

# *2011 HAZUS Scenario Study*

## *San Diego Region*

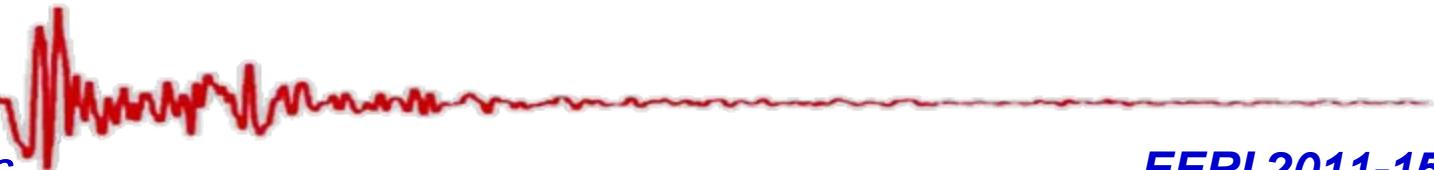


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*Presented at EERI Annual Meeting - February 10, 2011  
& San Diego Planning Scenario Workshop January 24, 2015*

# Presentation Outline

1. HAZUS – Loss Estimation Methodology - Overview
2. Regional Study of San Diego(-Tijuana) area for a Rose Canyon M7.2 Scenario event (HAZUS default data)
3. Enhanced AEBM Study - Census Tract 53 in downtown San Diego (enhanced Sanborn data)
4. Comparison of HAZUS default data to Sanborn & other local data
5. Conclusions & Recommendations



# HAZUS-MH Methodology

## Scenario Earthquake Hazard:

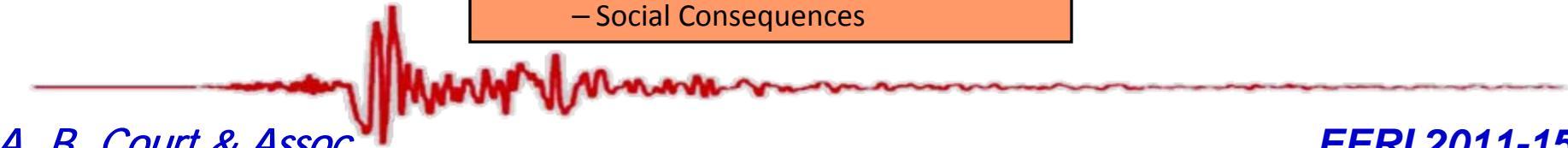
- USGS or User Defined earthquake
- Ground shaking intensity data & distribution
- Surface rupture, liquefaction, landslides

## Building (B-L-I) Inventory:

- Building type, location, number, square footage, and occupancy of all buildings, lifelines & infrastructure.
- Structural systems & damageability characteristics.

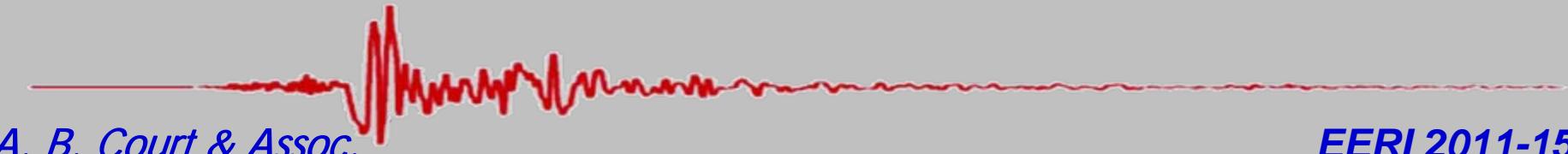
## Damage & Consequences

- Damage severity & distribution
- Consequences:
  - Casualties (injuries & fatalities)
  - Damage Repair Cost (\$\$\$)
  - Downtime – loss of building service
  - Lifeline & infrastructure losses
  - Economic disruption
  - Social Consequences

