Integration of the HAZUS Results and REMI Model: HayWired Scenario

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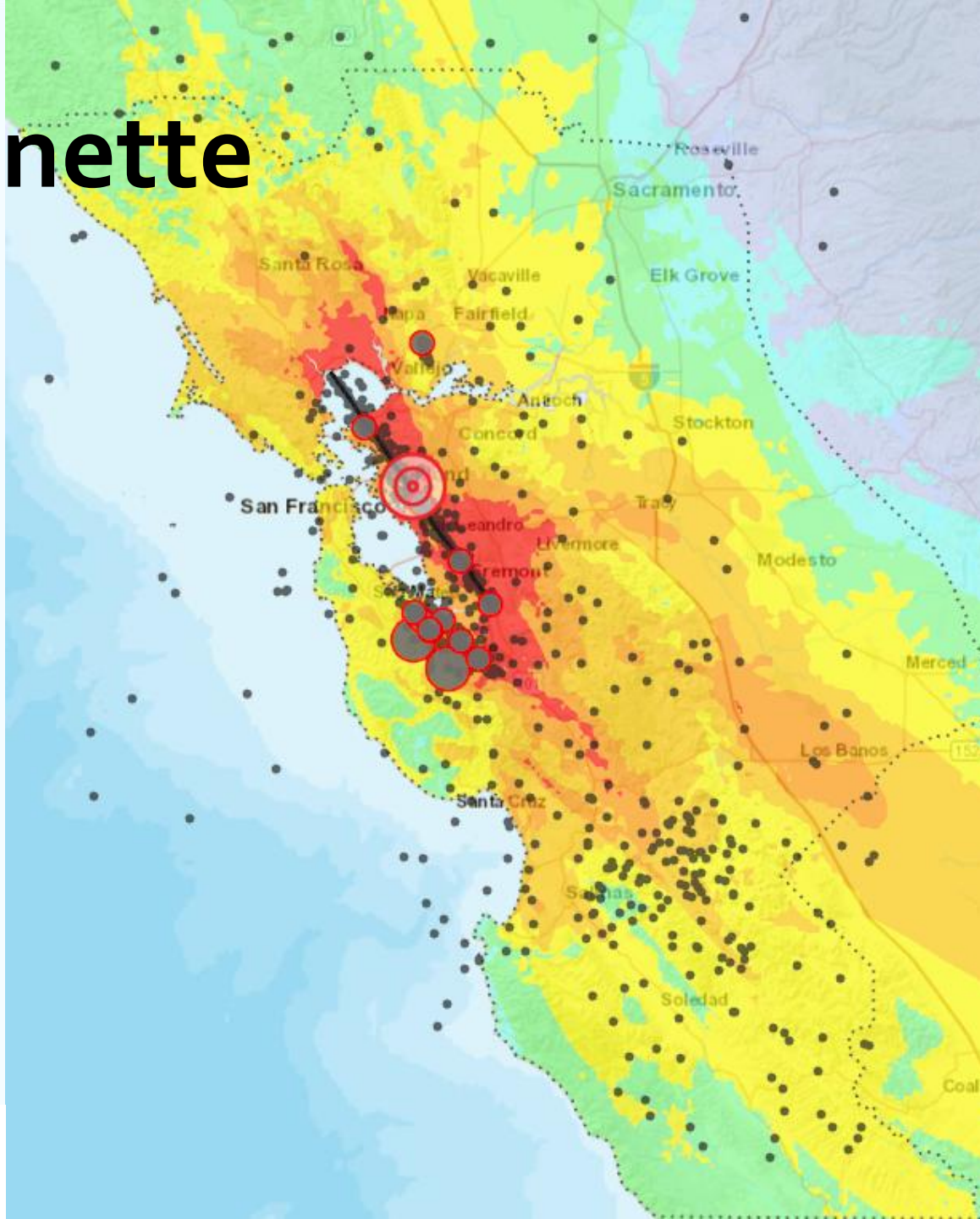
USGS HayWired Scenario Purpose

Earthquakes break our connections, as society becomes more interconnected, this aspect of earthquakes raises growing concerns.

“Use Science, Come Together, Start Planning Now”

HayWired Scenario Vignette

- April 18, 2018
- Epicenter in Oakland
- 18 second M 7 Hayward Fault rupture
  - Shaking
  - Liquefaction
  - Landslides
  - Aftershocks:
    - Over twelve M 5 or greater earthquakes
  - Fire following



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

A brief introduction of HAZUS-MH model

- Natural hazards model
- GIS technology based
- Physical, economic, and social impacts estimates

