# Final Project Summary — PEER Lifelines Program

| *Project Title*—**ID Number** | *Supplemental USGS Work for NGA Project*—**1L10** | | |
|---|---|---|---|
| **Start/End Dates** | 11/18/03 – 6/30/04 | Budget/ Funding Source | $36,761 / PG&E/CEC |
| **Project Leader (boldface)** and Other Team Members | **P. Spudich,** J. Boatwright, W. Mooney, C. Stephens, T. Brocher, R. Catchings, W. Savage | | |

### 1. Project goals and objectives

A. Development of improved functional forms for directivity, based on isochrone theory, that can be used by NGA attenuation relation developers in their new attenuation models.
B. Depths and uncertainties to 1.5 and 2.5 km/s S-wave velocities for all stations within the Bay Area and northern California that contribute strong motion recordings to the PEER/NGA database.
C. Processed accelerograms for 56 USGS 3-component accelerograms.

### 2. Benefits of the results of this project to develop technologies and protocols to mitigate the vulnerability of electric systems and other lifelines to damage directly and indirectly caused by earthquakes. Also, benefits to develop assessment techniques to evaluate damage to electric systems caused by earthquakes and to assess fiscal impacts due to the loss of electric service to the community.

This project contributes directly to the strong-motion data (C.) and meta-data (B.) in the PEER/NGA database, and to the development of physically-appropriate attenuation relations (A.) for the regressions that form the heart of NGA.

### 3. Brief description of the accomplishments of the project

A. Task A used isochrone theory to develop period-independent functional forms for directivity that have a basis in physics and can be easily used or generalized for nonplanar fault geometries. Several possible functional forms were developed, each of which has a wider range of applicability than previous forms.
B. Task B determined P-wave velocity structures for 6 refraction lines in the Bay Area. These P-wave velocity structures obtained from refraction studies were used to calibrate and revise the Brocher/Jachens/Wentworth Bay Area 3D velocity model. This revised model was used to estimate the depth to the 1.5 and 2.5 km/s S-wave velocities beneath the strong motion stations.
C. Task C vetted and processed 56 accelerograms, which has added important data to the PEER database.

### 4. Describe any instances where you are aware that your results have been used in industry

None yet.

### 5. Methodology employed

A. Task A used isochrone theory, a method based on ray theory, that yields simple analytical expressions.
B. Task B determined P-wave velocity structures for the 6 refraction lines in the Bay Area by standard analysis techniques. The P-wave velocity structures obtained from these refraction studies were systematically different from the Brocher/Jachens/Wentworth Bay Area 3D velocity model. Depths of isovelocity surfaces in the 3D model were revised to correct the systematic differences from the refraction results.
C. Task C vetted and processed the 56 accelerograms using standard USGS processing procedures.

### 6. Other related work conducted within and/or outside PEER

A similar 3D-velocity structure of the Los Angeles region has been developed for the Southern California Earthquake Center.

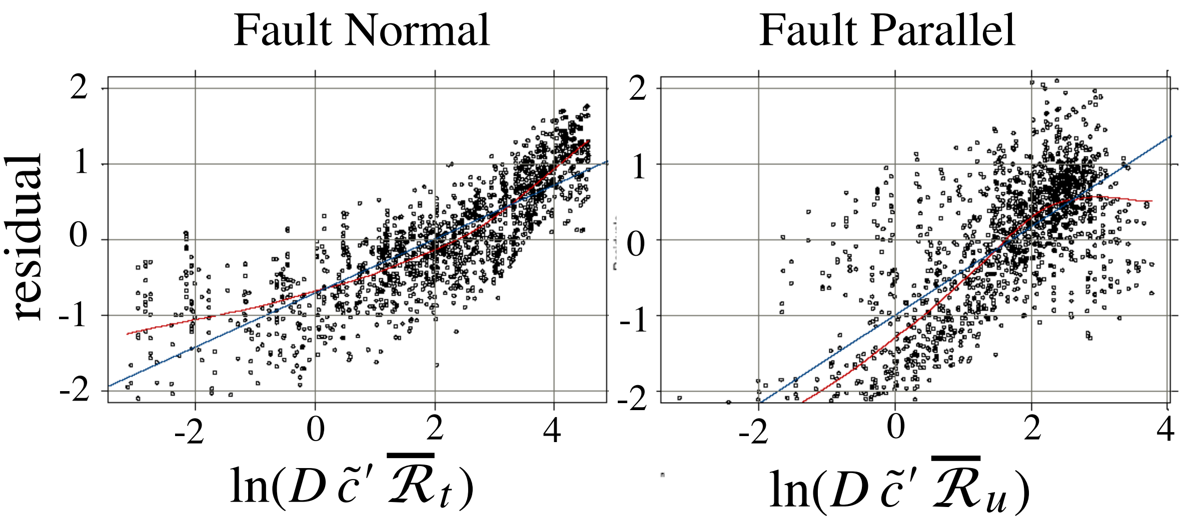
### 7. Recommendations for the future work: what do you think should be done next?

