

Earthquake Hazard

Hayward fault and Richmond

“California is all that it is cracked up to be”

Suresh Raman

Sierra Boyd

Christina Valen

UC Berkeley

Berkeley Seismology Lab

Intros



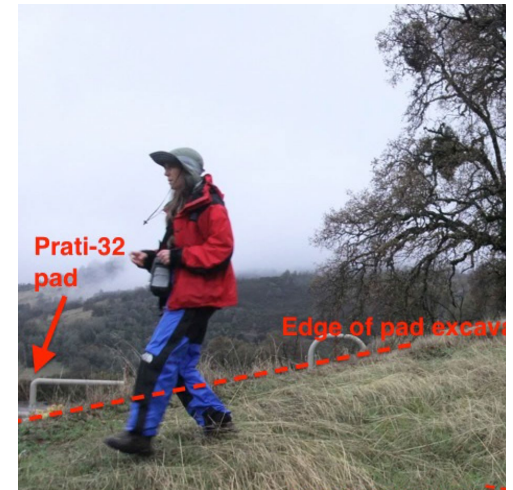
Suresh Raman
MS, Electrical Engineering
Software Professional for 30 years
MyShake Team Lead, BSL



Christina Valen
MS, Computational Science
Data Analyst, BSL

Sierra Boyd

PhD, Earth and Planetary Science
Research Data Analyst, BSL



Quick facts – notable earthquakes in CA

- 1906 M7.9 San Francisco (widespread fires)
- 1989 M6.9 Loma Prieta (freeway span collapse)
- 1994 M6.7 Northridge (most expensive earthquake in the US)

7 earthquakes in California greater than M6.7 since the 1994 Northridge earthquake (30+ years ago)

Measures of an Earthquake

Shaking Intensity and Magnitude

- **Shaking Intensity**, aka the Modified Mercalli Intensity (MMI), is a measure of the shaking caused by an earthquake (it is what you feel)
 - It is a subjective measure, not based on instrument readings (although instrument readings can supplement it)
 - It will vary with distance and soil characteristics
 - It is from 1 to 10, with 3 being *mild* and 6 being *strong*

Earthquake Intensity Scale

Modified Mercalli Intensity (MMI)



Not felt except by very few.

I	Not Felt
---	----------



Felt only by a few persons at rest, especially on upper floors of buildings.

II	Weak
----	------



Felt indoors, though many people do not recognize it as an earthquake. Standing cars may rock slightly.

III	Weak
-----	------



Felt indoors by many, outdoors by few. Dishes and windows are disturbed.

IV	Light
----	-------



Felt by nearly everyone, many awakened if at night. Dishes and windows are broken.

V	Moderate
---	----------



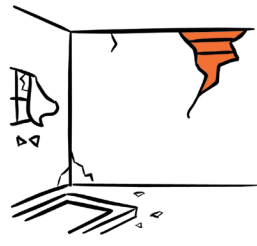
Felt by all; many frightened. Some heavy furniture moved. Damage is slight.

VI	Strong
----	--------



Slight to moderate damage in ordinary construction. Some chimneys broken.

VII	Very Strong
-----	-------------



Considerable damage to ordinary construction. Chimneys, columns, and walls may fall.

VIII	Severe
------	--------



Damage is great in substantial buildings, with partial collapse. Buildings shifted off foundations.

IX	Violent
----	---------



Some well-built wooden structures destroyed; most masonry and structures are destroyed.

X+	Extreme
----	---------

Earthquake Measure - Magnitude

- **Magnitude** is a measure of the size of the earthquake, specifically, the amount of energy released.
 - No longer called the Richter scale
 - It is now called just the *magnitude* scale (or “moment” magnitude scale)
 - It is from 1 to 10 (sort of), Northridge 1994 was M6.7

$$M_w = (2/3) * \log_{10}(\text{rigidity of rock} * \text{area of contact} * \text{length of slip}) - 10.7$$

For the 2004 Indian Ocean Earthquake (and Tsunami)

Rigidity is $3 * 10^{11}$ dyne/cm²

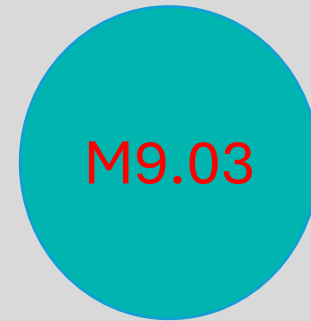
Area of slippage is 1100km * 120km

Length of slip is 10m

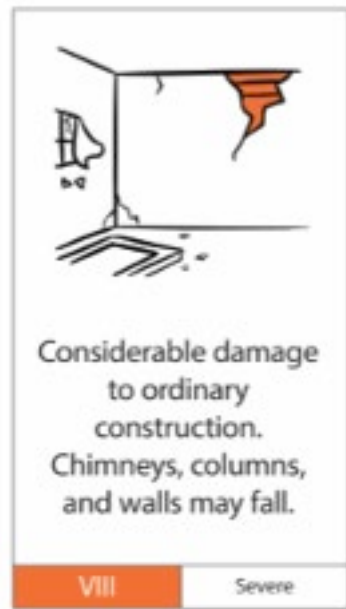
(all calculations in dyne-cm)

$$M_w = (2/3) * \log_{10}(3 * 10^{11} * 1100 * 120 * 10 * 10^{12}) - 10.7$$

0.7



Predicted Shaking due to an Earthquake of a given Magnitude (ie Ground Motion Prediction)



Shaking (MMI) = function of Magnitude(M), Distance(D), Site conditions

For eg (Davidson-Wald, 2007, simplified):

- $MMI = c1 + c2(M-6) + c3(M-6)^2 + c4 \cdot \log(D) + c5(D) + c6(M \log D)$

Using the simplified equation and the constants from Davidson-Wald:

- A M7 earthquake at 10km (6mi) distance would cause MMI 8 shaking.

