California Geological Survey

CGS Note 33

Hazards From "Mudslides"...Debris Avalanches and Debris Flows in Hillside and Wildfire Areas

- ***The single most important action that should be taken by residents on rainy nights is NOT to sleep in lower-floor bedrooms on the sides of houses that face hazardous slopes.***
- ***More than 100 Californians have been killed by debris flows during the past 25 years.***
- ***Most of these 100 deaths occurred when debris flows buried persons who were sleeping in lower-floor bedrooms that were adjacent to hazardous slopes.***

Sudden "mudslides" gushing down rain-sodden slopes and gullies are widely recognized by geologists as a hazard to human life and property. Most "mudslides" are localized in small gullies, threatening only those buildings in their direct path. They can burst out of the soil on almost any rain-saturated hill when rainfall is heavy enough. Often they occur without warning in localities where they have never been seen before.

The ashy slopes left denuded by wildfires in California are especially susceptible to "mudslides" during and immediately after major rainstorms.

Those who live downslope of a wildfire area should be aware of this potential for slope failure that is present until new vegetation rebinds the soil.

What Are Debris Avalanches and Debris Flows?

Debris avalanches and debris flows (both popularly called "mudslides") are shallow landslides, saturated with water, that travel rapidly downslope as muddy slurries. The flowing mud carries rocks, bushes, and other debris as it pours down the slopes.

A debris avalanche (Figure 1) is a fast-moving debris flow that travels faster than about 10 mph or approximately 25 yards in about 5 seconds. Speeds in excess of 20 mph are not uncommon, and speeds in excess of 100 mph, although rare, do occur locally.

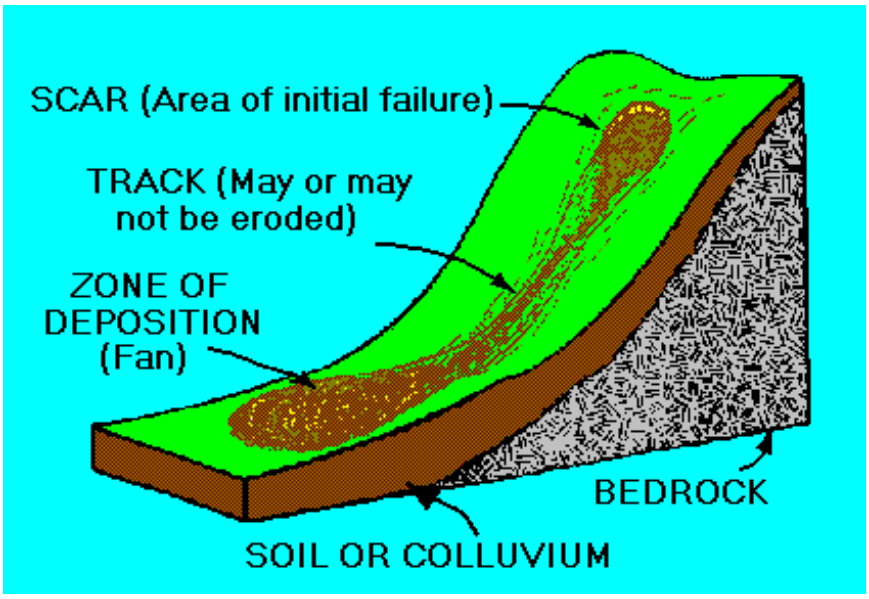

Figure 1. Sketch of a typical debris avalanche scar and track. Although this figure shows the "zone of deposition" as quite near the source, debris avalanches can travel thousands of feet or, in exceptional cases, miles from the point of origin. Original drawing by Janet K. Smith.

What Dangers Are Posed by Debris Avalanches?

Debris avalanches pose hazards that are often overlooked. Houses in the path of debris avalanches can be severely damaged or demolished. Persons in these structures can be severely injured or killed.

Most rainstorms are of such low intensity that they do not trigger debris avalanches. Some intense storms may trigger only a few debris avalanches. However, when the ground is already saturated from previous rain, even relatively short high-intensity rainstorms may trigger debris avalanches. For example, in January 1982, an intense rainstorm triggered literally tens of thousands of debris avalanches in the San Francisco Bay Area. These 1982 debris avalanches caught people unaware and caused 14 deaths and many injuries and destroyed or damaged several hundred homes and other structures.