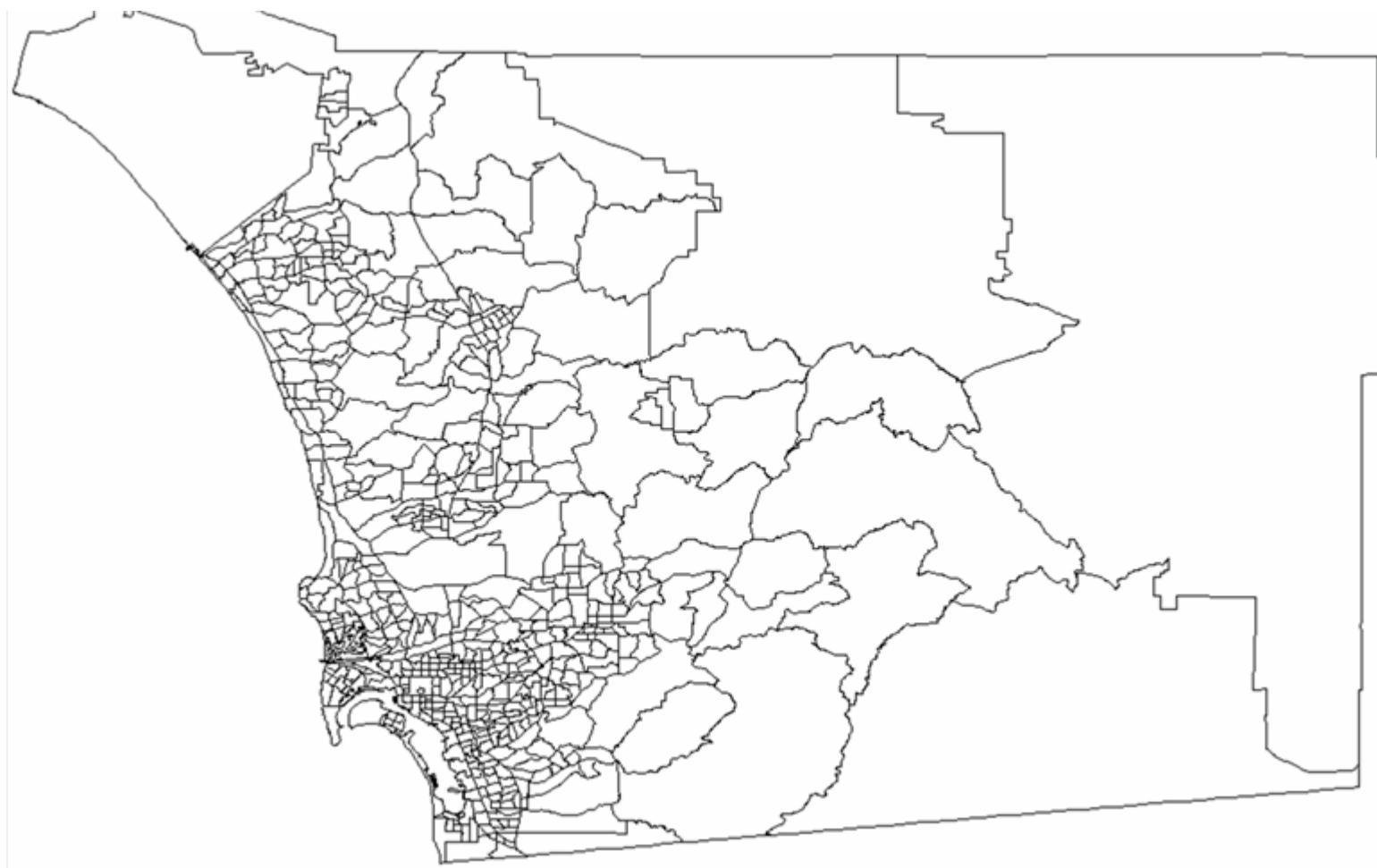


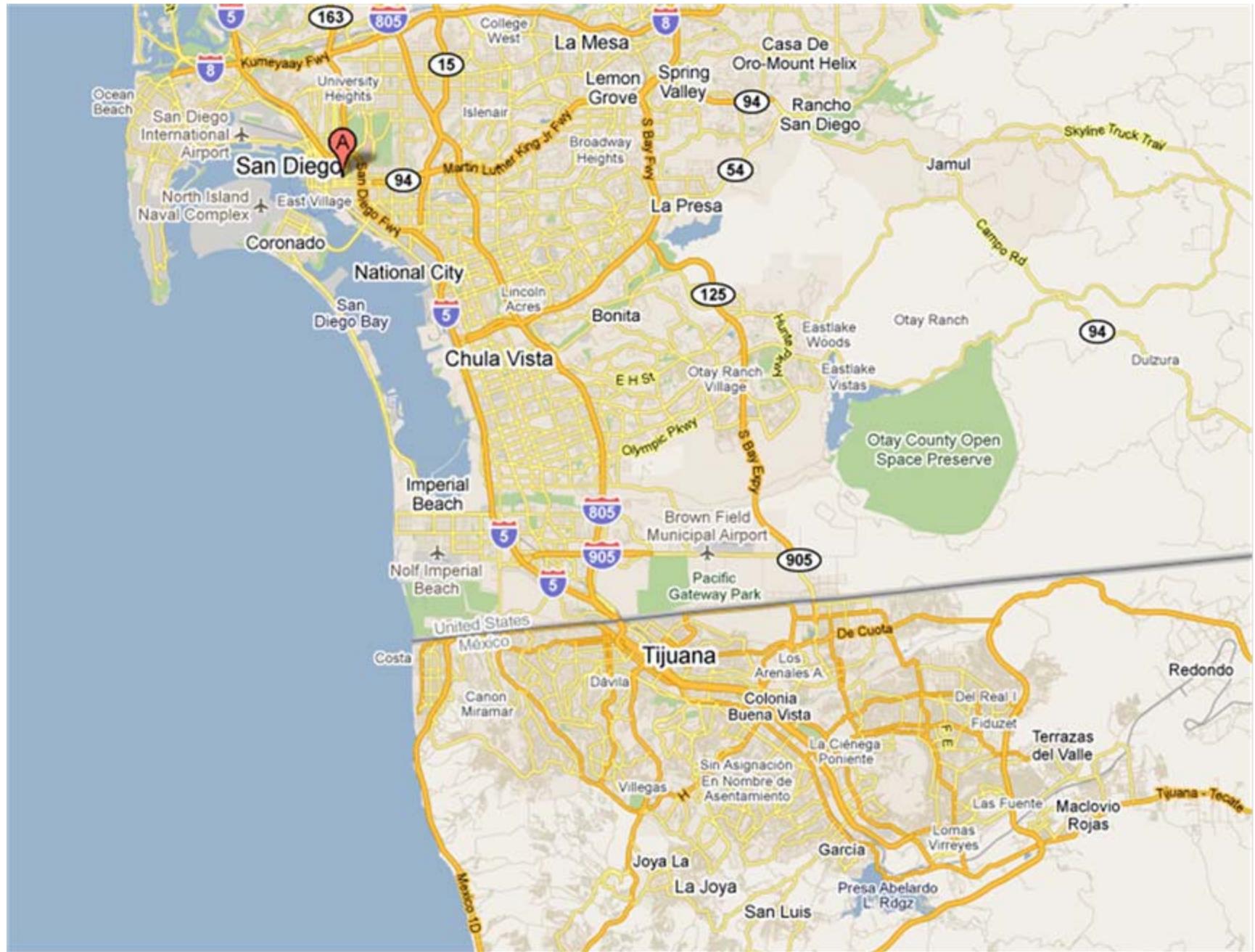
# HAZUS Study No. 1

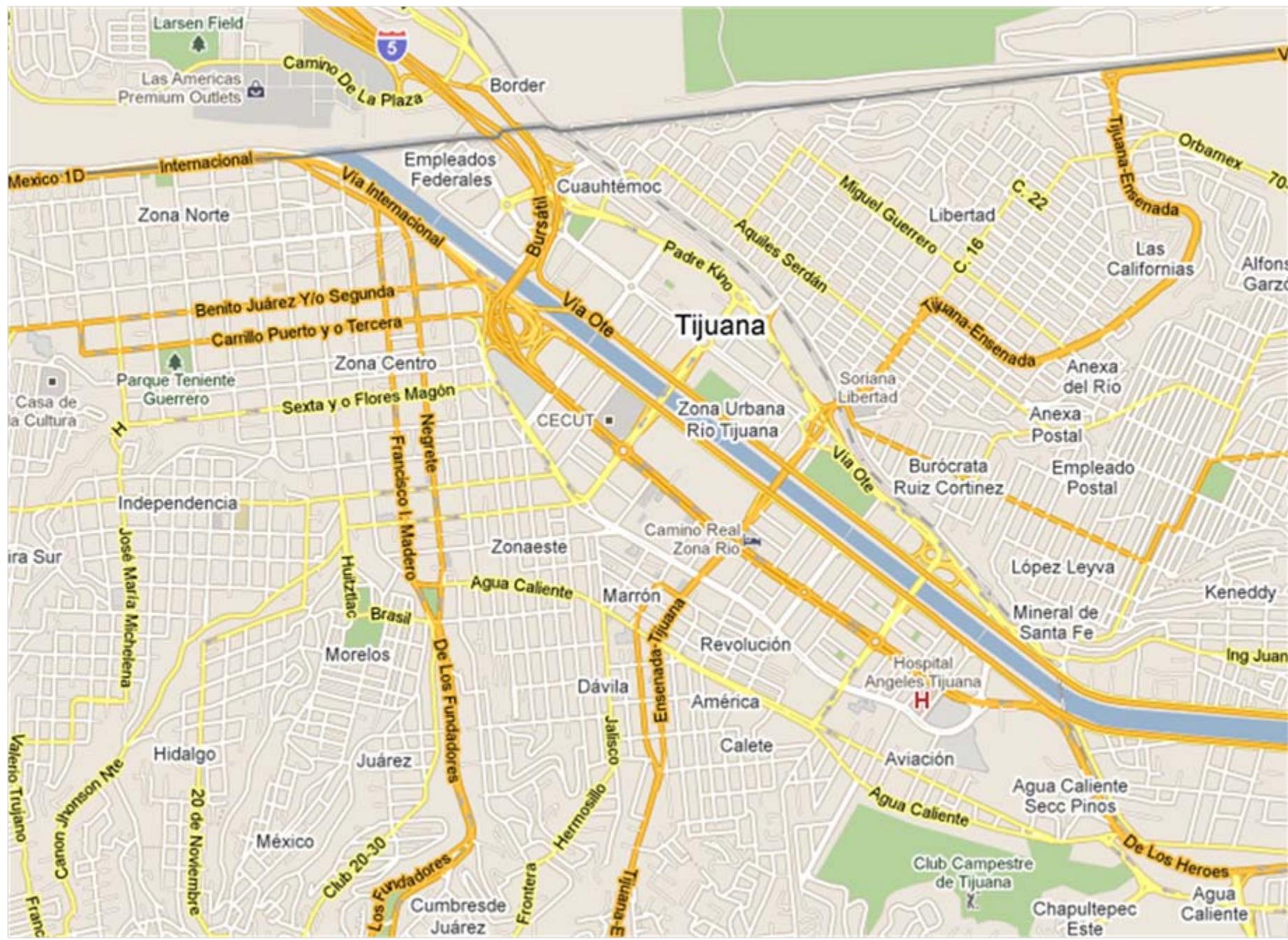
- Scenario – Rose Canyon M7.2
  - USGS shakemap for the Newport-Inglewood-Rose Canyon Fault
- Regional Study of San Diego County—(Not Tijuana or LA area)
- Building Inventory – HAZUS default data
- Fragility relationships – HAZUS default functions
- “push button” analysis



# HAZUS Study Area - Rose Canyon M7.2 – San Diego County

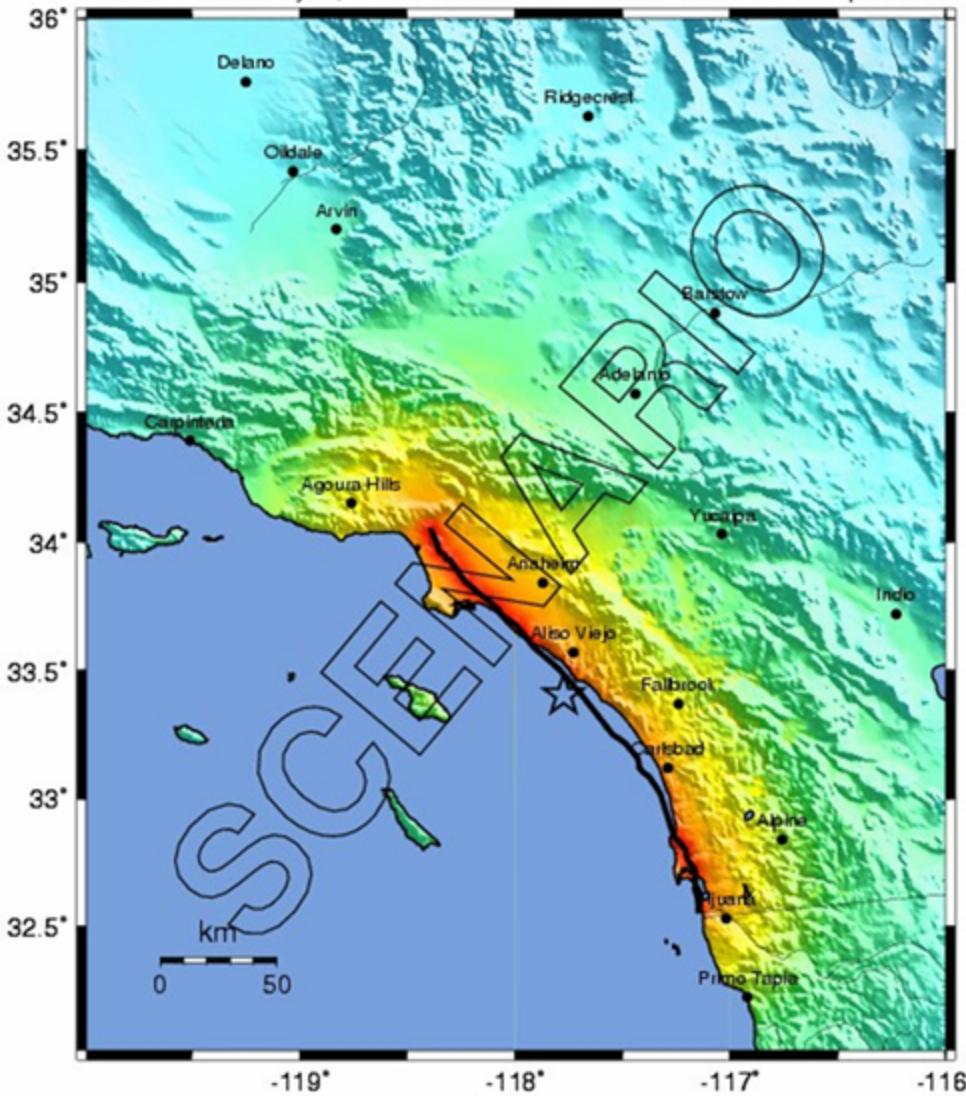






# ShakeMap for U10\_Newporting Scenario

Scenario Date: Fri May 29, 2009 12:00:00 GMT M 7.2 N33.40 W117.77 Depth: 0.0km



PLANNING SCENARIO ONLY -- Map Version 1 Processed Wed Jun 3, 2009 02:28:24 PM MDT

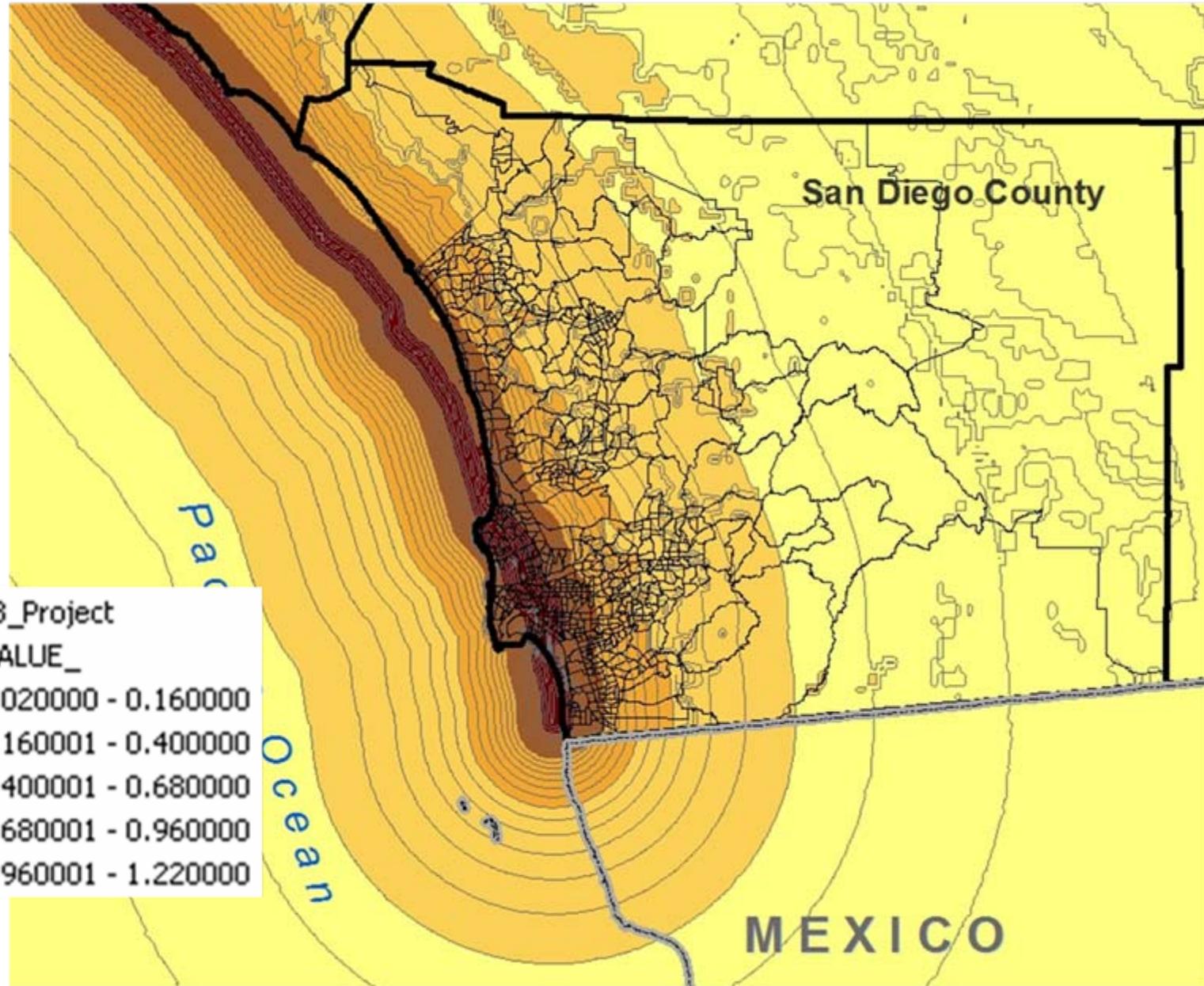
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

# ShakeMap for U10\_NewportIng Scenario



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
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INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

# HAZUS Study - Rose Canyon M7.2 - Contour Map PSA-03



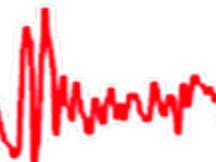
# Regional Statistical Overview

## San Diego (HAZUS Data)

- 3.1 million residents
- 4237 (1200) sq miles
- 822,000 buildings
- \$225 B replacement value (92% of B.E.)
- \$17 B transportation systems
- \$3 B infrastructure value

## Tijuana (Guestimates)

- 1.5M to 3.5M residents??
- 246 sq miles?
- 300k-500k bldgs?
- \$75B-\$125B ?? replacement value
- \$5B to \$10B ??? transportation systems
- \$1B to \$1.5B ??? infrastructure



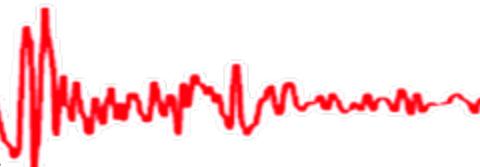
# Building Inventories

## San Diego Area:

- 822,000 bldgs
- 1500 to 2000 URM?
- Non-ductile concrete?
- Infill frame?
- Concrete & masonry shear wall buildings?
- Steel frame?
- Wood frame – 85%

## Tijuana Area:

- 300,000-500,000 bldgs??
- Many URM
- Many non-ductile concrete
- Many infill frame
- Many shear wall bldgs
- Not-many wood frame?
- Not-many steel frame?

