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NATURAL HAZARDS MISSION AREA



USGS Science for Seismic Resilience

Keith Knudsen, USGS Earthquake Science Center

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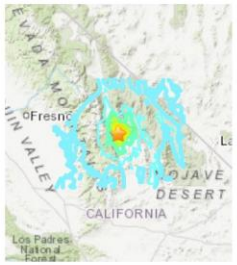
USGS: Products

M 5.8 – 18km SSE of Lone Pine, CA

2020-06-24 17:40:49 (UTC) | 36.447°N 117.975°W | 4.7 km depth

Interactive Map



Contributed by CI [4]

Regional Information

Contributed by CI [4]

Felt Report - Tell Us!

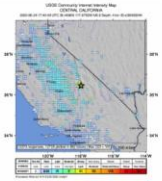
0 1 2 8 4 8

Responses

Contribute to citizen science. Please tell us about your experience.

Citizen Scientist Contributions

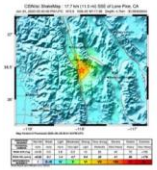
Did You Feel It? V



Community Internet Intensity Map

Contributed by US [8]

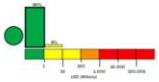
ShakeMap VIII



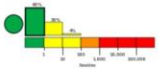
Estimated Intensity Map

Contributed by CI [4]

PAGER GREEN



Estimated Economic Losses



Estimated Fatalities

Contributed by US [8]

Ground Failure

Landslide Estimate

Little or no area affected

Little or no population exposed

Liquefaction Estimate

Little or no area affected

Little or no population exposed

Contributed by US [8]

Origin

Review Status
REVIEWED

Magnitude
5.8 mw

Depth
4.7 km

Time
2020-06-24 17:40:49 UTC

Contributed by CI [4]

Moment Tensor

Fault Plane Solution

Contributed by CI [4]

Aftershock Forecast

Be ready for more earthquakes.

Our model of the expected numbers and odds of future earthquakes.

Contributed by US [8]

Tsunami

U.S. Tsunami Warning System

To view any current tsunami advisories for this and other events please visit https://www.tsunami.gov.

NOAA

View Nearby Seismicity

Time Range
± Three Weeks

Search Radius
250.0 km

Magnitude Range
≥ 2.0

ANSS Comcat

ShakeAlert ®

CONFIRMED

Contributed by EW [5]

The USGS ShakeCast system provides rapid estimates of the severity and extent of earthquake shaking

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The SAFRR Scenarios

ShakeOut: San Andreas fault (southern California) earthquake scenario (2008)

ARkStorm: winter storm scenario impacting U.S. West Coast (2010)

Tsunami Scenario: tsunami generated by an Alaskan earthquake and impacting the U.S. West Coast (2013)

HayWired: Hayward fault (northern California) earthquake scenario (in progress; April 18, 2018 - *release date*)

Scenario Evaluation: What did right, wrong, didn't consider? How did we change the culture of preparedness?

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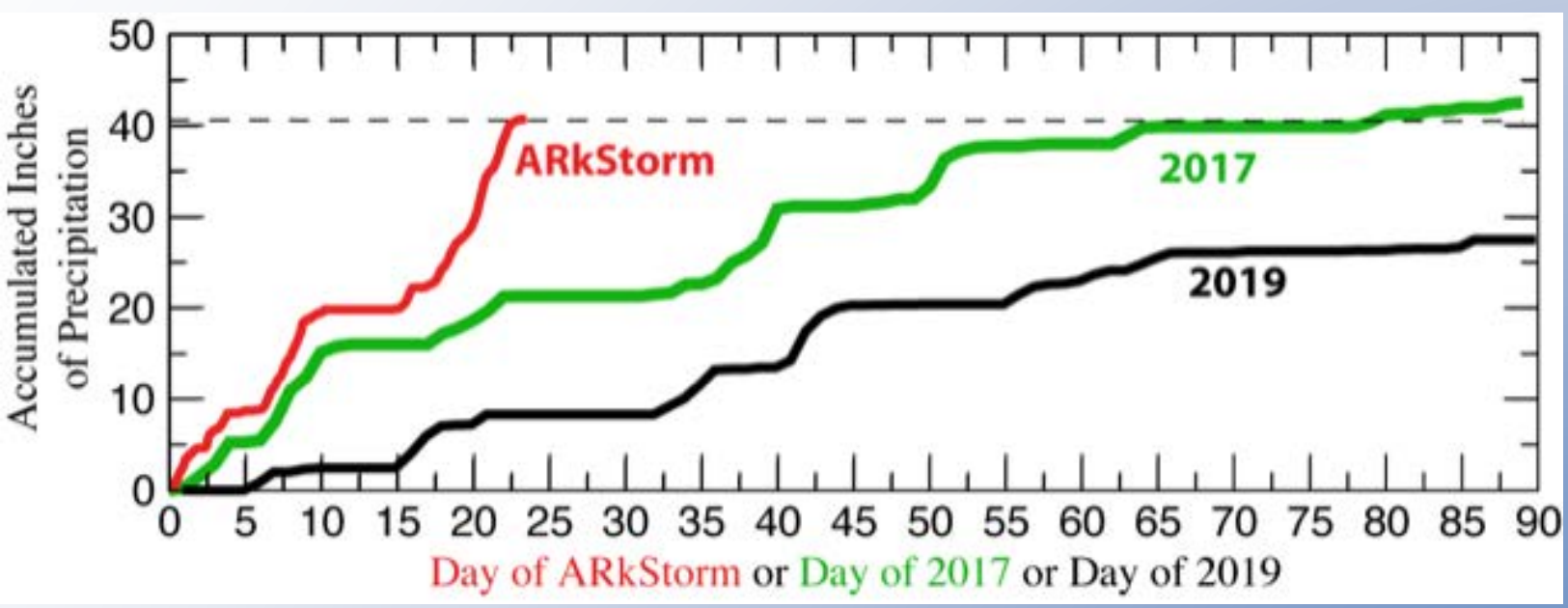
ARkStorm, 2017 & 2019 Storms



Oroville Dam 2017 (CBS)

#februburied 2019

Guernville 2019

WHO 2018 Pandemic Scenario and Exercise

FEATURE	ASSUMPTIONS	HOW TO USE ASSUMPTIONS IN YOUR SCENARIO
Social impact	• Disruption to normal social movement, public spaces, and commercial services will have a wide range of impacts on people's daily lives and may affect public reaction to how the pandemic is being managed. • Mainstream and social media coverage may or may not be supportive or accurate, affecting public sentiment and cooperation with the response.	***Consider including events such as the following to your scenario:*** • School closures • Market/store closures • Cancellation of public events • Rumours and misinformation • Negative media coverage of government response • Shortages of basic commodities (medicine, food, fuel) • Disruption of essential services (e.g. transport, energy, water) • Civil unrest
Economic impact	• Disruption to markets and businesses may affect both current and future economic activity. • Some sectors may be more badly affected than others, and may require support to recover.	***Consider including events such as the following to your scenario:*** • flight cancellations and airport closures • disruption of essential services (e.g. transport, energy and water) • business and livelihood losses • financial market disruption • lack of funding for pandemic recovery plans.

World Health Organization. (2018). A practical guide for developing and conducting simulation exercises to test and validate pandemic influenza preparedness plans. World Health Organization.

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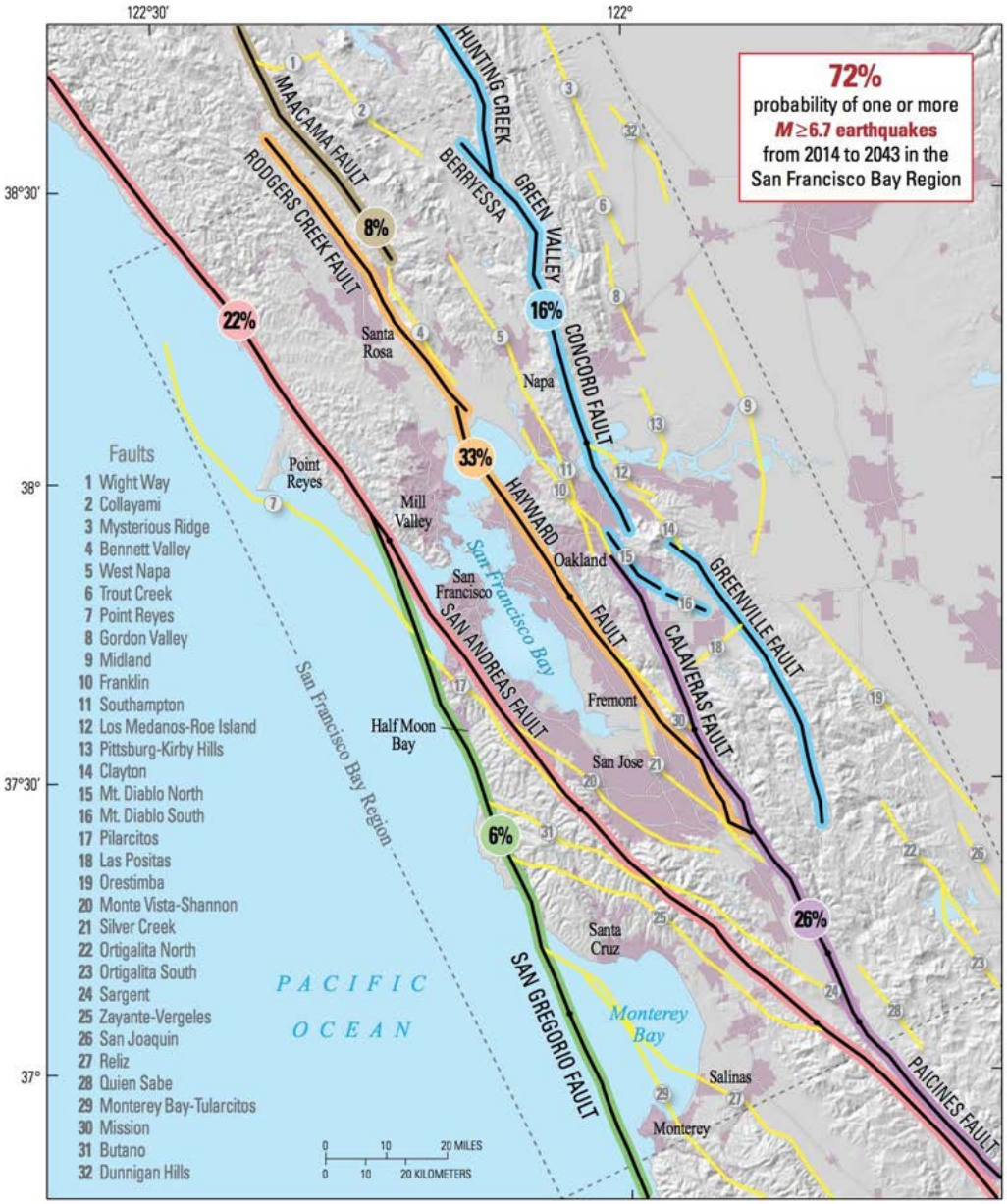

