SECTION 9. LANDSLIDE

The Nature of the Landslide Threat

A landslide is defined as, the movement of a mass of rock, debris, or earth flow down a slope. Landslides are a type of "mass wasting" which denotes any down slope movement of soil and rock under the direct influence of gravity (FEMA).

The term "landslide" encompasses events such as rock falls, topples, slides, spreads, and flows. Landslides can be initiated by rainfall, earthquakes, changes in groundwater, disturbance and change of a slope by man-made construction activities, or any combination of these factors. Underwater landslides can also occur causing tidal waves and damage to coastal areas.

The size of a landslide normally depends on the geology and the initial cause of the landslide. Landslides vary greatly in their volume of rock and soil, the length, width, and depth of the area affected, frequency of occurrence, and speed of movement. Some characteristics that determine the type of landslide are slope of the hillside, moisture content, and the nature of the underlying materials. Landslides are given different names, depending on the type of failure and their composition and characteristics.

Landslides can be described as either: (1) rapidly moving (generally known as debris flows), and (2) slow moving. Rapidly moving landslides or debris flows present the greatest risk to human life. People living in or traveling through areas prone to rapidly moving landslides are at increased risk of serious injury. Slow moving landslides can cause significant property damage but are less likely to result in serious human injuries (USGS).

Nationally, landslides cause 25 to 50 deaths each year. The best estimate of direct and indirect costs of landslide damage in the United States range between $1 billion and $2 billion annually (FEMA). As a seismically active region, California has had a significant number of locations impacted by landslides. In addition to the potential loss of life, landslides can result in private property damage, impact transportation corridors, break fuel and energy conduits, and disrupt communication facilities.

Within the Las Virgenes-Malibu Region there are areas that are susceptible to landslides due to slope instability, fire activity, rainfall and the geologic make-up of the area. Although all of the cities within the LVMCOG prohibit development in areas that may be prone to landslides, there are existing properties that may be susceptible to landslide activity.

Debris Flow

A debris or mud flow is a river of rock, earth and other materials, including vegetation that is saturated with water. This high percentage of water gives the debris flow a very rapid rate of movement down a slope. Debris flows can have speeds on the order of 20 mile per hour, and can often move much faster (California Department of Conservation). This high rate of speed makes debris flows extremely dangerous to people and property in its path. In the event of a major landslide, debris flow can destroy roadway pavement and fill the storm drain catch basins. Any significant surface movement along streets will isolate residents and disrupt utilities in those areas. Although no significant debris flow resulting from landslide activity has been recorded in the Las Virgenes-Malibu Region, it remains a possibility.

Historical Record of Landslide Events

1994 Northridge Earthquake Landslide Related Impact

As a result of the magnitude 6.7 Northridge, California, earthquake, more than 11,000 landslides occurred over an area of 10,000 km^2. Most were in the Santa Susana Mountains and in mountains north of the Santa Clara River Valley. The earth movement destroyed dozens of homes, blocked roads, and damaged oil-field infrastructure. It also caused deaths from Coccidioidomycosis (Valley Fever), the spore of which was released from the soil and blown toward the coastal populated areas. The spore was released from the soil by the landslide activity.