HAZUS Input

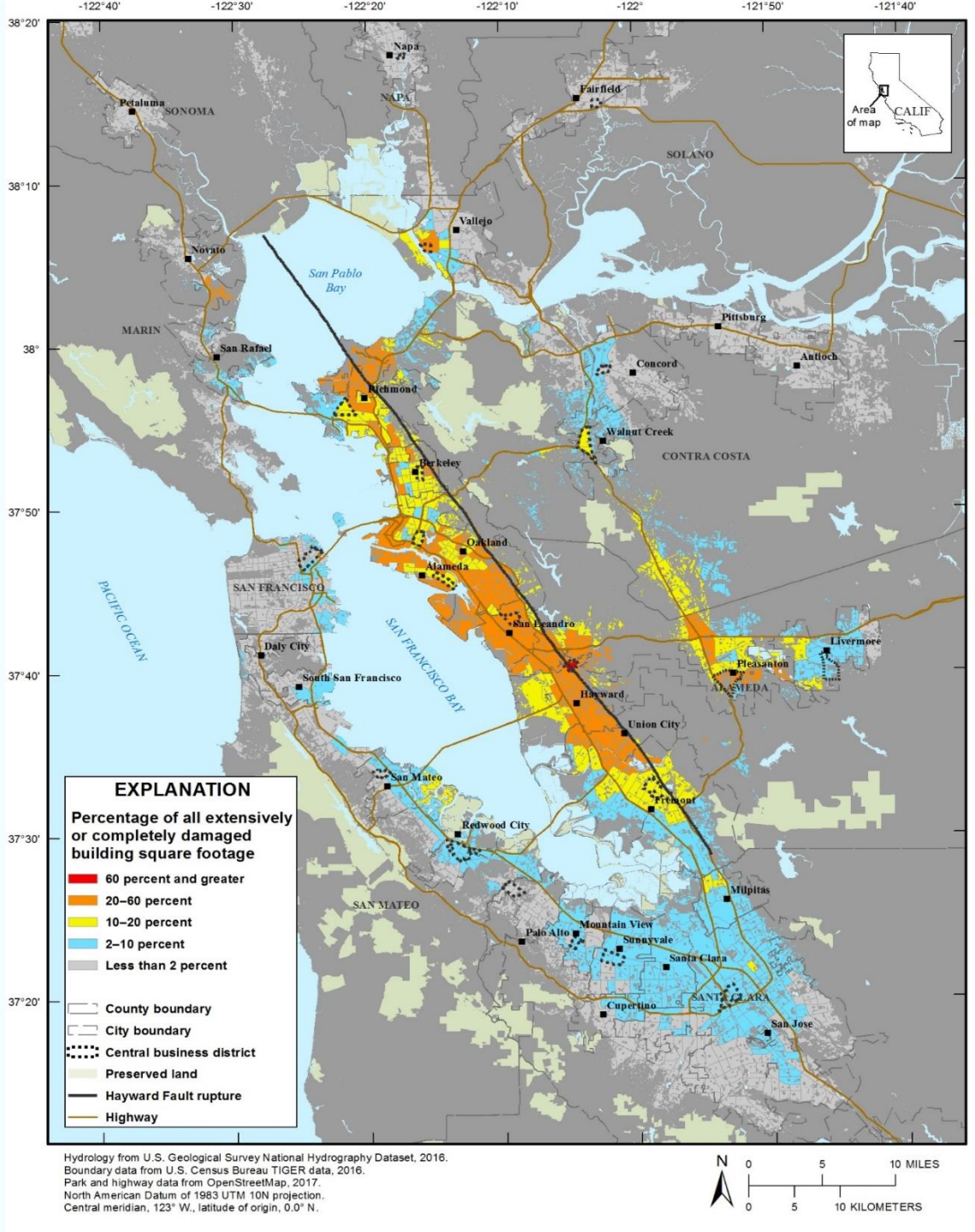
- Levels of analysis sophistication
  - Default database: general building stock, census demographic data
  - User-supplied input: locally available data on building and costs, locally defined scenarios
  - Or the combination of the two

HAZUS Output Categories

- Direct damage (buildings-structural/content/inventory, facilities, lifeline systems)
- Induced damage (fire following, hazardous materials, debris)
- Direct losses (wage/income/output loss, casualties, shelter needs)
- Indirect losses (supply shortages, sales decline, opportunity costs, economic loss)