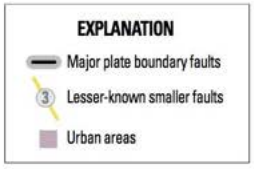

Figure 2. Map of known active geologic faults in the San Francisco Bay region, California, including the Hayward Fault. The 72 percent (%) probability of a magnitude (*M*) 6.7 or greater earthquake in the region includes well-known major plate-boundary faults, lesser-known faults, and unknown faults. The percentage shown within each colored circle is the probability that a magnitude 6.7 or greater earthquake will occur somewhere on that fault system by the year 2043. The probability that a magnitude 6.7 or greater earthquake will involve one of the lesser known faults is 13 percent. (From Aagaard and others, 2016.)

The Hayward Fault is arguably the most urbanized active fault in the United States.

It offers an informative case study of the effects of a large urban earthquake on a modern U.S. metropolis.

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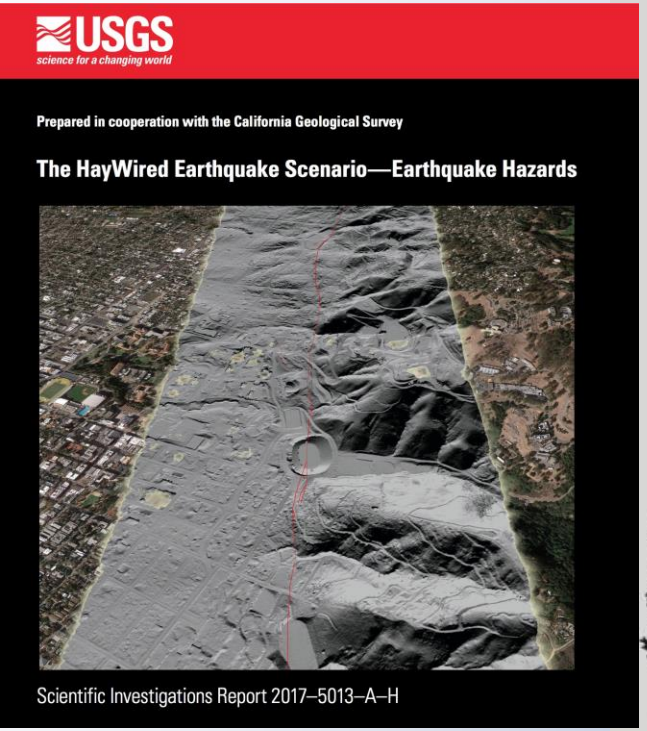
Hay**Wired:** Objectives

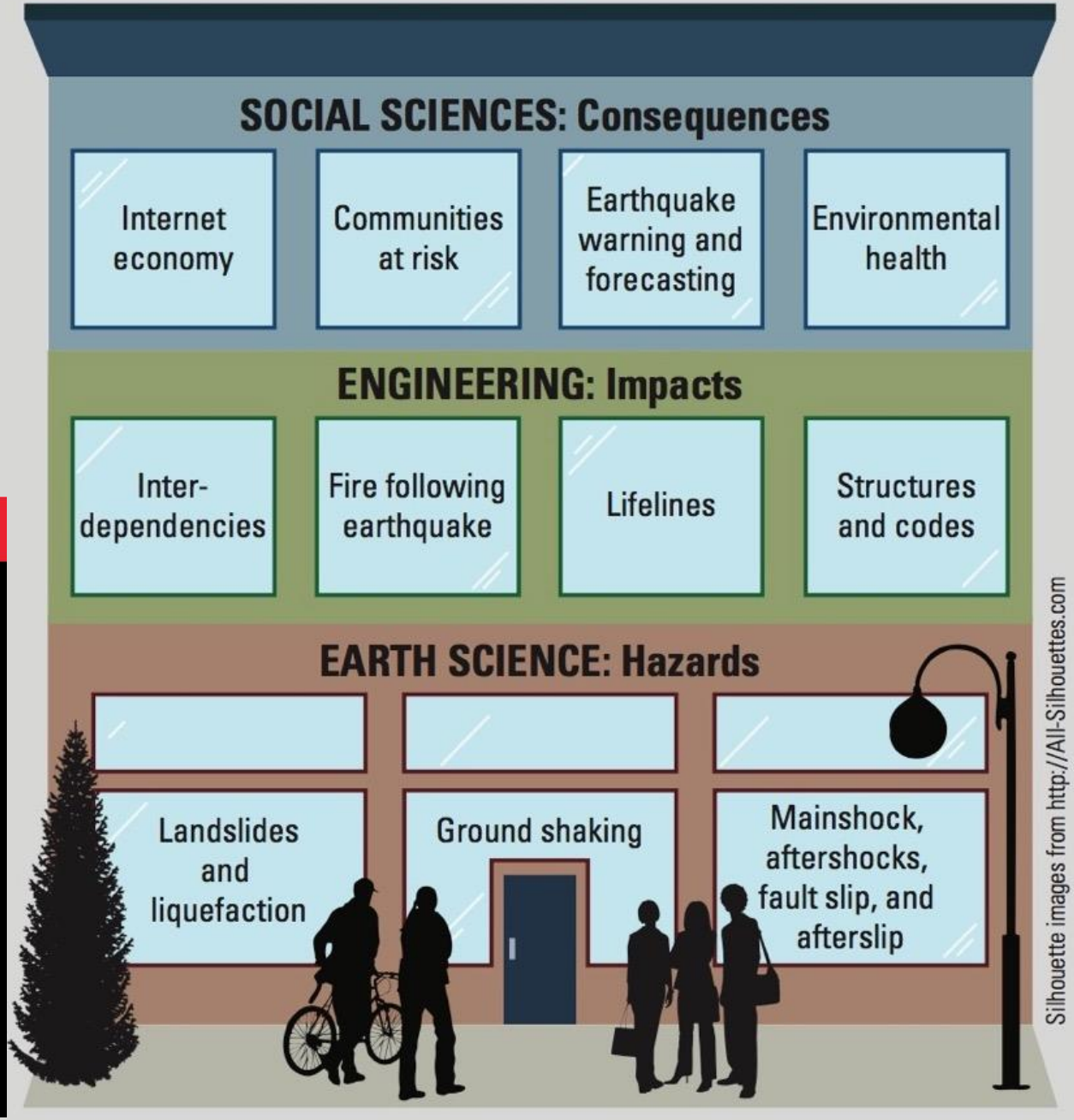
- Improve understanding of the benefits of earthquake early warning
- Facilitate conversations about lifeline restoration interdependencies (exercises on-going)
- Educate about building code performance and public preferences for the building code
- Help anticipate environmental health issues
- Engage stakeholders in the discussions about the vulnerabilities and resilience in cyber infrastructure & the internet economy
- Provide materials for emergency response, business continuity and recovery exercises

HAYWIRED

OUTSMART DISASTER



Integrating across disciplines...

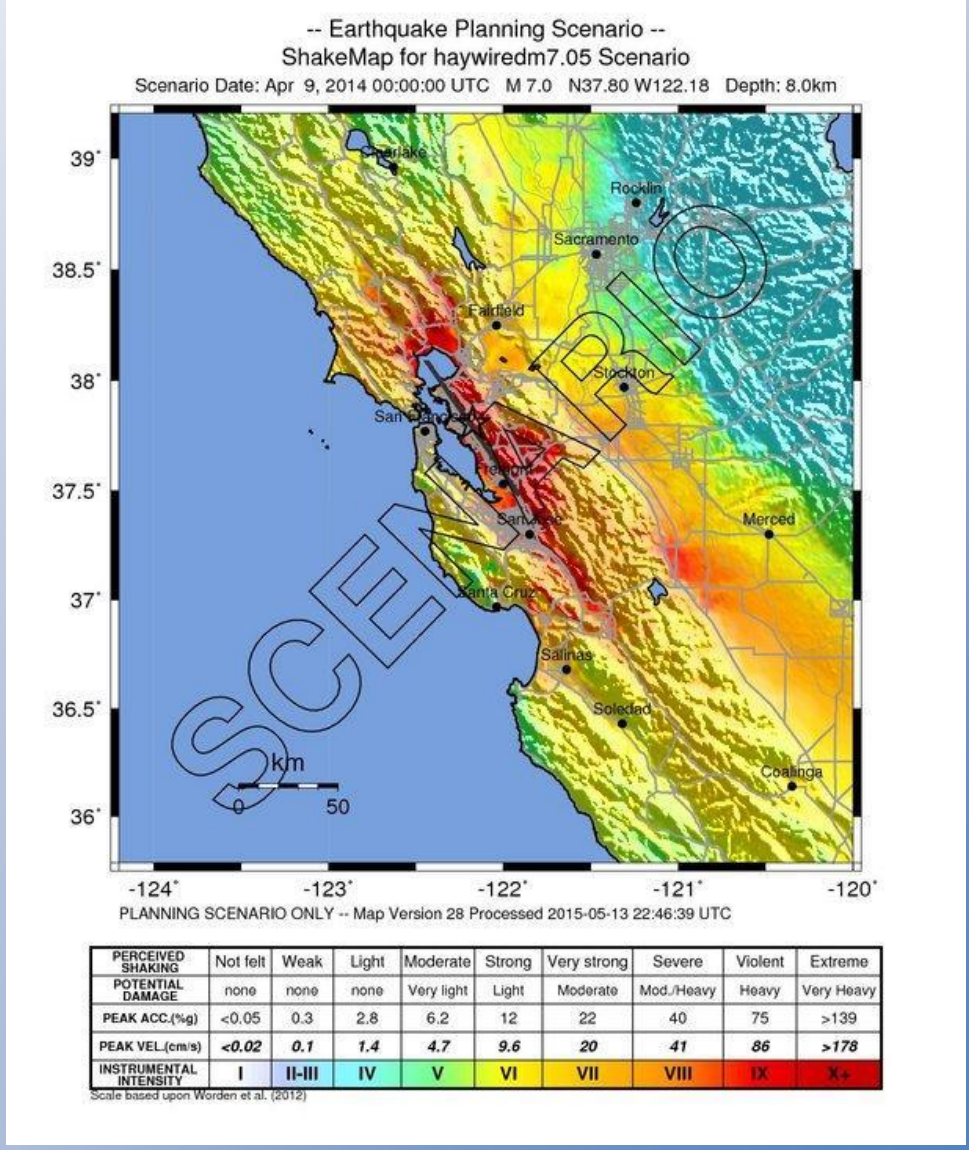


HayWired: Mainshock Ground Motions

M7.0 earthquake occurring on April 18, 2018, at 4:18 p.m, wind Is mild, no rain, temperature avg.

