

**Sonoma County
Hazard Mitigation Plan**

LANDSLIDE HAZARDS

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LANDSLIDE HAZARDS

Hazard Description

The rolling hills, coastal ranges, and steep canyons that characterize Sonoma County's landscape contribute to a widespread landslide hazard. Landslides are described as downward movement of earth materials under the force of gravity. Landslides are also secondary hazard of seismic shaking and can occur during large storms when soils are saturated. Extended periods of intense rainfall during the winter months is the primary cause of landslides in the County.

The main types of landslides that occur in Sonoma County include:

- Slides: Mass movements, along zones of weakness separating the slide material from more stable underlying material.
- Falls: Abrupt movements of rocks or boulders that become detached from steep slopes or cliffs.
- Debris Flows: Rapid mass movement of a combination of loose soil, rock, organic matter, air, and water that flow downslope as a slurry. These are most often caused by heavy precipitation and intense surface water runoff in steep gullies.
- Mudflows: Earthflow consisting of material that is wet enough to flow rapidly and contains at least 50 percent sand, silt, and clay. Mudflows can travel at speeds of 35 mph or greater.
- Creep: Imperceptibly slow, steady, downward movement of soil or rock.
- Coastal bluff erosion: The collapse of coastal bluffs due to undercutting erosive forces of wave action.

The hazard is highest on slopes of thirty percent or greater, but can occur on gentler depending on geologic material, vegetation, and development. Landslides are also likely along coastal cliffs. Natural factors that contribute to landslides include: 1) rock strength; 2) the orientation of joints and planes of weakness in rock formations; 3) the steepness of slopes; 4) degree of saturation of ground materials; 5) and type and density of vegetation.

Human factors that can further cause or exacerbate landslide risks include the over-steepening and overloading of slopes through construction activities, vegetation removal, and improper drainage.

Landslides are a significant tertiary hazard prevalent throughout the region, however they pose a relatively small danger to Sonoma County for several reasons. Landslides tend to be localized in nature. Also, only a small portion, less than 10 percent of the high landslide hazard area has been urbanized. Land use controls (such as prohibiting development on unstable soils or steep slopes) are the most cost effective way to prevent loss of life and property.

Building construction and grading activities are subject to County code that require a geotechnical report or slope stability analysis under specific slope conditions (CBC Sec 1808.7). The Permit and Resource Management Department requires that a site evaluation be conducted prior to building plan check. Geologic maps are reviewed during the site evaluation and where building or grading is proposed in areas mapped with landslides, expansive soils, liquefaction potential, or fault rupture hazards, a geotechnical report is required and design mitigations identified.

Climate Change

Climate change may result in precipitation extremes (i.e., wetter wet periods and drier dry periods). While total average annual rainfall may decrease only slightly, rainfall is predicted to occur in fewer, more intense precipitation events. The combination of a future drier climate creating an increasing in the chance of drought, wildland fires, and the occasional extreme downpour may result in increased size and frequency of mudslides and landslides.

Hazard History

The winters of 1982, 1983, 1986, and 1998 produced significant landslides in Sonoma County. An intense storm in late January 1983 triggered landslides in Blucher Valley, Glen Ellen, and the north Petaluma areas.

The most extreme example of Sonoma County's landslide risk occurred during the El Nino Winter Storms in January 6 – 7, 1998, in the community of Rio Nido. The upper portion of the slide consisted of a large rotational block failure that occurred near the top of the ridge, approximately 600 feet above the elevation of the canyon floor. Two debris flow failures, which are characterized by fluid and high speed downhill flows, were initiated from the face of the block simultaneously with or shortly after the initial rotation of the landslide block. The southern debris flow traveled approximately 1,500 feet down a narrow ravine causing the destruction of three homes and damaging four others in Upper Canyon Three. The northern debris flow traveled down an adjacent drainage ravine north of the homes and came to rest within a long-jam 15 to 20 feet high, located about 800 feet from the canyon floor. Additional debris flows occurred in the same area on February 21 and March 12, 1998 as a result of additional moderate rainfall (McCormick, 1998).

Residents were evacuated until the stability of the slides could be determined. Geologic studies were performed and movement of the slides monitored for years. Evacuation zones maps were periodically revised and residents gradually permitted to return to some areas. Other damaging slides occurred in the communities of Monte Rio, Gold Ridge, Hidden Acres, Blucher Valley, Fitch Mountain, and the coastal community of Gleason's Beach.

