MITIGATING EARTHQUAKE RISK THROUGH LAND USE PLANNING: USA AND NEW ZEALAND APPROACHES

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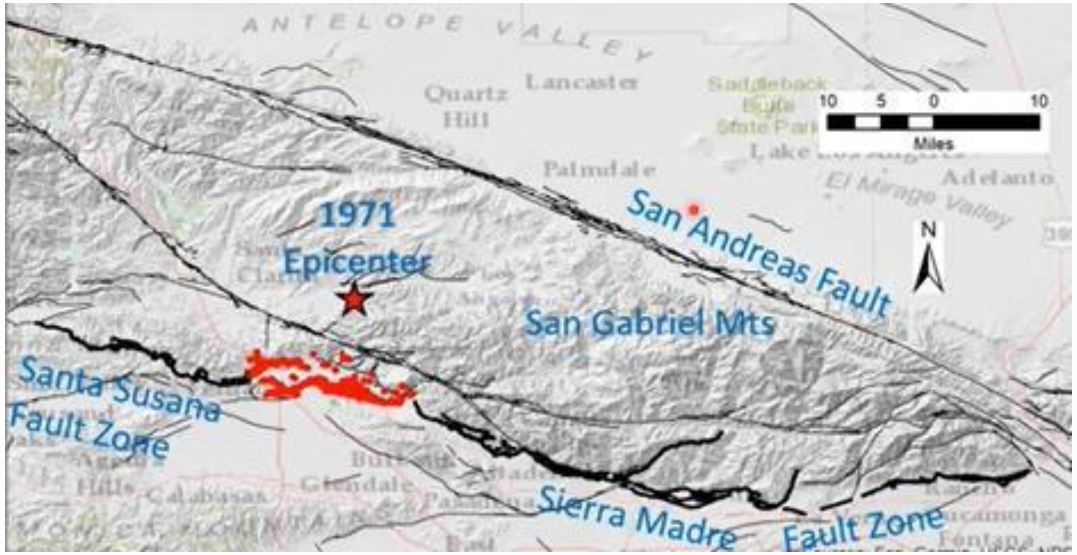
Urban Planning • Disaster Recovery • Risk Management

USA example focuses on California and begins with the magnitude (M)6.6 San Fernando earthquake of February 9, 1971

- 65 fatalities; 2,000 injured
- Collapse of major hospitals, community facilities and freeways
- Near collapse of a major dam
- Property damage of $500 million ($3.2 billion in today's dollars).



Locations of surface rupture in the 1971 San Fernando earthquake.
Sources: California Department of Conservation, California Geological Survey

Ground level and overhead view of the fault scarp at the Foothill Nursing Home, 1971 San Fernando earthquake

Photos: USGS – Wallace (1971)

Land Use Planning for Earthquake Hazards initiated by State of California

- 1972: Alquist-Priolo (AP) Earthquake Fault Zoning Act adopted by the State of California to mitigate the hazard of surface faulting to structures for human occupancy.
- AP zones are regulatory zones surrounding the surface traces of active faults (evidence of Holocene rupture in the last 11,000 years).
- Regulatory zones trigger required geologic investigations for new development:
  - There are some exceptions, such as single-family houses
  - The requirements are not retroactive to existing structures
- A structure cannot be placed over the fault and must be a minimum distance from the fault (generally 50 feet (15 meters)).

Expanded State-led Land Use Planning for Earthquake Hazards

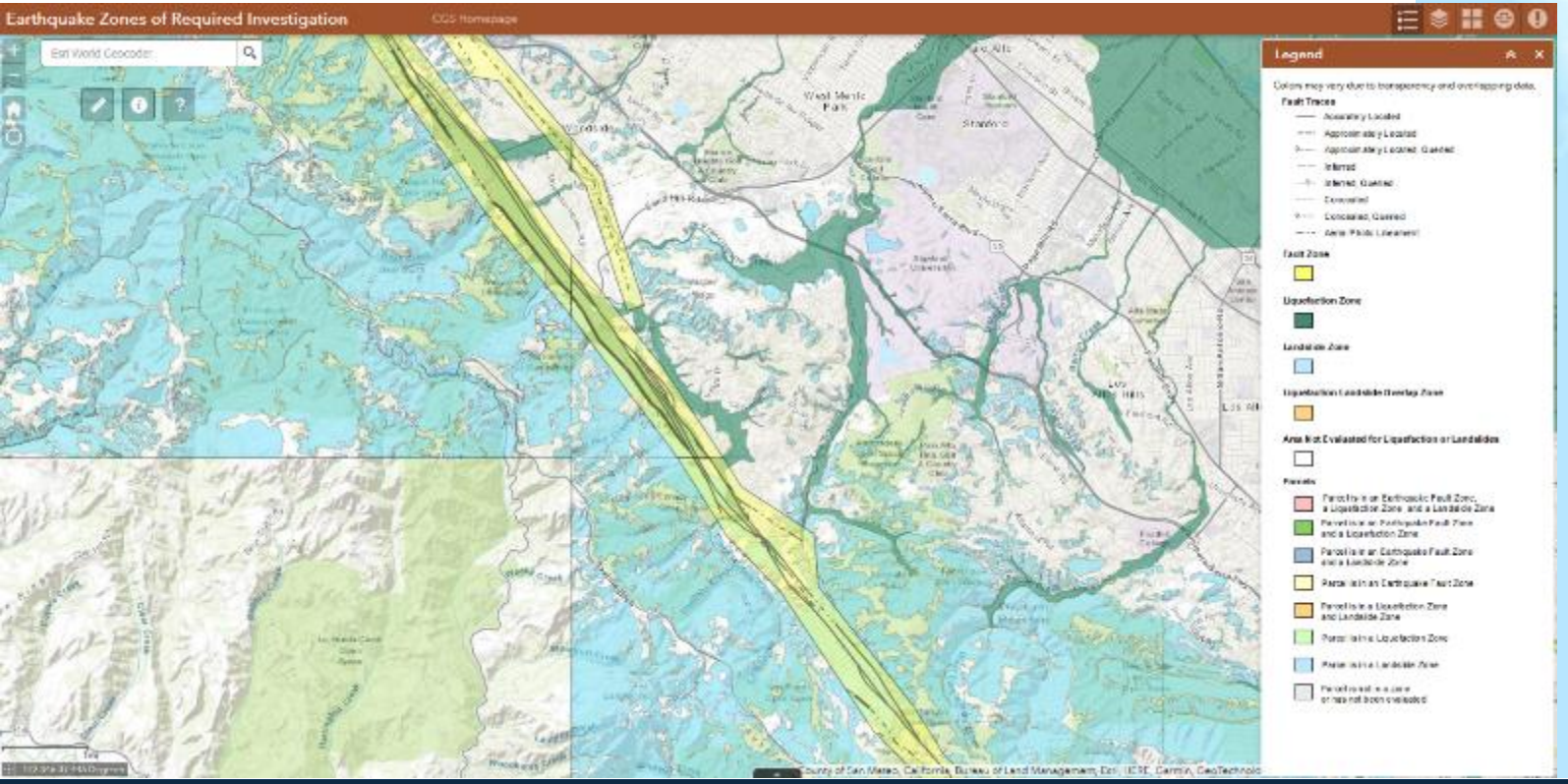
- 1990: Seismic Hazard Mapping (SHM) Act directs the State Geologist to map zones of required investigation for liquefaction, landslides, or other ground failure and other seismic hazards caused by earthquakes.
  - *Tsunami Regulatory Zones currently in the process of being added*

