On Building a Seismic Hazard Model for Tutuila, American Samoa, with Site Specific Vs30

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The basic PSHA for American Samoa was performed with the assumption that the site condition Vs30 is uniformly 760 m/s, the shear-wave velocity at the NEHRP B/C boundary, to be consistent with other USGS/NSHMP PSHA work. Computing site-dependent hazard instead of fixed-site-condition hazard requires a model of the local site conditions, which we characterize using the average shear-wave velocity in the top 30 m, or Vs30. At Tutuila, American Samoa, the only known map of Vs30 is that of the USGS, the topography/topographic slope derived Vs30, from a study by Wald and Allen (2007). Geology maps of Tutuila and other islands are also available, but these maps do not associate Vs30 with the geologic units, which tend to be volcanic, tuffs and andesite/basalt flows, with limited beach sand near coastlines.

For this preliminary study of site-dependent hazard, we use the Vs30 map of the USGS as our site data, available from the Web at URL http://earthquake.usgs.gov/hazards/apps/vs30/, last accessed September 7, 2012. Figure 1 is a map of the Vs30 we used. One feature of fig. 1 is that there is little effect from low-velocity beach sand around the main bays, whereas geologic maps do show beach sand surrounding these bays. The thickness of the low-velocity sand layer may be too limited for it to have a significant effect on spectral response at periods of engineering interest in many of those beach areas, although soil response properties such as susceptibility to liquefaction during episodes of strong ground shaking are always important. Topography is often quite steep right up to or very near these shorelines. Verifying or improving the Vs30 model near the shoreline would be helpful because of the concentration of businesses, port facilities and population there.

