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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

EXAMPLES OF THE USE OF EARTH-SCIENCE INFORMATION
BY DECISIONMAKERS

IN THE
SAN FRANCISCO BAY REGION, CALIFORNIA

by
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ABSTRACT

In the six examples discussed and illustrated here, innovative decisionmakers -- public and private -- have used earth-science information to avoid areas with geologic hazards, protect natural resources, and reduce possible property damage in the San Francisco Bay region. The examples show how: 1) development in fault-rupture areas is regulated, 2) potential waste-disposal sites are identified, 3) aquatic and wildlife habitats are protected, 4) site investigations are required in hazardous areas, 5) supplemental building standards can be applied to unstable baylands, and 6) hazards are disclosed to real-estate buyers.

INTRODUCTION

Six examples of the use of earth-science information by innovative public and private decisionmakers are shown and discussed in this report. We include among the decisionmakers State legislators, regional commissioners, county supervisors, mayors, councilmen, and real-estate buyers and sellers. The information is directed toward the objective of avoiding geologic hazards, protecting natural resources, and reducing property damage. Our examples include an entire State, a nine-county metropolitan region, a bay and shoreline district, a 1,312-square-mile county, a city of 55,000 people, and individual lots and acreages offered for sale.

We selected the examples to illustrate the range and types of uses of earth-science information; they do not imply endorsement by the U.S. Geological Survey. Similar examples from the San Francisco Bay region are reported elsewhere (Kockelman, 1975, 1976, 1979; Kockelman and Brabb, 1979; and Robinson and Spieker, eds., 1978).

Each example includes a summary of the problems faced by the decisionmakers, the information needed, the information available, the specific decisions or actions taken, the methods and procedures used to carry out the decision, and a brief comment on the decision's impact and its adaptation to other problems faced by other decisionmakers. Figures are taken from the decisionmakers' documents to illustrate the actual use of the earth-science information. They are reproduced as close to their original scale, color, and format as possible.

Acknowledgments

Constructive reviews of the six examples were made by those having special knowledge of, or responsibility for, each example: Earl Hart, Senior Geologist, California Division of Mines and Geology; Jeanne Perkins, Regional Planner III, Association of Bay Area Governments; George Reed, Senior Planner, San Francisco Bay Conservation and Development Commission; James Berkland, County Geologist, Santa Clara County; Charles Gyselbrecht, Former Chief Building Inspector, Redwood City; and John Freidlington, Associate Counsel, California Association of Realtors.

REGULATING DEVELOPMENT IN FAULT RUPTURE AREAS

Background

Several active fault zones -- broadly termed the San Andreas system -- underlie the San Francisco Bay region. Faults that have been active during the past 150 years include the San Andreas, San Gregorio, Hayward, Calaveras, Healdsburg-Rodgers Creek, Concord, and Sargent. Several other faults that moved during the last 10,000 years are also considered to be potentially active (Borcherdt, 1975, p. A10). Although earthquakes cause types of ground failures (including landslides, lateral spreads, settlement, and surface cracks) this example addresses just surface rupture -- the movement of rocks on one side of a fault trace with respect to the other side.

Some earthquakes of magnitude 4.5, and most of those larger than 5, cause property damage in developed areas. Great earthquakes -- magnitude 7 or larger -- cause severe damage and some loss of life if they occur in urban areas. In 1906, the San Andreas fault had a maximum horizontal displacement of 20 feet during a magnitude 8.3 earthquake. The magnitude of the largest historic earthquake on the Hayward fault was $7\pm 1/2$, and on the Calaveras, 6. Surface rupture was observed on both (Borcherdt, 1975, p. A11).

Some faults, such as the Hayward and Calaveras, also move by tectonic creep, a gradual relative movement across a fault at rates of only an inch or two per year.

The probability that an earthquake will destroy buildings and kill people is great where high-density urban development or critical facilities^{1/} straddle active faults. In addition, reconstruction commonly takes place in the same hazardous areas after an earthquake. Furthermore, if new fault traces are discovered and new areas designated as hazardous, existing structures may be found to be unsafe. For example, many schools, hospitals, and other public and private developments have been placed on or near the surface traces of active faults.

It is difficult and costly to design and construct a structure to withstand fault displacement. When displacement and shaking occur simultaneously, even an inch or two of fault movement can severely damage a building. The 1971 San Fernando earthquake in Southern California is a recent example of damage occurring to structures erected over an active fault whose trace was not apparent at the time of development.

^{1/} The term "critical facilities" is used to include:

- (a) Lifelines such as major utility and transportation lines and their connection to emergency facilities.
- (b) Unique or large structures where failure might be catastrophic, such as dams, or buildings where explosive, toxic, or radioactive materials are stored or handled.
- (c) High-occupancy buildings, such as schools, hotels, offices, auditoriums, and stadiums.
- (d) Emergency facilities such as police and fire stations, hospitals communications centers, and disaster-response centers.

Information Available

In California, many potentially active and recently active faults have been identified and mapped at different scales. The fault maps by the U.S. Geological Survey and the California Division of Mines and Geology are at 1 inch = 2,000 feet or smaller scales. Evidence for surface fault displacement, magnitudes of the largest historic earthquakes, and estimated recurrence intervals for maximum earthquakes are summarized for 25 faults in a report on seismic zonation edited by Borchardt (1975). Discussions of patterns of surface faulting, fault zone widths, and amounts of displacement are included. Methods for using seismic information and hazard mapping in land-use planning and regulations are discussed by Blair and Spangle (1979).

Much of the damage associated with fault rupture can be avoided by regulating construction on active faults. Utility and transportation facilities can be located, designed, and operated in such a way as to reduce disruption and outages.

The trace of an active fault cannot always be seen at the surface. It may be concealed, and the geologist may have to approximate its location. The ground area displaced is not always along a single fault trace. Various types of faults, branching segments, braided, and en echelon faults may result in wide areas of potential displacement. See figure 1. Therefore, regulatory measures for avoiding the hazards of fault rupture or reducing its damage will require some geologic investigations to identify and map the faults. Once located, specific regulations -- prohibiting certain uses or requiring specific building setbacks -- can be applied.

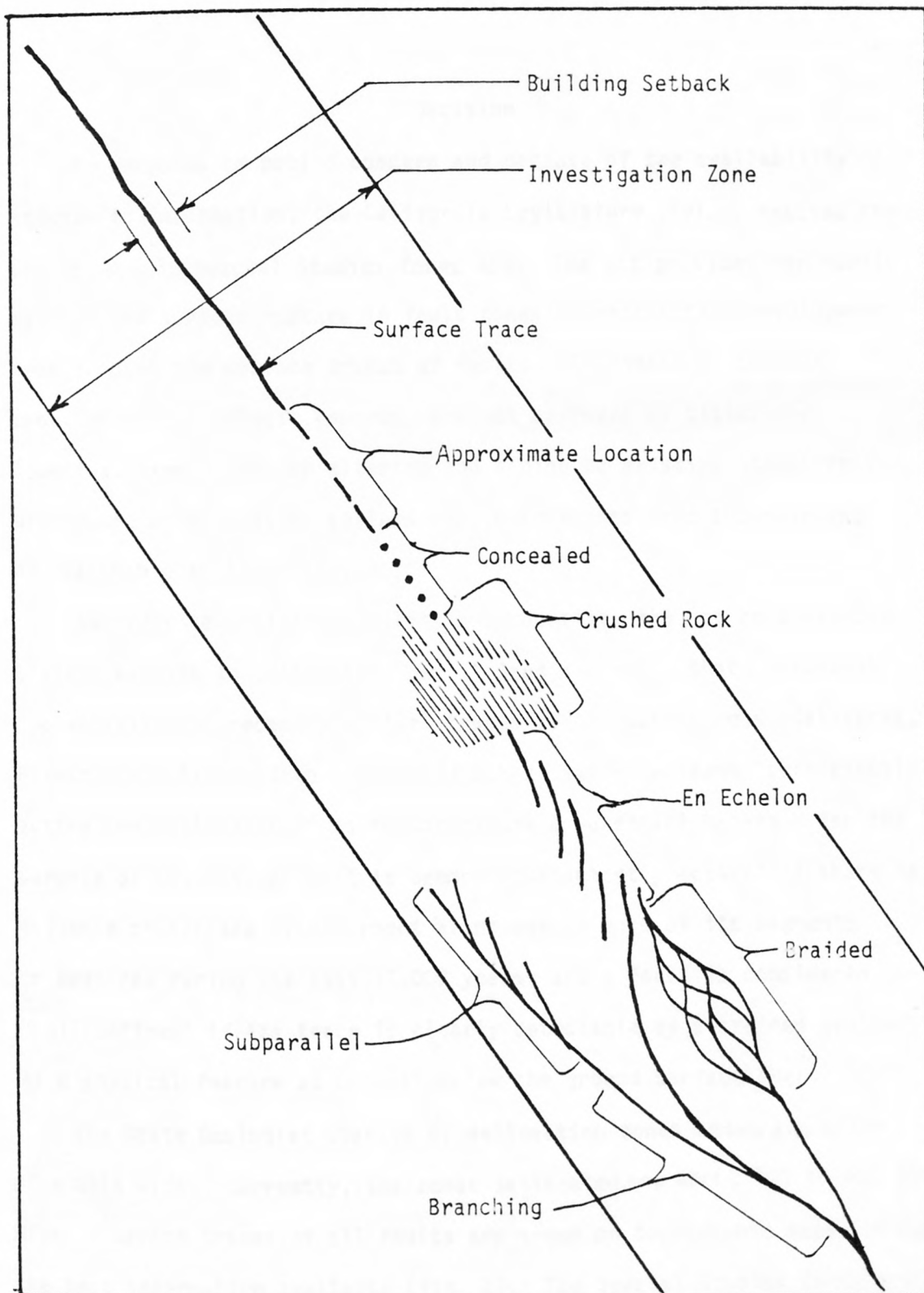


Figure 1.--Simplified diagram showing an area of fault ruptures and various types of fractures along which rocks have been displaced horizontally or vertically.

Decision

In response to public concern and because of the availability of scientific information, the California Legislature (1972a) enacted the Alquist-Priolo Special Studies Zones Act. The act provides for public safety from surface rupture in fault zones by restricting development near or over the surface traces of faults. In addition, the act provides for: geologic reports, project approval by cities and counties, exemptions for altering and adding to existing structures, disclosure of hazards by sellers and their agents, and the charging of reasonable application fees.

In order to assist the cities and counties, the act requires the State Geologist to delineate Special Studies Zones that include all "potentially and recently active" traces of the San Andreas, Calaveras, Hayward, and San Jacinto faults and other faults he deems "sufficiently active and well-defined" as to constitute a potential hazard. For the purpose of the act, a fault is deemed "sufficiently active" if there is evidence of surface displacement along one or more of its segments or branches during the last 11,000 years; and a fault is considered "well-defined" if its trace is clearly detectable by a trained geologist as a physical feature at or just below the ground surface (Hart, 1977).

The State Geologist started by delineating zones about a quarter of a mile wide. Currently, the zones delineated are about 400 to 600 feet wide. Surface traces of all faults are shown on topographic maps, using the best information available (fig. 2). The Special Studies Zones are

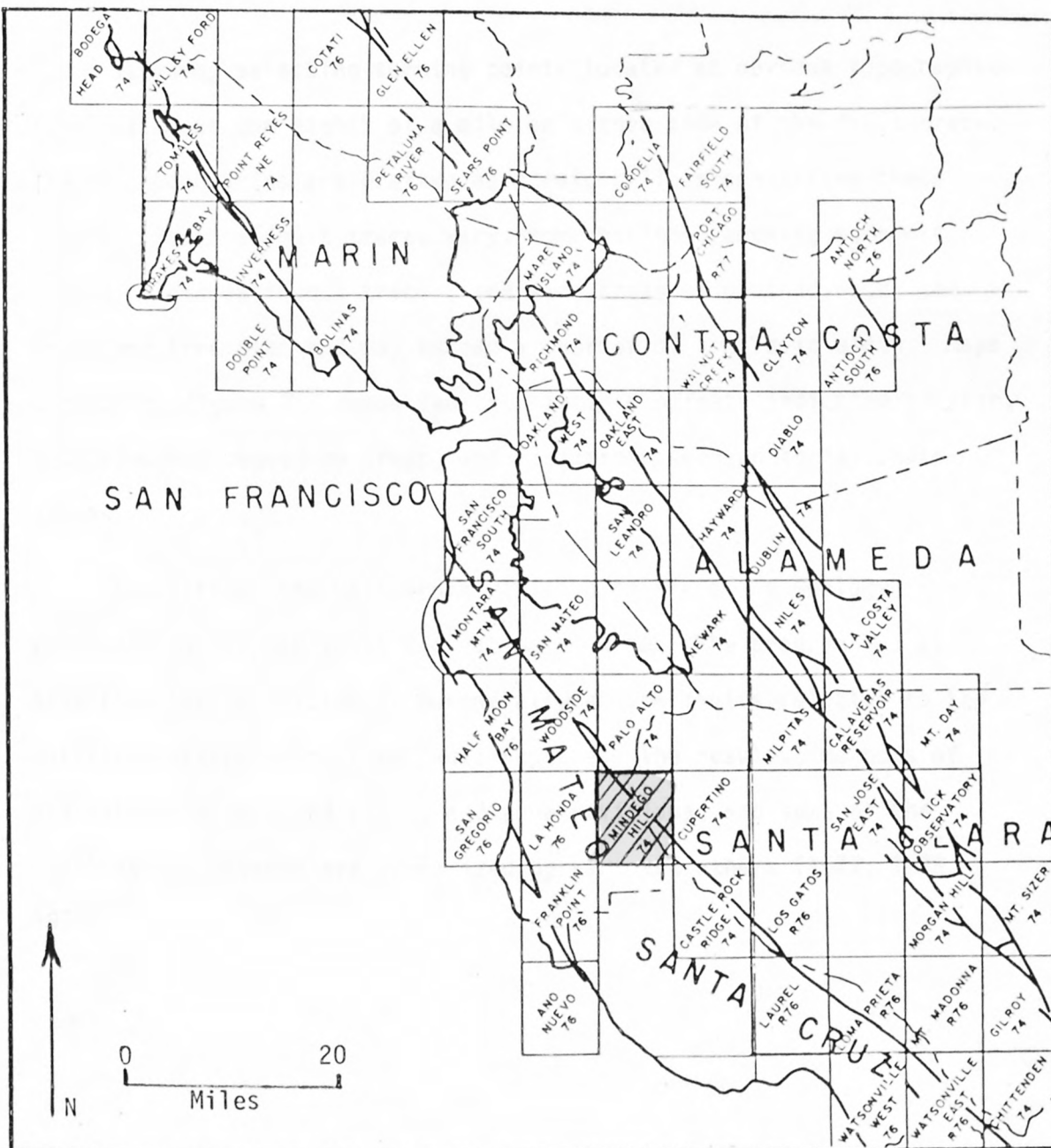


Figure 2.--Part of the Special Studies Zones index map (Hart, 1977) showing faults zoned for special geologic studies. Quadrangle names and numbers indicate the name of the official map and the year issued. Part of the cross-hatched quadrangle is shown as figure 3. Surface traces of well-known faults have been delineated on 267 topographic maps at a scale of 1 inch = 2,000 feet (1:24,000). Information about the availability of the maps can be obtained from the State Geologist, California Division of Mines and Geology, Room 1341, 1416 Ninth Street, Sacramento, CA 95814.

established by selecting turning points located at obvious topographic features about one eighth of a mile on either side of the fault trace. The zone boundaries are drafted as straight lines connecting these points. Because fault traces vary, some having branching segments, curved or discontinuous traces, and wide areas of crushed rock, the zones are irregular and may exceed a quarter of a mile in width. Maps similar to figure 3 show faults, historic offsets indicated by year, displacements caused by creep, and lineaments seen on aerial photographs.

In addition, the California Division of Mines and Geology is conducting a 10-year fault evaluation program. The program has as its objective the evaluation of potentially active faults relative to the potential hazard of surface fault rupture. The results, methods of evaluation, recommended zoning and zone revisions, and some of the problems encountered are summarized by Hart and others (1977, 1978, 1979).

