

Bay Area Earthquake Residential Building Damage + Displacement White Paper

An earthquake on any of the 16 major faults in the Bay Area has the potential to significantly damage residential housing, displacing residents and causing significant financial impacts to homeowners, building owners, and tenants. ABAG has identified housing as a major cornerstone of the region's resilience – retaining existing housing is crucial to expediting and ensuring an effective disaster recovery. Limiting catastrophic housing damage keeps residents in their homes and not only helps people who may lack the resources to effectively recover from a disaster, but keeps communities intact.¹

Though many people are familiar with the San Andreas and Hayward faults, and indeed these are the faults capable of producing the largest earthquakes in the Bay Area, earthquake hazards vary throughout the region due to the existence of numerous smaller faults. While impacts from an earthquake on these faults will not be as widespread, they could still produce significant localized impacts. A fault map and a deaggregation map, showing which fault is likely to be the largest contributor to shaking hazard at any given point in the Bay Area, are included in Appendix A.

What will be the impacts of a major earthquake on the region's housing?

The impacts of an earthquake on the residential housing stock, and therefore residents, can be measured in a few ways. In this study, we estimated the number of uninhabitable buildings, the building damage dollar amount (calculated using 2014 building values), and number of displaced households (determined similar to uninhabitable buildings, but using assumptions about occupancy rate to convert units to households). The number of uninhabitable buildings was calculated using the assumption that 100% of single family or multifamily homes with complete damage will be uninhabitable; 65% of multifamily homes and 40% of single family homes with extensive damage will be uninhabitable; and 40% of multifamily homes and 20% of single family homes with moderate damage will be uninhabitable.

San Andreas Scenario

In the earthquake scenario with the greatest impact to the region, a magnitude 7.8 on the San Andreas Fault (similar to the 1906 earthquake), approximately 198,700 households will be displaced from 68,900 uninhabitable buildings, with \$28.4 billion in direct residential damages. Approximately 35% of the displaced households (69,600) will be in San Francisco; San Mateo and Santa Clara Counties will also have large numbers of displaced households (42,200 and 47,200 respectively). In San Francisco, this number represents just over 20% of total households; in San Mateo County this is approximately 16% of households, but in more populated Santa Clara County these 47,200 households represent 7.8% of all households. Effects are much less severe for

¹ More analysis of the region's fragile housing types, as well as where these fragile housing types house vulnerable community members, can be found in ABAG's 2015 report *Stronger Housing, Safer Communities: Strategies for Seismic and Flood Risks*. http://resilience.abag.ca.gov/projects/stronger_housing_safer_communities_2015/

counties farther from the fault: in Solano, Contra Costa, and Napa Counties 1% or fewer households are anticipated to be displaced (0.5%, 1%, and 0.6%, respectively).