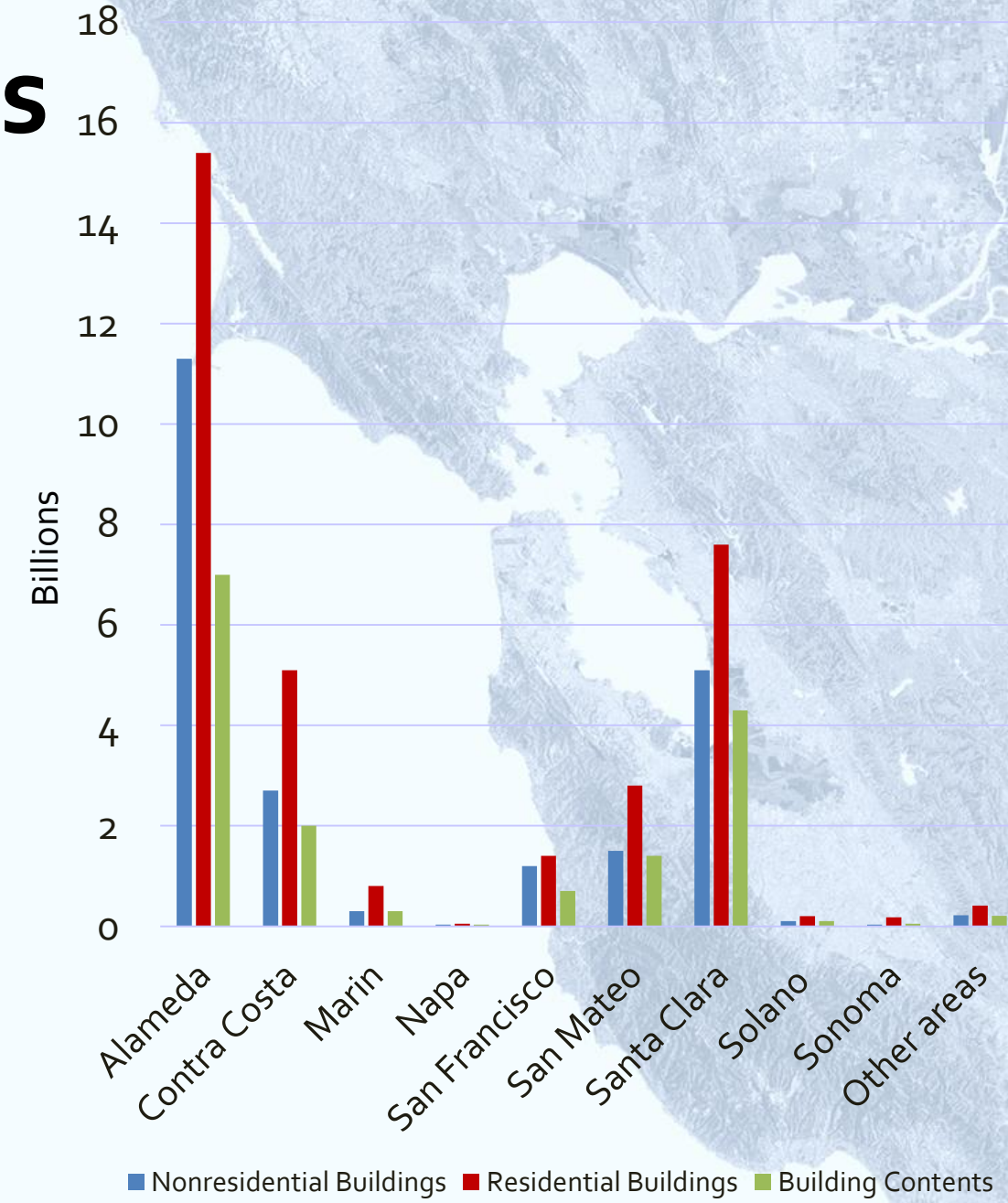
HAZUS HayWired results

- Degree of damage from multi-hazards
  - Building SQ. FT
  - By damage states
    - None
    - Slight
    - Moderate
    - Extensive & Complete
  - By building occupancy class
  - By census tract



Building & Content Loss

- From shocks, liquefaction and landslides:
  - Bay Area: $72 B
  - Alameda County: $33 B
- From fire: $30 B.



Note:
1. In 2016 dollars
2. Fire estimate was done by Scawthorn (2018) separately, not direct HAZUS model output.

Output Loss

- Direct building damage from mainshock, landslides, liquefaction:
  - Bay Area: $27 B
  - Alameda County: $17 B
- Aftershock: $500 M (most in Santa Clara County)
- Fire: $2.3 B

County	Mainshock, Landslides, Liquefaction	Plus Fire	Plus Aftershocks
Alameda	16.1	17.4	17.5
Contra Costa	2.8	2.9	3.0
Marin	0.1	0.2	0.2
Napa	0.0	0.0	0.0
San Francisco	0.7	0.7	0.7
San Mateo	0.8	0.9	0.9
Santa Clara	3.5	4.0	4.4
Solano	0.1	0.1	0.1
Sonoma	0.0	0.0	0.0
Other Areas	0.1	0.1	0.1
Total	24.2	26.5	27.0

Unit: Billions

Note:
1. In 2016 dollars
2. Fire estimate was done by Scawthorn (2018) separately, not direct HAZUS model output.

HAZUS-MH integration with REMI

HAZUS	REMI	Issues
Building, content, inventory loss	Capital stock loss	In REMI model, capital stock loss leads to increase in investment (to get back to projected regional economic activities) and output, which further leads to increase in employment.
Output loss	Industry sales loss	HAZUS-MH occupancy class categories are different from REMI industry code.

HAZUS-MH Integration with REMI

- We chose to adjust industry sales in REMI based on HAZUS output estimates.
- We developed crosswalk between HAZUS occupancy class and REMI industry.
- We assume that the share of loss for each REMI sector equals the share of loss for the occupancy class the sector belongs to.

