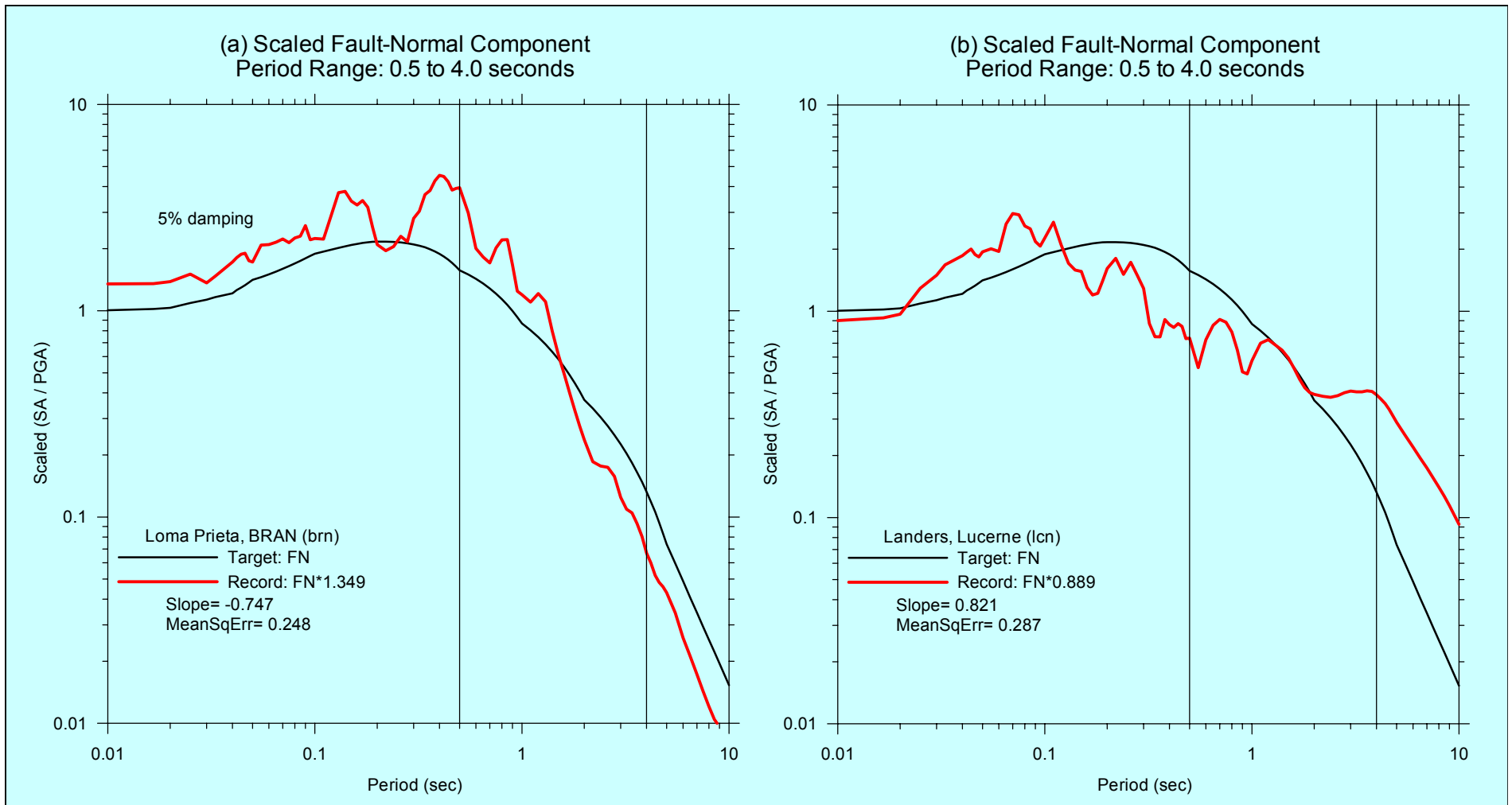
Characterization of “Spectral Match” to Target Spectral Shape