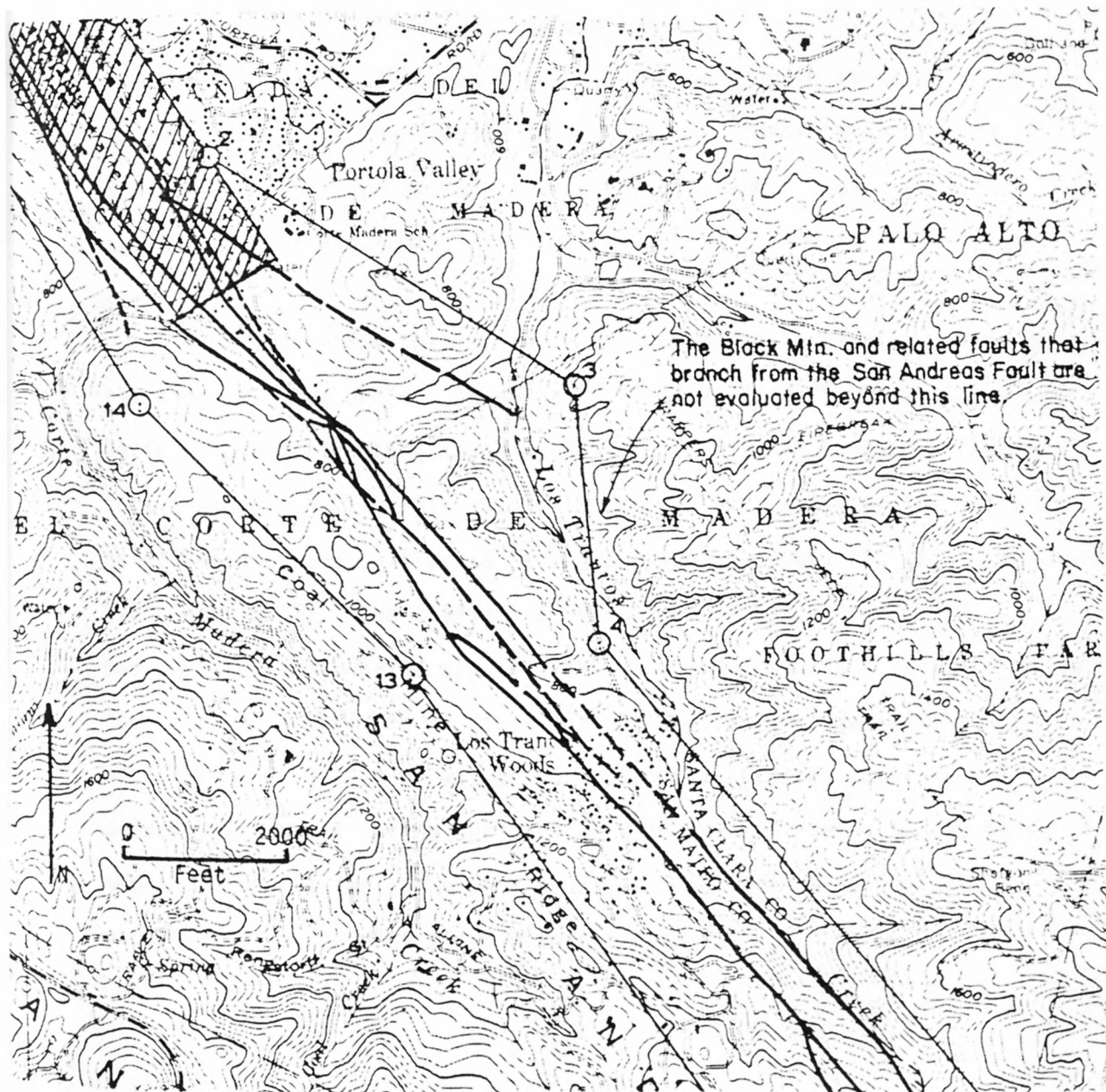


Figure 3.--Part of the Mindego Hill quadrangle map originally released at a scale of 1 inch = 2,000 feet (1:24,000) prepared by the California Division of Mines and Geology (1974) showing the Special Studies Zones along part of the San Andreas fault. The fault is indicated by a solid line where it is accurately located, by a long dash where it is approximately located, by a short dash where it is inferred, and by dots where it is concealed. The map also shows zone boundaries with numbered turning points. The cross-hatched area is shown on figure 4 at a larger scale. Special Studies Zones have been delineated in over 20 counties and 60 cities in California.

Application

The State Geologist used 7 1/2-minute topographic quadrangles as the base for all of the Special Studies Zones. Information from fault and geologic maps were transferred to the quadrangle maps. Each of the 267 maps contain specific references to the scientific information used.

The act provides that cities and counties shall require, prior to the approval of a project in a Special Studies Zones "a geologic report defining and delineating any hazard of surface fault rupture," and that approval shall be given only if the project satisfies the criteria established by the California Mining and Geology Board (Calif. Legislature, 1976, sec. 2623). The California Mining and Geology Board (1979) has prepared and adopted specific and detailed criteria. In addition, the California Division of Mines and Geology can provide information on: the availability of waiver forms, Special Studies Zones maps, guidelines for evaluating surface fault ruptures, indexes to the maps, model ordinances for cities and counties, and indexes to geologic reports for development sites within the zones.

The board's criteria prohibit specific development in Special Studies Zones until a registered geologist retained by each city and county has evaluated geologic reports prepared by a registered geologist. The fault information shown on a quadrangle map (fig. 3) is not sufficient to meet the requirement for a "geologic report." The cities and counties must require that the developer evaluate the sites within the Special Studies Zones to determine if a potential hazard from any fault exists. If a city or county finds that no undue hazard exists, the required geologic report may be waived with the approval of the State Geologist. The act and the criteria provide that cities and counties may establish more restrictive policies and criteria if they so desire.

One criterion initially adopted by the board provided that "No structure for human occupancy ... shall be ... placed across the trace of an active fault" or within 50 feet of it. The area within 50 feet is assumed to be underlain by active branches until proven otherwise by a geologic investigation by a registered geologist.

In 1976, the California Legislature (1972a, sec. 2621.6(a)) subsequently amended the original act to exclude developments consisting of up to three "single-family wood-frame dwellings" from the act and therefore removed such buildings from the board's criteria. However, many cities and counties retain the 50-foot setback for all structures for human occupancy; others require even greater setbacks (fig. 4).

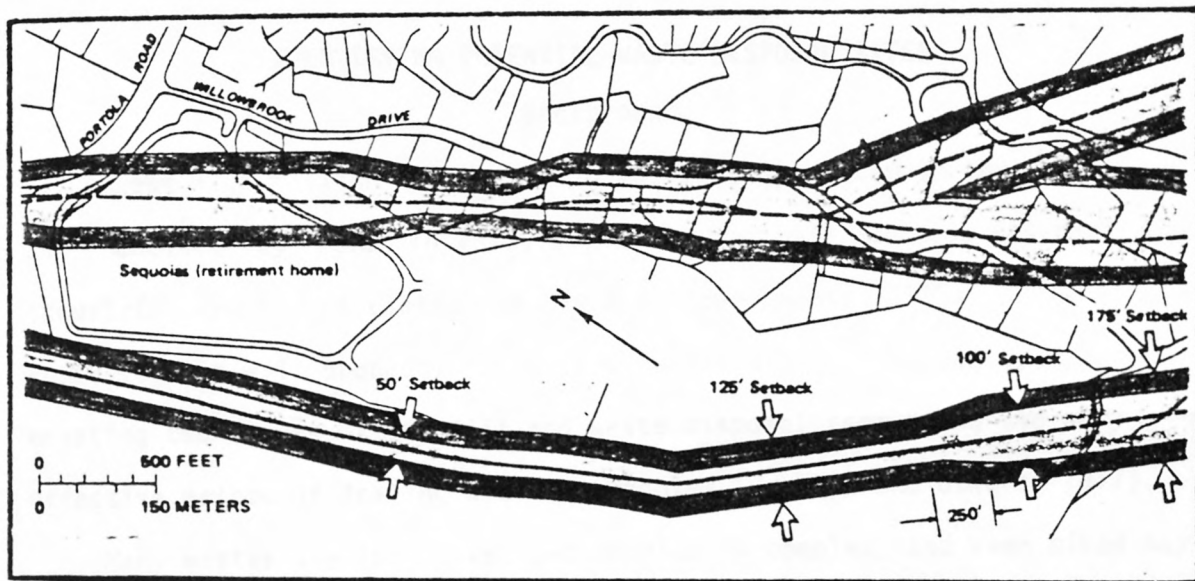


Figure 4.--Example of minimum easements required for building setbacks from active fault traces as mandated by town ordinance in Portola Valley, California. All new building construction is prohibited within the 100-foot wide, lightly-shaded zone (50 feet on each side of the accurately-located portion of the San Andreas fault); structures housing more than a single family are required to be 125 feet from the fault trace (dark shading). Where location of the fault trace is less well known, more conservative setbacks of 100 feet for single-family residences and 175 feet for structures with higher occupancies are required (modified from Mader and others, 1972, fig. 5).

Comment

This example illustrates how geologic and seismic evidence is used by State legislators, State scientists, city and county officials, and consulting geologists to avoid fault-rupture hazards throughout California.

The act's provisions, board's criteria, and local ordinances deter the placement of public and private buildings over faults which may creep, or move suddenly during a major earthquake.

This method of providing for public safety can be adapted to other types of potential ground failures including landslides and liquefaction; and to other States where similar hazards exist, and where good scientific information can be obtained.

IDENTIFYING POTENTIAL WASTE-DISPOSAL SITES

Background

About 11.5 million tons of solid waste was produced in the San Francisco Bay region in 1975, of which about 820,000 tons was hazardous industrial waste (Association of Bay Area Governments, 1978a, p. V-17). These figures will probably increase about five percent annually, and existing techniques of landfill and waste disposal seem to be the only effective method of dealing with the problem (Perkins and others, 1977).

Many wastes are long lived and chemically complex, and when mixed may form new compounds whose effects on health are largely unknown. Ground water contaminated by such wastes may remain in an unusable or hazardous condition for decades or even centuries. Pettyjohn (1979) reports that such contamination has occurred at Keizer, Oregon; Niagara Falls, New York; Barstow, California; Bellevue, Ohio, and many other areas.

The four most common methods of solid-waste disposal -- open dumps, sanitary landfills, incineration, and onsite disposal -- carry an inherent potential for pollution. Seepage of rainwater through the wastes leaches out constituents which can reach the ground water. This leachate is generally contaminated both biologically and chemically.

The extent of pollution from the leachate depends upon the hydrogeology of the disposal site. The possibility of pollution is greatest where waste-disposal sites are located in flood-prone areas, near fault traces, on landslide areas, on permeable soil and rocks, on steep slopes, in areas of high precipitation, in areas where the water table is high, or in recharge areas.

Information Available

Most of the basic information needed to make wise decisions concerning safe locations for waste-disposal sites in the bay region is available -- information on flood-prone areas, relative intensities of ground shaking, surface traces of faults, landslide deposits and areas susceptible to landslides, slope maps, annual precipitation, probable maximum well yield, geology, areas with a high-water table, and historic marshlands.

Sources of pollution, critical resources, critical geologic and hydrologic conditions, and suitability ratings for several types of waste disposal sites are discussed by Hines (1973). The development costs associated with geologic and hydrologic constraints and resources for several land uses are demonstrated in a quantitative land-capability analysis report by Laird and others (1979).

A wide range of hydrologic and geologic information is needed to identify safe waste-disposal sites. Although large-scale and detailed information is necessary for identifying specific sites, smaller scale and less-detailed information, if accurate and clear, can help identify acceptable areas.

The use of a wide range of information requires the selection and systematic application of specific criteria relating to surface and ground-water quality. The criteria and their application can assist decisionmakers in understanding and using the results to identify and regulate specific sites.

Decision

Hazardous waste management was identified as a regional concern in seven of the nine bay area county plans and by the nine-county group charged with solid-waste plan coordination (Perkins and others, 1977). Because of this concern, ABAG (Association of Bay Area Governments) identified potential Class I sites (Perkins, 1978) as part of a regional solid-waste management plan. Class I sites are disposal areas for hazardous wastes such as toxic chemicals, soluble industrial wastes, saline brines, and unquenched incineration ashes. The California Hazardous Waste Control Law defines "hazardous waste" as:

...a waste, or combination of wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may either: (a) Cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness. (b) Pose a substantial present or potential hazard to human health or environment when improperly treated, stored, transported, or disposed of, or otherwise managed (California Legislature, 1978a).

The ABAG study identifies areas that warrant further study for use as disposal sites for toxic and hazardous wastes and recommends that the disposal sites and facilities be located so that they do not adversely affect human health and safety, air and water quality, wildlife, critical environmental resources, and urbanized areas (Perkins and others, 1977).

Application

The hydrogeologic criteria used by ABAG for evaluating waste-disposal sites have been adapted from those of the California State Water Resources Control Board (1976) and those suggested by Hines (1973). The Board also requires all Class I sites to have a natural barrier to prevent downward movement of the wastes to usable ground water. Sites that may be subject to innundation, washout, faulting, liquefaction, landsliding, or accelerated erosion conditions are not acceptable. The criteria used by ABAG have been divided into the three groups shown in figure 5.

Map information from the sources shown on figure 5 were digitized and converted into grid cells (1/4 square kilometer, or approximately 62 acres), resulting in eight computer files. These computer files were combined so that a shaded map including both the "strict" and "graded" factors could be produced by the printer-plotter (fig. 6).

<u>Strict Factors</u>	<u>Map Source</u>
Out of flood-prone areas	Areas on 100-year flood plains (Limerinos and others, 1973)
Not in areas which average more than 30 inches of rain, annually	Areas within 30-inch isohyet (Rantz, 1971)
Not in an active earthquake area	Areas within 0.2km. of a fault capable of producing ground shaking (ABAG, 1978b)
Not on unconsolidated materials	Areas shown as Quaternary or Quaternary/Tertiary on maps by Schlocker, 1971, and California Division of Mines and Geology
Not on unstable materials or on a slope greater than 15%	Areas shown as Categories 1 or 2 on map by Nilsen, 1979
<u>Graded Factors</u>	<u>Map Source</u>
Amount of precipitation	Assign "3" to 0 to 20 inches and assign "2" to 20 to 30 inches as shown on map by Rantz, 1971
Yield from wells	Assign "3" to Category A, "1" to Category B and "0" to categories C and D as shown on map by Webster, 1972
Rock types	Assign "1" to Franciscan Assemblage and granitic rocks and assign "3" to other Tertiary or older rocks as shown on maps by Schlocker, 1971, and California Division of Mines and Geology
Soil permeability	Assign "3" to extremely impermeable soils, "2" to very impermeable soils, "1" to moderately permeable soils, and "0" to permeable soils as shown on the Soil Conservation Service Map of soil associations.
Relative slope stability and soil erosion	Assign "3" to category 1 and "1" to category 2 as shown on map by Nilsen, 1979

Figure 5.--List of criteria used to select Class I sites modified from Perkins (1978, Table 2). The criteria have been divided into three groups -- strict, graded, and acceptability factors. The strict factors eliminate those areas that are hydrologically and geologically unsuitable for sites. The graded factors identify the remaining areas as most likely, moderately likely, or not likely to be found suitable. The acceptability factors attempt to identify site limitations that are unrelated to hydrology or geology, or those that require on-site investigation.

<u>Acceptability Factors</u>	<u>Source</u>
Not in or adjacent to developed areas or areas with development potential	Developed lands and lands with development potential as shown on ABAG's Local Policy Survey Summary Map
Not publically owned for parks, recreation, etc.	Road maps (various scales); local plans when applicable
Not in ecologically sensitive area	USGS topographic quadrangles (scale 1:24,000) and ABAG's Areas of Critical Environmental Concern (1976)
Not affecting significant agricultural crops	No available maps-general information from ABAG's San Mateo Coast Corridor Evaluation (1975), and Areas of Critical Environmental Concern (1976)
Reasonably accessible by trucks	Road maps (various scales) and ABAG base map
Acceptable to the public and the government (to the extent possible prior to public workshops)	Based on discussions with selected county staff
Located on shales or sandstones, not on highly sheared materials	Various geologic maps
Away from waters used for drinking or recreation	ABAG base map

Figure 5.--Solid-Waste Disposal Site Criteria -- continued.

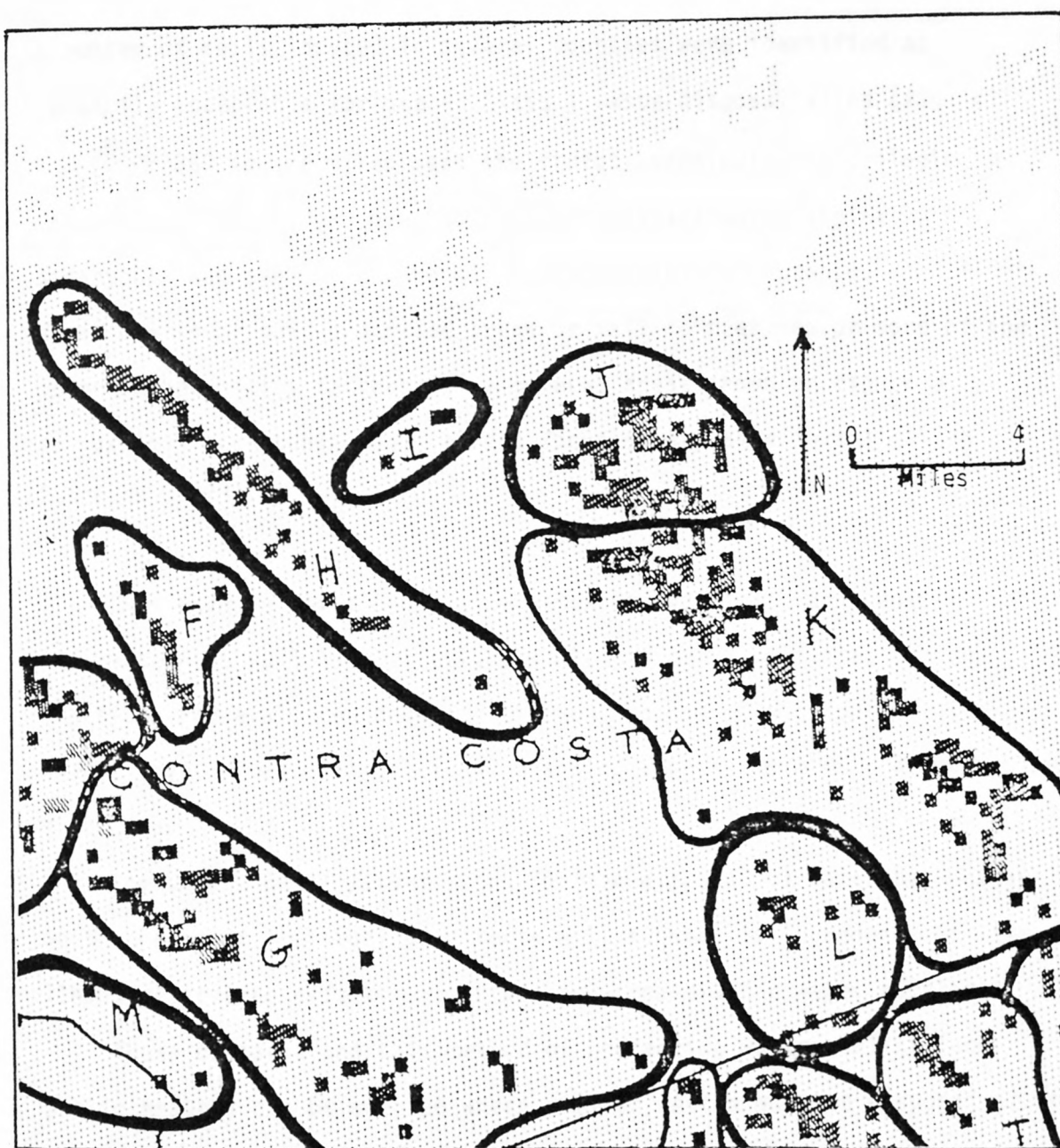


Figure 6.--Part of a map from Perkins (1978) produced by a STATOS^{1/} printer-plotter after a VARIAN mini-computer was used to combine individual digitized maps and apply the strict and graded factors. The shaded grid cells indicate areas which meet the strict and graded factors. The letters are used to designate areas (fig. 7) with similar social and environmental characteristics to which the acceptability factors were applied manually.