Rupture starts under Oakland, north into San Pablo Bay and south to the city of Fremont (53 miles)

The HayWired scenario describes a M 7.0 earthquake, 83-km (51 mile) rupture, with up to 2 meters (6.5 feet) of fault offset either in the form of coseismic slip or afterslip



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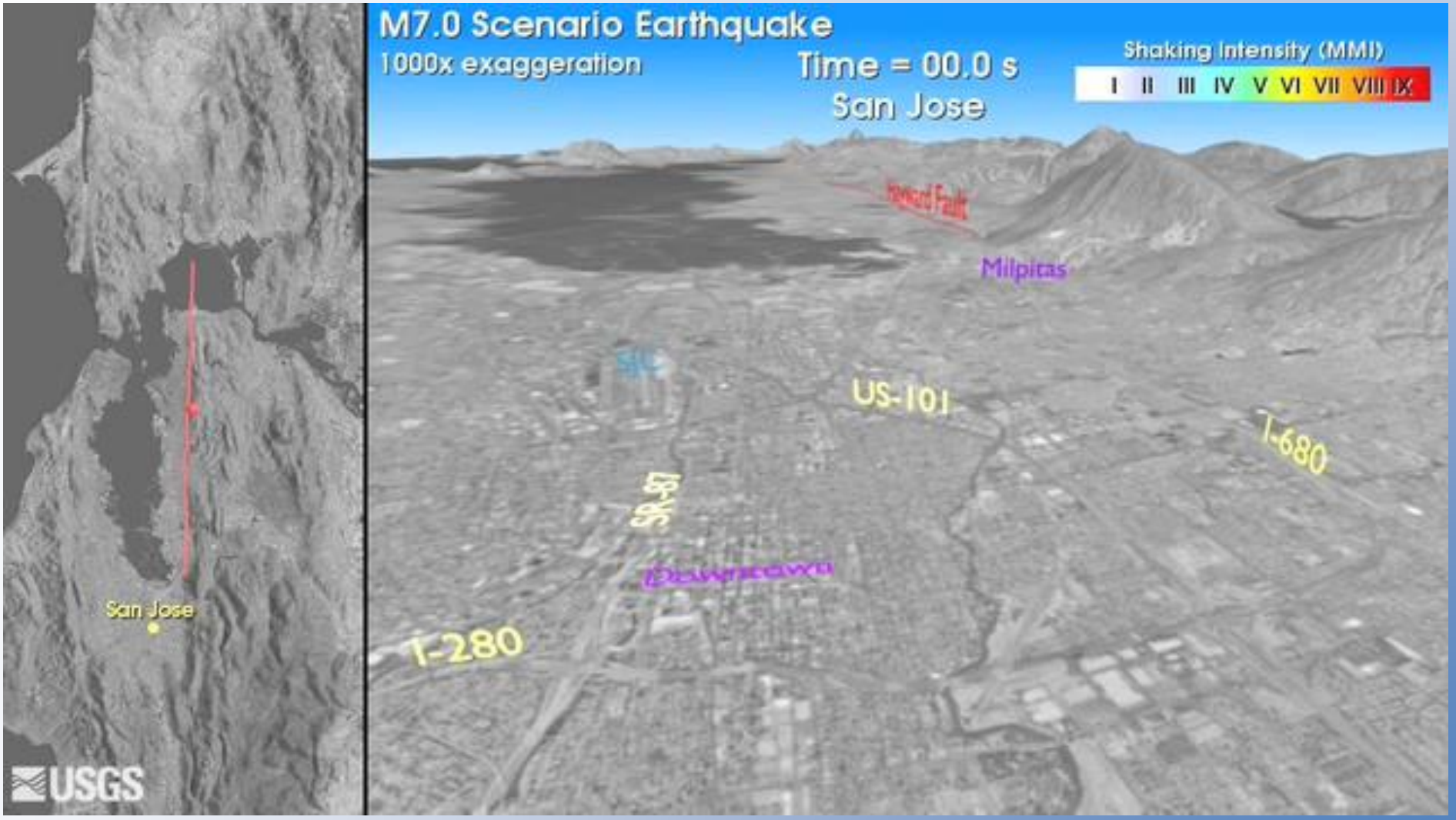
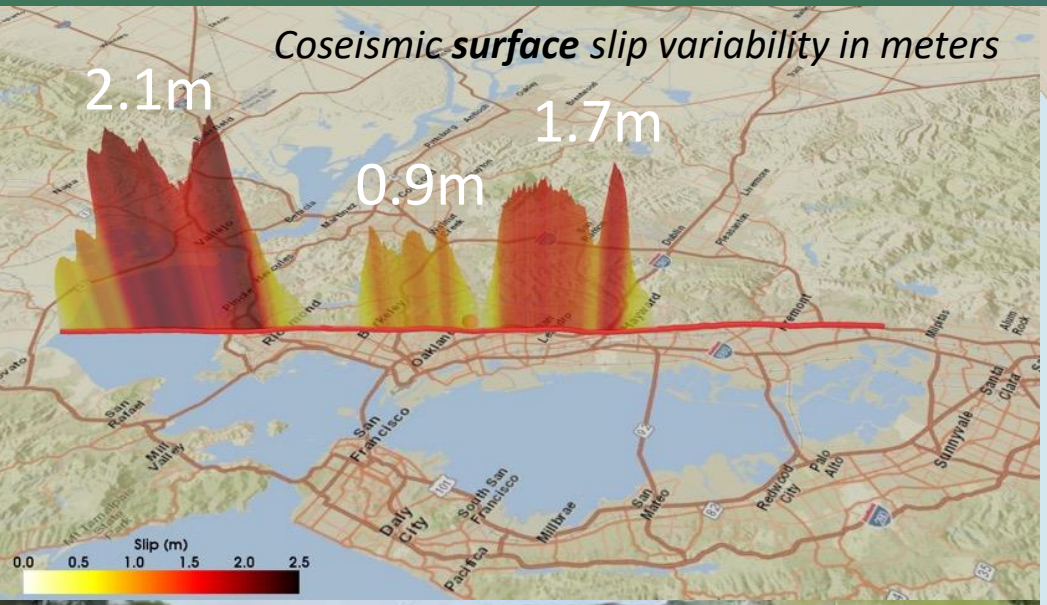
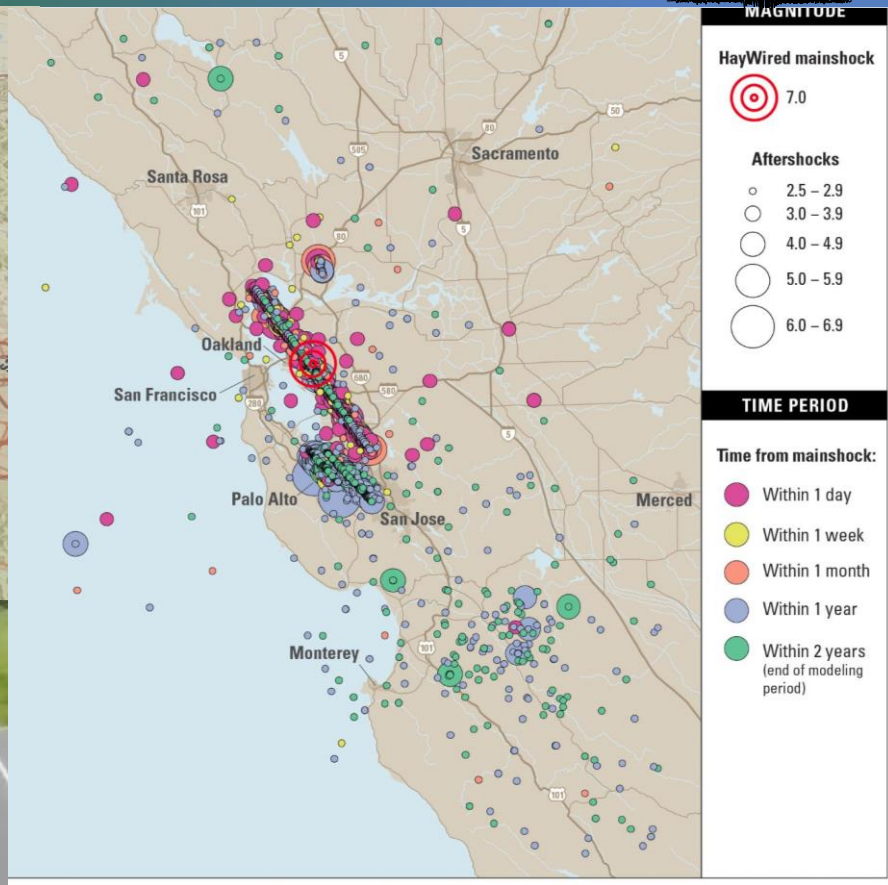
HayWired shaking animation