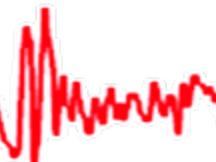


# Building Values - HAZUS

## Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California	San Diego	2,813,833	179,258	45,457	224,715
Total State		2,813,833	179,258	45,457	224,715
Total Region		2,813,833	179,258	45,457	224,715

\$224B in building value. 80% in residential buildings. (2000 data)



# Critical Facility Inventory

## San Diego County

- Essential Facilities
  - Hospitals: **27** facilities, 6574 beds
  - Schools: **993**
  - Police Stations: 73
  - Fire Stations: 62
  - Emergency Operations Center: 2
- High Potential Loss Facilities
  - **54** Dams
  - 228 hazardous materials sites
  - 1 nuclear facilities



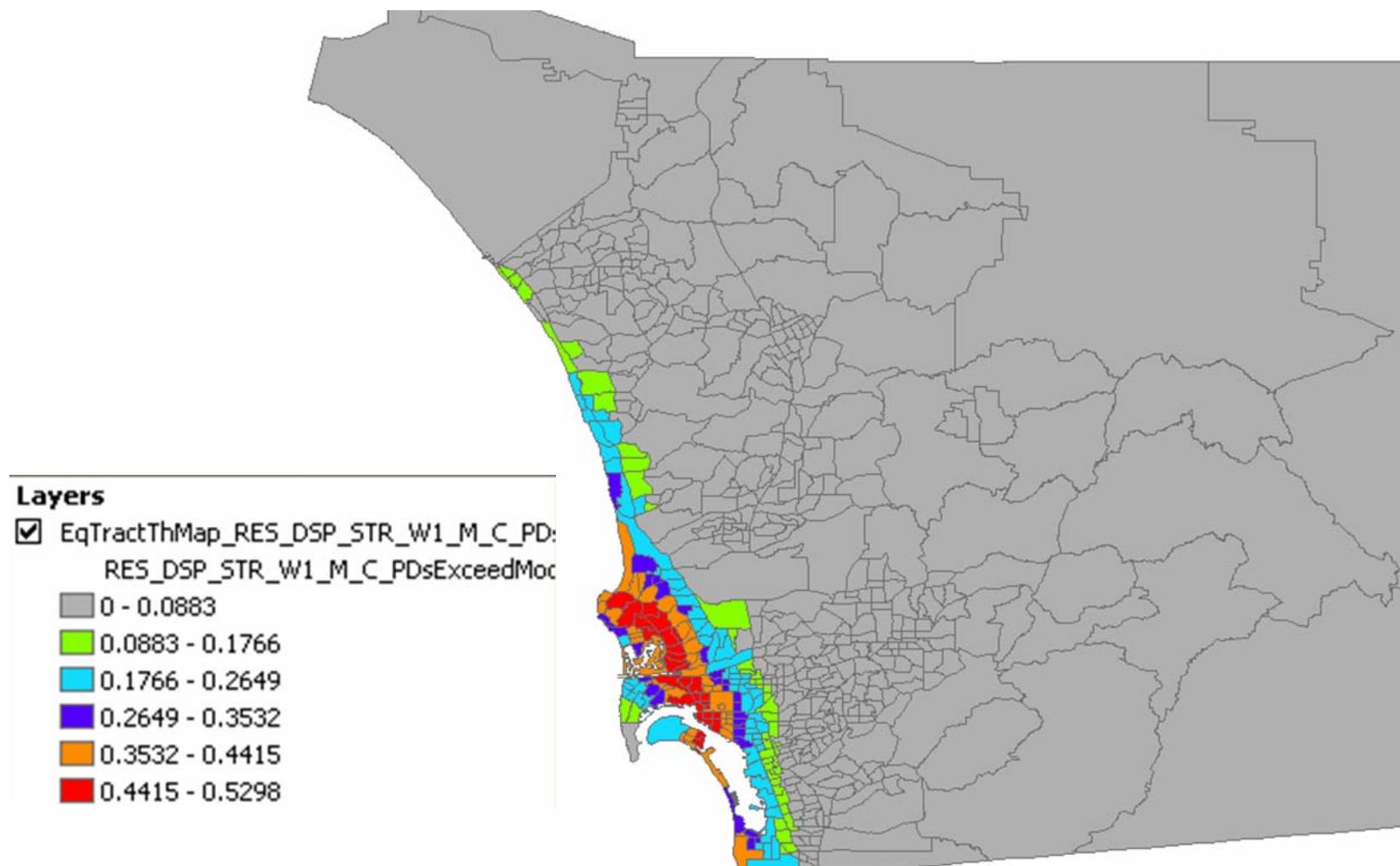
# Transportation & Lifeline Utilities

## (\$21 B replacement value)

- Transportation Systems (7-types)
  - Highways, rail, light rail, buses, ports, ferries, airports
- Lifeline Utility Systems
  - potable water, wastewater, natural gas, crude & refined oil, electric power and communications

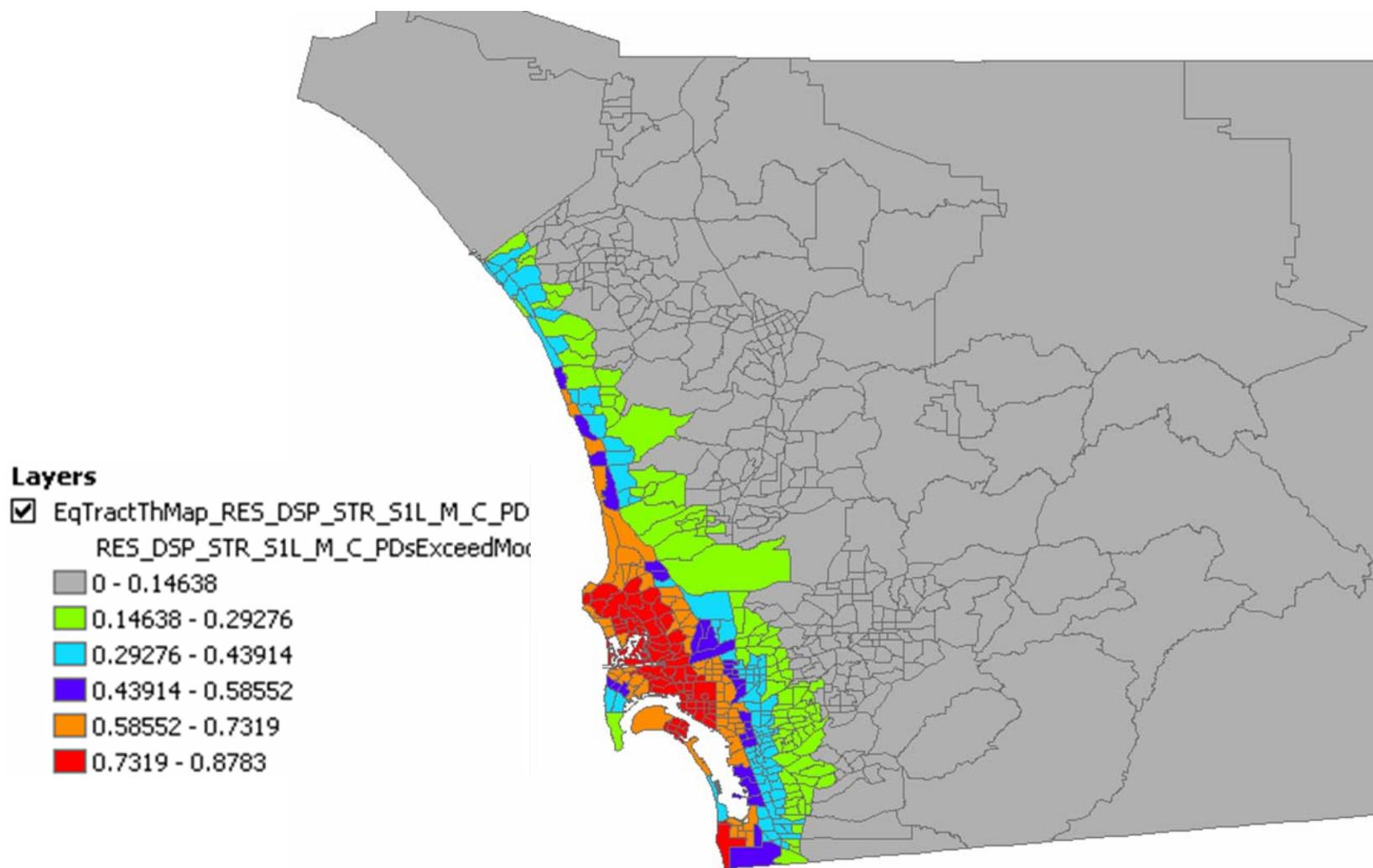
# HAZUS default data assessment for Rose Canyon M7.2