REMI Sectors (Information sector example)	NAICS Code	HAZUS Occupancy Class
Publishing industries, except Internet	511	IND2
Motion picture and sound recording industries	512	IND2, COM4
Internet publishing and broadcasting; ISPs, search portals, and data processing; Other information services	518-519	COM4
Broadcasting, except Internet	515	IND2, COM4
Telecommunications	517	COM8

When considering only Output Loss Related to Building Damage, REMI says:

REMI Estimate of Total 2018 Employment and Population Impacts relative to ABAG Forecast Levels

Region	Employment loss	Employment loss relative to baseline	Population loss from job loss	Population loss relative to baseline
East Bay	-158872	-10.5%	-36243	-1.3%
North Bay	-7623	-1.3%	-2856	-0.3%
West Bay	-32585	-2.0%	-5527	-0.3%
South Bay	-33212	-2.5%	-5495	-0.3%
Bay Area	-232293	-4.6%	-50121	-0.6%

Lifeline Recovery Time

- Electric power: 3-4 weeks
- Fuel: 7 -10 days (minimum)
- Voice and data: 7-10 days
- Water: up to 6 months in core damage areas
- Highway bridges: up to 4-10 months
- BART stations: up to 1-3 years
- Longest restoration times in Alameda, Contra Costa (water) counties
- Intermediate restoration times in Contra Costa, San Mateo, Santa Clara, and San Francisco counties

Transportation Network Disruptions

- Electric power: 3-4 weeks
- Fuel: 7 -10 days (minimum)
- Voice and data: 7-10 days
- Water: up to 6 months in core damage areas
- **Highway bridges: up to 4-10 months**
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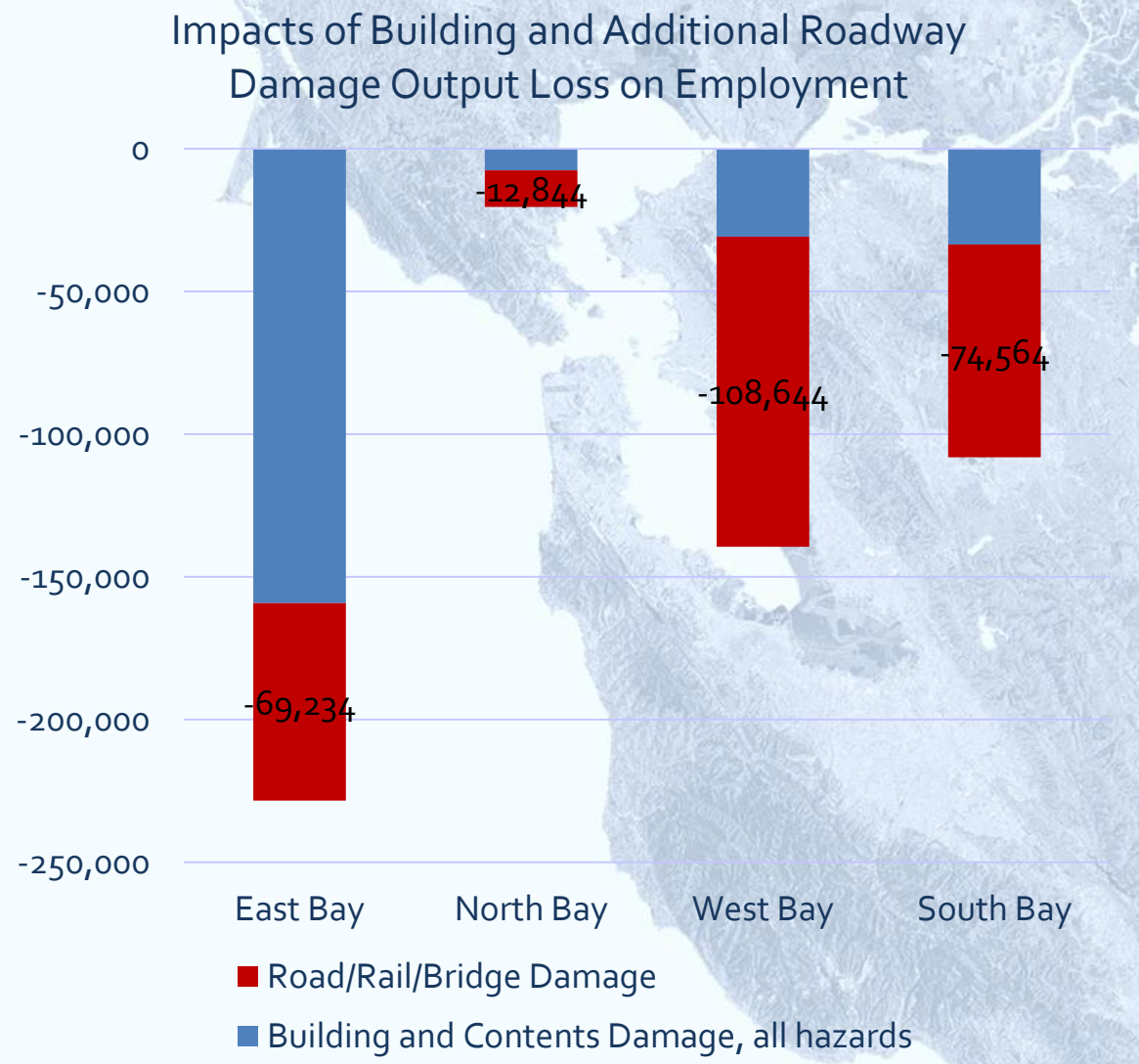
- **We assume that the percentage of output loss equals the percentage of all workers' working weeks lost in a year while commuters wait for repairs of roadways and bridges.**
- **Discount factors were applied to account for resilient commuting solutions.**

