## Debris Flows Triggered by the El Niño Rainstorm of February 2-3, 1998, Walpert Ridge and Vicinity, Alameda County, California

Jeffrey A. Coe *and* Jonathan W. Godt 2001



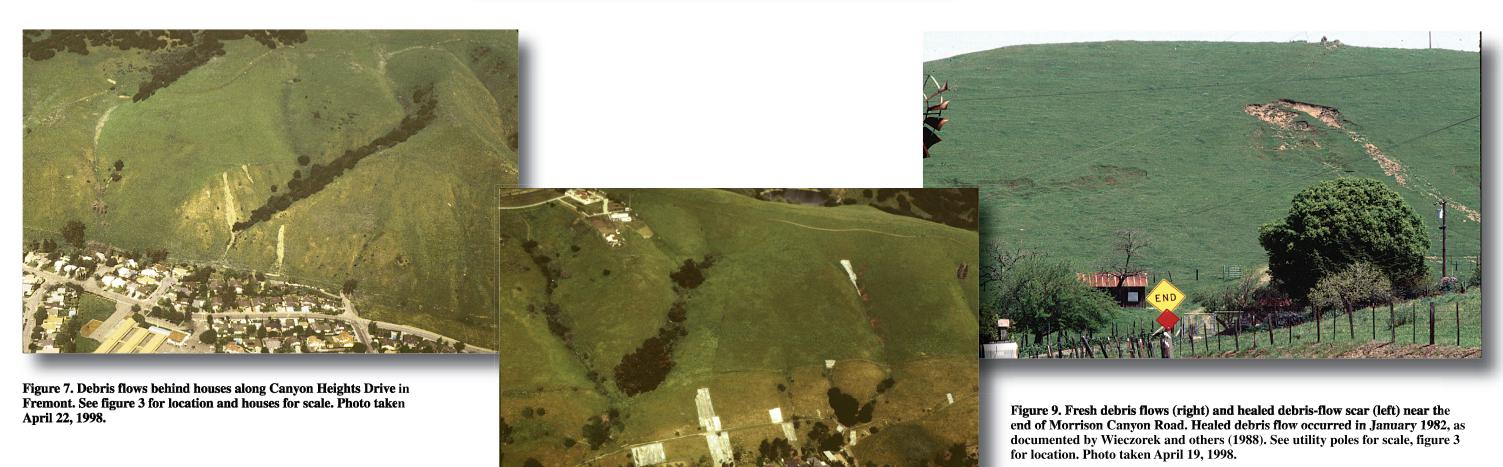


Figure 8. Plastic-covered debris flows above Faircliff Street in Hayward. Flooding and(or) blockage of the v-shaped ditch near base of the hillslope may have contributed to triggering some of the debris flows (see table 2). See figure 3 for location and houses for scale. Photo taken April 22, 1998.

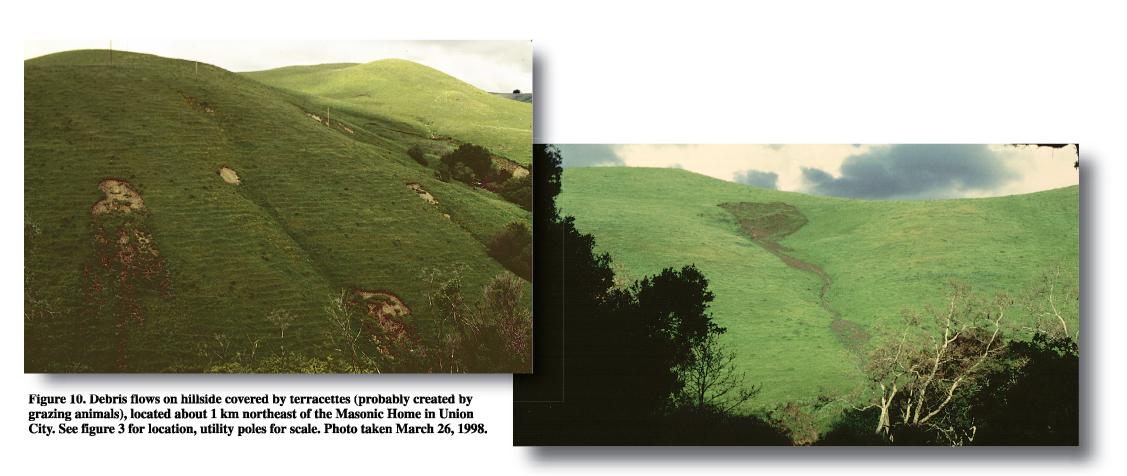


Figure 11. Debris flow mobilized from the toe of an earth flow in Garin Park. See figure 3 for location. Horizontal distance from headscarp to distal end of deposit is about 23 m. Photo taken April 23, 1998.