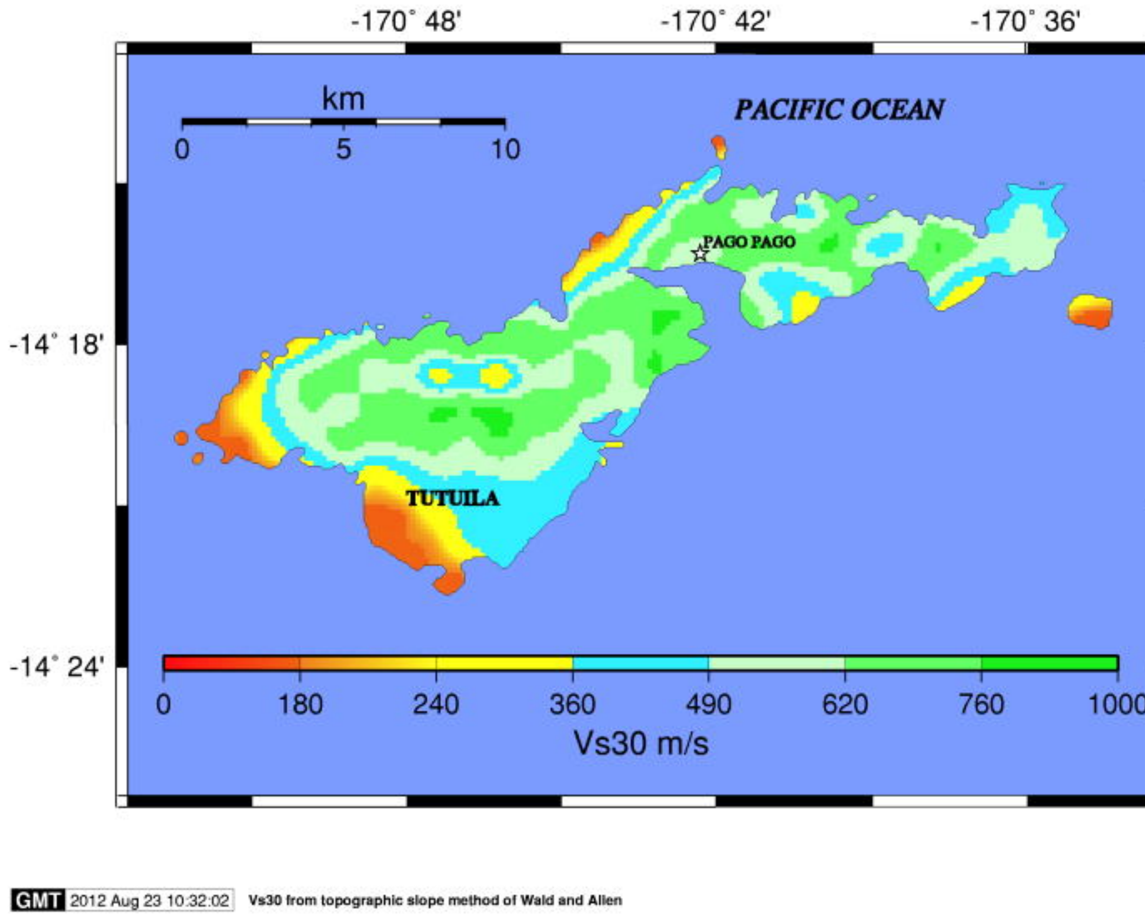

Figure 1. Modeled average shear-wave velocity in top 30 meters, from USGS maps available on the web.

We use the soil-response models that are embedded in the ground motion prediction equations, or GMPEs, to compute the hazard "inside the hazard integral," as distinguished from computing a site-amplification factor from the corresponding rock motions at each site based on the assigned Vs30 and the NEHRP tables. The Zhao *et al.* (2006) GMPE bases predicted response on five site classes, hard rock, rock, hard soil, medium soil, and soft soil, but does not vary soil-column amplification with intensity of rock ground motion at the base of the soil column. The hard-rock category, with Vs30> 1100 m/s, is not sampled in the Tutuila Vs30 map. All of the NGA-W GMPEs, however, do vary site response continuously with Vs30 and with intensity of rock ground-motion at the base of soil column. This non-linear site response feature is an important enhancement that the NGA-W developers wanted to add to their models.

We used the source model of the latest NSHMP PSHA for American Samoa, the one post-dating Open-File Report 2012-1087, for this study. Site locations are sampled at 0.01˚ increments in latitude and longitude to prepare these figures. The resulting hazard curves and map values for 0.2-s and 1.0-s spectral acceleration (SA) and for PGA are stored in the Samoa data folder. Figures 2, 3, and 4 show the probabilistic PGA, 0.2-s SA, and 1.0-s SA, respectively, computed at the 2% in 50 year probability of exceedance for site condition shown in the Vs30 map of fig. 1.