## Wood frame bldgs with at least moderate damage.



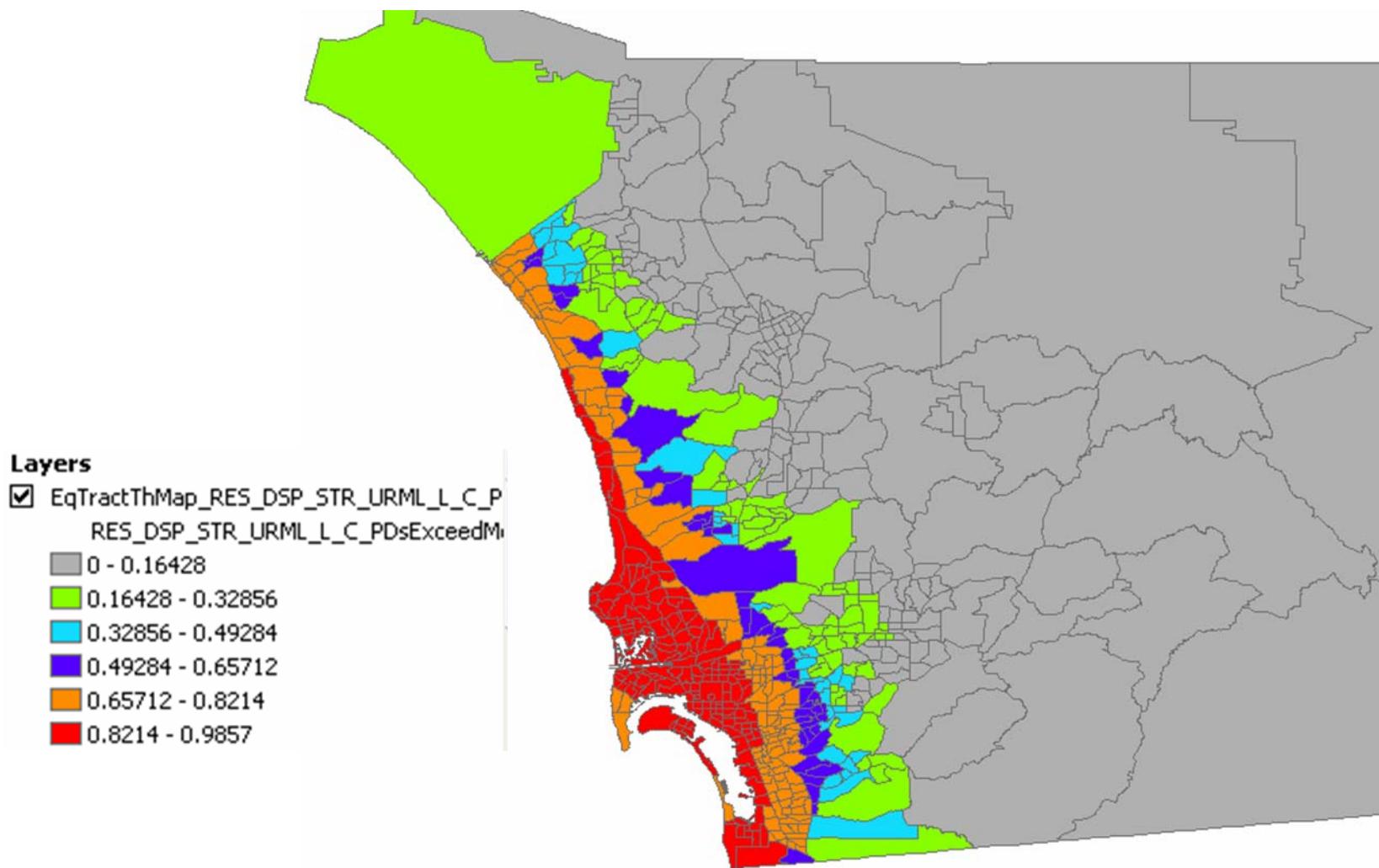
# HAZUS default data assessment for Rose Canyon M7.2

## M-C Steel frame bldgs with at least moderate damage



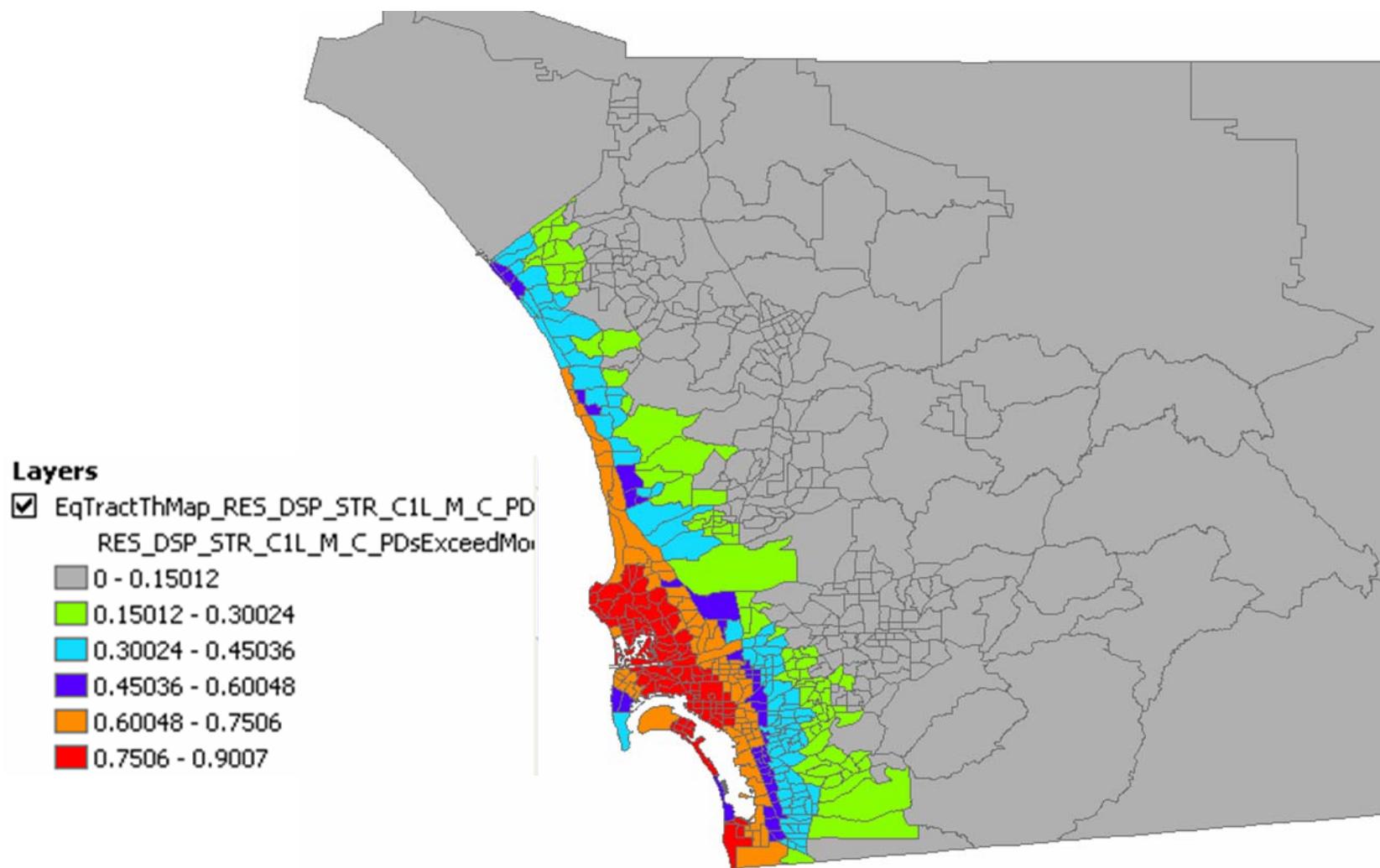
# HAZUS default data assessment for Rose Canyon M7.2

## URM bldgs with at least moderate damage



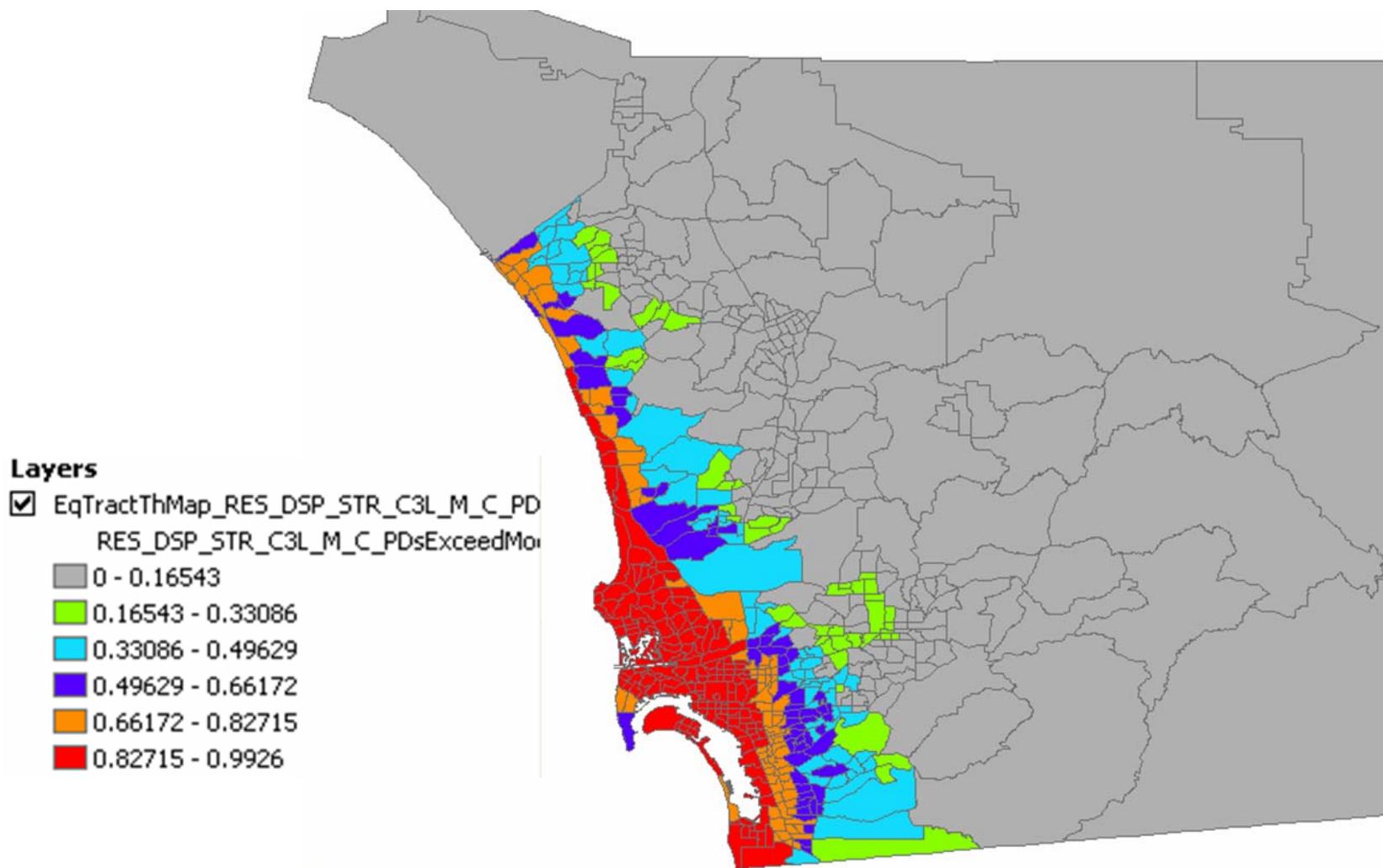
# HAZUS default data assessment for Rose Canyon M7.2

