APPENDIX E
Assessing Vulnerability: An Analysis of Land Use Development Trends and Hazards

This appendix analyzes the current land use patterns in the Bay Area, especially as they relate to the hazard areas as established in this multi-jurisdictional Local Hazard Mitigation Plan. In addition, this section discusses projected development trends in the Bay Area, including the type and location of projected future development, so Bay Area local governments can determine the general vulnerability of current and planned development to natural hazards. For purposes of this analysis, the Bay Area includes the counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma.

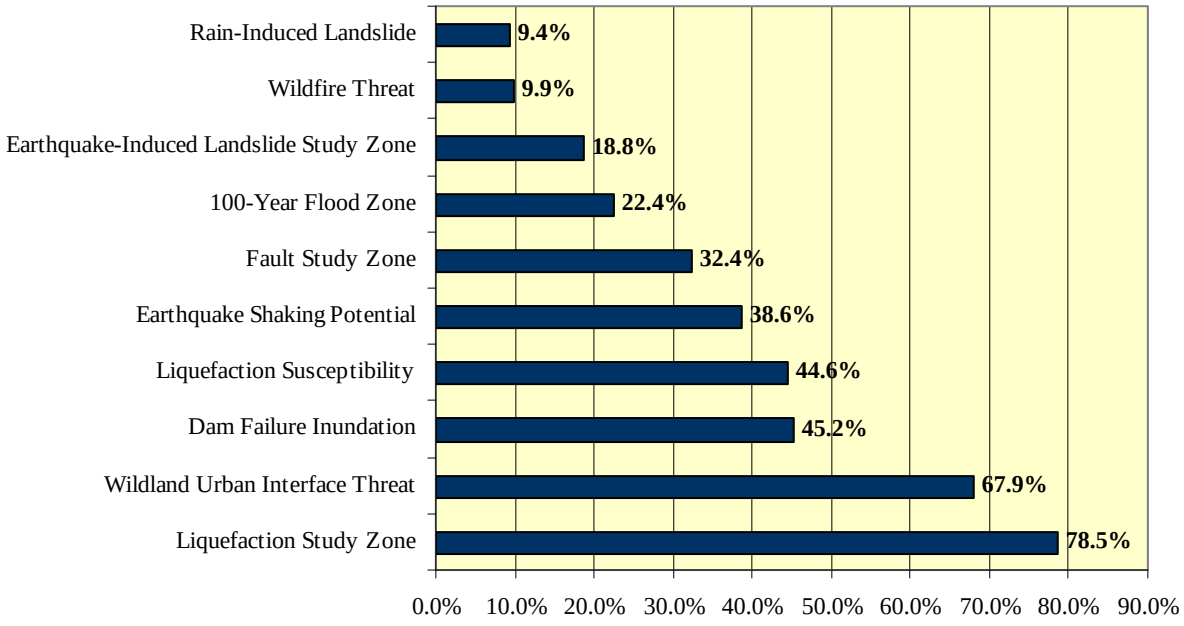
Conclusions and Findings

The San Francisco Bay Area supports a very diverse set of land uses, with the nature of the land use in each county varying considerably from the next. Every county supports some urban population, and almost every county (except San Francisco) has large rural areas, supported by agriculture or ranching. The urban land use patterns also vary considerably among counties, based largely upon the era in which the cities and towns developed, with older areas generally supporting higher urban densities and a larger population.

The region is subject to a number of natural hazards posing a range of risks, and nearly every acre of every land use type is subject to some form of hazard. Based upon acreage alone, the most significant threats in the region are earthquake shaking, wildfires, and to a lesser extent, liquefaction and rainfall-induced landslides. In reality, the first two are the most significant hazards for they have the potential to cause the most damage and loss of life, as landslides and liquefaction are more likely to be localized. The nature of these hazards can vary by the nature of the land use type, as urbanization alters the natural landscape and can affect the potential likeliness of a hazard (usually lessening it by mitigating against the potential hazard). For example, the threat of a wildfire has a strong and complex relationship with urban density. As density intensifies, the risk of fire is increased due to introduced vegetation and structures adding fuel for a wildland fire. Wildfire threat is reduced once urban densities are reached due to the loss of vegetation is lost and changes in building construction.

This appendix focuses on urban land use patterns in high hazard areas because hazards pose a relatively large threat to life and property in an urban area due to the concentration of people and structures. The region has significant amounts of urbanization in high hazard areas. Urbanization has occurred in at least 20% of the total land in seven of the high hazard areas, and in at least 50% in two of the high hazard areas (see Figure 1 and Table 5). While urban development in high hazard areas is unavoidable in many circumstances, these numbers demonstrate that hazards information has not played a significant role in land use decisions. In fact, in several cases urbanization has occurred disproportionately in high hazard areas. For example, the northern part of Santa Clara County, which is highly urbanized, lies in a very large floodplain and is subject not only to flooding but to high liquefaction susceptibility as well. This area is home to San Jose and other cities, has the highest

FIGURE 1 – Percentage of High Hazard Area* that is Urbanized (2005)



*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

population and many of the jobs in the region, and is therefore a major economic backbone to the region and to the State.

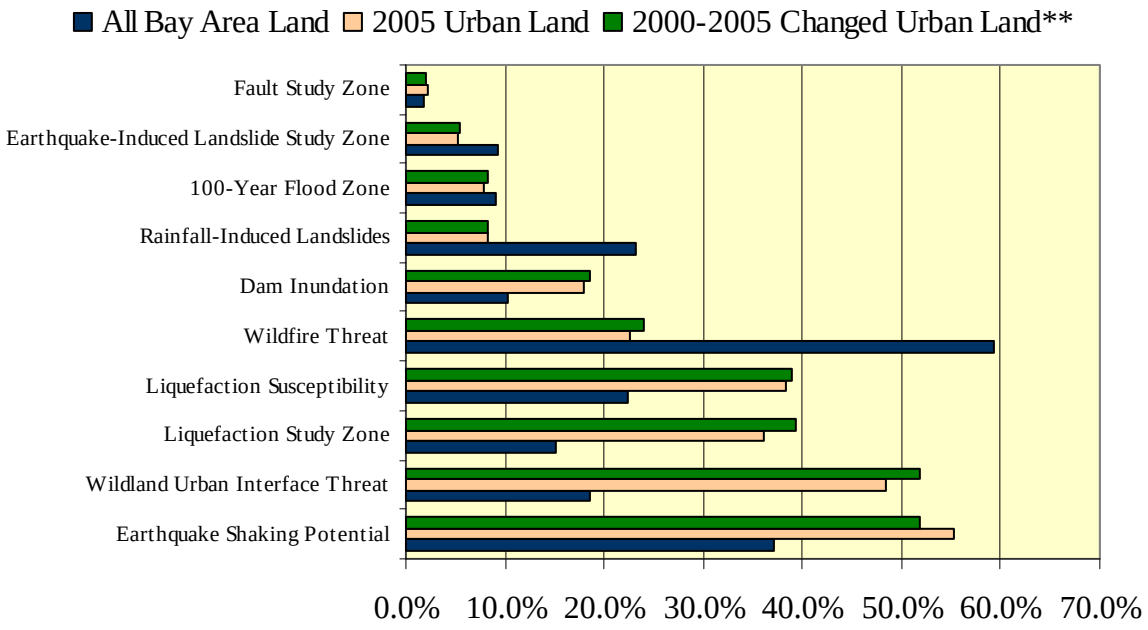
Land use change data for 2000-2005 indicate that hazard information continues to play a very minor role in land use decisions. In addition, land use controls typically remain an insignificant contributor to hazard mitigation efforts. Given the limitations of data, it is not possible to state definitively where development in hazard areas has increased, decreased, or remained the same. It is, however, certain that urbanization in hazard areas is continuing. This trend is a particular concern for those hazards where the percentage of 2000-2005 changed urban land use in the hazard area is greater than the percentage of 2005 urban land in the hazard area (as shown in figure 2). Figure 2 shows that urban development has occurred disproportionately in the high hazard areas for Wildfire (including Wildland-Urban-Interface Threat), Flooding, Liquefaction, and Dam Inundation.

It is important to mention that, while land use regulation has not played a major role in mitigating the effects of hazards, there has been a significant focus on strategies such as building and fire codes, public awareness campaigns, and other approaches to mitigating hazards as outlined in this Local Hazard Mitigation Plan. All of these can significantly reduce the potential effects of any hazard, and occasionally lessen the severity of a disaster. Yet there is no single mitigation strategy that is as foolproof as controlling land use in hazard areas. Simply not developing or limiting development to a certain type within hazard areas reduces the potential effects of a hazard dramatically and possibly eliminates any potential losses. While this is a very strong argument for hazard information to play a much larger role in land use decisions (and land use regulation to play a much larger role in hazard mitigation efforts), this change is unlikely to occur due to the inertia of planning and development decision-making.

While it is impossible to know the extent and location of all new urban development, the trends suggest that there will be increased infill development in urban cores combined with continued development of outlying areas, possibly using a more transit-oriented and mixed-use approach. To the extent that redevelopment increases, this densification will lead to a slower increase in exposure to wildfires and landslides because these are more likely to occur in lower-density areas. In addition, due to lower per capita water use in multifamily areas, this densification will also lead to a slower increase in exposure to drought and water supply shortages. On the other hand, higher densities in existing urban areas will accelerate the exposure to liquefaction, flooding, and earthquake shaking.

There is little indication that hazard information will play any more or less of a role in land use decisions than it currently does today. The ***Seismic Hazards Mapping Act*** of 1990 may provide increased incorporation of liquefaction and earthquake-induced landslide concerns into development decisions as new mapping occurs. Perhaps the most encouraging fact is that there was increased concern among citizens and policy makers following Hurricane Katrina in 2005. How this increased concern will play into development decisions and regulations surrounding hazards has yet to be seen.

FIGURE 2 – Percentage of Land Use in High Hazard Areas* (2000-2005)



* Source: ABAG 2006. See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations.
** Changed Urban Land 2000-2005 includes both new development as well as redevelopment. Source: ABAG 2006.

Information Sources, Definitions, and Hazard Analysis Limitations

One of the core programs of ABAG is to examine past development trends and current development patterns, and to use this information to project future growth patterns in terms of jobs, population, and household growth. Thus, this appendix is based on a variety of ABAG publications, as well as data available internally concerning current land use patterns in designated hazard areas. In addition, outside references have been used to discuss drought concerns. See the reference section at the end of this appendix for a full list of these sources.

High Hazard Areas

High hazard areas are discussed in more detail in the "Land Use Densities in Hazard Areas" section. ***Note that this appendix analyzes only land uses in the high hazard areas, and makes no comment upon the probability of a hazard occurring in a given high hazard area***. The probability of a high hazard area resulting in a disaster varies by hazard. See Appendix C for more information on these probabilities.

- **Fault Rupture Hazard** – There is no map of all active faults in the region that accurately describes their locations. As a substitute, this appendix uses the Alquist-Priolo Fault Rupture Study Zones to determine the threat of fault rupture. High hazard areas for this hazard therefore consist of all acres in this Study Zone. These Zones are much wider than the actual fault traces, and therefore the number of acres in the high hazard areas is overestimated. These maps have not changed for the nine-county Bay Area since the 2005 MJ_LHMP was adopted.
- **Earthquake Shaking Potential** – Earthquake shaking hazard is divided into five categories of increasing shaking potential on the composite USGS Shaking Map (as described in LHMP Appendix C). The two categories of highest potential shaking were used to define the high hazard areas. This map has also not changed since the 2005 MJ-LHMP was adopted.
- **Liquefaction Susceptibility –** Liquefaction is divided into five categories of increasing liquefaction susceptibility on USGS Liquefaction Susceptibility map. This analysis uses the Knudsen and others (2000) version of a map that has been updated after 2005. ***The decision has been made to use the 2000 version of this map because this is the hazard mapping that would have been available for local government use in making land use decisions between 2000 and 2005.*** The three categories of highest liquefaction susceptibility were used to define the high hazard areas. In addition, the California Geological Survey (CGS) has mapped San Francisco and portions of Alameda and Santa Clara counties. The USGS compilation is used for this analysis because it covers the entire Bay Area.
- **Earthquake-Induced Landslides** – These maps were mandated under the ***Seismic Hazards Mapping Act*** of 1990. CGS has completed mapping for a portion of the Bay Area. ***Again, the decision has been made to use the mapping available in 2004 because this is the hazard mapping that would have been available for local government use in making these past land use decisions.*** For these hazard areas, the regional total will consist only of these counties. The hazard area is defined as those areas that are within the study zones (and are therefore subject to the hazard).
- **Tsunamis –** These maps are currently being revised by the CalEMA. CalEMA has stated that the maps are to be used only for evacuation planning, not for this type of analysis. ***Thus, no analysis of hazard mapping impacts on land use has been conducted.*** This omission does ***not*** mean that tsunamis are not a hazard in the region.