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0–3.0	I
3.0–3.9	II–III
4.0–4.9	IV–V
5.0–5.9	VI–VII
6.0–6.9	VII–IX
7.0 and higher	VIII or higher

Magnitude/intensity comparison, USGS

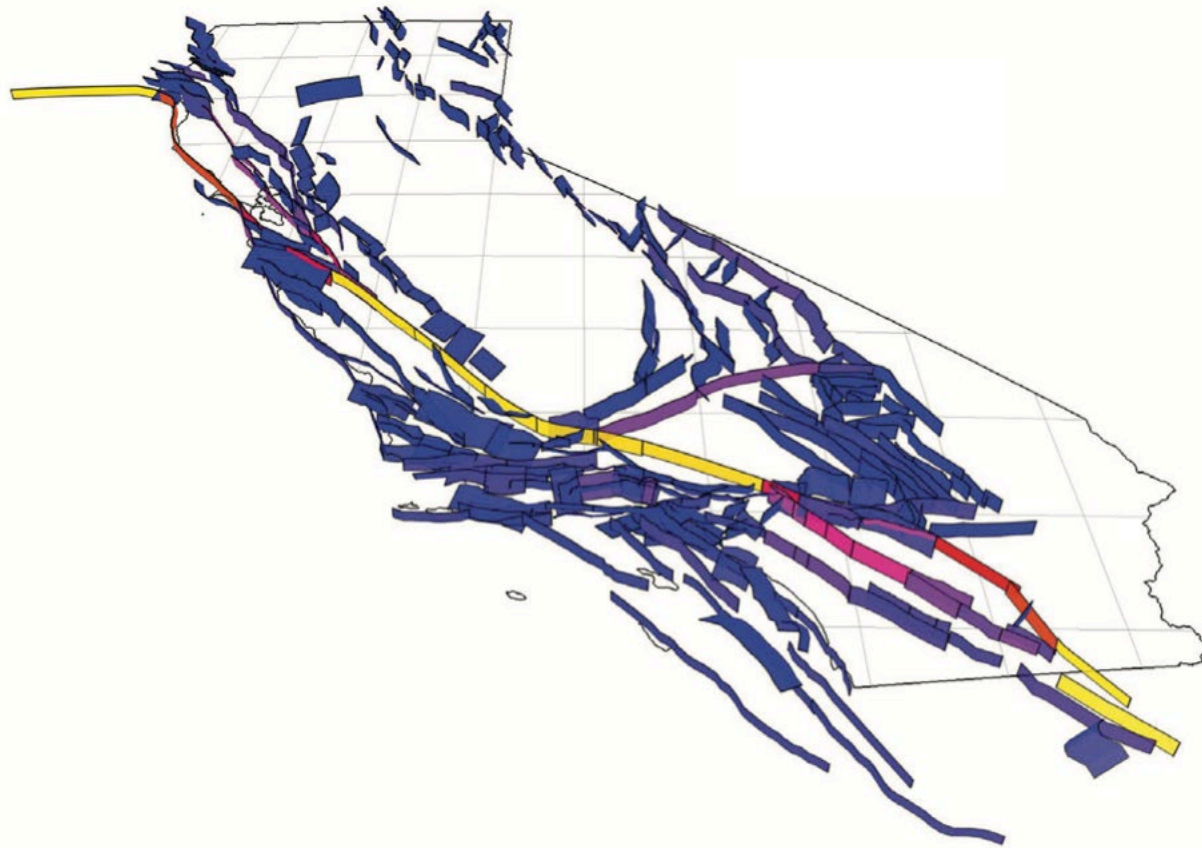
Hayward fault major history

- Last notable earthquake was a M5.8 near Berkeley in 1870.
- Previous M7 earthquake on the Hayward fault was in 1868, originated in Fremont and ruptured north till Berkeley. It had 6 ft of horizontal slip.
- Last six major earthquakes occurred at intervals of 95 to 183 years, with an average interval of about 150 years.
- We are currently at 157 years!

Uniform California Earthquake Rupture Forecast (UCERF version 3)

- By the Working Group on California Earthquake Probabilities
- Endorsed by USGS, Southern California Earthquake Center (SCEC), California Geological Survey (CGS)

UCERF3 Fault Model



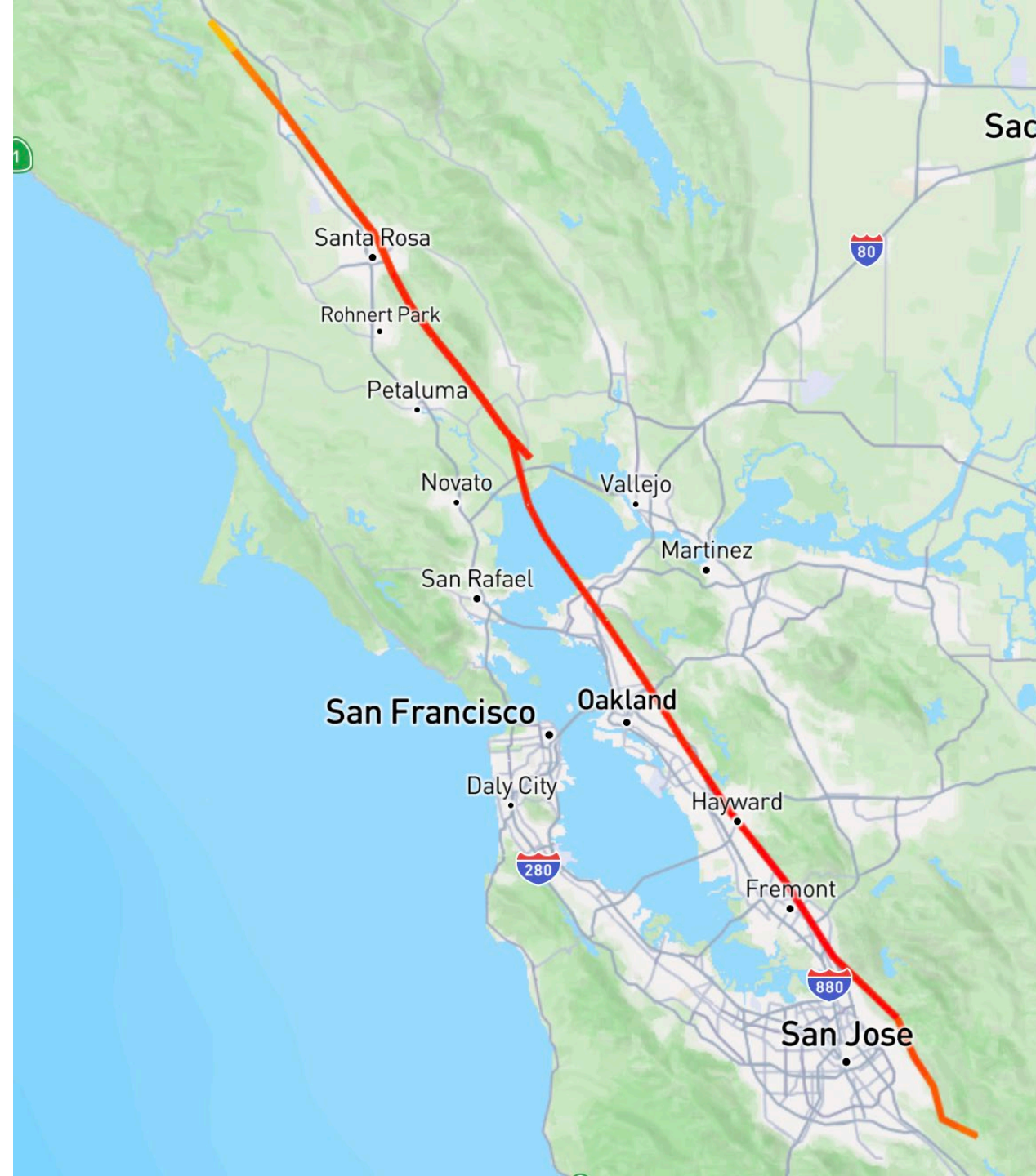
The warmer colors (ie, towards red) represent higher fault slip rates

