



Figure 1  
Distribution of landslides that  
damaged manmade structures  
during the 1972-73 rainy  
season. Each dot represents  
the location of one or more  
landslides.

Scale 1:500,000  
0 10 20 MI  
0 10 20 KM

Planimetric base from San Francisco  
Bay Region ABAG 1:250,000 map.  
Shaded relief from I:100,000 State  
Map of California.

**INTRODUCTION**  
This report presents data on the location and cost of damage related to landslides in the San Francisco Bay region during the rainy season of 1972-73 (Figs. 1 and 2). By showing the general location of landslides that caused damage during that season, the report also shows which parts of the region have the most severe problems. These data supplement earlier reports by the U.S. Geological Survey on the damage caused by landsliding throughout the bay region during the rainy season of 1968-69 (Nilsen and Brabb, 1972), in Contra Costa County from 1950 to 1971 (Nilsen and Turner, 1975), in Alameda County from 1940 to 1971 (Nilsen and others, 1975), and in the northeastern part of the city of San Jose from 1967 to 1971 (Nilsen and Brabb, 1972).

The nine San Francisco Bay region counties are included in this investigation: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. Landslide costs for these counties during the 1972-73 rainy season (Table 1) were at least \$9,716,284. Of this total, \$3,284,918 was direct loss of or damage to private property, mainly by lowering the property market value, and \$6,431,366 was for public property, chiefly for repair or relocation of roads. The data used to compile these costs are incomplete, thus the total cost could be significantly greater.

**DEFINITION OF LANDSLIDES**

In this study, landslides are defined as the downward and outward movement of slope-forming materials, which may be composed of natural rock, colluvium, soil, alluvium, artificial fill, or combinations thereof. Landslides can be subdivided in many different ways, such as by manner of movement, age and type of materials, but no such differentiation is made in this report. Some agencies reporting landslide data commonly use the term "slipout" to describe areas where a section of a road has moved downward or the underlying material has "slipped" out from beneath the road. "Slipouts" are included here as landslides. The landslides that are recorded ranged in size from a few tens to several hundreds of feet in maximum dimension.

**REPORTING PERIOD**

Most of the data in this report are for the rainy season of 1972-73. However, because the various agencies involved used different recording intervals—fiscal year, calendar year, or seasonal year—and different procedures, some data from other rainy periods may be included. As far as we can determine, this discrepancy is not significant enough to affect the total cost estimate.

**METHOD**

Agencies that were thought to have data about damage caused by landsliding in the bay region were contacted. These included federal, state, county, and city agencies, road departments, planning commissions and assessors, and utility companies, sewage disposal districts, and consulting geologists. In most cases, only one individual per agency was contacted, and his information may not be completely representative of the agency as a whole. Because the information from some cities could not be attributed to a particular source, no individual or agency is listed. However, in order to establish for the record which agencies were contacted so that the scope of the sampling can be assessed, we are including here a list by county of offices or individuals that were contacted or that contributed information.

**Alameda County**—Alameda, Building Inspector; Albany, Office of the City Engineer; Berkeley, Department of Public Works; Emeryville, Front, Maintenance Engineer; Hayward, Department of Public Works; Livermore, Building Inspector; Newark, Office of the City Engineer; Oakland, City Engineer; Piedmont, Building Inspector; Pleasanton, Office of the City Engineer; San Leandro, Department of Public Works; Union City, Department of Public Works; County Flood Control and Water Conservation District; East Bay Regional Park District; Mt. Diablo State Park, California Department of Transportation; and the Pacific Gas and Electric Company.

**Contra Costa County**—Concord, Department of Public Works; El Cerrito, Office of the City Engineer; Martinez, Building Inspector; Pinole, Department of Public Works; Pleasant Hill; Richmond, Building Inspector; San Pablo, Department of Public Works; Halfnut Creek, Community Developer; County Design Office; County Disaster Office; County Assessor; East Bay Municipal Utilities District; East Bay Regional Park District; Mt. Diablo State Park, California Department of Transportation; and the Pacific Gas and Electric Company.

**Marin County**—Belvedere, Department of Public Works; Corte Madera, City Engineer; Fairfax, Building Inspector and Road Superintendent; Larkspur, Department of Public Works; Mill Valley, Office of the City Engineer; Novato, Department of Public Works; Ross, Department of Public Works; San Anselmo, Department of Public Works; San Rafael, Department of Public Works; Sausalito, Department of Public Works; Tiburon, Office of the City Engineer; County Department of Public Works; County Assessor; Small Business Association Disaster Office; Private consulting geologists; California Department of Transportation.