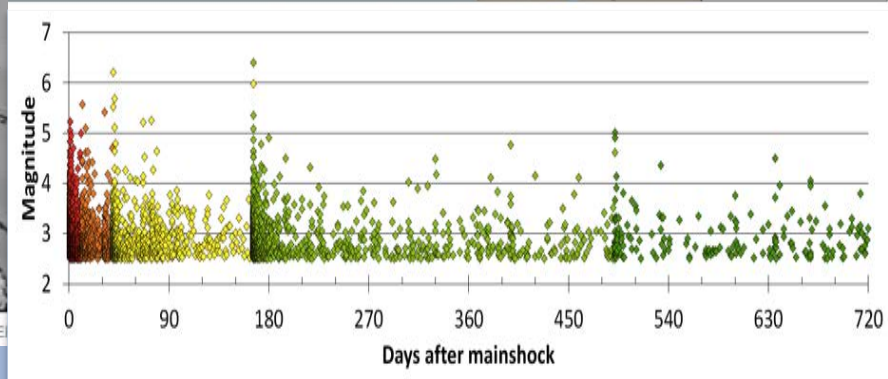


Hay**Wired**: Fault Slip, Afterslip and Aftershocks



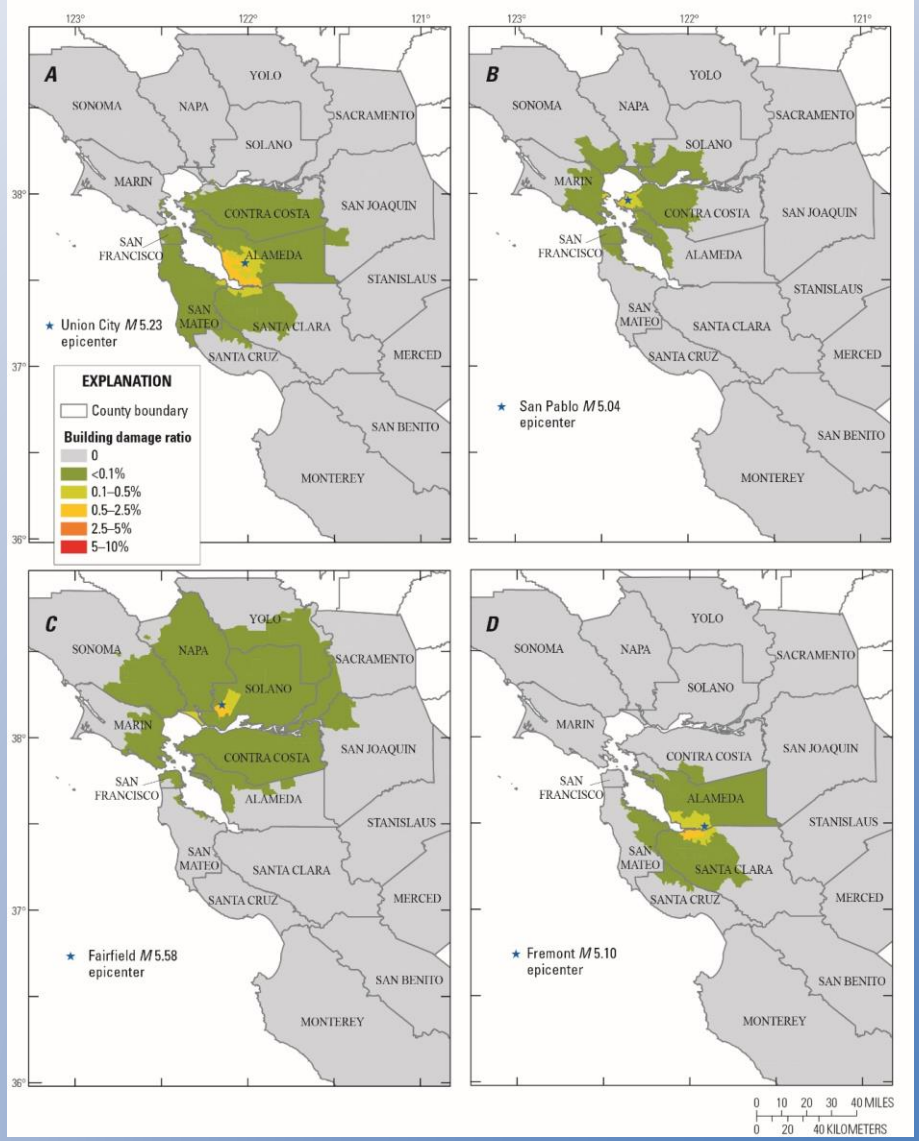
2016 M 7.8 Kaikoura,NZ earthquake





HayWired: Hazus aftershock analysis

- Aftershocks contribute 20% of loss
  - 12% from 3 aftershocks M_w 6.0 to 6.4
  - 8% to 13 aftershocks M_w 5.0 to 5.9
- Some areas more damaged by aftershocks
- Repeat liquefaction is a concern
- 1st Hazus-MH analysis of entire earthquake sequence in a scenario



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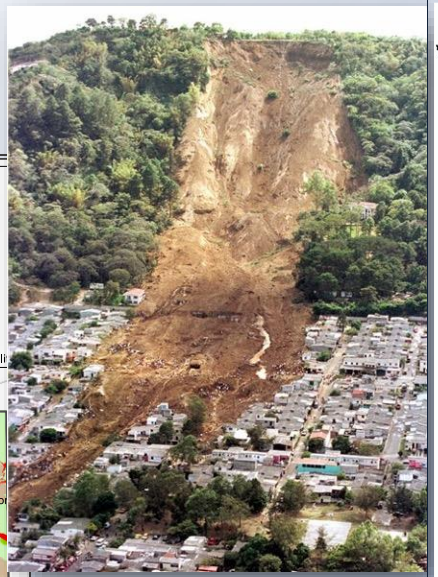
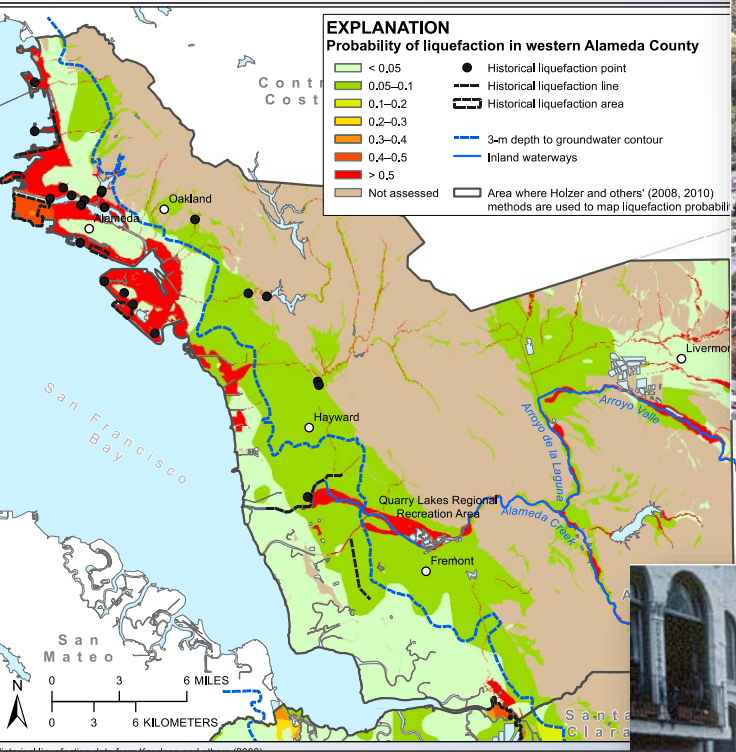
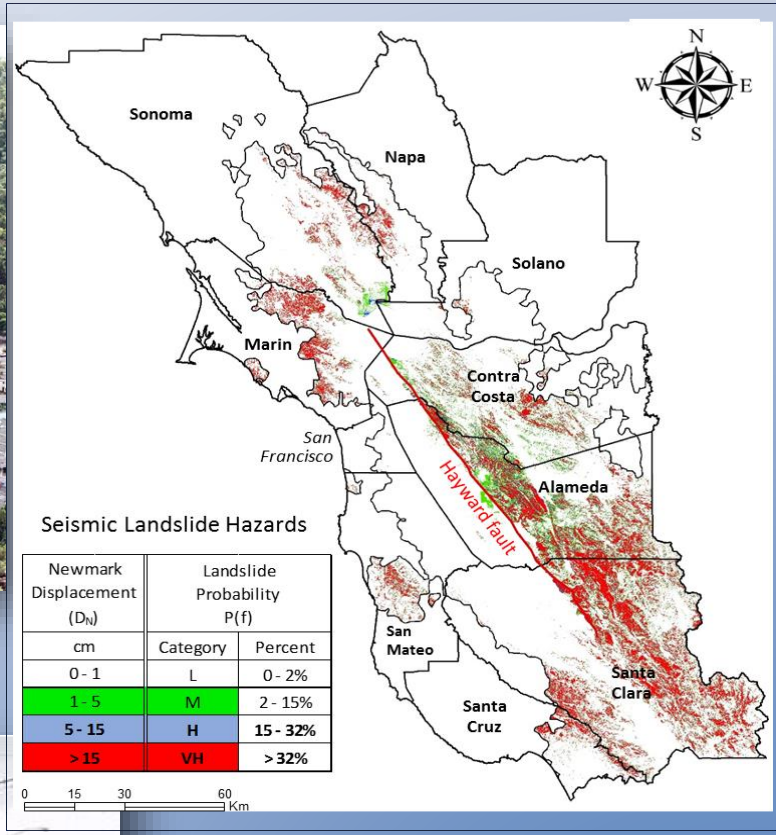
Hay**Wired**: Landslide & Liquefaction

2001 El Salvador earthquake-induced landslide







Seismic Landslide Hazards

Newmark Displacement (D_N)	Landslide Probability P(f)	
cm	Category	Percent
0 - 1	L	0 - 2%
1 - 5	M	2 - 15%
5 - 15	H	15 - 32%
> 15	VH	> 32%