- **Flooding –** Areas within the 100-year flood zone (including due to wave action) are in the high hazard area based on FEMA Q3 map. These maps are currently being updated by FEMA to create DFIRM maps that are being used to determine hazard exposure. ***Again, however, the decision has been made to use the Q3 mapping previously available because this is the hazard mapping that would have been available for local government use in making these past land use decisions.***
- **Rainfall-Induced Landslides –** Areas designated "mostly a landslide area" on the USGS Existing Landslide Map are considered to be in the high hazard area for rainfall-induced landslides. These maps have not changed since the 2005 MJ-LHMP was adopted.
- **Wildfire Threat** – Wildfire threat is divided into five categories of increasing wildfire threat as described on the CalFIRE Wildfire Threat Maps. The three categories of highest wildfire threat were used to define the high hazard areas. These areas typically occur further from urban areas that wildland urban interface (WUI) threat areas described below. While there is some overlap in the WUI threat and wildfire threat areas, wildfire is defined on the CalFIRE maps as occurring in non-urban areas outside of city fire department jurisdictions. CalFIRE has completed an update of this mapping since 2005. ***While the new maps are being used for hazard exposure assessment, the decision has been made to use the older mapping because this is the hazard mapping that would have been available for local government use in making these past land use decisions.***
- **Wildland-Urban-Interface Threat** – The high hazard areas are defined as any area within the WUI Threat Zone as described in the WUI Threat maps created by CalFIRE. These hazard areas generally occur on the edge of urban areas. These maps were recently found to somewhat overestimate the amount of land in the threat area. Specifically, land that was urban and bordering the bay was included in the threat region when it should not have been, meaning that the amount of certain land types in this region (medium and high density residential, mixed use lands, all types of employment land uses) is likely to be somewhat high. ***While the new maps are being used for hazard exposure assessment, the decision has been made to use the older mapping because this is the hazard mapping that would have been available for local government use in making these past land use decisions.***
- **Drought –** While drought is a concern for the region, it is not a hazard that can be mapped in the traditional sense. There are no high hazard areas for this hazard, then. This appendix does, however, provide a discussion of the uses of water and potential effects of a drought for varying land uses (see section "Land Use Densities in Hazard Areas").
- **Dam Inundation Maps –** Any area subject to inundation from at least one dam is located in the high hazard area for Dam Inundation. These maps were created under the assumption that a dam would simply disappear, and therefore represent a worst case scenario. In addition, these maps are nearly 40 years old and do not reflect current land conditions that would direct the floodwaters.

Urban Land Use

Urban land use refers to all non-agricultural land uses that involve some development. This includes residential, commercial, infrastructure, industrial, public/institutional, military, and urban open space (including city parks, golf courses, cemeteries and other uses).

Land Use Densities

One section of this of the appendix discusses "land use densities" in hazard areas. These discussions refer to the following land use categories. Data were available to divided residential land uses into a number of categories that directly reflect the density of development. These categories are:

- **Rural Residential (less than 1 unit/acre)** – This development can be characterized by the residential portions of ranches and farms, as well as ranchettes and other large properties.
- **Low-Density Residential (between 1 and 3 units/acre)** – This development is typical of new outer suburbs, as well as more affluent suburbs within older urban areas, where houses and lots tend to be fairly large.
- **Medium-Density Residential (between 3 and 8 units/acre)** – This development is typical of older suburbs and some outer suburbs.
- **High-Density Residential (above 8 units/acre)** – This use encompasses a wide range of development types, including very high-density urban cores, inner suburbs, apartment buildings and condominiums.
- **Mobile Home Parks**
- **Mixed-Use Residential/Commercial Development** – This use includes parcels where retail stores or offices are on the ground floor with residential units above, as well as isolated areas with commercial and residential uses on separate buildings on a single parcel.

Due to a lack of available information, it was not practical to divide employment areas into "employment densities." In addition, it seemed more reflective of the on-the-ground development to discuss the nature of employment development in terms of the land use as opposed to the density of employment. The employment land has therefore been divided into these categories:

- **Commercial Services** – This use includes retail, office, research, hotel, and intensive outdoor areas (such as amusement parks, tennis and swim clubs, and golf clubhouses).
- **Industrial –** This use includes heavy and light industrial, food processing (such as canneries and wineries), scrap metal recycling, and warehousing.
- **Infrastructure** – This use includes airports, marinas, ports, and utility lands and structures for communications, electricity, water supply, and wastewater. It also includes rail lines, park and ride lots, and other public transit associated areas. Roads and highways were excluded due to the large number of acres, which detracted from the quality of meaningful analysis of the other land use types.
- **Public/Institutional** – This use includes government centers, police and fire stations, hospitals, schools and universities, community centers, museums and libraries, religious institutions, jails and professional sports stadiums.
- **Mixed-Use Residential/Commercial Development** – See the definition above. This category is analyzed twice due to the presence of both residential and commercial services. Analyses of all urban land, however, do not double-count this land use type.
- **Mixed-Use Industrial/Commercial Development** – This use includes any parcels where there is a roughly equal mix of industrial and commercial uses. On-site offices of industrial operations are included in the industrial category.

Changed Land Use

The 2005 update of the San Francisco Bay Area Existing Land Use Map allowed for an analysis of land that has changed uses in the last five years from previous uses. This "changed" land use includes new development on formerly undeveloped lands (including urban and agricultural development), as well as areas that have been redeveloped from one urban land use to another. The update also includes detailed information on 2005 Existing Land Use. No equivalent file detailed enough for the purposes of this analysis is available for 2000. Thus, this analysis cannot discuss urbanization rates in comparison to the year 2000. In addition, this appendix can only generalize urbanization rates in hazard areas by comparing 2005 land uses in hazard areas to 2000-2005 changed land uses in hazard areas (as is done in figure 2).

More Information

Tables of existing land use for 2000, 2005, and land use change by hazard, city, and county area available at http://quake.abag.ca.gov/mitigation/pickdbh2.html.

Overview of Land Use Patterns in the Bay Area

General Land Uses in the Region

The San Francisco Bay Area consists of approximately 4.4 million acres of land, of which 26.0% is urbanized, 21.4% is used for agriculture, and the remainder of which is undeveloped rangeland (27.8%), forest land (21.8%), or wetlands (2.4%). The major type of land use varies strongly by county, from completely urbanized San Francisco County to Napa County, which has only a few medium-sized towns and one small city. Figure 3 depicts existing land uses across the region, while Figure 4 shows general land uses by subregions. As can be seen from both Figures 3 and 4, the most rural counties are Napa, Sonoma, and Solano Counties, in which nearly half (41.4%) of the land is used for agriculture. Marin and San Mateo Counties are the next most rural, with a significant amount of built-out urban development along the Bay shore, and large rural and undeveloped areas closer to the coast. In addition, much of Marin County and some of San Mateo County's undeveloped areas are federal or state protected lands that will not experience any new development. Contra Costa, Alameda, and Santa Clara Counties all are highly urbanized along the Bay shore, with varying degrees of development further inland. All three of these counties are experiencing tremendous further urbanization as they have available lands (see the sections "Past Land Use Development Trends 1985-2005" and "Projected Land Use Development Trends 2005-2030"). San Francisco County is by far the most urbanized county in the region, with 97.7% of the land characterized as urban in 2005.

Urban Land Use Types in the Region

TABLE 1 – Percentage of All Urban Land in Each Category by County (2005)

	Residential	Employment Areas (excluding Roads and Highways)	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	Other Urban Land*
9-County Region	58.3%	21.3%	0.2%	0.4%	19.8%
Alameda County	49.7%	26.8%	0.1%	0.9%	22.5%
Contra Costa	54.6%	20.3%	0.0%	0.0%	25.1%
Marin County	72.1%	15.9%	0.0%	0.0%	12.0%
Napa County	65.7%	17.3%	0.1%	0.1%	16.8%
San Francisco County	42.9%	19.7%	4.6%	0.0%	32.8%
San Mateo County	65.2%	21.3%	0.2%	1.9%	11.4%
Santa Clara County	57.1%	26.3%	0.1%	0.3%	16.2%
Solano County	55.0%	19.4%	0.1%	0.0%	25.4%
Sonoma County	64.3%	16.7%	0.1%	0.0%	19.0%

* Other Urban Land is defined as Military Land, Urban Parks, Cemeteries, Vacant Land, and land use for extensive recreation, such as golf courses, campgrounds, and race tracks.

As shown in Table 1, residential development is the majority of urban development in the region, both across and within counties. Table 2 shows that rural residential development (less than 1 unit per acre) is the most common type of residential development in the most rural counties mentioned previously. In the three largely-urbanized counties of Alameda, Contra Costa, and Santa Clara, medium-density residential development (3-8 units per acre) is the most common form of residential development. This type of development is characterized by moderate to large single-family homes in suburban areas. Only San Francisco is characterized by high density development (over 8 units an acre) due to its highly urban nature. In addition, San Francisco is the only county in the region to have a significant amount of mixed use (residential/commercial) development. It is important to note that, while rural residential development takes up a large number of acres (37.9%), the number of housing units is approximately only 15-20% of all housing units in the region (based upon estimates from the ***2005 Existing Land Use Report*** [Perkins and others, 2006] and the ***2000 US Census***).

The most common form of employment land use across the region is industrial (including light and heavy industrial, warehousing, and food processing), followed very closely by commercial services (retail, office, research centers, hotels and motels) and public/institutional uses. By county, these three uses are typically the most widespread uses, with the most common use being industrial in five counties and commercial in the other four.

TABLE 2 – Percentage of Residential Land in Each Density Category by County (2005)

The most common density category in each county is highlighted.

	Rural Residential (<1 unit/acre)	Low Density (1-3 units/acre)	Medium Density (3-8 units/acre)	High Density Residential (>1 unit/acre)	Mobile Home Parks	Mixed Use Residential/ Commercial
9-County Region	37.9%	12.0%	33.5%	15.4%	1.0%	0.3%
Alameda County	9.6%	11.0%	51.9%	26.1%	1.1%	0.2%
Contra Costa	14.0%	20.1%	43.0%	22.2%	0.7%	0.0%
Marin County	37.2%	27.4%	26.0%	8.8%	0.6%	0.0%
Napa County	50.5%	12.7%	24.1%	8.6%	3.9%	0.2%
San Francisco County	0.0%	0.3%	4.2%	85.7%	0.0%	9.8%
San Mateo County	42.9%	13.6%	25.7%	16.8%	0.7%	0.3%
Santa Clara County	21.7%	11.4%	53.9%	12.4%	0.4%	0.1%
Solano County	53.3%	5.5%	36.3%	3.8%	0.9%	0.2%
Sonoma County	74.1%	6.6%	9.8%	8.1%	1.4%	0.1%

TABLE 3 – Percentage of Employment Land of Each Type Category by County (2005)

The most common land use category in each county is highlighted.

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial
9-County Region	30.4%	34.6%	9.8%	22.8%	0.9%	1.6%
Alameda County	28.6%	35.8%	11.9%	20.2%	0.4%	3.1%
Contra Costa	23.6%	40.8%	10.7%	25.0%	0.0%	0.0%
Marin County	78.2%	8.7%	6.6%	6.4%	0.0%	0.0%
Napa County	13.8%	56.3%	20.6%	7.8%	0.7%	0.8%
San Francisco County	35.3%	18.9%	0.9%	25.8%	19.0%	0.1%
San Mateo County	27.1%	17.4%	22.4%	24.3%	0.9%	8.0%
Santa Clara County	36.1%	28.9%	5.6%	28.0%	0.3%	1.0%
Solano County	28.5%	35.8%	9.5%	25.6%	0.5%	0.0%
Sonoma County	25.3%	48.5%	6.0%	19.8%	0.5%	0.0%

Urban Land Use Development Patterns in the Region

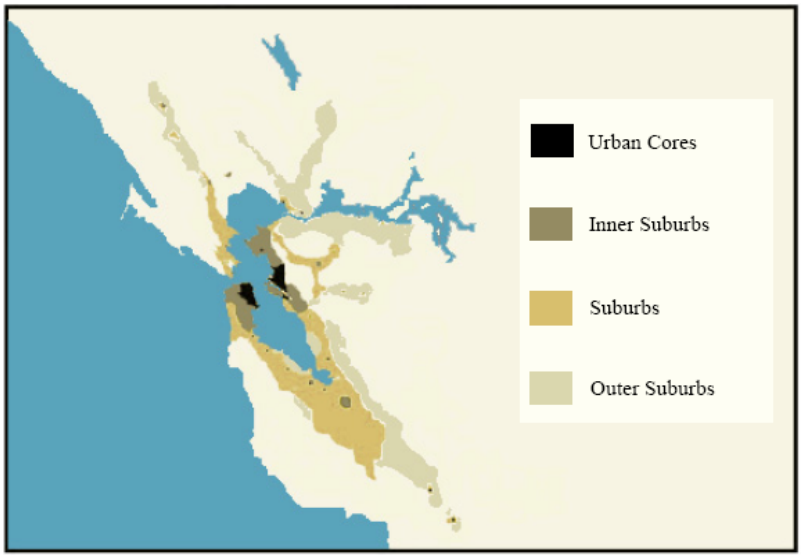
The urban Bay Area has been broadly classified according to the time period of development into:

- **Inner Cities** or **Urban Cores** (areas largely built out by 1900);
- **Inner Suburbs** (areas which developed between 1900 and 1940);
- **Suburbs** (areas which developed between 1940 and 1980); and
- **Outer Suburbs** (areas which developed after 1980).