The widespread damage caused in both northern and southern California prompted the Federal Emergency Management Agency (FEMA) and CalOES, formerly Cal EMA, to initiate the first federally funded landslide acquisition program. The program was designed to permanently remove the properties destroyed, damaged, or still at risk from the landslides. Sonoma County received funds for the acquisition of 45 properties in the four communities that suffered the greatest damage.

Landslides and coastal erosion both play a role in threatening development along the Sonoma County coast. In some areas west of State Highway 1, such as Gleason's Beach, dwellings and septic systems have been built on or near the edge of sea cliffs and on steep slopes. Landslides, in conjunction with wave action have resulted in seawall failure severe erosion, cliff failure, and loss of bluff top area that threaten the development. Lots have been significantly reduced in size in the last 25 years, several houses have been damaged to the extent that they are no longer habitable.

Poor road design and construction can contribute to landslide hazards through side-casting on sloping lands, over steepened cut slopes and inadequate drainage facilities. State Highway 1 along the North Coast has had major landslides and erosion to the extent that the road is frequently closed for repair by Caltrans. The County Department of Transportation and Public Works also conduct slide repair and debris removal as needed. The size and number of landslides varies but typically 50 landslides occur each winter that block County roads. The River Road landslides repair required extensive grading and excavation and installation of numerous drains to dewater and stabilize the slope.

Future Potential

Areas of high hazard from earthquake-induced landslides are delineated in the CGS Landslide Study Zones in Figure 8.11. The landslide map indicates areas of high and low landslide potential based on slope and earth materials; however, the risk of landslide would increase if these areas are subject to either strong earthquake shaking or ground saturation. Landslide risks increase significantly when rainfall saturates soil on steep slopes, triggering mud or debris flows. As mentioned previously, the most extreme example of Sonoma County's rain induced landslide risk occurred during the El Nino Winter Storms in January 1998, in the community of Rio Nido. Figure 8.12 shows the areas of the county with high annual rainfall.

In Sonoma County, the hillside areas in both the incorporated and unincorporated areas pose a significant landslide risk to property and infrastructure. This makes much of the County highly susceptible to landslide hazards. Historic landslides are the best indicator of where landslides may occur in the future, unless the conditions that contributed to the prior landslide have been mitigated. Current County codes prohibits construction of new structures on known landslide areas. However, existing development and their communities, such as Monte Rio and Rio Nido with histories of damaging landslides, remain at risk from future events.

Exposure and Vulnerability

Methodology

This section examines the exposure and vulnerability of important elements of Sonoma County to landslide risk. The term exposure refers to the number of facilities, their value, and the functions they support that are located in areas at risk of landslides. The term vulnerability refers to how likely each of those facilities is to be damaged if impacted by a landslide. Whenever possible, facilities exposed to landslide risk are listed and their values are presented. For each of the facilities examined, all available information was collected from the County and

other sources, including GIS maps, databases, reports, and studies. A detailed explanation of the data sources and analysis techniques used for analyzing each type of facility is presented in Appendix C.

Areas that are vulnerable to landslide hazards contain hundreds of homes, businesses, government offices, structures, roads, sidewalks, underground utilities (water pipes, sewer lines, storm drains, natural gas lines, conduits) and aboveground utilities (electricity, telecommunications, cable); many of which are critical for emergency access and evacuation. As development spreads into the County's hilly regions, the potential for damage, casualties, and economic losses increases.

Facilities listed in this HMP as being at potential risk of landslide were identified by review of California Geology Survey landslide hazard maps (this data was also used to develop the General Plan Public Safety Element Landslide Hazard Areas). These maps incorporate slope steepness, geology, and vegetation cover, to identify parcels within high landslide risk areas. It was not possible to assess whether individual facilities within a parcel were located in high landslide risk areas. Critical facilities incorporate essential facilities such as emergency operations centers, police and fire stations, hospitals and shelters; transportation systems; lifeline utility systems; high potential loss facilities, such as dams; and facilities housing hazardous materials. Some of these facilities are owned and operated by the County, others are operated by other government jurisdictions or private entities. All critical facilities are discussed here, but those that are the direct responsibility of the County are examined in detail.

Emergency Response Buildings

Fire stations located in parcels that face significant landslide risk are listed below. Determining the actual landslide risk of these fire stations would require a site specific evaluation.