It would be possible to use isochrone theory to develop period-dependent functional forms for directivity.

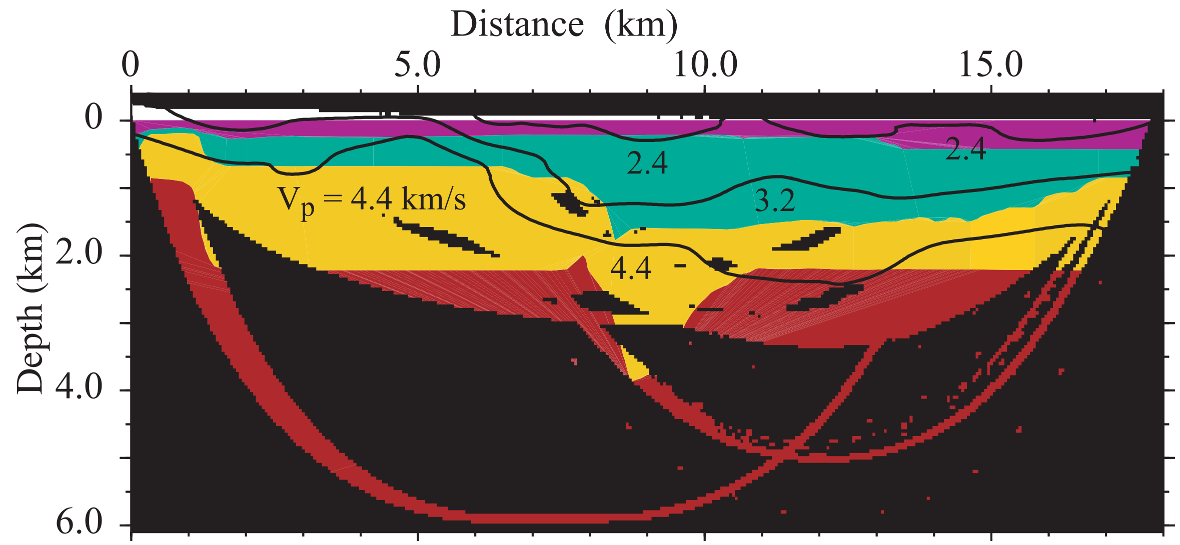
### 8. Author(s), Title, and Date for the final report for this project

Spudich, P., Chiou, S.J., Graves, R., Collins, N., and Somerville, P., A formulation of directivity for earthquake sources using isochrone theory, U.S. Geological Survey Open-File Report 2004-1268, 54 pp., http://pubs.usgs.gov/of/2004/1268/

Boatwright, J., Blair, L., Catchings, R., Goldman, M., Perosi, F., and Steedman, C., Using twelve years of USGS refraction lines to calibrate the Brocher and others 3D Velocity model of the Bay Area, Geological Survey Open-File Report 2004-1282, 33 pp., http://pubs.usgs.gov/of/2004/1282/




Correlation of isochrone directivity parameter with 3-s SA residual for fault-normal and fault-parallel components of motion for synthetic test strike-slip event. Residual is ln(numerically generated SA for test event) - ln(best-fitting nondirective model).




Comparison of a slice through the Brocher et al. (1997) 3D velocity model (solid colors) with Catchings et al. (2004) model (black contours) derived from a linear seismic refraction profile 1025 through Los Gatos, CA. Solid black areas are regions where the Catchings model is undefined. Purple/teal, teal/yellow, and yellow/maroon interfaces are the 2.4, 3.2, and 4.4 km/s contours in the Brocher model. In general, Catchings' velocity contours are shallower than Brocher's.