- Using 350 fault sections
- 250,000 fault scenarios
- Incl. multi-fault rupture scenarios

- One of the fundamental physical quantities being evaluated in the models is the amount of “moment” (energy) locked/released due to various slip scenarios.

UCERF3 rupture probabilities for earthquake \geq M6.7 before 2044

Fault Name	Probability
Southern San Andreas	53%
Northern San Andreas	33%
Calaveras	25%
Hayward	15%
Hayward-Rodgers Creek	32%

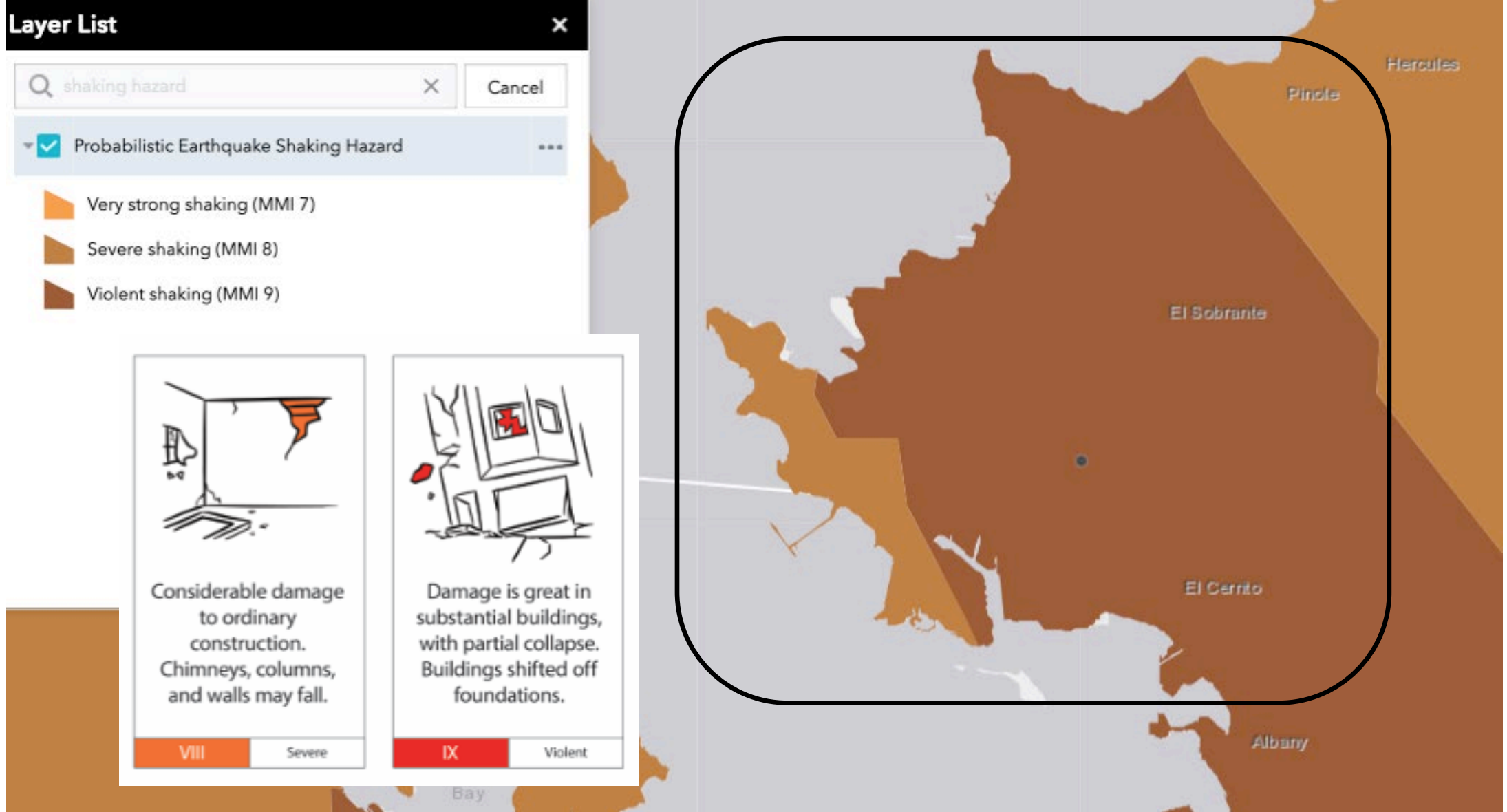


Richmond Hazard Map by

Metropolitan Transport and Assoc. of Bay Area
Govts. (aka MT/ABAG)

