Potential Earthquake Risk:

Faulting, Shaking & Ground Failure Hazards

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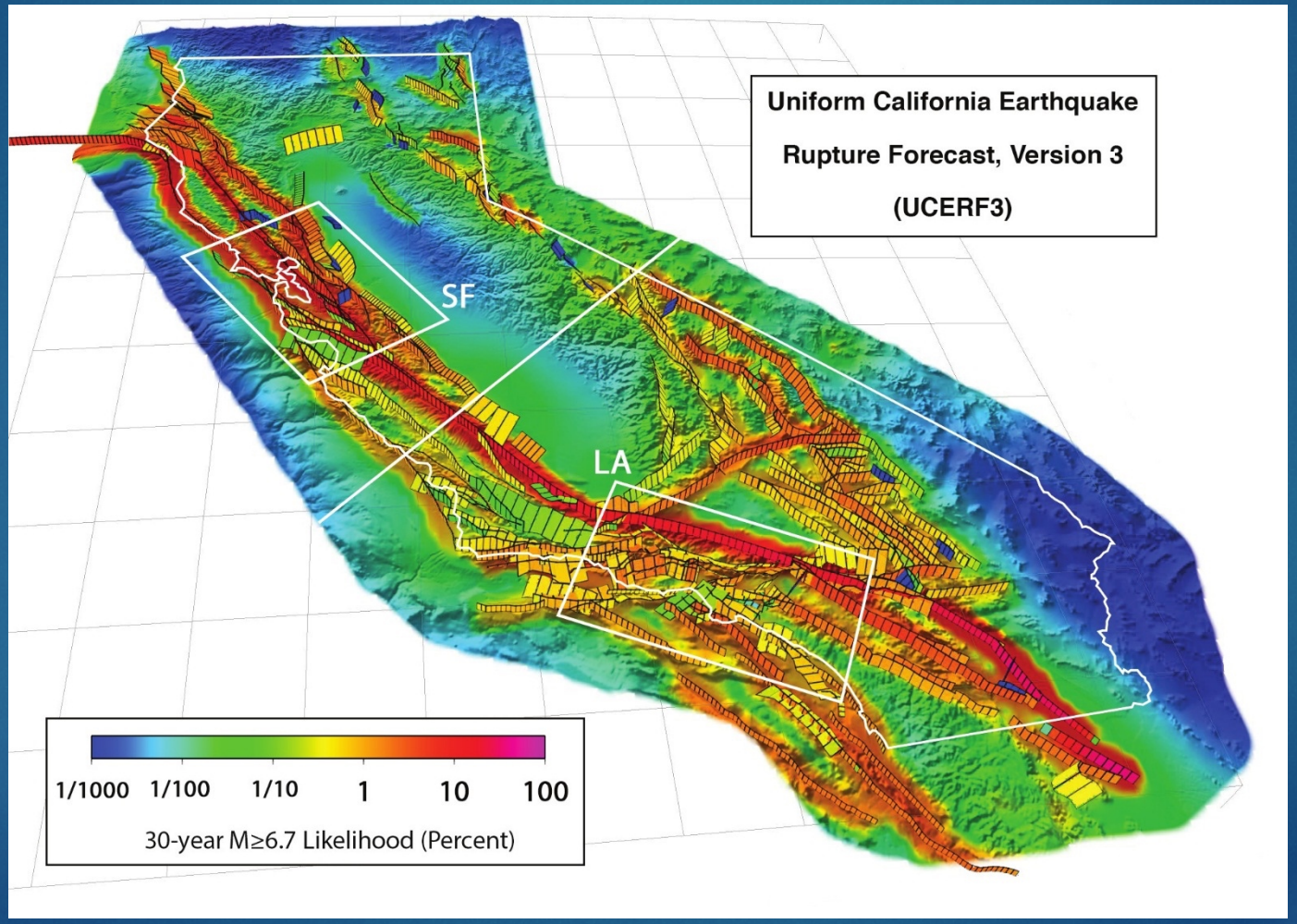
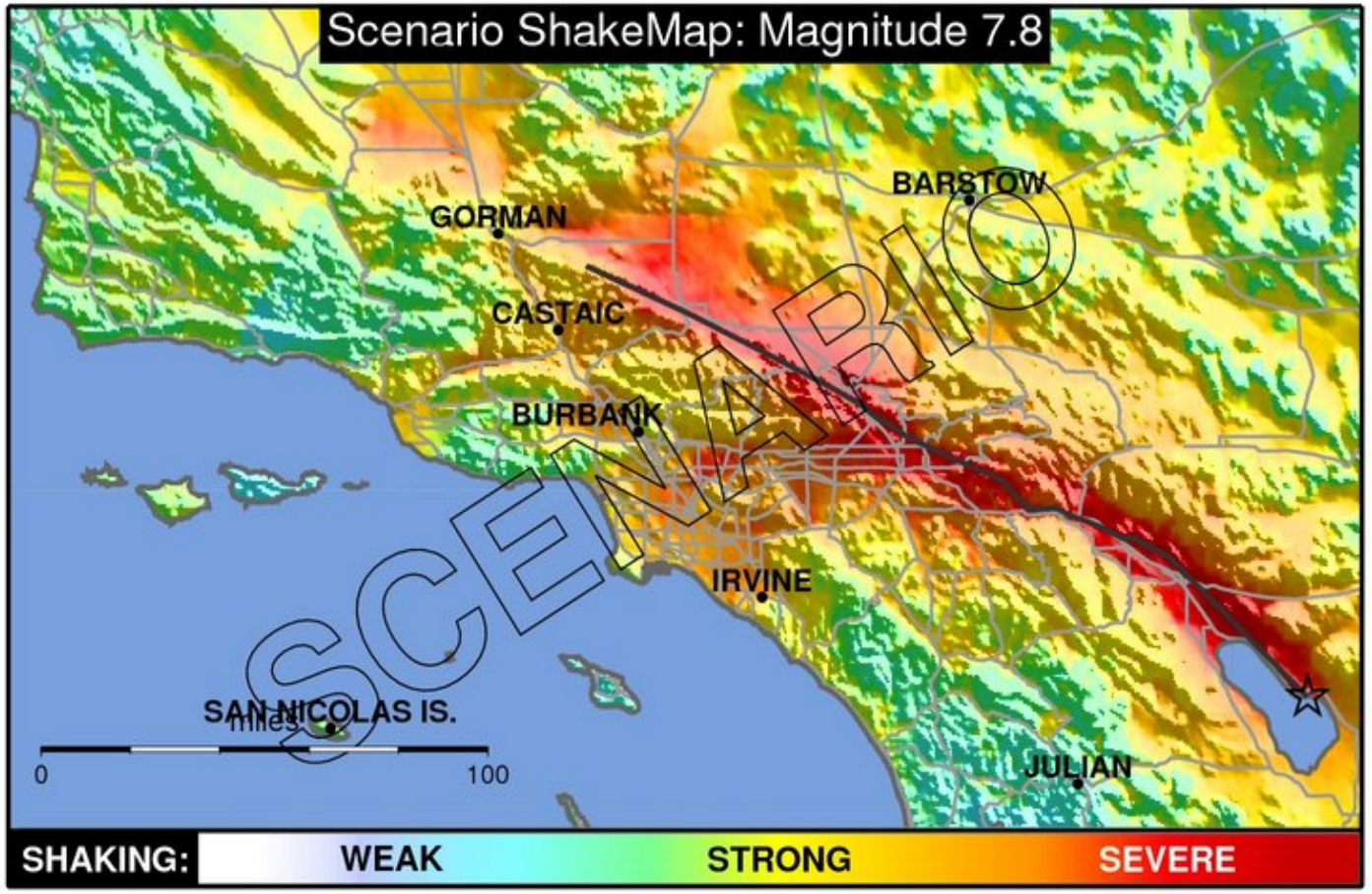
San Diego, CA
February 21, 2019