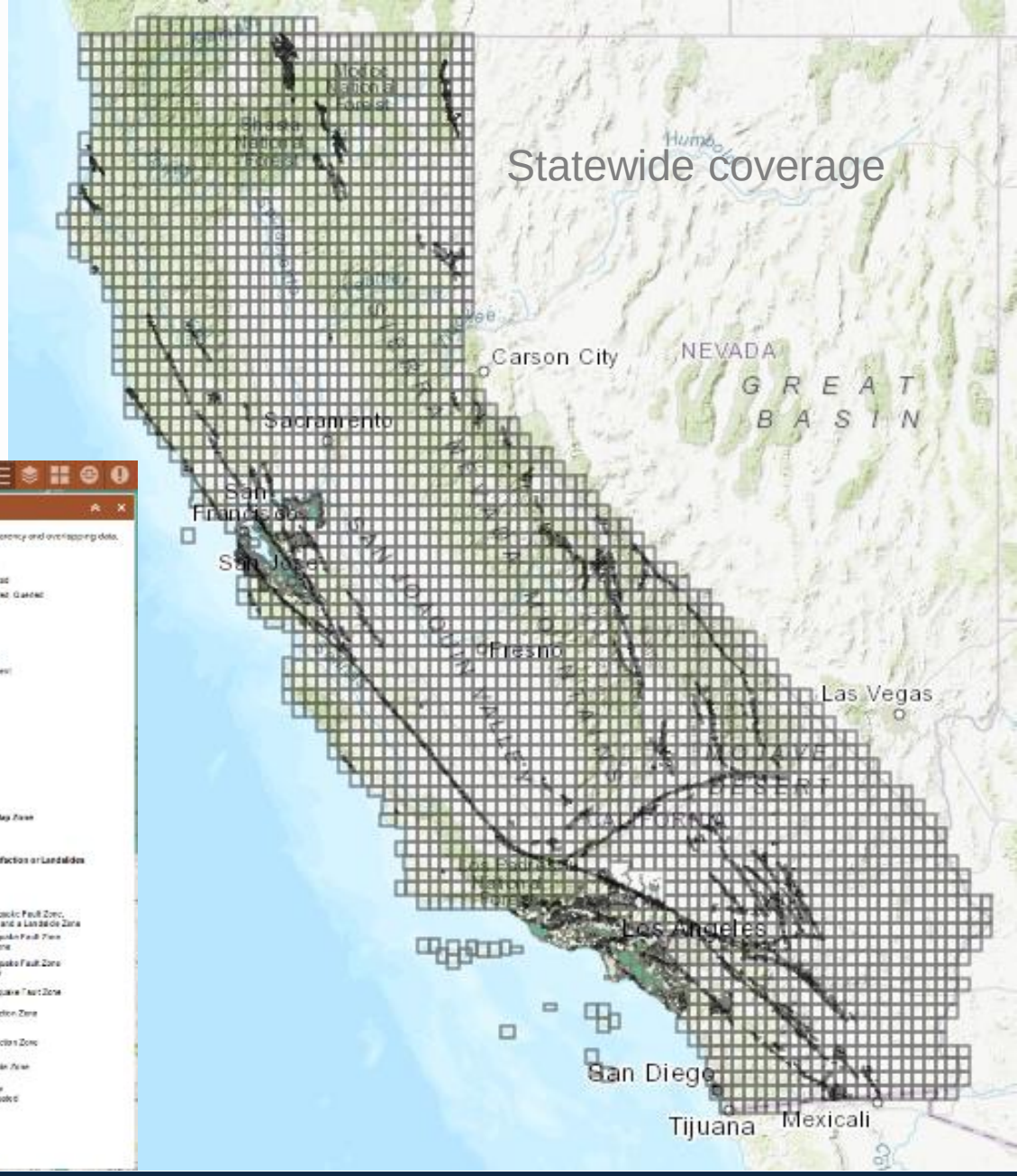
- Alquist-Priolo (AP) and SHM zones of required investigation are delineated by the California Geological Survey.
- Cities, counties, and state construction agencies must require investigations for new development projects, avoid high hazard areas, and identify where higher building standards may be necessary for safe development.
  - Cities and counties may adopt more stringent regulations, but cannot be less restrictive than the State requirements.
- Acts also require owners and agents of properties within a mapped hazard zone to disclose (at the time of sale) that the property lies within such a zone.

- Pros to a state-led mapping program include mapping consistency, less political influence.
- Cons include coverage gaps due to budget constraints and time delays.