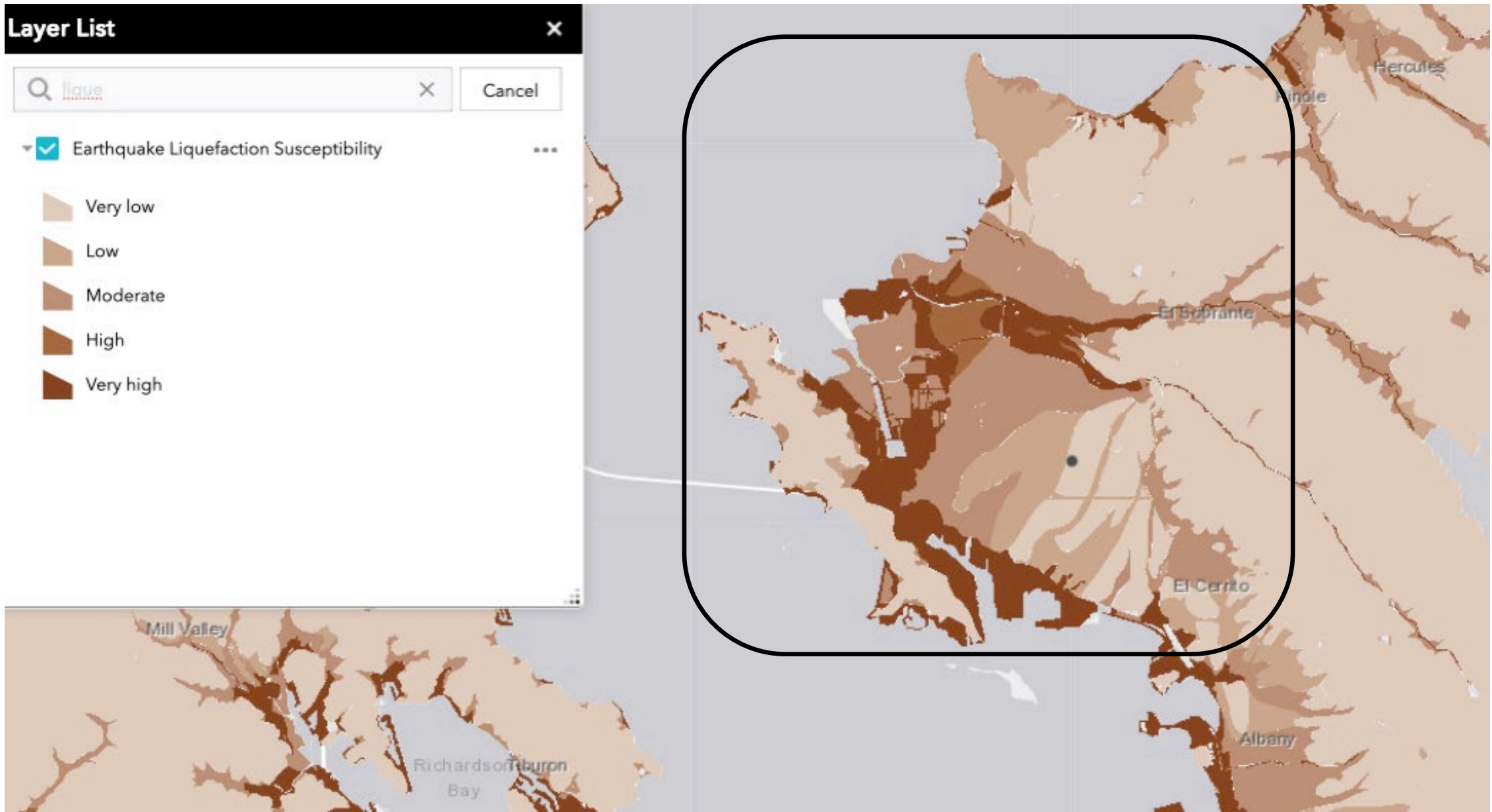
<https://mtc.maps.arcgis.com/apps/webappviewer/index.html?id=4a6f3f1259df42eab29b35dfcd086fc8>

Shaking Hazard Map



This map shows a composite shaking hazard for the Bay Area based on the probability of many different possible earthquakes. The shaking level shown on the map has a 10% chance of being exceeded over the next 50 years.

Liquefaction susceptibility



Thank You!

Questions?

Suresh Raman
Sierra Boyd
Christina Valen

System of Systems

“The benefit of infrastructure is diffused...”
“How do we show the value?”