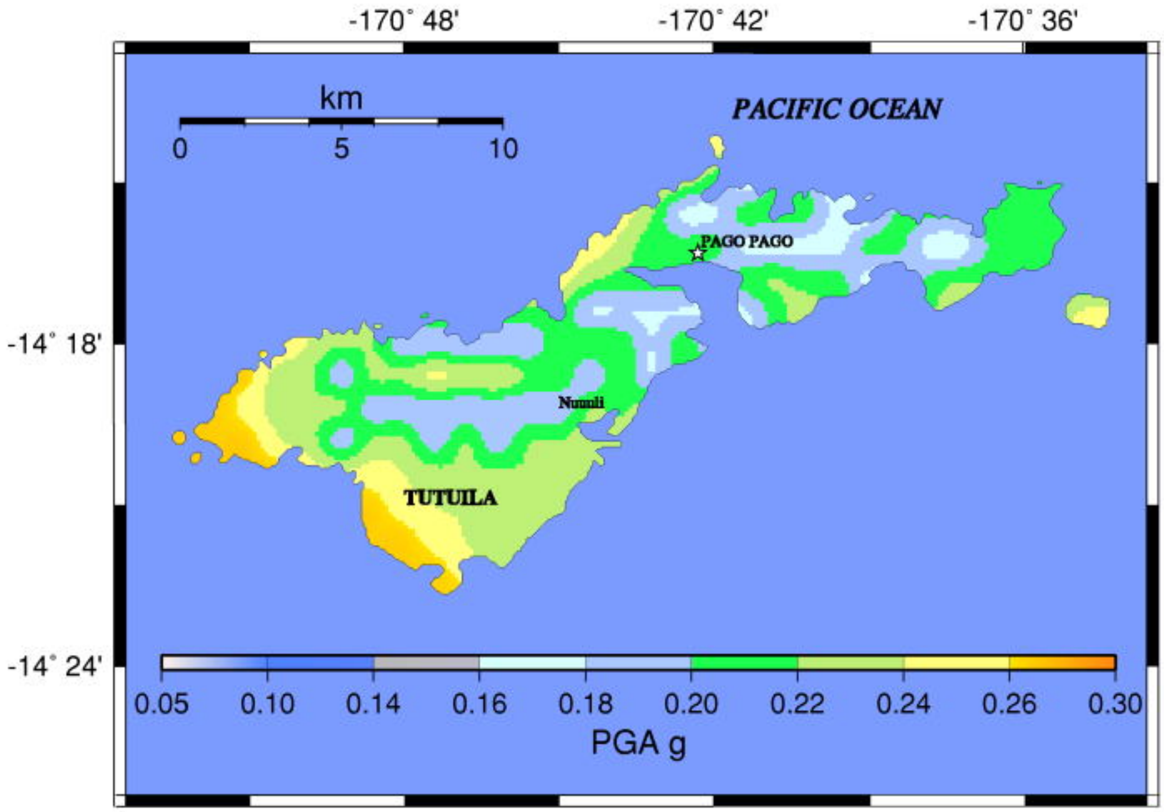

Figure 2. Probabilistic peak ground acceleration at sites on Tutuila with site-specific Vs30 having probability of exceedance of 2% in 50 years.