California Seismic Hazard Maps and Regulatory Zones of Required Investigation

EQ Zapp app: https://maps.conservation.ca.gov/cgs/EQZApp/app/





Local Land Use Planning in the State of California

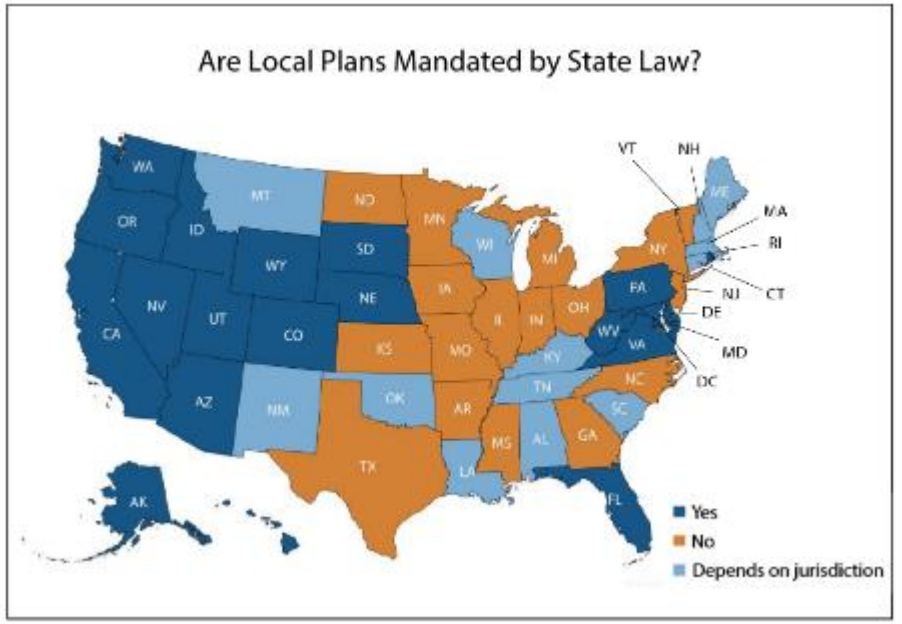
Every city and county in California is required to adopt a General Plan that must include elements (or chapters) on the following topics:

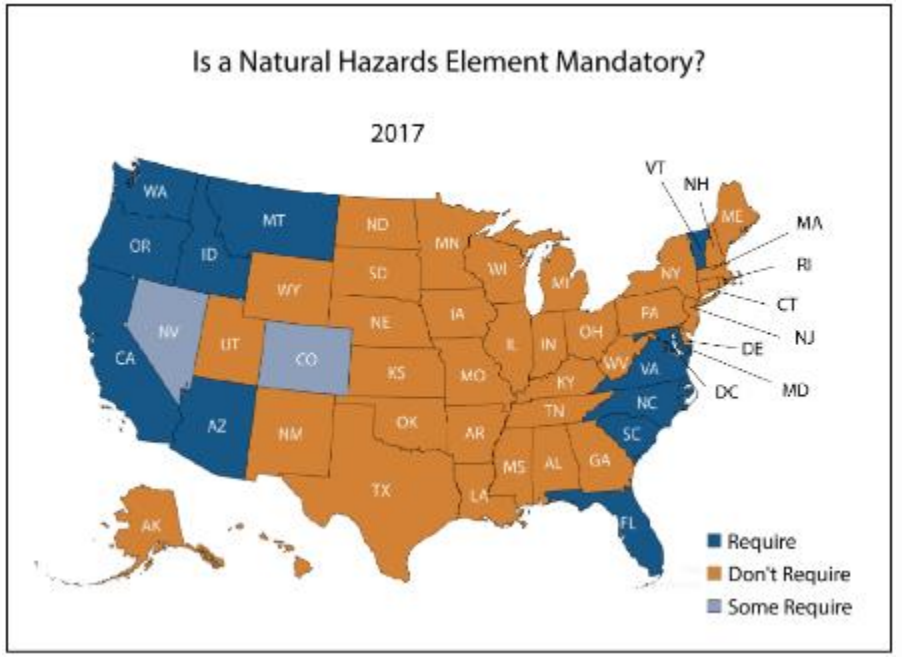
- Land Use
- Open Space/Conservation
- Housing
- Transportation
- Safety
- Noise
- Environmental Justice *(for disadvantaged communities)*

- Originally a *(Seismic)* Safety Element, the Safety Element focuses on reducing the potential short and long-term risk of death, injuries, property damage, and economic and social dislocation resulting from the effects of various geologic hazards, flooding, wildland and urban fires, and must include climate adaptation and resilience strategies
- Plan consistency required. Safety element updates required upon the next revision of the housing element or local hazard mitigation plan.

Governmental Authority for Planning and Hazards Management in the U.S.

- Most authority and responsibility resides with states
  - States can plan and regulate land use and adopt building codes, if they want to.
  - States have laws that enable cities to conduct their affairs, including planning.
  - Cities' planning laws depend on their state.
- Federal government
  - Provides (limited) funding, policy guidance and technical assistance for planning
  - Regulates air and water quality
  - Requires preparation of State and Local Hazard Mitigation Plans in order to receive federal disaster relief funds
  - Prepares flood risk maps for National Flood Insurance Program (NFIP) and National Seismic Hazard Maps for seismic provisions in building codes