This classification is based upon ***Geography and Urban Evolution of the San Francisco Bay Area*** (Vance, 1964), which discusses the process of growth and change in the Bay Area, and interpretations of the urban growth that has occurred since 1964.

Figure 5 depicts these different zones in broad terms. It should be noted that within the suburb and outer suburb zones, there may or may not be small urban pockets that were developed before World War II; however, because of the broadness of this diagram, they are not shown.

FIGURE 5 – Spatial-Temporal Development Diagram of the San Francisco Bay Area



Inner Cities and Urban Cores

The Bay Area's inner cities constitute the historic core of the region and include the urban centers of Oakland and San Francisco. These cities, typically built out by 1900, are characterized by streets arranged in grids. These areas also generally have the largest populations in the Bay Area (with the exception of San Jose), and contain medium to high-density residential and high density employment centers in the city centers. Nearly all of San Francisco's residential land, for example, occurs at a density of greater than eight units per acre. These areas are also often characterized by a large amount of mixed-use development when compared to more recently developed areas.

Inner Suburbs

The Bay Area's inner suburbs include those suburbs that developed after the turn of the century and before World War II. These areas typically developed around the streetcar and railroad systems, which were the main transportation networks for the Bay Area during this time period. Included within these zones are the residential areas surrounding the inner city as well as those communities that developed as the railroad system expanded beyond core areas during the teens and twenties. Generally, the urban form of these areas continues to follow a grid pattern. Typically they consist of residential areas with commercial development along arterial streets. Areas characterized by inner suburbs include the region just south of San Francisco, as well as parts of the East Bay north of Oakland such as the cities of Richmond, Berkeley, and Alameda, as well as parts of San Jose.

Suburbs

This classification refers to the large portions of the Bay Area that developed after World War II and before 1980. Referred to by Vance (1964) as "non-centric industrial and housing areas", most of the urban Bay Area falls within these areas. According to the 2000 Census, 76% of the Bay Area housing stock has been built since 1950, with 68% of those homes built between 1950 and 1980 (52% of all homes that were built after 1950). While suburbs include large and varied portions of the Bay Area, these areas developed around a newly expanding automobile transportation system. These areas are characterized by the prevalence of wide commercial arterials connecting pockets of single-family dwellings. Areas that fall into this category include the majority of the South Bay and Peninsula, as well as areas in the East Bay south of Oakland, along the I-680 corridor, and much of eastern Marin County.

Outer Suburbs

Outer suburbs are those areas with new residential use that have been subdivided in the last 10 or 15 years. These are primarily located around some of the smaller old railroad communities in the outlying portions of the greater Bay Area. Typically these areas are characterized by residential development in the form of single-family dwelling subdivisions and large retail service developments with high square-footage ("big box") stores. These areas continue the pattern of development along highway corridors, including Interstate 80 in the North Bay, Highways 4 and 580 in the East Bay, and Highway 101 in the South and North Bay areas. Cities typical of this type of development include Dublin and Livermore in Alameda County, Petaluma in Sonoma County, and Antioch in Contra Costa County.

Past Land Use Development Trends (1985-2005)

Two major trends appear when analyzing land use changes in the Bay Area in recent years. The first trend is that of continued outward expansion of suburbs and the conversion of agricultural and grazing land into suburban developments. This is a typical pattern seen across the country, and, in the Bay Area, this has significant implications for the potential impacts of hazards. This is because this pattern of development is increasingly occurring in low-lying agricultural areas and areas exposed to high wildfire threat or liquefaction susceptibility. The second trend is that of the redevelopment of urbanized areas, especially in formerly industrial areas. This trend has become increasingly common in the past ten to fifteen years. These trends exist through all four

Spatial-Temporal Development Zones in the Bay Area and, as will be demonstrated, the predicted growth can be largely interpreted by these two development trends.

Figure 6 shows the areas in the region that have changed land use in the last five years. These areas are discussed in more detail below. It can be seen, however, that, with one significant exception, the major land use changes have been the development (or redevelopment) into residential and employment areas. The significant exception to this is in Sonoma and Napa counties, where large areas have been converted to vineyards and wineries.

Inner Cities and Urban Cores

Land use change within the urban core areas of the Bay Area during the last twenty years has consisted largely of the redevelopment of large industrial areas, former military areas, or small-scale individual lots of a variety of prior land uses.

Alameda County's urban cores recently experienced significant amounts of redevelopment of these large industrial areas. For example, areas such as Emeryville and West Oakland saw part of the former industrial area along or near the Bay shore converted to large-scale developments such as the Emery Bay outdoor mall (which is currently in the process of adding residential units). In addition, many "smart growth" high-density mixed-use developments have been built adjacent to public transit stations. Examples of these developments include the Mandela Gateway Hope VI project by the West Oakland BART Station and the Fruitvale Station by the Fruitvale BART Station in Oakland.

In San Francisco, the Rincon and Mission Bay Areas have also seen significant redevelopment in the past decade. In the Rincon District, formerly industrial areas have been redeveloped into commercial and residential towers, expanding San Francisco's downtown south. In the Mission Bay District, the extension of the University of California San Francisco campus, complete with supporting residential and commercial services, has revitalized another formerly industrial area.

Military land has also served as another major source of land for redevelopment, as many bases in the region have been closed and ceded from military control in the past 15 years. For example, construction has just begun in parts of the former Hunter's Point Shipyard in San Francisco, which unofficially closed in the mid 1970's but has since been mired in costly cleanup of pollutants, being designated a Superfund site in the 1980's. Also, the Presidio in San Francisco was transferred from the military to the National Park Service in the mid 1990's and has since both been used as parkland and as office and retail space for a variety of industries. The latest development on the Presidio, the Letterman Digital Arts Center, is a 23-acre redevelopment of the former Letterman Medical Center which now houses Lucasfilm's operations. In addition, the Oakland Army Base was transferred from the military to the Oakland Redevelopment Agency in the early 2000s and is currently under redevelopment planning.

With these types of exceptions, land use changes tended to be limited to specific lots and specific buildings.

Inner Suburbs

The inner suburb areas have experienced very modest changes in the past twenty years, maintaining essentially the same form and land uses that were originally established in these

areas. Some changes have occurred, however, and these areas are experiencing some redevelopment where land is available. For example, the Richmond Marina saw new residential and commercial-service development in the last twenty years.

Like the urban cores, the inner suburbs have recently had land freed up from military base closures. Specifically, the Alameda Naval Air Station in Alameda County and Treasure Island in San Francisco County are currently in the planning processes for redevelopment. Currently the Final Alameda Point Reuse Plan has been approved, and calls for the redevelopment of the 700 acres base into a variety of uses. These uses include significant mixed-use development in a walkable civic center, various densities of residential development, urban parks and open space, protected wetlands, a golf course, and a sports complex. Preliminary Treasure Island redevelopment proposals suggest a similar redevelopment pattern, with the possibility of agriculture on the island as well.

Suburbs

Although these areas experienced changes in land use during the 1985-2005 period in the form of infill development, the scale of these infill projects tends to be large and focused around wide commercial arterials. The construction of apartments and condominiums as well as the infill of large-scale service, retail and office developments has been fairly typical of the development in many suburbs. Overall, the suburban areas of the region experienced the greatest diversity in land use change of any of the four Development Zones.

Regions of the Bay Area, such as the I-880 Corridor in San Jose, I-680 corridor in Alameda and Contra Costa counties and the Highway 85 corridor in Santa Clara County, have continued to experience modest but diverse land use changes. In both these instances, development occurred in the form of residential development, as well as growth of commercial and light industrial uses. For example, during the past twenty years, Blackhawk in Contra Costa County grew from a few hundred residential units to thousands of residential units. Modest growth resulting in land use changes also occurred in some areas along San Pablo Bay in the North Bay. In the Highway 85 corridor, some land that was classified as "Marsh" or "Sparsely Vegetated" now is utilized mostly by "Light Industry." A notable exception is an area east of Fremont that was once used as golf course. It is now one of the few areas surrounding the bay which is, for the most part, being allowed to revert to "Marsh."

Outer Suburbs

The expansion of the outer suburbs was the major type of land use change in the region from 1985-2005. This type of development generally turned non-urban land uses, such as rangeland, forestland, and agricultural land, into the low-density pattern of land use mentioned previously. This development has occurred mainly in four counties: Alameda (Livermore, Pleasanton, Dublin), Santa Clara (Morgan Hill, Gilroy, San Jose), Contra Costa (Antioch, Brentwood, Oakley, Pittsburg), and Solano (Fairfield, Vacaville, Rio Vista). These counties are similar in that they all have significant amounts of undeveloped land which have provided room for this type of low-density development to occur.

A significant exception to this type of development occurred in Sonoma and Napa counties, which, due to the success and growth of the wine industry, have taken large steps to promote new winery and vineyard development. Strict urban growth policies restricting growth outside

of city boundaries and promoting wine industry expansion and development have resulted in the development of thousands of acres of new vineyards in the last five years.

Land Use in Hazard Areas (2005)

General Land Uses in Hazard Areas

The first step in making an analysis of land use in hazard areas is to establish the base case for all other statistics to be compared against. For the purposes of this appendix, the base case is to analyze how much land in each county is in the high hazard area for a particular hazard. This analysis uses the newly completed 2005 existing land use information to more accurately reflect current development in hazard areas.

Table 4 gives the percentage of all land in each high hazard area by county and across the entire region. According to these percentages, the hazards that are most prevalent are wildfire threat (59.3%) and earthquake shaking (37.1%), followed by rainfall-induced landslides (23.1%) and liquefaction susceptibility (22.3%). By comparing individual counties to the region as a whole, one can begin to determine which threats are most significant to a particular county. For example, 79.5% of Marin County's land is in a high wildfire threat area, far above the region's total of 59.3%. Similarly, San Francisco and San Mateo counties are particularly susceptible to earthquake shaking, with 78.3% and 83.4% of the land in the high hazard area respectively.

The first analysis that can be undertaken is to better understand the nature of development in the high hazard areas. Specifically, it is important to understand how much of the high hazard land is urban, as this suggests the risk to people and property due to a given hazard. Table 5 shows the percentage of the high hazard land within counties and across the region that is urbanized.

This statistic can be used with Table 4 to understand the nature of the risk imposed by a hazard in a given county. For instance, although Sonoma and Napa County both have similar amounts of land in high liquefaction susceptibility areas, Sonoma County has developed upon 41.4% of these lands, while Napa County has developed only 15.9% of these lands. Liquefaction, therefore, is significantly more of a risk in Sonoma County than Napa County, despite similar amounts of land in the high hazard areas.

Table 5 by itself also demonstrates that there is a significant amount of development in nearly all high hazard areas. Across the region, over 20% of the high hazard area has been developed for seven of the ten hazards discussed in this appendix, and over 50% of the high hazard land has been developed for two of those hazards. Most importantly, the amount of urban land in the high hazard areas tends to reflect the degree of urbanization in the county, with percentages lowest in the rural counties and highest in the most urban counties. What this suggests is that, with some exceptions, urban development in the region probably traditionally occurred without a strong regard for hazard concerns. If the alternative were true (hazard concerns have strongly affected the pattern of urban development), then one would expect to see levels of urbanization in hazard areas less correlated with levels of urbanization and more reflective of land use policies restricting development in hazard areas.

This conclusion is complicated by the fact that land use controls occur at the local, not the county, level and that urbanization would be reflected in the data somewhat regardless of land use policies.