^{1/} The use of brand, trade, or firm names in this report is for identification purposes and does not constitute endorsement by the U.S. Geological Survey.

Cells with similar characteristics in each county were grouped and the "acceptability" factors manually applied (fig. 7). As a result, a number of cells located in several counties were identified as possibly acceptable for use as Class I waste-disposal sites (fig. 8).

Over 350 square miles meet the strict hydrologic and geologic factors. Of this area, over 85 square miles are only marginally acceptable and over 54 square miles are possibly acceptable. The other areas are in or near urbanized areas or fail to meet one or more of the other acceptability factors. The general areas shown on figure 8 as possibly acceptable would be the focus of any site investigation (Perkins, 1978).

Comment

This example shows how a wide range of hydrologic and geologic information as well as physical, social, and political data, can be digitized and evaluated together through the use of a computer. The study, by a nine-county regional planning agency, covered a 7,000 square mile area.

The selection of future sites for the disposal of hazardous wastes on the basis of the study's criteria will substantially reduce the likelihood of adverse effects on surface and ground-water water supplies.

These criteria and this method of protecting water quality (and public health) can be adapted where similar wastes must be disposed of on land and where adequate hydrologic and geologic information is available. The value to other counties and regions is increased because the California Legislature (1972b) requires solid-waste management plans and section 208 of the Federal Water Pollution Control Act (U.S. Congress, 1977) requires waste-treatment management plans.

CODE	SIZE (# cells)	LOCATION	PRESENT USE	ADJACENT USE(S)	TRANSPORTA- TION ACCESS	GEOLOGIC MATERIALS	NEAREST SURFACE WATER	OTHER ISSUES	OVERALL AREA ACCEPTABILITY
F	15	Lime Ridge/ Concord Hills	Undev. (15)	Urban, undev. and open space	Highway 680; Ygnacio Val- ley Road through res- idential areas	Tertiary and Cretaceous sandstone and shale	Drainage through Walnut Ck. and Concord to Carquinez Straits	Probably not polit- ically acceptable 1 cell is scattered	Probably un- acceptable for all but 1 scattered cell that is unacceptable
G	77	East of San Ramon Valley	Undev. (77)	Urban and undev. grazing	Highway 680; poor to out- lying areas	Tertiary and Cretaceous sandstone and shale; much is unconsol- idated	Drainage to San Ramon Ck.	-	Probably un- acceptable for all but 5 scattered cells that are unac- ceptable
I	3	Hills South of Pittsburg	Dev. Pot. (1) Undev. (2) grazing	Urban and undev.	Highway 4; Buchanan and Kirkner Pass Roads	Tertiary and Cretaceous sandstone and shale	Drainage through Pittsburg; Kirkner Ck. to Delta	Scattered	Unacceptable
J	56	North Central Valley Foothills	Urban (1) Dev. Pot. (28) Undev. (27)	Urban and undev. grazing and row crops	Highways 4 and 160	Tertiary sandstone and shale	Contra Costa Costa, Sand and Marsh Creeks to Suisun Marsh	-	Probably un- acceptable for undev. cells
K	127	South Central Valley Foothills	Undev. (127)	Undev. grazing and row crops	Highway 4 and Byron High- way; poor to outlying areas	Cretaceous and Tertiary sandstone and shale	Marsh and Kellogg Creeks to San Joaquin River	-	Possibly acceptable
L	16	North of Alta- mont Pass	Undev. (16)	Undev. grazing	Highway 4 and Vasco Road; poor to out- lying areas	Largely Cretaceous sandstone and shale	Kellogg Creek to San Joaquin River		Possibly acceptable

Figure 7.--Part of a table from Perkins (1978, Appendix B) showing the application of the acceptability factors to several areas -- designated by letters -- in Contra Costa County. Acceptability tables for each designated area in each county in the San Francisco Bay region are available from the Association of Bay Area Governments, Hotel Claremont, Berkeley, 94705.

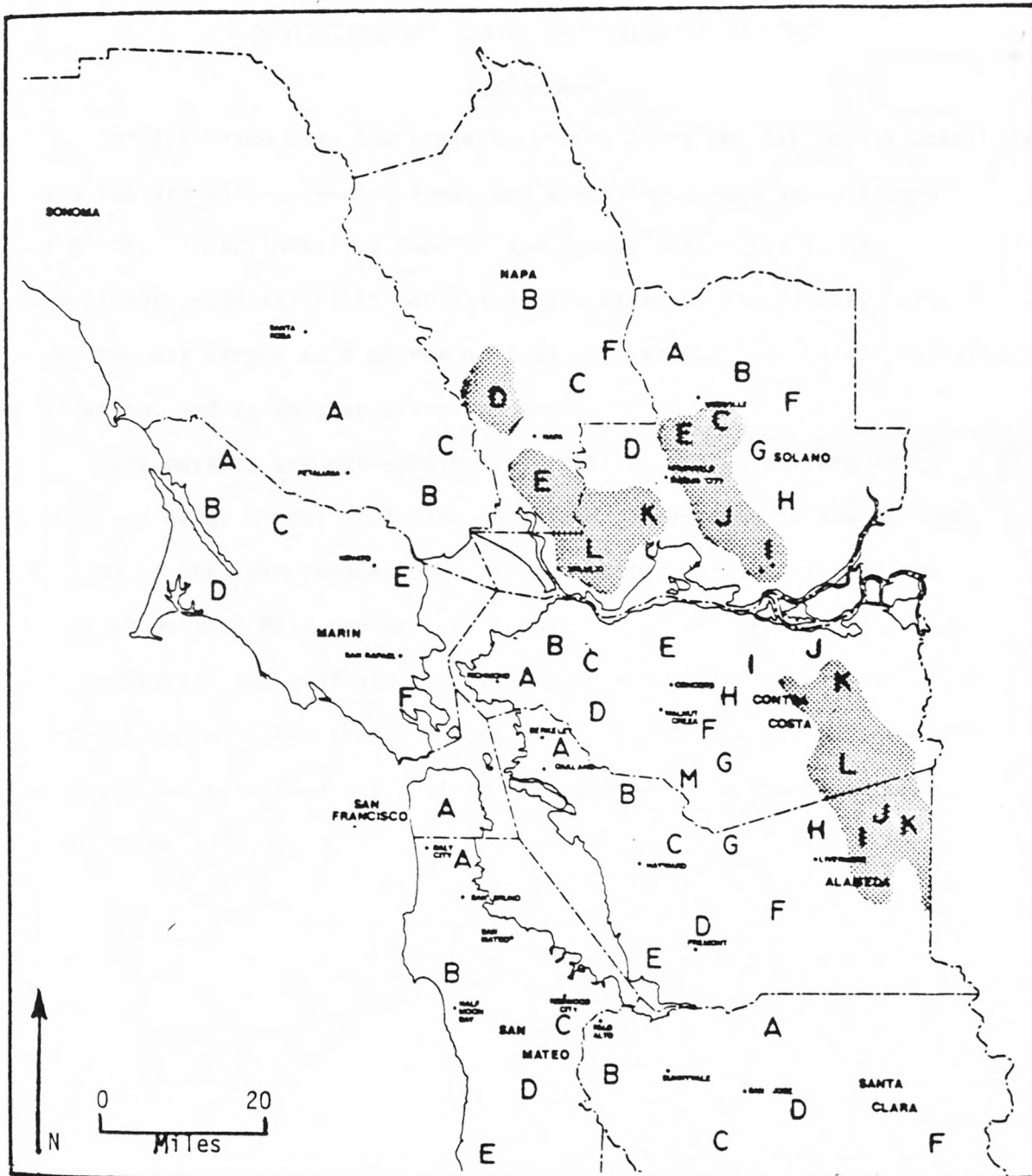


Figure 8.--Part of an index map from Perkins (1978, Plate I) showing areas -- designated by letters -- evaluated in the acceptability tables (fig. 7) and areas found to be possibly acceptable for hazardous waste disposal -- designated by shading. The possibly acceptable areas in Alameda County are in the vicinity of Altamont Pass. Those in Contra Costa County are in the eastern part of the county on the edge of the Central Valley. Those in Napa County border the hills in the southern portion of that county. Those in Solano County are in the hills south of Vacaville, in the hills northwest of Fairfield, in the western Montezuma hills, in the hills near Suisun and Denverton, and in the hills north of Benecia and Vallejo.

PROTECTING AN AQUATIC AND WILDLIFE HABITAT

Background

San Francisco Bay, the largest estuary along the California coastline, is a resting place, feeding area, and wintering ground for millions of birds. Also, nearly a hundred species of fish live in the marshlands, mudflats, salt pans, and open water of the estuary. For man, the bay serves as a source of food, recreation, scientific research, education, and as an unusual environment.

Salt marshes are extraordinarily fertile. Large numbers of shore and water birds, including ducks and geese, come to the marshes to feed on the lush vegetation or on the animals that thrive in the brackish water. Most marine life in the bay either depends directly on the marshes and mudflats for its sustenance or indirectly upon other marine life nourished there. Shore birds depend upon the marshes and mudflats for both food and shelter (Bay Conservation and Development Commission, 1969, p. 11).

All bay filling has some harmful effects. It may destroy the habitat of fish and wildlife; increase the danger of water pollution; reduce the air-conditioning effects of the bay, thereby increasing the danger of air pollution; and (or) diminish the scenic beauty of the bay. Past diking and filling of tidelands and marshlands has already reduced the size of the bay from about 680 square miles to little more than 400. Although some of this diked land remains, at least temporarily, as salt ponds or managed wetlands, it has nevertheless been removed from the effects of the tide (Bay Conservation and Development Commission, 1969, p. 2). The marshlands bordering the bay now total about 125 square miles (fig. 9). In 1850, before diking and filling had begun, marshlands covered as much as 313 square miles (Nichols and Wright, 1971).

The Suisun Marsh is the largest remaining wetland near San Francisco and contains approximately 85,000 acres of tidal marsh, managed wetland, adjacent grassland, and waterways -- more than 10 percent of California's remaining wetland area. It is a wildlife habitat of national importance. Suisun Marsh is located where the salt water of the Pacific Ocean and fresh water from the Sacramento and San Joaquin Rivers meet and mix (fig. 9). The marsh supports a great diversity of plants, fish, and wildlife, all of which are essential to the life chain. It also provides an important resting place for waterfowl on the Pacific Flyway from Canada to Mexico.

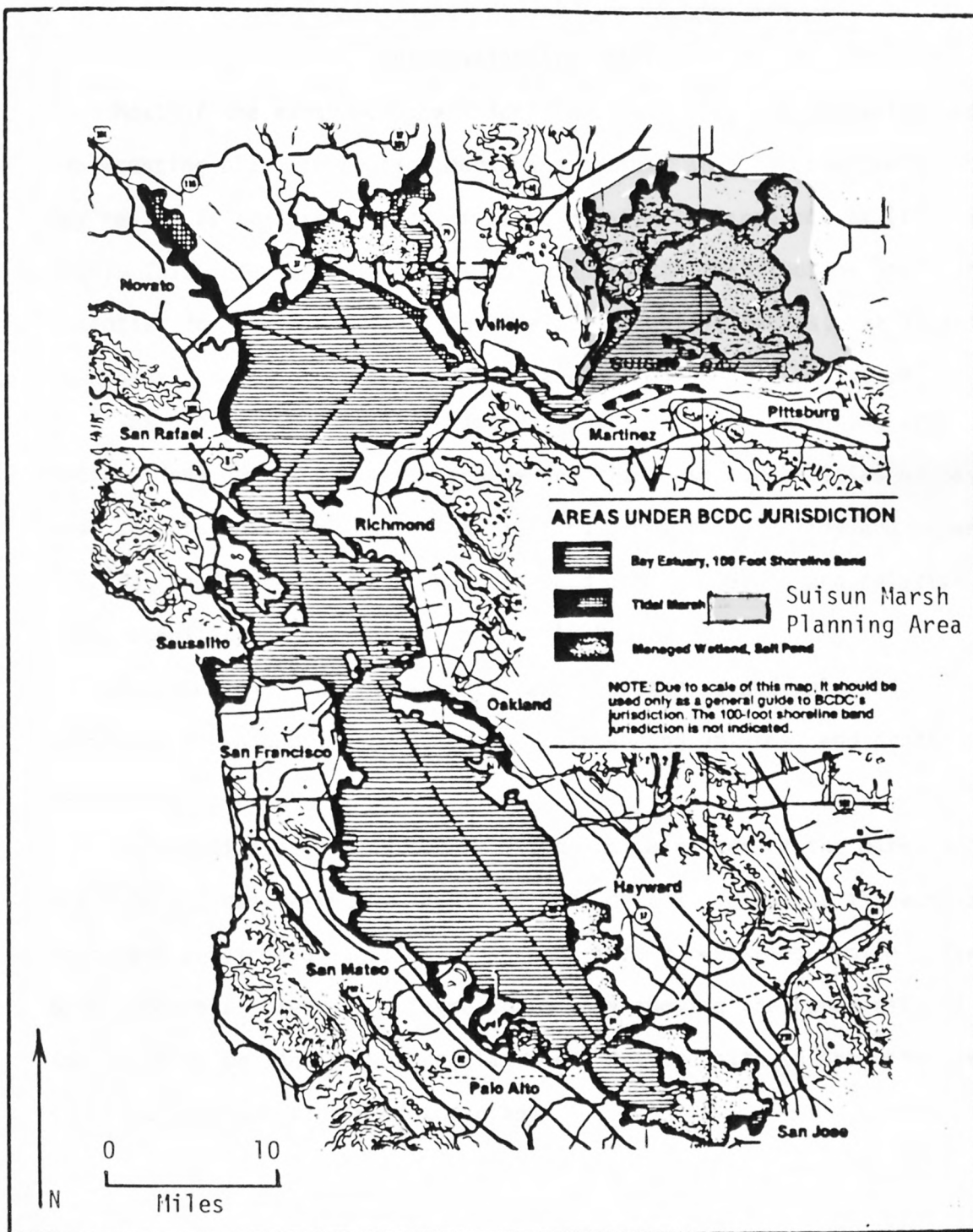


Figure 9.--A Bay Conservation and Development Commission (1976a) map showing their area of jurisdiction including the Suisun Marsh shown in yellow. The Commission has jurisdiction over the San Francisco Bay system including San Pablo and Suisun Bays; all sloughs, marshlands, tidelands, and submerged lands; a 100-foot strip inland from the bay system; diked saltponds; managed wetlands; and certain waterways.

Information Available

Most of the earth-science information necessary for preparing and implementing plans to protect marsh and coastal areas in the San Francisco Bay region is available, much of it at relatively large scales (1" = 2,000 feet). This information includes topography, the distribution of -- and potential for -- landslides, the location of active faults, the extent of historic marshlands, and data on land use, flooding, and slope.

The geologic and seismic history, physical and engineering properties, development problems, and general land-use capabilities of bay mud are discussed in reports on flatland deposits by Helley and others (1979), flood-prone areas by Waananen and others (1977), and relative slope stability by Nilsen and others (1979).

Aquatic and wildlife habitats can be preserved and enlarged by acquiring marshlands, regulating the surrounding uplands, and proper management.

Information regarding the location and character of the marshlands, geologic hazards, existing land uses, and natural resources is necessary to secure public and legislative support before preparing a plan. Furthermore, accurate, clear, and large-scale maps showing the boundaries of the lands to be acquired or regulated are prerequisite to the effective and legal implementation of the plan.

Decision

Widespread public interest -- State, national, and even international -- led the California Legislature to create a 27-member Bay Conservation and Development Commission in 1965 to protect the bay from uncoordinated, haphazard filling and to encourage proper shoreline development with arrangements for public access. The Legislature required the Commission to study the bay and plan for its conservation.