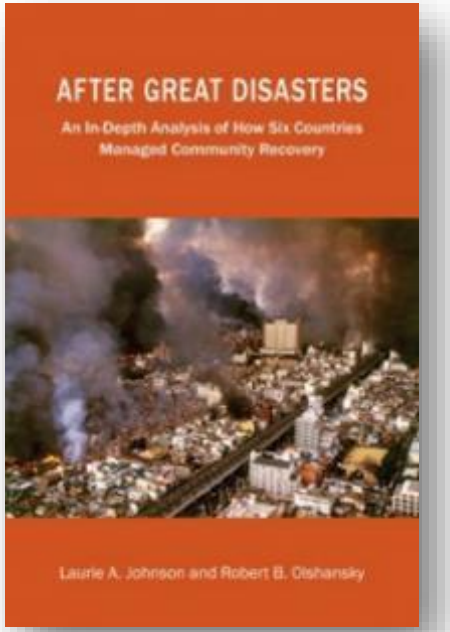


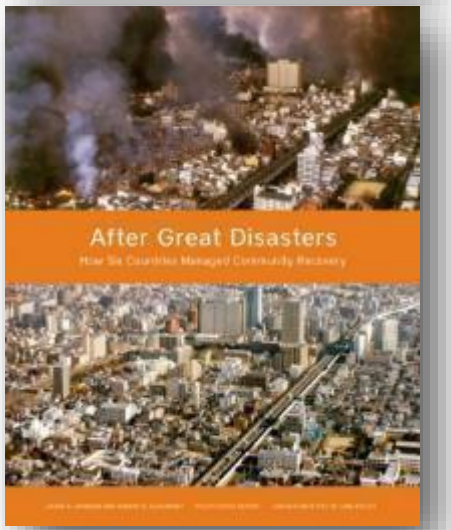


(American Planning Association, Survey of State Land-Use and Natural Hazards Planning Laws, 2017)

After Great Disasters: An In-depth Analysis of How Six Countries Managed Community Recovery

Laurie A. Johnson and Robert B. Olshansky (2017)





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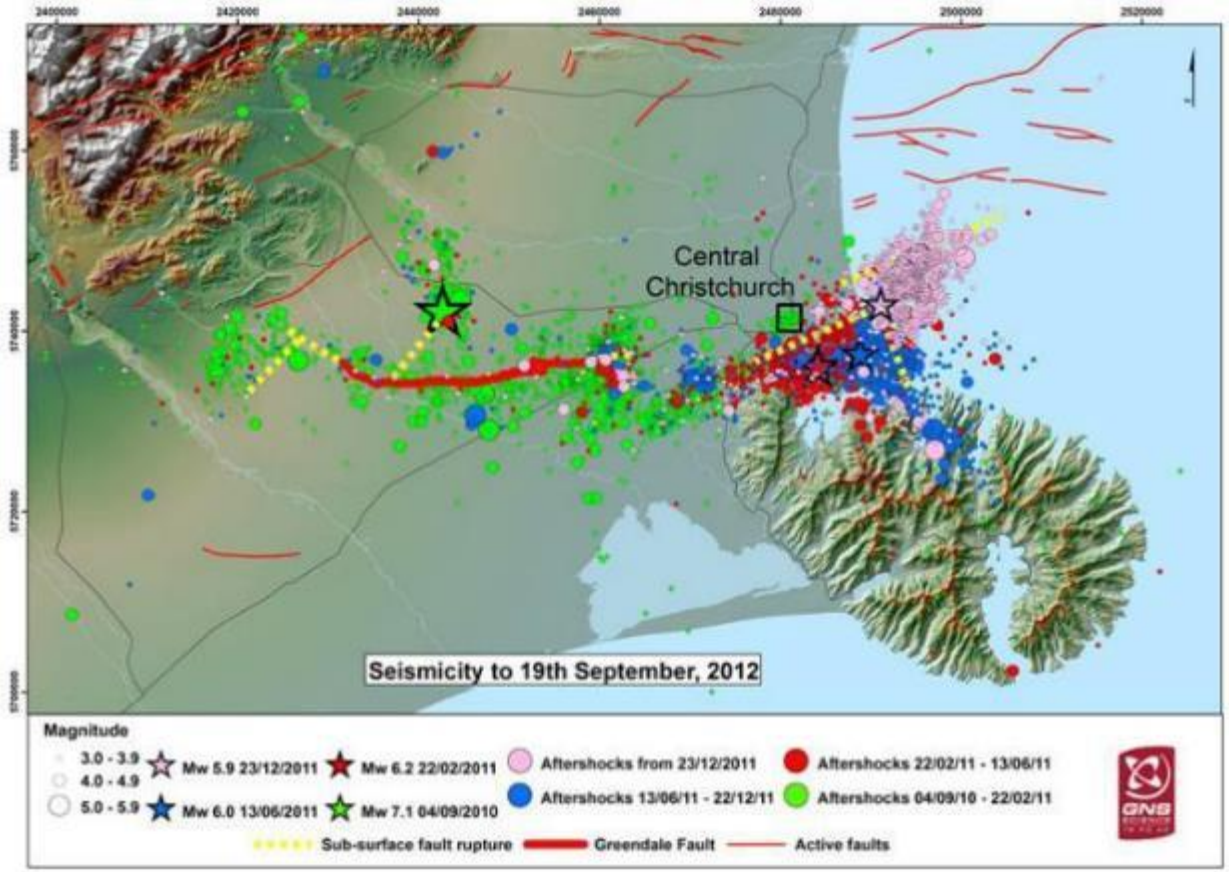
Christchurch City, Canterbury Region, New Zealand, February 22, 2011

- M7.1 September 4, 2010 earthquake, followed by 3 large earthquakes (M6.2 February 22, 2011, M6.0 June 13, 2011, M5.9 December 23, 2011) and thousands of aftershocks
- Deaths: 185, majority in 2 concrete-building collapses; others due to unreinforced masonry buildings
- 180,000 housing units damaged
- >1,500 commercial buildings demolished
- >1,600 community and 375+ heritage buildings majorly damaged/destroyed
- 25% of 6,000 km of network infrastructure and 35% of 2,000 km of roads repaired/replaced
- Economic Loss: NZ$40 billion (> 20% GDP)
- Insured Loss: NZ$21 billion (~50/50 split residential and commercial claims; >NZ$18 billion paid as of July 2016)

Dust cloud rising as building collapse in downtown Christchurch NZ on 2/22/11
Gilly Needham

2010-2011 earthquake sequence had 10 distinct episodes of liquefaction as well as lateral spread, subsidence, rockfalls and landslides

Affected >50% Christchurch area with 1-2 m of settlement and 2-3 m of lateral spread. Liquefaction resulted in 1,000 building demolitions in central business district and 15,000 damaged residences (Quilter et al 2015).