Liquefaction in San Francisco Marina, Loma Prieta Earthquake 1989

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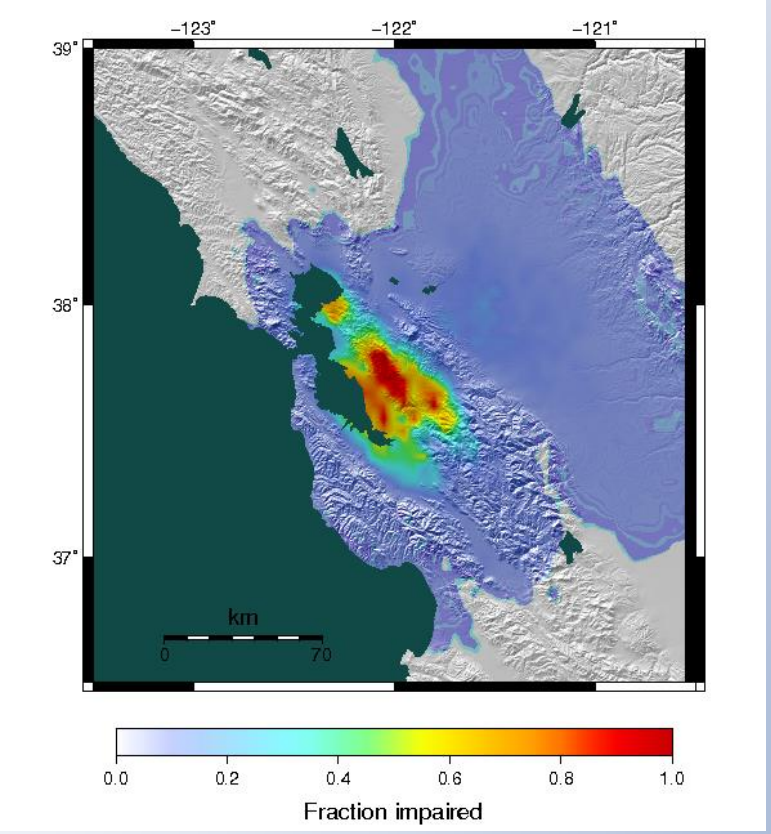
An immediate occupancy code? Build 50% stronger & stiffer; cost 1% more; reduce impairment by 3/4th

Life Safety

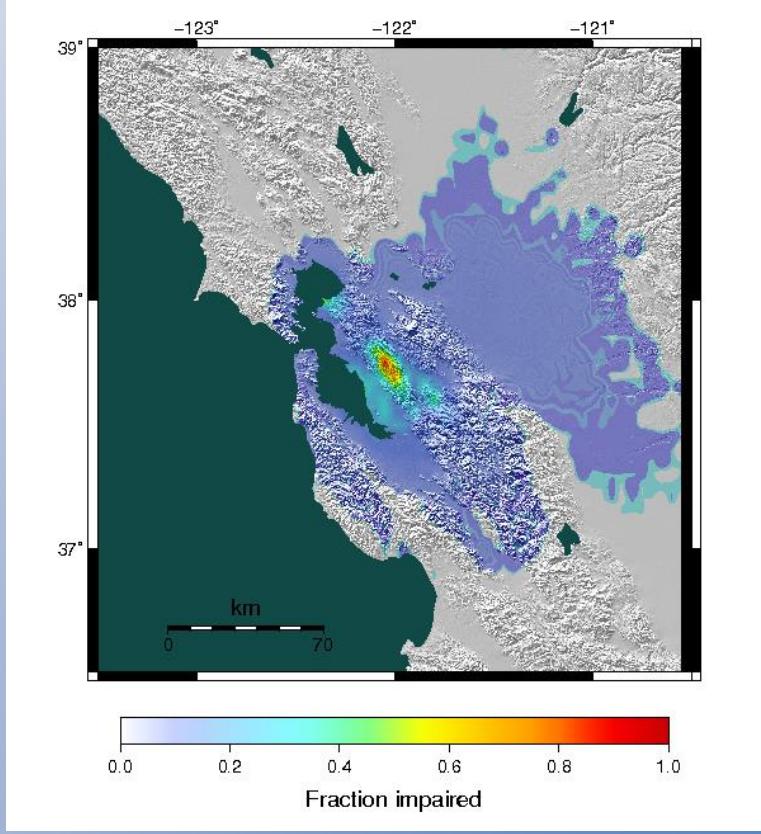
8,000 buildings (0.4%) collapse
490,000 (24%) red or yellow tag



Vs.

Immediate Occupancy

95% shelter in place, collapse, red, and yellow tags reduced by 3/4



Preliminary information subject to revision. Do not cite.

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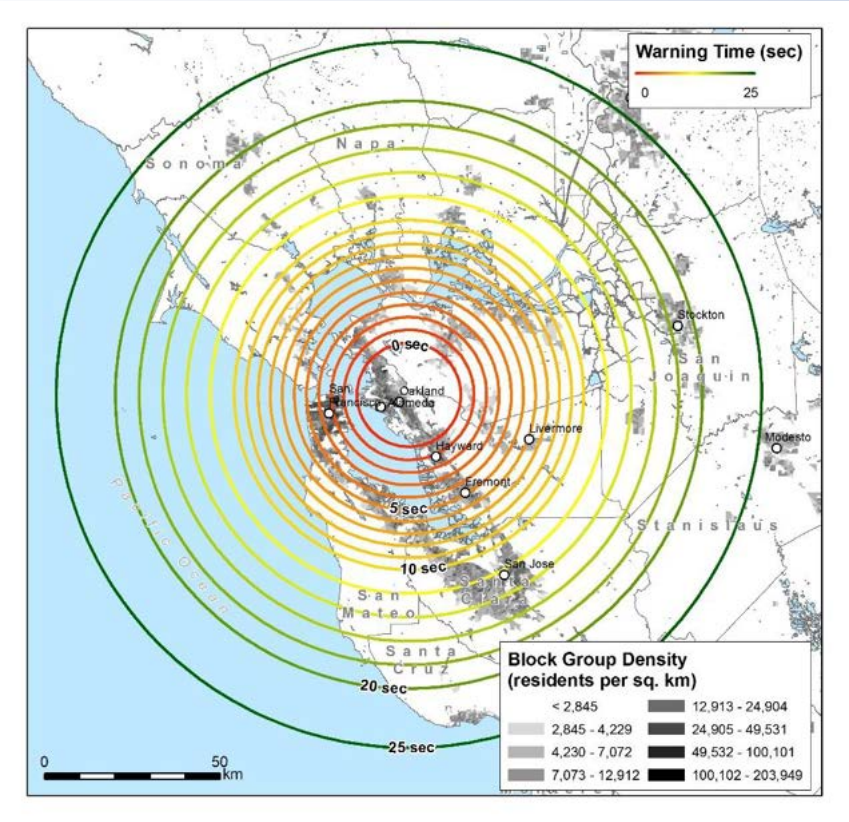
Hay**Wired:** EEW and DCHO

Earthquake early warning (EEW) time in HayWired



Drop, cover, and hold on (DCHO) reaction time

EEW + DCHO could prevent 1,500 injuries "worth" $300M in Mw 7.0 Hayward

Preliminary information subject to revision. Do not cite.

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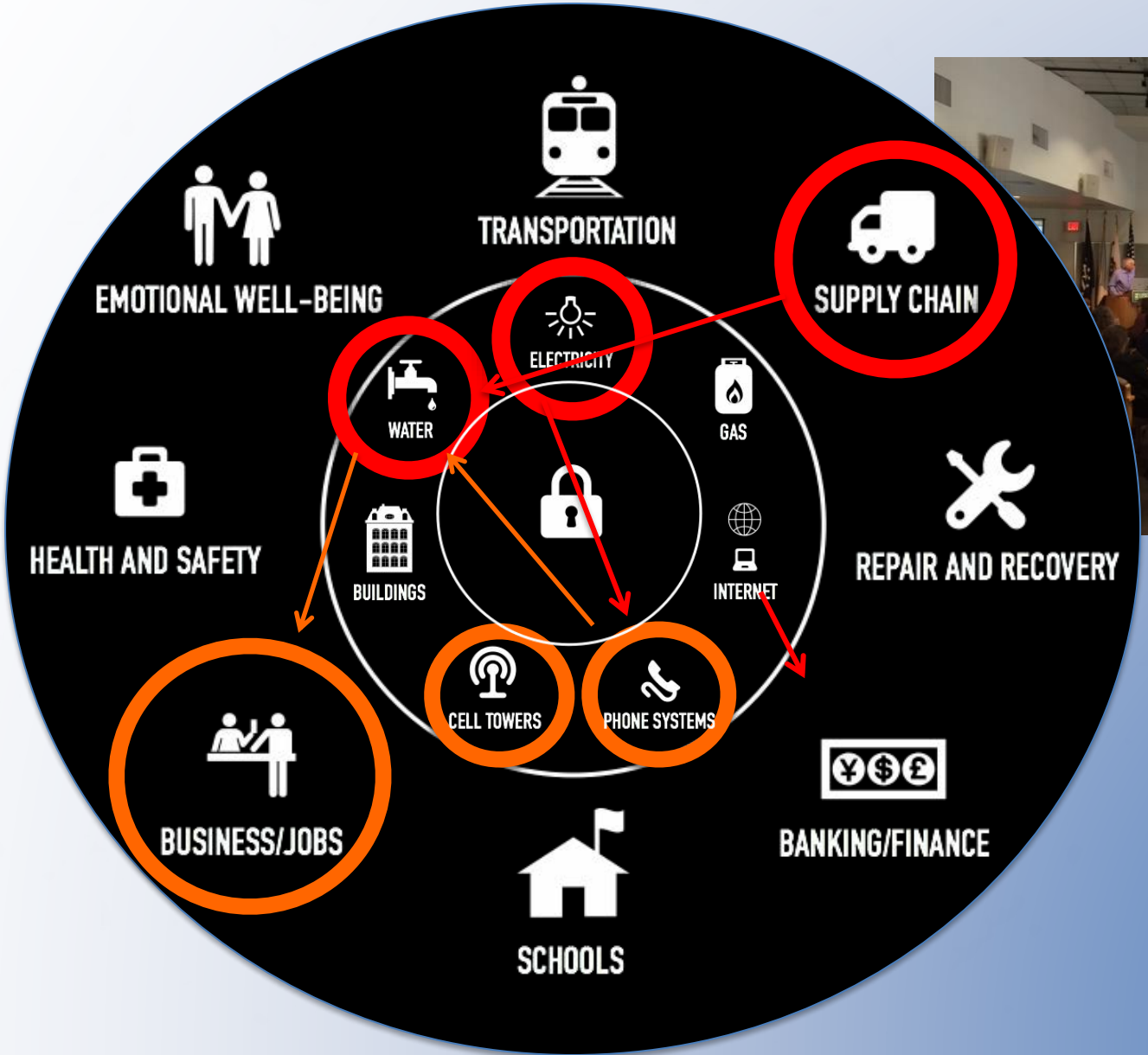
Hay**Wired:** Our Interconnected World