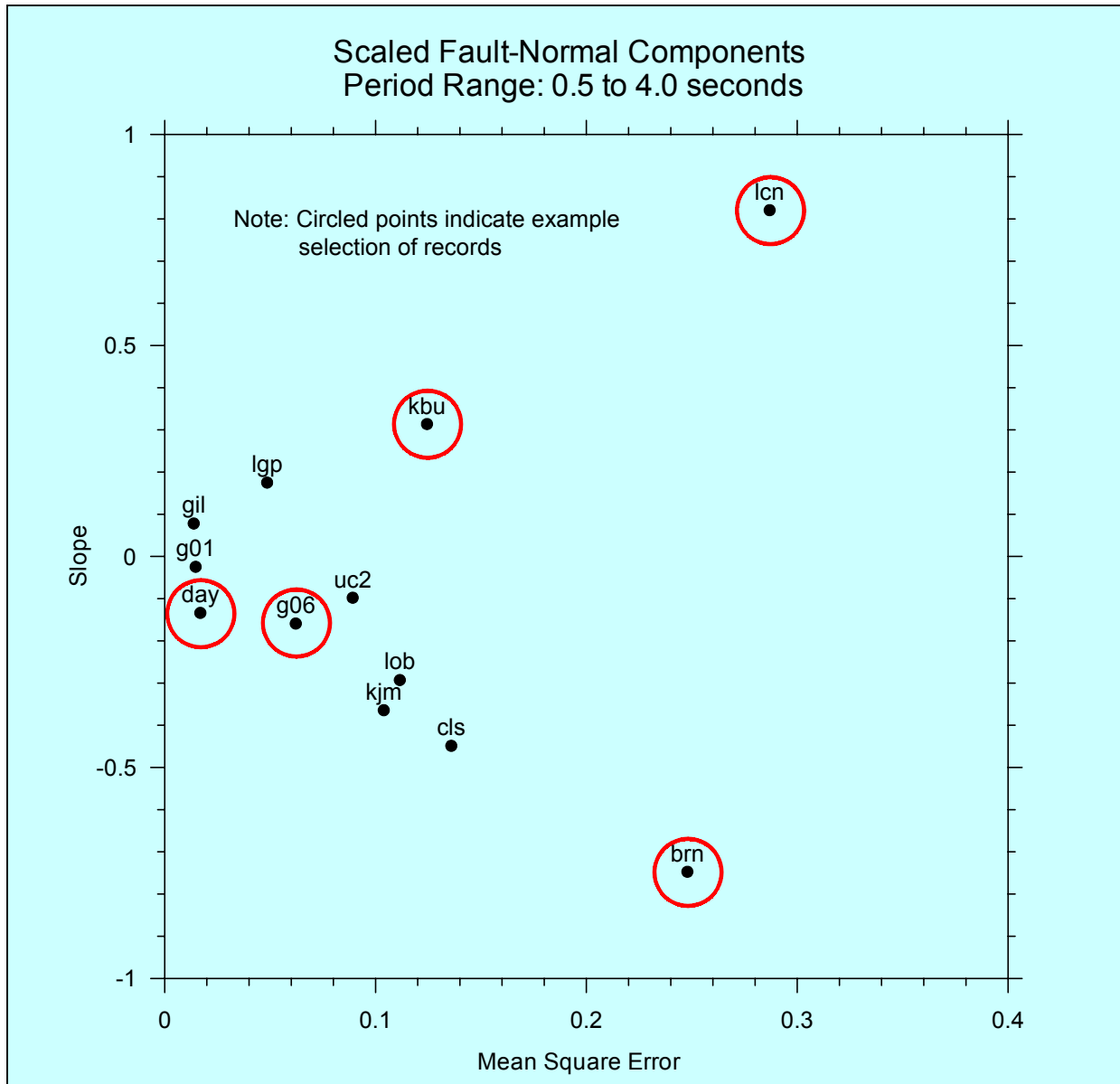
Example Comparisons