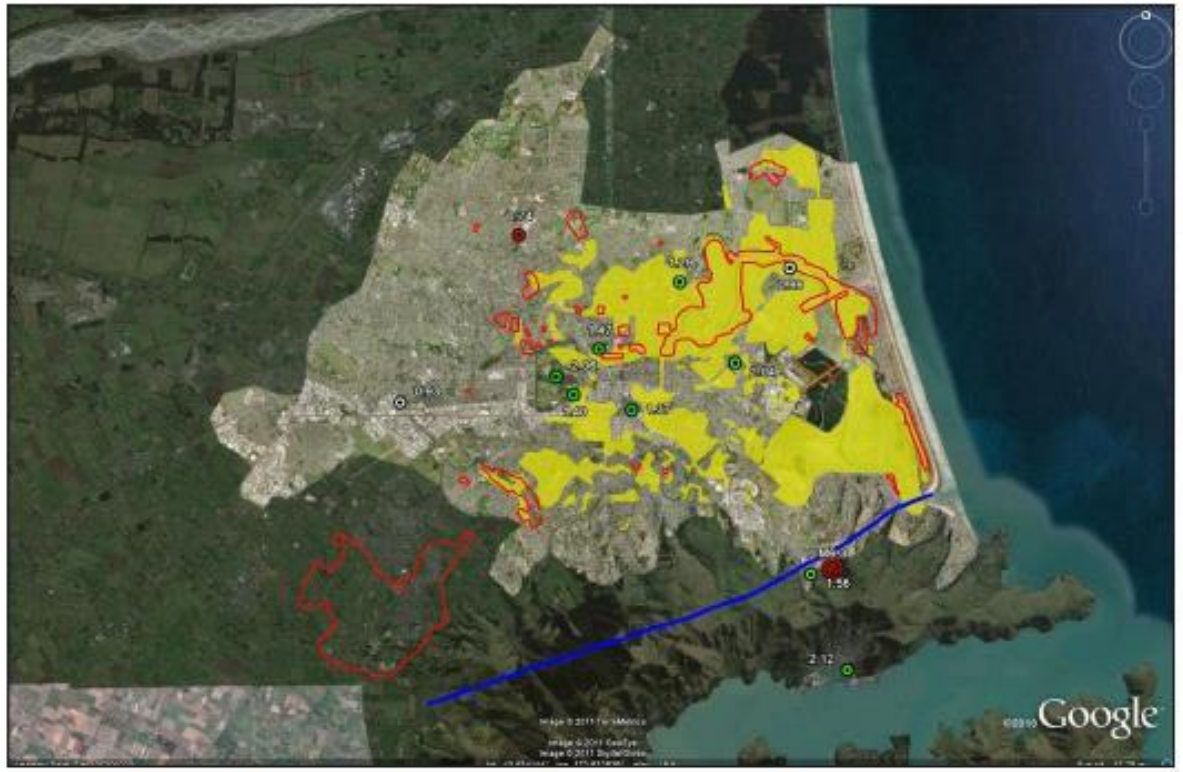
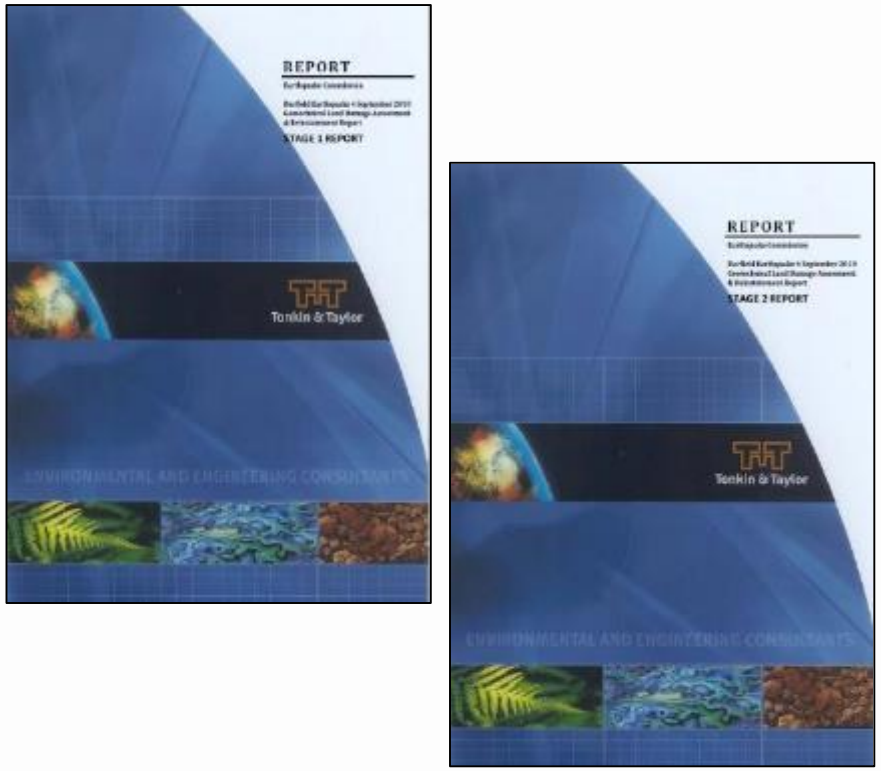


Figure 3. *Liquefaction in February 2011 (green) and September 2010 (red contours) (courtesy of R. Green; GEER 2011).*