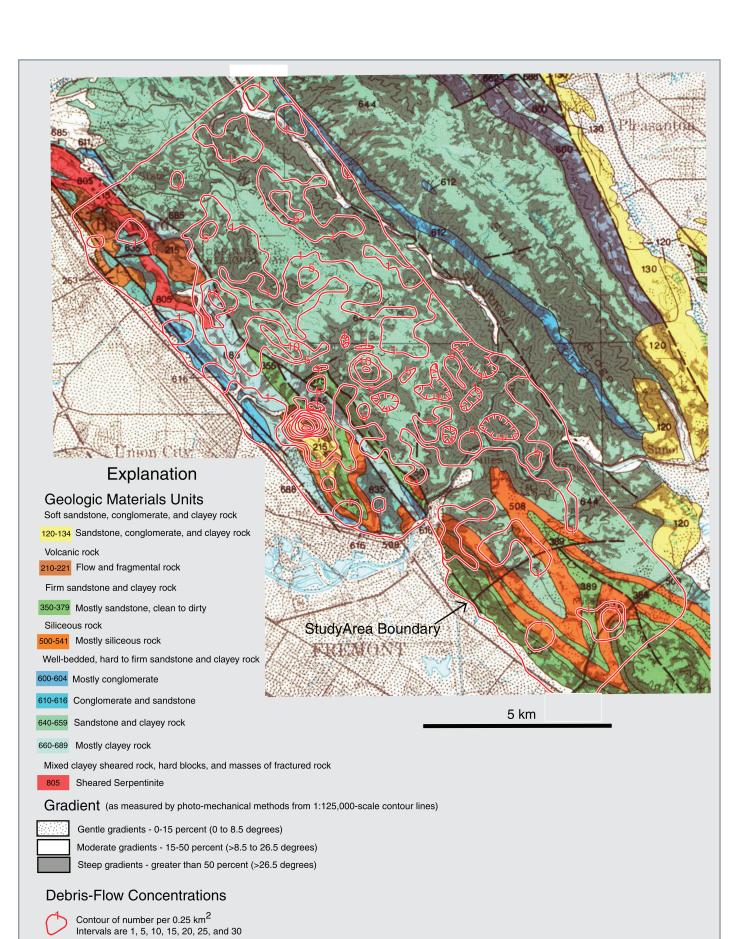


Figure 12. Debris-flow isopleths overlain on map of geologic materials and gradient by Ellen and Wentworth (1995).