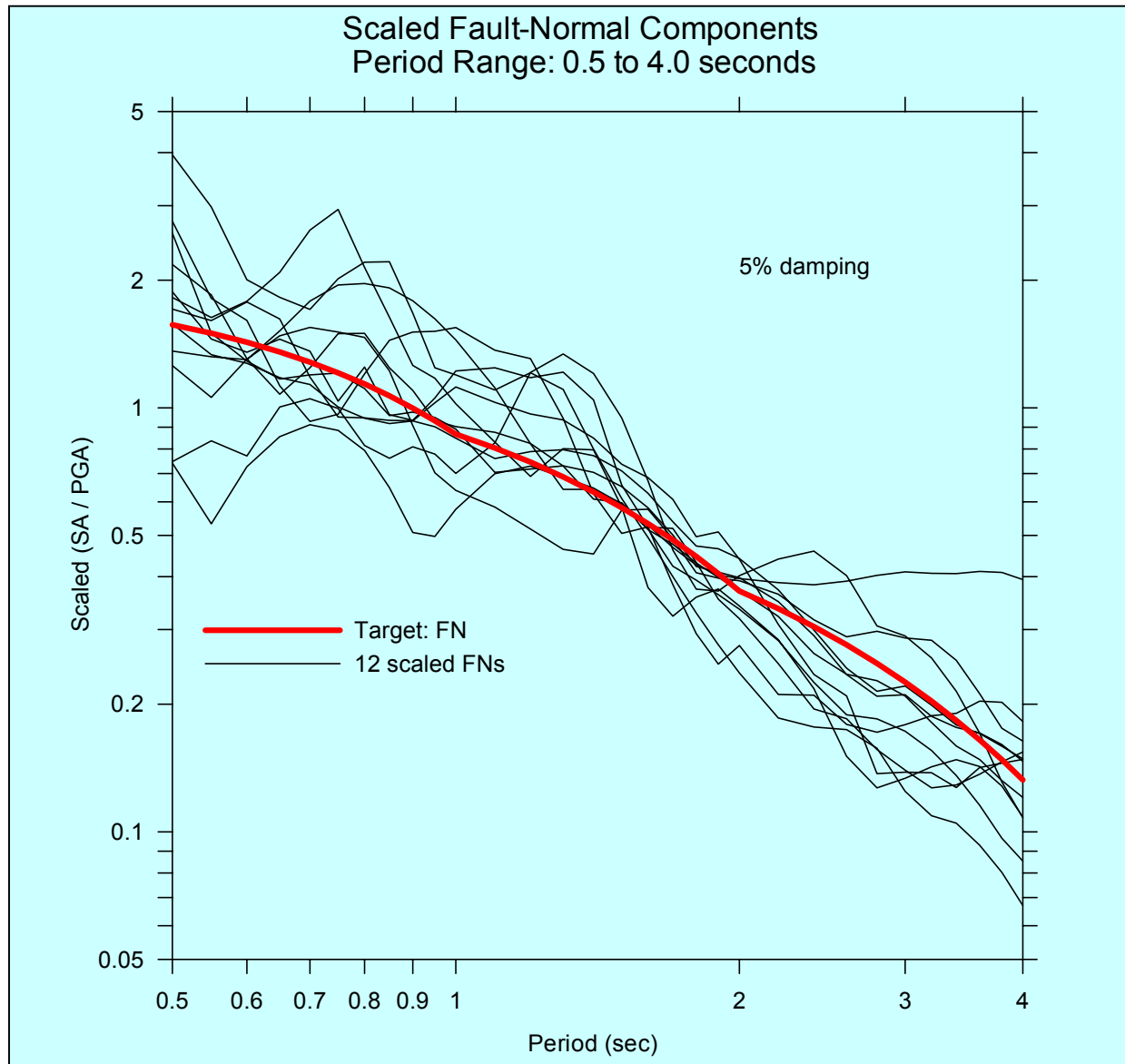
Example Comparisons (cont'd)