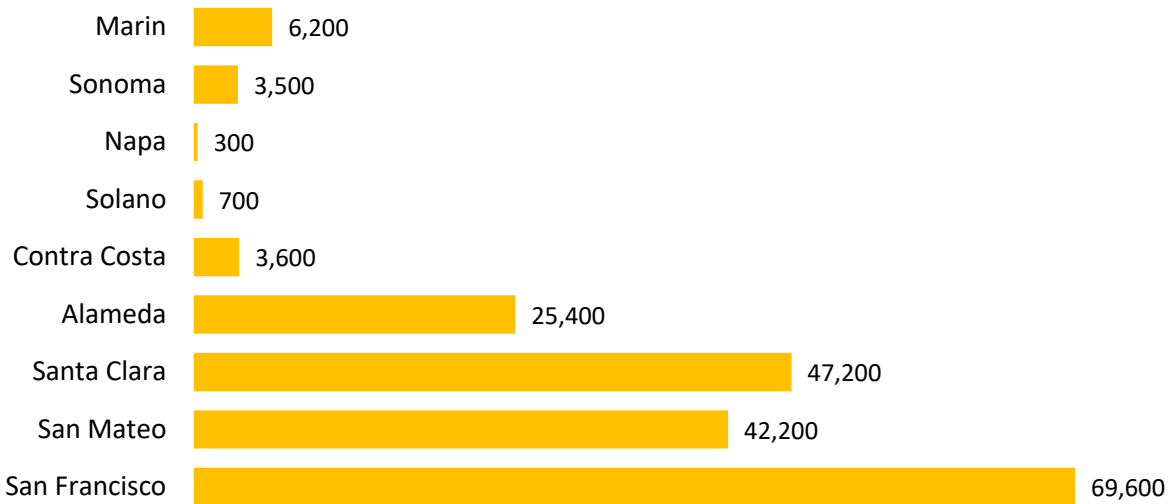
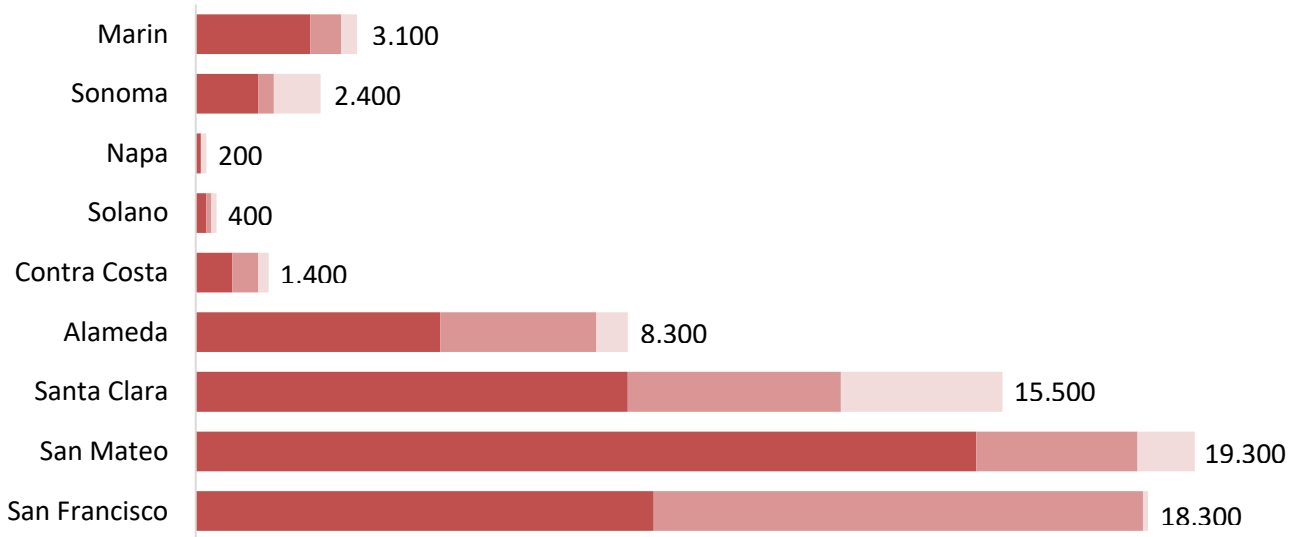


Figure 1: Displaced households (all residential types) from a M7.8 earthquake scenario on all Northern segments of the San Andreas Fault

While the absolute number of *households displaced* is highest in San Francisco, San Mateo County will have the largest number of uninhabitable residential *buildings* (19,300, approximately 10% of total residential buildings in San Mateo), followed by San Francisco (18,300, approximately 11% of total residential buildings in San Francisco) and Santa Clara (15,500, approximately 3.5% of total residential buildings in Santa Clara). On average, San Francisco has a higher number of households per building due to more multifamily buildings (an average ratio of 3.8 displaced households for every uninhabitable building) while San Mateo County has a lower number of households per building due to more single family buildings (an average ratio of 2.2 displaced households for every uninhabitable dwelling), so even though fewer total residential *buildings* are damaged in San Francisco, more households per building means more displaced households.² Napa County, on the other hand, will have only 200 uninhabitable residential buildings (0.4% of total number of residential buildings in Napa), Solano County 400 (0.3% of total number of residential buildings in Solano County), and Contra Costa County 1,400 (0.4% of total number of residential buildings in Contra Costa County).