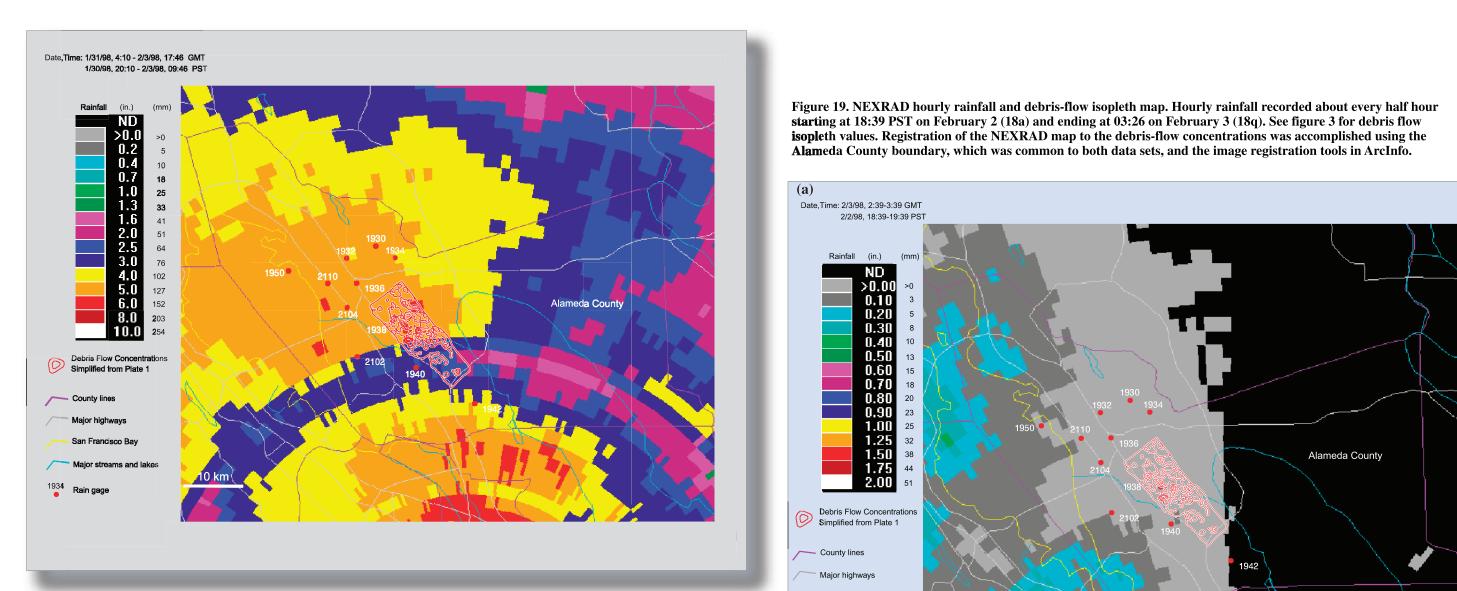
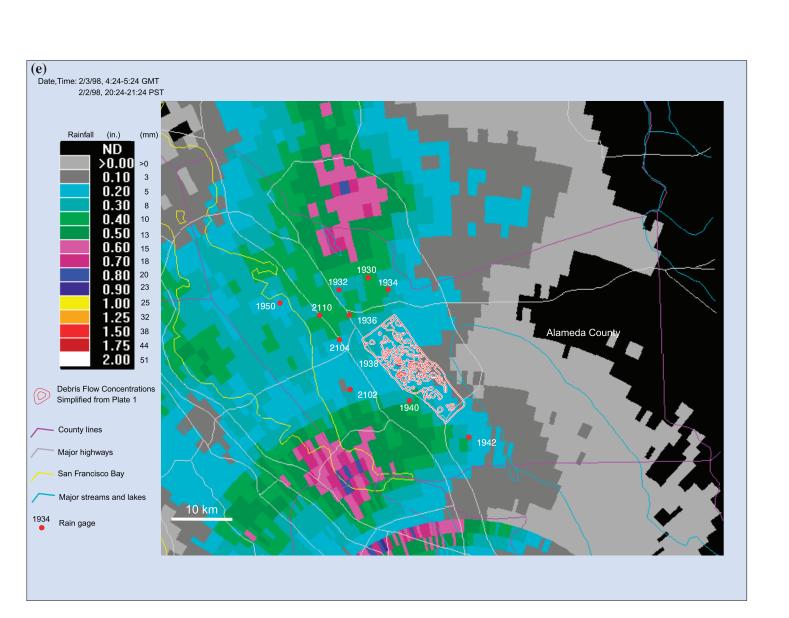
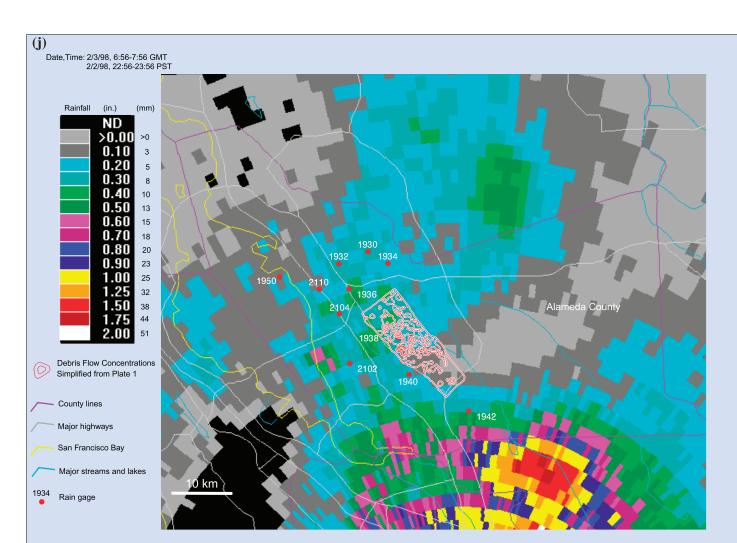