The California Legislature (1965) declared that the public has an interest in the bay since it is the most valuable single natural resource in the entire region. In 1970, the Legislature further declared that the Commission had

... made a detailed study of all the characteristics of the bay, including: the quality, quantity, and movement of bay waters, [and] ecological balance of the bay ...[and] on the basis of the study ... prepared a comprehensive and enforceable plan for the conservation of the water of the bay and the development of its shoreline

The Commission was also required to prepare a protection plan for Suisun Marsh for submission to the Governor and the California Legislature (1974). In response, the Commission (1976b) prepared a proposal for the preservation and enhancement of the large aquatic and wildlife habitat, entitled Suisun Marsh Protection Plan (figs. 10 and 11).

The plan calls for the creation of a primary management area that encompasses 89,000 acres within which existing uses -- generally duck hunting, limited grain production, and cattle grazing -- will continue. The Commission would have the major regulatory responsibility in the primary management area. To insulate the primary management area from incompatible upland land uses and agricultural practices, the plan also

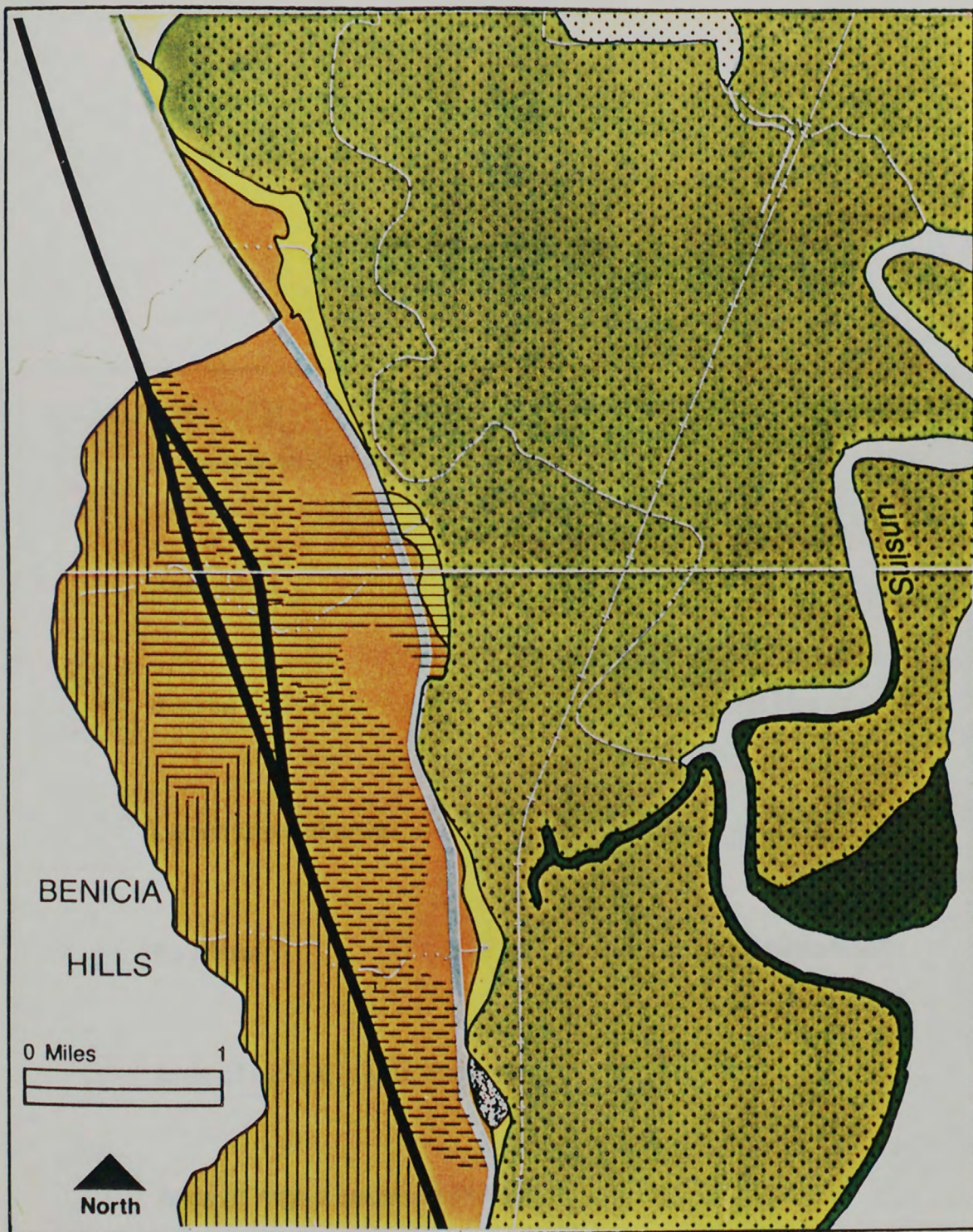
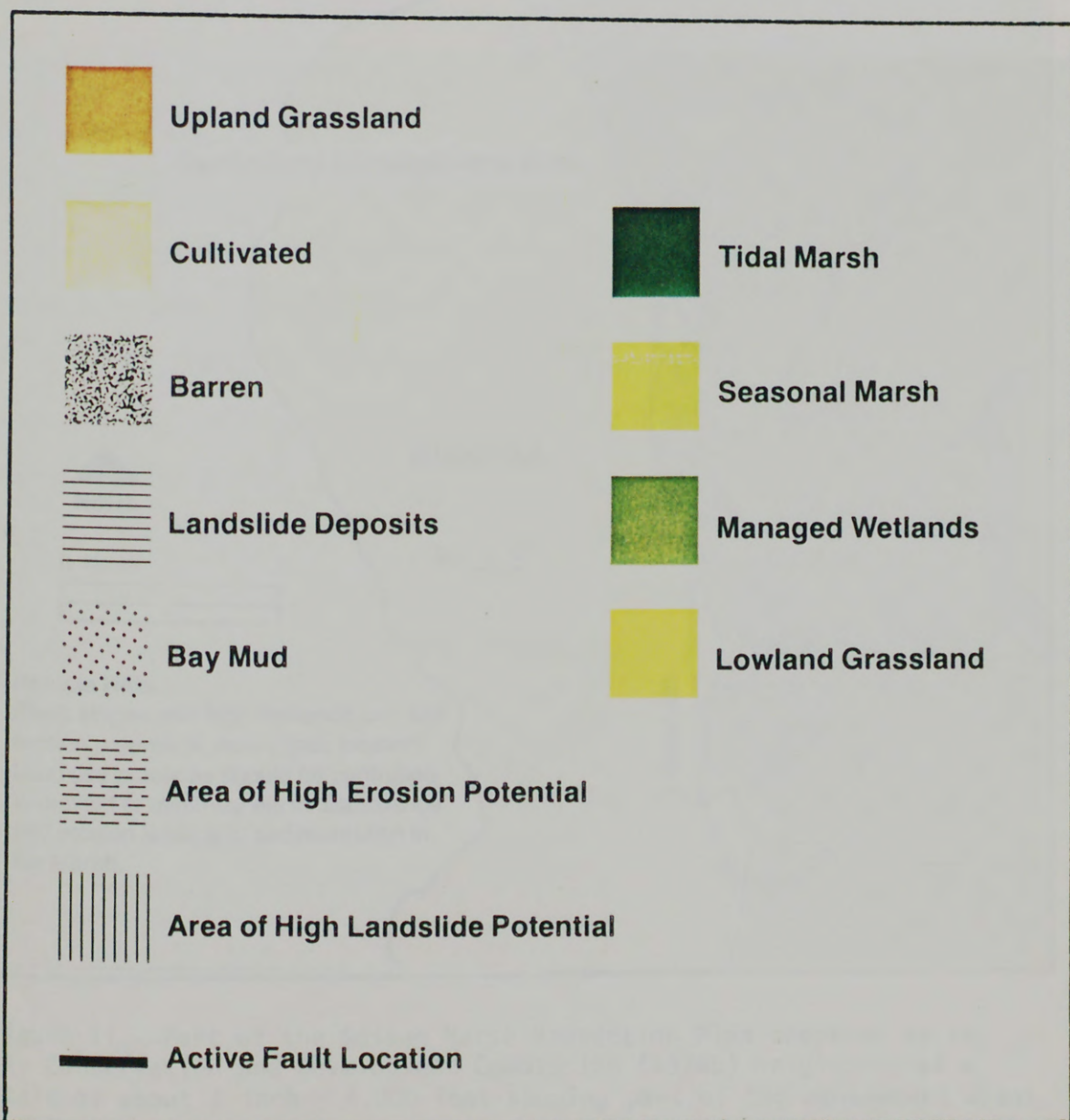


Figure 10.--Part of the Natural Factors Map originally at a scale of about 1 inch = 4,000 feet used in preparing the Suisun Marsh Protection Plan. The Bay Conservation and Development Commission (1976b) derived the location of the primary and secondary management areas shown on figure 11 from the natural factors shown here.

FIGURE 10.--continued
Natural Factors Map



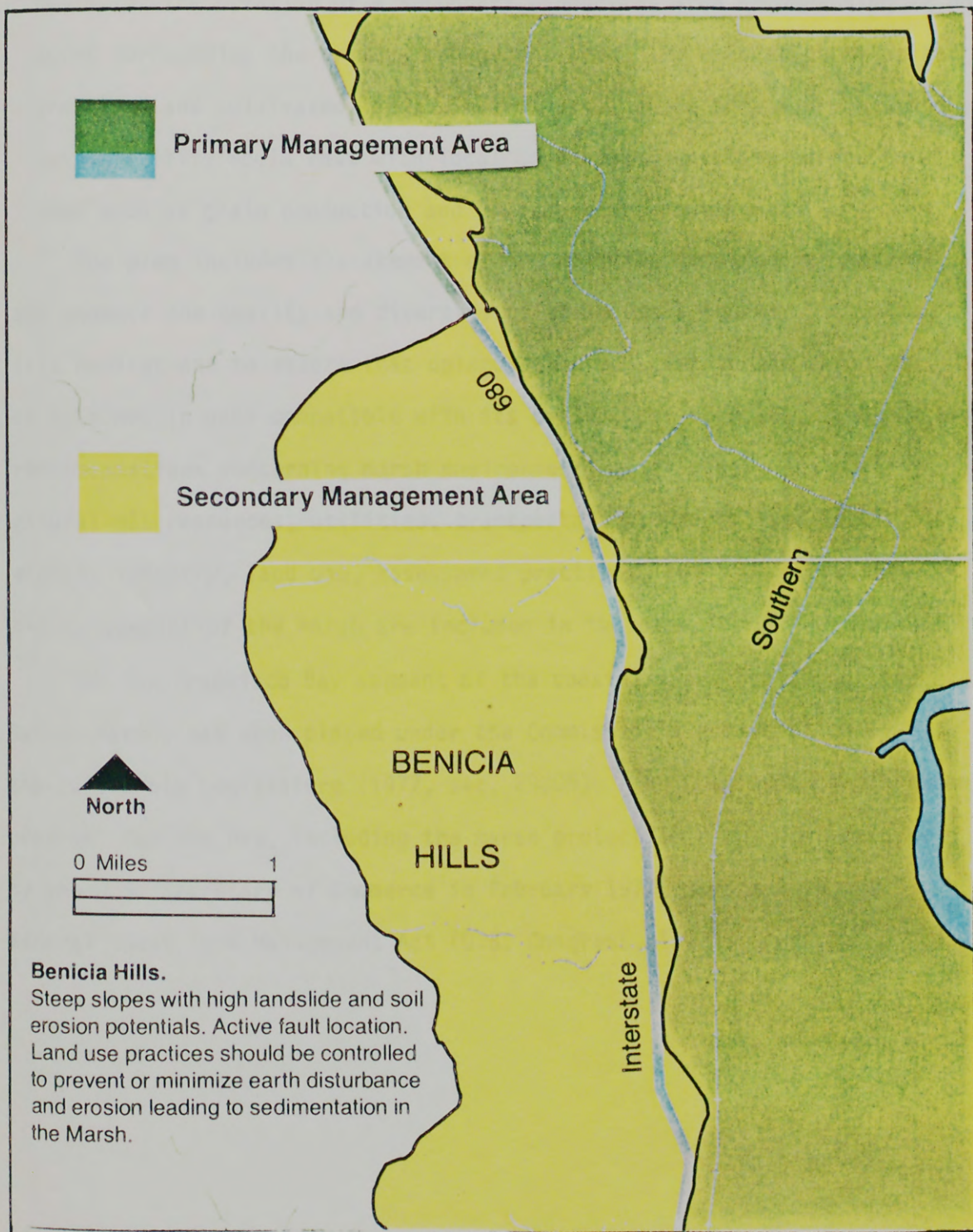


Figure 11.--Part of the Suisun Marsh Protection Plan prepared by the Bay Conservation and Development Commission (1976b) originally at a scale of about 1 inch = 4,000 feet showing part of the management areas.

calls for the creation of a secondary management area encompassing 22,500 acres surrounding the primary management area, and consisting of upland grassland and cultivated land. In this area, where the major regulatory responsibility would rest with local government, existing agricultural uses such as grain production and grazing would continue.

The plan includes a statement of the policies designed to preserve and enhance the quality and diversity of the marsh's aquatic and wildlife habitat and to assure that upland areas adjacent to the marsh will be retained in uses compatible with its protection. Specific findings and recommendations concerning marsh environment, water supply and quality, natural-gas resources, utilities, transportation, recreation, public access, industry, land use, assessment practices, and the acquisition and management of the marsh are included in the plan.

The San Francisco Bay segment of the coastal zone, including the Suisun Marsh, has been placed under the Commission's jurisdiction by the California Legislature (1977, sec. 29205). The Commission's management program for the bay, including the marsh protection plan, was approved by the U.S. Secretary of Commerce in February 1977, pursuant to the Federal Coast Zone Management Act (U.S. Congress, 1972).

Application

Information on landslide deposits, historic marshlands, landslide susceptibility, land use, flood-prone areas, steep slopes, and active faults was obtained from published and unpublished sources, transferred to regional topographic work maps, and then summarized on a Natural Factors Map (fig. 10). From this map, the marsh protection plan (fig. 11) was prepared. Recommendations for land-use practices in the Benicia Hills are also based upon earth-science information, as were some of the legal boundaries and areas of jurisdiction (fig. 9) for the Commission's planning and regulatory functions (Kockelman, 1979, p. 102).

The California Legislature (1977) declared the Suisun Marsh a unique and irreplaceable resource, approved the marsh protection plan, provided for implementation of the plan, and assigned the Commission the primary responsibility. The implementation process includes (1) requiring local governments -- Solano County, Benicia, Fairfield, Suisun City, and special districts -- to develop a local protection program and controls consistent with the plan; (2) acquiring lands for public use or resource management through the California Wildlife Conservation Board; (3) regulating development within the primary management area through permits issued by the Commission; (4) regulating development within the secondary management area through permits issued by the local governments; (5) managing fish and wildlife through

the California Department of Fish and Game; (6) creating a Suisun Resource Conservation District to regulate and improve water-management practices on privately owned lands; (7) requiring preferential-assessment practices; and (8) providing for cease and desist orders.

The development to be regulated in the primary and secondary management areas includes placement of any material or erection of any structure, discharge or disposal of any material, grading or removal of any material, change in density or intensity of land use, land division, alteration or demolition of any structure, and the removal or harvesting of vegetation other than for agricultural purposes.

The Commission has prepared a detailed map for the marsh at a scale of 1 inch = 2,000 feet (1:24,000) showing both the primary and secondary management areas. The Commission has also prepared guidelines (1978) for the local protection program, and the county and cities are preparing the program for Commission review.

About four million dollars was available to the California Wildlife Conservation Board for acquiring and improving lands in the marsh. Almost 1,400 acres have been acquired, and additional acreage is being considered for acquisition.

The Commission is authorized to grant, deny, or grant subject to conditions, permits to place fill, extract materials, or make any substantial change in the use of any water, land, or structure within its area of jurisdiction (California Legislature, 1975, Sec. 66632). Pursuant to this authority, the Commission has adopted an application and permit system, and prescribed the content and procedures required

for obtaining permits. The Commission has integrated the marsh-development permit system (a system which required that any proposed development be consistent with the Commission's plan or local protection programs) into the existing bay development permit system. Under its enforcement powers, the Commission monitors development in its area of jurisdiction (fig. 9) and has issued "cease and desist" orders for filling and other work in the marsh area.

In addition, the Commission reviews and comments on environmental impact reports for actions affecting the marsh and has filed lawsuits where a report was felt to be inadequate.

Comment

This example shows how basic and interpretive scientific information can be employed to protect an irreplaceable aquatic and wildlife habitat for an area of more than 110,000 acres.

The combined use of regulations, acquisition, local controls, fish and wildlife management, water management, and preferential tax assessments has preserved specific resources.

Scientific information can be applied similarly to resource protection planning and plan implementation in other estuarine environments, including those in the coastal areas of the United States affected by the Federal Coastal Management Act (U.S. Congress, 1972).

REQUIRING SITE INVESTIGATIONS IN HAZARDOUS AREAS

Background

Santa Clara County is subject to numerous earthquake hazards. These hazards include ground displacement, landslides, liquefaction of bay mud and other materials, and flooding (fig. 12). The county is traversed by several major active faults, and it has been shaken by many earthquakes, some of which caused severe damage.