Additionally, while the total residential uninhabitable building count in San Francisco is slightly lower than San Mateo County, the total dollar amount in residential building damage is slightly higher, at \$8.0 billion versus \$7.9 billion in San Mateo County. Santa Clara County will sustain \$6.3 billion in residential building damages, and Alameda County \$3.2 billion. Napa is expected to sustain \$60 million.

² In San Francisco, the percent of residential buildings that are single household is 76%, vs 24% for multifamily households. In San Mateo, these percentages are 95% and 5%.



	Marin	Sonoma	Napa	Solano	Contra Costa	Alameda	Santa Clara	San Mateo	San Francisco	Total
Uninhabitable buildings – Single Family	2,200	1,200	100	200	700	4,700	8,300	15,000	8,800	36,800
Uninhabitable buildings – Multi-Family	600	300	0	100	500	3,000	4,100	3,100	9,400	19,600
Uninhabitable buildings – Manufactured Homes	300	900	100	100	200	600	3,100	1,100	100	4,900
Total	3,100	2,400	200	400	1,400	8,300	15,500	19,300	18,300	61,400

Figure 2: Uninhabitable buildings by residential building type from a M7.8 earthquake scenario on all Northern segments of the San Andreas Fault

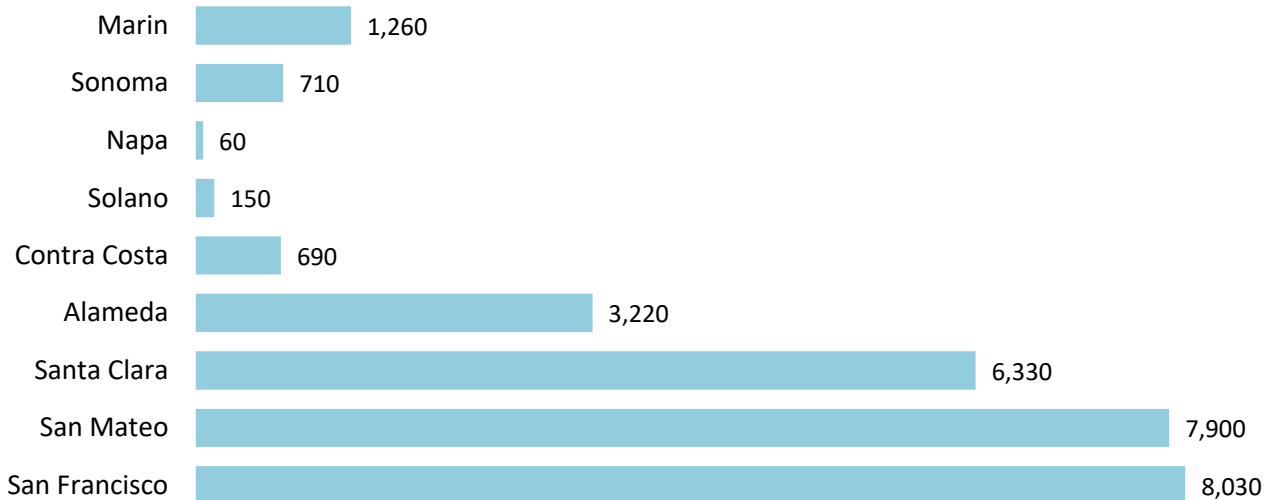


Figure 3: Building damage value (in \$millions) for all residential building types from a M7.8 earthquake scenario on all Northern segments of the San Andreas Fault

Hayward Scenario

In an East Bay fault earthquake, a magnitude 7.0 on the North and South segments of the Hayward Fault, the overall region-wide numbers will be slightly lower than those for the M7.8 San Andreas event, but distributed differently across the region. In total, approximately 145,000 households will be displaced from 55,100 uninhabitable residential buildings, with \$20.9 billion in damages to those residential buildings. Alameda will have the most displaced households, 75,500 (52% of total displaced households in the region, representing approximately 14% of total households in Alameda County). Santa Clara and San Francisco Counties will each have approximately 15% of the region’s total displaced households each (22,600 households, 3.8% of the county’s total households, and 22,200 households, 6.4% of the county’s total households, respectively). Napa County will have approximately 500 displaced households, or about 1% of the county’s total households, and Sonoma County will have approximately 0.5% of the county’s total households displaced, or about 1,000 households.