The earthquake threat is real in California; We need to be *ready!*

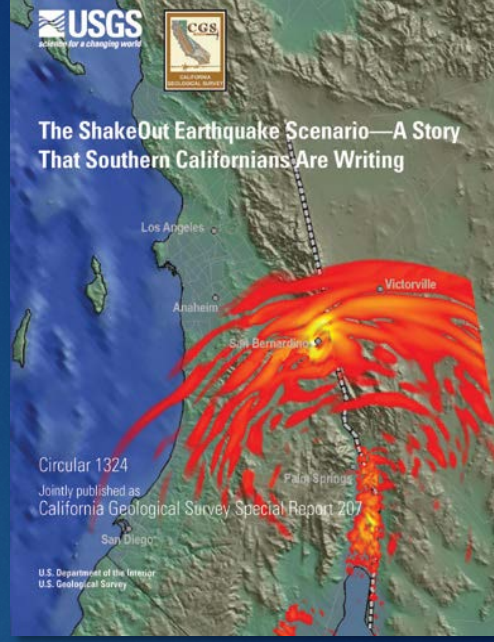


M 7.8 'BIG ONE' ON THE SAN ANDREAS FAULT; EXTENSIVE SCENARIO DEVELOPED BY USGS SAFRR (ALREADY USED HEAVILY IN GG'08, GG'12, CAPSTONE-AS'15 & VG'17, ETC.)