- Camp Meeker Volunteer Fire Company, Bohemian Highway station
- Mayacamas Volunteer Fire Company, Cavedale Road station
- Cazadero Community Services District, Austin Creek Road and Cazadero Highway stations
- Monte Rio Fire Protection Department, Highway 116, Main Street, and Highway 1 stations
- Glen Ellen Fire Protection Department, Sonoma Mountain Road station
- San Antonio Volunteer Fire Company, Petaluma Blvd South station
- Sonoma Valley Fire and Rescue Authority, Prospect Drive station

Emergency Communications System

Four communication towers and antennas are located in rugged terrain that could experience landslides. However, the communications system is designed to be functional even after the loss of one or more antennas, and it is unlikely that landslides could significantly reduce communications effectiveness.

Roads and Highways

Landslides can damage roads or block roads with rocks, mud and other debris create barriers. Roads may be impassable until debris is cleared and the hillside above is stabilized. Roads on top of, or cut into, a hillside can be damaged in a landslide. Injury and death can occur when vehicles, bikes, or pedestrians are present on a road affected by a landslide. Landslide repair requires rebuilding the road bed as well as stabilizing the hillside. County roads that are most frequently blocked are listed below:

- Geysers Road
- Stewarts Point Skaggs Spring Road
- River Road Cazadero Highway
- Bohemian Highway
- Porter Creek Road/ Mark West Spring Road
- Steep hillside residential streets, in the Guerneville to Monte Rio area
- Calistoga Road
- Westside Road
- Fort Ross Road
- Chalk Hill Road
- North and South Fitch Mountain Road
- Ida Clayton Road

State and federal highways pass through areas with high landslide risk and occasionally experience damaging landslides. The frequency and impact of slides on these roads is variable. State and federal highways that cross through areas most at-risk of landslides are listed below.

- Highway 1, many locations between Marin County border and Fort Ross
- Highway 116, between Jenner and Guerneville
- Highway 116, west of Temelec
- Highway 128, north of Cloverdale
- Highway 128 near Kellogg

SCWA Water Systems

The SCWA analysis of geologic and regional landslide hazard maps indicate that most of the system components lie outside of active landslide areas with only a few locations susceptible to landslide hazard, such as a portion of the Santa Rosa aqueduct near the collectors; a small section of the Russian River-Cotati Intertie south of Forestville tanks; and areas near the Kastania, Eldridge, Cotati, and Annadel No. 2 tanks. However, more detailed assessments concluded that the landslide hazard at these locations is low.

Other Utilities

Landslides potentially threaten utilities that serve Sonoma County residents, including water, sewer, electricity, natural gas, telephone, and cable services. Distribution lines for each of these utilities may be disrupted locally when landslides occur. Larger areas of service could be disrupted if transmission lines or important facilities are impacted. At least three PG&E substations (Fort Ross, Eagle Rock, and Geysers) are located in areas at potential risk of

landslides. The Geysers geothermal generation plant, a source of energy to the power grid, is also located in a potential landslide risk zone.

Hazardous Materials Sites

The County has many sites containing hazardous materials. These sites include drycleaners, gas and service stations, agricultural sites, industrial sites, and high-tech facilities. The majority of the sites are clustered along Highway 101 or associated with the Geysers geothermal field. There are nearly 50 hazardous materials sites located in areas at potential risk of landslides, including the Geysers geothermal generation plant. A hazardous materials spill could cause environmental damage and complicate landslide clean-up efforts.

Schools

Nine public schools and three public school office buildings are located in areas that are potentially at risk of landslides. Four private schools are also located in potential landslide risk zones. Site specific investigations have not been conducted on individual buildings and actual risk is not known.

County Buildings

County-owned buildings that are potentially at risk from landslides are identified in Appendix G, County Facilities Hazard Exposure Inventory. The actual risk of damage by landslides to each of these facilities is not known and would require a site-specific geologic investigation to assess.

People and Private Buildings

An estimated 19,200 people in unincorporated Sonoma County live in areas potentially at risk of landslides, representing five percent of the population. About 6,500 privately owned buildings are located in areas with potential landslide risk. The estimate of the number of private buildings includes commercial, multi-family residential, and single family residential buildings greater than 1,000 square feet. The use of these buildings is not known, but assuming an average replacement value per square foot of \$150, this represents an economic value of about \$2.6 billion.

Many landslides move very slowly and damage foundations and other structural elements over a period of years. This type of landslide result in costly damage but is usually not life-threatening. Debris flows and mudslides occur quickly, threatening life safety and causing rapid, devastating damage to structures. Proper foundation design can minimize landslide risk, but all structures on unstable slopes could experience damage.