Increased Loss in West & South Bay

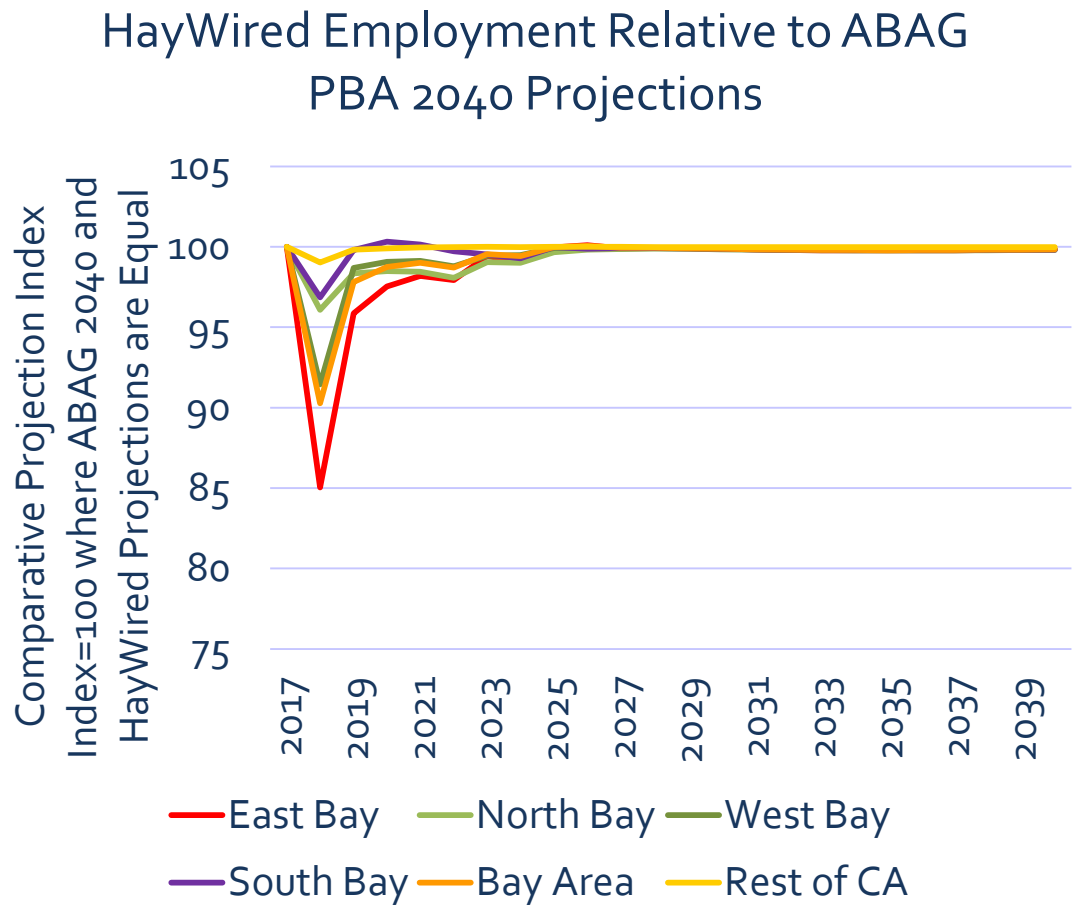
- Transportation disruption increases overall impacts, especially in the West and South Bay.

