



Bay Area Housing and Community Multiple Hazard Regional Assessment Approach (rev. 12/01/14)

Hazard Indicators

The assessment considered three hazards: ground shaking, liquefaction, and flooding. The hazard scenarios (see below) were selected based on their potential to affect the recoverability of housing and communities.

Ground shaking hazard levels were examined at MMI VIII or higher from two earthquake scenario shaking maps – a M 7.8 on the San Andreas fault or a M 6.9 on the Hayward fault. Previous research¹ indicates a significant threshold for housing damage (the number of homes likely to be red-tagged) at MMI VIII and above.

Liquefaction hazard levels were determined based on liquefaction susceptibility² combined with the MMI value using the correlation table below.³ For the purpose of this project, we examined any areas of Moderate or High liquefaction hazard from the two scenarios outlined above (a San Andreas or Hayward event) as these levels are the most likely to cause significant building damage.

MMI Value	Liquefaction Susceptibility Category		
	Moderate	High	Very High
VII – Strong	Low Hazard	Low Hazard	Moderate Hazard
VIII – Very Strong	Moderate Hazard	Moderate Hazard	Moderate Hazard
IX – Violent	High Hazard	High Hazard	High Hazard
X – Very Violent	High Hazard	High Hazard	High Hazard

Flood hazard levels were evaluated for both current and future conditions. Current flooding was based on published National Flood Insurance Program (NFIP) rate maps. Future flooding was based on a three regional inundation maps developed by NOAA Coastal Services Center⁴. These three inundation maps are being used to represent different combinations of sea level rise (SLR) and tide level, including the daily high tide (mean higher high water, MHHW) and a range of extreme tides that could occur during coastal storm surge events. Example possible combinations are shown below.

Flood Hazard	Description
Current	100-year flood zone based on NFIP rate maps ⁵
Future, 24" of sea level rise*	Daily high tide with 24" SLR; 1-year tide with 12" SLR; today's 5-year tide (no SLR)
Future, 36" of sea level rise	Daily high tide with 36" SLR; 10-year tide with 6" SLR; today's 50-year tide (no SLR)
Future, 48" of sea level rise	Daily high tide with 48" SLR; 10-year tide with 18" SLR;

¹ Shaken Awake! Estimates of Uninhabitable Dwelling Units and Peak Shelter Populations in Future Earthquakes Affecting the San Francisco Bay Region, ABAG, 1996

² USGS Open-File Reports 00-444 and 2006-1037

³ The Real Dirt on Liquefaction, A Guide to the Liquefaction Hazard in Future Earthquakes Affecting the San Francisco Bay Area, ABAG, 2001

⁴ NOAA Sea Level Rise and Coastal Flooding Impacts Viewer, <http://csc.noaa.gov/digitalcoast/tools/slrviewer>

⁵ FEMA, 2009. Digital Flood Insurance Rate Maps (DFIRMS), <http://msc.fema.gov/portal>

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	100-year tide with 6" SLR
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* Future sea level rise in inches above MHHW (NAVD88)

Housing Vulnerability

Regional housing vulnerability was determined based on the eight (8) potentially fragile building types (based on location, units, stories, and age) commonly found in the Bay Area. The presence of vulnerable housing was indicated if 30% or more of housing units in a block group are a fragile building type located in the applicable hazard zone.

Hazard	Fragile Building Type*
Ground Shaking MMI XIII or above	Single family cripple wall
	Single family house over garage
	Unreinforced masonry
	Multi-family cripple wall
	Multi-family weak story or open front
	Multi-family non-ductile concrete
Moderate Liquefaction Hazard	Insufficient foundation to withstand liquefaction, e.g., less than 10 floors
High Liquefaction Hazard	
Current 100-year flood zone	All housing types
Future flooding with sea level rise	

* Excluding mobile or manufactured homes, no available regional data sources

Community Vulnerability

Community vulnerability was determined using ten (10) indicators that were feasible and appropriate at the regional scale. Indicators were selected based on regionally relevant research and best professional judgment. Indicators were measured and scored using the approach developed by the Metropolitan Transportation Commission (MTC) to identify Communities of Concern (CoC). Individual block groups received 1 point for each indicator that was greater than an indicator-specific percentage or block group level defined by the MTC CoC. For example, block groups with greater than 10% of individuals over 75 years would receive a score of 1. For indicators that were not considered in the MTC CoC, the indicator-specific amount per block group was determined using the mean plus one standard deviation which was the approach used in the MTC CoC process. The total possible score each block group could receive ranged from 0 to 10.

Indicator	Measure	Percentage or amount per block group	Score
Housing cost burden	Severely burdened, spending > 50% of gross monthly income on housing	>15%	1
Transportation cost burden	Spending > 5% of gross monthly income on transportation	>15%	1
Home ownership	Housing tenure, rented (not owner occupied) housing	Mean + 1 standard deviation	1
Household income	Households with income <50% area median income (AMI)	>30%	1
Education	Persons without a high school diploma > 18 years old	Mean + 1 standard deviation	1

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Racial/Cultural Composition	Persons of color, e.g., non-white	>70%	1
Transit dependence	Households without a vehicle	>10%	1
Non-English speakers	Households where no one ≥ 15 years old speaks English well	>20%	1
Age - Young children	Persons ≤ 5 years old	Mean + 1 standard deviation	1
Age – Elderly	Persons ≥ 75 years old	>10%	1
Total Possible Score			10

Part II. Combining Indicators

There are different ways to combine hazards, housing, and community vulnerability to inform a regional understanding of the ability to prepared for, respond to, and recover from earthquakes and flooding due to sea level rise and storm events. Below are the combinations of hazard, housing and community vulnerabilities assessed at the regional scale and what we anticipate they will show.

Indicator	Indicator	Combination	Description
Hazard(s)			Areas potentially exposed to ground shaking, liquefaction, current and future flooding
Hazard(s)	+ Community Vulnerability	= Communities At Risk	Communities potentially exposed to hazards that are less able to prepare, respond and recover
Hazard(s)	+ Vulnerable Housing	= Fragile Housing	Housing that will likely be damaged if exposed to a hazard
Community At Risk	+ Fragile Housing	= Communities At Risk in Fragile Housing	Communities that are less able to prepare, respond and recover that are potentially living in fragile housing