TABLE 4 – Percentage of All (Urban and Non Urban) Land in High Hazard Areas* by County (2005)

	Fault Study Zone	Earthquake Shaking Potential	Liquefaction Susceptibility	Liquefaction Study Zone*	Earthquake-Induced Landslide Study Zone*	100-Year Flood Zone	Rainfall-Induced Landslide Areas	Wildfire Threat	Wildland-Urban-Interface Threat Areas*	Dam Failure Inundation
9-County Region	1.8%	37.1%	22.3%	15.1%	9.2%	9.1%	23.1%	59.3%	18.5%	10.3%
Alameda County	3.2%	51.3%	27.7%	20.2%	6.9%	8.1%	26.8%	57.2%	19.6%	18.7%
Contra Costa County	1.1%	28.6%	29.1%	N/A	N/A	13.8%	21.7%	48.2%	33.6%	7.0%
Marin County	1.8%	56.8%	14.8%	N/A	N/A	6.3%	35.0%	79.5%	17.9%	1.8%
Napa County	0.3%	2.5%	10.1%	N/A	N/A	6.1%	18.6%	77.8%	10.5%	5.6%
San Francisco County	0.0%	78.3%	48.9%	20.2%	3.4%	0.0%	1.0%	2.3%	46.8%	5.9%
San Mateo County	3.7%	83.4%	17.2%	N/A	N/A	3.6%	23.0%	49.3%	24.7%	3.7%
Santa Clara County	2.6%	46.8%	20.9%	12.0%	10.6%	6.6%	29.7%	66.1%	16.0%	12.0%
Solano County	0.7%	13.2%	49.2%	N/A	N/A	30.4%	4.8%	18.9%	9.4%	25.7%
Sonoma County	1.8%	34.5%	12.8%	N/A	N/A	2.8%	24.9%	70.1%	19.2%	5.3%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

The conclusion remain intuitive, however, given that many cities have not adopted regulations regarding many of these hazards, as well as the fact that many of these areas were built previous to State of California regulations regarding development and hazards. The analysis of change in hazard areas will discuss if and how this has changed in recent years (see the section "Changes in Land Use Development in Hazard Areas 2000-2005").

Land Use "Densities" in Hazard Areas

It is important to note a few pieces of information before further examining land use in hazard areas. First, in analyzing the density of development occurring in a given hazard zone, it should not be surprising that the most common density is largely a function of the type of development that is common in the county of concern (see Tables 2 and 3). For example, since the majority of residential development in the Bay Area is either rural or medium density, one should expect to see these types of development occurring most frequently in hazard areas. This expectation is borne out in the available data, as demonstrated in Table 6.

TABLE 5 – Percentage of High Hazard Land* that is Urban by County (2005)

	Fault Study Zone	Earthquake Shaking Potential	Liquefaction Susceptibility	Liquefaction Study Zone*	Earthquake-Induced Landslide Study Zone*	100-Year Flood Zone	Rainfall-Induced Landslide Areas	Wildfire Threat	Wildland-Urban-Interface Threat Areas *	Dam Failure Inundation
9-County Region	32.4%	38.6%	44.6%	78.5%	18.8%	22.4%	9.4%	9.9%	67.9%	45.2%
Alameda County	52.3%	59.5%	68.8%	73.5%	34.7%	31.9%	7.5%	10.0%	83.8%	64.2%
Contra Costa County	68.5%	60.9%	44.1%	N/A	N/A	22.5%	20.2%	17.1%	77.2%	57.3%
Marin County	12.7%	12.1%	38.0%	N/A	N/A	31.3%	8.4%	6.5%	68.5%	43.2%
Napa County	28.7%	9.3%	15.9%	N/A	N/A	12.9%	2.4%	3.5%	31.2%	21.6%
San Francisco County	0.0%	98.8%	97.2%	97.5%	94.3%	0.0%	99.0%	87.4%	97.7%	99.7%
San Mateo County	44.1%	39.2%	68.8%	N/A	N/A	48.1%	13.3%	11.7%	78.8%	89.5%
Santa Clara County	19.9%	44.7%	72.3%	82.1%	11.9%	47.0%	4.1%	5.0%	70.3%	71.6%
Solano County	28.9%	9.3%	14.8%	N/A	N/A	9.0%	13.4%	19.0%	67.3%	12.6%
Sonoma County	20.6%	25.5%	41.4%	N/A	N/A	31.6%	12.5%	14.3%	54.5%	41.3%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Second, because of this trend above, one must be careful when making generalizations about the susceptibility of a type of development to a particular hazard based upon the type of development
in the hazard area. A good example of this concerns San Francisco County, in which the residential development is almost exclusively high density. Almost all land in any hazard zone in San Francisco is therefore high density, and this says nothing of the susceptibility of high density housing to a particular disaster. Some generalizations can be drawn from the data, however, concerning the susceptibility of a particular *residential* density to some of the hazards. For others, however, no obvious trends appear. The trends that can be drawn from the data in Table 7 are listed below:

- **Liquefaction Susceptibility** increases with increasing density, as higher density residential developments are more likely to be built either on landfill or in floodplains than rural homes.
- **Tsunamis Threat** can be assumed to be related only to the proximity to the shoreline, not to the type of development, despite the lack of data to directly demonstrate this fact.
- **Rainfall-Induced Landslide Areas** decrease with increasing density, as more developed areas will have more measures in place to prevent landslides than rural areas, as well as more impervious surfaces and storm sewers.

- **Wildfire (including Wildland Urban Interface) Threat** - As density intensifies, the risk of fire is increased due to introduced vegetation and structures adding fuel for a wildland fire. Wildfire threat is reduced once urban densities are reached due to the loss of vegetation and changes in building construction.
- **Mobile Home Park Land** tends to be more subject to flooding, liquefaction and dam failure inundation than other densities, likely due to the fact that mobile park homes are often situated in areas where permanent development is unsafe or undesirable.

Finally, two types of tables have been prepared for each major category of use (residential density and employment use). The first table is intended to answer the question "How much of this hazard area is a particular density or use?" It therefore gives percentages that relate to the total land in that particular hazard area. The second table answers the question "How much of a particular density or use is in the hazard area?" The percentages therefore relate to the amount of land in that particular density or use category.

TABLE 6 – Percentage of All Residential Land in High Hazard Areas* by Density (2005)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the residential development in this high hazard area is this density."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Residential Development
Fault Study Zone	40.2%	12.9%	33.0%	12.8%	0.9%	0.2%	100.0%
Earthquake Shaking Potential	27.3%	12.7%	37.7%	20.9%	1.0%	0.4%	100.0%
Liquefaction Susceptibility	19.5%	9.9%	46.2%	22.3%	1.6%	0.5%	100.0%
Liquefaction Study Zone*	5.3%	3.7%	58.2%	30.4%	1.8%	0.5%	100.0%
Earthquake-Induced Landslide Study Zone*	10.1%	10.1%	67.6%	11.6%	0.1%	0.4%	100.0%
100-Year Flood Zone	32.0%	11.5%	39.6%	14.0%	2.6%	0.3%	100.0%
Rainfall-Induced Landslide Areas	63.6%	13.5%	14.4%	8.2%	0.3%	0.0%	100.0%
Wildfire Threat	73.0%	9.4%	10.2%	6.9%	0.4%	0.0%	100.0%
Wildland-Urban-Interface Threat Areas*	37.8%	15.5%	32.0%	13.5%	0.9%	0.3%	100.0%
Dam Failure Inundation	21.3%	8.2%	47.1%	21.8%	1.3%	0.3%	100.0%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Fault Study Zones

Fault rupture represents a minor hazard across the region, with only 1.8% of all the land in the region in the Fault Study Zones (which, as stated previously, is an overestimate of the actual land in danger of surface ruptures). Areas subject to surface rupture are strictly regulated by the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (see the section "Projections of Future Land Uses in Hazard Areas"), which means that no residential structures and essentially no other structures can be built astride active faults subject to surface rupture. It should therefore be expected that there has been no new development or redevelopment on the faults themselves, and very little change in the Fault Study Zones.

TABLE 7 – Percentage of Each Residential Density in High Hazard Areas* by Hazard (2005)

The density with the largest percentage of land in the high hazard area is highlighted.
This table should be read as "Across the region, x% of the residential development of this density is in the high hazard area for this hazard."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Densities
Fault Study Zone	2.4%	2.4%	2.2%	1.9%	2.1%	1.7%	2.3%
Earthquake Shaking Potential	37.9%	55.5%	59.3%	71.2%	53.0%	72.0%	52.5%
Liquefaction Susceptibility	16.3%	26.2%	43.8%	45.8%	51.5%	46.4%	31.7%
Liquefaction Study Zone *	9.3%	9.5%	31.8%	38.3%	73.1%	20.7%	27.5%
Earthquake-Induced Landslide Study Zone *	2.8%	4.1%	5.8%	2.3%	0.5%	2.7%	4.3%
100-Year Flood Zone	3.7%	4.2%	5.2%	4.0%	11.8%	4.3%	4.4%
Rainfall-Induced Landslide Areas	16.6%	11.2%	4.2%	5.2%	2.9%	0.4%	9.9%
Wildfire Threat	47.9%	19.5%	7.6%	11.1%	10.8%	2.8%	24.8%
Wildland-Urban-Interface Threat Areas *	58.2%	75.6%	55.6%	51.1%	52.2%	50.1%	58.2%
Dam Failure Inundation	7.8%	9.4%	19.5%	19.6%	19.1%	11.4%	13.8%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Existing Land Use (2005)

- Among existing residential densities, rural residential is the most prevalent in the Fault Study Zones, representing 40.2% of all the residential land in the Study Zones.
- Overall, 2.3% of residential land is present in the Fault Study Zones.
- Counties of note include San Mateo, in which 5.5% of all residential land is in the Study Zone, with 16.4% of all of the mobile home park land, and 9.4% of all rural residential in the county in Fault Study Zones. In addition, 12.8% of Alameda County's mixed-use development is in Fault Study Zones.
- No fault traces in San Francisco have been designated as active by the State Geologist meaning that no land is in these study zones in that county, despite its high shaking potential.
- In terms of existing employment land use types, the most prevalent use in the Fault Study Zones is industrial (32.7%), followed closely by commercial services (31.0%).
- Overall, 1.8% of the employment land is in the Study Zones, led by public/institutional land, 3.0c% of which is in the study zone.
- The only county of note is Napa County, in which 10.5% of the infrastructure is in the Fault Study Zones.

TABLE 8 – Percentage of All Employment Land in High Hazard Areas* by Type (2005)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the employment-oriented development in this high hazard area is this type."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Employment-Oriented Development
Fault Study Zone	18.8%	31.5%	10.9%	37.3%	0.8%	0.7%	100.0%
Earthquake Shaking Potential	31.0%	32.7%	10.1%	23.0%	1.0%	2.2%	100.0%
Liquefaction Susceptibility	33.4%	35.8%	10.7%	17.8%	0.6%	1.7%	100.0%
Liquefaction Study Zone*	29.9%	42.6%	11.6%	12.7%	0.5%	2.6%	100.0%
Earthquake-Induced Landslide Study Zone *	23.5%	18.2%	2.3%	54.8%	1.2%	0.0%	100.0%
100-Year Flood Zone	31.8%	44.4%	12.9%	8.0%	0.3%	2.7%	100.0%
Rainfall-Induced Landslide Areas	29.8%	39.7%	3.4%	25.7%	0.1%	1.2%	100.0%
Wildfire Threat	32.3%	20.1%	10.2%	35.8%	0.3%	1.4%	100.0%
Wildland-Urban-Interface Threat Areas *	31.1%	28.9%	7.3%	30.1%	1.2%	1.4%	100.0%
Dam Failure Inundation	33.7%	39.6%	6.7%	17.6%	0.4%	2.0%	100.0%

* See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Changed Land Use (2000-2005)

- 2.1% of changed residential and 1.0% of the changed employment land occurred in Fault Study Zones.

While it is uncertain where in the Study Zones these changes are taking place, it must be assumed that State law is being properly enforced and no new structures have been built in the past five years astride active faults. The percentage of new development in the Study Zones generally reflects this, with one exception. This is in San Mateo County, where 13.6% of new rural residential and 58.8% of new or redeveloped Mobile Home Park Land is in the Fault Study Zones! This discrepancy is probably accounted for by the fact that both of these things can occur without actual construction of a dwelling on an active fault, and that construction of a single home is also exempt from the act. Mobile home parks do not consist of permanent structures and, since the majority of a rural residential parcel is not built upon, there likely are no homes built on any active faults.

TABLE 9 -Percentage of Each Employment Type in High Hazard Areas* by Hazard (2005)

The land use with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the development of this type is in the high hazard area for this hazard."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Types
Fault Study Zone	1.1%	1.7%	2.0%	3.0%	1.7%	0.8%	1.8%
Earthquake Shaking Potential	65.1%	60.1%	65.7%	64.3%	72.0%	88.6%	63.7%
Liquefaction Susceptibility	59.5%	55.8%	58.9%	42.1%	35.8%	58.7%	54.0%
Liquefaction Study Zone*	49.1%	73.0%	77.1%	27.9%	20.7%	75.0%	53.8%
Earthquake-Induced Landslide Study Zone*	2.3%	1.9%	0.9%	7.2%	2.7%	0.1%	3.2%
100-Year Flood Zone	13.8%	16.9%	17.3%	4.6%	4.3%	22.1%	13.2%
Rainfall-Induced Landslide Areas	3.4%	4.0%	1.2%	3.9%	0.5%	2.6%	3.5%
Wildfire Threat	9.2%	5.0%	9.0%	13.6%	2.8%	7.4%	8.7%
Wildland-Urban-Interface Threat Areas*	35.1%	28.6%	25.4%	45.3%	50.1%	29.9%	34.3%
Dam Failure Inundation	28.3%	29.1%	17.4%	19.7%	11.4%	31.3%	25.5%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Earthquake Shaking Potential

The most significant hazard to the majority of residential land in the Bay Area is earthquakes and the damage that would result from shaking. The high hazard area is pervasive throughout almost all of the Bay Area, as there are a number of active faults in the region. The highest potential for shaking occurs near fault lines which run through or adjacent to most counties, but especially San Francisco, San Mateo, western Alameda, western Contra Costa, Sonoma, and western Marin counties. Shaking Potential is relatively low in Napa and Solano counties, as well as in eastern Contra Costa County. Across the region 37.1%, of the region's land is in a high hazard area for shaking potential, second only to wildfire threat. Shaking potential poses a much more significant threat than wildfires because it acts over a much larger area for any given event, and is much higher in highly urbanized areas than wildfire, representing a higher risk of life and property. This earthquake threat will be exacerbated by the added threat of earthquake-induced wildfires.