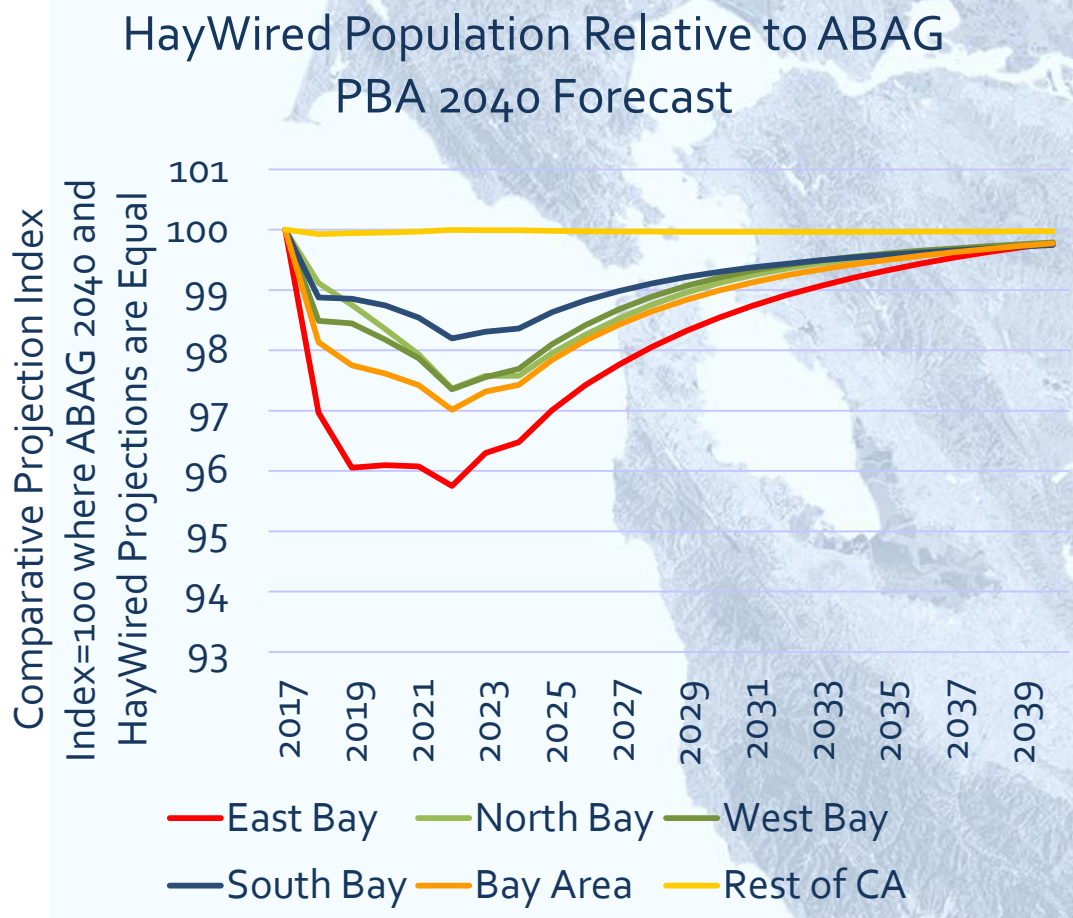


Additional Assumptions

- Recovery time increases for retail trade, wholesale trade, mining, and selected manufacturing sectors.
- Housing and rental prices increase for 7 years following the earthquake.
- Senior (65 years old and above) outmigration.
- Government Recovery Assistance

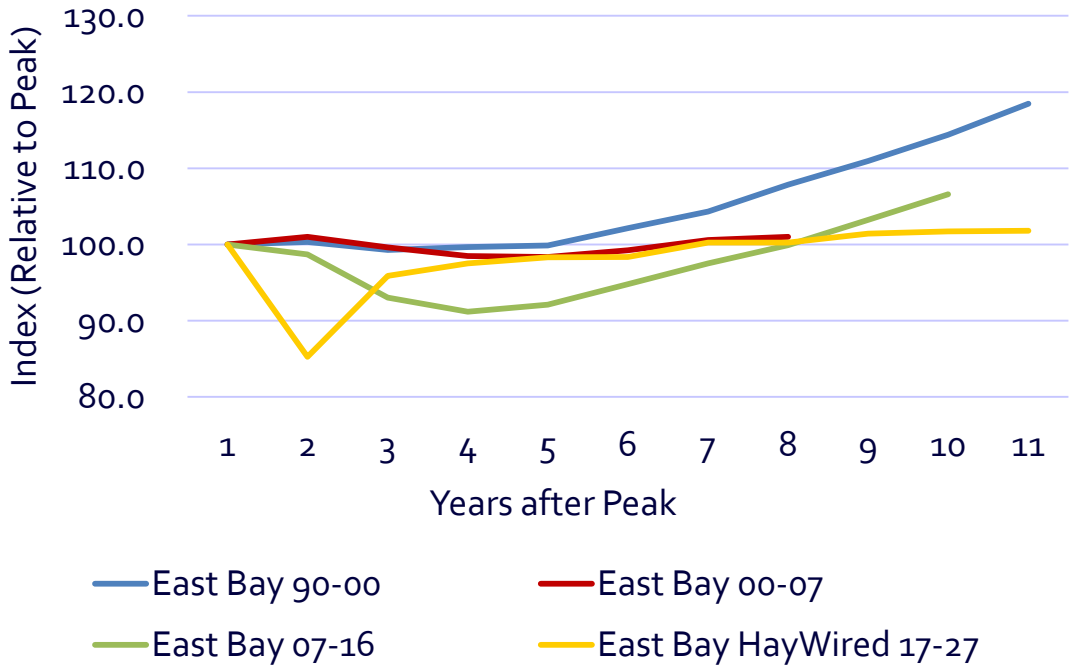
HayWired REMI Results (PRELIMINARY)