ShakeOut scenario



PLANNING SCENARIO ONLY -- Map Version 1 Processed 2015-02-27 06:50:17 UTC



1,800 killed

53,000 injured

1,600 fire ignitions *super-conflagrations*

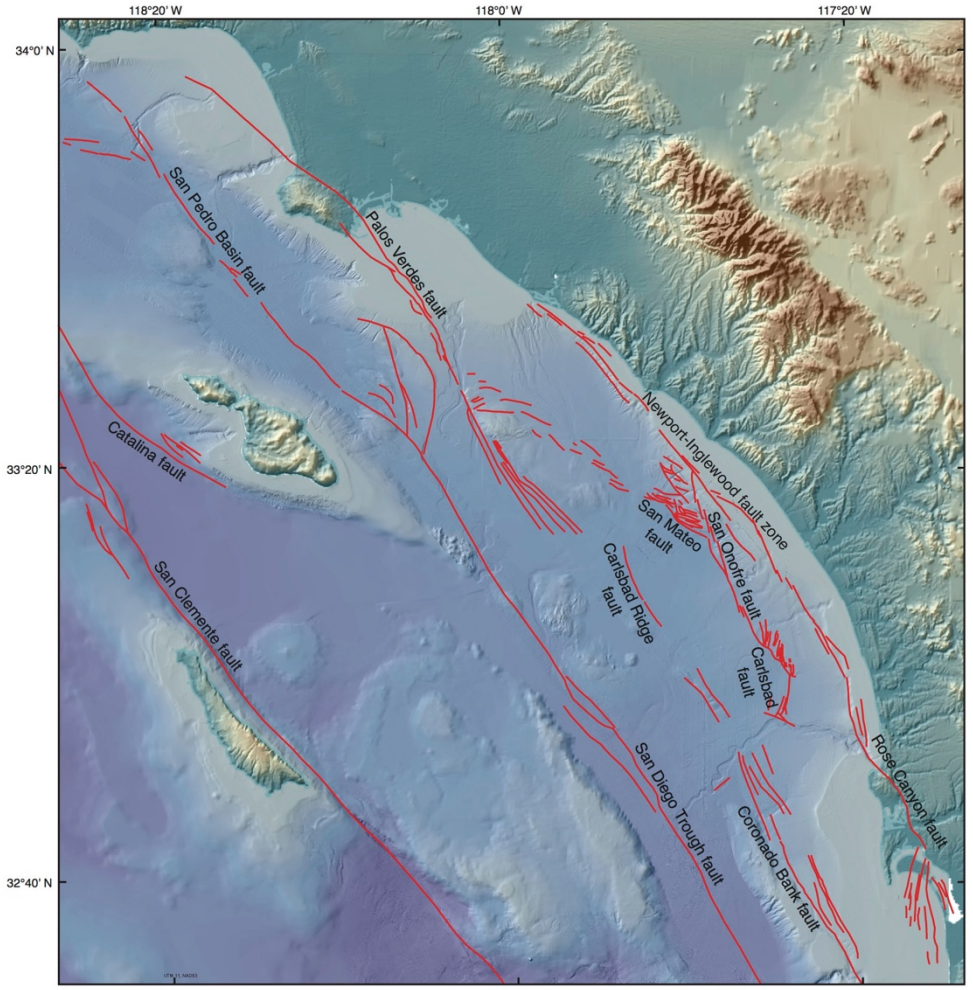
1,500 buildings collapsed

300,000 buildings damaged

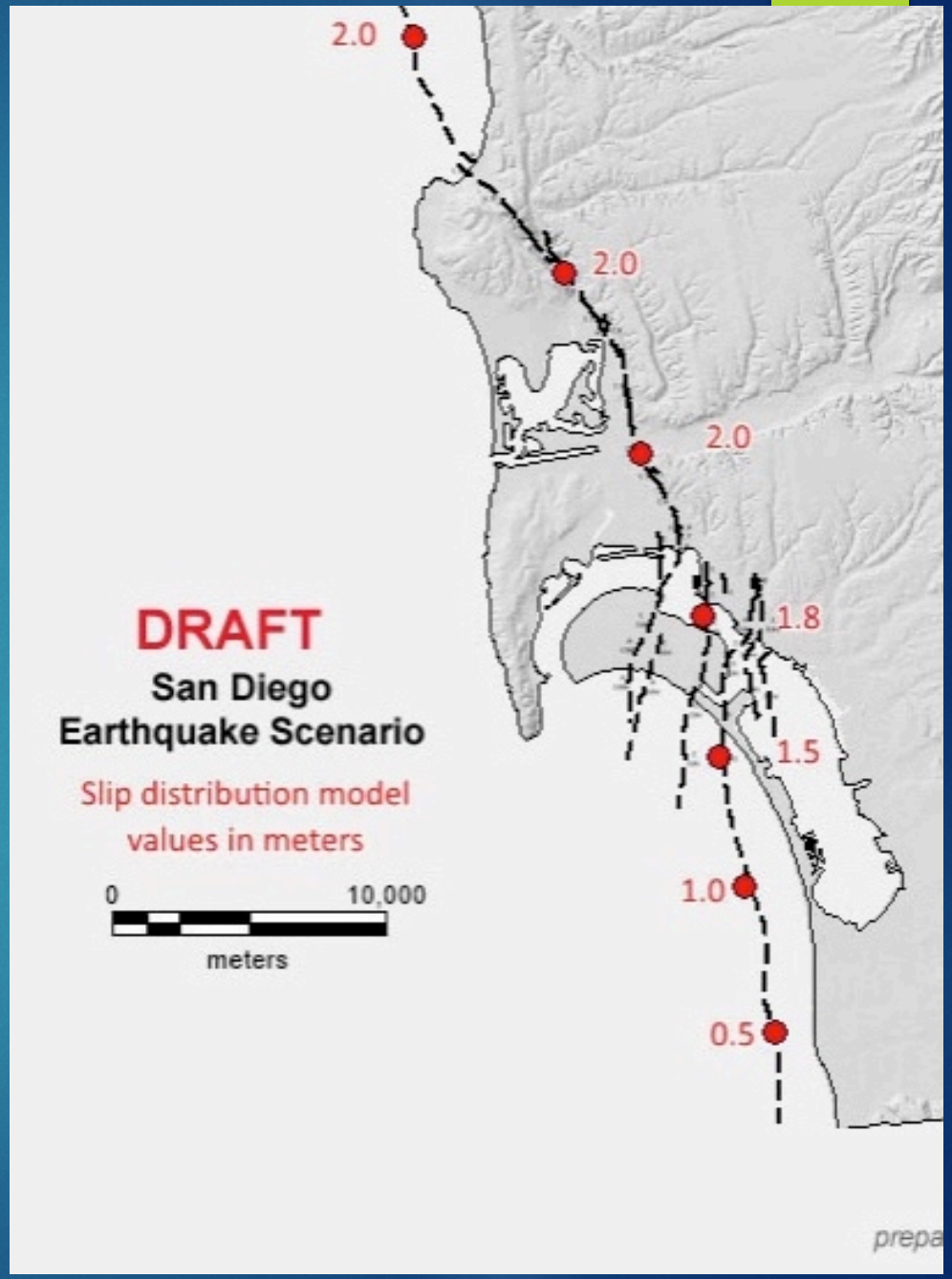
255,000 people left homeless

$213 billion in total damages (incl. FFE)

Rose Canyon Fault



Active faults in the southern California Inner Borderland



Scenario Earthquakes – What to Expect?

- Surface Fault Rupture
- Other Ground Failure; landslides, liquefaction
- Shaking-related Damage

- Surface fault rupture of up to 6 1/2 feet of right-lateral (horizontal shift) offset that would contribute significantly to the overall damage, i.e., offset pipelines.
- Significant disruption at lifeline infrastructure intersections with fault rupture & damage especially to facilities along the fault zone (also from strong shaking).
- Extensive soil liquefaction causing lateral spreading and subsidence in the port complex.
- Fire following earthquake (FFE) would likely increase casualties and total losses.
- Potential for spills and leaks; sloshing of fluids in certain tanks can cause buckling failures.