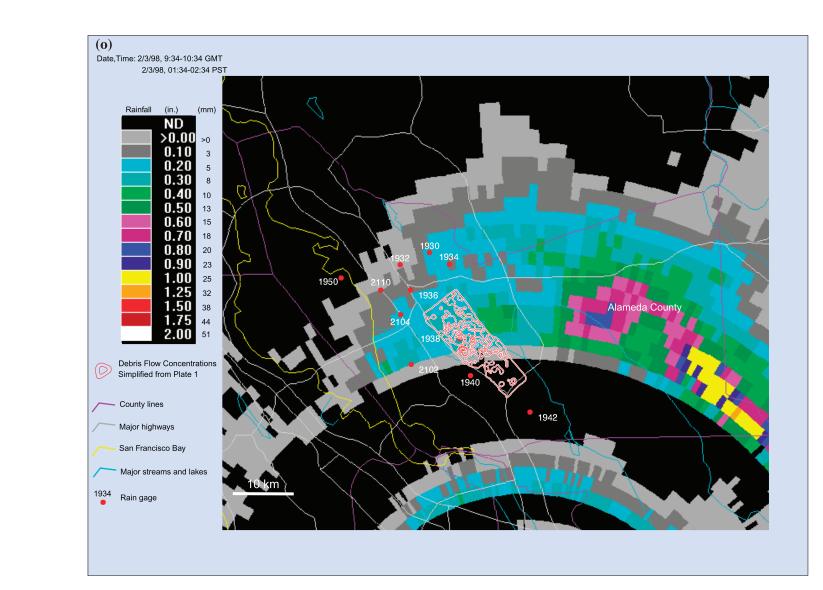
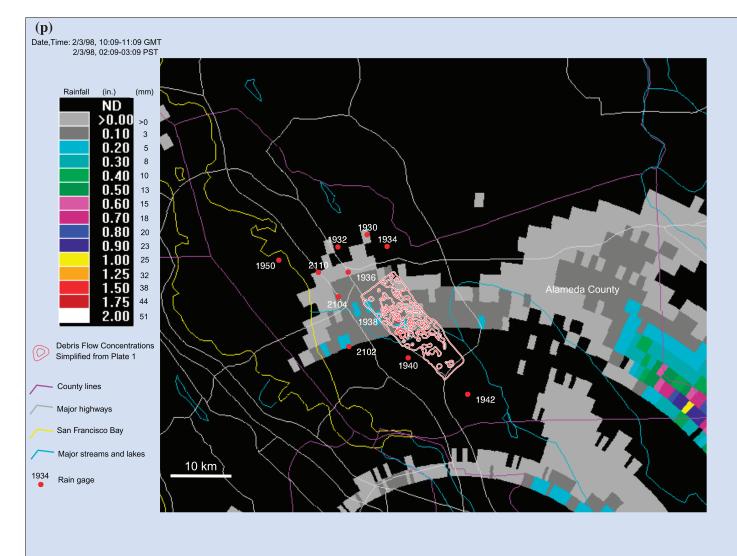