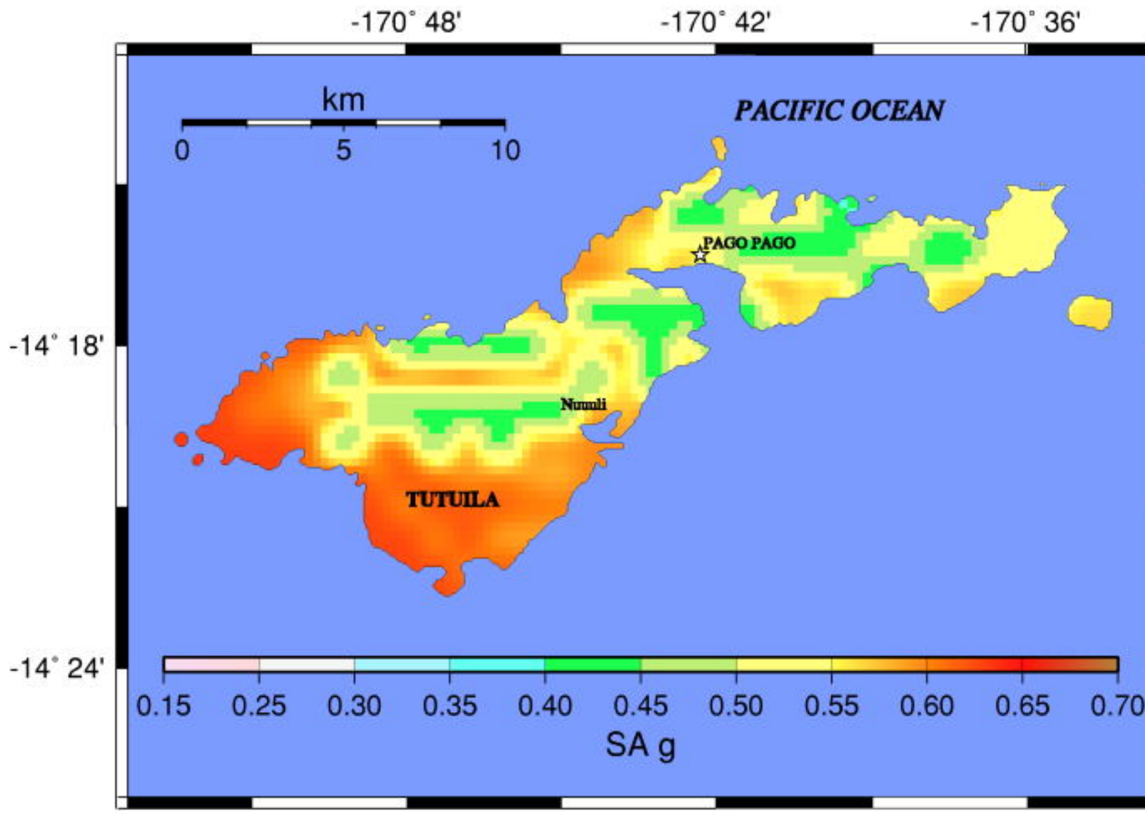

Figure 3. Probabilistic spectral acceleration for spectral period 0.2-s at sites on Tutuila with site-specific Vs30 having probability of exceedance of 2% in 50 years.

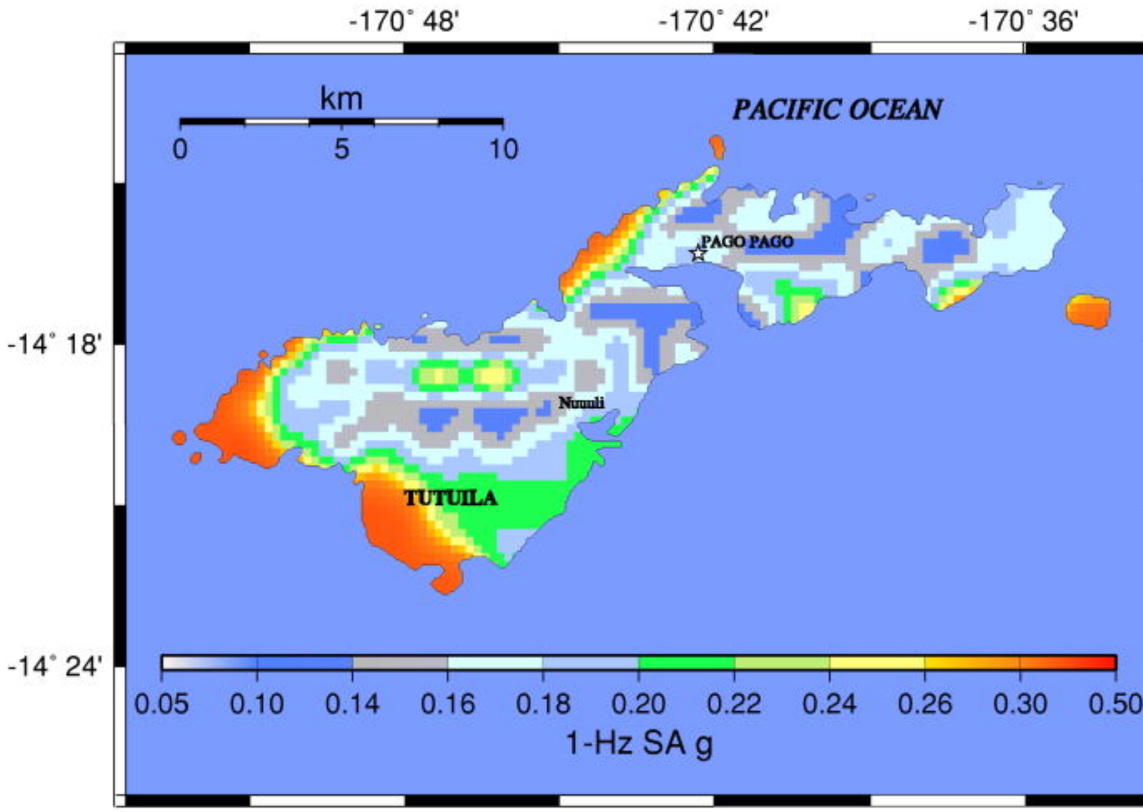

Figure 4. Probabilistic spectral acceleration for spectral period 1.0-s at sites on Tutuila with site-specific Vs30 having probability of exceedance of 2% in 50 years.