Many parts of the county are affected by unfavorable natural factors that produce landslides, such as weak rock or soil conditions, high moisture content, and steep slopes (fig. 12). Landslides also commonly accompany earthquakes, as was the case during the 1906 earthquake. In addition, many of man's activities trigger slides, such as steepening slopes, removing vegetation and downslope support, increasing upslope weight, disrupting surface drainage, and adding fluids by watering lawns and septic-tank discharges. Landslides have made it necessary for the county to relocate roads, repair houses and lots, replace utility services, remove reservoir sediments, and lower property assessments (Taylor and Brabb, 1972).

Natural and filled marshlands in the county are underlain by soft bay mud that in places contains fine-grained, water-saturated silt and sand (fig. 12). The areas of clay-free alluvium below the water table are subject to seismically induced ground failure by liquefaction, lurching, lateral spreading, or differential settlement. In 1906, such ground failures were observed to result in displacements of more than 6 feet with cracks up to 5 feet wide, 6 feet deep, and 100 feet long (Youd and Hoose, 1978, p. 114).

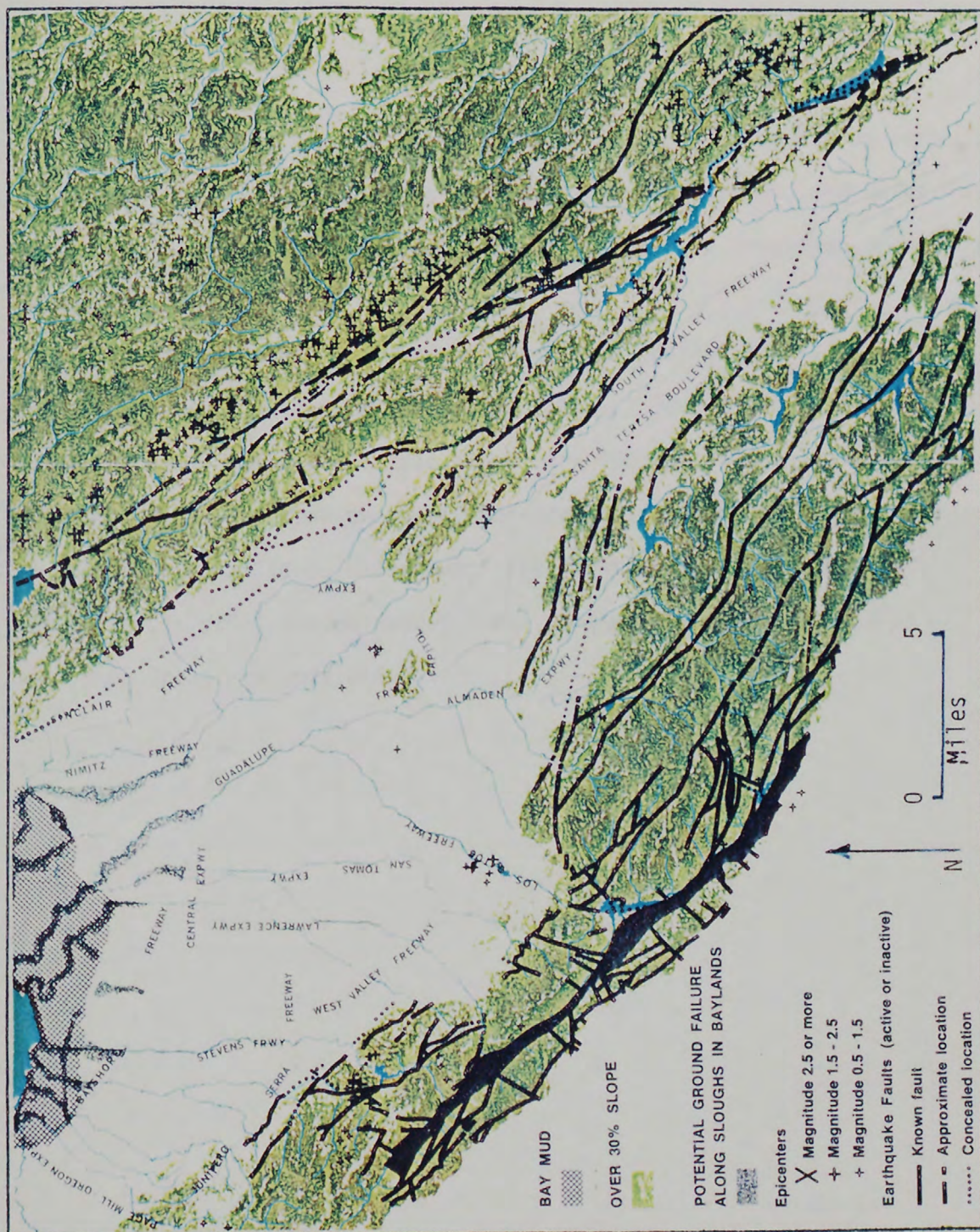


Figure 12.--Part of a map originally at a scale of about 1 inch = 2 1/2 miles showing some of the earthquake hazards in Santa Clara County. The map was prepared and used by the Santa Clara County Planning Department (1973) for public-information purposes. The preparation and distribution of the map took place prior to the adoption of the county's seismic safety plan and ordinance enforcing on-site geologic investigations prior to construction. Its wide distribution made the general public aware of earthquake hazards and partially contributed to the unanimous adoption of both the plan and ordinance (Eleanor Young, Senior Planner, oral commun., Oct. 3, 1979).

If the dike system that borders the bay failed during strong earthquake shaking, storm waves, high tide, and possibly seismic sea waves could cause extensive salt-water flooding -- the area inundated depending on the tidal level.

Santa Clara County has over 1 1/4 million people and is one of the fastest growing counties in the United States. Some urban development, involving major gas and electric lines, transportation facilities, major water conduits, and some emergency service facilities, has taken place in areas now known to be hazardous. See figures 13 and 15. However, the county is still predominately rural, and most of the potentially hazardous areas are undeveloped.

Information Available

Most of the seismic, geologic, and other information that is needed in preparing safety plans for counties in the San Francisco Bay region is available -- topographic maps, land-use maps, and maps showing active fault breaks, landslide deposits and susceptibility, historic marshlands, liquefaction potential, relative intensities of ground shaking, geology, and steepness of slopes. Some of the information is available at scales as large as 1 inch = 2,000 feet.

The geologic and seismic history, physical and engineering properties, development problems, and general land-use capabilities of areas involving bay mud, landslides, and active faults are discussed in reports on seismic zonation edited by Borchardt (1975), relative slope stability by Nilsen and others (1979), hillsides by Wentworth and others (1980), or flatlands by Helley and others (1979).

Much of this information is often not available at the scale or level of detail needed for administering the local land-development ordinances that affect individual building sites (usually scales of 1 inch = 200 to 500 feet). Such large-scale, detailed information must be gathered for individual sites by carefully designed geologic investigations.

Hazard maps of the entire community are a prerequisite to requiring site investigations -- usually at a scale of 1 inch = 2,000 feet -- but larger-scale maps (1 inch = 500 to 1,000 feet) that show hazards related to ownership boundaries are also desirable. Once the site investigation and geologic report are completed, development can be guided to safe, stable parts of the site, or remedial measures can be required. All maps should be readable, and readily available to land developers, home builders, real-estate salespersons, appraisers, assessors, lot purchasers, lending institutions, and insurance companies.

Decision

In compliance with the State law requiring all cities and counties to prepare and adopt a general plan for their physical development (California Legislature, 1978b), the Santa Clara County Planning Department (1975) prepared such a plan. The plan includes two major recommendations to the county -- retain the services of an engineering geologist, and require on-site geologic investigations prior to construction.

The Planning Department combined all the potential earthquake hazards -- liquefaction, lurching, lateral spreading, differential settlement, ground displacement, landslides, and flooding due to dike failure -- on a seismic stability map. Three zones, shown in red, yellow, and green, were then delineated on the map to indicate three degrees of need for detailed site investigations as determined by the level of hazards (fig. 13). Large-scale cadastral maps (fig. 14) show potential hazards in relation to individual lots.

The plan, unanimously adopted by the County Planning Commission and Board of Supervisors, is now implemented under the county geologic ordinance (Santa Clara County Board of Supervisors, 1978). The ordinance affects the county's other land-development ordinances -- building, subdivision, grading, and zoning. The ordinance cites the seismic stability map as one of the county's official hazard maps and includes a statement that "Development within a known geologic hazard area will be discouraged."

The county established a position for a State-certified engineering geologist in its Department of Land Development Engineering and Surveying. He helped prepare the seismic safety plan and the geologic ordinance, and has major responsibility for administering the ordinance.

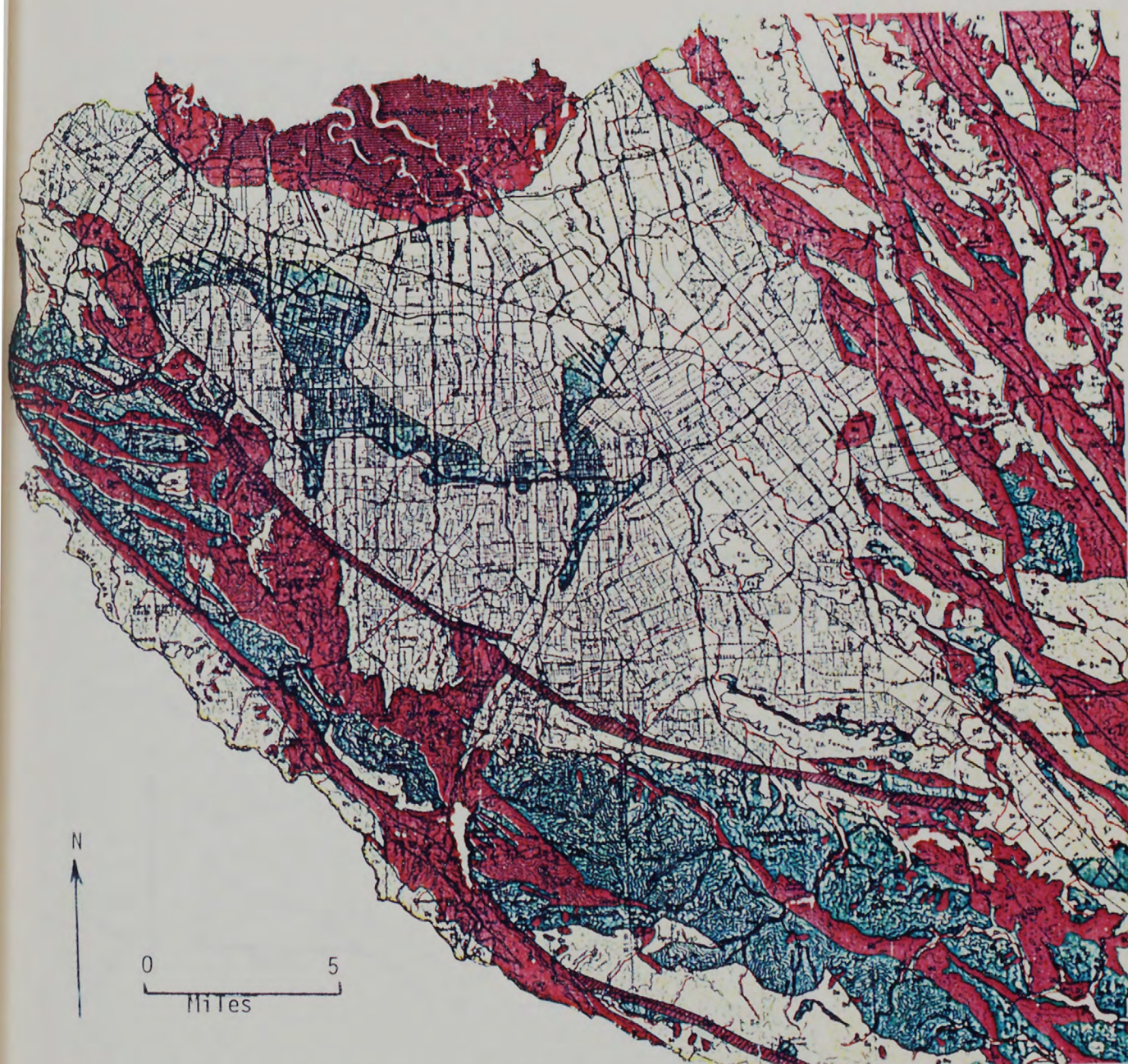


Figure 13.--Part of the Santa Clara County Relative Seismic Stability Map originally at a scale of about 1 inch = 4 miles prepared by Williams and Rogers (1974) and revised by Santa Clara County in 1978. The colors indicate degrees of hazard and where a site investigation may be required. Red zones indicate areas with major hazards where site investigations are mandatory; yellow indicates areas with moderate hazards where site investigations are required unless waived; and green indicates areas with minor hazards where site investigations are not automatically required but may be required. Larger scale cadastral maps of the area (fig. 14) showing hazard areas and property lines are available.

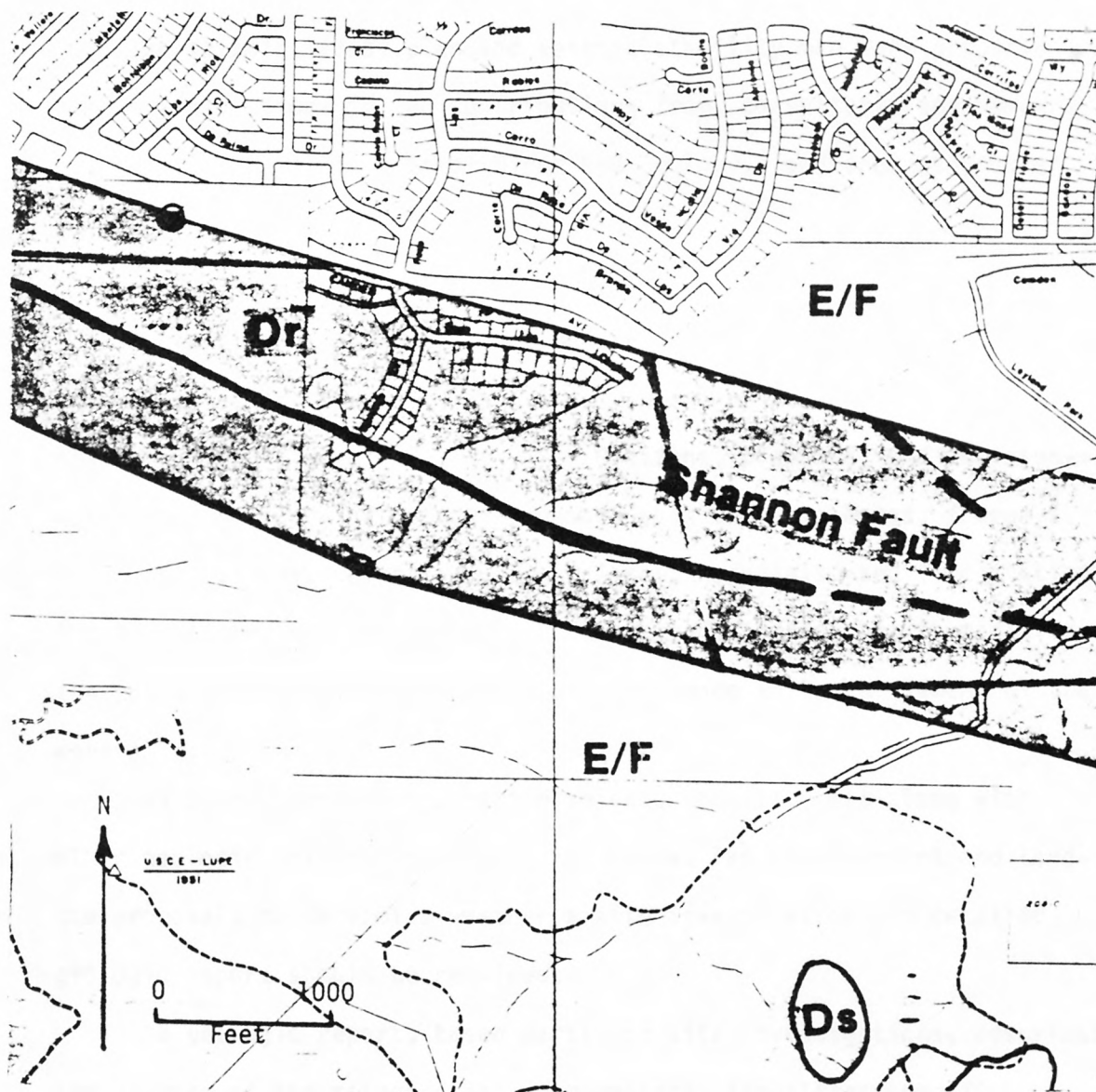


Figure 14.--Part of one of Santa Clara County's cadastral maps, which show earthquake hazards at a scale of 1 inch = 1,000 feet (1:12,000). The shaded area indicates zones where site investigations are required along active or potentially active faults. The letters indicate specific hazards that need to be investigated and evaluated: Dr - area of high potential for ground displacement, Ds - areas of high potential for earthquake-induced landslides, E/F - areas of moderate to low potential for any geologic hazard. Information on the availability of these maps can be obtained from the County Geologist, Department of Land Development Engineering and Surveying, County of Santa Clara, 70 West Hedding Street, San Jose, CA 95110.

Application

The seismic safety plan and seismic stability map were prepared with the assistance of, or contributions from, consultants and members of the California Division of Mines and Geology, and from many other sources.