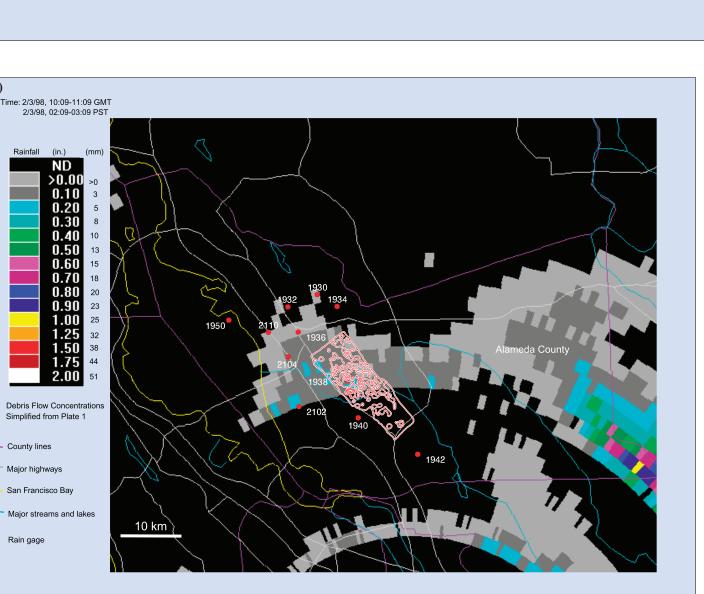
Figure 18. NEXRAD cumulative rainfall and debris-flow isopleth map. Cumulative rainfall measured between 20:10 on January 30 and 10:03 on February 3, 1998. See figure 3 for isopleth values. Registration of the NEXRAD map to the debris-flow concentrations was accomplished using the Alameda County boundary, which was common to both data sets, and the image registration tools in ArcInfo.