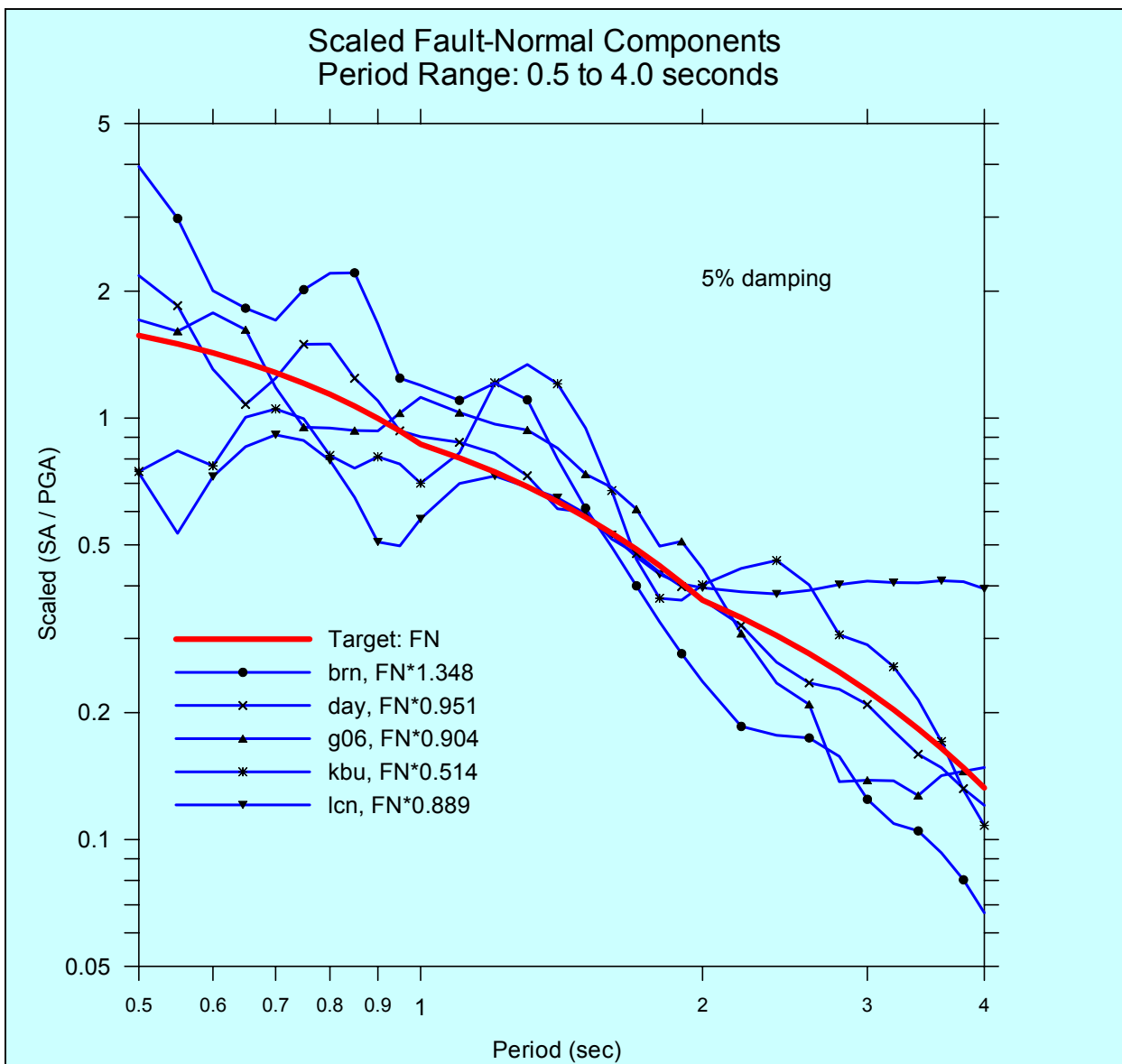
Select Records to Represent Distribution of Fits