TABLE 10 – Percentage of All Residential Land in High Hazard Areas* by Density (2000-2005 Change)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped residential development in this high hazard area is this density."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Residential Development
Fault Study Zone	30.2%	16.5%	23.9%	22.8%	6.6%	0.1%	100.0%
Earthquake Shaking Potential	24.0%	13.8%	17.6%	41.6%	2.3%	0.6%	100.0%
Liquefaction Susceptibility	18.5%	10.0%	28.8%	39.7%	2.2%	0.7%	100.0%
Liquefaction Study Zone*	9.8%	8.0%	14.8%	62.2%	4.8%	0.4%	100.0%
Earthquake-Induced Landslide Study Zone*	47.5%	28.4%	16.2%	7.9%	0.0%	0.0%	100.0%
100-Year Flood Zone	26.5%	11.4%	21.7%	38.4%	1.8%	0.1%	100.0%
Rainfall-Induced Landslide Areas	37.2%	14.2%	10.5%	35.1%	3.0%	0.0%	100.0%
Wildfire Threat	29.9%	16.0%	24.0%	29.0%	0.8%	0.3%	100.0%
Wildland-Urban-Interface Threat Areas*	41.0%	11.4%	15.4%	29.9%	2.2%	0.0%	100.0%
Dam Failure Inundation	21.0%	9.6%	25.6%	40.1%	3.5%	0.2%	100.0%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Existing Land Use (2005)

- Of all residential densities, medium density residential is the most prevalent in the high hazard area for shaking potential (37.7%), a fact which reflects that this is the most common type of residential development in the more urbanized counties (mentioned above).
- 52.5% of all residential land in the region is in the high hazard area for shaking.
- High-density residential and mixed-use developments are most represented, with 71.2% and 72.0% of the land in those densities in the high hazard area respectively. Again, this is reflective of the fact that the high hazard area for shaking potential occurs largely in the older urbanized, higher density areas of the region such as Oakland, San Francisco, and San Mateo County.
- While the percentages are high across all densities (generally 20-50% in all counties except Napa), San Mateo County has a staggering 90.9% of its residential land in the high hazard area! This is followed by San Francisco and Alameda counties, with 80.1% and 79.9% of all residential land in the high hazard areas respectively.

TABLE 11 – Percentage of Each Residential Density in High Hazard Areas* by Hazard (2000-2005 Change)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped residential development of this density is in the high hazard area for this hazard."

	Rural Residential (<1 unit/acre or 1-5 acres/unit)	Low-Density Residential (1-3 units/acre)	Medium-Density Residential (3-8 units/acre)	High-Density Residential (>8 units/acre)	Mobile Home Park Land	Mixed Use Residential/ Commercial	All Densities
Fault Study Zone	2.3%	2.7%	2.1%	1.4%	8.2%	0.8%	2.1%
Earthquake Shaking Potential	38.4%	47.3%	33.2%	54.6%	60.8%	72.4%	44.3%
Liquefaction Susceptibility	19.9%	23.1%	36.4%	35.0%	38.3%	58.3%	29.7%
Liquefaction Study Zone*	11.3%	12.9%	17.6%	43.4%	36.1%	10.2%	25.5%
Earthquake-Induced Landslide Study Zone*	16.6%	13.9%	5.8%	1.7%	0.0%	0.0%	7.7%
100-Year Flood Zone	5.0%	4.6%	4.8%	5.9%	5.7%	1.6%	5.2%
Rainfall-Induced Landslide Areas	16.3%	13.3%	5.4%	12.6%	21.6%	0.0%	12.1%
Wildfire Threat	41.6%	24.9%	18.4%	24.9%	36.6%	0.0%	28.1%
Wildland-Urban-Interface Threat Areas*	69.5%	79.9%	65.5%	55.3%	30.8%	47.2%	64.4%
Dam Failure Inundation	9.8%	9.6%	14.1%	15.4%	27.3%	6.3%	12.9%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

TABLE 12 – Percentage of All Employment Land in High Hazard Areas* by Type (2000-2005 Change)

The density with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped employment-oriented development in this high hazard area is this type."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Types
Fault Study Zone	38.0%	39.3%	0.0%	22.2%	0.4%	0.0%	100.0%
Earthquake Shaking Potential	47.6%	43.1%	0.2%	8.0%	0.6%	0.4%	100.0%
Liquefaction Susceptibility	51.0%	40.0%	0.3%	7.8%	0.6%	0.4%	100.0%
Liquefaction Study Zone*	48.3%	47.7%	0.4%	2.9%	0.1%	0.6%	100.0%
Earthquake-Induced Landslide Study Zone*	80.2%	3.1%	0.0%	16.8%	0.0%	0.0%	100.0%
100-Year Flood Zone	50.1%	44.8%	0.3%	4.6%	0.1%	0.0%	100.0%
Rainfall-Induced Landslide Areas	30.0%	63.1%	0.0%	6.9%	0.0%	0.0%	100.0%
Wildfire Threat	35.3%	53.3%	0.0%	11.4%	0.0%	0.0%	100.0%
Wildland-Urban-Interface Threat Areas*	47.9%	37.8%	0.1%	13.3%	0.7%	0.3%	100.0%
Dam Failure Inundation	47.1%	47.3%	0.1%	5.3%	0.1%	0.0%	100.0%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

Changed Land Use (2005)

- 44.3% of all changed residential and 64.1% of all changed employment lands were in the high hazard area for shaking.
- Mixed-use (residential/commercial) development had the most change in the high hazard zone, at 72.4%.

Among counties, changed high-density residential had a particularly large percentage of development in the hazard areas, including 92.9% in Alameda, 88.2% in San Mateo, and 85.8% in Santa Clara counties.

Earthquake-Induced Landslide Study Zones

Similar to the Fault Study Zone situation, the areas of high hazard from earthquake-induced landslides are represented here by their presence in the CGS Landslide Study Zones. This again means that the number of acres at risk is overrepresented in this analysis, and serves only as a proxy for development in the actual high hazard areas. In addition, the Study Zone Mapping is still in progress and maps have been created for Alameda, San Francisco, and Santa Clara

TABLE 13 – Percentage of Each Commercial Type in High Hazard Areas* by Hazard (2000-2005 Change)

The land use with the largest percentage of land in the high hazard area is highlighted. This table should be read as "Across the region, x% of the new or redeveloped land of this type is in the high hazard area for this hazard."

	Commercial Services	Industrial	Infrastructure (Excluding Roads and Highways)	Public and Institutional	Mixed Use Residential/ Commercial	Mixed Use Industrial/ Commercial	All Types
Fault Study Zone	0.8%	0.9%	0.0%	2.2%	0.8%	0.0%	1.0%
Earthquake Shaking Potential	66.3%	64.6%	70.2%	51.6%	72.4%	66.0%	64.1%
Liquefaction Susceptibility	61.7%	52.1%	74.5%	43.5%	58.3%	53.2%	55.7%
Liquefaction Study Zone*	55.1%	68.8%	92.6%	21.4%	10.2%	71.4%	57.8%
Earthquake-Induced Landslide Study Zone*	1.8%	0.1%	0.0%	2.5%	0.0%	0.0%	1.1%
100-Year Flood Zone	14.6%	14.0%	23.4%	6.2%	1.6%	1.1%	13.4%
Rainfall-Induced Landslide Areas	2.2%	4.9%	0.0%	2.3%	0.0%	0.0%	3.3%
Wildfire Threat	8.9%	14.5%	0.0%	13.3%	0.0%	1.1%	11.6%
Wildland-Urban-Interface Threat Areas*	37.8%	32.1%	10.6%	48.5%	47.2%	25.5%	36.4%
Dam Failure Inundation	31.0%	33.6%	10.6%	16.2%	6.3%	3.2%	30.3%

*See Local Hazard Mitigation Plan Appendix E, Information Sources and Definitions for definitions of high hazard areas and data limitations. Source: ABAG 2006.

counties only. The numbers presented here only represent these parts of the region. It is therefore very difficult to draw any conclusion as to the potential seriousness of this hazard at the current time.

Existing Land Use (2005)

- In the available areas, 9.2% of all land is located within the Study Zones.
- Of all existing residential development in these areas, 4.3% is in the Study Zones, the majority of which (67.6%) is medium-density residential, reflecting the most common form of residential development in the available areas.
- Alameda County has the most residential land in the Study Zone at 6.9%.
- Of all available existing employment areas, only 3.2% is in the Study Zones, a disproportionate amount of which (54.8%) is public or institutional. This trend is especially true in Alameda County, where 93.6% of the land in the Study Zone is public or institutional.

Changed Land Use (2000-2005)

- Examining recent land use changes paints roughly the same picture.
- Across all three counties, 7.7% of the changed residential land and 1.1% of the changed employment areas are in the Study Zones.
- Residential percentages are comparably high, especially in Santa Clara County, where 10.7% of the change residential land is in the Study Zone.
- In San Francisco, no redeveloped land in the last five years was in the Study Zone.

Liquefaction Susceptibility

Liquefaction susceptibility is one of the more significant hazards in the region, for a number of reasons. First, the higher susceptibility categories represent 22.3% of the region's land. Second, there is a high degree of urbanization that has occurred in these areas (44.6%), especially in the areas along the Bay shore in nearly every county (but especially in San Francisco, Alameda, Contra Costa, and Santa Clara counties) in the region. Third, the liquefaction poses a threat to the infrastructure of pipes and roads that comes with urbanization (28.1% of the 2004 existing infrastructure miles is located in the high hazard area for liquefaction).

Additionally, the threat of liquefaction is important in the low-lying agricultural lands in the San Francisco Bay-Delta, which includes eastern Contra Costa and Solano Counties. These areas are protected by levees which are susceptible to breach due to liquefaction of the soils underneath the levees, with a significant potential to flood agricultural, and, increasingly, suburban land. These levee failures might also impact water supply by disrupting the water delivery system.

Existing Land Use (2005)

- Across the region, 31.7% of all residential land is in the high hazard area, with medium-density residential comprising the majority (46.2%) of the hazard area.
- High-density and rural residential are also highly present in the hazard area, reflecting the fact that the high hazard area lies largely in older areas along the bay and in the delta areas of Solano and Contra Costa Counties.
- Alameda (46.4%), San Francisco (42.2%), and Santa Clara counties (48.4%) have very high levels of residential land in the high hazard areas.
- In Santa Clara County, four of the six residential densities have over 50% of the land in the high hazard area.
- Among all employment areas, the numbers are generally higher than for residential, with 54.0% of all employment types in the high hazard area.
- Santa Clara County especially has a significant amount of land in the high hazard area (71.6%).
- Among employment land uses, industrial is generally the most prevalent in the high hazard areas, which reflects the large amount of industrial development along the Bay shore in most counties in the region.

Changed Land Use (2000-2005)

- Recent changes in land use show similar statistics, suggesting that development and redevelopment in liquefaction high hazard areas is continuing at roughly the same pace as it traditionally has occurred.

- Across residential densities, high density is most prevalent (39.7%) for all of the changed land in the hazard area, followed by medium density (28.8%).
- San Francisco has redeveloped the most residential land in the high hazard area (51.3%), followed again by Alameda and Santa Clara Counties.
- Again, the numbers were generally higher for employment areas than for residential areas, with 55.7% of the changed employment areas in the high hazard area.
- Commercial services and industrial were the most prevalent changed employment areas in the high hazard area, representing 51.0% and 40.0% of this land in the high hazard area.
- Marin, San Francisco, and Santa Clara counties have the highest percentages of changed employment land, with more than 70% of this in the high hazard area for each county.

100-Year Flood Zones

Areas susceptible to flooding are geographically similar to the areas that are susceptible to liquefaction, so there is a significant overlap in development in these two hazard areas. Specifically, approximately half of the land that is in the high hazard area for liquefaction is in the 100-year flood zone ("flood zone"). The areas most subject to flooding in the region are along the southern part of San Francisco Bay (southwestern Alameda County, northern Santa Clara County), the northern parts of San Pablo and Suisun Bay (southern Napa and Solano Counties), and the delta region (northeastern Contra Costa and eastern Solano Counties).