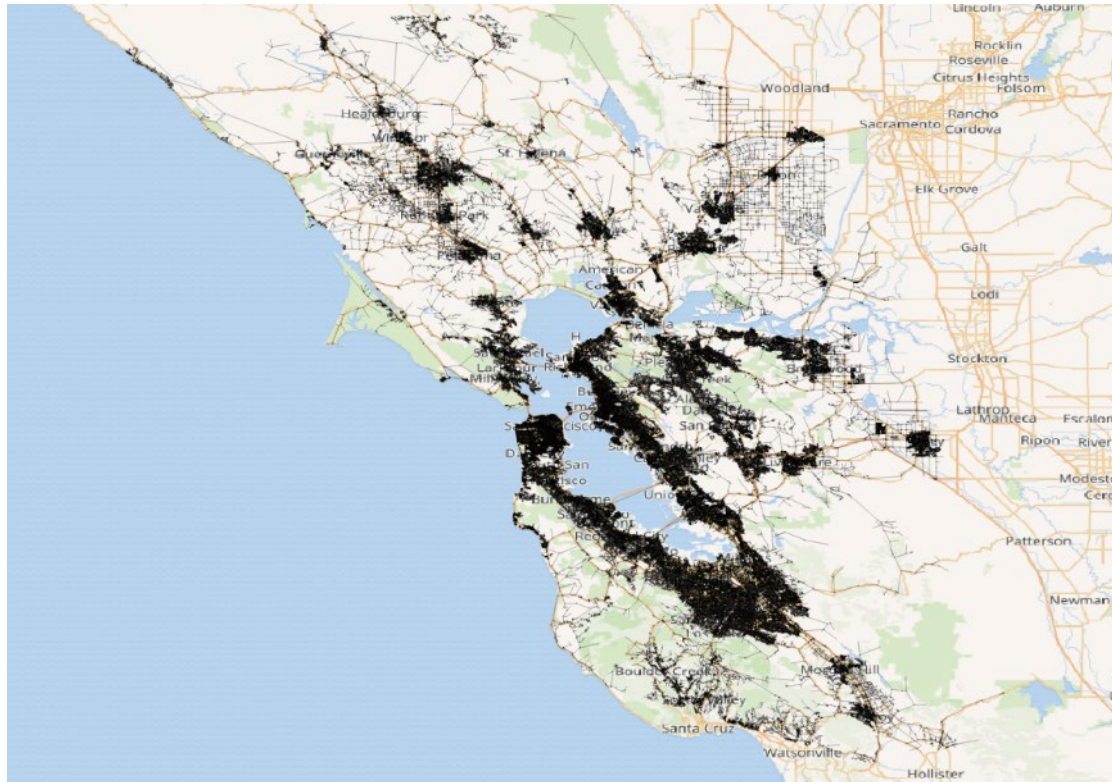


Berkeley
CENTER FOR
Smart Infrastructure

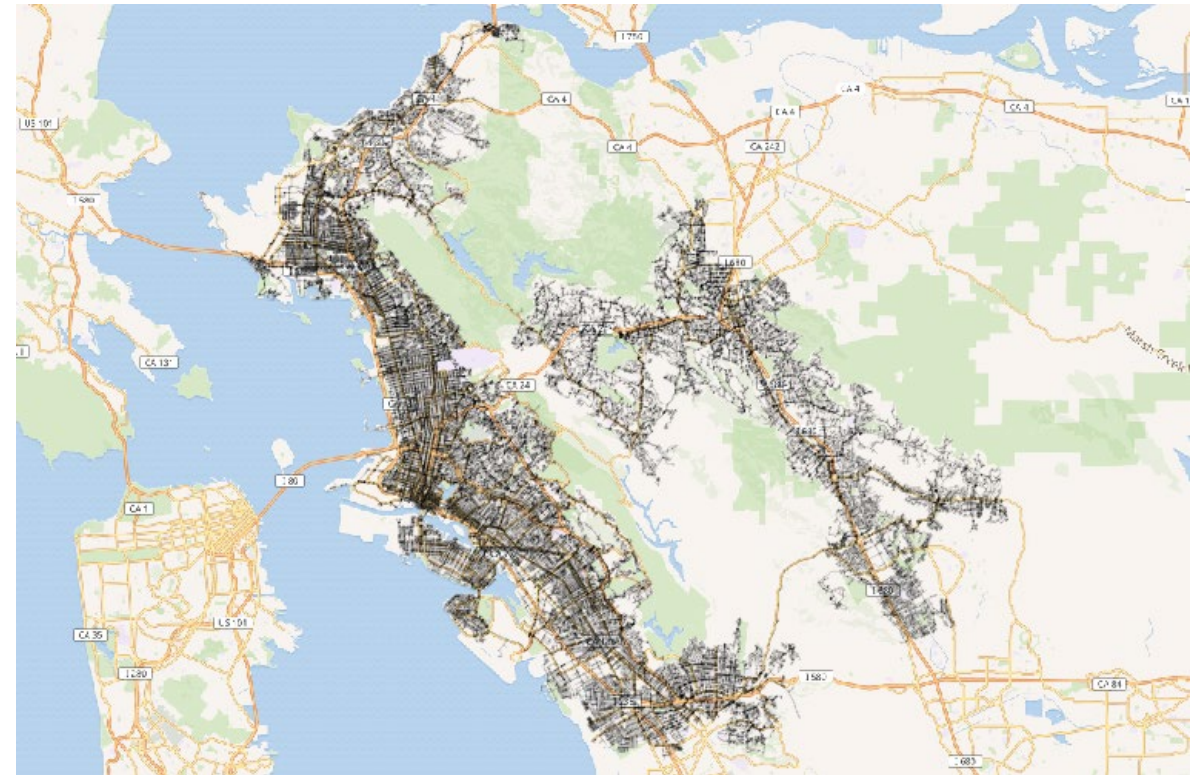


Center for Computational Modeling and Simulation

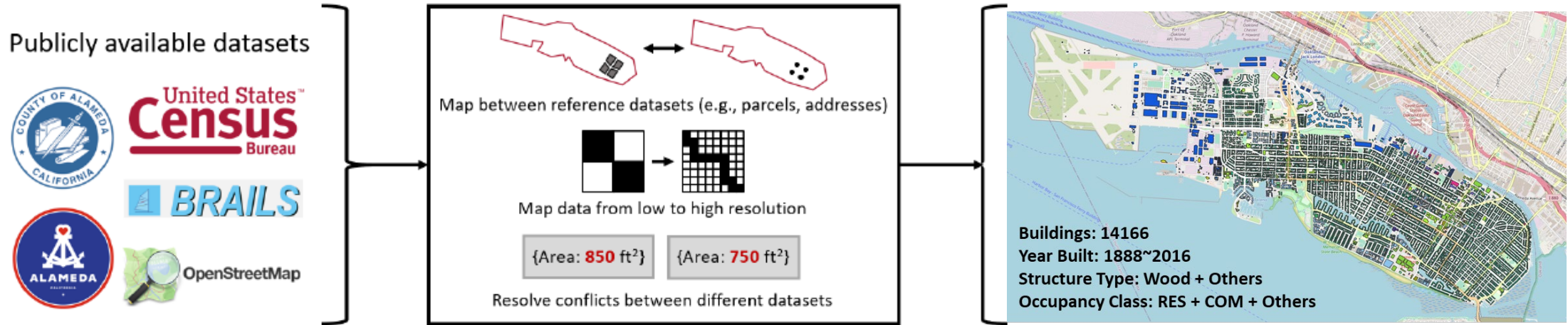
Road Network
250k nodes, 550k edges (OSM)
7 million people
13 people/road segment



Water Network
100k joints, 100k pipes (EBMUD)
1.4 million customers
14 people/pipe segment