Figures 5 and 6 show the probabilistic spectral acceleration at 0.2-s and 1.0-s periods, respectively, where now we assume a uniform rock at the NEHRP B/C boundary, with Vs30=760 m/s as the site condition. The main factor affecting variations in rock probabilistic ground motion on the island of Tutuila is nearness to the trench and its subduction and nearby outer-rise sources.

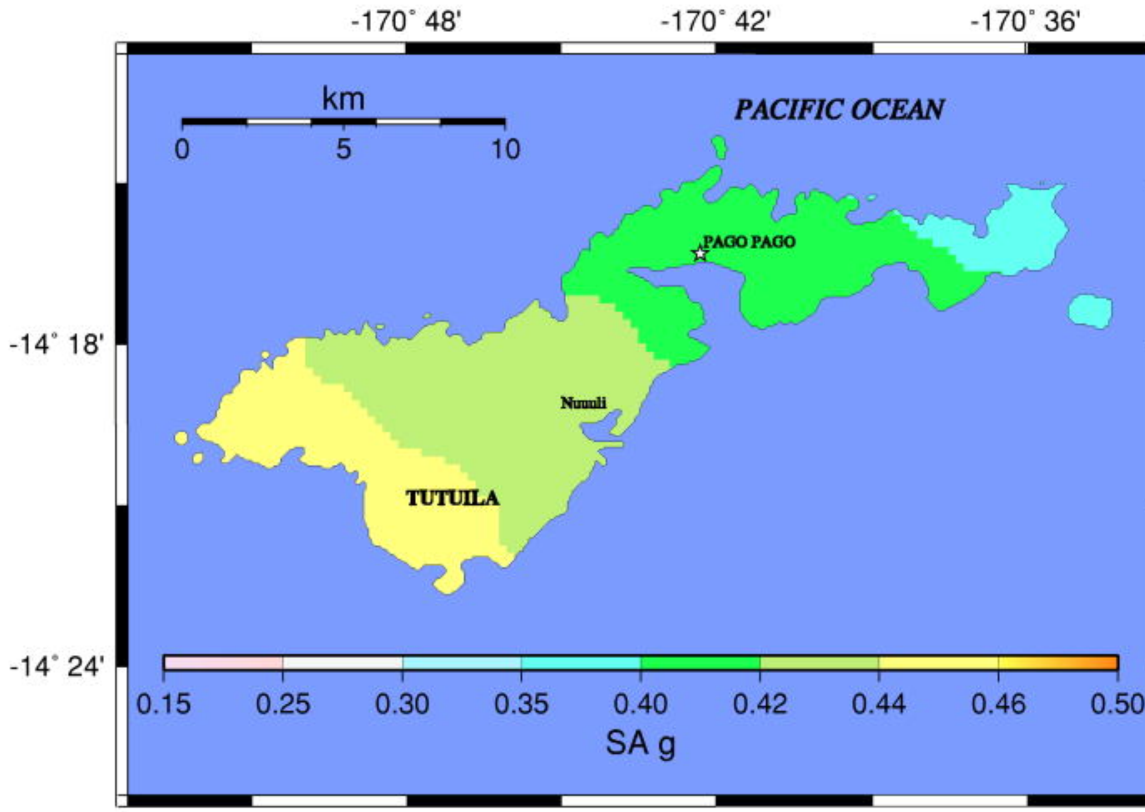

Figure 5. Probabilistic spectral acceleration at 0.2-s period (5 Hz) on the island of Tutuila, assuming B/C rock site condition.