Impact and Loss Estimates

A severe rainstorm or strong earthquake shaking could cause dozens of simultaneous slope failures threatening buildings and infrastructure. Areas at highest risk include Monte Rio, Rio Nido, Jenner at the sea wall, Fitch Mountain and Gold Ridge. The Sonoma County Operational Area Emergency Operations Plan estimates that the Costs of damage and emergency response to the Rio Nido landslides in 1998 at \$28 million. If numerous simultaneous events of this type were to occur in various locations of the County, costs of several times this amount could be expected.

Plans

Sonoma County General Plan 2020

California State law requires each County to prepare a General Plan to set forth community policies to guide development of the county and the distribution of future land uses, while protecting and maintain the public health, safety and welfare. Sonoma County adopted a new updated general plan, in September of 2008. The Hazard Mitigation Plan guides land use and development decisions. Land use or zoning changes, development proposal review, use permits, subdivisions, capital improvement plans, must be found consistent with the general plan before they can be approved.

The General Plan includes a Public Safety Element, which includes goals and policies to reduce damage from geologic hazards and establishes the following goal:

- GOAL PS-1: Prevent unnecessary exposure of people and property to risks of damage or injury from earthquakes, landslides and other geologic hazards.

The Safety Element includes mapping of “High” and “Very High” landslide hazard zones as identified in the County’s 2011 Hazard Mitigation Plan and Safety Element policies (See Appendix B). Policies include requiring preparation of site-specific geologic studies to assess development proposals risk from slope failure or contribution to increased potential for landslides.

Codes and Regulations

California Environmental Quality Act (CEQA)

Prior to any action on a discretionary project subject to CEQA, the lead agency must conduct environmental review of the proposed project including assessing whether the project would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving landslides,
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse, and/or
- Be in an area affected by “mudflow”
- Building and Grading Ordinances

The County has adopted the state-mandated California Building Code, Chapter 7 of the Sonoma County Code, to ensure structures are properly sited and designed to ensure life-safety. The code is applied to all new construction and to substantial renovations to existing structures. The County Code includes up-to-date standards for site preparation, design, materials, and construction methods to minimize risk from landslides. Building officials can require detailed geotechnical investigations to confirm the level of landslide hazard at proposed development

sites. The county may issue a construction permit in hazard areas only when appropriate mitigation measures are incorporated into the project to reduce or avoid landslide hazards.

Zoning Codes: Coastal Zoning

The County's coastal zoning requirements are contained in Chapter 26C of the County Code. The ordinance regulates land use type and density, allowed uses, permit requirements, and design standards and operation of development in the Coastal Zone consistent with the Sonoma County Local Coastal Plan and the California Coastal Act.

Structures designed for human occupancy in coastal areas of high landslide risk require special review and approval for grading, site preparation, drainage, and foundations. Plans must be prepared by a registered professional engineer. The ordinance provides standards for sediment basins, settling ponds, ditches, levees, dikes, culverts, and erosion control and streambank protection measures.

Mitigation Programs and Activities

County Landslide Maintenance

The County Department of Transportation and Public Works (DTPW) routinely repairs damage on public roads and schedules road and drainage maintenance projects in known unstable areas. Numerous landslides occur each winter that block County roads. These range from large slides that impede traffic for several days, to minor slides that can be cleared in a short period of time. The DTPW clears landslides and debris falls that obstruct any County roads and repair structures as needed. Debris must be cleared to a location where it will not impact water quality or fish habitat. The County spends an estimated \$150,000 per year on landslide clean-up and repair. These response costs are considered more beneficial and cost-effective than mitigating potential landslides.

Financial Resources

Geologic Hazard Abatement Districts

A Geologic Hazard Abatement District (GHAD) is a potential approach to reducing geotechnical problems associated with development in geologically active areas such as high erosion, unstable slopes, or coastal erosion. Established by the Beverly Act in 1979, a GHAD is an independent public entity formed as a Board of Directors which oversees the prevention, mitigation, and abatement of geologic hazards. A GHAD provides a funding mechanism for planning and mitigating geotechnical risk.

The public entity has similar authority to tax and bond and certain legal immunity as do other public agencies. Funding of the GHAD is through supplemental property tax assessments. A GHAD was proposed for shoreline protection and bluff stabilization for the Gleason Beach community in 2003, but was not adopted.

Other Potential Funding Resources and Key Entities

Additional potential multi-hazard funding sources are identified in Chapter 1 (Introduction) of this Hazard Mitigation Plan. Key Local, State and Federal agencies and nongovernmental entities who play a key role in landslide mitigation are identified in Chapter 3 (Seismic Hazard) and Chapter 1 (Introduction) of this Hazard Mitigation Plan.