## M-C Concrete Frame bldgs with at least moderate damage

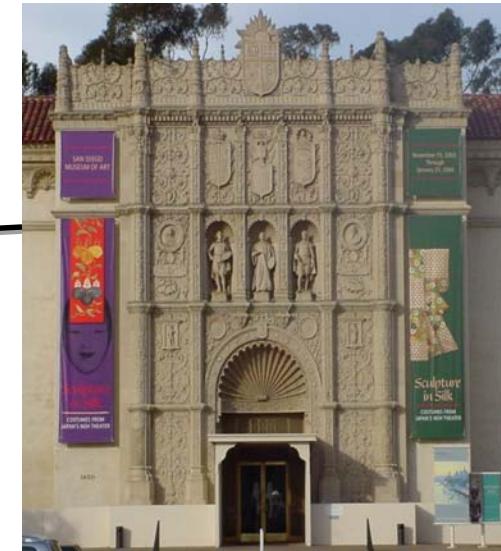
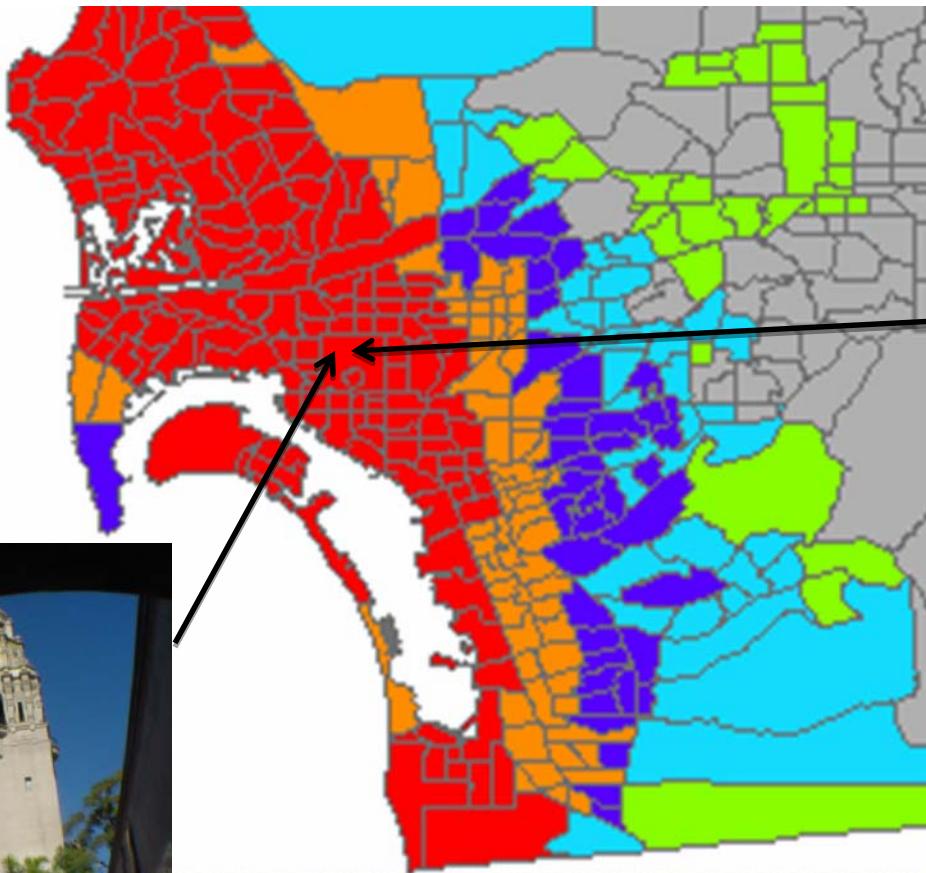
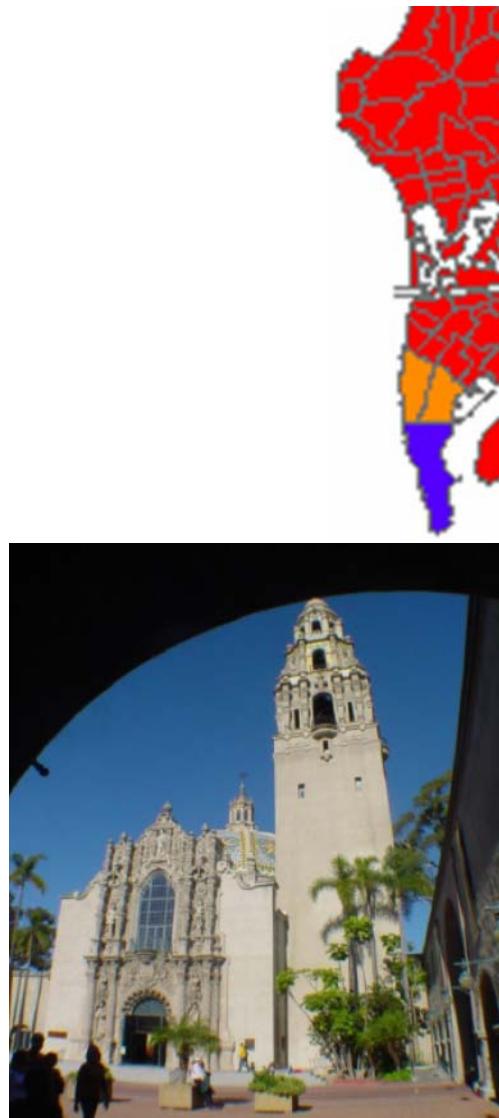


# HAZUS default data assessment with Rose Canyon M7.2

## M-C Concrete Infill Frame Bldgs with at least moderate damage

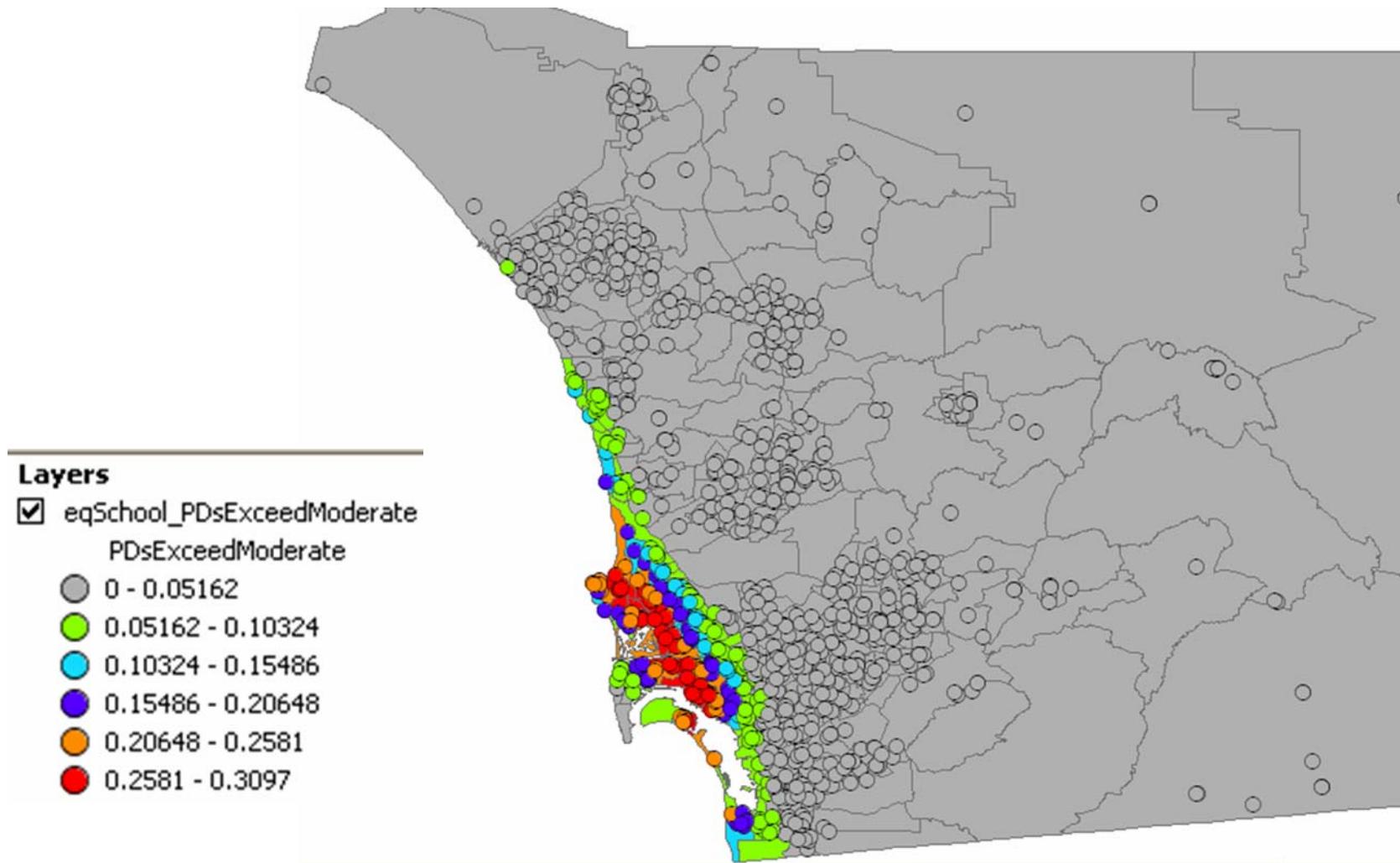


# HAZUS default data with Rose Canyon M7.2 Shakemap Concrete Infill Frame Bldgs with moderate to severe damage



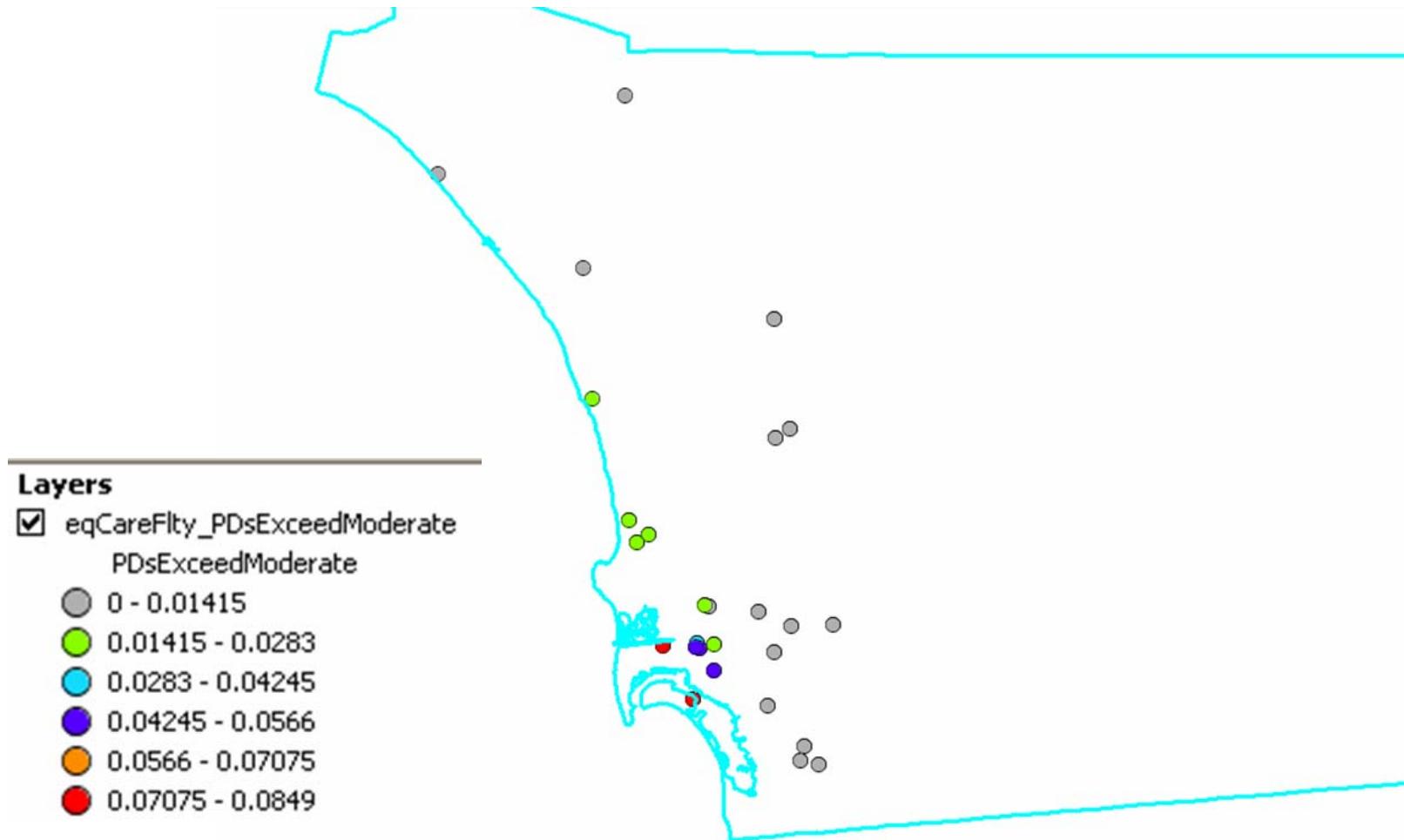
# HAZUS default data assessment for Rose Canyon M7.2

## Schools with at least moderate damage



# HAZUS default data assessment for Rose Canyon M7.2

## Hospitals with at least moderate damage.



# HAZUS Building Damage Summary

- 96,066 buildings will be at least moderately damaged
- 12.00 % of all buildings in the County
- 784 buildings will be damaged beyond repair
- High damage rates in multi-family residential & commercial buildings – large economic & housing impacts
- Heavy damage ratios in URM and non-ductile concrete, also in steel buildings

# HAZUS estimate of Casualties

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 PM	Commercial	2,138	391	45	88
	Commuting	2	3	5	1
	Educational	300	45	4	8
	Hotels	9	2	0	0
	Industrial	203	30	3	5
	Other-Residential	163	23	2	4
	Single Family	120	8	0	0
	Total	2,934	502	59	106

3600 injuries total, 106 at Level 4.