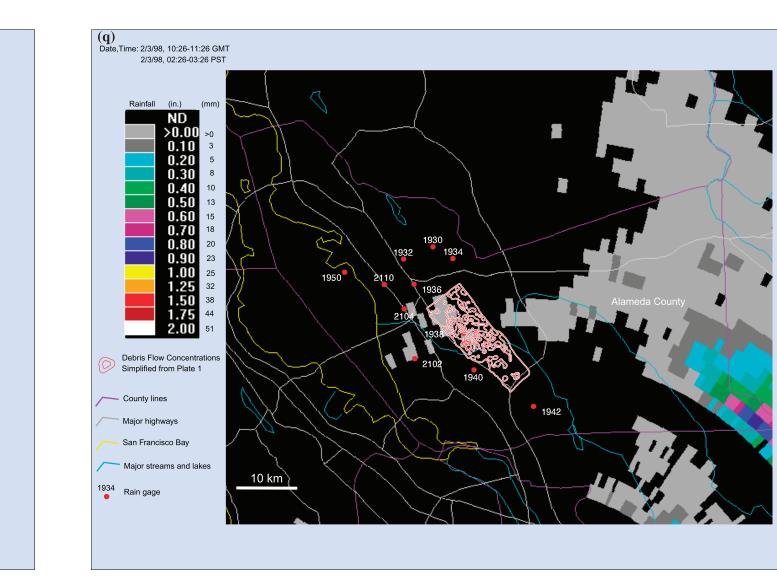








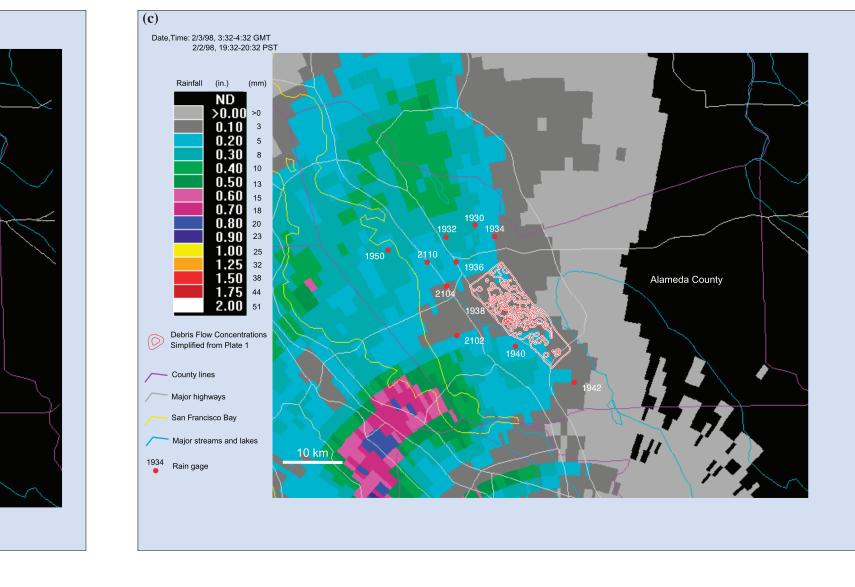


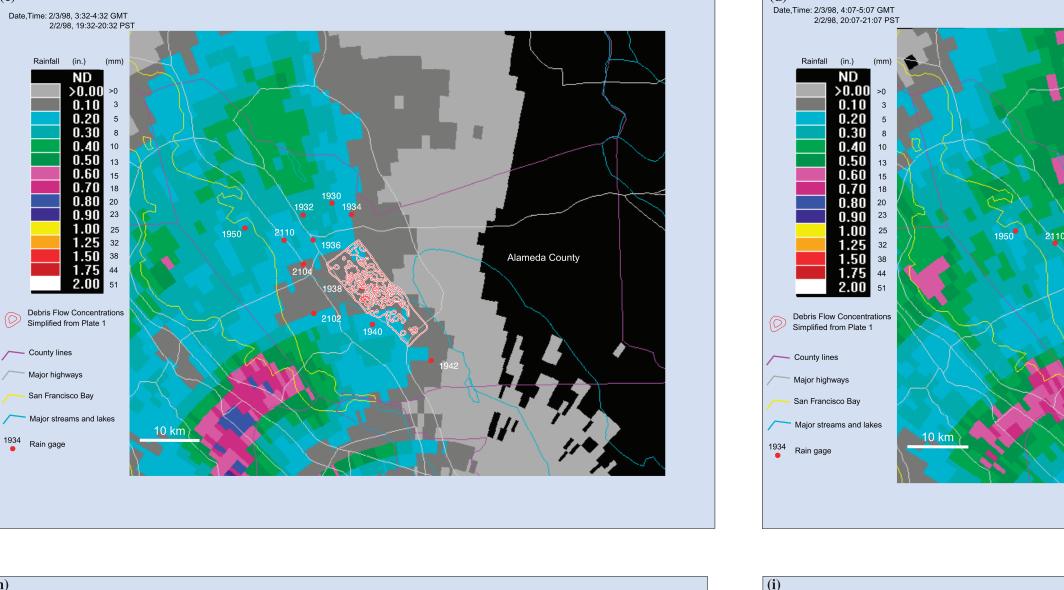


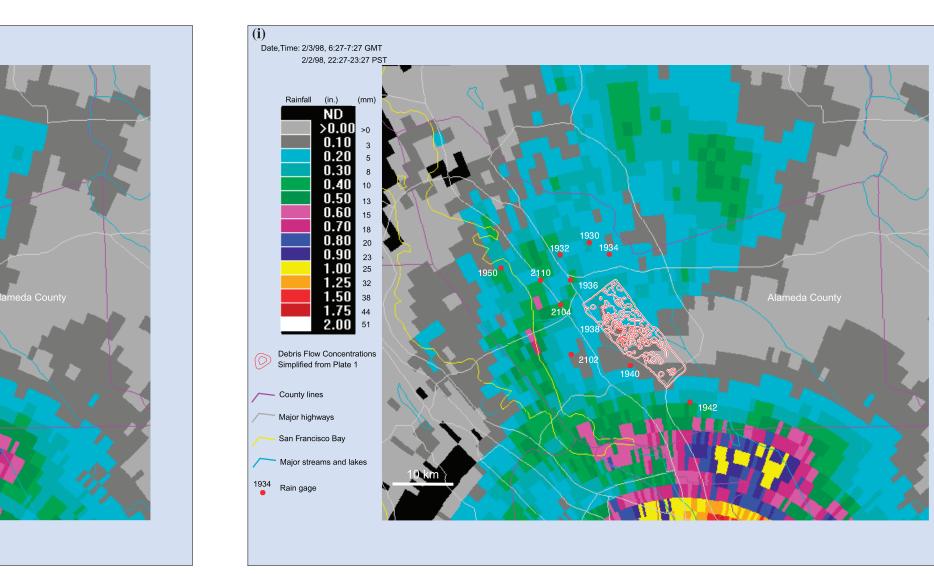
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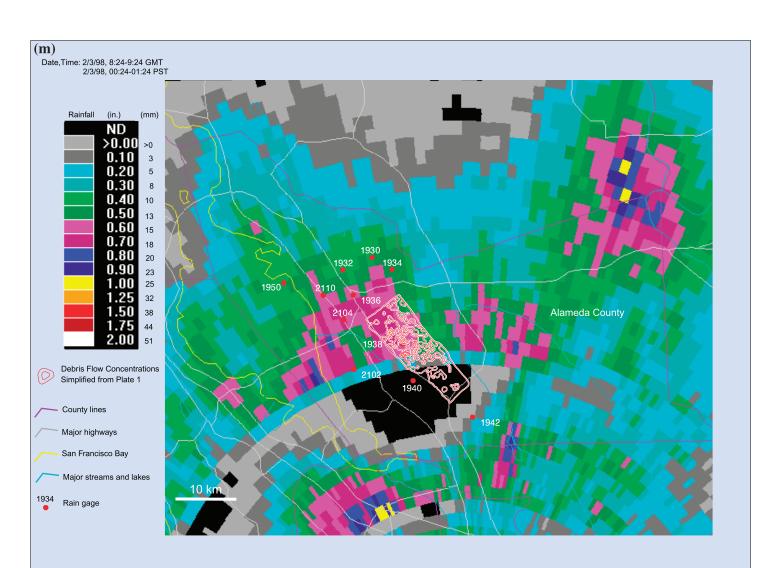
Major streams and lake