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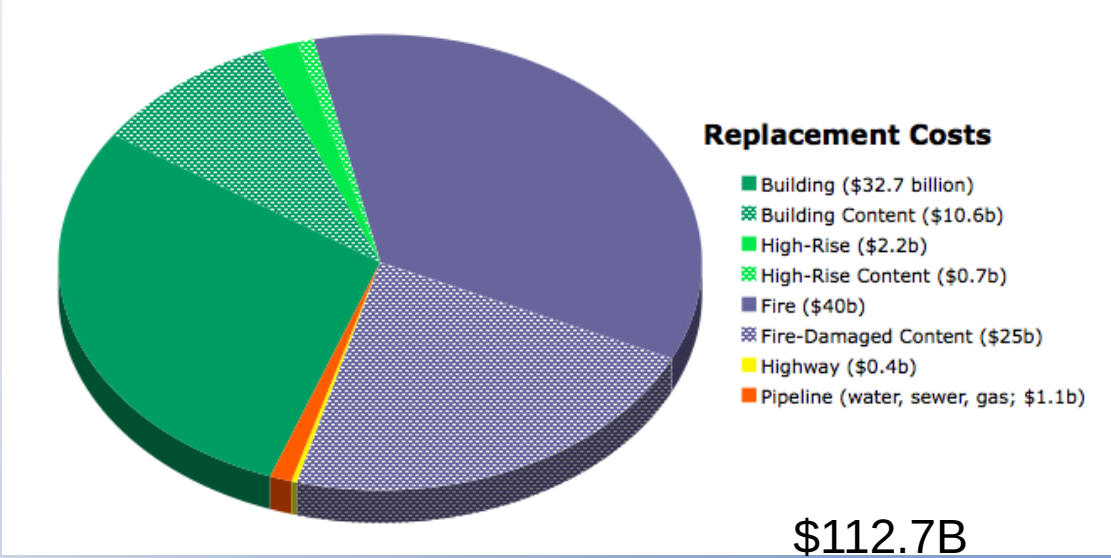
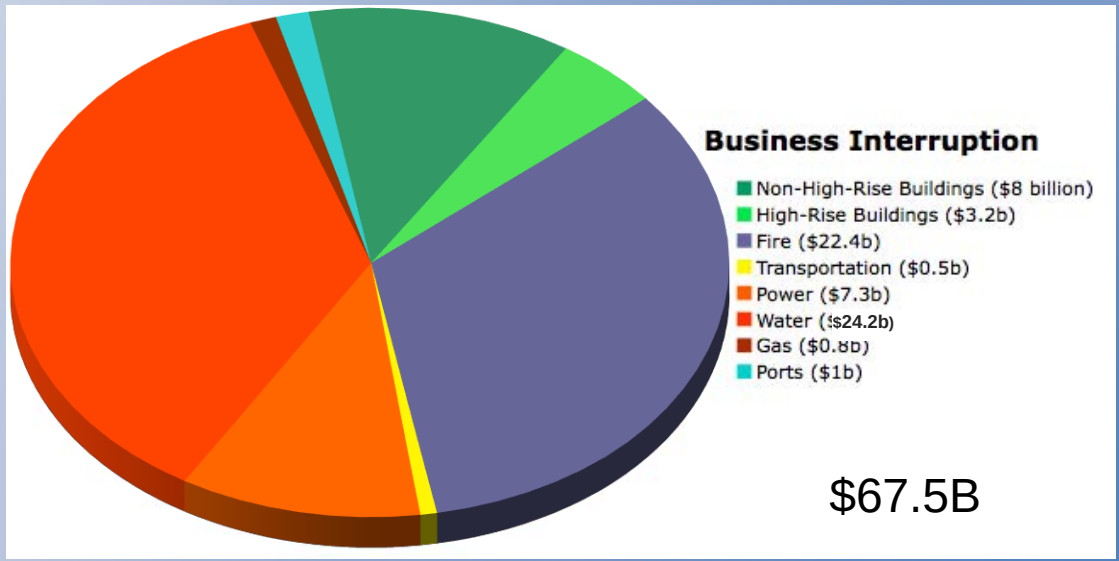
ShakeOut





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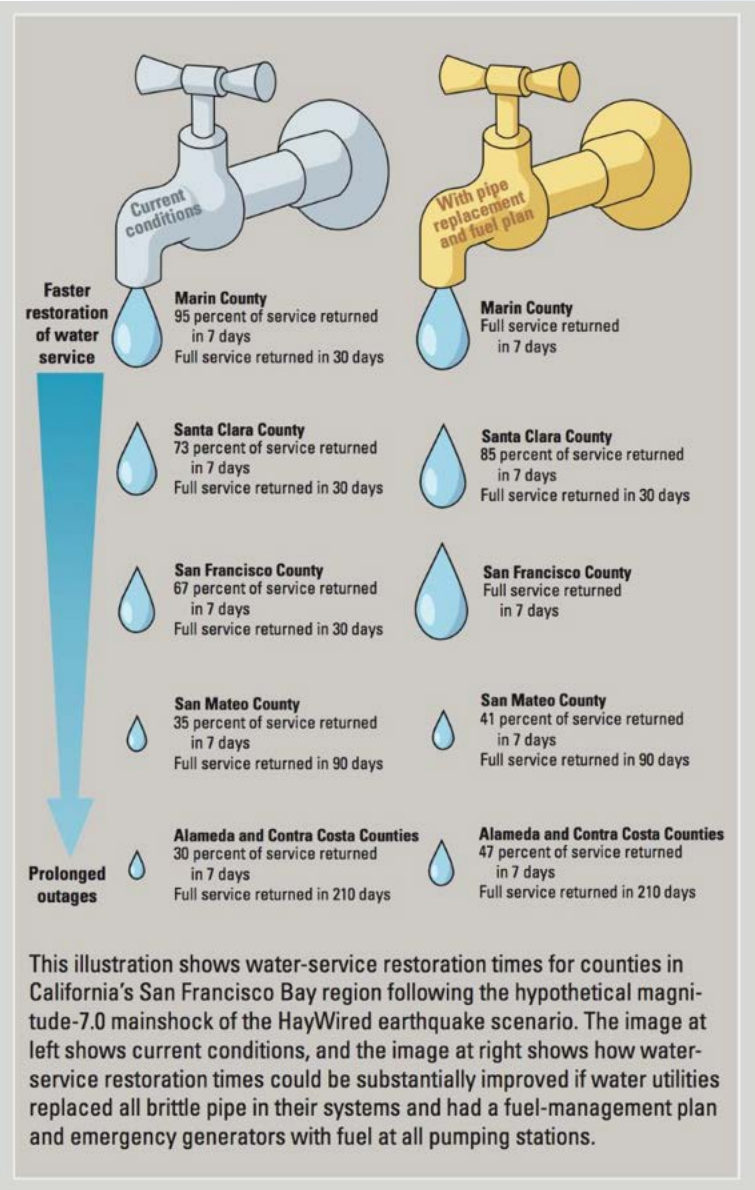
HayWired: Water Supply Disruption and Exposure



This illustration shows water-service restoration times for counties in California's San Francisco Bay region following the hypothetical magnitude-7.0 mainshock of the HayWired earthquake scenario. The image at left shows current conditions, and the image at right shows how water-service restoration times could be substantially improved if water utilities replaced all brittle pipe in their systems and had a fuel-management plan and emergency generators with fuel at all pumping stations.

- Two major water-transmission conveyances (the San Pablo Tunnel and the Mokelumne Aqueduct) cross the fault rupture zone in three places
- Ten percent of the dams in the study area are exposed to high shaking intensity.
- Wastewater treatment plants are the most exposed (of all water infrastructure) to high liquefaction intensity

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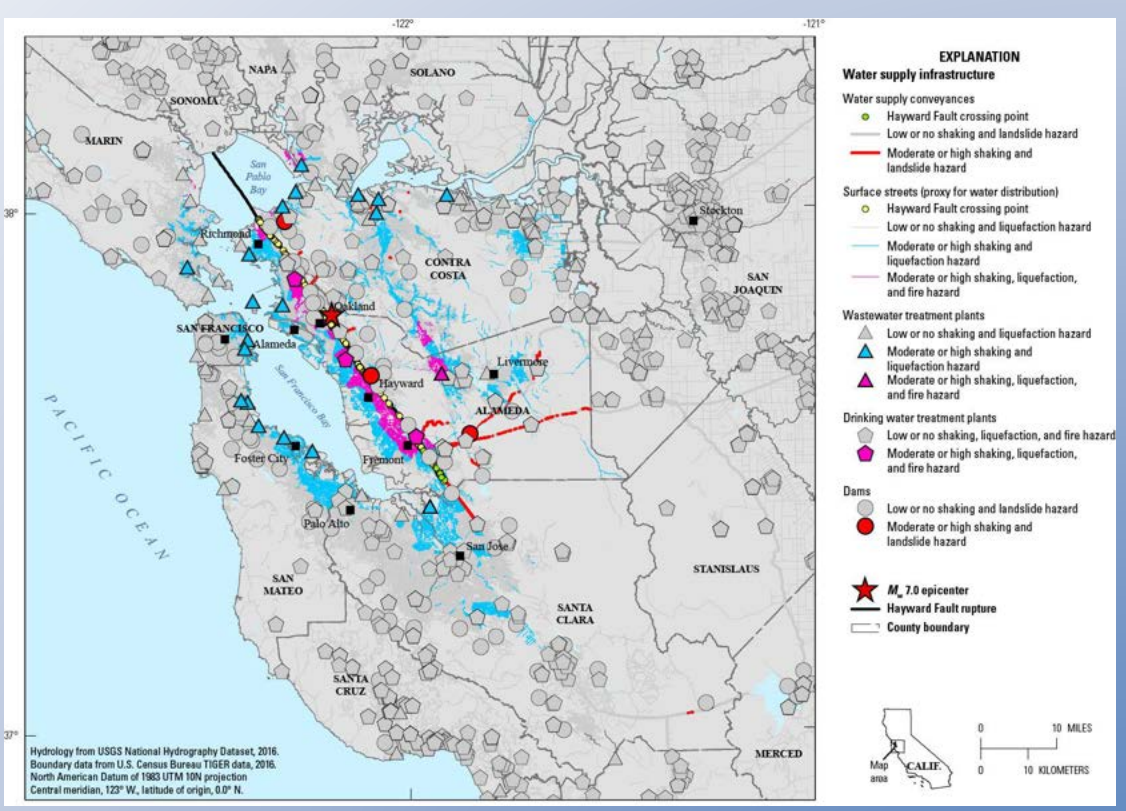
HayWired: Water Infrastructure in Hazardous Areas