What Can Go Wrong? Surface Fault Rupture

Photo Credits: CUREe, Keith Johnson, NZ

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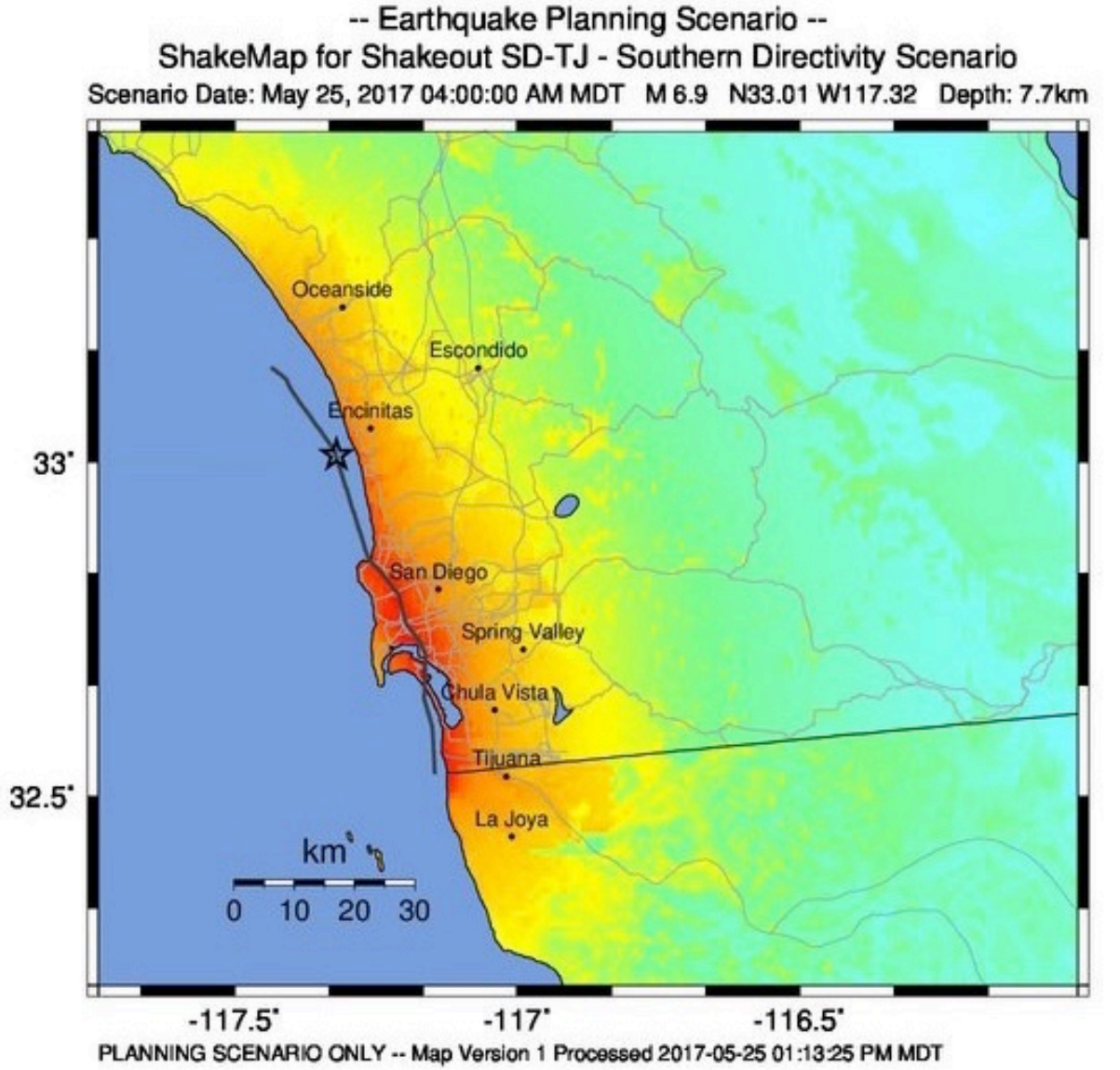


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Scenario: Magnitude 6.9 Earthquake on the Rose Canyon fault zone

USGS science for a changing world

Earthquake Shaking Red Alert

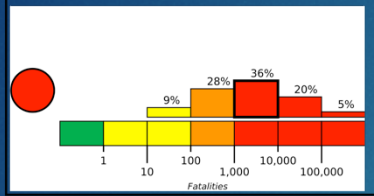
USAID FROM THE AMERICAN PEOPLE

M 6.9, Shakeout SD-TJ Scenario

Origin Time: 2017-05-25 10:00:00 UTC (Thu 03:00:00 local)
Location: 33.0100° N 117.3200° W Depth: 7.7 km

PAGER Version 1

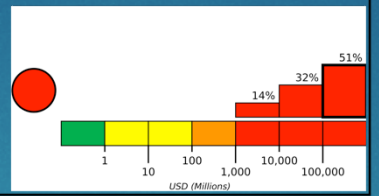
Estimated Fatalities



Red alert for shaking-related fatalities and economic losses. High casualties and extensive damage are probable and the disaster is likely widespread. Past red alerts have required a national or international response.

Estimated economic losses are 0-2% GDP of the United States.