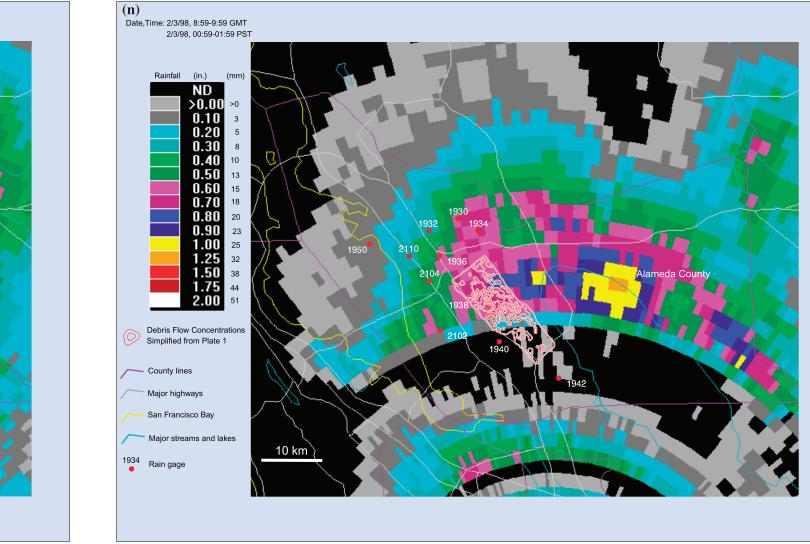
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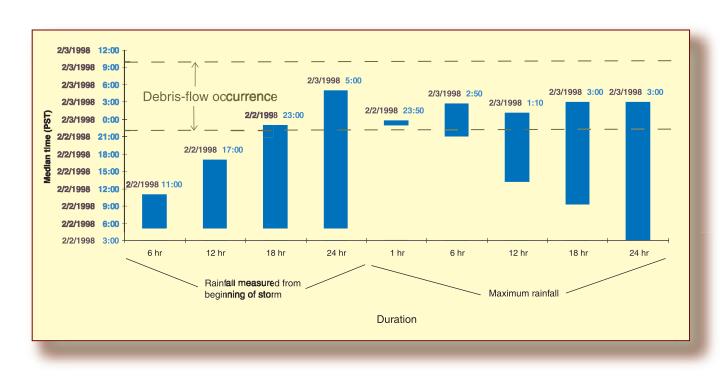


Figure 20. Rainfall for various durations compared with time of debris-flow occurrence. Range in time of debris-flow occurrence from table 2. Rainfall times are median values of all gages near study area (table 6). Plots of rainfall measured from beginning of the storm drawn from median value of start times. Plots of maximum duration drawn from median values of end



Figure 16. Photographs showing change in appearance of flow paths with time, for debris flows located about 1 km northeast of the Masonic Home in Union City. A, Photo taken February 4, 1998, by M.E. Reid. B, Photo taken March 26, 1998. Trees in the foreground are about 5 m tall. See figure 3 for location and figure 5 for aerial view of same area.