Infrastructure	Hazards (strong shaking + …)
Dams & water conveyance	Landslides
Water & sewer distribution (roads)	Liquefaction Liquefaction/fire Fault crossings
Drinking water treatment	Liquefaction/fire
Wastewater treatment	Liquefaction



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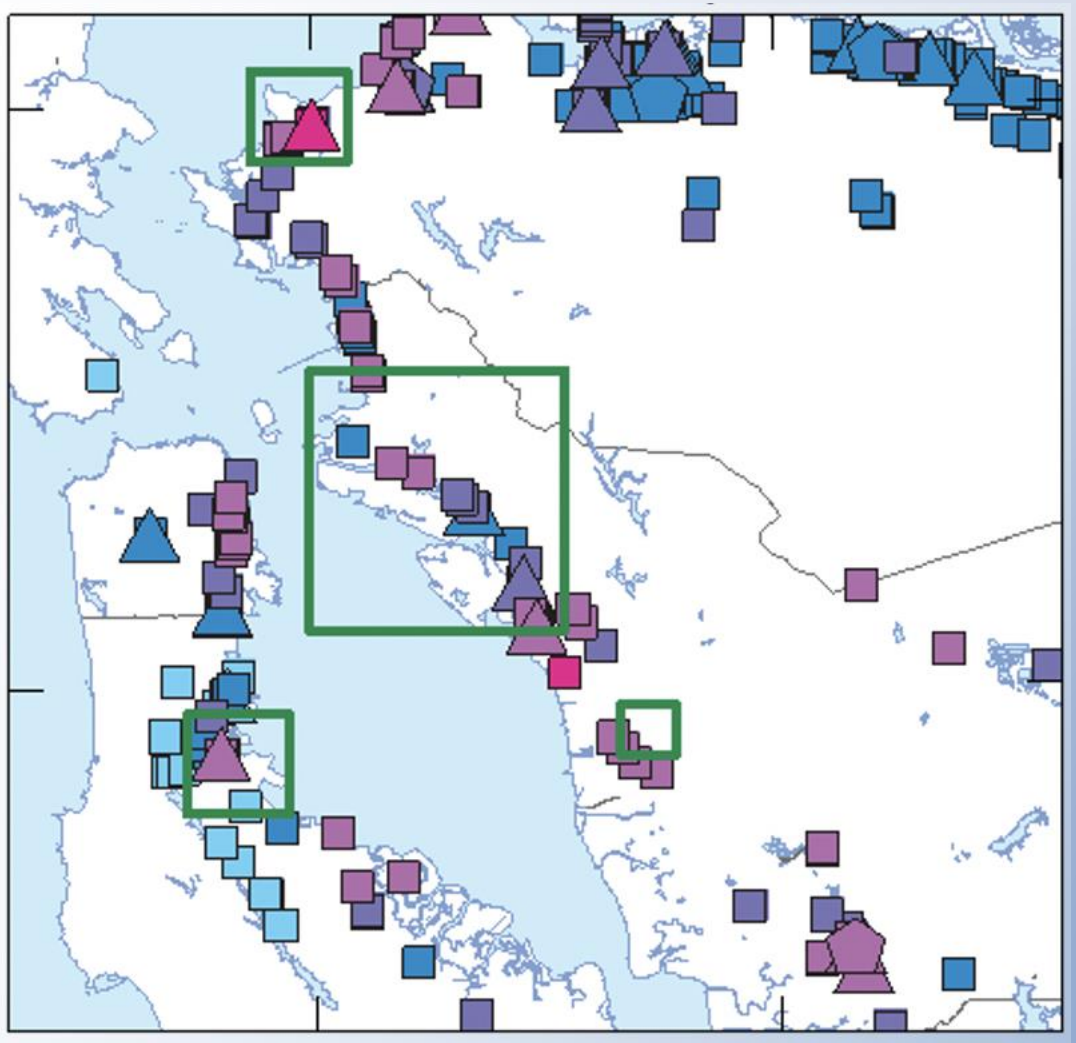
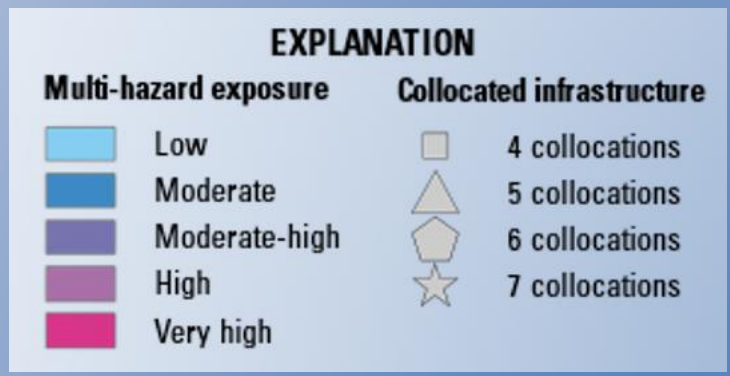
HayWired: Collocation of Lifeline Infrastructure



Water conveyance collocated in hazardous (purple, pink) areas	Count
Electric transmission	32
Highway	12
Caltrans bridge	6
Class 1, 2 or 3 nat. gas pipeline	6
Heavy railway	2
Long-haul fiber route	2



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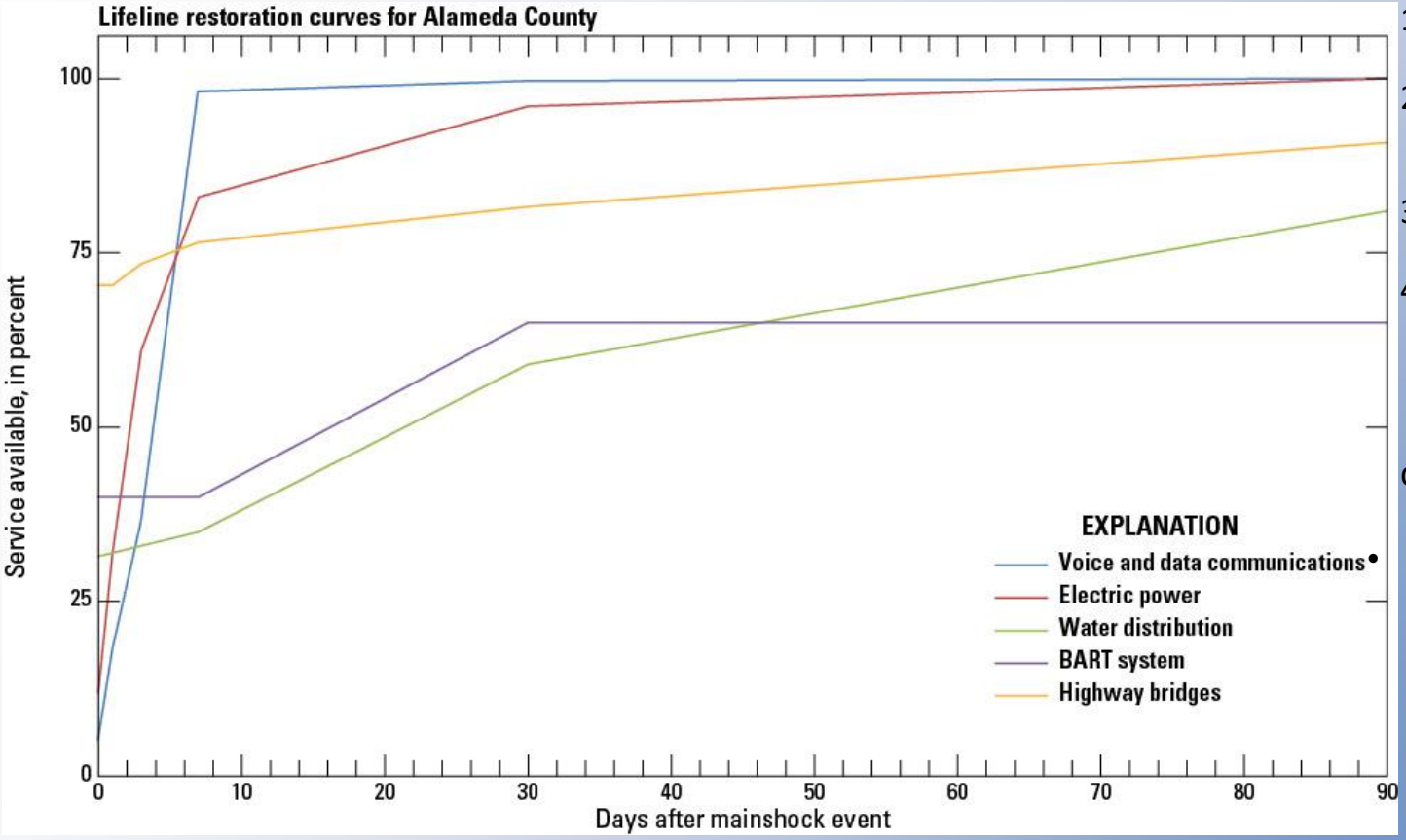
HayWired: County Lifeline Service Restoration