History of Landslides in the Las Virgenes-Malibu Region

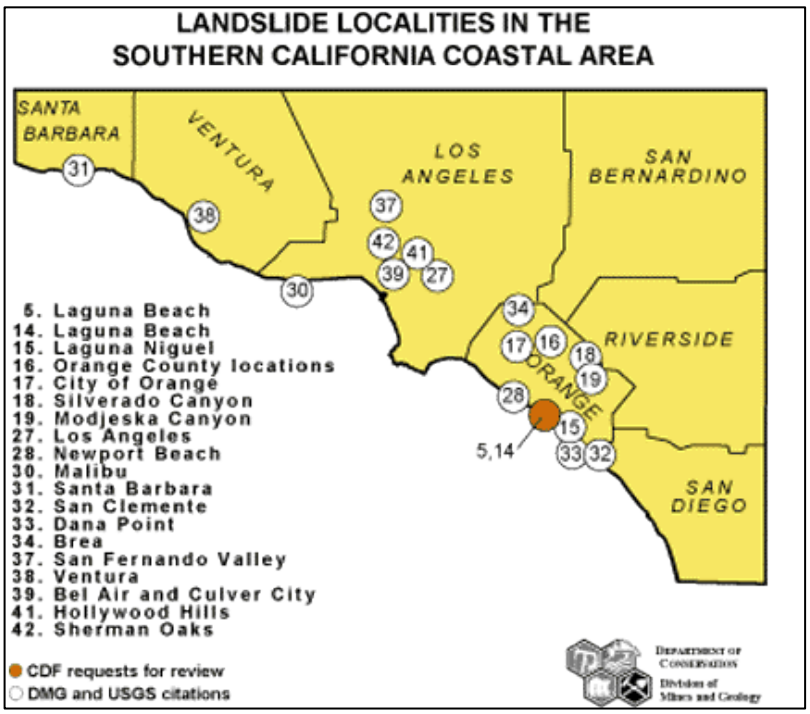
Several cities in the Las Virgenes-Malibu Region have experienced landslide events due to heavy rains or seismic events. Examples for the cities of Agoura Hills and Malibu are provided below.

Agoura Hills Landslides

Examples of landslide events in the City of Agoura Hills since 1990 include the Via Amistosa, Morrison Ranch, Liberty Canyon Slope Failure, Laura La Plante, Laro, and Chateau Park landslides. In 1999, Agoura Hills experienced the Kanan Slope Repair as a result of the El Nino storms of 1998.

Malibu Landslides

Landslide events in the City of Malibu have included the Calle del Barco, Kanan, Pacific Coast Highway, Las Flores, Love, and Malibu Road landslides. Due to the topography of the area, landslides in Malibu can severely disrupt transportation at a regional level. For example, Pacific Coast Highway is a heavily used transportation route and road closures due to landslides are a major concern. The *Landslide Localities in Southern California Coastal Area Map* depicts landslides along coastal areas in Southern California (1997-1998) including Malibu (Number 30). The summary on the next page describes a timeline of events in Malibu.



Map 47: Landslide Localities in the S. Calif. Coastal Area

Landslide Localities in Southern California Coastal Area

30. Malibu, Los Angeles County. On 12/06/97 homes in Malibu were damaged by waves and seacliff erosion. On 02/07 Malibu Canyon Road closed due to mudslides and rockfalls (Tan, 02/11). On 02/08 an ocean-eroded cliff buckled, causing one home to collapse and two others threatened. The homes along Broad Beach Road were undermined by high tides (Tan, 02/11). On 02/16 several houses along the beach of Malibu were damaged by the high surf and rainstorms (Tan, 02/19). On 02/23

Pacific Coast Highway, Topanga Canyon Boulevard, and Malibu Canyon Road were blocked by mudslides. A Union Pacific railroad trestle was undermined by the surging flows of the Ventura River and was not reopened to rail traffic for weeks (Tan, 03/05). On 02/24 in Malibu's Las Flores Canyon, officials called for evacuation of about a dozen homes because of unstable ground. Also, more mudslides on Pacific Coast Highway forced officials to close the local courthouse (Tan, 03/05). On 02/25 a 140-foot-long retaining wall partially collapsed, damaging two homes above the slide on Calle del Barco. The 20-year-wall, along a narrow road (Rambla Orienta) just above Pacific Coast Highway, began to give away during the evening of 02/24 (Tan, 03/05).

SOURCE: http://www.consrv.ca.gov/cgs/fwgp/ls_response/Pages/ls_la.aspx

Causes and Characteristics of Landslides

Landslide Events and Impacts

Landslides are a common hazard in California. Weathering and the decomposition of geologic materials produces conditions conducive to landslides and human activity further exacerbates landslide potential. Many landslides are difficult to mitigate, particularly in areas of large historic movement with weak underlying geologic materials.

Rock falls occur when blocks of material come loose on steep slopes. Weathering, erosion, or excavations, such as those along highways, can cause falls where the road has been cut through bedrock. These rock falls are fast moving with materials free falling or bouncing down slopes. The volume of material involved is generally small, but large boulders or blocks of rock can cause significant damage.