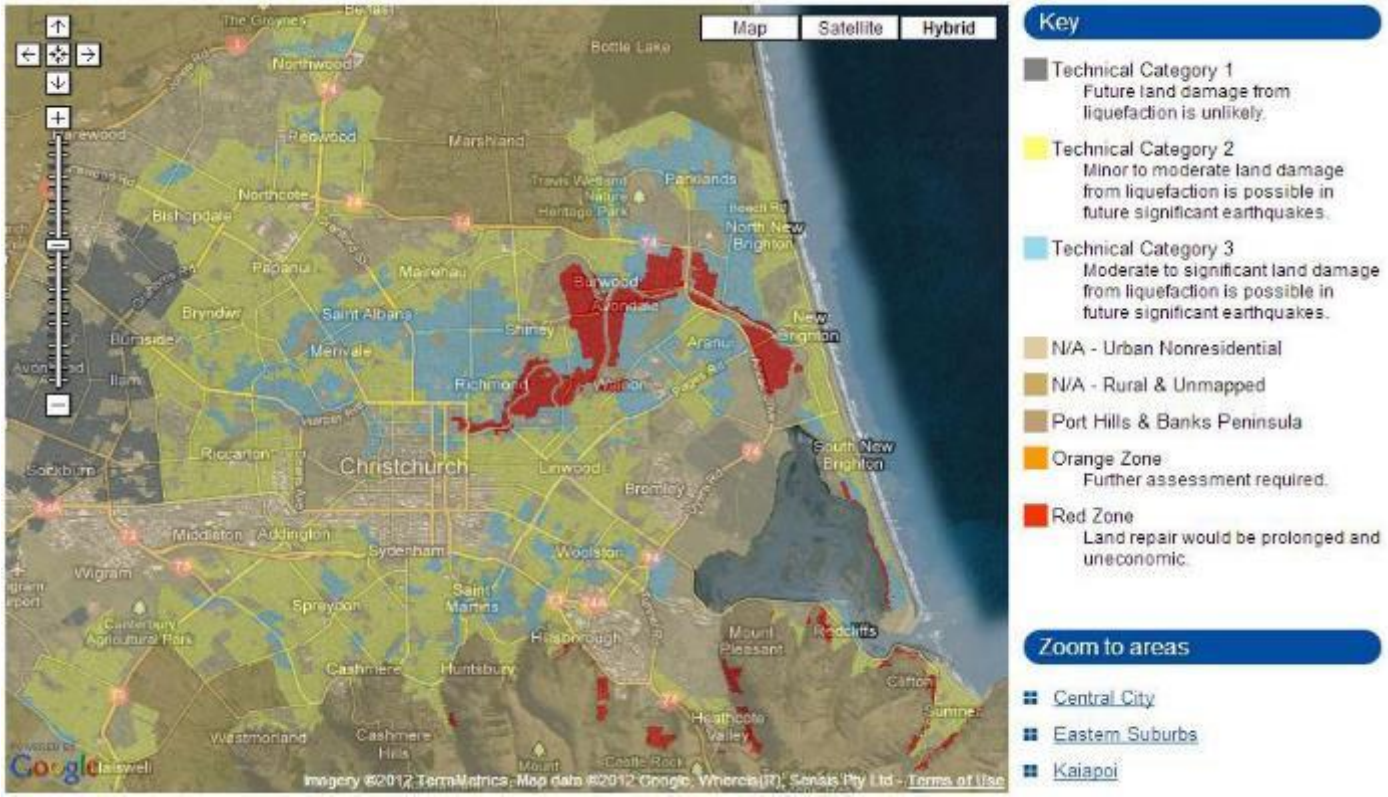
Residential Impacts of the Canterbury Earthquake Sequence

Liquefaction, rockfalls, and other ground failures

National government funded investigations and eventually a “Residential Red Zone Buyout” 2011 – 2014

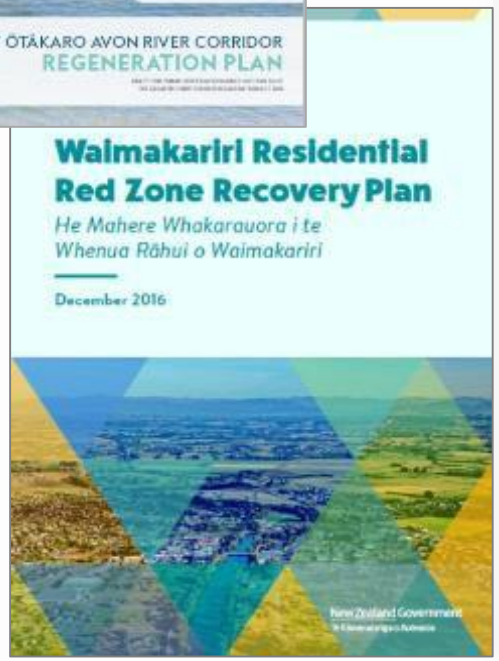


New Zealand Earthquake Commission funded areawide geotechnical investigations. Stage 1 report Oct 2010, Stage 2 report Nov 2010