Estimated Economic Losses



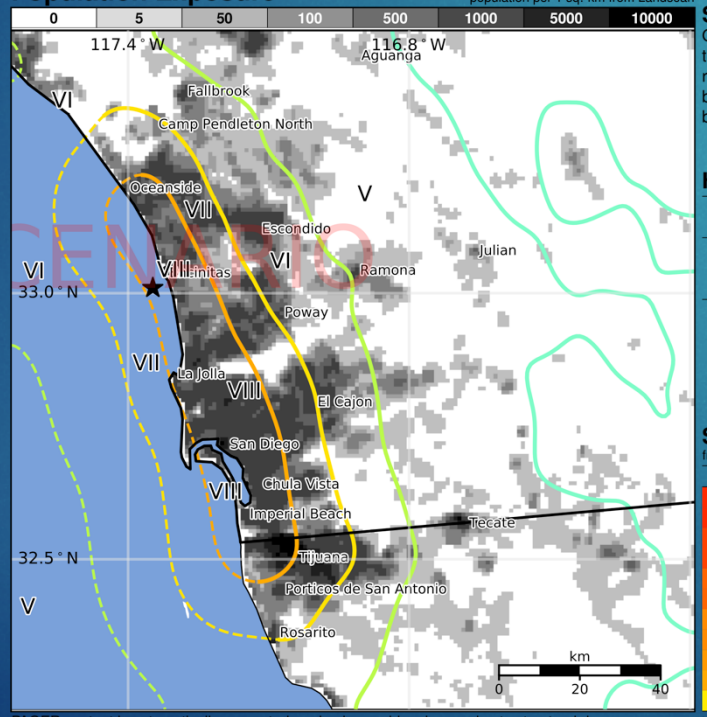
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k=x1000)		–*	–*	6k*	161k	904k	1,947k	1,950k	344k	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	None	None	None	V. Light	Light	Moderate	Mod./Heavy	Heavy	V. Heavy
	Vulnerable Structures	None	None	None	Light	Moderate	Mod./Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per 1 sq. km from Landscan



Structures

Overall, the population in this region resides in structures that are a mix of vulnerable and earthquake resistant construction. The predominant vulnerable building types are adobe block with concrete bond beam and unreinforced brick masonry construction.

Historical Earthquakes

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1986-07-13	49	5.8	V(9,528k)	0
1994-01-17	172	6.7	IX(73k)	33
1971-02-09	183	6.6	IX(21k)	65

Recent earthquakes in this area have caused secondary hazards such as landslides and liquefaction that might have contributed to losses.

Selected City Exposure

from GeoNames.org

MMI	City	Population
IX	San Diego	1,307k
IX	Coronado	19k
IX	Imperial Beach	26k
IX	La Jolla	43k
VIII	Del Mar	4k
VIII	Encinitas	60k
VIII	Carlsbad	105k
VIII	Chula Vista	244k
VIII	Oceanside	167k
VIII	Tijuana	1,376k
VI	Escondido	144k

bold cities appear on map. (k=x1000)

PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty.
http://earthquake.usgs.gov/data/pager/

Event ID: usshakeout_sdtj2015_hybridvs30_tj_se

USGS science for a changing world

Scenario: Magnitude 6.9 Earthquake on the Rose Canyon fault zone

EERI-led Scenario Estimates:

Fatalities; preliminary - several hundred (HAZUS)

Economics; preliminary – $38 Billion total (up to $40 billion HAZUS)