As communities continue to modify the terrain and influence natural processes, it is important to be aware of the physical properties of the underlying soils as they (along with climate) create landslide hazards. This is especially important with the demands placed on buildable land (particularly in urban areas) that increases the tendency to build on geologically marginal areas such as hillside lots.

Landslide Hazard Identification

Landslides are often triggered by periods of heavy rainfall. Earthquakes, subterranean water flows, pipeline ruptures, and excavations may also trigger landslides. Certain geologic formations are more susceptible to landslides than others. Human activities, including locating development near steep slopes, can increase susceptibility to landslide events.

Natural Processes

Natural processes can cause landslides or re-activate historical landslide sites. Seismic tremors can trigger landslides on slopes with a history of landslide movement. Earthquakes can also cause additional failure (lateral spreading) that can occur on moderate slopes above steep streams and riverbanks.

Land Development, Grading, and Excavation

Although landslides are a natural geologic process, the incidence of landslides and their impacts on people can be exacerbated by human activities. Grading for road construction and development can increase slope steepness. Grading and excavation can decrease the stability of a hill slope by adding weight to the top of the slope, removing support at the base of the slope, and increasing water content.

Drivers for hillside development include intensification of existing development on residential lots and expansion into undeveloped areas. Intensification consists of additional construction and modification of existing construction or the complete demolition and redevelopment of a residential lot.

Intensification expands developed pad areas into previously “natural” hill slope areas and often involves a corresponding increase in the size and volume of the onsite sewage disposal systems. Other human activities effecting landslides include: excavation, drainage modifications, groundwater alterations, and changes in vegetation and soil conditions.

Drainage and Groundwater Alterations

Water flowing through or above ground is often the trigger for landslides. Any activity that increases the amount of water flowing into landslide-prone slopes can increase landslide hazards. Broken or leaking water or sewer lines can be especially problematic, as can water retention facilities that direct water onto slopes. Ineffective storm water management and excess runoff can also cause erosion and increase the risk of landslide hazards. Drainage can be affected naturally by the geology and topography of an area; development that results in an increase in impervious surfaces impairs the ability of the land to absorb water and may redirect water to other areas. Channels, streams, ponding, and erosion on slopes all indicate potential slope problems.

Road and driveway drains, gutters, downspouts, and other constructed drainage facilities can concentrate and accelerate flow. Ground saturation and concentrated velocity flow are major causes of slope problems and may trigger landslides. Building Codes require drainage devices to dispose storm runoff away from hillside developments. Storm runoff is designed to be discharged into the storm drain system. Storm drain catch basins are normally maintained by Public Works Departments and are regularly cleaned to prevent any flooding or ponding.

Changes in Vegetation and Soil Conditions

Wildland fires in hills covered with chaparral are often a precursor to debris flows in burned out canyons. The extreme heat of a wildfire can create a soil condition in which the earth becomes impervious to water by creating a waxy-like layer just below the ground surface. Since water cannot be absorbed into the soil, it rapidly accumulates on slopes, often gathering loose particles of soil in to a sheet of mud and debris.

If vegetation on very steep slopes has been removed either by wildfire or man-made development, there is an increased risk of a landslide. Additionally, changing away from native ground cover plants may increase the risk of landslide. For example, if certain vegetation requires heavy watering, soil conditions can change and trigger landslides.