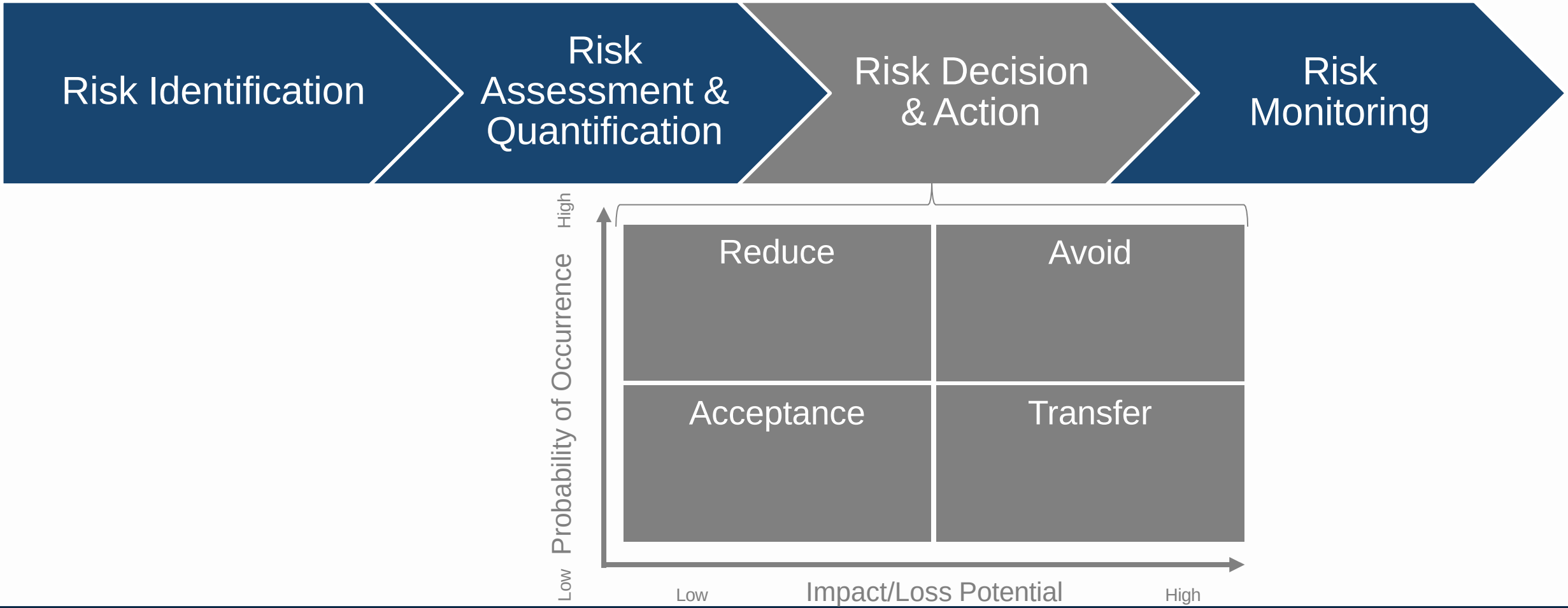


National government releases land zoning decision on June 23, 2011 with offer to buy >7,000 residential properties in the “red zones.” Lawsuits forced national government to extend offers to vacant land and insured commercial properties within the “red zones.”

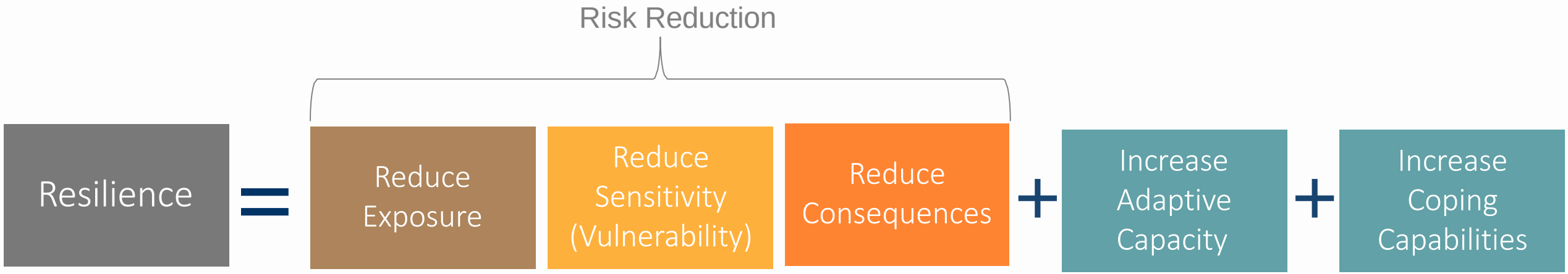
Planning for future use of Red Zone land is still ongoing today



In considering risk management approaches, land use planning is an effective risk avoidance tool (high probability/high impact risks)



Potential Framework for Community Resilience Planning, Policy and Programs



(Adapted from: Bay Area Metro, Resilient Housing Policies & Programs, Version 1.1, September 2021, and California Climate Adaptation Guide, 2020)

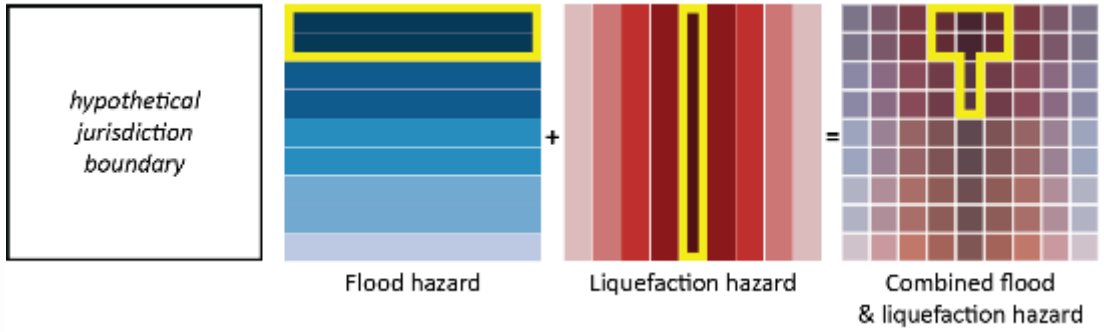
Potential Framework for Community Resilience Planning Policy and Programs

Reduce Exposure		Reduce Sensitivity	Reduce Consequences		Increase Adaptive Capacity and Coping Capabilities		
Avoid	Protect	Accommodate	Life & Safety	Property	Government Process	Complete and Updated Data	Community Education & Engagement
• Reduce or prohibit development in most hazardous areas • Adaptative resettlement program or policy of strategic realignment • Use agriculture and open space to buffer development from hazards	• Site and design protective measures to reduce the extent of hazard and climate impacts • Encourage forest and watershed management activities that reduce wildfire intensity/spread and downstream flooding intensity	• Require flood-proof construction methods, techniques and mitigation • Apply existing requirements to areas with high future risk • Expand use of drought tolerant requirements • Expand extreme heat adaptation requirements • Expand seismic retrofit requirements • Require modern home energy and building materials, construction methods and energy systems.	• Ensure evacuation routes and plans consider future populations and future hazard conditions • Require measures to reduce the consequences of utility outages	• Establish a pre-disaster rebuilding and recovery plan to assist post-disaster recovery • Promote long-term and more expansive insurance coverage • Create a fragile housing inventory	• Ensure consistency across multiple plans and synchronize local plans	• Ensure planning includes best available science, adequate mapping and appropriate planning horizons	• Develop an inclusive public engagement and education strategy • Educate community on actions they can take to reduce risk