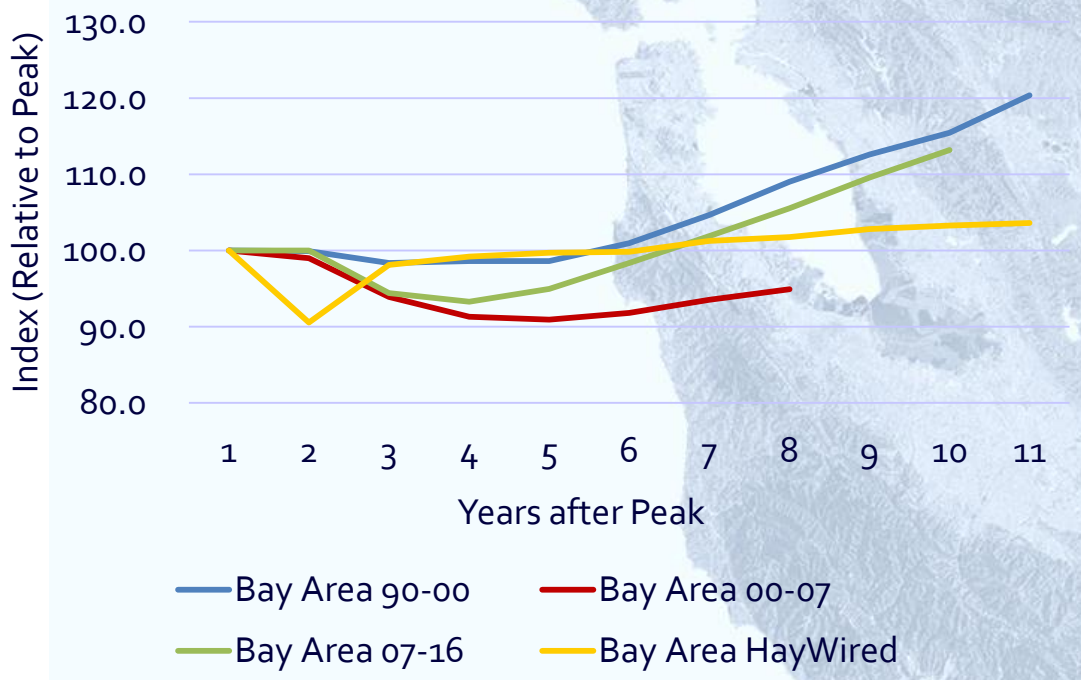


HayWired: a Sharper, Shorter Recession

East Bay Recovery Progression from Pre-recession Peak to Peak of Recovery or Next Upturn Compared to Job Projection in HayWired Scenario



Bay Area Recovery Progression from Pre-recession Peak to Peak of Recovery or Next Upturn Compared to Job Projection in HayWired Scenario