What Causes Debris Avalanches and Debris Flows?

The most common cause of debris avalanches and debris flows is the combination of heavy rainfall, steep slopes, and loose soil. Most fairly steep slopes have enough soil and loose rock for potential landslides. Although "stable" when dry, such slopes can produce local debris flows, often without warning.

Normally the source of the excess water is intense rainfall, although broken water pipes or misdirected runoff concentrated by roads, roofs, or large paved areas may trigger, or help to trigger, debris avalanches and debris flows. In California, most debris flows occur during wet winters.

Where Do Debris Flows and Debris Avalanches Occur?

Debris avalanches occur all over the world. They are particularly common in mountainous areas underlain by rocks that produce sandy soils. Debris avalanches have been noted in southern California during at least nine rainy seasons since 1915. They have occurred in northern California during at least 14 rainy seasons since 1905.

Debris flows are known to start on slopes as low as 15 degrees, but the more dangerous, faster moving flows (debris avalanches) are more likely to develop on steeper slopes. About two-thirds of all debris avalanches start in hollows or troughs at the heads of small drainage courses. Typically, a debris avalanche bursts out of a hillside and flows quickly downslope, inundating anything in its path. Because the path of a debris flow is controlled by the local topography just like flowing water, debris avalanches and debris flows generally follow stream courses.

Slopes burned by range and forest fires are especially susceptible to debris avalanches and debris flows because of the absence of vegetation and roots to bind the soil. The areas directly downslope are especially subject to damage from debris flows.

What Can Be Done to Avoid or Reduce the Hazard Posed by Debris Avalanches?

To be safe, assume that all drainages in steep, hilly, or mountainous areas are capable of carrying debris flows, especially if relatively loose, sandy soils are present in the watershed. Areas that have been burned by regional fires are especially vulnerable.

Avoid building sites at the bottoms and mouths of steep ravines and drainage courses. These areas are the most likely to be inundated by debris flows. The outer "banks" of bends along such ravines also should be avoided because swiftly flowing debris avalanches can "ride up" out of the bottom of the stream channel where it bends.

Avoid building on or below steep slopes. In general, the steeper the slope the greater the risk. If these areas must be used, consult with a soils engineer and an engineering geologist. These specialists will be able to evaluate the potential for mudslide problems and give advice on the best way to minimize the risk to life and property.

The hazard from debris flows that occurs in modified slope cuts can be decreased by: 1) limiting the height and slope of cuts and fills; 2) properly compacting fills and keying them into bedrock; and 3) properly controlling the flow of water onto slopes.

If steep cuts or fills occur below the discharge points of runoff water from streets, downspouts, or similar drainage facilities onto a slope, it may be wise to obtain advice from an engineering geologist or erosion control specialist.

In some cases, walls can be built to deflect potential mudflows away from or around structures (Figure 2). To be effective, diversion walls must be properly designed and regularly maintained.