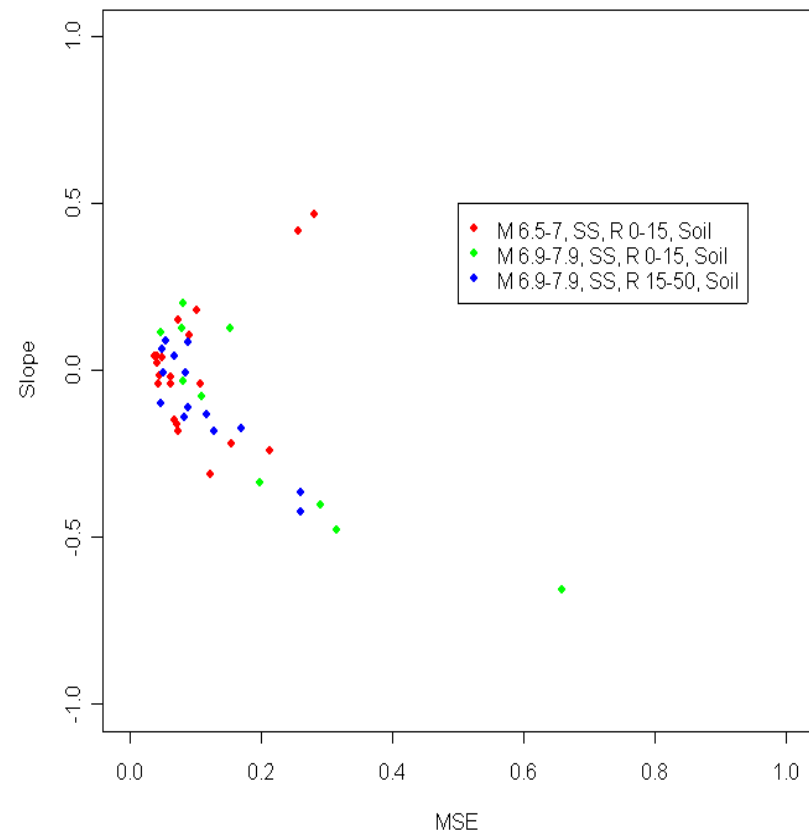
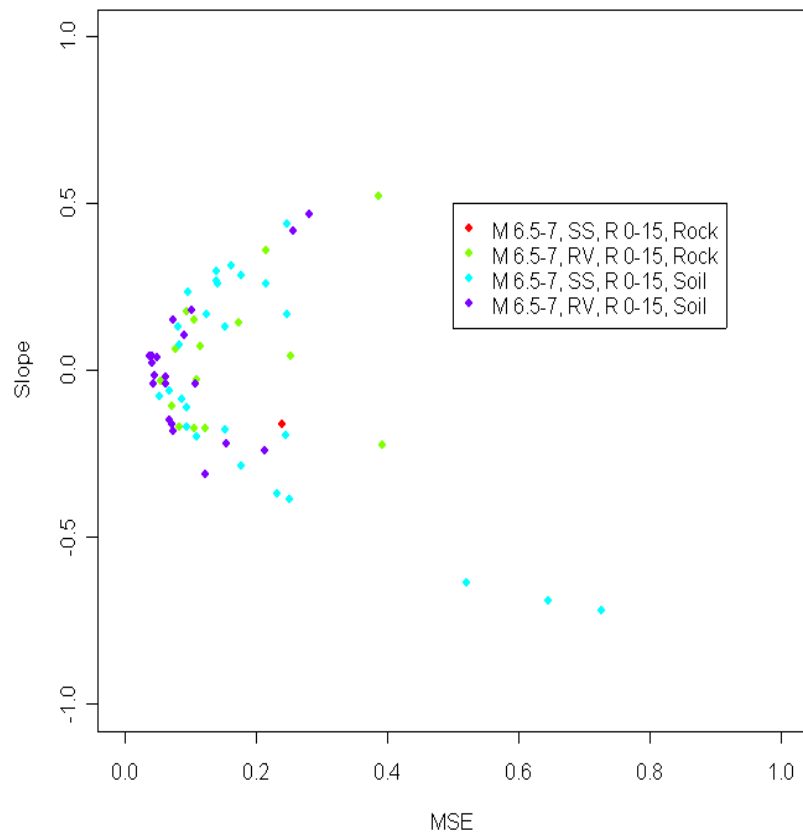
Example Set of Records Representing Distribution of Matches to Target



