

**SUMMARY**

The heavy rains of the El Niño winter of 1997-98 resulted in at least 119 damaging landslides of various types in Contra Costa County. Two patterns in the county wide distribution of landslides were observed. Many landslides occurred during or soon after the heaviest rains in early February. However, information on the timing of a majority of the landslides is unavailable. A preliminary estimate of \$27 million in damage caused by landslides includes both public and private direct costs.

The damaging landslides were for the most part slump-earthflows or debris slides, but also included several debris flows and at least one rock fall. Failure of artificial fill material contributed to the damage caused by landsliding at many locations. However, the interaction between fill and underlying materials was not explored. Although a variety of other human factors contributed to much of the damage, no attempt has been made to discriminate or evaluate the effect of human development on the occurrence of landslides.

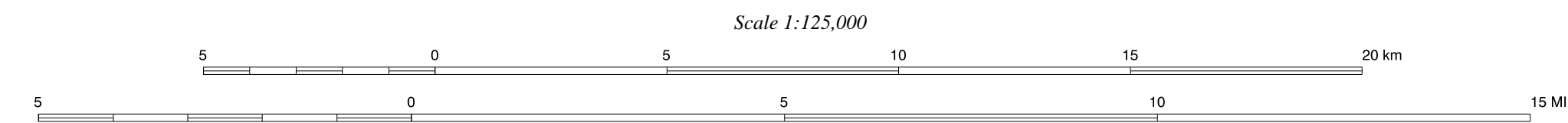
More damage from landslides occurred in the heavily developed western and northern parts of the County than in the less developed south and east parts. Geology was also a factor. Comparison of landslide locations with a geologic map of the county indicated that almost half of the observed damaging landslides occurred in only four lithologic units: Miocene Orinda Formation (20 landslides), Miocene unnamed sandstone and conglomerate (15 landslides), Eocene Markley sandstone (11 landslides), and an unnamed Cretaceous sandstone and shale unit (12 landslides). Although this concentration suggests a correlation between landsliding and bedrock, the focus of the study on damaging landslides rather than all landslides precludes any definitive conclusion about bedrock-landslide relations. Only two areas received the concentrated rainfall necessary for debris flows: the Black Diamond Regional Park area north of Mount Diablo and the area north and south of Highway 4 west of Martinez.

Approximately 70 percent of the direct-cost damage in Contra Costa County was caused by landslides that affected public infrastructure (electric, gas, water, and sewer lines as well as roads). Six houses and two small apartment buildings were red-tagged in unincorporated areas of the county (Contra Costa County does not use yellow tags, but at least three additional houses in the area of red-tagged houses were visibly damaged or unoccupied). "Tagged" structures are those that have been either condemned (red) or in need of significant repair (yellow). In all but

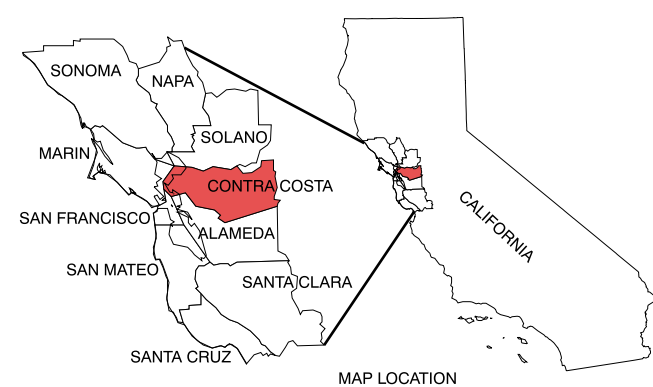
one case the structures probably are a total loss. For the most part the land value as well as that of the structure will be sacrificed, leading to an estimated direct cost of at least \$7.5 million to structures and land value in unincorporated areas. Work on landslides affecting county roads had a direct cost of about \$3 million, according to the County Office of Public Works. Figures for damage in incorporated areas of the county, as well as to freeways and state highways, were unavailable at the time of the inventory, and a general estimate by the first author of damage to state, municipal and park infrastructure was used to compile the total figure of \$27 million.

**EXPLANATION**

- Location of damaging landslide. The number identifies the landslide in the database. Data on file with authors, USGS, Menlo Park, California and Golden, Colorado.



Scale 1:125,000  
Universal Transverse Mercator Projection  
Zone 10



**MAP SHOWING LOCATIONS OF DAMAGING LANDSLIDES IN CONTRA COSTA COUNTY, CALIFORNIA, RESULTING FROM 1997-98 EL NIÑO RAINSTORMS**

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Digital data prepared using ARC/INFO 7.1.2 running under Solaris 2.6 on a UNIX workstation. Map formatted using Adobe Illustrator 8.0 running under Mac OS 8.6.

Shaded relief base derived from Graham, S.E., and Pike, R.J., 1997. Shaded Relief Map of the San Francisco Bay Region. California, U.S. Geological Survey Open-File Report 97-745-B.

Any use of trade, product or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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This map was produced on request, directly from digital file, on an electronic plotter. It is also available as a PDF file at <http://greenwood.cr.usgs.gov>

For sale by U.S. Geological Survey Information Services Box 25286, Federal center, Denver, CO 80225.