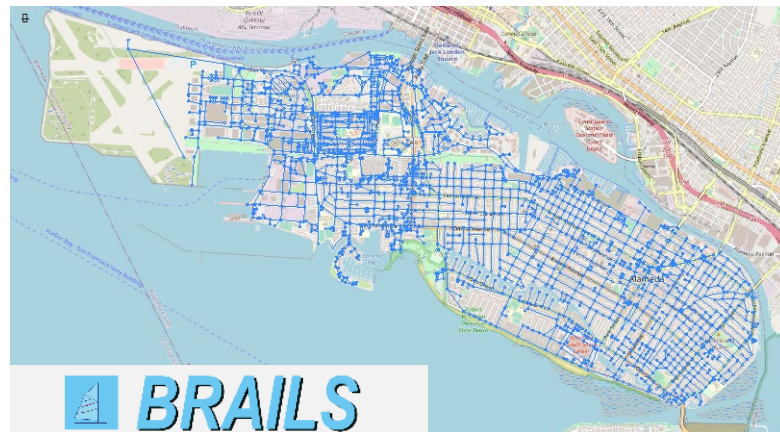


Interdependency - Alameda Case Study

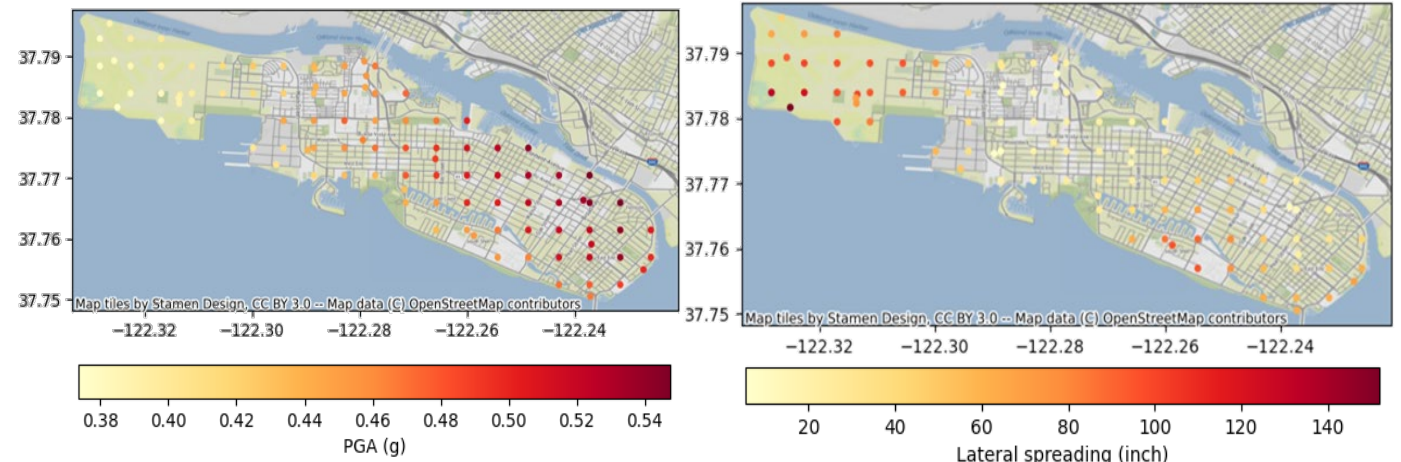


Bassman T.J., Zsarnóczy A., Saw J., Wang S., Deierlein G.G., "High-Fidelity Testbed Development for Regional Risk Assessment in Alameda, California", 12th NCEE, 2022