Existing Land Use (2005)

- Across existing residential densities, 4.4% of the land is in the 100-year flood zone, with medium-density residential (39.6%) and rural residential (32.0%) making up the bulk of the residential in the flood zone.
- A disproportionate amount of the mobile home park land (11.8%) is located in the flood zone, likely for reasons mentioned previously (this is true across nearly every county as well).
- By county, the amount of residential development in the 100-year flood zone varies from 0% (San Francisco) to approximately 7% (Napa, Santa Clara, and Solano counties).
- Mixed-use development (residential/commercial) is also slightly disproportionately located in 100-year flood zone, especially in Santa Clara County, where 32.0% of the county's mixed use development is located in the flood zone.
- Similar to the liquefaction susceptibility areas, employment land use types generally have higher percentages of land in the flood zone than do residential densities, with 13.4% of all types in the flood zone.
- Among the counties, industrial generally has the highest percentage of land in the Flood Zone. Commercial and infrastructure have slightly less land in the flood zone, and, in some cases, have more land in the flood zone than industrial.
- Marin County has the most employment development in the flood zone (29.7%) of all counties, with 74.1% of that development being commercial services.

Changed Land Use (2000-2005)

- The changed land use numbers suggest that development in the 100-year flood zone has certainly continued, and likely increased fairly significantly in the last five years.

- The amount of changed residential land in the flood zone is 5.2%, which is higher than the existing 2005 statistic (which means that the 2000 statistic was actually much lower than 4.4%).
- Employment land uses as a whole have not particularly increased in the flood zone, though development has continued there, with 13.4% of the changed employment development in the flood zone.
- Marin, Contra Costa, and Santa Clara counties experienced the largest amount of changed residential land use in the flood zone at 7-8%.
- No one residential density had more changes in the flood zone across counties, with all densities except mixed use at roughly 5-6%.
- In terms of employment land, Marin County again had the highest amount of change in the flood zone at 59.7% of all changed employment land (although this was only 37 acres total).
- Across counties, commercial services (14.6%) and industrial (14.0%) were most developed in the flood zone. It must be noted that, while a higher percentage of changed infrastructure (23.4%) was in the flood zone, this amounted to only 11 changed acres (as opposed to roughly 1500 changed acres each for industrial and commercial services).

Rainfall-Induced Landslide Areas

While landslides are prevalent throughout the region (23.1% of the region is in a high hazard0 area for landslides), they pose a relatively small danger (when compared to earthquakes or liquefaction) for at least three reasons. First, they are highly localized in nature, and any one landslide is unlikely to cause damage to more than a few structures, unless there are very severe landslides caused by particularly heavy rains. Second, only a very small portion (9.4%) of the high hazard area for landslides has been urbanized as of 2005. Third, most of the urbanized areas in the high hazard area are rural, posing an overall small risk to homes and businesses. However, understanding land use in landslide areas is important because land use controls (such as prohibiting development on unstable soils or steep slopes) are the most effective and cheapest way to prevent loss of life and property due to landslides.

Existing Land Use (2005)

- Across the region, 9.9% of the residential development is in the high hazard area, of which 63.6% of the land is rural residential.
- With some exceptions the amount of land in the high hazard area generally decreases with increasing residential density, both across and within counties.
- The counties with the largest amount of residential land in the high hazard area are Marin (21.2%) and Sonoma (14.4%), followed by Contra Costa and San Mateo (with roughly 12% each).
- Employment land uses have lower percentages of land in the high hazard area than residential uses across all counties, with only 3.5% of all employment land in the high hazard area in the region.
- Across the region, industrial is most prevalent in the high hazard area (39.7% of high hazard land) followed by commercial services (39.8%) and public or institutional (25.7%).

Changed Land Use (2000-2005)

- Development is still occurring in areas subject to landslides across the region, as 12.1% of the changed residential land use and 3.3% of the changed employment land was in the high hazard area.

- Significantly more changed development in the high hazard area was residential than employment-oriented (4200 acres of changed residential versus 780 acres of changed employment land).
- Marin, Sonoma and Contra Costa had the most residential changed land in high hazard areas in the region, and Sonoma had the most changed employment land in the region.

Wildfire

In this appendix, threat due to fire is measured using two separate hazard maps, WUI threat and wildfire threat. The California Department of Forestry (CDF) separates has created these two maps based upon the nature of response to the fire; local jurisdictions respond to fires in WUI threat areas, while CDF responds to those in the wildfire threat areas. In addition, as noted in Appendix C, there is a difference in probability of a fire occurring in the different threat areas; fires are statistically more likely to occur in wildfire threat areas than WUI threat areas (based upon past acreage burned in each area).

This separation of fire hazards into two hazard areas is essentially artificial, and this separation affects the way the data show the relationship between fires and land uses. Specifically, wildfire threat clearly is highest in rural densities and lowers with increasing density, while WUI threat peaks at low densities and then decreases as vegetation is lost due to urbanization. Examining either one of these two maps by itself therefore gives a somewhat misleading picture of the true nature of fire as it relates to urban densities. As density intensifies, the risk of fire is increased due to introduced vegetation and structures adding fuel for a wildland fire. Wildfire threat is reduced once urban densities are reached due to the loss of vegetation is lost and changes in building construction.

Wildfire Threat

Of all hazards, the threat of wildfires is likely the most causally linked to the density of development in an area, with an inverse relationship existing between density and wildfire threat. This can be seen in the general county land uses, where the counties with the smallest amounts of urban land generally have the highest potential for wildfires. For example, in San Francisco County, the only lands subject to wildfire threat are in the large park areas such as Golden Gate Park and the Presidio, not in highly urbanized areas. It can also be seen in the existing residential densities, where the amount of land in the wildfire threat areas generally dramatically decreases between the two lower densities and the two higher densities. The causal link is fairly simple in that highly urbanized areas lack the fuel load in terms of vegetation (especially dry dead vegetation and tinder) when compared to rural areas. Wildfires therefore pose a significantly higher threat to the development in rural areas than to the development in urban areas.

Existing Land Use (2005)

- Across all counties, 24.8% of all residential land is in a high wildfire threat area, with rural residential comprising 73.0% of that area. Nearly half (47.9%) of the rural residential land in the region is in a high wildfire threat area.
- Rural Sonoma County (74.1% rural residential) alone comprises 46.3% of all of the residential acres in the region in the high wildfire threat area.

- Counties in which the majority of residential land is rural (San Mateo, Marin, Solano, Sonoma, Napa) have roughly 20%-50% of the residential land in high wildfire threat areas. The other counties (in which rural is not the most common form of residential development) have 0%-16% of the residential land in the threat areas.
- While the figures are smaller for existing employment lands, similar comparisons can be drawn across counties, as less urbanized counties have higher percentages of land in the high hazard areas.
- Among employment land types, commercial, industrial, and public or institutional lands tend to share the highest percentages in the wildfire threat areas, the top one varying by county.
- Overall, 8.7% of existing employment lands was in the high wildfire threat areas.

Changed Land Use (2000-2005)

- As for many other hazards, changed land use patterns are very similar to existing land use patterns for both residential and employment densities. 28.1% of changed residential lands and 11.6% of changed employment lands are in the high hazard area.
- North Bay counties (Sonoma, Marin, and Napa) have the highest amount of changed residential lands in wildfire threat areas (44.2%, 39.0%, and 33.9% respectively).
- Going against two generalizations, Contra Costa (a fairly urbanized county) has also had 31.2% of the changed residential development in the county in high wildfire threat areas, the majority of which (48.1%) is high-density residential.
- Due mostly to the above fact, changed high-density residential represents approximately 30% of all changed residential development in the high wildfire threat areas (second only to rural residential).
- 50.1% of the changed employment land in Napa County (including 69.1% of commercial services land) and 32.4% of the changed employment land in Sonoma County was in the high wildfire threat area. The actual effect is much bigger in Sonoma County, as there were roughly 1,500 acres of changed employment in threat areas in that county, versus 350 acres in Napa County.

Wildland-Urban-Interface Threat Areas

The amount of development in the WUI threat areas is very high when compared to most other hazards, reflecting the large threat that wildfire poses to the much of region's residential development.

Existing Land Use (2005)

- 58.2% of the region's residential development is in WUI threat areas, including 58.2% of the rural residential and 75.6% of the low-density residential development.
- Contra Costa and Marin counties, in particular, had very high levels of residential development in the WUI threat areas, with approximately 78% of all densities in the threat areas.
- In Contra Costa County, 91.6% of all low-density residential development (15,585 acres) is in the WUI threat areas.
- Values for existing employment lands were much lower than residential lands, with 34.3% of the employment lands in the WUI threat areas.
- Marin (59.2%), Contra Costa (48.0%), and San Mateo counties (46.6%) had the most employment lands in WUI threat areas.

Changed Land Use (2000-2005)

- Residential development continued at a dramatic rate in the WUI threat areas, with 64.4% of the changed residential land and 36.4% of the changed employment land in the WUI threat areas.
- Across the region, 79.9% of the changed low-density residential was in a WUI threat area.
- Across all counties, no one changed residential density had consistently higher percentages of development in threat areas than others. Very generally, however, the two lower densities (rural and low-density) tend to have larger proportions of land in the threat areas than the higher densities.
- Again, Contra Costa, San Mateo and Marin counties had the largest percentage of changed development in the WUI threat areas.

Dam Inundation Areas

Dam failure presents a relatively small but potentially very significant threat to the region. While only 10.3% of the region's land is in a dam inundation area, nearly half of this land (45.2%) is urbanized. This percentage includes 99.7% of San Francisco, 89.5% of San Mateo, 71.6% of Santa Clara, and 64.2% of Alameda counties. In fact only two counties have less than 25% of the land in the dam inundation areas urbanized (Napa and Solano). Dam failures therefore present a very high potential risk for loss of life and property (For exposure estimates, see Appendix F).

Existing Land Use (2005)

- Across all counties 13.8% of the existing residential land and 25.5% of the existing employment land is located in dam inundation areas.
- Within the dam inundation areas of most counties, the representation of residential densities is consistent with the representation of the densities in the rest of the county. The exceptions are San Mateo, Napa, and Marin counties, which all three have medium-density residential as the most common form of residential development in the dam inundation areas.
- Across counties, medium-density residential is the most common form of residential development in the dam inundation areas, representing 47.1% of all residential land in the dam inundation areas.
- Prevalence of land in the dam inundation areas increases with increasing residential density across nearly every county. The only exception is Solano County, where the large majority of land in the dam inundation areas is agricultural (and thus the associated land is low density and rural).
- Among employment land types, commercial, industrial, and public or institutional lands tend to share the highest percentages in the dam inundation areas, the top one varying by county.
- Santa Clara (43.1%) and Alameda (36.6%) counties have the most employment land in the dam inundation areas, including 64.4% of Santa Clara's infrastructure and 48.7% of Alameda's industrial.

Changed Land Use (2000-2005)

- Across all counties, 13.0% of the changed residential land and 30.3% of the changed employment land is located in the dam inundation areas, similar numbers to 2005 existing numbers.

- For the region, high-density residential is the most common form of changed residential land use in dam inundation areas, at 40.1%. Within counties, the most common density varies considerably from one county to the next.
- Santa Clara (25.5%) and Alameda (30.8%) counties have the most changed residential land in the dam inundation areas, including approximately 37% of Alameda's medium and high-density residential.
- For the region, commercial services and industrial comprise nearly all of the changed employment land uses in dam inundation areas, at 47.3% and 47.1% respectively. This is true for each county as well.
- Santa Clara (51.7%) and Alameda (42.4%) counties have the most changed employment land in the dam inundation areas, including 62.7% of Santa Clara's industrial.

Drought

Drought is a fairly unique type of hazard in that it deals with the supply of a physical resource that can be directly manipulated, moved, and stored. The impacts of a drought therefore, unlike most of the other hazards, can be prevented (or at least drastically mitigated), given adequate planning before a drought year. It therefore is less practical to discuss drought in terms of geographically delineated "drought hazard areas" than it is to discuss how different residential densities use water, and thus how they can be differently affected by drought.

Residential water use statistics are reported by the 90 local or regional water districts in the Bay Area to the California Department of Water Resources (DWR). DWR breaks up residential water use into statistics by customer class, which is a measure generally reflects the density of development. Specifically, DWR breaks up residential customer classes into Single-Family Residential, which includes rural, low and medium-density development, and Multifamily Residential, which includes medium- to high-density development. Residential water use is further broken up into two categories of use: indoor and outdoor. Indoor uses include dishwashing and laundry, showers, and other household uses of water. Outdoor uses, which focus on maintenance of landscaping and gardens, are generally more water intensive than indoor uses. For example, in 2000, outdoor residential use of water comprised 52% of all residential water use, and 33% of all urban water use. Figure 7 demonstrates both the break up of customer class as well as amount of water consumed in 2000 for each customer class in the Bay Area.