**Napa County**—Calistoga, Napa, Department of Public Works; St. Helena, Department of Public Works; Yountville, Office of the City Engineer; County Engineering Department, County Assessor, County Public Works Department, County Park Department; State Forestry Division; California Department of Transportation; and the Pacific Gas and Electric Company.

**San Francisco County**—San Francisco, City Engineer; County Assessor; Department of Survey and Mapping; and the California Department of Transportation.

**San Mateo County**—Atherton, City Engineer; Belmont, Office of the City Engineer; Burlingame, Office of the City Engineer; Daly City, Department of Public Works; Menlo Park, City Engineer and Menlo Park Sanitary District; Millbrae, Public Works Department; Pacifica, Engineering Department; Redwood City, Department of Public Works; San Bruno, Assistant Engineer; San Carlos, Department of Maintenance; San Mateo, Office of the City Engineer; South San Francisco, Department of Public Works; County Planning Commission, County Engineers, County Department of Roads, County Assessor; and the California Department of Transportation.

**Santa Clara County**—Campbell, Department of Public Works; Cupertino, Department of Public Works; Gilroy, Los Altos, City Engineer; Morgan Hill; Mountain View; Palo Alto, Department of Public Works; Santa Clara, Department of Public Works; Saratoga, Department of Public Works; Sunnyvale; County Planning Commission, County Assessor, County Director of Public Works, County Road Maintenance, County Flood Control District, County Parks and Recreation Department; California Department of Transportation; U.S. Department of Agriculture Soil Conservation Service; and the Pacific Gas and Electric Company.

**Solano County**—Benicia, Department of Public Works; Fairfield, Office of the City Engineer; Suisun City; Vacaville, Department of Public Works; Vallejo, Office of the City Engineer; County Public Works Department, County Assessor, County Farm Advisor; Vallejo Water Department; California Department of Transportation; and the Pacific Gas and Electric Company.

**Sonoma County**—Cotati; Healdsburg, Department of Public Works; Petaluma; Santa Rosa, Building Inspector; Sebastopol; Sonoma; County Public Works Department, County Department of Advanced Planning, County Agricultural Commission, County Appraiser, County Department of Roads, County Department of Parks and Recreation, County Department of Sanitation; State Forestry and State Park Departments; U.S. Department of Agriculture Soil Conservation Service; and the Pacific Gas and Electric Company.

We wish to thank the agencies and individuals listed above for their cooperation and assistance in this study.

**EXPLANATION OF RESULTS**

Costs are reported under two main categories—public and private. Public costs are dollars spent or lost by governmental agencies, costs ultimately paid by the taxpayer. Private costs are expenses to individuals and nonpublic groups.

The method of recording information about landslides differed greatly from county to county. Some counties compiled separate files for each landslide, whereas others included landslide cleanup and repair in a total maintenance budget. No single department in any county had a complete record relating to landslides within that county. The use of different maps and map scales sometimes caused difficulties in making our compilation. The apportioning of costs was occasionally a problem, as expenses sometimes involved major improvements as well as repair. In addition, it was difficult to assign the exact costs of some landslide damage to a given period of time, as some landslides undergo repeated movement each year and hence require continuing repairs. The apportioning of these costs to a particular period of time varied with the individuals or agencies involved but may have resulted in some costs being assigned to years other than the one in which the movement took place. Several sources of information for private costs requested that specific data be kept confidential, so that a breakdown of total cost was not always listed. Storm damage reports required by the Federal Government for disaster relief, were found to be very useful in Marin and Contra Costa Counties. As a result, the compilation of dates, locations, and costs of landslides varies considerably in accuracy and completeness.

Most of the public landslide cost is the direct expense of repairing, restoring, or relocating roads. This includes expenses readily attributed to specific large landslides and an educated guess for smaller landslides that commonly included with budgets for routine road maintenance and repair. Lesser expenses resulting from damage to sewer lines, street lighting, sidewalks, and other public utility owned facilities are also included. Public agencies must sometimes obtain title to privately owned land to further protect property or to repair existing landslides. In addition to the cost of procurement, the agency assumes costs for erosion control, weed abatement, and other minor costs. It sometimes becomes more economical to obtain title to property and have it vacated than to attempt to maintain services that are continually disrupted by an active landslide. However, tax revenue is lost when land is transferred from private to public ownership in this manner. Revenue loss also results from the devaluation of private property because of landslide damage. These losses in tax revenue were not determined in our study, inasmuch as they are an ongoing yearly expense not readily attributed to one season.