Transportation & Water Infrastructure



Inventory Generation Tools



Ground Shaking and Permanent Deformation

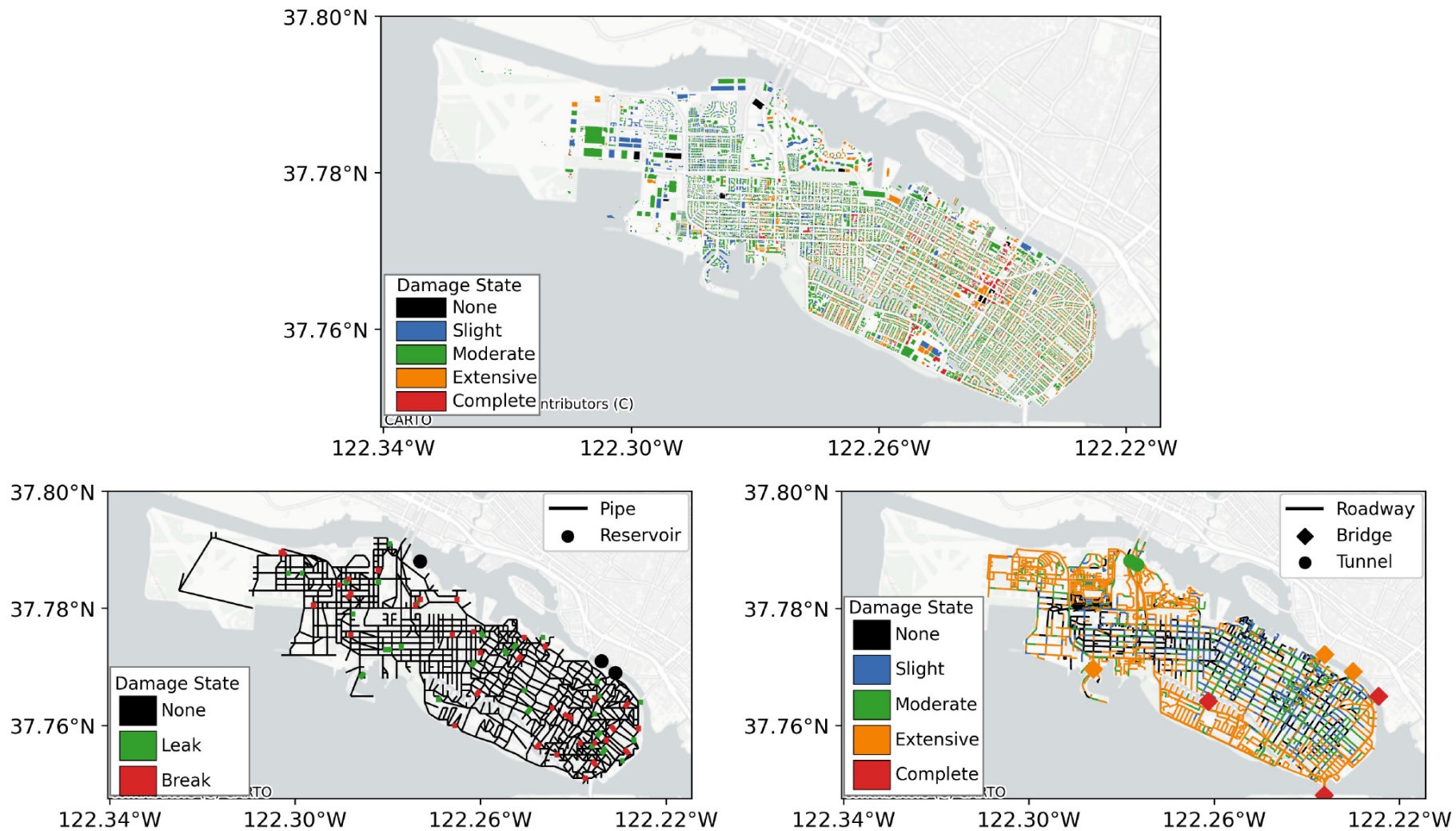


Figure 6: Damage state immediately after the case study earthquake. Top: Building stock. Bottom left: Potable water distribution infrastructure. Bottom right: Transportation infrastructure.

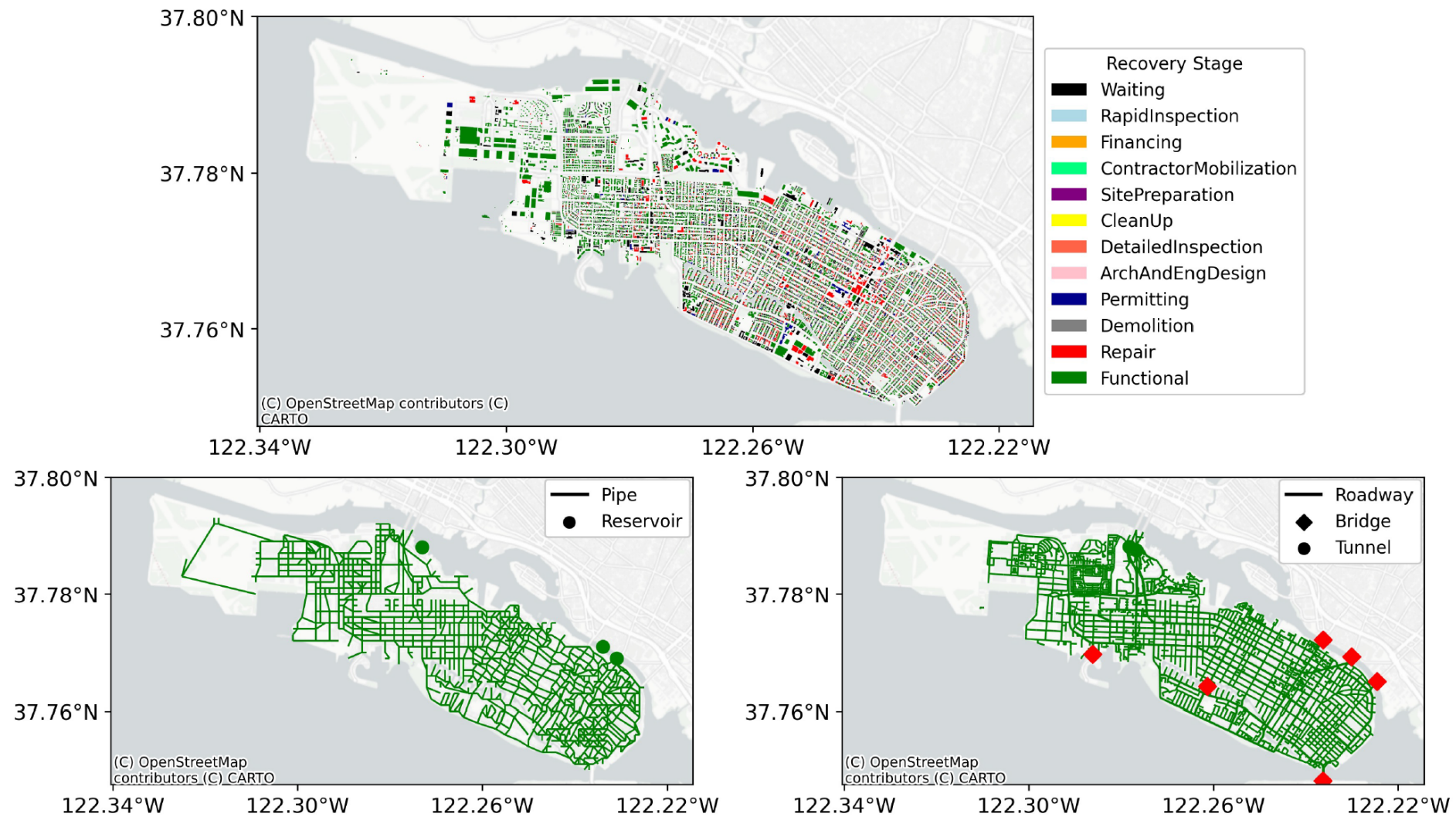


Figure 8: Damage and recovery state of infrastructure components 150 days after the earthquake.



We Can Expect Scenes Like This

The sooner and the better organized we are, the less time and expense it will take for recovery.





Why Use Radios After an Earthquake?

- Radios may be the only option to communicate in your neighborhood and to call out for help.
- Neighbors can help first responders by using hand-held radios to report victims and hazards, and help save lives



**Richmond Emergency
Communication (EMCOMM)
Radio Operators train, drill and
practice regularly.
Communication is Key**

Equipment & Radio Check Out Sheet

Directions:
• ID #s: Some items may have identification codes, ex. "R-1" for "Radio-1". If no ID #, put a piece of tape on equipment with owner's name & phone number.