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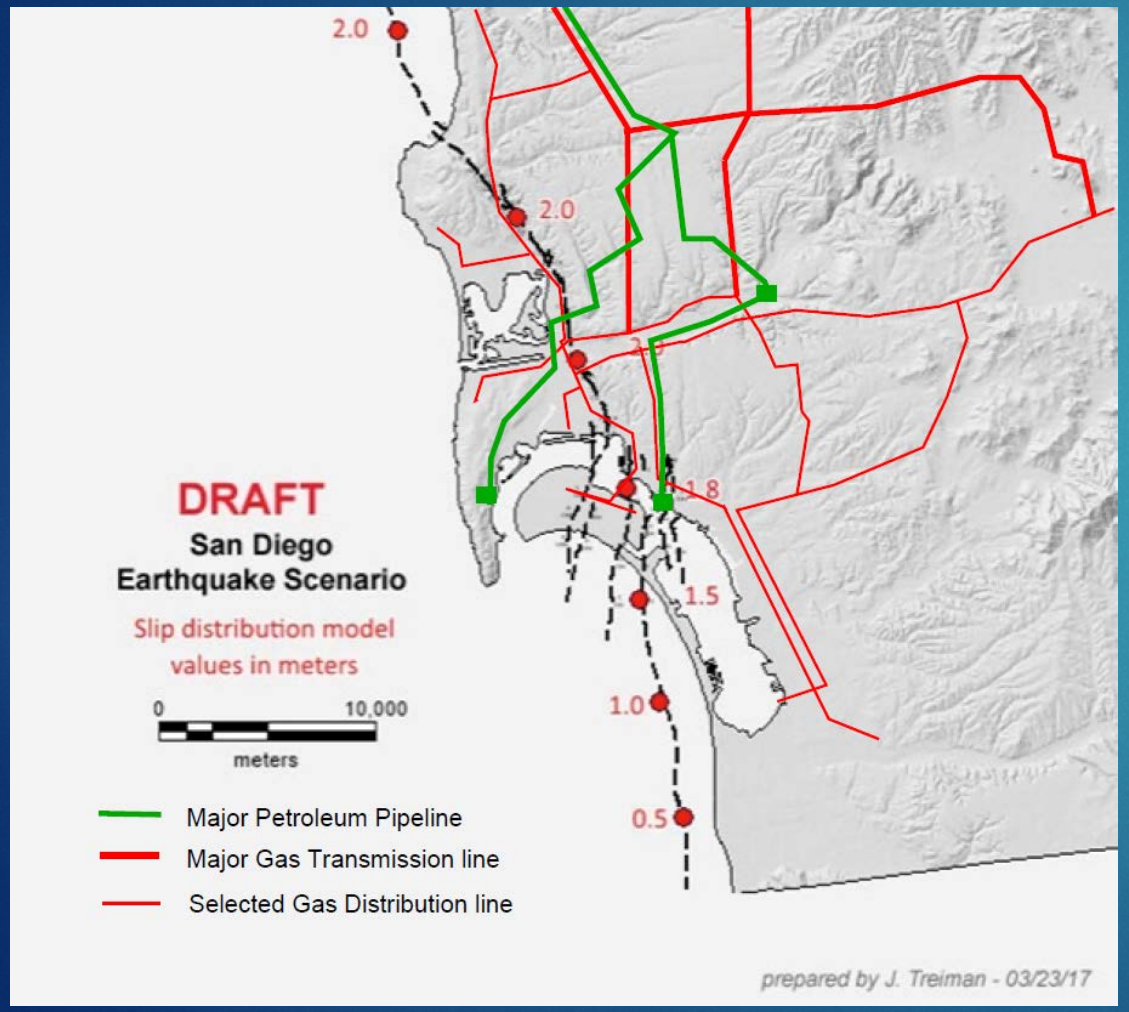
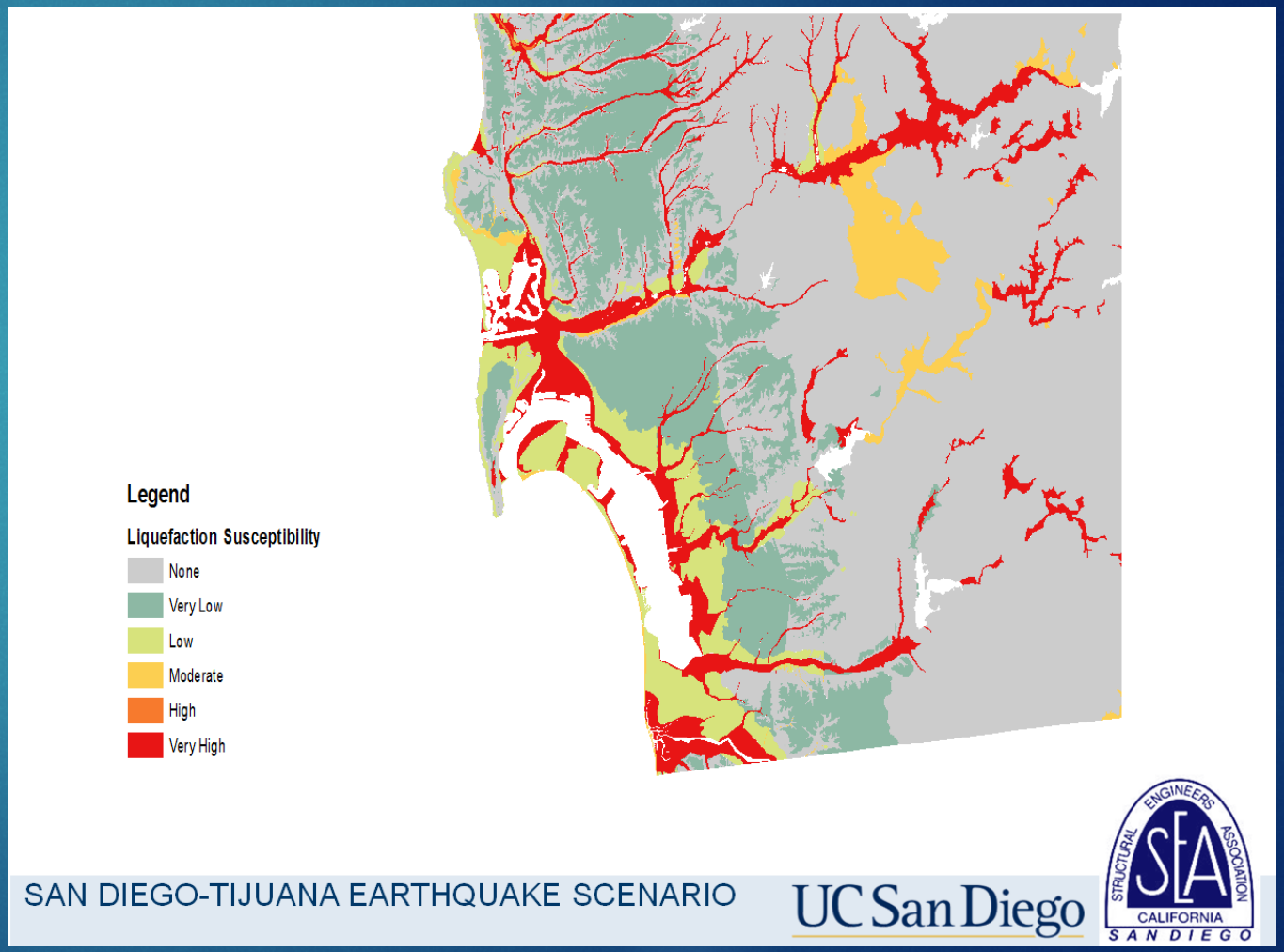
What Can Go Wrong?
- Surface Rupture (from CGS) & fuel and gas lines
- Liquefaction Potential Map
  (groundwater updated data from USGS)