Example Set of Records Representing Distribution of Matches to Target (cont'd)



Distribution of Records



ADDITIONAL CRITERIA FOR RECORD SET SELECTION

- Record Set Sizes
 - 10 Records
 - Capture variability in spectral shape for M-R-S-Mech and period range.
 - Average responses from time history analyses may be used.
 - 3 Records
 - Select records having closest match in spectral shapes.
 - Maximum responses from time history analyses should be used.
 - 3-record sets will not be provided for near-source bins.

(continued)

ADDITIONAL CRITERIA FOR RECORD SET SELECTION

- Record Sets for 2D vs. 3D Analyses
 - 2D Analyses -- Records consist of 1 horizontal component + vertical component scaled by same factor.
 - 3D Analyses -- Records consist of 2 horizontal components + vertical component scaled by same factor. Spectral shape is evaluated for horizontal components taken together.

(continued)

ADDITIONAL CRITERIA FOR RECORD SET SELECTION

- Near-Source Record Sets
 - Separate target spectra are defined for fault-normal and fault-parallel components for $T > 0.5$ sec.
 - Two record sets are formed for $T > 0.5$ sec.
 - (1) Representative of expected directivity.
 - (2) Representative of strongest directivity.

GROUND MOTION RECORD PARAMETERS CONSIDERED FOR QUANTIFICATION IN DGML

PARAMETER	Published Attenuation Relationship Available	Presently Proposed to be Quantified for Records in DGML
• PGA, PGV, PGD	•	•
• Elastic response spectra	•	•
• Inelastic response spectra	✱	•
• Duration	•	•
• Cumulative Absolute Velocity (CAV)	✱	•
• Energy		
• Damage indices		
• Arias Intensity	•	•
• Housner Spectrum Intensity		•
• Near-source record characteristics		
- pulse velocity	•	•
- pulse period	•	•
- no. of pulses	•	•
✱ Relationships developed, not yet published.		

SUPPORTING INFORMATION ABOUT RECORDS QUANTIFICATION IN DGML

Presently Proposed to
be Quantified
for Records in DGML

Parameter or Characteristic

- Earthquake moment magnitude
- Faulting mechanism (strike slip, reverse, normal, reverse-oblique, normal-oblique)
- Hanging wall vs. foot wall
- Source-to-site distance (closest distance to rupture surface, Joyner-Boore distance)
- Near-fault directivity parameters:
Somerville et al. (1997): s or d , X or Y ,
 $\cos \theta$, $\cos \Phi$, $X \cos \theta$, $Y \cos \Phi$
- Site classification(s): Geomatrix; NEHRP
- Basin response influence

UTILIZATION GUIDELINES FOR THE DGML

- Explanation of bases for record set selections.
- Size of record sets as related to use in design applications.
- Scaling of records to design spectrum.
- Period increments for evaluating aggregate fit of scaled spectra of selected records to design spectrum.