Private costs result from loss of real property and possessions, and any improvements that are required owing to landslide damage. Possessions can be replaced and improvements undertaken if an individual is financially able, but property may be rendered unusable. In addition to the direct costs of repairs, property that has been damaged by landsliding is often depreciated in value. Reappraisals by the tax assessor's office, which indicate the decrease in the fair market value of property if landslides occurred, represent a loss to the property owner. No attempt was made to evaluate the costs of inconveniences such as time lost taking detours or the costs that resulted from a home being evacuated—the cost of food and lodging for example. Litigation results in another cost. No figures were obtained on costs of preparing and conducting court proceedings and only limited data are available on settlements of civil suits resulting from landslide damage.

**COST OF LANDSLIDE DAMAGE**

Alameda County		
Identified costs were as follows:		
Public costs		\$270,845
state	\$191,000	
county	20,000	
cities	57,500	
tax loss on property depreciation	2,345	
Private costs		88,400
Total		\$359,245

State, county, and city costs are basically those reported for roadway repair. Private costs include \$67,900 loss in assessed valuation on nine parcels of land due to landslide damage. All incorporated cities were contacted, but only Hayward reported a landslide involving city expense. Berkeley had an estimate for minor landslide cleanup, and Oakland spent a small amount for landslide investigations.

Contra Costa County		
Identified costs were as follows:		
Public costs		\$974,628
state	\$40,243	
county	901,400	
cities	22,140	
tax loss on property depreciation	10,845	
Private costs		\$712,550
property depreciation, repair and physical loss	\$656,150	
utility companies	56,400	
Total		\$1,687,178

County road maintenance accounts for the major portion of total public costs. Private costs include \$485,300 for property depreciation on 82 parcels due to landslides. One hundred and ten landslides were reported within the county. A high concentration is present in the Orinda-Lafayette area and a lesser concentration in the El Sobrante region. The city of Pinole reported one landslide but had no cost estimate for repair. All other cities reported no landslide damage.

Marin County		
Identified costs were as follows:		
Public costs		\$1,970,540
state	\$340,000	
county	\$20,570	
city	967,150	
tax loss on property depreciation	32,820	
Private costs		1,093,950
Total		\$3,064,490

Only 111 of the 153 reported landslides are shown on the map owing to scale limitations. The mapping shows a high concentration of reported landslides in the Mill Valley and Fairfax-San Anselmo regions and lesser concentrations throughout the county.

Napa County		
Identified costs were as follows:		
Public costs		\$129,300
state	\$87,000	
county	42,000	
city	0	
parks	300	
Private costs		2,000
Total		\$131,300

The assessor's office had no requests for reappraisals of property due to landslide damage. With one exception, all reported landslides occurred along roadways.

San Francisco City and County		
Identified costs were as follows:		
Public costs		\$490,000
state	\$400,000	
county	0	
city	90,000	
Private costs		none reported
Total		\$490,000

All reported costs were along roadways.

San Mateo County		
Identified costs were as follows:		
Public costs		\$2,311,310
state	\$2,182,500	
county	50,000	
city	49,000	
tax loss on property depreciation	29,810	
Private costs		1,284,000
Total		\$3,595,310

County road personnel report no major landslides on county roads and estimate debris removal for minor landslides at \$50,000. State Highway figures include an amount in excess of \$1,200,000 for a single landslide.

Santa Clara County		
Identified costs were as follows:		
Public costs		\$75,543
state	\$41,000	
county	unknown	
city	30,543	
parks	4,000	
Private costs		74,518
Total		\$150,061

Most landslides occurred on county roads for which officials had no estimate of costs for repairs or maintenance. Cities within the county reported only four landslides.

Solano County		
Identified costs were as follows:		
Public costs		\$8,950
state	0	
county	\$8,750	
city	200	
Private costs		19,500
Total		\$28,450

Numerous small landslides occurred throughout the western part of the county, and nineteen affected county roads.

Sonoma County		
Identified costs were as follows:		
Public costs		\$200,250
state	\$195,000	
county	unreported	
city	1,000	
parks	4,250	
Private costs		10,000
utilities only	10,000	
Total		\$210,250

**SUMMARY AND CONCLUSIONS**

The data in this report represent a conservative estimate of the amount of damage to manmade structures caused by landslides during the rainy season of 1972-73 in the bay region. The data are general and should be used in the context of a regional comparison rather than for a specific analysis of landslide problems. Figures 1 and 2 show certain areas which were most prone to landsliding and what the total reported public and private costs were. Contra Costa County, and the northern Berkeley area of Marin County, the Orinda-Lafayette area of Alameda County, and the northern Berkeley area of Alameda County, appear to have been particularly susceptible to landsliding.