Landslide Risk Factors

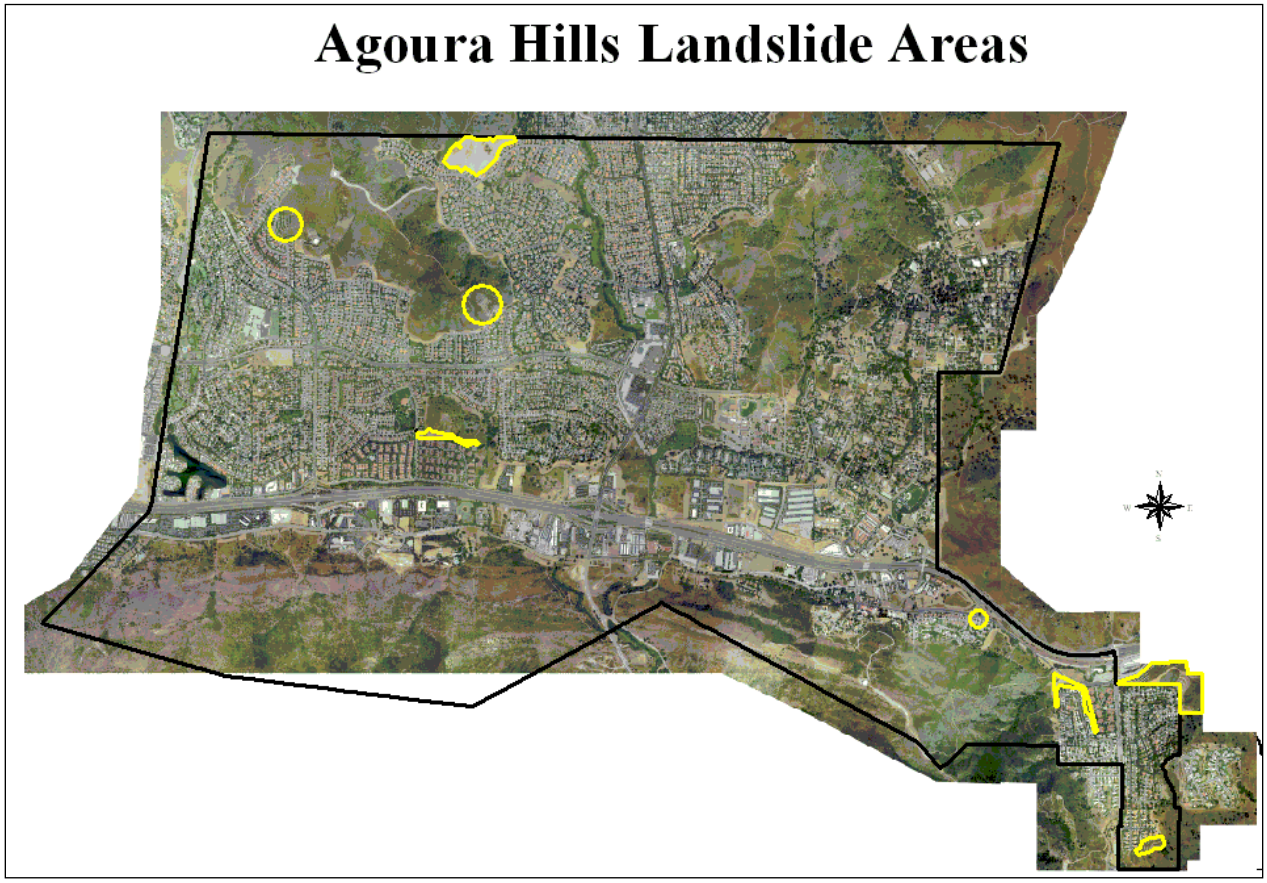
Locations at risk from landslides or debris flows include areas with one or more of the following conditions:

1. On or close to steep hills;
2. Steep road-cuts or excavations;
3. Existing landslides or places of known historic landslides (such sites often have tilted power lines, trees tilted in various directions, cracks in the ground, and irregular-surfaced ground);
4. Steep areas where surface runoff is channeled, such as below culverts, V -shaped valleys, canyon bottoms, and steep stream channels; and
5. Fan-shaped areas of sediment and boulder accumulation at the outlets of canyons.
6. Canyon areas below hillside and mountains that have recently (within 1-6 years) been subjected to a wildland fire.