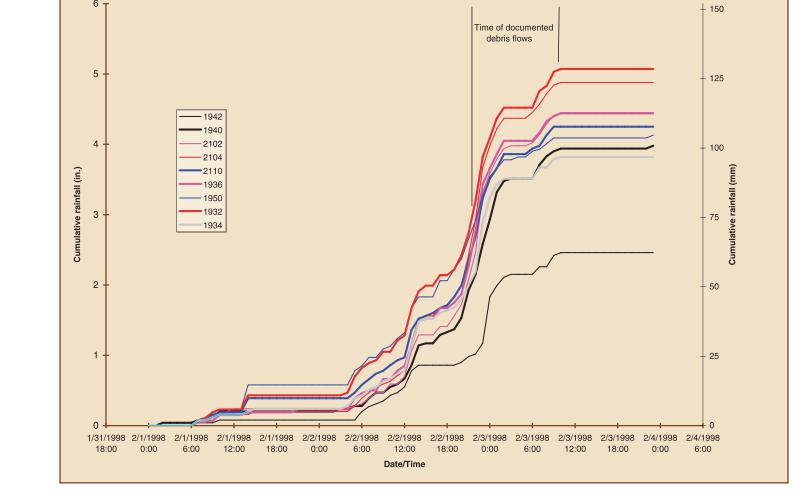
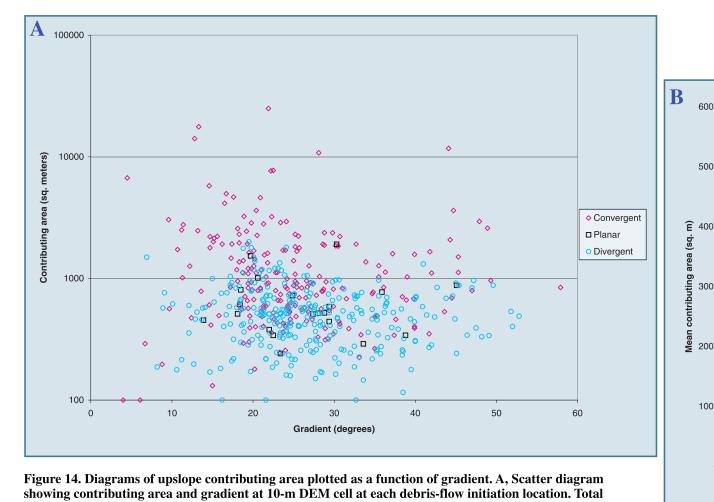


Figure 17. Cumulative rainfall at East-Bay ALERT gages, February 1-3, 1998. See figure 2b and table 6 for location of gages and table 2 for documented times of debris flows. All rainfall data provided by Andreas Godfrey of the Alameda County Public Works Agency.

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curvature of each cell is also shown. B, Scatter diagram showing means of contributing areas (calculated

for each set of debris flows partitioned by 1° increments of gradient) plotted as a function of gradient.

Gradients in study area, percent of total

in a debris-flow gradient/study-area gradient ratio of 52 percent.

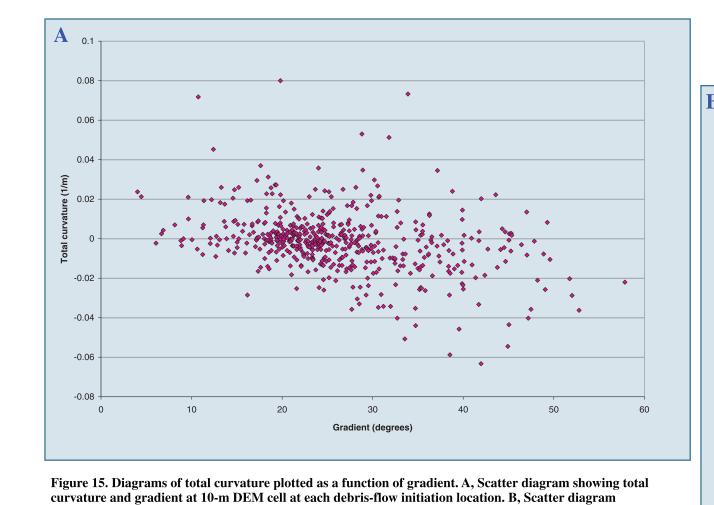
■ Debris-flow initiation gradients, percent of total

■ Ratio of debris-flow gradients to study area gradients

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54

Gradient (degrees)

Figure 13. Histograms of gradients measured from 10-m DEMs. Number of 10-m cells in the study area is about 913,200. Number of debris flows is 531. Data are not shown above 55°. One debris flow occurred at 58° and resulted



gradient) plotted as a function of gradient. Best-fit line and equation computed using a least-squares fit.

County lines

1934 Rain gage

Major streams and lak

Major highways San Francisco Bay

Rain gage

Major streams and lakes