- Economic Impacts
  1. Property damage - extensive
  2. Transportation disruption – to less impacted areas
  3. Water disruption – length of outage
  4. a. Telecomm disruption – economic reach of outage

     b. Electric power disruption

- Population Displacement

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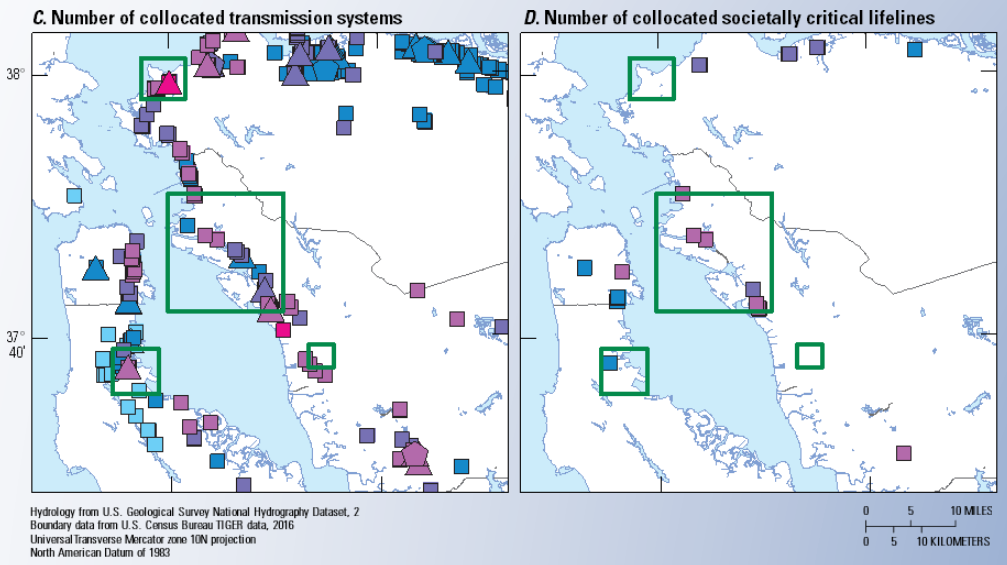
Collocation of lifeline infrastructure

- Counts of collocated infrastructure
  - transmission
  - societally critical for
    - economic impact
    - service area
    - safety

Water conveyance collocated in hazardous (purple, pink) areas	Count
Electric transmission	32
Highway	12
Caltrans bridge	6
Class 1, 2 or 3 nat. gas pipeline	6
Heavy railway	2
Long-haul fiber route	2



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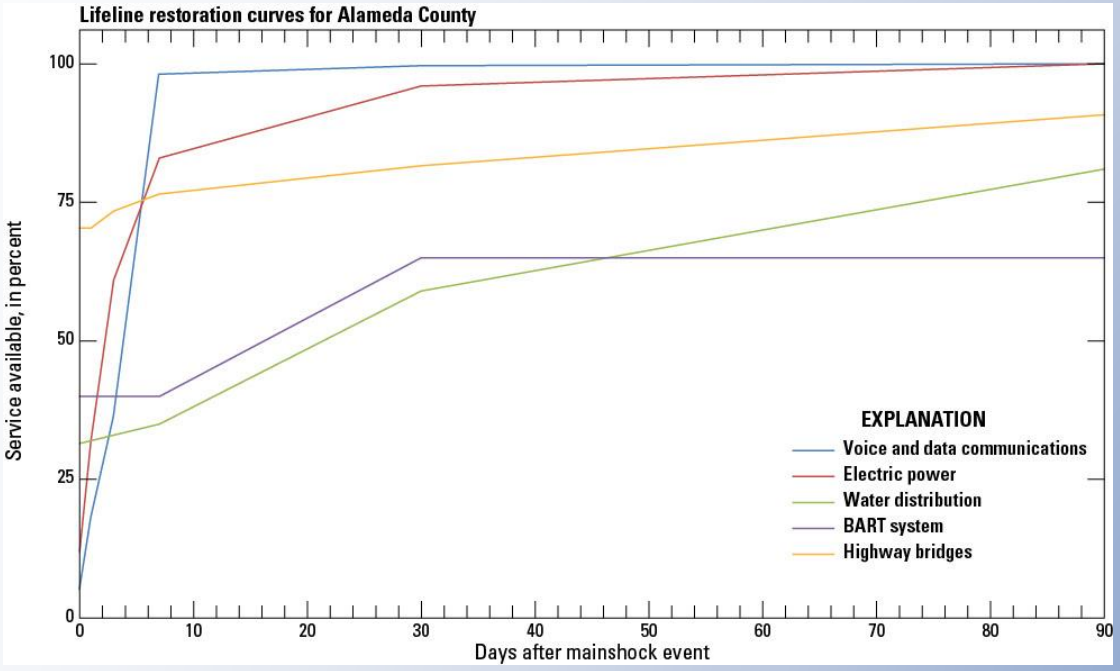
County lifeline service restorations



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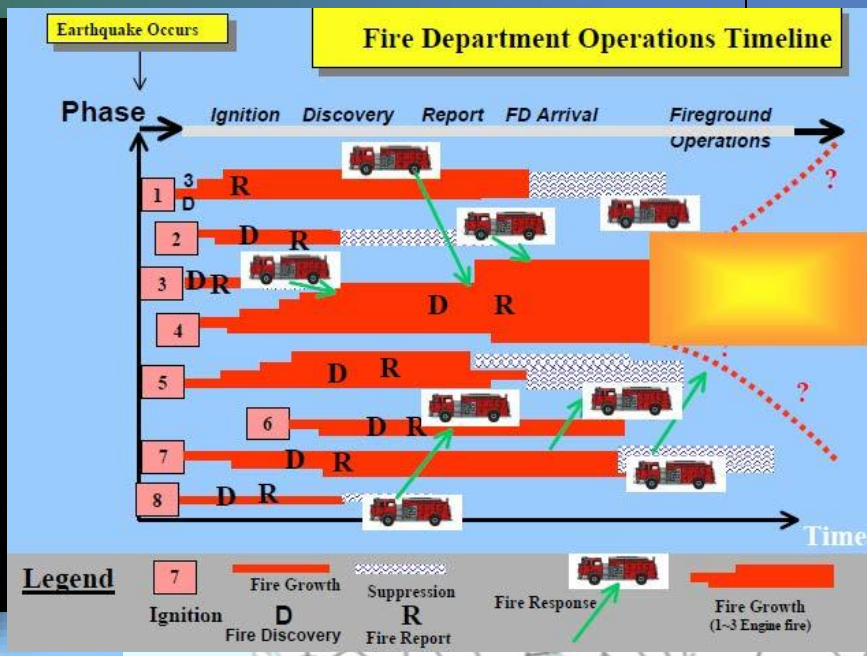
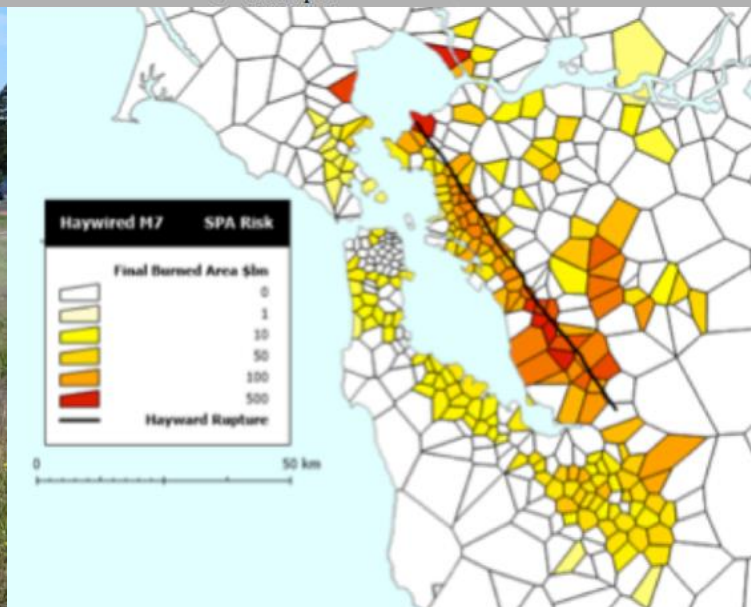
  4. a. Telecomm disruption – economic reach of outage

     b. Electric power disruption
- Population Displacement

Hay**Wired:** Fire Following Earthquake





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The HayWired Scenario video:

https://www.usgs.gov/media/videos/haywired-scenario-movie

HAYWIRED

OUTSMART DISASTER

ARUP—Design and Engineering Consultants
Association of Bay Area Governments
Aurecon
Bay Area Center for Regional Disaster Resilience
Bay Area Rapid Transit Authority
Boston University
California Department of Public Health
California Department of Transportation
California Earthquake Authority
California Earthquake Clearinghouse
California Geological Survey
California Governor's Office of Business and Economic Development
California Governor's Office of Emergency Services
California Public Utilities Commission
California Resiliency Alliance
California Seismic Safety Commission
Carnegie Melon University Silicon Valley
City of Berkeley
City of Oakland
City of San Francisco, Department of Emergency Management
City of Walnut Creek
Earthquake Country Alliance
Earthquake Engineering Research Institute
East Bay Municipal Utilities District
Federal Emergency Management Agency
Joint Venture Silicon Valley
Laurie Johnson Consulting
MMI Engineering
Pacific Earthquake Engineering Research Center
Pacific Gas and Electric
Palo Alto University
Red Cross
Rockefeller Foundation—100 Resilient Cities
San Jose Water Company
Southern California Earthquake Center
SPA Risk LLC
San Francisco Bay Area Planning and Urban Research Association
Strategic Economics
Structural Engineers Association of Northern California
University of California Berkeley Seismological Laboratory
University of Colorado Boulder
University of Southern California
U.S. Geological Survey

PEER

ABAG ASSOCIATION OF BAY AREA GOVERNMENTS

Joint Venture SILICON VALLEY

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Questions?

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Dale A. Cox, dacox@usgs.gov