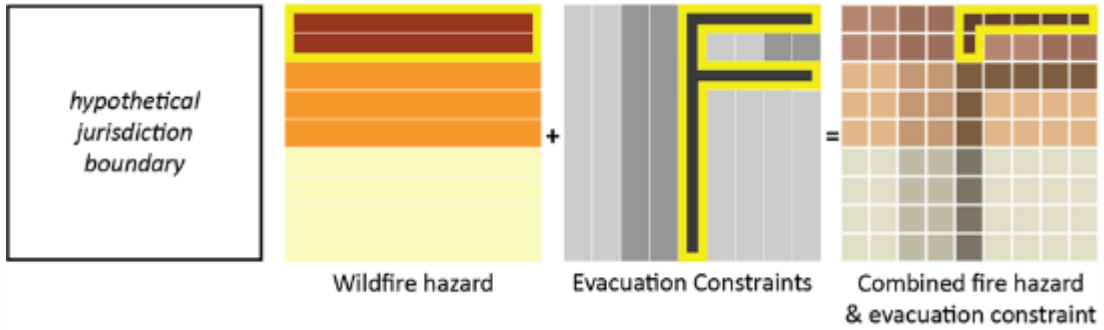
(Bay Area Metro, Resilient Housing Policies & Programs, Version 1.1, September 2021)

Planning to Reduce Exposure: *Reduce or prohibit development in most hazardous areas pre- and post-disaster.*

Example of how a narrower definition of *most* hazardous area could be determined using two hazards.



Example of how a narrower definition of *most* hazardous area could be determined using hazard and other consequence constraints



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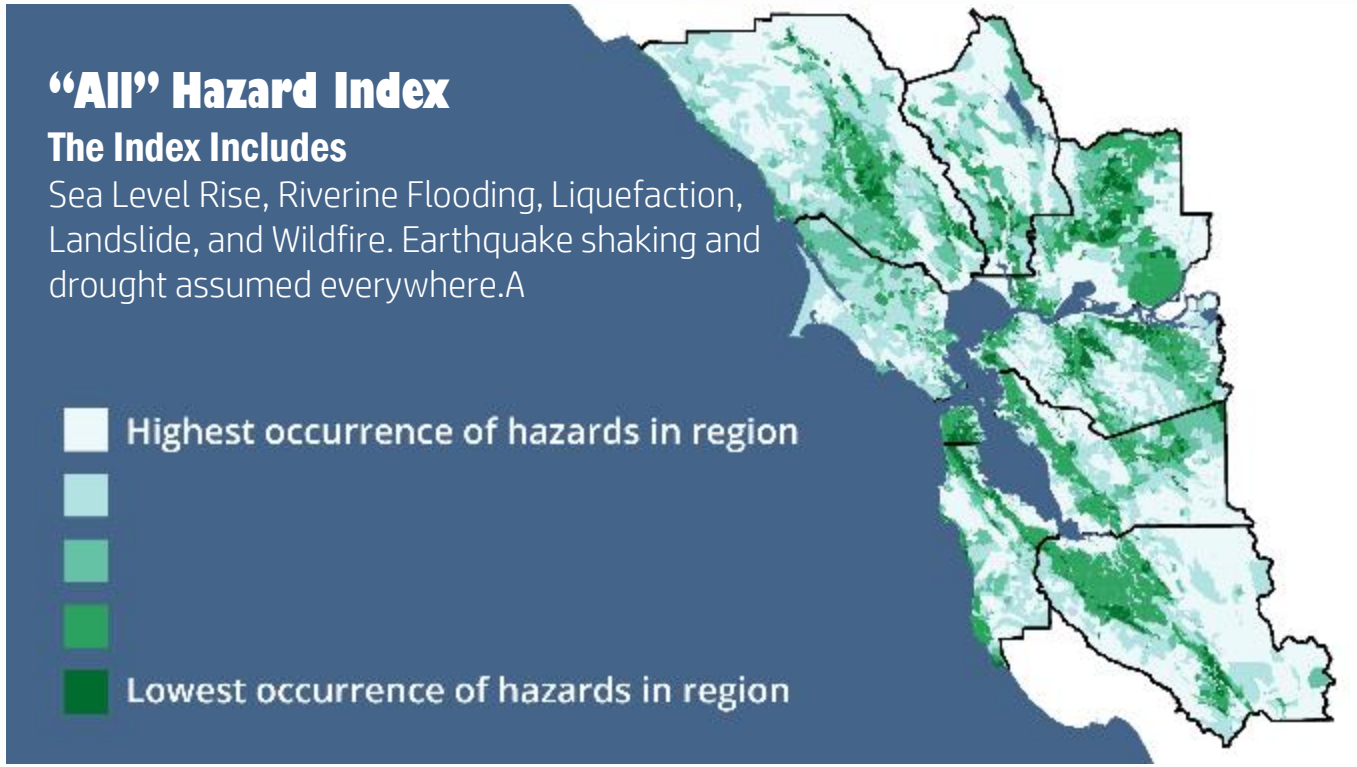

(Bay Area Metro, Regional Resilience Program)

Policy to Reduce Exposure: *Develop an adaptative resettlement program or policy of strategic relocation/managed retreat ahead of disaster.*

Framework for considering relocation/managed retreat based upon a qualitative review of 53 cases of disaster induced relocation.

- The natural science
- The risk decision
- Livelihoods, economy, social ties
- The process of leaving one place for another
- Property rights, sources of funding, financing
- Politics, other planning goals (It's never just about safety from natural hazards)

(Balachandran, Olshansky, Johnson, 2021, "Planning for Disaster Induced Relocation", *Journal of the American Planning Association*)

Hazard risk = probability of a hazard event occurring or reaching a tipping point, and its likely impact on life and property

Social risk = probability that relocation (or return) will cause losses to: livelihoods, social capital, political capital, cultural identity, historical values

MUCHAS GRACIAS!
THANK YOU!

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