# Building Related Economic Losses

Table 11: Building-Related Economic Loss Estimates  
(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
<b>Income Losses</b>							
	Wage	0.00	59.89	462.01	11.61	21.86	555.38
	Capital-Related	0.00	25.58	430.71	7.00	5.16	468.44
	Rental	60.93	202.00	249.38	6.18	12.92	531.41
	Relocation	224.05	142.72	378.07	31.81	83.92	860.57
	<b>Subtotal</b>	<b>284.98</b>	<b>430.19</b>	<b>1,520.18</b>	<b>56.59</b>	<b>123.86</b>	<b>2,415.80</b>
<b>Capital Stock Losses</b>							
	Structural	450.44	316.14	439.19	70.89	75.13	1,351.80
	Non_Structural	2,678.00	2,068.64	1,466.61	258.01	264.71	6,735.98
	Content	998.34	564.57	738.26	179.81	143.27	2,624.24
	Inventory	0.00	0.00	15.74	31.48	2.27	49.49
	<b>Subtotal</b>	<b>4,126.78</b>	<b>2,949.36</b>	<b>2,659.80</b>	<b>540.19</b>	<b>485.37</b>	<b>10,761.50</b>
	<b>Total</b>	<b>4,411.76</b>	<b>3,379.55</b>	<b>4,179.98</b>	<b>596.78</b>	<b>609.24</b>	<b>13,177.30</b>

\$13.2 B in Capital Stock Losses. \$2.4 B in income losses.

# Additional Losses



# HAZUS Study – No. 2

- Scenario – Rose Canyon M7.2
- Area – San Diego **Census Tract 53**
- **AEBM** (advanced engineering building module) analysis
- **Enhanced Building Inventory data** based on **Sanborn** data supplemented by **field observation** to record structural data
- Fragility relationships – HAZUS default functions **adapted slightly** to account for retrofitted URM s and soft story conditions



# San Diego Census Tract 53 – Sanborn Map



# Census Tract 53 – AEBM Analysis

## Building Ages by Year Built



# Census Tract 53 – AEBM Analysis

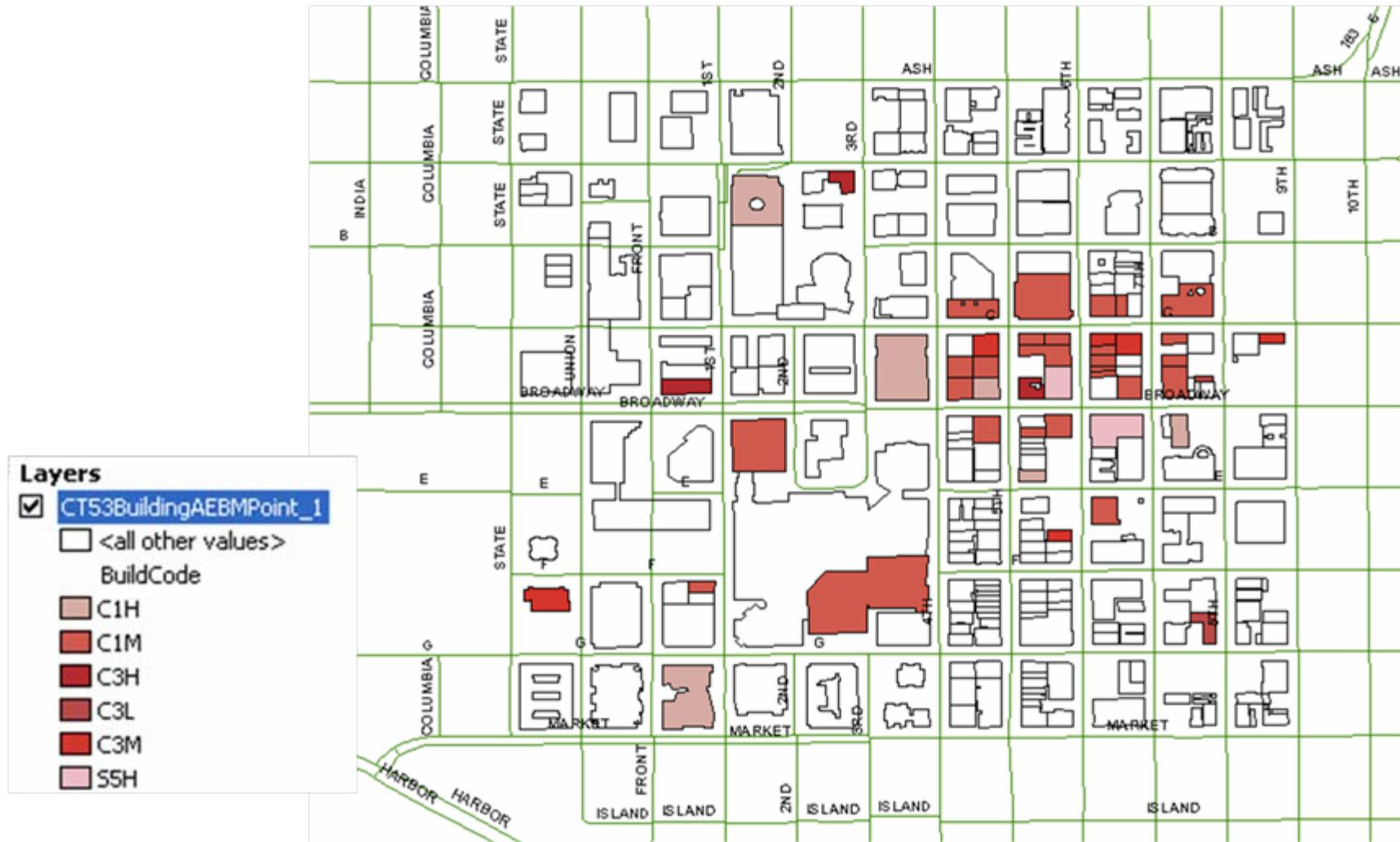
## URM Buildings

Layers	
<input checked="" type="checkbox"/>	CT53BuildingAEBMPoint_1
	YearBuilt
	0.000000 - 1912.000000
	1912.000001 - 1940.000000
	1940.000001 - 1975.000000
	1975.000001 - 1994.000000
	1994.000001 - 2005.000000