Potential Landslide Areas

Agoura Hills

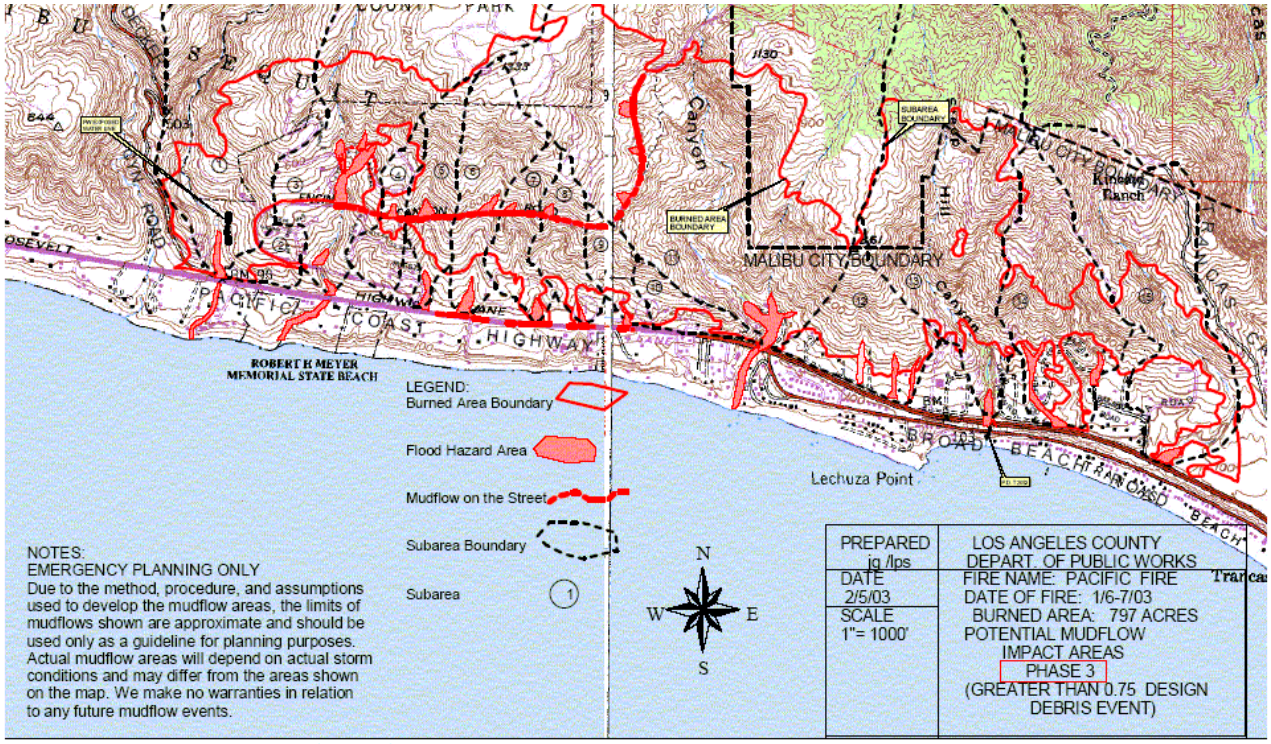
The City of Agoura Hills has identified areas that may be prone to landslides (see Agoura Hills Landslide Areas map on the following page). Yellow boundaries enclose areas that may be prone to landslide events within the City.



Map 48: Agoura Hills Landslide Areas
Source: City of Agoura Hills Internal Map

Malibu

For the City of Malibu, a mudflow risk assessment was conducted by the Los Angeles County Department of Public Works as a result of the Pacific Fire. The fire destroyed much native vegetation and left the soil and terrain vulnerable to absorbing higher than normal amounts of water from rainfall, creating a risk of landslide. The following map shows Phase III of the Potential Mudflow Impact Areas (which reflects a worst case scenario) i.e., greater than .75 design debris event.



Map 49: Potential Mudflow Impact, City of Malibu

Westlake Village

In the City of Westlake Village, potential landslide hazards are primarily limited to areas of sedimentary rocks in the northeast tip of the City. Areas with sediments have moderate to high slope instability potential. Areas with volcanic rocks have moderate to low slope instability potential.

Estimated Impact of an Event

If multiple landslides were to occur, the consequences to local populations and housing could be significant. The table below provides the estimated impact of a disaster using a 0.1% loss baseline.