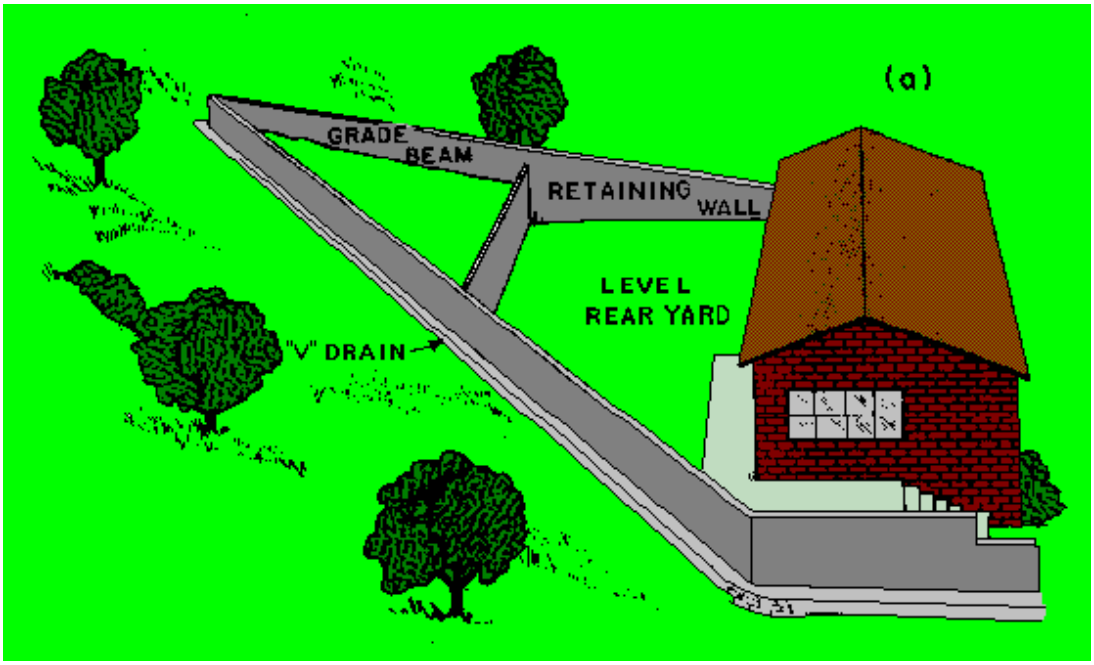

Figure 2. Methods to reduce the hazard from debris avalanches include construction of a) deflection walls and b) debris fences. Because of the extreme force of impact associated with debris flows, these and similar structures should be carefully engineered and constructed. The specifics of these designs will vary from site to site (After Hollingsworth and Kovacs, 1981.)

"Mud Floods" and "Debris Floods" Pose Hazards, Too

Residents living directly downslope of mountainous wildfire areas should be aware that, in addition to life-threatening potential debris flows and other forms of mass movement, there is another, perhaps deadlier hazard-- debris flooding or mud flooding at and near the mouths of channels that drain burned-over, ashy slopes. Studies have shown that, in the first year following a wildfire, sediment yields and peak discharges or such streams can increase up to 35-fold. Thus occupants of dwellings near such drainage channels could be endangered by floods that incorporate enormous amounts of debris and mud washed off the burned hillsides.

Tips and Clues That May Save Your Life...

- Mitigation of hazards from debris flows and debris avalanches through construction of permanent engineering measures takes considerable time and money. In the meantime, preparation for rapid evacuations should be made.

- Before and during rains, frequent inspection of the slopes (above vulnerable sites) for extension cracks and other symptoms of downslope movements of slope materials can be a guide to impending failure and a warning to evacuate. In particular, watch for new springs or seeps on slopes; cracks in snow, ice, soil, or rock; bulges at the base of slopes; the appearance of holes or bare spots on hillsides; tilting trees; or increased muddiness of streams. Any sudden increase in runoff is cause for concern.

- Listen for unusual rumbling sounds or noises that may indicate shifting bedrock or breaking vegetation or structures.

- Stay alert to the amount of rain falling locally during intense rainstorms. Buy a rain gauge (an inexpensive plastic one will suffice) and install it where it can be checked frequently.

- Whenever rainfall has exceeded 3 or 4 inches per day or ¼ inch per hour, the soil may be waterlogged and more rain can trigger mudflows.

- Again, the single most important action that should be taken by residents on rainy nights is NOT to sleep in lower-floor bedrooms on the sides of houses that face hazardous slopes. More than 100 Californians have been killed by debris flows during the past 25 years. Most of these 100 deaths occurred when debris flows buried persons who were sleeping in lower-floor bedrooms that were adjacent to hazardous slopes.

Where Can More Information Be Obtained?

For general information about debris avalanches and other kinds of landslides, contact your city or county geologist, or any office of the California Geological Survey.

For an assessment of the landslide risk to an individual property or homesite, obtain the services of a state-licensed engineering geologist (see the Yellow Pages of the telephone directory). The California Geological Survey does not perform individual site assessments or recommend particular consultants.

For more information about the design and construction of debris basins, debris fences, deflection walls, or other protective works, consult your city or county engineer, local flood control agency, or the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS).

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