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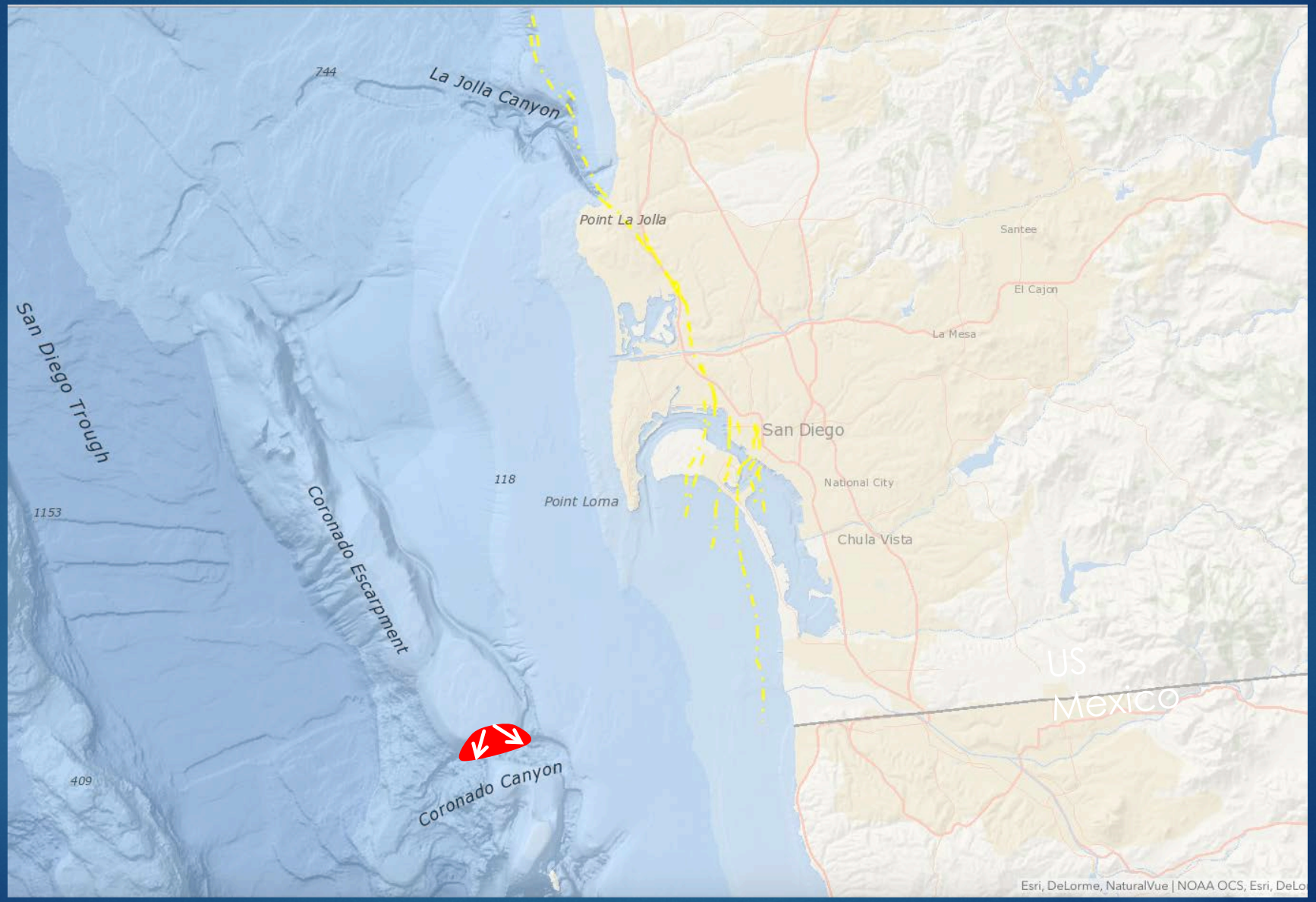
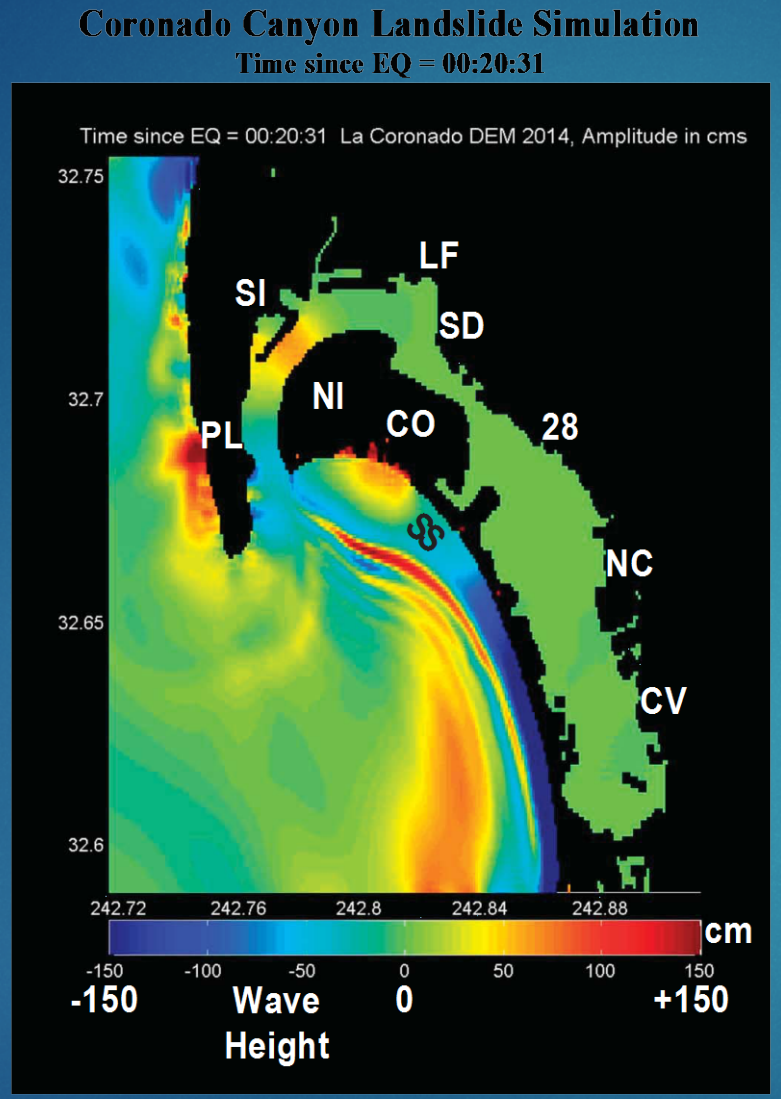
“Every major worldwide example of fire following earthquake has included at least one refinery fire” – Charles Scawthorn