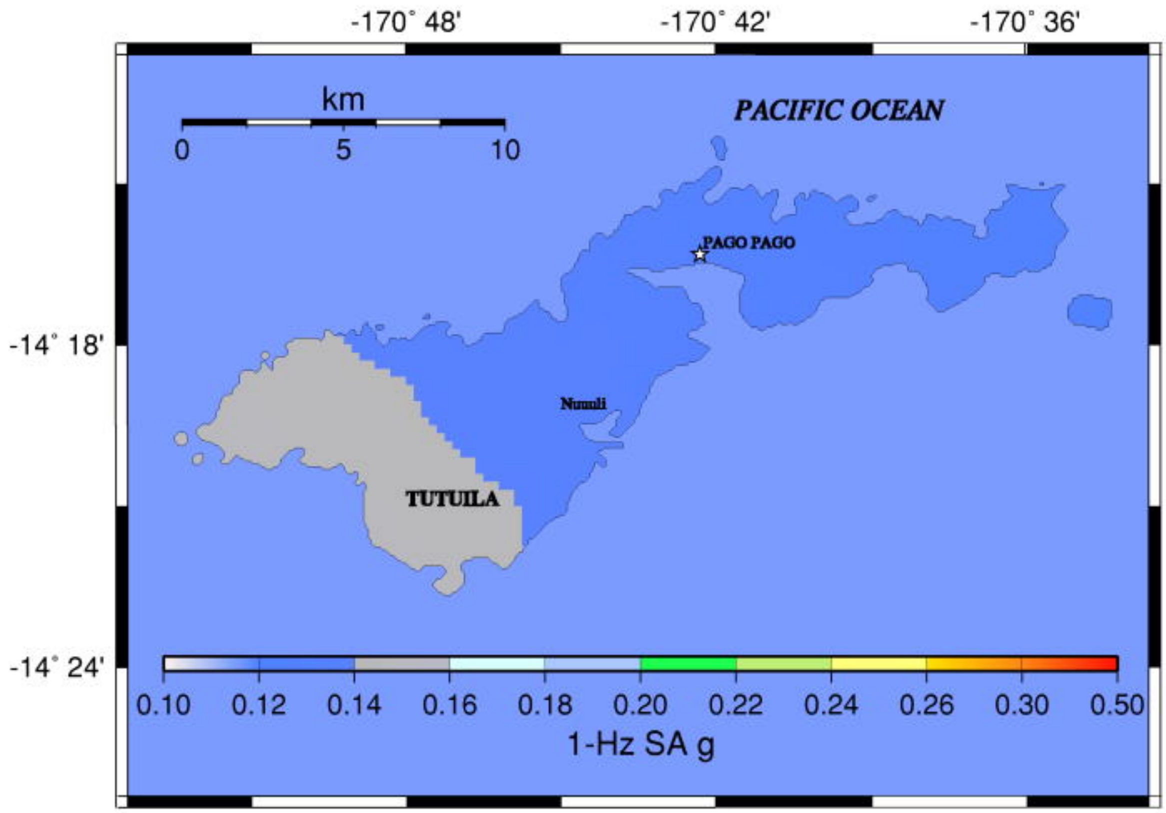

Figure 6. Probabilistic spectral acceleration at 1.0-s period (1 Hz) on the island of Tutuila, assuming B/C rock site condition.

On the island of Tutuila, probabilistic ground motions at the 2% in 50 year probability of exceedance tend to be relatively low, and non-linear damping in the soil column is not expected to be a major consideration. Thus the limitations of the Zhao *et al*. GMPE relative to the NGA-W GMPEs are not believed to be severe. Several soft-soil sites (with velocity near NEHRP D/E boundary) are present in fig. 1 although further geotechnical analysis is needed to demonstrate the validity of this assertion; furthermore, several potential soft-soil sites may exist near the main bays of Tutuila but may not have been recognized by the topographic slope method.

Reference:

Wald, D. J., and T. I. Allen (2007). Topographic slope as a proxy for seismic site conditions and amplification, Bull., Seism. Soc. Am., Vol. 97, No. 5, 1379-1395.