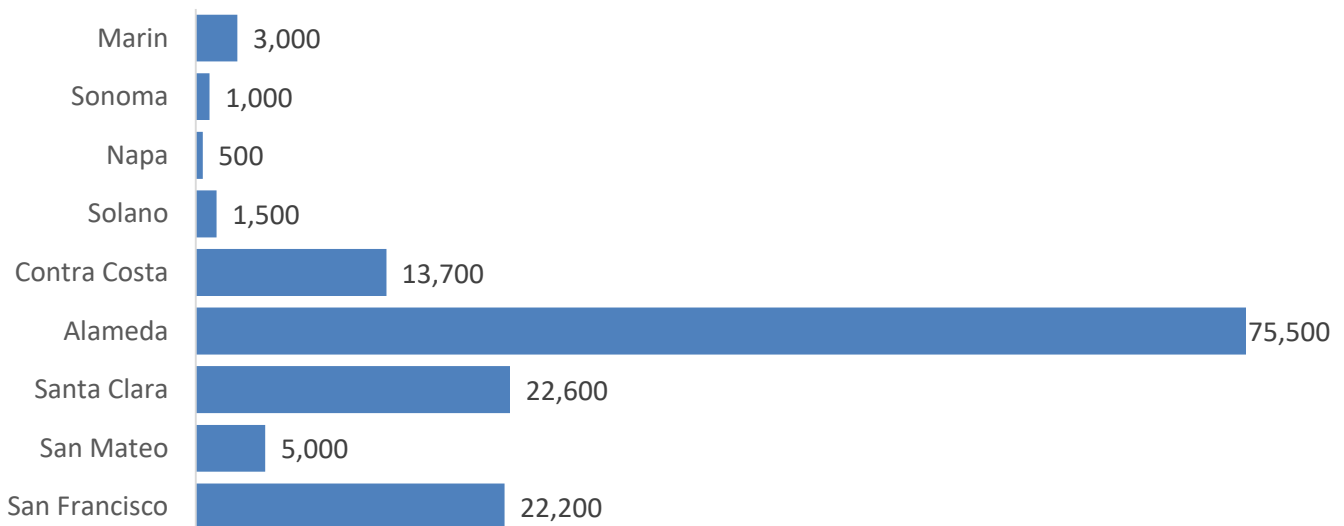


Figure 4: Displaced households (all residential types) from a M7.0 earthquake scenario on North and South segments of the Hayward Fault

Alameda County will also have the largest number of uninhabitable residential buildings (32,200, approximately 8% of total residential buildings in Alameda County). All other counties will have fewer than 8,000 uninhabitable residential buildings each, many counties under 1,000 (Solano, Sonoma, and Napa Counties at 800, 600, and 300 uninhabitable residential buildings, respectively). Contra Costa County will have 7,200 uninhabitable residential buildings (just over 2% of total residential buildings in the county), Santa Clara 7,100 (1.6% of total residential buildings in the county), and San Francisco 3,700 (just over 2% of total residential buildings in the county). Again, San Francisco will have a disproportionately large number of displaced households relative to number of buildings because of its prevalence of multifamily buildings³ (an average of 6 displaced households for every uninhabitable building in San Francisco as compared to an average of 2.3 displaced households per

³ In Alameda County, the ratio of single household residential buildings to multifamily household residential buildings is 92%:8%, vs. 76%:24% in San Francisco.

uninhabitable building in Alameda County or an average of 1.7 displaced households per uninhabitable building in Napa and Sonoma Counties).