Submarine Landslide Tsunami Location



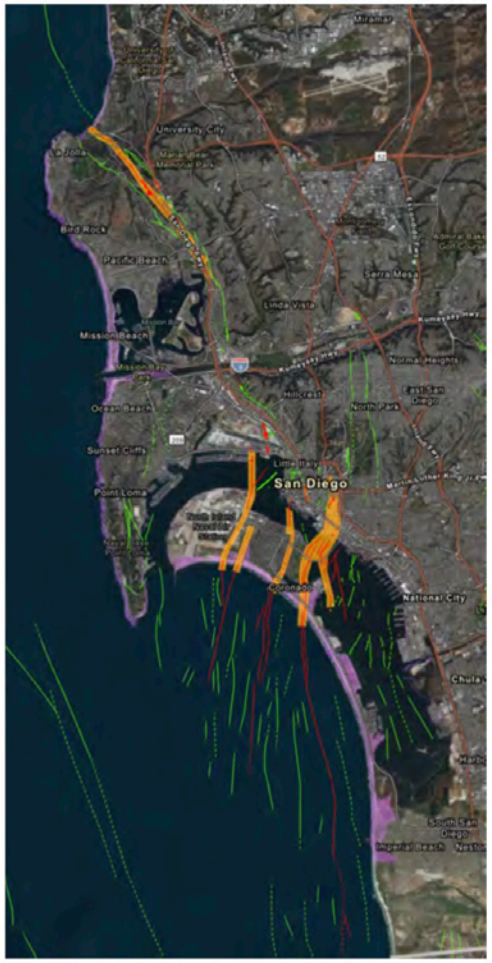
Coronado Canyon Submarine Landslide Tsunami

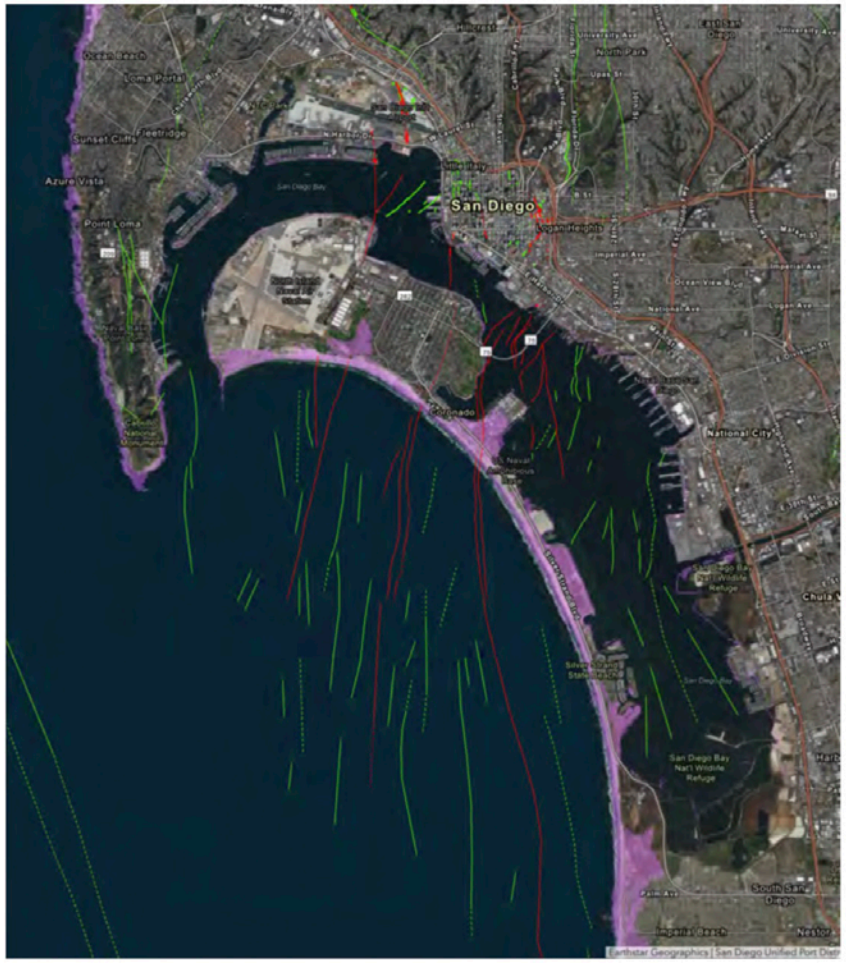


LP = La Playa NI = North Island DF = Dutch Flat NC = National City
SI = Shelter Island CO = Coronado LF = Lindbergh Field CV = Chula Vista
PL = Point Loma SS= Silver Strand SD = San Diego 28 = 28th Street Pier

Please give credit for the Tsunami Animation which was provided by Aggeliki Barberopoulou, Mark R. Legg, and Edison Gica. Based on published paper: Time Evolution of Man-Made Harbor Modifications in San Diego: Effects on Tsunamis In the Journal of Marine Science and Engineering ISSN 2077-1312 www.mdpi.com/journal/jmse. Published: 19 November 2015.

Tsunami HAZUS Inundation (purple)





Includes Building & Casualties; Does not include Harbor Infrastructure Losses (i.e. docks, facilities, etc.)

Together... we can #OutsmartDisaster

HAYWIRED

OUTSMART DISASTER

@HayWiredCA

Questions ?

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