Thus, residential densities with more landscaping will have a much higher outdoor water use, and a corresponding higher total water use, than residential densities with little or no landscaping. Since lower densities generally have higher levels of landscaping than higher densities, it can be generalized that, as residential density decreases, water use increases. This generalization is borne out in available data, as demonstrated in Table 14 below. Notice how, while indoor water use is comparable between densities (and is in fact lower for Single Family Residential), outdoor water use is significantly higher for lower-density developments, making overall water use higher at lower densities. This is accentuated by the fact that most higher-density development in the region occurs in areas that are generally cooler, such as San Francisco, San Mateo, western Alameda, and western Contra Costa counties, compared with lower-density areas in the drier regions in the North and South Bay, as well as the eastern parts of Alameda and Contra Costa counties.

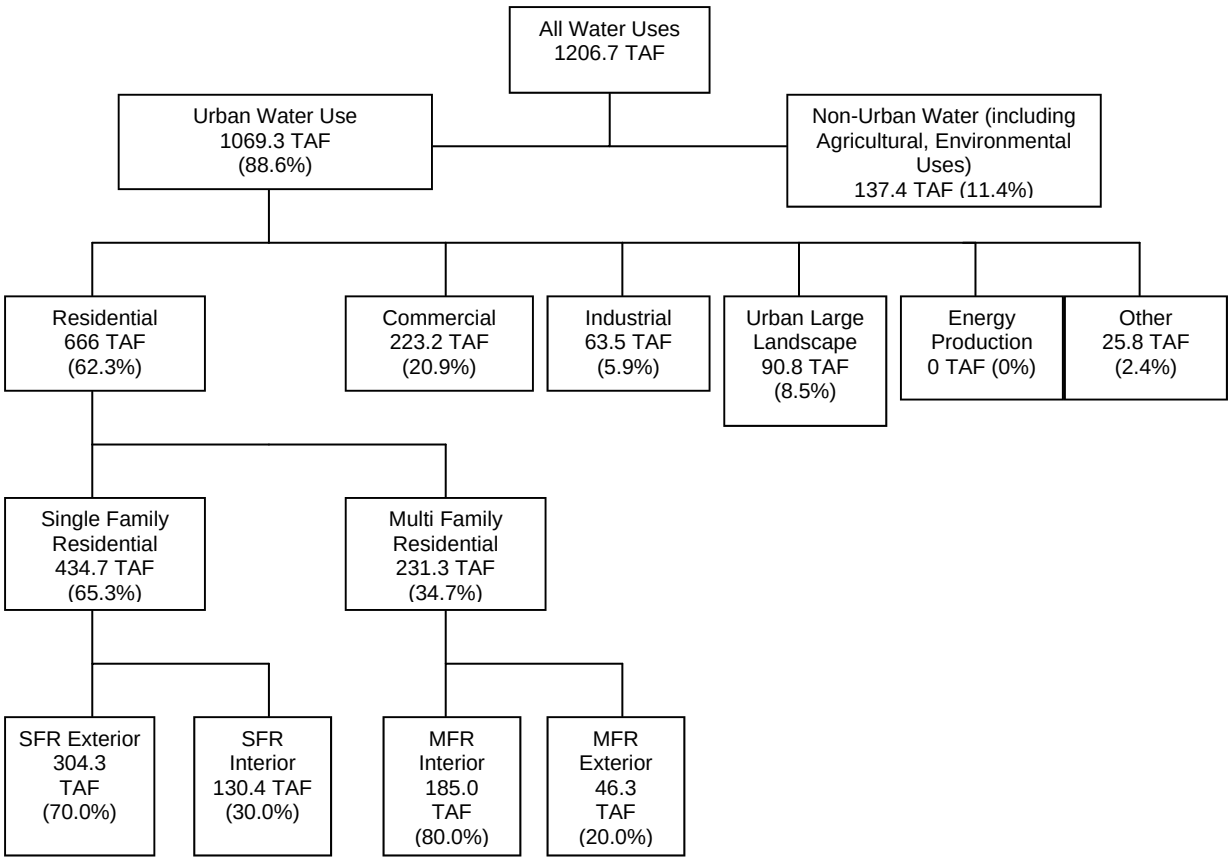


FIGURE 7 – Bay Area Water Use in 2000 by Customer Class (DWR in print)
Percentages indicate percentage of parent category, not of total water use.

How different residential areas will be affected by drought is a complex mixture of how much water is normally used in that area (which is, in part, a function of the density of that area), the policies of the water agency for that area, and the intensity and duration of the drought. The Urban Water Management Planning Act, passed by the State in 1983, requires all water districts with at least 3,000 customers to create an Urban Water Management Plan in order to obtain state drought mitigation funding. Generally, as part of this plan, water districts create a Water Shortage Contingency Plan to discuss what conservation, pricing, and regulatory measures will take effect during water shortages of varying intensities and durations. Thus, when drought occurs for a particular water district, the effects are spread out over the service area according to the contingency plan of that district, rather than felt in a particular "hazard area." In addition, every water district has different general policies on water use and water recycling, and this affects how much water its customers consume. In general, outdoor uses are less essential to normal household function than indoor uses, and thus are more likely to be cut back first during a drought. Indoor water conservation measures would take place only when outdoor conservation and pricing measures do not alleviate the drought.

Table 14 – Bay Area Residential Water Use (1998, 2000, and 2001)
Units are Thousand Acre Feet

	Single Family Residential-Exterior	Percent of Total Residential Water Use	Single Family Residential-Interior	Percent of Total Residential Water Use	All Single Family Residential Percentage of Total Residential Water Use	Multiple Family Residential-Exterior	Percent of Total Residential Water Use	Multiple Family Residential-Interior	Percent of Total Residential Water Use	All Multiple Family Residential Percentage of Total Residential Water Use
1998	280.0	45.5%	120.3	19.6%	65.1%	42.8	7.0%	171.3	27.9%	34.9%
2000	304.3	45.7%	130.4	19.6%	65.3%	46.3	7.0%	185.0	27.7%	34.7%
2001	317.0	45.6%	135.9	19.6%	65.2%	48.4	7.0%	193.5	27.8%	34.8%

(Source: DWR, 2005)

Projected Land Use Development Trends (2005-2030)

This county-by-county analysis uses projected job growth a proxy for commercial development and projected household growth as a proxy for residential development.

An analysis of projected growth trends indicates that three counties will likely dominate the urban development in the next 25 years. The first is Santa Clara, which is the most populated county in the region and is expected to continue to grow the fastest (in numbers of households). The next fastest counties are Alameda and Contra Costa counties, which are also the second and third most populous counties respectively. These two counties are expected to experience the largest job growth between now and 2030, followed by Santa Clara County. The dominance by these three counties can be explained by recalling the two main development patterns explained in the previous section. Namely, these three counties are experiencing both patterns of development, in that previously developed areas urban areas are redeveloping and outlying areas composed of agricultural and rural land are developing into residential suburbs. These counties are experiencing both patterns of growth because they have both the available land for outward expansion as well as because some local governments are making efforts to promote redevelopment of existing urban areas. The remaining counties do not have the available land or have taken steps to declare much of the unincorporated land off-limits to development. These counties are therefore projected to experience less growth in the next ten years than the three mentioned above.

Alameda County

Alameda County is expected to experience a tremendous amount of growth, largely due to the redevelopment of Oakland and other cities in northern Alameda County, which began within the past decade and is projected to continue picking up pace. This development has been almost exclusively residential and commercial, as cities pursue urban revitalization project that are either high-density residential, commercial, or mixed-use developments. Oakland alone is

expected to add more than 40,000 new households by 2030. In addition, suburban cities in the Tri-Valley area (Pleasanton, Dublin, and Livermore) and southern Alameda County (Fremont, Newark, Union City) will likely continue outward single-use residential and commercial expansion. Overall, over 134,860 new households and 341,370 new jobs are expected to be added in Alameda County.

Contra Costa County

Between now and 2030, Contra Costa County is expected to add approximately 88,350 new households, with major development continuing to occur in outlying cities such as San Ramon, Brentwood, and Concord and Antioch at first. In fact, 47% of the county's growth in the next ten years is expected to occur in the outlying eastern cities of the county, combining low and medium density single-use suburban development, and some low-density mixed use development. Growth will likely slow somewhat in these areas after 2015. In addition, there will likely be some urban redevelopment occurring in the western county cities of Richmond and Hercules as vacant and industrial land is reused. Jobs growth and commercial development is projected to be about half that of Alameda County, with almost 170,860 new jobs to be added by 2030. This growth is expected to occur largely in the cities of Hercules, Pittsburgh, and Antioch (which are all located along the major east-west transportation corridor of Highway 4), and Concord and San Ramon (located along the major north-south I-680 corridor). Despite the development of new land into suburban neighborhoods, the county is expected to retain two-thirds of its agricultural and rural open space by 2030.

Marin County

Marin County is one of the least populated counties in the region largely due to the lack of developable land in the county. The small population is due to the county's mountainous terrain, the presence of a significant amount of parkland that is federally or State owned, and smart growth policies in the county that have preserved a large portion of the remaining agricultural lands. In addition, the aging and affluent nature of the county's residents means that there will likely be little increase in the population; few children are born that can replace the aging population and the area is generally too expensive for newcomers with families to move there. The development that will likely occur in the county is expected to occur largely in the City of Novato, Marin's largest city, which is expected to add over 15,000 new jobs and approximately 4,000 new households by 2030, the majority of which will likely be low density single family homes. Overall, Marin County is projected to add approximately 13,000 new households and 38,000 new jobs.

Napa County

Napa County's land use patterns center on the wine industry and the profits that it creates, from both the production of grapes and wine and the resulting tourism that it attracts. Napa is the least populous county in the region and has only five incorporated areas, of which the City of Napa is the largest. It is therefore expected that there will be little growth, especially in the unincorporated areas, where growth should slow due to the county's growth policies that discourage development in favor of agriculture. The significant majority of growth is expected to occur in the two largest cities, Napa and American Canyon, which are forecasted to add roughly 7,000 of the county's new 8,200 households by 2030. The majority of the 19,800 jobs added will likely be related to the wine and tourist industries or to providing services for

residents, and development should reflect this by remaining near cities or by agricultural and winery development in the outlying areas of the county.

San Francisco County

The City and County of San Francisco is unique in the region in that it has no undeveloped land available for expansion, and all of the County's development must therefore come in the form of redevelopment and revitalization of former industrial and military areas. San Francisco's development is one of the densest in the United States, and new development will likely continue to reflect this pattern. For example, the South of Market area (SOMA) is already experiencing very high-density residential and commercial development as new high rises are constructed, a pattern which is likely to continue. Other areas to be redeveloped include the Mission Bay and Bayview/Hunter's Point areas, which are receiving light rail and transit-oriented style development. Overall, San Francisco is expected to add 59,500 new households and 253,000 new jobs by 2030, maintaining its status as the region's cultural and economic center.

San Mateo County

San Mateo County's location between the employment centers of San Francisco and the Silicon Valley has allowed it to develop in such a way that its residents now supply a large portion of the neighboring counties' workforces. San Mateo is therefore a county of 20 small to medium-sized cities that are largely of an older, medium-density suburban residential character. Its economy is linked to both San Francisco and Santa Clara counties, and has seen a drop off in the number of jobs as the economy slowed in 2000. Job growth and commercial development is expected to continue slowly through 2015, after which it will likely increase pace. Residential development will also likely be slow, with the county adding only 36,000 new households by 2030, distributed over the whole north-south axis of the county.

Santa Clara County

The Bay Area's most populous county, despite the setbacks of the early 2000's, is forecasted to continue to expand fairly rapidly (proportionally), led by the region's most populous city, San Jose. As stated before, this trend is due to the large amount of developable land on the outskirts of the county, as well as the fact that many local governments are focusing on urban redevelopment, especially as it is linked to transit. San Jose in particular is expected to add nearly 95,000 of the county's 167,000 new households, much of it along transit-oriented developments along new and planned extensions of light rail, Caltrain and BART extension. San Jose is projected to also add 220,000 of the County's new 437,000 jobs. Other regions expected to experience growth will be Mountain View in northern Santa Clara County, which is projected to add 22,000 new jobs, and the cities of Santa Clara and Sunnyvale which are expected to collectively add approximately 22,000 new households by 2030. The cities of Gilroy and Morgan Hill in southern Santa Clara County will likely also expand rapidly given their current small size.

Solano County

Solano County is expected to experience the highest percentage of growth in coming years of all regions, with the population growing by more than one-third by 2030. This growth will likely take place almost exclusively in the seven incorporated areas in the county, due to the Orderly Growth Initiative passed in 1994, which restricts development on agricultural lands. The

development in the county is projected to take place largely in the three centers of Solano County, the cities of Vacaville, Vallejo, and Fairfield. Fairfield alone is expected to add 37,000 of the county's 52,000 new households by 2030. This development is likely to be very low-density residential, continuing current patterns, especially in the more northerly cities of Fairfield and Vacaville.