Category	Agoura Hills	Calabasas	Hidden Hills	Malibu	Westlake Village	Impact if a 1% Loss Occurs
Population	20,330	23,058	1,856	12,645	8,270	66
Total Housing Units	7,681	8,686	606	6,252	3,322	27
Median Home Value	$740,200	$962,700	More than $1,000,000	More than $1,000,000	More than $1,000,000	More than $26M

Table 120: Estimated Population and Economic Loss of Multiple Landslides

Based on a 1% loss projection, more than 66 people could be displaced or significantly impacted and more than 41 homes could be damaged or destroyed resulting in over $26 million in losses (see Community Profile section for population, housing, and economic data).

Landslide Vulnerabilities

Landslides can affect a variety of functions including utility services, transportation systems, and critical lifelines. Communities may suffer immediate damages and loss of service. Disruption of infrastructure, roads, and critical facilities may also have a long-term effect on the economy. Utilities, including potable water, wastewater, telecommunications, natural gas, and electric power are all essential to service community needs. Natural gas pipes may also be at risk of breakage from landslide movements.

Roads

Public Works Departments along with other departments within the cities in the Las Virgenes-Malibu Region are responsible for cleaning-up slides that inhibit the flow of traffic or are damaging roadways. Public agencies can usually only repair the roadway itself, as well as the areas adjacent to the slide. Individual property damage does fall under their immediate attention.

Landslide hazards can be alleviated by grading slides, by: installing load bearing walls on roadsides and installing new drainage systems on slopes to divert water from potential landslide areas. This type of response activity is often the most cost-effective in the short-term, but is only temporary.

Lifelines and Critical Facilities

Landslides can have direct and indirect impacts on lifelines and critical facilities. Closed transportation arteries may result in an inability of hospitals and other emergency facilities to receive and transport patients as well as obtain emergency supplies. Loss of power and telephone service are also potential consequences of landslide events. Soil erosion in hillside areas can undermine the soil supporting high voltage transmission towers and communication networks. Finally, soil displacement can result in pipeline breaks, further exasperating the potential for landslides.

Landslide Mitigation Strategies

LVCOG Mitigation Activities

Landslide mitigation activities include current mitigation programs and activities that are being implemented by local or regional organizations. Building and Zoning Codes provide examples of mitigation activities common to all LVMCOG cities.

Landslide Building/Zoning Codes

All cities within the Las Virgenes-Malibu Region follow the California Building Code. The CBC requires geotechnical investigation of the potential soil liquefaction and soil strength loss during earthquakes for development in the liquefaction zones. The geotechnical reports are to address potential consequences of any liquefaction and soil strength loss and discuss mitigating measures.

Agoura Hills

The City of Agoura Hills has implemented the following regulations in order to provide better preventive measures for loss of life and property due to landslide:

- Requirement for geotechnical and geologic report submittal and review prior to development entitlement.
- Requirement for graded slopes to be landscaped for stability.
- More restrictive slope-setback requirements than the State adopted Building and Residential codes (CBC, CRC).

The following building codes provide examples of how Agoura Hills has enacted preventative measures against loss of life and property because of a landslide.

Section	Title
8103(a) 110.2	Geologic Hazard
8103(u) 1806.5	Foundations on Adjacent Slopes
8103(aaa) 3304.6.11	Debris Prohibited

Calabasas

There have been no significant landslide events in recent history in the City of Calabasas. Consequently, the City currently does not take additional measures beyond standard CBC requirements.

Hidden Hills

The following building codes are implemented as preventative measures for loss of life and property because of a landslide hazard event.

Section	Title
3316	Erosion Control
1806.11	Foundations on Expansive Soil

Malibu

The City of Malibu Building Code addresses development on steep slopes. Generally, the ordinance requires soils and engineering geologic studies for proposed developments on slopes of 20 percent or greater. More detailed surface and subsurface investigations are warranted if indicated by engineering and geologic studies. This may include soils, vegetation, geologic formations, and drainage patterns. Site evaluations may also occur where stability might be lessened by proposed grading/filling or land clearing.

Westlake Village

The City of Westlake Village has identified areas in the city that may have unstable slopes. Engineering/geology soils investigations are required prior to hillside development in unstable slope areas in order to mitigate the loss of property or life due to a landslide.