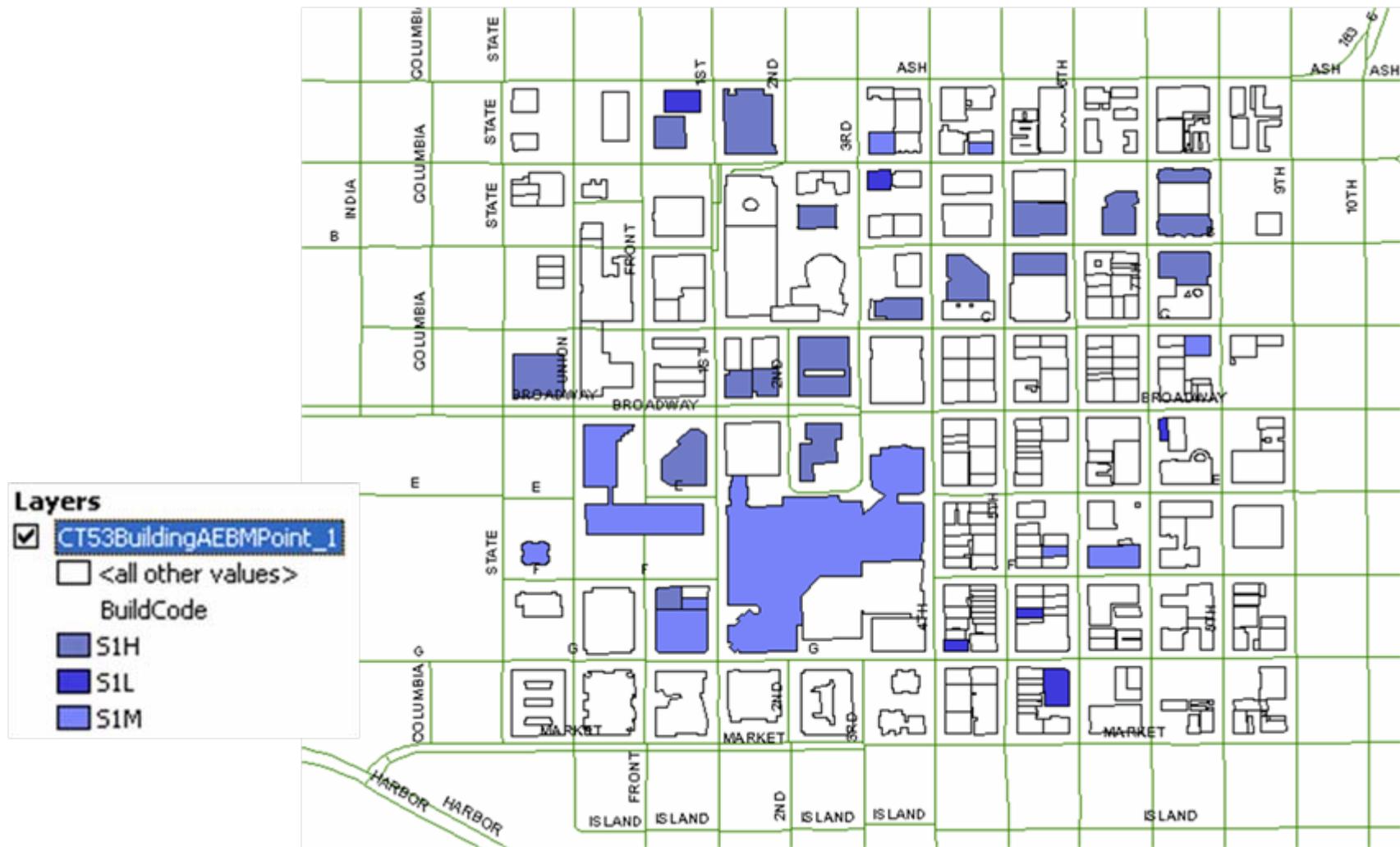
# Census Tract 53 – AEBM Analysis

## Infill frames and Non-ductile Concrete Frame Bldgs



# Census Tract 53 – AEBM Analysis

## M-C Steel Moment Frame Bldgs



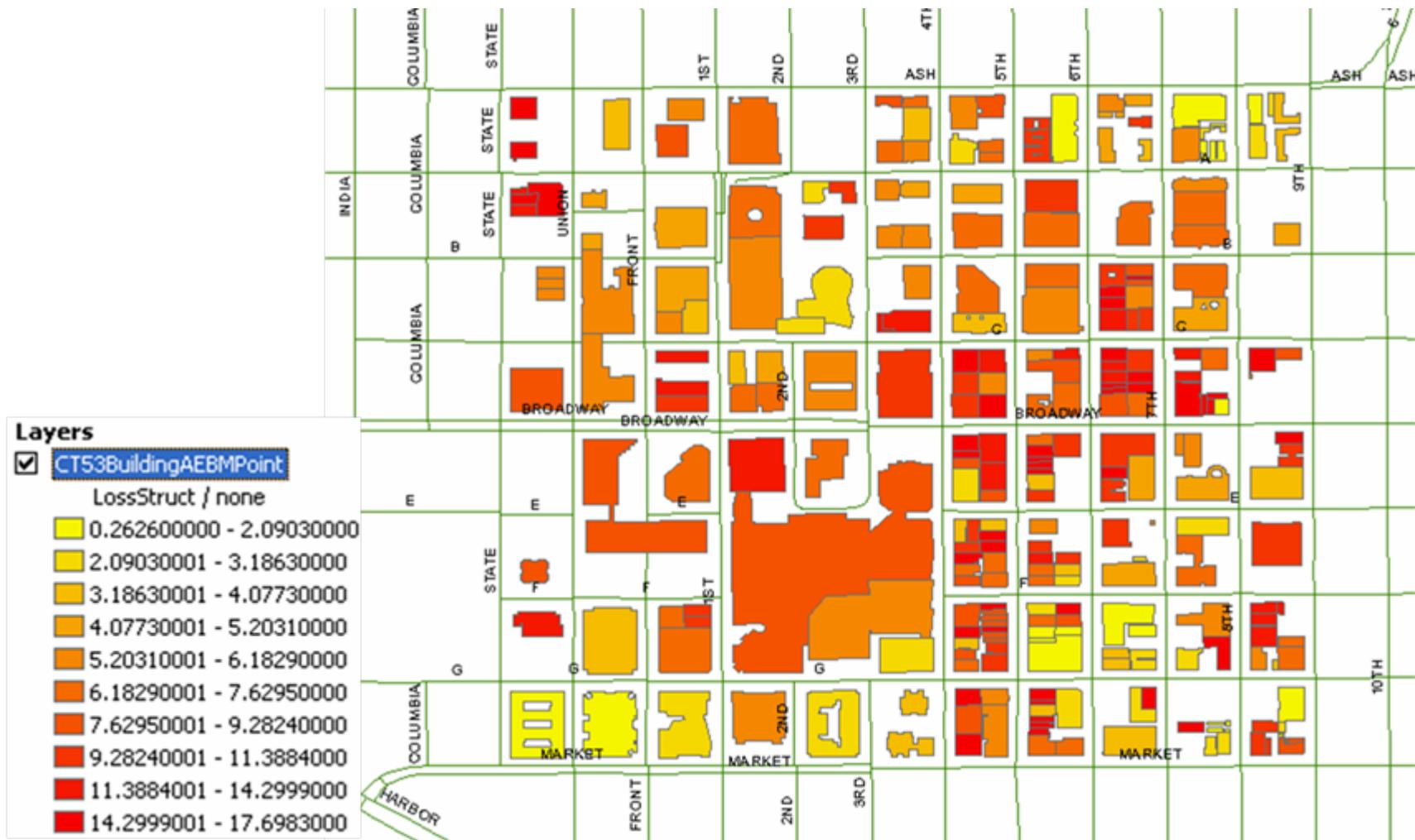
# Census Tract 53 – AEBM Analysis

## Wood Frame Bldgs



# Census Tract 53 – AEBM Analysis

## Structural Losses per Bldg (x \$1,000?)

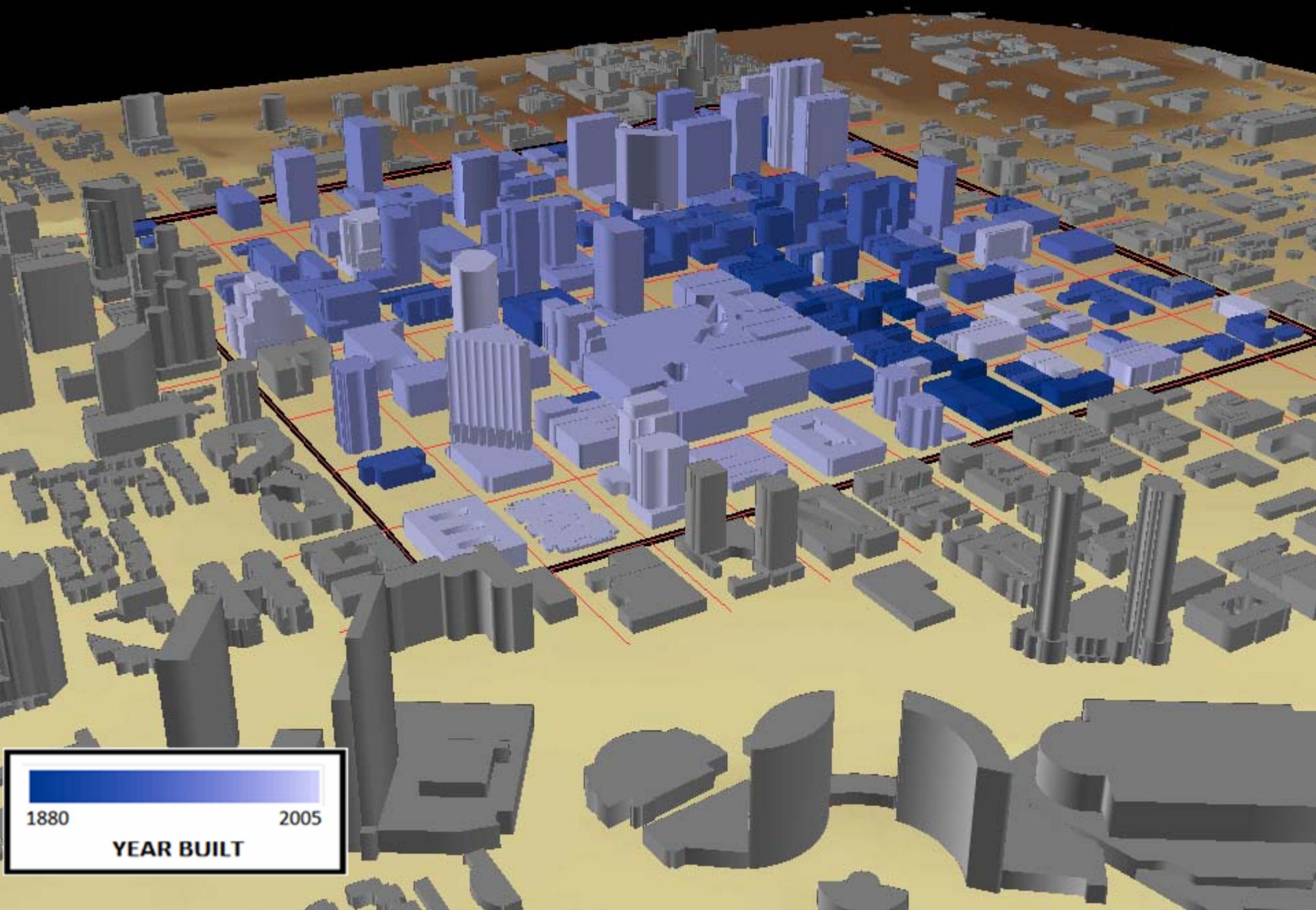


# Census Tract 53 – AEBM Analysis – Total Building Losses

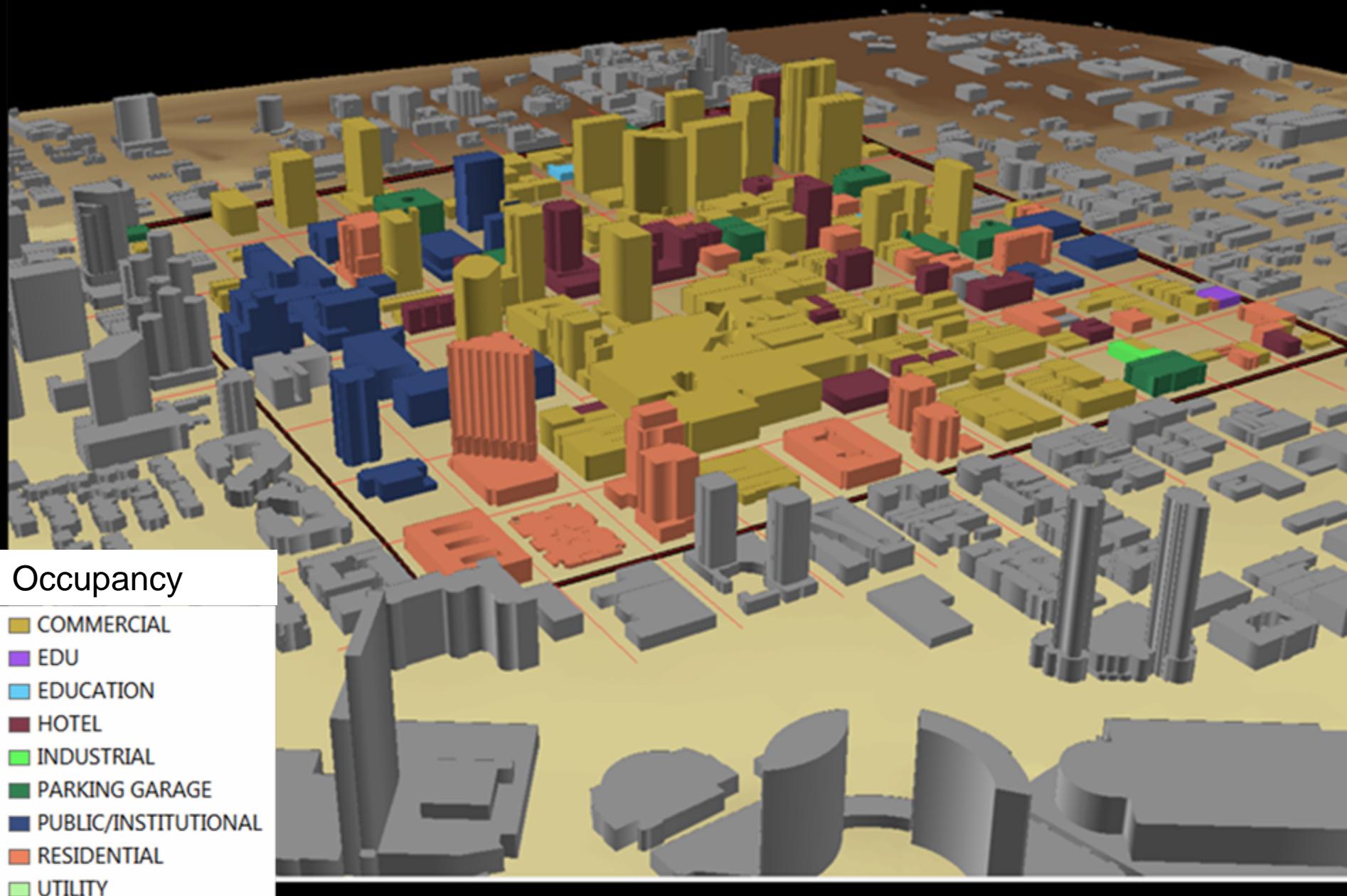
## Structural, Non-structural & Contents (x \$1,000?)

