CLARK COUNTY EARTHQUAKE PARCEL MAP VS30 EFFECTS ON PREDICTIONS OF SHAKING FOR LAS VEGAS

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Tuesday, June 26, TT0003. SEISMIC HAZARD ASSESSMENT
Fractal Dimension of Shear-Wave Velocity, from 1 meter to 60 kilometer scale – $D = 1.7$

Spatial spectra of a shear-velocity transect across the LA Basin and a borehole to 350 m give similar fractal dimension.

Fractal Dimension: $D = \frac{5 - \beta}{2}$ (Carr, 1995)
Measurements show deterministic and apparent stochastic (aleatory) parts.

Within the 1500 km² measured, average array spacing of 300 m.

$Vs_{30}$ = time-averaged shear velocity from surface to 30 m depth.

Clark County Parcel Map
Pancha et al., BSSA 2017

Imagery Data: 6/14/2013 36°09'08.45" N 115°02'56.24" W
Spatial Statistics of CCPM Vs30

Fractal Dimension: $D = \frac{5 - \beta}{2}$

- Linear fall on log-log plot shows fractal nature, self-similarity at different scales
- East-west and north-south fractal dimensions match, isotropic

(Carr, 1995)
Model Building: Enterprise M3.6 Oct. 5, 2014

USGS Basin Thickness

CCPM Geotechnical Vs30
Waves from Enterprise M3.6 Oct. 5, 2014

**NSZ-E3D at 0.5 Hz**

**3D Computed PGV Map**

Amplification in Small Sub-Basins
Good Match to Recorded PGV

Small Sub-Basins, Edges

Recorded vs. Computed GM

Enterprise M3.6 10/05/14

<table>
<thead>
<tr>
<th>Location</th>
<th>Recorded PGV (cm/sec)</th>
<th>Computed PGV (cm/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RRK</td>
<td>0.059</td>
<td>0.131</td>
</tr>
<tr>
<td>UNVG</td>
<td>0.128</td>
<td>0.115</td>
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<tr>
<td>LV04</td>
<td>0.085</td>
<td>0.112</td>
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<tr>
<td>WTNK</td>
<td>n/a</td>
<td>0.011</td>
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<tr>
<td>CC16</td>
<td>0.045</td>
<td>0.026</td>
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</tbody>
</table>

PGV, cm/sec
Sensitivity Test on Parcel Map

**PGV Ratio Map:**

48% - 193% amplification from Parcel Map (blue to red)

Hard to predict; Amplifications on same spatial scale as Vs30 variations.
## Origins of Basin Amplification Effects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Conservation of Energy</th>
<th>Vertical Resonance</th>
<th>Horizontal Resonance</th>
<th>Trapping</th>
<th>Channeling</th>
<th>Basin-Edge Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vs</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>Contrast</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Freq.</td>
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<td>✓</td>
<td>x</td>
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<tr>
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<td>x</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Thick.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Azim.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Conservation of Energy
- In Code

### Vertical Resonance
- Not In Code

### Horizontal Resonance
- Not In Code

### Trapping
- In Code

### Channeling
- Not In Code

### Basin-Edge Conversion
- In Code
We Model 40 sec Shaking Durations – But >80 sec Durations Recorded in Basin

Strong late-arriving surface waves in recorded data (red)

Flinchum et al. (BSSA 2014) 0.2 Hz 3D synthetics (blue)
Maps of Amplification Due to CCPM: Code Equations vs. 3-D Wave Computation

Amplifications spread out from Vs30 variations in the CCPM
PGV predicted shaking maps for M6.7 Frenchman Mtn: ShakeMap vs. 3D Waves

1D, USGS ShakeMap into HAZUS

- $4.8 Billion Loss
- 22-58 Casualties

3D, Basin & Parcel Map into HAZUS

- $8.6 Billion Loss
- 287-610 Casualties
Conclusions

- 10,722 Vs profiles of the CCPM show much 3D spatial variation
- Spatial variations in Vs are fractal from 60 km to 1 m scale, horizontally and vertically
- Factor of 2 amplifications at 1 Hz due to 3D CCPM variations
- Amplification map depends on 3D earthquake scenario-model likely sources
- CCPM 3D amplifications greatly affect casualty and damage estimates
Felt Reports from Western Basin?

**Basin-Edge Effect?**

**Focusing by Vs30 Heterogeneity?**
Sensitivity Test on Parcel Map

Little difference at these 5 stations

Big differences nearby and across the basin