Other elements of the county general plan, such as urban development, and major gas and electric lines, were superimposed on the seismic stability map (figure 15). Citizens, planners, and decision-makers become aware of potential damage when they see homes, freeways, railroads, bridges, pipelines, power lines, hospitals, and fire stations located in the "red" hazard zones. Recommendations on how to minimize the possible loss of life and property are made for each element of the general plan.

The county geologist uses the seismic stability map along with other geologic information, when he reviews land-development and land-use proposals to determine whether a site investigation and detailed geologic report should be required.

The geologic report, based partly on site investigations, describes the geology of the site and its surroundings, identifies specific problems of the site, and specifies remedial measures necessary to make the proposed development reasonably safe.

Review and approval of the geologic report by the county geologist must precede final action on applications for building sites and mobile homes, final approval of subdivisions, issuing of grading permits, and approval of use permits and rezonings. The geologic report and the county geologist's recommendations serve as the basis for approval or disapproval of all land-use and land-development proposals or any special conditions that may be imposed.

If the geologic report indicates unusually severe geologic constraints, development may proceed only after the property owner signs a statement acknowledging the existence of the hazards, accepting the risks, and relieving the county of liability. The statement is recorded in the county recorder's office and may be expunged if subsequent information -- approved by the county geologist -- indicates the hazard no longer exists or has been reduced. However, no new structures for human occupancy can be located on active fault traces or active landslides that have not been stabilized by acceptable engineering procedures.

The county geologic ordinance provides for a waiver of the site-investigation and geologic report in rare situations. The waiver must be signed by the property owner, acknowledged and recorded in the office of the county recorder, and state that the property owner accepts all risks and consequences. The waiver can be expunged upon approval by the county geologist that a favorable geologic report has been received. The ordinance also provides that a seller of real property lying within a major hazard zone shall disclose to the buyer -- by a written statement -- the existence of the geologic risk.

These statements, waivers, and acknowledgments serve to inform all parties to a real-estate transaction -- buyer, seller, agents, builder, lender, insurer, and local building and zoning officials -- that the property is subject to earthquake hazards.

Comment

This example illustrates how earthquake-hazard information can be used by a county prior to development to determine where site investigations and detailed geological reports are necessary.

The public understanding and buyer awareness which derive from the county's seismic safety plan, seismic stability map, and geologic ordinance will help guide development to less hazardous areas, encourage remedial measures in other areas, and generally result in reasonably safe development in one of the United States' most populous and seismically active counties.

These methods for avoiding earthquake hazards and reducing damage can be adapted to other natural hazards and to other counties where hazard information is available, and where seismic safety plans are required by the California Legislature (1978b).

SUPPLEMENTING BUILDING STANDARDS ON UNSTABLE BAYLANDS

Background

Recent estuarine deposits called bay mud underlie the San Francisco Bay and the present and historic tidal marshes. Their thickness ranges from 120 feet beneath parts of the bay to less than one foot around the edges of the marshlands. Most of the historic tidal marshes have been covered by a few feet of artificial fill (Helley and others, 1979, p. 21-22). The term "bay mud" is used in this example to refer to the soft saturated silty clay that has been deposited in the San Francisco Bay during relatively recent times -- the last 10,000 years. Lying beneath these soft clays are similar but much older clays which have a low water content, are very firm, and provide much more stable foundation conditions.

Bay mud has an extremely high water content, a low permeability, a fine grain size, and loose packing. These physical properties, together with the high water table and distribution at or below mean sea level result in several potential problems for urban development, such as flooding, ponding, foundation shifting, uneven settlement, liquefaction, and amplification of seismically induced ground shaking (Helley and others, 1979, p. 72).

Therefore, retention of the natural estuarine environment -- as has been recommended by the Bay Conservation and Development Commission, and several cities -- is often the more economical and practical alternative.

However, the location of these lands on level ground, close to freeways, and near a scenic and recreational estuarine environment, has resulted in intense development pressures on many of those communities that border San Francisco Bay. Development proposals include plans for single- and multi-family dwellings, office buildings, shopping centers, hotels, airport and seaport facilities, industries, and amusement parks. Over 30 cities in the bay region have existing or historic tidal marshes underlain by bay mud within their jurisdiction. Some have planned and provided for urban development by dewatering and demulching the bay mud, and reconditioning diked land.

For example, over one-half of the land under the jurisdiction of Redwood City (population about 55,000 located 25 miles south of San Francisco) lies on bay mud. At present, less than ten percent of the over 6,000 acres underlain by bay mud are developed. The comprehensive general plan prepared by the Redwood City Planning Department (1975) proposes residential, commercial, institutional, industrial, public facilities, open space, and unclassified uses for the undeveloped lands. The land-use plan being implemented by a zoning ordinance (Redwood City Council, 1978) permits urban use in some areas, but most of the undeveloped bay lands are zoned for tidal-plain uses.

Even where dikes and fills reduce the risk from flooding, a major earthquake could cause severe damage to certain types of urban development as a result of liquefaction and subsequent ground failure. Youd and Hoose (1978) found that ground failures in San Francisco have been limited mainly to areas underlain by filled-over marsh and bay mud deposits, filled-in ravines, loose sand deposits, sand dunes, and steep slopes.

The effects of ground shaking are likely to be especially severe in areas underlain by bay mud and alluvium. In historic earthquakes, building damage from liquefaction and ground shaking included failure of foundations or footings, collapse of unreinforced masonry walls and chimneys, movement of houses off their foundations, and toppling of unanchored machinery, storage tanks, and electrical equipment along with rupture of the lines.

Information Available

Information on the location and general seismic response of bay mud necessary for supplementing the building standards is available: information on historic marshlands, liquefaction potential, and relative intensities of ground shaking. In addition, larger scale (1" = 2,000') work sheets of the historic marshlands are available in the U.S. Geological Survey Western Region library at Menlo Park.

The response of bay mud to ground shaking, ground failure associated with liquefaction, and predicted geologic effects of a postulated earthquake is discussed in a report on seismic zonation edited by Borchardt (1975).

In addition, the geologic and seismic history, physical and engineering properties, development problems, and general land-use capabilities of bay muds are discussed in a U.S. Geological Survey professional paper on flatland deposits by Helley and others (1979). Maps of flatland deposits useful to public and private decisionmakers are included.

Damage due to ground failure can be mitigated by first investigating and then designing for recognized site problems. Properly engineered fills, carefully designed foundations and structures, reinforced masonry, anchored machinery and equipment, and well-supervised construction are some of the supplemental measures that can be incorporated into building regulations to reduce damage from earthquake shaking.

Information as to seismic response, examples of damage to be expected, and the location of the unstable lands are necessary for public information before adopting the supplemental building standards. An accurate, clear, and large-scale map showing the boundaries of the unstable lands is essential for effective and legal administration of the standards.

Decision

To ensure community safety and welfare, the Redwood City Council (1974, 1977a) adopted an ordinance which provides for special seismic requirements relating to design and construction standards. The standards supplement those recommended by the International Conference of Building Officials (1976) for structures in seismic zone 4 under the Uniform Building Code -- the code adopted by the city as its building code. The adoption of the ordinance was accompanied by a resolution by the Redwood City Council (1977b) expressly determining the necessity of the additional requirements because:

....local seismic and geologic conditions, experience, and comprehensive engineering, geological, seismic and soils analyses have shown that implementation of these detailed requirements in the specified areas can greatly minimize differential settlement of structures and provide increased structural integrity with respect to seismic safety.

The ordinance is consistent with the city's initial Seismic Safety Element (Redwood City Planning Department, 1974) which had placed the bay mud in a moderately high-risk zone and recommended that the Uniform Building Code be reviewed and amended as "frequently as may be prudent." The ordinance also follows recommendations of the Redwood City Seismic Advisory Board (1972) with respect to foundation design, building design, and equipment anchorage.

The ordinance was unanimously adopted and is being administered by the city's building department. The supplemental structural-design and construction standards (fig. 16) called for in the ordinance relate to special foundation-design criteria, design provisions for greater lateral force, foundation systems to resist settlement, wood-frame sheathing, moment-resisting frames, reinforced masonry construction, elements of redundancy, response spectrums, and reinforcement of structural members. The standards apply only to those lands within the city that are underlain by bay mud as shown on a map adopted by reference in the ordinance (fig. 17).

The last part of the ordinance provides that all equipment within any structure that would be an earthquake hazard shall be securely anchored. This part of the ordinance affects new installations throughout the entire city -- including those on bay mud, alluvium, or hillside materials.

DIVISION 2. AREAS OF REDWOOD CITY UNDERLAIN BY
YOUNGER BAY MUD

Sec. 9.121. Applicability of provisions.

The provisions of this division shall be applicable to that portion of the City of Redwood City underlain by younger bay mud as indicated on that map prepared by the building department of the City of Redwood City entitled "Area of Redwood City Underlain by Younger Bay Mud," and on file in the office of the city clerk. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.122. One and two story structures.

For one and two story residential buildings or structures only, all lot grading, soils design, foundation design, and construction design including lateral force analysis, shall be in accordance with the recommendations of the "Recommended Foundation Design Criteria for One and Two Story Residences" (dated April 15, 1974) as prepared by Rutherford and Chekene, Consulting Structural Engineers and as approved by the Redwood City Building Department, which document is on file in the office of the city clerk. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.123. Structural design.

All structural design shall be in accordance with the building code including lateral force provisions for earthquakes. Structural design for major structures in the longer range period (three-fourths ($\frac{3}{4}$) of a second or more) shall use the "Recommended Base Shear Coefficient 'CS' for Lateral Force Design," as shown on Plate V-1, as revised, October 6, 1977, following page 75A, 1972 Seismic Advisory Board Report (on file in the office of the city clerk). (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.124. Foundation systems.

Foundation systems shall consist of mat, grill, piles or a similar system with a demonstrated ability to resist differential settlement and for tying the foundation elements together. The minimum tie strength shall be at least ten (10) per cent of the greatest load imposed on a foundation or foundation element. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.125. Sheathing on exterior frame of wood frame buildings.

All wood frame buildings shall be provided with five-sixteenths ($\frac{5}{16}$) inch plywood sheathing on the exterior frame in accordance with the "Design Criteria" prescribed by section 9.122 herein unless structural design and calculations prescribe lateral force parameters equal to or greater than the "Design Criteria Recommendations" of section 9.122. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.126. Walls or frames to resist lateral loads.

"Frame only" (space frame-ductile moment resisting and space frame-moment resisting as per the building code) structures where $K = 0.67$ are not permitted. Shear walls or braced frames are required to resist the entire lateral load. In buildings of more than one hundred sixty (160) feet in height a moment-resisting ductile frame is required; this frame shall be capable of resisting twenty-five (25) per cent of the required lateral load. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.127. Unit masonry structures.

Unit masonry structures (concrete block, brick, unitized precast, prestressed concrete) are not permitted unless the project design engineer can demonstrate, by thorough analysis and/or tests, that the strength and ductility (including the effects of temperature, foundation settlement, shrinkage and creep) are equal to that of monolithic construction. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.128. Design of certain structures to incorporate sufficient elements of redundancy.

For all structures more than four (4) stories irrespective of height or which contain more than twenty thousand (20,000) square feet of floor area, the design shall incorporate sufficient elements of redundancy such that complete failure of any one bracing element will not reduce the bracing capacity of the structures by more than seventy-five (75) per cent. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.129. Design of structures based on response spectra.

The design of buildings or structures more than six (6) stories must, irrespective of height, be based on a response spectrum computed for the site. This response spectrum shall be compared with the average spectrum in accordance with Plate V-1 "Recommended Base Shear Coefficients 'CS' for Lateral Force Design," as revised October 6, 1977, following page 75A, 1972 Seismic Advisory Board Report (on file in the office of the city clerk) and the higher valued spectrum incorporated in the design. (Ord. No. 1727, § 2, 11-28-77)

DIVISION 3. REDWOOD CITY GENERALLY

Sec. 9.135. Provisions cumulative; applicability.

The provisions of this division shall be applicable throughout Redwood City and shall be in addition to all other applicable provisions of the building code. (Ord. No. 1727, § 2, 11-28-77)

Sec. 9.136. Anchoring of machinery or equipment.

Whenever connected to, part of, or housed within a building or structure, towers, tanks, storage-type water heaters, lighting fixtures, power transformers, machinery or other equipment that would constitute or contribute to earthquake hazards shall be securely anchored in accordance with Table 23J, item 4 of the building code. Exception: Domestic storage-type water heaters installed in one and two story residential buildings shall be anchored as recommended in the "Design Criteria" referenced in section 9.122. (Ord. No. 1727, § 2, 11-28-77)

Figure 16.--Part of the Redwood City Council (1977) building code supplementing the design and construction standards for lands underlain by bay mud. Their location is shown on fig. 17.

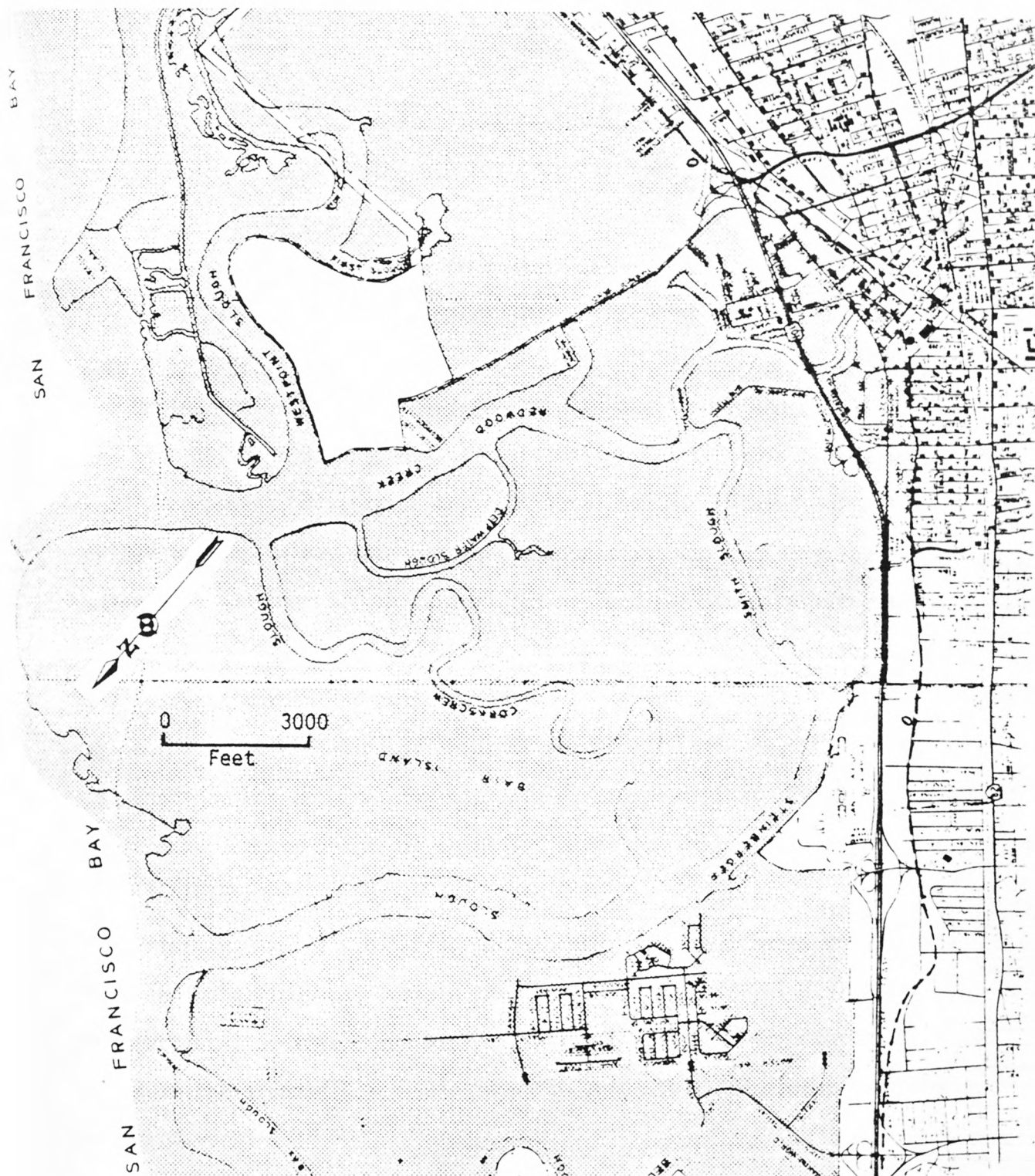


Figure 17.--Part of a map at an original scale of about 1 inch = 3,000 feet showing the area in Redwood City underlain by bay mud. The map is attached to the Building Code (Redwood City Council, 1977a) which requires supplemental structural-design and construction standards for all new development. The bay mud is indicated by a shaded pattern and its southwesterly boundary by a dashed line. The unshaded area along U.S. Highway No. 101 lies outside the city's jurisdiction.

Application

The city's map showing bay mud (fig. 17) was based on a published map by Nichols and Wright (1971) that showed historic margins of marshlands, but more detailed information from their unpublished materials was also incorporated (Robert Bruce, former city building official, oral commun., July 13, 1979).

During preconstruction conferences with developers and builders, the city building department staff ascertains the location of the proposed development, advises on any additional seismic requirement for development on bay mud, recommends foundation design criteria (Rutherford and Chekene, 1974, a,b) for one and two-story residences, and sometimes provides visual guides similar to that shown on figure 18. A site investigation and soils report by a geologist or soils engineer and the retention of an architect, civil engineer, or structural engineer are required for any development on bay mud (Charles Gyselbrecht, former chief city building official, oral commun., July 18, 1979).