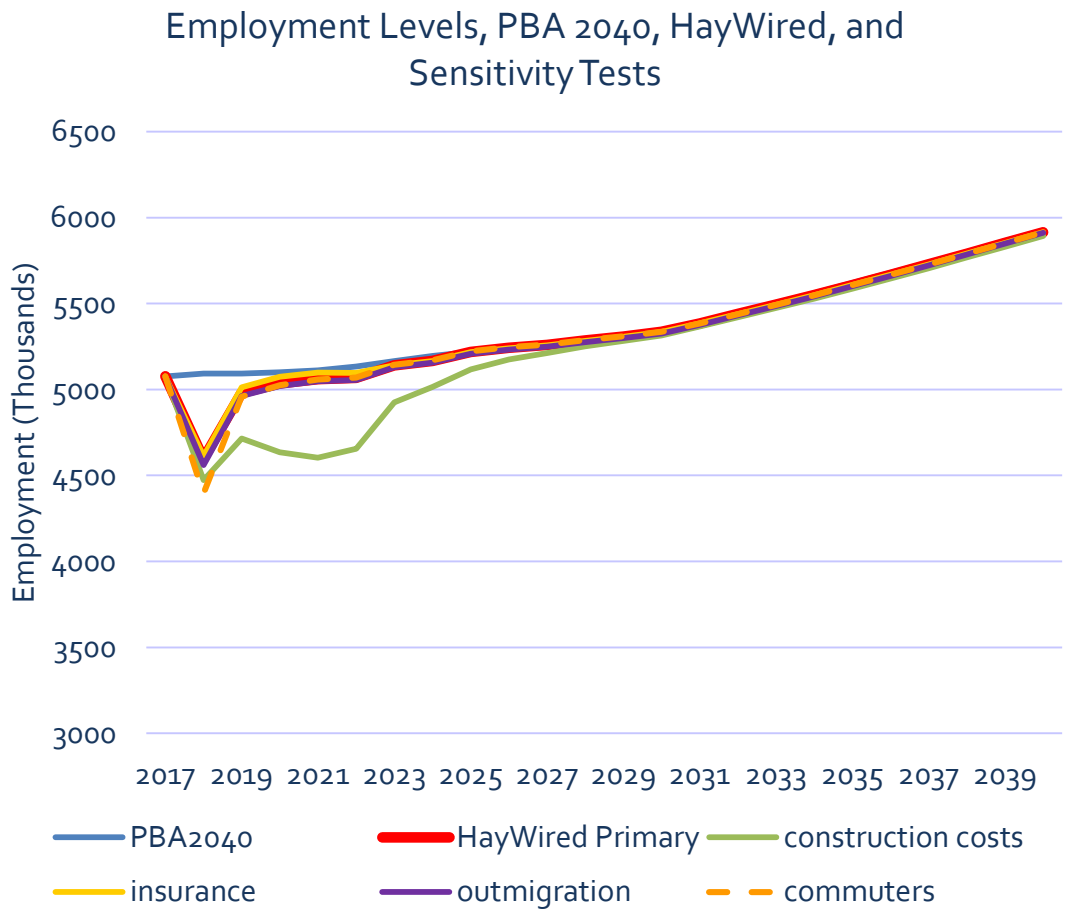


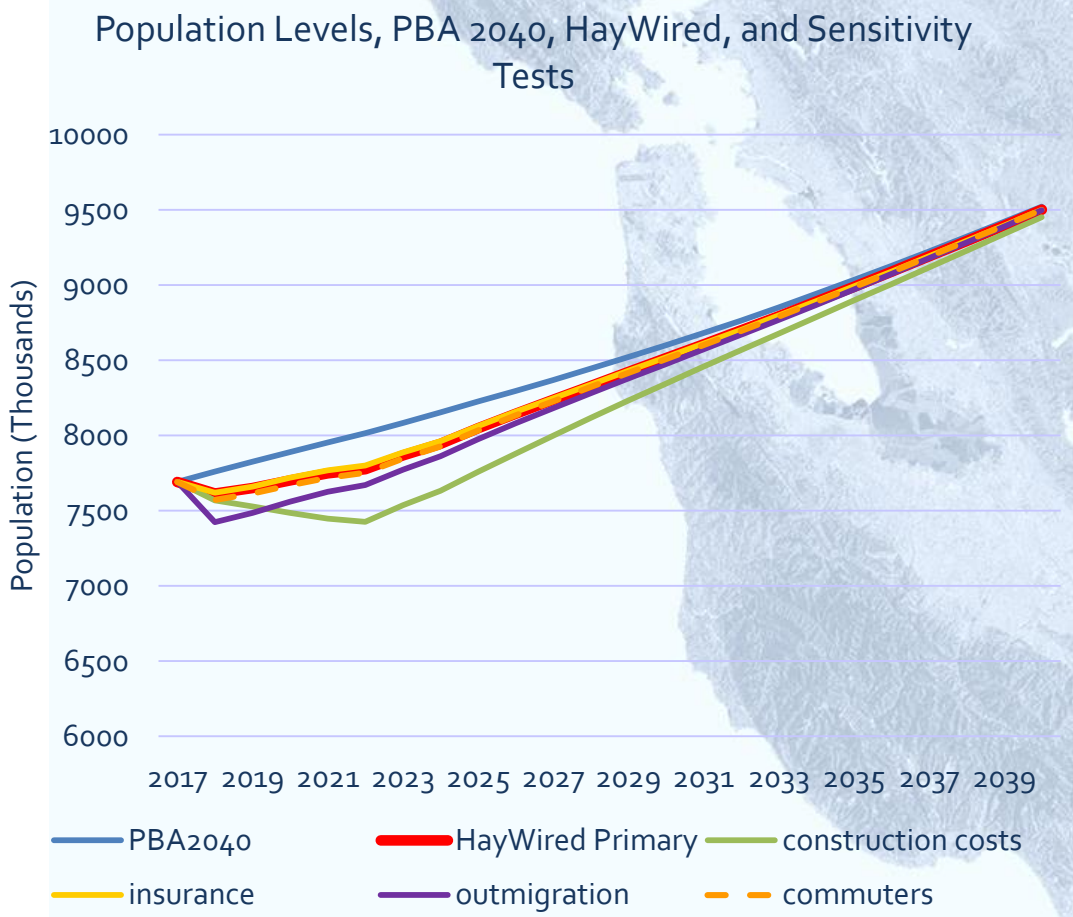
Limitations

- Higher wages paid to construction workers and worker shortages may delay rebuilding and repairs.
- Population displacement effects could persist for longer, especially in heavily impacted portions of the East Bay.
- We may have been too optimistic in our assessment of the ability of commuters to make flexible work arrangements.
- We may have been too optimistic in our assessment of the federal government spending
- The earthquake could have a significant effect on local revenues and spending, beyond the shift in spending towards reconstruction activities

Sensitivity Test

- Higher construction costs could delay recovery several years
- Longer term trajectory could still be resilient





HayWired Scenario Summary

- Job and output loss would be like a severe recession
- It would take several years to return to pre-quake levels, perhaps a decade longer to return to the long term trajectory.
- In contrast to a recession, the pain will be much more focused on the areas of concentrated damage.
  - Cities where concentrated damage affects half of their population or employment base
  - Cities facing severe revenue shortfalls
  - Cities losing downtowns or other major business centers.
- Rebuilding will offer risks and opportunities
  - Risks
    - Even greater displacement pressures at the lower end of the income scale
    - Particular vulnerability for middle wage industry sectors
  - Opportunities
    - Replace what is lost while meeting growing demands.

Lesson One

REMI:

- Behavior of Normal Function
- Or Exceptional Function?

Lesson Two

BE PREPARED!

THANK YOU!