Total residential building damage is most costly in Alameda County, reaching \$11.2 billion. This is almost four times more than in the second most costly counties, Contra Costa and Santa Clara Counties (\$2.7 billion and \$2.9 billion, respectively). Solano, Sonoma, and Napa Counties are expected to sustain just \$310 million, \$220 million, and \$100 million in residential building damages, respectively.

Other Scenarios

Other earthquake scenarios show a wide range of damage across the region. A smaller San Andreas Fault earthquake, a magnitude 7.2 on just the peninsula segment of the fault, could produce approximately 120,000 displaced households and 40,000 uninhabitable buildings region-wide, with a smaller Hayward fault earthquake producing similar results. On the other end of the spectrum, a magnitude 7.4 earthquake on the Maacama fault (located in Northern Sonoma County) would displace approximately 9,000 households and render 3,800 residential buildings uninhabitable. A summary of all modeled earthquake scenarios is shown below in Figure 5.

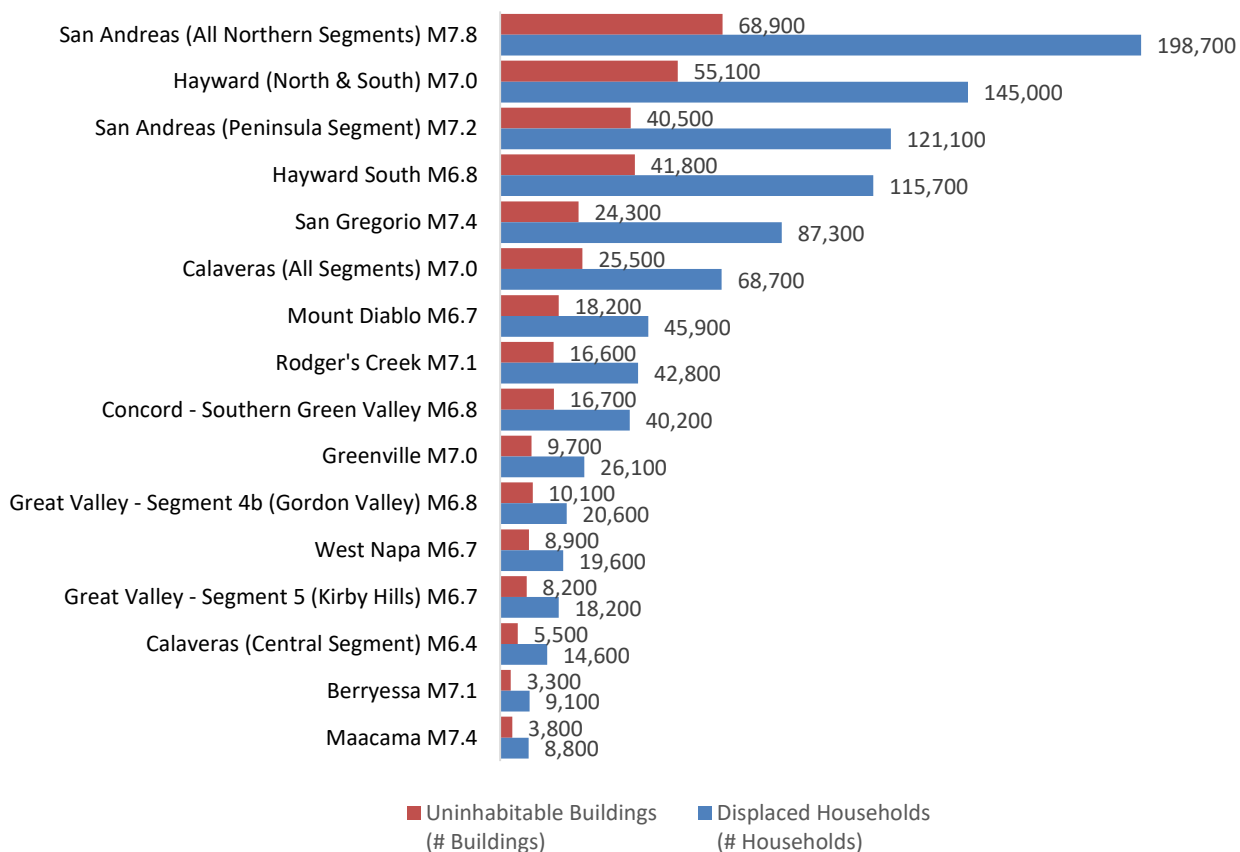


Figure 5: Uninhabitable Buildings and Displaced Households region-wide for 16 Bay Area earthquake scenarios