Prior to issuing a building permit, the city staff verifies that the plans and specifications contain the appropriate structural design and construction standards. The staff inspects the work during construction to ensure the standards are complied with prior to final approval of the completed work.

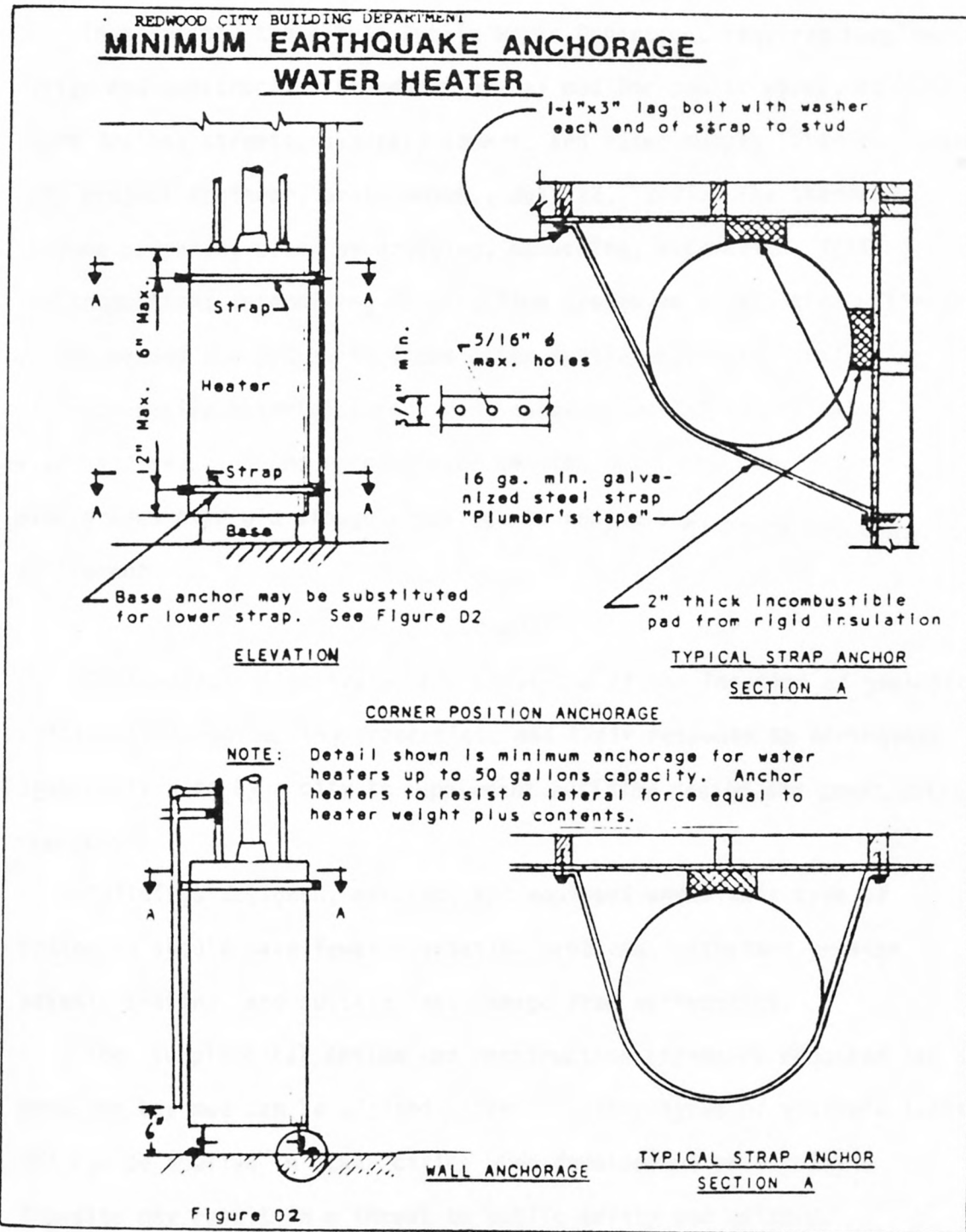


Figure 18.--Part of the earthquake anchorage guide prepared and distributed by the Redwood City Building Department (1974) to applicants for water-heater installations. Use of the guide ensures compliance with Section 9.136 of the building code shown on figure 16.

In addition, the city's Public Works Department requires supplemental design and construction standards on bay mud for public works, such as storm drains, streets, sanitary sewers, and water supply (Charles Csicsman, city project engineer, oral commun., July 12, 1979). The standards include preparing sites by dredging, demucking, excavation, filling, and compaction; determining construction grades to obtain the "ultimate" grades needed for hydraulic flows after settlement; using drain pipes of noncorrosive materials; requiring gates at outfalls to tidal waterways; and reducing underground pipe lengths and increasing underground pipe grades over old slough crossings to reduce pipe damage during settlement.

Comment

This example illustrates how knowledge of the location of geologic units, their engineering properties, and their response to earthquake shaking is used by a city to supplement building design and construction standards.

Buildings designed, erected, and equipped under this type of ordinance should have fewer foundation problems, withstand greater seismic shaking, and sustain less damage from earthquakes.

The supplemental design and construction standards required for developments on bay mud can be adapted for other types of unstable lands and can be applied in other cities when development on estuarine deposits may result in a threat to public safety and welfare.

DISCLOSING HAZARDS TO REAL-ESTATE BUYERS

Background

The San Francisco Bay region has many hydrologic, seismic, and other geologic hazards. Streams in the bay region flood periodically during heavy rains. Occasionally, extremely high tides in the bay and coastal areas, or combinations of high tides, winds, and floods on the streams, cause coastal flooding of lands adjacent to San Francisco Bay.

Many of the San Francisco Bay hillside areas are relatively unstable and susceptible to natural slope failures. All of the primary conditions that cause slope failure are present: steep irregular slopes, heavy rainfall, weak and unconsolidated rocks, expansive clays, strong seismic activity, and extensive human activity. Many of the human activities that can cause slope failure are present: steepening the angle of slope, increasing the height, adding water, removing support, and adding extra loads (Nilsen and others, 1979). Active fault systems underlie the San Francisco Bay region, and great earthquakes have occurred.

The population of the nine-county San Francisco Bay region was more than 3.6 million in 1960 and over 4.5 million in 1970. The California Department of Finance (1979) estimated the population to be almost 5 million on January 1, 1979, and the Association of Bay Area Governments (1979) projects about 5.2, 5.7, and 6.2 million people in years 1980, 1990, and 2000, respectively. In 1975, these people lived in an estimated 1,770,000 dwelling units (Association of Bay Area Governments, 1979).

The construction of dwellings and other development continues in the bay region. Subdivision activity during the four-year period ending June 1979 shows a rising trend in residential construction. The Real Estate Research Council of Northern California (1979) reports that the number of lots cleared for building in the bay region during two 12-month periods increased from 19,787 (1975-1976) to 32,356 (1978-1979). In addition, the total building valuation for the nine-county bay region has increased from 1.71 billion dollars in 1975 to 3.37 billion dollars in 1978 (Security Pacific National Bank, 1978). The California Association of Realtors^{1/} advises that about 140,000 residential transactions (sales, exchanges, and other transfers) occur annually in the bay region (Joel Singer, California Association of Realtors, oral commun., September 11, 1979).

Some of the new lots, dwellings, and other developments have been located or constructed in areas subject to flooding, slope failure, or fault rupture. Many of the lots and dwellings have been purchased or repurchased without the sellers, buyers, or their agents even being aware of the hazards that may affect the use or value of the property.

^{1/} The word "Realtors" is used in this report to denote members of the National Association of Real Estate Boards.

Information Available

Much information on hydrologic, seismic, and other geologic hazards is available for the bay region. Flood-prone maps, landslide susceptibility maps, and fault rupture maps have been prepared in a form understandable to, and at relatively large scales useable by, buyers who have no education or training in science or engineering.

Flood-plain characteristics, maps of flood-prone areas, measures to prevent and reduce flood loss, and the national flood-insurance program are discussed in a report on flood-prone areas and land-use planning by Waananen and others (1977). Indexes to flood-plain maps and other flood information are included. Types of landslides, factors causing landslides, and landslide mapping are discussed in a report on relative slope stability and land-use planning by Nilsen and others (1979). A regional map showing six categories of susceptibility to slope failure is included. Evidence for surface fault displacement, magnitude of the largest historic earthquake, and estimated recurrence interval for a maximum earthquake are presented for 25 faults in a report on seismic zonation edited by Borchardt (1975). Discussions of patterns of surface faulting, fault-zone width, and amount of displacement are included.

In addition, the Federal Insurance Administrator has identified communities in the bay area that have flood hazards and has prepared maps showing the flood-hazard boundaries or the flood-insurance rates for many of these communities at scales varying from 1 inch = 400 feet to 1 inch = 2,000 feet. The State Geologist has prepared Special Studies

Zones maps showing the fault-rupture traces at a relatively large scale (1" = 2,000'). At least one county in the bay region has transferred flood-prone, landslide, and fault rupture areas onto cadastral maps at a large scale (1" = 1,000').

Information about hazards can be obtained by buyers of lots, dwellings, or other real estate through school classes, briefings, university courses, adult-education programs, special workshops, field trips, displays, regional conferences, lectures, and publications.

However, an awareness that hydrologic, seismic, and other geologic hazards exist and may affect the property being purchased is prerequisite to obtaining such information. One way to make property owners aware that their property may be affected by floods, landslides, or fault rupture is to disclose such hazards at the time of purchase.

Decision

To provide for protection against flood losses through a federally subsidized flood-insurance program, the U.S. Congress (1974) requires lenders to notify prospective borrowers that the real estate being mortgaged is located in flood hazard areas, as identified by the Federal Insurance Administrator.

When providing for the public safety from fault rupture through the use of the Special Studies Zones Act, the California Legislature (1972a) requires a seller or his agent to tell the prospective buyer that the real estate is located within a fault-rupture zone, as delineated by the State Geologist.

In the ordinance enforcing on-site geologic investigations prior to construction, the Santa Clara County Board of Supervisors (1978) also requires all sellers of real estate lying partly or wholly within the county's flood, landslide, and fault-rupture zones to provide the buyer with a written statement of the geologic risk.

To assist them in complying with these Federal, State, or county laws, five local boards of Realtors in the bay region had colored street index maps prepared on which some or all of the flood, landslide, and fault-rupture zones were shown. The five maps together cover one entire county and parts of three others and include more than 50 cities. The maps show the flood hazard and fault rupture zones (fig. 19) designated and mapped by the Federal Insurance Administrator and the California State Geologist, respectively. In addition, two maps show a county-designated fault-rupture zone; one of these maps shows areas where there may be

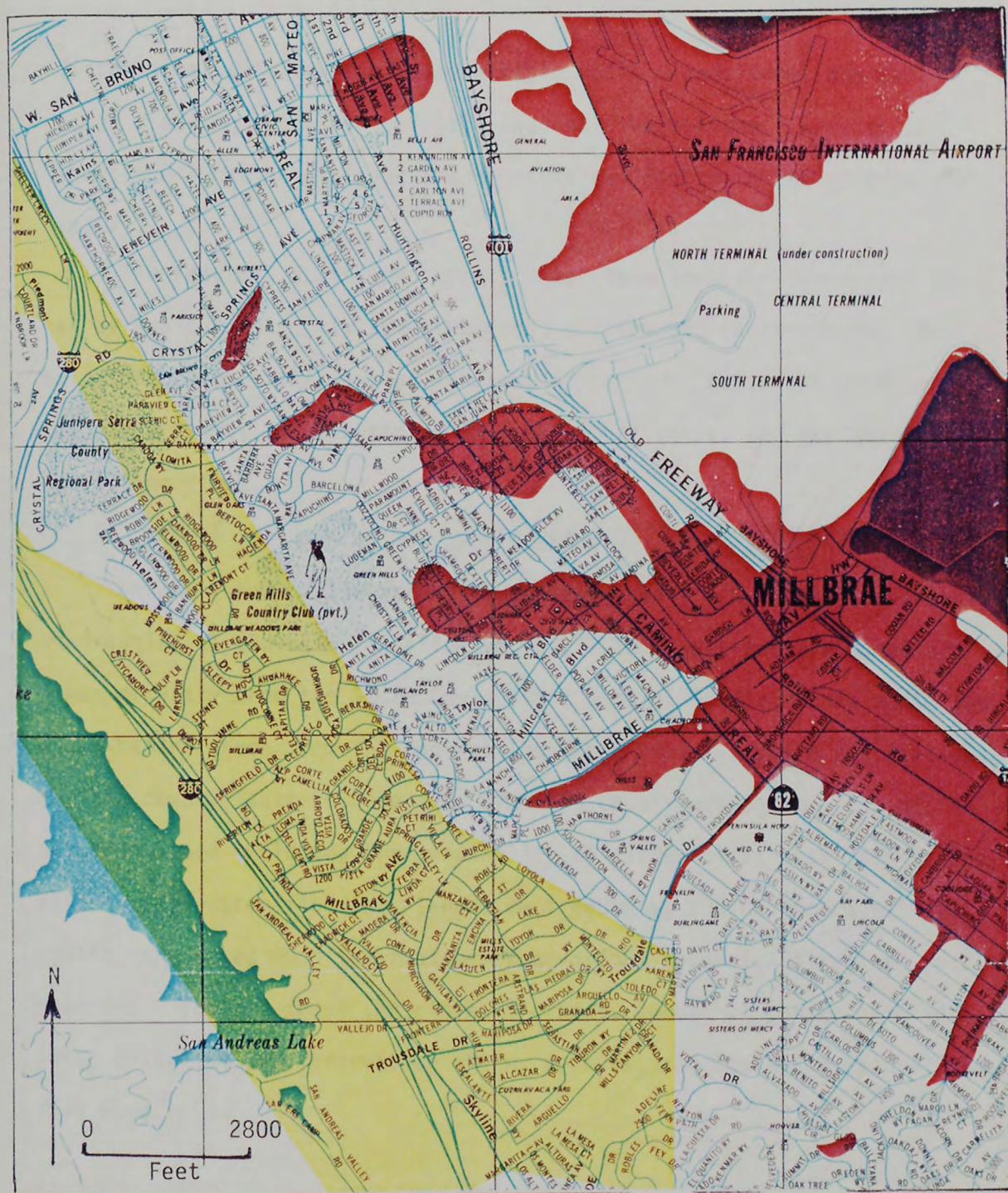


Figure 19.--Part of the Mid-Peninsula Cities street index map originally at a scale of about 1 inch = 2,800 feet prepared for the San Mateo-Burlingame Board of Realtors (1979). The colors indicate hazard zones. The red indicates flood-prone areas; the yellow shades indicate fault-rupture zones; and the green and maroon indicate water areas that have been overlain by the red or yellow zones. Maps are available from the publisher -- Barclay Maps, 1206 Panoche Avenue, San Jose, CA 95122.

differential settlement of compressible soils, landslides, and salt-water flooding due to seismically induced dike failure. Another map shows the location of landslide deposits and faults in the Livermore Valley.

The Federal, State, and county disclosure laws and the use of the map by Realtors directly affect buyers, sellers and their agents, and help interconnect the work of lenders, appraisers, builders, developers, insurance firms, local building and zoning officials, and geotechnical consulting firms.

Application

The publisher of the street index maps used 7 1/2-minute topographic quadrangles as the base for all five maps. The fault-rupture zones are taken directly from the State Geologist's Special Studies Zones maps, the flood-hazard areas from the Federal Insurance Administration publications, and the county fault-rupture zone from the county geologist. All of the hazards mapped including the possibility of differential settlement, landslides, salt-water flooding, landslide frequency, and Livermore Valley faults, are based upon information from various Federal, State, and local agencies. Table 1 shows the cities included, number of copies printed, cost, distribution, information shown, sources, and scale for each of the five maps.