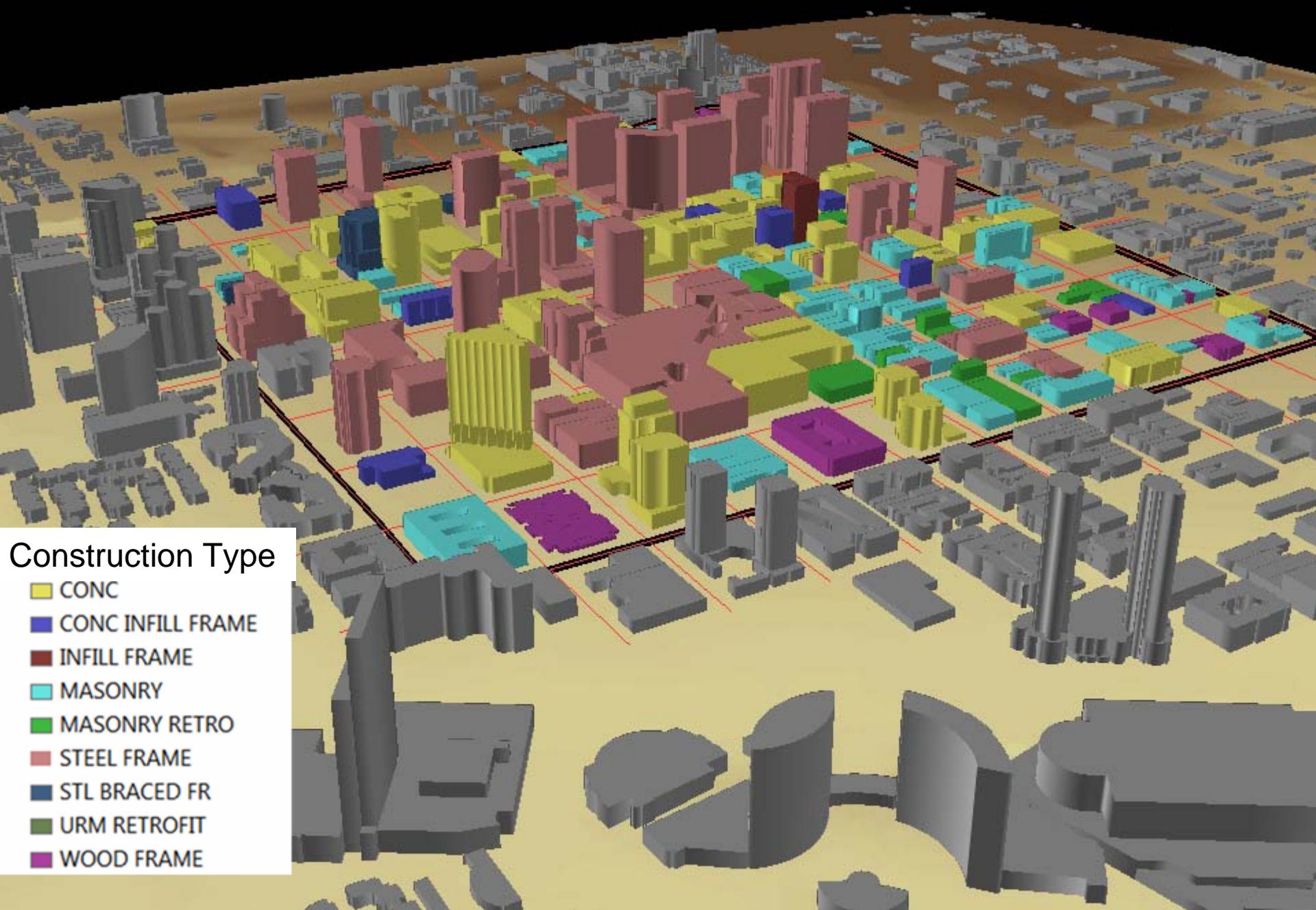
(Does not include business operations/relocation losses)





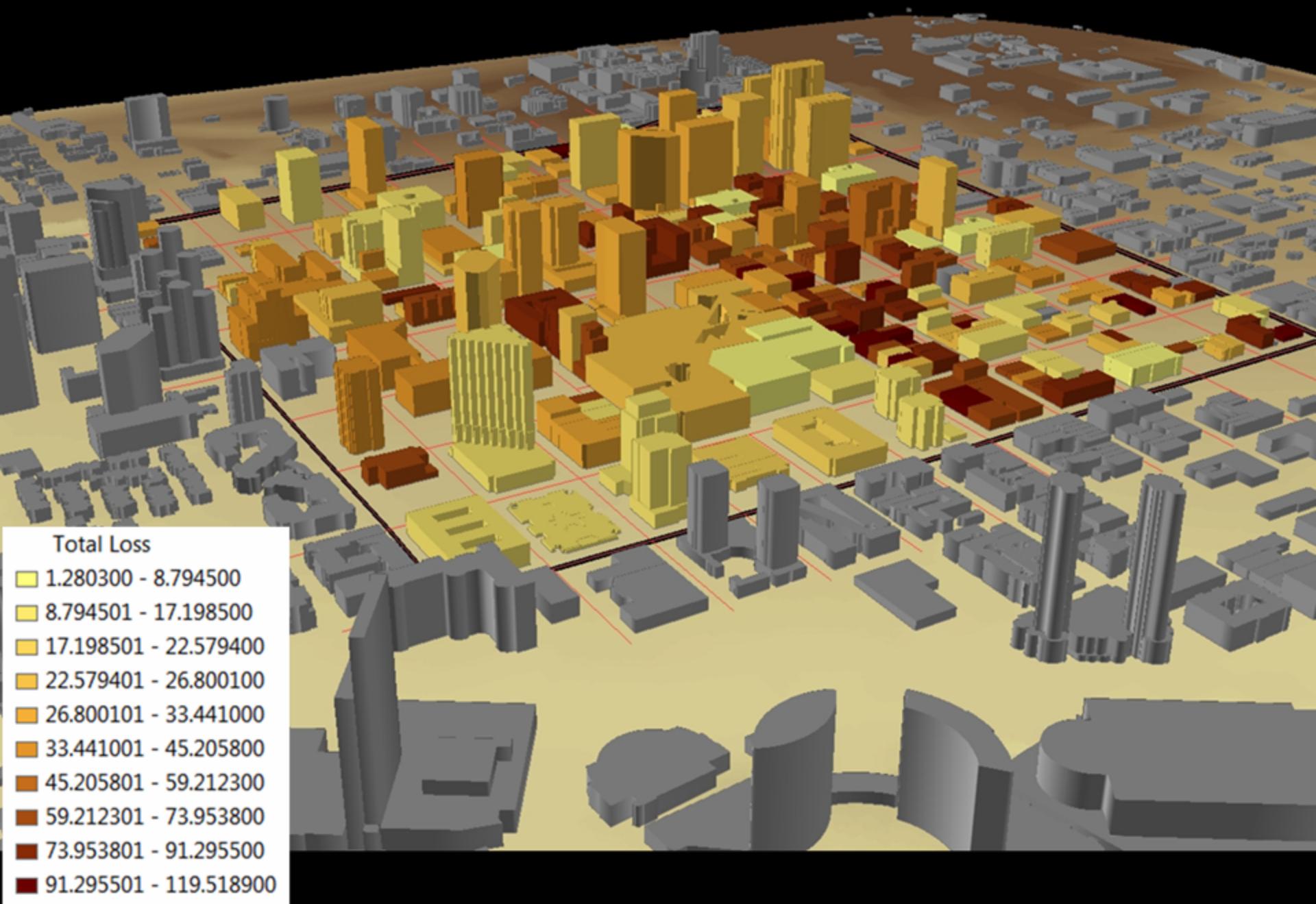






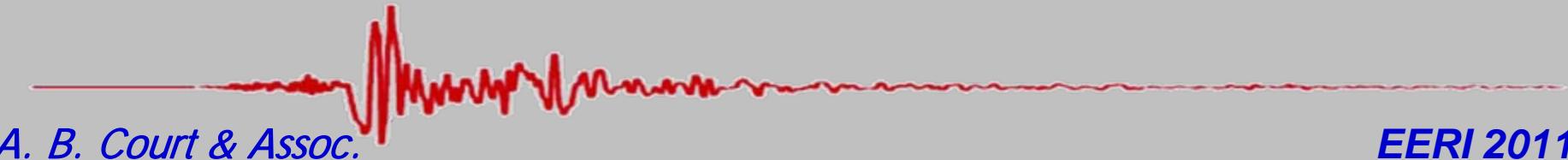
### Construction Type

- CONC
- CONC INFILL FRAME
- INFILL FRAME
- MASONRY
- MASONRY RETRO
- STEEL FRAME
- STL BRACED FR
- URM RETROFIT
- WOOD FRAME



# Comparisons:

HAZUS default inventory data compared to  
Sanborn & other local inventory data



## HAZUS Study - Rose Canyon M7.2 Scenario Census Tract 53 Comparison

### 2. Comparison of Building Inventory by Structure Type: HAZUS v. Local Data

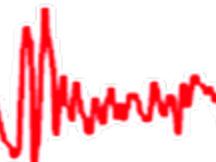
Structure Type	Hazus Default data		Local Tract 53 data		Ratio	
	Sq ft x1000	Count	Sq ft x1000	Count	Sq ft	Count
Wood	3519	329	416	18	846%	1828%
Steel	1225	147	12433	47	10%	313%
Reinforced Concrete	1571	126	9689	83	16%	152%
Precast Concrete	795	81	0	0	n.a.	n.a.
Reinforced Masonry	1655	152	1258	42	132%	362%
Unreinforced Masonry	362	33	1577	78	23%	42%
Mobile Homes	5	2	0	0	n.a.	n.a.
<b>Total</b>	<b>9132</b>	<b>870</b>	<b>25373</b>	<b>268</b>	<b>36%</b>	<b>325%</b>

HAZUS data reflects approximately 1/3 the square footage and 3 times the number of buildings compared to current inventory in Tract 53.

Note: Similar types of discrepancies are reported in similar studies of Seattle (Maheshwari, 2007) and New York City (Nordenson et al, 1999).

# Conclusions & Suggestions

1. The San Diego-Tijuana building inventory has very significant vulnerability in a major event on the Rose Canyon fault.
2. HAZUS provides a powerful tool for assessing the risks and potential losses, but does not extend across the border --- no data for Tijuana.
3. The HAZUS US default inventory data captures a reasonable estimate seismic vulnerability on a regional basis, but not necessarily on a local or census tract level.



# Conclusions & Suggestions

4. HAZUS inventory for redeveloping downtown areas can be particularly erroneous.
5. Local data bases such as Sanborn's data, or assessor's data, supplemented with local engineering insights can provide much more accurate inventory and seismic vulnerability accounting.
6. Sanborn's data can provide a very good starting point. Their building footprint data and 3D imagery can provide powerful communication tools for emergency planners.



# Conclusions & Suggestions

7. HAZUS studies particularly using enhanced data sets can provide City building officials and political leaders with useful insights to help develop appropriate seismic retrofit policies and seismic risk mitigation strategies.
8. Recommendation: San Diego should consider taking some more aggressive steps toward inventorying its vulnerable building stocks and toward protecting and preserving its architectural heritage, in particular: the **Gaslamp Quarter** and the **Balboa Park's historical monuments.**



# Conclusions & Suggestions

9. We know very little about the building inventory and seismic vulnerability across the boarder. Tijuana's participation can help fill these knowledge gaps.
  
10. HAZUS and Sanborn type data bases for Tijuana could be very useful to Mexico's planning and risk mitigation and can help ameliorate the cross boarder consequences of a major Rose Canyon event.



# Gaslamp District



# Gaslamp District



# Gaslamp District



# Balboa Park - MoA



# Balboa Park - MoM





San Ysidro Land Port of Entry

MILLER | HULL

*Thank you.*