What can cities do?

- **Create an inventory of vulnerable residential buildings, their exposure to hazards, and their demographic characteristics.** While some earthquakes, such as a large magnitude earthquake on the San Andreas or Hayward faults will likely cause widespread, significant damage, many earthquakes will produce variable damage throughout the region or even within a city. Every county has a different combination of multifamily, single family, and mobile homes that will contribute to the overall residential building damage picture. Loss of each of these home types has different impacts on the community. Additionally, residents within buildings may have highly varied needs, particularly if they house young children, the elderly, residents with medical or functional needs, non-English speakers, or households who depend on social services for food or housing. Multifamily buildings house more residents, so damage to multifamily buildings will result in more displacement; multifamily homes may also sustain greater damage than single family homes. Mobile homes typically sustain the most damage, and typically house lower-income residents, so while they may be a small percentage of the total housing stock in a county, they may contribute a significant proportion of displaced households (in Napa County, where mobile homes represent 8% of residential buildings, in a San Andreas M 7.8 event 30% of displaced residents will be from mobile homes). Other factors, like soil type, liquefaction or landsliding, age, construction type, number of stories, and number of units can also influence how homes will perform in an earthquake. Some neighborhoods may be devastated while others remain largely intact. While it is impossible to know exactly where and how damage will play out, jurisdictions should be prepared to assume that some areas will require more resources for response and recovery while others may require less. Jurisdictions should develop inventories of potentially fragile homes, and overlay this information with hazards maps and demographic information, to better understand how an earthquake will impact residents.
- **Make a plan for retrofitting homes that are likely to be damaged.** Once a jurisdiction has a sense of what homes are most fragile in the community, passing policies to encourage or require retrofit helps ensure that the residents who live in the homes will be more protected from death, injury, or displacement during an earthquake. It is important to note that many older buildings will not be able to be retrofitted to a shelter-in-place standard, meaning that damage is minimized to the degree that the homes will be habitable after an earthquake, but can still be retrofitted to protect lives. Any reduction in damage improves the lives of residents, reduces recovery time, protects assets, and helps keep communities more intact.
- **Educate homeowners, building owners, and tenants about their risks.** Everyone in the region – renter, homeowner, high income, or low income – can benefit from enhanced knowledge about risks to make smarter decisions to prepare for earthquakes. While there are many factors that influence how people choose to respond to risk, including what their neighbors are doing, knowledge of risks, and what can be done to help mitigate those risks, is fundamental. Making information easily accessible is important, such as through a city website, and conducting varied outreach to all communities can help with information sharing. Cities and counties can educate residents on options such as structural retrofit, bracing hot water heaters, mitigating brick chimneys, securing furniture, cupboards, and other interior falling hazards, preparing to shelter in place by making an earthquake kit with food, water, and other necessary supplies, and purchasing earthquake insurance (for both homeowners and renters).