In the San Francisco Bay Region

Map Name and Area Covered	Copies Printed	Name	Whole-sale Cost	Retail Cost	Distribution #/	Information Shown	Credited Sources	USGS Sources	Scale
MENLO PARK - AHERN Including the cities of Woodside, Portola Valley, Redwood City, and East Palo Alto in San Mateo County; and the cities of Palo Alto, Mountain View, Los Altos, and Los Altos Hills in Santa Clara County	20,000 ^{b/}	Menlo Park - Aherthorn Board of Realtors	\$.50	\$1.25	Five free copies to each member -- 125 brokers, 600 salespersons, and 30 affiliates.***	Special Studies Zones	State Geologist	Brabb & Pampeyan, 1972 Brown, 1972 Schlocker & others, 1965 Pampeyan, 1970 Brabb, 1970	1" = 3,000'
						Special flood-hazard areas	HUD	WRD Flood-prone maps	1:36,000
						Fault-rupture hazard zone	Santa Clara County Geologist	McLaughlin, 1971 Sorg & McLaughlin, 1975	
SOUTHERN ALAMEDA COUNTY, 1978 Including the cities of San Leandro, Hayward, Union City, Newark, Fremont, Pleasanton, Livermore, Dublin, Castro Valley, and San Lorenzo	3,000	Southern Alameda County Board of Realtors	\$2.50	\$3.00	Sold to members -- 627 brokers, 2919 salespersons, and 400 affiliates	Special Studies Zones	State Geologist	Radbruch, 1968 Robinson, 1956 Cotton, 1972 Dibblee, 1972 Brown, 1970	1" = 2,857'
						Special flood-hazard areas	HUD	WRD Flood-prone maps	1:34,500
						Relative landslide frequency	Wright & Nilsen, 1974	Wright & Nilsen, 1974	
						Livermore Valley faults	Herd, 1977	Herd, 1977	
SANTA CLARA COUNTY Including the cities of Palo Alto, Mountain View, Los Altos, Los Altos Hills, Portola Valley, Cupertino, Sunnyvale, Santa Clara, Milpitas, San Jose, Campbell, Los Gatos, Saratoga, Gilroy, and Morgan Hill	4,000 ^{c/}	San Jose Board of Realtors	\$2.50	\$5.00	Sold to members -- 1395 brokers, 5019 salespersons, and 114 affiliates	Special Studies Zones	State Geologist	Pampeyan, 1970 Brabb, 1970 Brown, 1972 Dibblee, 1972 Radbruch, 1968 Cotton, 1972 Schlocker & others, 1965 Brabb & Pampeyan, 1972 Dibblee, 1973	1" = 3,140'
						Special flood-hazard areas	HUD	WRD Flood-prone maps	1:37,680
						Fault-rupture hazard zone	Santa Clara County Geologist	McLaughlin, 1971 Sorg & McLaughlin, 1975	
						Differential settlement potential	Santa Clara County Geologist	Nichols & Wright, 1971	
						Landslide potential	Santa Clara County Geologist	Nilsen, 1972a,b Nilsen & Brabb, 1972 Wright & Nilsen, 1974	
						Salt-Water flooding potential due to seismically induced dike failure	Santa Clara County Geologist	Nichols & Wright, 1971	
MID PENINSULA CITIES Including the cities of Pacifica, San Bruno, Milbrae, Burlingame, Hillsborough, San Mateo, Foster City, Brimont, Redwood Shores, San Carlos, and Redwood City	4,000	San Mateo - Burlingame Board of Realtors	\$2.50	Not for sale	One free copy to each member -- 300 brokers, 1800 salespersons and 88 affiliates	Special Studies Zones	State Geologist	Brabb & Pampeyan, 1972 Brown, 1972 Schlocker & others, 1965	1" = 2,777'
						Special flood-hazard areas	HUD	WRD Flood-prone maps	1:33,324
CENTRAL CONTRA COSTA COUNTY Including the cities of Benicia, Martinez, Pleasant Hill, Walnut Creek, Lafayette, Orinda, Concord, Clayton, Antioch, Pittsburg, Moraga, San Ramon, and Dublin	17,000 ^{c/}	Contra Costa Board of Realtors	\$.50	\$2.00	For sale to their members -- 775 brokers, 2600 salespersons ^{d/} , and 140 affiliates	Special Studies Zones	State Geologist	Sims & others, 1973 Sharp, 1973 Brabb & others, 1971 Brown, 1970	1" = 3,000'
						Special flood-hazard areas	HUD	WRD Flood-prone maps	1:36,000

a/ Published by Barclay Maps, San Jose.

b/ Almost all copies distributed free.

c/ Being corrected, updated, and reprinted.

d/ Affiliates include banks, savings and loans, and other real property investors.

e/ Salespersons purchased maps and distributed them free to all home owners in their sales areas.

Members of the five boards of Realtors have either received notice of and have access to, or have received free copies of, the maps for their jurisdiction. Almost all of the 20,000 maps of Menlo Park - Atherton were distributed free. In some instances, the maps are used by Realtors to indicate, on the form which lists or offers real estate for sale, that it is located in a flood-hazard or fault-rupture zone. (A listing form is one of the primary devices used by a seller's agent to make other Realtors aware of real property that is being offered for sale.) In other instances, the maps are used by realtors as a general reference for advising prospective buyers on the location of officially recognized hazards as required by State and county disclosure laws.

Since these types and scales of maps are not lot and site specific, the Realtors either merely alert the buyers to the hazards, or the Realtors request supplemental advice from consulting geologists, county geologists, or local building officials. The publisher has placed a caveat on each of the maps which reads in essence:

The primary purpose of the map is to provide a ready reference for quick identification of areas within officially designated hazard zones. The zone boundaries were compiled from official maps available at the time and cannot be guaranteed to be accurate because of changes in map scale. Also, periodic revisions of the official maps are made by such responsible agencies as the Federal Insurance Administration, the State Geologist, and county agencies. Therefore, questions involving specific parcels at or near zone boundaries should be answered by checking the appropriate official maps or contacting local firms offering consulting services.

In Santa Clara County, the Realtors have begun to use new cadastral maps at a scale of 1 inch = 1,000 feet upon which the county geologist has shown fault-rupture zones, flood-hazard zones, and areas of possible ground failure. The California Association of Realtors (1977) has published an instruction booklet on the legal obligations of Realtors to disclose geologic hazards that relate to the use of real estate. The Association (1978a) also provides, in its real-estate purchase contract form (fig. 20), a place for attaching information about flood (hazard) insurance and Special Studies (fault rupture) Zones.

The California Association of Realtors (1978b) has also prepared a disclosure form for Special Studies (fault rupture) Zones (fig. 21) which can be attached to the contract. The last paragraph of this form provides a place for entering the number of days a prospective buyer has, from the time of the seller's acceptance, to make further inquiries concerning the use of the property under the Special Studies Zones Act; and provides that where inquiry discloses conditions unsatisfactory to the buyer, the buyer may cancel the contract. In addition, some Realtors in the bay region use other forms which can be attached to the contract and which disclose to prospective buyers that the property is located in areas subject to floods, fault rupture, or other geologic hazards (fig. 22).

REAL ESTATE PURCHASE CONTRACT AND RECEIPT FOR DEPOSIT

THIS IS MORE THAN A RECEIPT FOR MONEY. IT IS INTENDED TO BE A LEGALLY BINDING CONTRACT. READ IT CAREFULLY.

_____, California _____, 19 _____
 Received from _____
 herein called Buyer, the sum of _____ Dollars \$ _____
 evidenced by cash ☐, cashier's check ☐, or _____ ☐, personal check ☐ payable to _____
 _____, to be held uncashed until acceptance of this offer, as deposit on account of purchase price of
 _____ Dollars \$ _____
 for the purchase of property, situated in _____, County of _____, California,
 described as follows: _____

1. Buyer will deposit in escrow with _____ the balance of purchase price as follows:

Set forth above any terms and conditions of a factual nature applicable to this sale, such as financing, prior sale of other property, the matter of structural pest control inspection, repairs and personal property to be included in the sale.

2. Deposit will ☐ will not ☐ be increased by \$ _____ to \$ _____ within _____ days of acceptance of this offer.

3. Buyer does ☐ does not ☐ intend to occupy subject property as his residence.

4. The supplements initialed below are incorporated as part of this agreement

_____ Structural Pest Control Certification Agreement	_____ Occupancy Agreement	_____ Other _____
_____ Special Studies Zone Disclosure	_____ VA Amendment	_____
_____ Flood Insurance Disclosure	_____ FHA Amendment	_____

5. Buyer and Seller acknowledge receipt of a copy of this page, which constitutes Page 1 of _____ Pages.

X _____ X _____
 BUYER SELLER

Figure 20.--Part of a real-estate purchase-contract form prepared by the California Association of Realtors (1978a) and approved by the State Bar of California. This form or a similar one is used by many Realtors in the bay region to legally bind the buyer to his offer and the seller to his acceptance. Item no. 4 provides for supplemental disclosure forms (fig. 21). The forms are available from the California Association of Realtors, 505 Shatto Place, Los Angeles, CA 90020. Reprinted by permission. Endorsement not implied.

This Addendum is attached as Page _____ of _____ Pages to the Real Estate Purchase Contract and Receipt for Deposit dated _____, 19____ in which _____ is referred to as Buyer and _____ is referred to as Seller.

The property which is the subject of the contract is situated in a Special Study Zone as designated under Sections 2621-2625, inclusive, of the California Public Resources Code; and, as such, the construction or development on this property of any structure for human occupancy may be subject to the findings of a geologic report prepared by a geologist registered in the State of California, unless such report is waived by the city or county under the terms of that act. No representations on the subject are made by Seller or Agent, and the Buyer should make his own inquiry or investigation.

Note: California Public Resources Code #2621.5 excludes structures in existence prior to May 4, 1975;
California Public Resources Code #2621.6 excludes wood frame dwellings not exceeding two (2) stories in height and mobile homes over eight (8) feet in width;
California Public Resources Code #2621.7 excludes conversion of existing apartment houses into condominiums;
California Public Resources Code #2621.8 excludes alterations and additions under 50% of value of structure from the Special Studies Zone Act.

Buyer is allowed _____ days from date of Seller's acceptance to make further inquiries at appropriate governmental agencies concerning the use of the subject property under the terms of the Special Study Zone Act and local building, zoning, fire, health and safety codes. When such inquiries disclose conditions or information unsatisfactory to the Buyer, Buyer may cancel this agreement. If notice in writing has not been delivered within such time, this condition shall be deemed waived.

Receipt of a copy is hereby acknowledged.

DATED: _____, 19____ BUYER: _____

Figure 21.--Part of a Special Studies (fault rupture) Zone disclosure form prepared by the California Association of Realtors (1978b). The form is designed to be attached to a real-estate purchase contract, as shown in figure 20, and is used by many Realtors in the bay region to comply with the disclosure provisions of the California Legislature (1976). The form is available from the California Association of Realtors, 505 Shatto Place, Los Angeles, CA 90020. Reprinted by permission. Endorsement not implied.

2. NATIONAL FLOOD CONTROL ACT DISCLOSURE: The property which is the subject of this contract may be located in an area which has been identified as having special flood and/or mudslide hazards by the Secretary of Housing and Urban Development pursuant to Title 42 of the United States Code Annotated, Sections 400 and following.

In the event said property is situated within such an area, the Buyer of said property will be required to purchase, in addition to other insurance, flood insurance as a condition to obtaining financing through a federally backed mortgage or through federally supervised, regulated or insured agencies or institutions.

3. SPECIAL STUDIES ZONE ACT DISCLOSURE: The property which is the subject of the contract is or may be situated in a Special Studies Zone as designated under the Alquist-Priolo Special Studies Zone Act, Sections 2621-2625, inclusive, of the California Public Resources Code; and, as such, the construction or development on this property of any structure for human occupancy may be subject to the findings of a geologic report prepared by a geologist registered in the State of California, unless such report is waived by the city or county under the terms of that act. No representations on the subject are made by Seller or Agent, and the Buyer should make his own inquiry or investigation. This act provides certain exemptions from the necessity of obtaining a geologic report. These exemptions are set out as follows:

California Public Resources Code § 2621.5 provides in part as follows: "This chapter is applicable to any project, as defined in § 2621.6...."

California Public Resources Code § 2621.6 excludes from the definition of "project"

- 1) Uses which do not contemplate the eventual construction of structures for human occupancy subject to the Subdivision Map Act;
- 2) Single family woodframe dwellings not exceeding two stories in height (which is further defined to include mobilehomes whose body width exceeds eight feet), unless located as part of a development of four or more such dwellings constructed by a single person, individual partnership or other organization;

California Public Resources Code § 2621.7 excludes from the definition of "project" the conversion of an existing apartment complex to a condominium;

California Public Resources Code § 2621.8 excludes from the definition of "project" the alteration or addition to any structure within a Special Studies Zone, the value of which does not exceed 50% of the value of the structure;

California Public Resources Code § 2621.8 excludes from the definition of "project" properties in which a previous geologic report has been approved or waiver granted provided such new geological data warranting further investigation is not recorded;

California Public Resources Code § 2621.5 provides that the provisions of the act do not apply to any development or structures in existence prior to May 4, 1975.

The above is a summary of exemptions available under the California Public Resources Code. In the event further information is desired, you are directed to Chapter 7.5 of Division 2 of the California Public Resources Code (§§ 2621 et seq.).

For Further Information Contact Appropriate City or County Agencies

4. OTHER MAJOR GEOTECHNICAL HAZARD ZONES DISCLOSURE (REQUIRED BY SANTA CLARA COUNTY) — Other than Alquist-Priolo Special Studies Zones: The property which is the subject of this contract is or may be situated in a zone of high geologic hazard (other than Alquist-Priolo Special Studies Zones) as shown on the Santa Clara County Relative Seismic Stability Map, as revised. Such zones are designated on the described map, as follows: (Place a check mark in the appropriate box indicating the zone or zones in which the subject property is or may be situated.)

- ☐ DC — areas of high potential for liquefaction and differential settlement.
- ☐ DR — areas of high potential for ground displacement along fault traces believed to be possibly active, but not presently in an Alquist-Priolo Special Studies Zone.
- ☐ DS — areas of high potential for earthquake-induced landslides.
- ☐ DF — areas of high potential for salt water flooding from failure of dikes.

For further information, contact County Geologist, telephone No. 299-2871.

Seller

Buyer

Figure 22.--Part of a form prepared for the San Jose Board of Realtors (1978). The form is designed to be attached to a real-estate purchase contract, as shown in figure 20, and is used by many local Realtors in the Board's jurisdiction to comply with the disclosure provisions of the California Legislature (1976), and the Santa Clara County Board of Supervisors (1978). Items 2, 3, and 4 provide for disclosure of hydrologic, seismic, and other geologic hazards.

Comment

This example shows that complex hydrologic, seismic, and other geologic information can be conveyed to real-estate buyers before the sale. The five maps of single-line indexed streets overlain with hazard zones provide easy reference and quick identification. Furthermore, they have unusually wide distribution throughout four counties in one of the most seismically active regions in the United States.

Presenting scientific information in the form of relative degrees of hazard; passing Federal, State, and county disclosure laws; preparing real-estate contract disclosure forms; and the preparing and distributing of hazard maps have resulted in making many buyers at least aware of, if not knowledgeable about, floods, fault rupture, and other hazards.

The method of conveying scientific information on these hazards to real-estate buyers can be applied to other areas within the bay region, and to other geologic hazards in areas where the interpretive information exists.

SUMMARY AND CONCLUSIONS

The six examples presented in this report show typical problems faced by decisionmakers, and the innovative responses that were based on earth-science information and designed to avoid geologic hazards, protect natural resources, and reduce property damage. Each decision was influenced by many of the same factors -- a hazardous geologic environment, general public awareness, strong community interest, Federal or State enabling legislation, availability of scientific information, and the ability of scientific, engineering, planning, and legal staffs to incorporate the information into a program, policy, or regulation.

Decisionmakers -- public and private -- live and work in a complex geologic environment. However, the geologic environment is just one aspect of the surroundings that affect a decisionmaker's life and work. Other aspects are social, economic, political, and aesthetic -- some of which are more apparent or more important than others to individual decisionmakers.

The crises faced by decisionmakers who fail to accommodate to a geologic environment impacted by urban growth include (1) the danger and trauma that accompany major earthquakes, landslides, and floods, (2) the contamination or loss of natural resources caused by pollution or unnecessary use, and (3) the damage or disruption to public facilities, utilities, and private property that are located in hazardous areas. Many of the adverse geologic processes can be triggered by man's activities simply because he lacks an awareness or an appreciation of the hazard or resource. For example, watering landslide areas or draining septic systems into well-water aquifers can cause property damage and resource contamination.

Most of the scientific information needed for prudent use of land in the San Francisco Bay region is available to decisionmakers and their staffs. The information includes the location of fault ruptures, flood-prone areas, soil and rock materials, landslide deposits, slope zones, high-water tables, land uses, annual precipitation, and marshlands.

Some of the information is readily available at the detail and scale (1 inch = 2,000 feet) needed for general decisionmaking. However, greater detail and larger scales (ranging from 1 inch = 100 feet to 1,000 feet) are needed for detailed planning, site investigations, ordinance administration, project review, and permit issuance. Public staffs, private consultants, and applicants for permits provide decisionmakers with information in greater detail and at larger scales.

Decisionmakers cannot be expected to have the training or experience to understand and use scientific information. To enable nonscientists to use the information available, much of it has been interpreted and placed on readable maps. Such information includes recurrence intervals for maximum earthquakes and specific floods; relative intensities of ground shaking; susceptibility to landsliding; suitability ratings for waste-disposal sites; general land-use capabilities of bay muds, locations of landslides or active faults; potential for liquefaction; and predicted geologic effects of a postulated earthquake.

Effect of the Decisions

The individual effects of the decisions in the six examples include preventing the placement of buildings over faults, reducing water pollution, protecting an aquatic and wildlife resource, guiding development to less hazardous areas or requiring remedial measures in hazardous areas, requiring better building design and construction, and making real-estate buyers aware of hazards. The collective effect of the decisions is to provide for greater public safety, health, welfare, and prosperity of individuals and their communities.

The lasting effectiveness of the decisions depends upon many factors, including:

- Continued awareness and interest by the public
- Careful revision of enabling legislation (if needed) by the legislative bodies
- Accurate site investigations by competent geologists
- Conscientious administration of regulations by inspectors
- Consistent enforcement by government attorneys
- Sustained support of those officials by the political leaders
- Judicious adjustment of regulations by administrative appeal bodies
- Skillful advocacy (if challenged) and proper interpretation by the courts
- Concern for individual, family, and community safety by real-estate buyers and developers

The criteria, decisions, and methods used in each of these examples can be of value to other jurisdictions where similar hazards and resources exist, and where adequate scientific information is available. The adaptation to, and adoption by, other jurisdictions depends on the presence of similar public awareness, enabling legislation, hazard and resource issues, priorities, community interest, innovative decisionmakers, and staff abilities.

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