Table 1 shows the total breakdown of damage costs in the nine bay counties. It is evident from this study and throughout the bay region, reports such as these may provide local and regional planners, developers, and citizens of the region with a basis for evaluating these costs and eventually minimizing them through effective urban and regional planning.

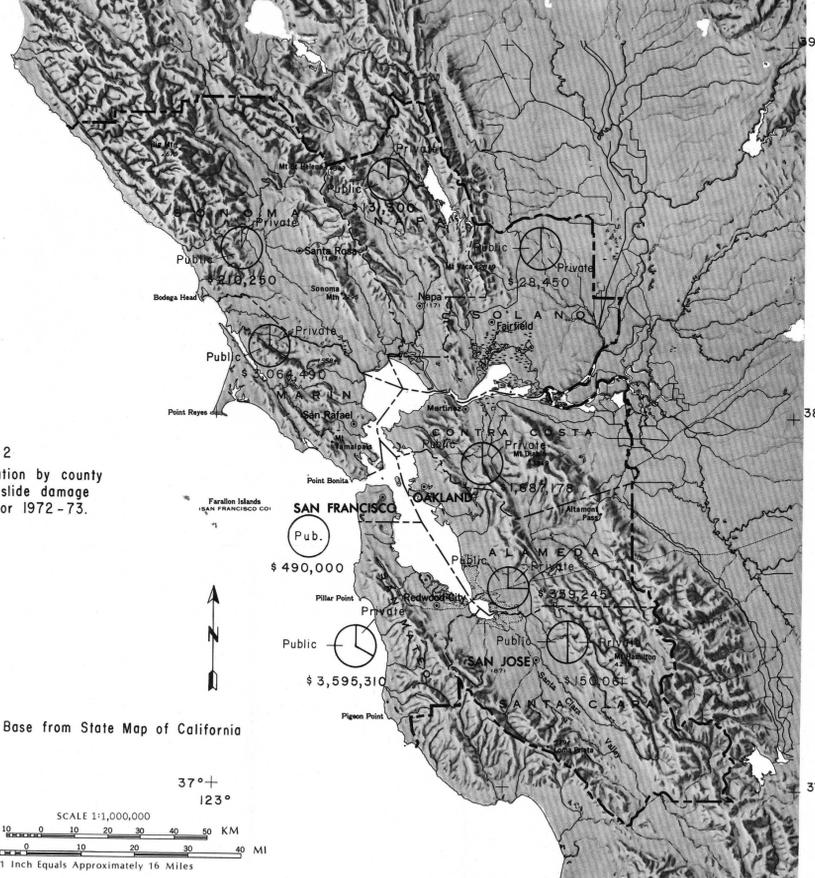
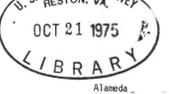


Figure 2  
Distribution by county of  
landslide damage  
costs for 1972-73.

Base from State Map of California  
SCALE 1:1,000,000  
1 Inch Equals Approximately 16 Miles

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County	Public				Private		Total
	State	County	City	Parks	Tax Loss		
Alameda	\$191,000	\$20,000	\$7,500	0	\$2,345	\$88,400	\$359,245
Contra Costa	40,243	901,400	0	10,845	22,140	712,550	1,687,178
Marin	340,000	630,570	967,150	0	32,820	1,093,950	3,064,490
Napa	87,000	42,000	0	300	0	0	490,000
San Francisco	400,000	see city	2,000	0	0	0	131,300
San Mateo	2,182,500	50,000	49,000	0	29,810	1,284,000	3,595,310
Santa Clara	41,000	unknown	39,543	4,000	0	19,500	150,061
Solano	0	8,750	200	0	0	0	28,450
Sonoma	195,000	no report	1,000	4,250	unknown	10,000	210,250
Totals	\$3,476,743	\$1,652,720	1,195,393	\$19,395	\$87,115	\$3,284,918	\$9,716,284

**DISTRIBUTION AND COST OF LANDSLIDES THAT HAVE DAMAGED MANMADE STRUCTURES DURING THE RAINY SEASON OF 1972-1973 IN THE SAN FRANCISCO BAY REGION, CALIFORNIA**

by Fred A. Taylor, Tor H. Nilsen, and Robert M. Dean — 1975

California (San Francisco Bay)  
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