Sonoma County

Sonoma County, a largely rural county with the exception of a few medium sized-cities, is projected to experience strong proportional growth, largely due to its diversified economy and large amount of developable land. The growth will likely occur mainly in the largest cities, especially Santa Rosa, the largest city in the county, which is expected to add 53,000 new jobs and 14,000 new households by 2015. The character of this development is likely to continue on the current path of very low-density development on the outskirts of the cities. Overall, Sonoma County is expected to add 31,000 new households and 104,000 new jobs by 2030.

Projections of Future Land Uses in Hazard Areas

There are strong pressures to build in areas of natural hazards. ABAG's **Projections 2005** forecasts for the region to grow from a population of 7,091,700 in 2005 to 8,747,100 in 2030. At the same time, these people, who live in 2,582,980 households in 2005, are projected to live in 3,182,220 households in 2030. Finally, while the Bay Area employed 3,516,960 in 2005, it is expected to employ 5,120,600 people in 2030.

This growth continues to place increasing pressure on the region to expand urban development, both by increasing the density of areas of existing urban and inner suburban housing, and by the conversion of agricultural and grazing lands to suburban development.

Yet at the same time there are strong pressures not to build in hazardous areas. Over the past few decades, a desire to build more disaster-resistant communities and create more environmentally-sensitive growth has led to a series of state laws and local regulations. These restrictions on development are intended to promote one of the eight major objectives of this Local Hazard Mitigation Plan:

> ***Land use change needs to be accompanied by a respect for hazardous areas and facilities, as well as recognize the interconnected nature of the Bay Area.***

Because these conflicting pressures concerning development in hazard area have been in existence for several years, it is probable that the development trends and future land use densities in these areas of the last five years will continue for the foreseeable future. This trend, however, will be affected by more stringent mitigation measures and a continual replacement of older structures and development with new, better engineered, but denser, development.

While it is impossible to know the extent and location of all new urban development, the trends suggest that there will be increased infill development in urban cores combined with continued development of outlying areas, possibly using a more transit-oriented and mixed-use approach. To the extent that redevelopment increases, this densification will lead to a slower increase in exposure to wildfires and landslides because these are more likely to occur in lower-density areas. In addition,

due to lower per capita water use in multifamily areas, this densification will also lead to a slower increase in exposure to drought and water supply shortages. On the other hand, higher densities in existing urban areas will accelerate the exposure to liquefaction, flooding, and earthquake shaking.

It is important to mention that, while land use regulation has not played a major role in mitigating the effects of hazards, there has been a significant focus on strategies such as building and fire codes, public awareness campaigns, and other approaches to mitigating hazards as outlined in this Local Hazard Mitigation Plan. All of these can significantly reduce the potential effects of any hazard, and occasionally lessen the severity of a disaster. Yet there is no single mitigation strategy that is as foolproof as controlling land use in hazard areas. Simply not developing or limiting development to a certain type within hazard areas reduces the potential effects of a hazard dramatically and possibly eliminates any potential losses. While this is a very strong argument for hazard information to play a much larger role in land use decisions (and land use regulation to play a much larger role in hazard mitigation efforts), this change is unlikely to occur due to the inertia of planning and development decision-making.

There is little indication that hazard information will play any more or less of a role in land use decisions than it currently does today. The ***Seismic Hazards Mapping Act*** of 1990 may provide increased incorporation of liquefaction and earthquake-induced landslide concerns into development decisions as new mapping occurs. Perhaps the most encouraging fact is that there is increased concern among citizens and policy makers following Hurricane Katrina in 2005. How this increased concern will play into development decisions and regulations surrounding hazards has yet to be seen. Interestingly, the California Legislative Analyst recently issued a statement that discusses reducing risks trough land use decisions, which may signal an increased awareness on these issues at the state level (California Legislative Analyst, 2006).

Two State laws related to land use and disaster mitigation were enacted in the early 1970s and a third one was enacted in 1990. Additional local regulations typically have been instituted more recently. Some have been implemented as a result of adopting annexes to the Bay Area multi-jurisdictional Local Hazard Mitigation Plan. For a comprehensive picture of the priorities being established for the identified strategies, see **http://quake.abag.ca.gov/mitigation/strategy.html.**

The following sections catalog some of the State laws and local regulations controlling development in hazard areas that could potentially affect future land use densities in hazard areas. These laws take varying approaches to mitigating the effects of hazards. At their most efficient, these controls can eliminate a hazard, particularly hazards associated with new construction. On the other hand, most regulations are merely requirements to mitigate a hazard through engineering, not avoidance of the land where the hazard is located. Finally, for two of the hazards (dam failure and tsunamis) the strategy is to expedite evacuations, not mitigation.

State Laws Applying to Multiple Hazards

Every city and county is required to prepare a General Plan. Over the years, required elements have been specified, including the Safety and Seismic Safety elements (now consolidated into a single Safety Element), which has been required since 1971. The General Plan contains seven required elements outlining local policies guiding future development in the jurisdiction. Local zoning for future development is required to be consistent with the policies identified in this

General Plan (except for in charter cities). All California cities and counties have a Safety Element, either as a separate document or integrated into their General Plan. As part of that plan, jurisdictions must identify and map natural hazards.

Most of the local governments are implementing the mitigation strategies of their annexes to this multi-jurisdictional plan by adopting them as an implementation appendix to their Safety Elements. This re-examination of the Safety Element will be useful, for many of these elements are several years old and out of date. See http://ceres.ca.gov/planning/genplan/gpg.pdf for the California ***General Plan Guidelines*** published by the California Office of Planning and Research (OPR).

Local Regulations Applying to Multiple Hazards

Smart Growth programs are intended to revitalize urban areas and promote sustainability **as an alternative to developing in outlying and hazard-prone areas**. ABAG and the other regional agencies in the region, including the Metropolitan Transportation Commission (MTC) and the Bay Area Air Quality Management District have adopted polices to promote Smart Growth. In addition, boards of supervisors of all nine Bay Area counties and city councils of 66 of the regions cities have taken action in support of the objectives of the Bay Area Alliance for Sustainable Communities, is a multi-stakeholder coalition established in 1997 to develop and implement an action plan that will lead to a more sustainable region. Ways to meld Smart Growth and sustainability concepts with hazard mitigation include –

1) Prioritizing retrofit of infrastructure that serves urban areas over constructing new infrastructure to serve outlying areas.
2) Working to retrofit homes in older areas to provide safe housing close to job centers.
3) Working to retrofit older downtown areas to protect architectural diversity and promote disaster-resistance.
4) Protecting areas susceptible to extreme hazards as open space.
5) Providing new buffers and preserving existing buffers between urban development and existing users of large amounts of hazardous materials, such as major industry, due to the potential for catastrophic releases in a major earthquake, flood, or terrorism disaster.

Hillside development can be problematic due to the potential hazards of wildfire and landsliding. The pressure to convert hillside areas to urban uses is great, however, in inner suburban communities that have no remaining non-urban land, as well as in communities actively preserving agricultural land (particularly in the North Bay where vineyards are prevalent). Tools to mitigate risks available to local governments are –

1) Establishing a buffer zone between residential properties and landslide or wildfire hazard areas.
2) Discouraging, adding additional mitigation strategies for, or preventing construction on slopes greater than a set percentage, such as 15%, due to landslide or wildfire hazard concerns.

State Laws Applying to Earthquakes

The ***Seismic Hazards Mapping Act*** of 1990 requires the preparation of site-specific geotechnical reports for development proposals in areas identified as Zones of Required Investigation for ***earthquake-induced landslides or liquefaction*** as designated by the State Geologist. Cities and Counties are also required to incorporate the Official Seismic Hazard Zone Maps into their Safety Elements. Lastly, the Seismic Hazards Mapping Act, as well as the Natural Hazard Disclosure Statement, requires sellers of real property to disclose to buyers if property is within a Zone of Required Investigation. Due to funding, Seismic Hazard Zone maps have only been completed in selected portions of the Bay Area. As maps become available, affected cities and counties are required to enforce the preparation of these reports and condition project approval on the incorporation of necessary mitigation measures related to site remediation, structure and foundation design, and/or avoidance. This Act must be implemented by cities and counties in the region with hazards mapped by CGS. In 2005, this included San Francisco and parts of Alameda, Contra Costa, San Mateo, and Santa Clara counties, as well as 43 cities.

Since the Act has only been in place for less than 15 years, and most Bay Area maps are recent, the impact of this legislation has not been as great as the Alquist-Priolo Fault Study Zones Act. In addition, the focus on the Act is on new development, not existing development, and on mitigation, rather than avoidance of the identified seismic (liquefaction or earthquake-induced landslide) hazards.

The ***Alquist-Priolo Earthquake Fault Zoning Act*** of 1972 was passed by the legislature as a result of the San Fernando earthquake in southern California. This Act is intended to deal with the specific hazard of active faults that extend to the earth's surface, creating a ***surface rupture hazard***. The Act requires that the State Geologist (the head of the California Geological Survey – CGS) designate zones approximately ¼-mile wide along known active faults. Within these zones, site-specific geologic reports must be prepared for development proposals (except for housing developments of less than four units or not involving structures intended for human occupancy). Typically, at a minimum, structures intended for human occupancy cannot be placed within 50 feet of an active fault trace. Finally, the Act requires disclosure to potential buyers in these zones.

The Act's ability to eliminate the surface fault rupture hazards in the region for future development is limited because it specifically exempts:

- existing development;
- new developments containing less than four single family homes; and
- structures not intended for human occupancy (including pipelines, power substations, and pumping plants).

Local governments need to ensure that these facilities, many of which are actually constructed by local governments, have adequate mitigation to increase safety.

Local Regulations Applying to Earthquakes

First, Section 2624 of the Fault Zoning Act specifically states that local governments have the authority to recognize that some faults may be a hazard for surface rupture even though they do not meet the strict criteria imposed by the Fault Zoning Act. For example, zones have been

identified by Santa Clara County and by the City of Saratoga for the Monte Vista-Shannon fault system.

Second, recognizing that CGS has not completed earthquake-induced landslide and liquefaction mapping for significant portions of the Bay Area, local governments can require geologic reports in areas mapped by others as having significant liquefaction or landslide hazards.

Third, CGS's efforts to complete the earthquake-induced landslide and liquefaction mapping will be easier if cities and counties cooperate by providing access to their records and by expediting permitting for new research conducted in their jurisdiction.

Finally, local governments review the geologic and engineering reports prepared by developers to implement the Fault Zoning Act and the Seismic Hazards Mapping Act. Local governments are required to ensure that reviews are conducted by appropriately trained and credentialed personnel, whether they use their own staff or outside consultants.

Local Regulations Applying to Wildland and Structural Fires

Local government regulations mitigating fire hazards include –

1) Reviewing development proposals to ensure that they incorporate required and appropriate fire-mitigation measures, including adequate provisions for occupant evacuation and access by emergency response personnel and equipment.
2) Developing a clear legislative and regulatory framework at both the state and local levels to manage the wildland-urban-interface consistent with ***Fire Wise*** and sustainable community principles.

Local Regulations Applying to Flooding

Local government regulations mitigating flooding hazards include –

1) Establishing and enforce requirements for new development so that site-specific designs and source-control techniques are used to manage peak stormwater runoff flows and impacts from increased runoff volumes.
2) Incorporating FEMA guidelines, regulatory standards (such as ASCE 24), and other suggested activities into local government plans and procedures for managing flood hazards.
3) Providing an institutional mechanism to ensure that development proposals adjacent to floodways and in floodplains are referred to flood control districts and wastewater agencies for review and comment (consistent with the NPDES program).
4) Establishing and enforce regulations concerning new construction (and major improvements to existing structures) within flood zones in order to be in compliance with federal requirements and, thus, be a participant in the Community Rating System of the ***National Flood Insurance Program.***

Local Regulations Applying to Landslides and Erosion

Local government regulations mitigating rainfall-induced landslide hazards and erosion include:

1) Establishing and enforcing provisions (under subdivision ordinances or other means) that geotechnical and soil-hazard investigations be conducted and filed to prevent grading from

creating unstable slopes, and that any necessary corrective actions be taken prior to development approval.
2) Requiring that local government reviews of these investigations are conducted by appropriately trained and credentialed personnel.
3) Establishing and enforcing grading, erosion, and sedimentation ordinances by requiring, under certain conditions, grading permits and plans to control erosion and sedimentation prior to development approval.
4) Establishing and enforcing provisions under the creek protection, storm water management, and discharge control ordinances designed to control erosion and sedimentation.
5) Establishing requirements in zoning ordinances to address hillside development constraints, especially in areas of existing landslides.

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