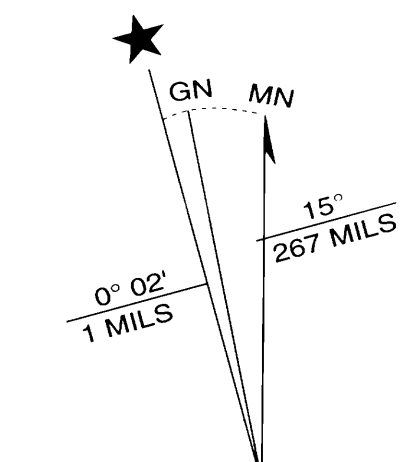
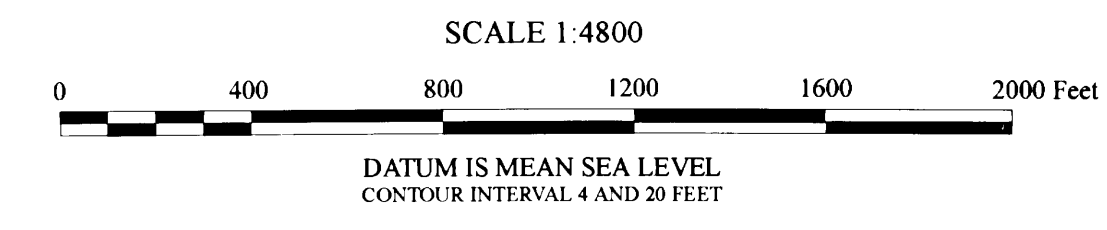


Topographic Base by San Bernardino County Flood Control



**PLATE A-2**

**MAP SHOWING RELATIVE ROCKFALL SUSCEPTIBILITY OF THE FOREST FALLS AREA, SAN BERNARDINO COUNTY, CALIFORNIA**

**ROCKFALL AND STREAM-RELATED DEBRIS-FLOW HAZARDS OF THE FOREST FALLS AREA, SAN BERNARDINO COUNTY, CALIFORNIA**

**Landslide Hazard Identification Map No. 43**

by

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**EXPLANATION**

**Introduction**

Plate A-2 documents areas that may be susceptible to hazards from rockfall, especially earthquake-triggered rockfalls, in the Forest Falls community.

Rockfall is the collapse of bedrock from very steep slopes. Rockfall is the most rapid form of slope failure and is most common in mountainous areas. Abundant rockfalls are commonly triggered simultaneously by strong earthquake shaking, often causing life-threatening situations.

The Forest Falls area was affected by a series of rockfalls triggered by the M<sub>s</sub> 6.4 Big Bear earthquake of June 28, 1992 at 8:05 a.m. (3 hours after the M<sub>s</sub> 7.3 Landers earthquake). As a result, large boulders cut paths in several places down the southern slope of the area and came to rest near homes, outbuildings, water tanks, and other structures close to the base of the slope. The earthquake shook loose boulders of granitic rock, some with diameters of 8 to 30 feet. The boulders weigh between 50 to 250 tons and have volumes ranging between 500 to 3,000 cubic feet.

**Previous Work**

The following background on the regional conditions in the Forest Falls area comes from Tan (1990; cited on Plate A-1). A Special Note for Area 4 (most susceptible to landslides) summarizes the conditions:

"The extremely steep and high slopes... on the mountain range south of Forest Falls... are highly susceptible to debris flows, rock slides, rock falls... due to (a) nearly vertical slopes; (b) high slope relief (up to 5,000 feet); (c) presence of colluvium, landslide deposit, rock debris, and (d) seasonal water saturation of these loose deposits resulting from annual snowfall and rainy periods. Developments at the toe/base of these very steep and high relief slopes, such as the Forest Falls community, may be subject to these potential hazards."

**Methods**

In response to a request by the County of San Bernardino, additional studies were performed, including mapping of rockfall boulders and aerial photograph analysis of potential rockfall source areas. Field surveys were made to plot large boulders, both those displaced by the Big Bear earthquake and by previous seismic events, or possibly by rock debris flow/floods. Potential source areas for large blocks high on the southern slope of Mill Creek canyon that could contribute to hazardous rockfall were also identified.