- **Plan for sheltering residents.** In any earthquake scenario, cities and counties will likely need to shelter residents whose homes are significantly damaged. Cities and counties need to have an accurate estimate of the magnitude of likely shelter needs in probable earthquake scenarios and develop a plan for serving these populations after an earthquake. A separate White Paper, entitled Bay Area Earthquake Shelter Needs White Paper, outlines in more detail estimated short-term shelter needs as well as considerations for jurisdictions in planning shelters. However, the paper focuses primarily on short-term sheltering. In a larger earthquake, residents may need shelter for several months or even years as their homes are repaired or rebuilt, so cities will need to plan for not just short-term shelters, but interim housing for these residents as well.
- **Encourage protection of investments through insurance.** In some cases, retrofit is infeasible or too costly to justify the level of protection it would provide, such as in very high liquefaction areas or in instances where a building sits on top of a fault rupture zone. Additionally, renters have little to no control over whether their buildings are retrofitted. In cases where retrofit is either infeasible or out of an individual's control, earthquake insurance may be the best option for protecting a resident's financial well-being after an earthquake. Earthquake insurance is a separate policy than a traditional homeowner's policy and can be costly, with high deductibles, but in cases of extreme damage, may help homeowners avoid catastrophic financial loss. Insurance can help homeowners repair or rebuild. For renters, earthquake insurance is typically very affordable and can not only protect against loss of building contents but can assist policyholders in paying for alternate housing if their building is damaged to a degree that they cannot live in it. Insurance is especially important for individuals and families that may not have a large financial cushion through savings or family, such as lower income households or young adults. Currently, very few households have earthquake insurance – only 10% of homeowners and 5% of renters have an earthquake policy.
- **Build resilience into your community through building codes for new construction.** While the numbers presented in this paper discuss only existing housing, which, when older, tends to be more fragile and prone to damage than new construction, new construction offers a significant opportunity to build resilience into the next generation of a city. Currently in California, building codes ensure life safety during a major earthquake but are not designed to shelter-in-place standards. This means that while residents will not lose their lives through catastrophic collapse, buildings may very well be damaged to the degree that they will be uninhabitable, leading to displacement, shelter seeking, and costly repairs. Most residents and elected officials are not aware of this and assume that current code ensures adequate performance in an earthquake; while new buildings will most likely perform better than older buildings, "adequate" performance in the eyes of the public may be different than in the eyes of the code developers. Amending the building code with a local amendment that raises new construction standards can help prevent these consequences and build a more resilient future into the next generation of a city.
- **Plan for Whole Community Recovery.** Housing is critical to disaster recovery – when people are able to stay in their homes after a disaster, social networks remain intact, vulnerable populations are less likely to be pushed out, employees are able to return to work faster and keep the economy stronger, and recovery overall moves quicker. Less damage to housing also means fewer repairs and less loss of personal wealth. However, housing is not the only factor that dictates whether residents stay or leave

the community. There are a number of other interconnected factors that either ensure that residents can stay or forces them to leave, independent of the state of their housing. One of the most critical, particularly after the first few days, is utility services. While residents may be able to survive for several days or weeks without electricity, access to water and wastewater services are far more critical to public health. After these basic needs, once recovery begins, residents will also need to meet other everyday needs such as access to grocery stores, pharmacies, day care, and doctor's offices as well as be able to access their jobs to maintain their income. Critical to accessing these resources is a functioning transportation system, including bridges and roads as well as public transit. Longer term, societal trends will impact whether people stay or go. If the economy is unable to recover, people may leave to access better jobs elsewhere. If major demographic shifts occur due to displacement, people may choose to leave if they no longer feel welcome in their community. Lastly, if residents no longer feel a sense of community because their social group, church community, or neighbors are no longer intact, they may choose to leave the region even if all other aspects are in place.

- **Talk to your neighboring jurisdictions and plan outside your jurisdictional boundaries.** Many neighboring jurisdictions will also be significantly damaged, so displaced people may have to go far to find short and long-term housing. The effects of a major earthquake will impact the whole region, so cooperation between neighboring cities will be critical. You will not likely be able to depend on your neighboring jurisdictions to house displaced residents, leading many displaced residents out of the region entirely. This exodus can be managed by ensuring that adequate shelters are planned for as well as strengthening existing housing. Housing retrofit is most beneficial when it occurs where fragile housing exists, not just within specific jurisdictional boundaries. Nearby cities with similar housing stock should work together to develop similar policies and ensure that buildings are retrofitted along similar timelines to avoid uneven devastation, displacing residents across city boundaries.