ID # and Owner Info	Item Description (ex. 2x 8. Solar Panel)	Name of Borrower and Phone	Initials of Borrower	Time Checked Out	Status (Include when returned)	Comments (ex. Returned missing)
FAS 1	Mobile EXT	Gene Hanes 415-232-0221	EAH	9/09/24	Returned	
					Returned	
					Returned	



**Richmond CERTs
(Community Emergency Response Teams)
train for immediate response.**



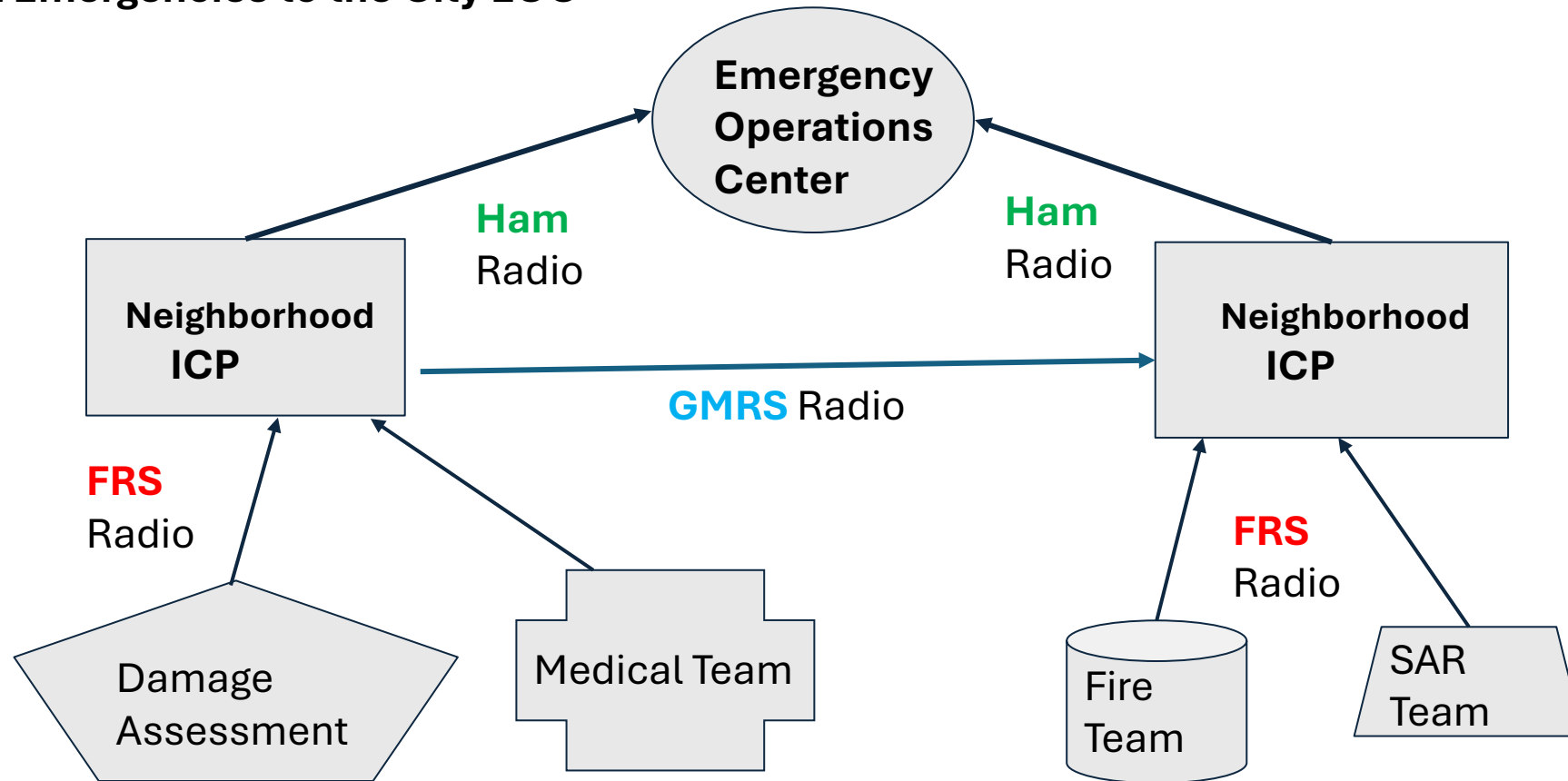
CERTs and EMCOMM Radio Operators are trained in the Incident Command System (ICS).

Richmond neighborhoods have Incident Command Posts (ICPs)

➤ Richmond Communication / Incident Command Post Structure

ICPs report Emergencies to the City EOC

ICPs also communicate with each other.



Neighborhood Field Teams send messages to their ICP

EMCOMM begins and ends in the Field.



Field (IC)



Local Government /City



Operational Area/County



OES Region



State

The Incident
Command Post
Communication
structure in
Richmond will
be used after
the earthquake
for recovery,
but...

To respond effectively
community volunteers
need support

- Caches of **Supplies** within reach
- Emergency Response and **ICP Training** for more citizens



Richmond Needs More Neighborhood Incident Command Posts

- Neighbors helping neighbors
- Training and using a common structure and language
- Communicating when situations cannot be handled

Thank you and Remember

- The sooner and the better organized we are, the less time and expense it will take for recovery.



SPRING 2024 TRAINING SESSION

REGISTER NOW!

Classes begin Thursday,
March 28th at 6:00pm



Become a CERT volunteer and help your community during times of need.

Learn basic skills in fire safety, medical assessment, light search & rescue, and more!

No pre-requisites or special skills needed.



Register by Email:

certrichmond@gmail.com

(include your city address & phone number)

The Power of Neighbor-to-Neighbor (N2N)



Rocky Saunders
West Contra Costa Fire Safe Council



Neighbors are First Responders

- Neighbors helping neighbors is the first response action in any emergency or disaster event.
- N2N assistance within the first hour of an event (aka the “Golden Hour”) has the highest potential return for first aid and community response like evacuation.
- N2N is a force-multiplier leveraging fire, law enforcement, and emergency medical responses.



N2N is an Investment Our Citizenry

- Investment in N2N is a leveraged investment in your citizenry.
- N2N benefits includes:
 - Delivering Disaster Response: first-aid, coordinated evacuations, effective neighborhood response including evacuations, if necessary
 - Building community awareness
 - Creating an informed citizenry
- Summary: N2N is a force-multiplier that can leverage emergency response. It is an investment in Richmond's citizenry.