Plate A-2 depicts the relationship of the rockfall hazard areas (I and II) to the topographic conditions and the upslope/potential source area (IIA) for rockfall. The limits of the hazard areas are based on interpretations and inferences about the conditions necessary for very large rockfalls to occur. Therefore, the map should be used: (a) with consideration of local features at any particular site (such as presence of deflecting ridges or minor topographic features); and (b) recognition that earthquake shaking from very large or threshold events may be necessary to trigger very large blocks.

The rockfall hazard areas within urban Forest Falls are divided into the following categories (relative rockfall susceptibility areas):

**Area I: Generally Susceptible Rockfall Area**

This area is at and near the base of north-facing slopes outside Area II. This area is susceptible to rockfall that originates from any part of the slope. Although these rockfalls are expected to be less hazardous because of smaller boulders than the ones in Area II, they could endanger life and damage property.

**Area II: Most Susceptible Rockfall Area**

This area is at and near the base of the north-facing slopes below potential source area (IIA) and is highly susceptible to rockfall originating from this area. Area II typically contains larger boulders than those found in Area I. These larger boulders are potentially more damaging to property and lives. Area II contains all rockfall boulders larger than 8 feet in diameter plotted on Plate A-1.

**Area IIA: Potential Source Area**

This area consists of a 300-to-600-foot high, nearly vertical surface of bare jointed or fractured, generally massive, and essentially unweathered granitic rock. Large blocks can break loose during strong seismic shaking. The top of the most prominent cliff of fractured rocks is typically 800 to 1000 feet above the residential district. During strong seismic shaking, large blocks are loosened from the steep cliff face and fall. During the Big Bear earthquake, the blocks came from the source area designated on this plate as Area IIA (see Photos 4 and 5 in Barrows, 1993; cited on Plate A-1). Apparently, blocks of rock that originate at higher elevations (higher than 1000 feet above the impacted area at the base of the slope) break into smaller fragments during the fall.

**Special Note:** Future earthquakes (stronger than M7.5) could shake loose much larger, more hazardous blocks from higher elevations at greater speeds, that could impact a much larger area than Area II. The San Andreas Fault System, which is capable of very large earthquakes, passes through Forest Falls (see Plate A-1). The large blocks that were dislodged during the Big Bear earthquake came from outcrops along a trend of a branch of this fault system. No surface rupture along this fault was observed (the area is inaccessible).

**Conclusions**

- Hazard from rockfalls threatens most of the southernmost structures in Forest Falls; more than a dozen homes were affected by the June 28, 1992 earthquake. Blocks that might fall cannot be specified or predicted; nevertheless, the areas most threatened are outlined on the Rockfall Susceptibility Map (Plate A-2).
- Investigations should be conducted to determine mitigation to reduce the rockfall hazard to the community. A possible strategy could be to intercept the falling blocks and retard their movement while not creating major environmental disturbance. Mitigation of this hazard might include sidetail benches as collectors or landing areas to absorb and reduce the energy of the major falls, along with various types of barriers (such as walls, fences, cables, mesh nets, etc.) to prevent blocks from hitting homes and other structures. One alternative is to install a series of cable barriers by using existing large pine and cedar trees as supports at various levels on the slope. Mesh nets placed at the surface of outcrops that may be potential rockfall sources may reduce rockfalls endangering lower lying residential areas.
- All homeowners, landowners, occupants, or tenants in hazard Area II should be informed of the potential rockfall hazards. In addition, the potential for rockfall hazard should be disclosed to future buyers or occupants of homes prior to sale or occupancy.
- Hazardous rockfalls involving very large blocks apparently only happen during sufficiently strong earthquake shaking, which does not occur frequently. Because the San Andreas Fault System (see Plate A-1), the most prominent active fault system in California, passes through Forest Falls, careful consideration should be given to rockfall hazard in future preparedness and development decisions for this area.

**Acknowledgments**

We would like to acknowledge the contributions and guidance of Allan G. Barrows (Division of Mines and Geology). We would also like to thank Westly A. Reeder, San Bernardino County geologist for suggesting this study and providing advice.

**SYMBOLS**

- I** Generally Susceptible Rockfall Area
- II** Most Susceptible Rockfall Area
- IIA** Potential Source Area
- ↗ Inferred Direction of Rockfall
- Upslope Boundary for Area IIA

**NOTE:** This is not an Official Seismic Hazard Zone Map under the provisions of Chapter 7.8 of the California Public Resources Code.

