



FLOOD-PRONE AREAS IN THE SAN FRANCISCO BAY REGION, CALIFORNIA

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INTRODUCTION

The San Francisco Bay region periodically experiences damaging floods. In recent years millions of dollars have been spent to reduce the flood hazard, but the average annual flood damage has not decreased because land development continues to encroach on the flood plains of streams and on the periphery of San Francisco Bay. It rarely is economically feasible to protect a flood-plain development from the maximum flood that may occur, and the severe floods that have been experienced in the recent past are not the greatest that can occur. In general, the greatest floods experienced in the region since the turn of the century have a probability of being exceeded once in about 40 years, on the average. Planning for flood-plain management, however, is usually based on the 100-year flood, a flood that has a probability of being exceeded once in 100 years, on the average, or a probability of 1 in 100 of being exceeded in any given year.

Areas in the nine-county San Francisco Bay region that are subject to inundation by the 100-year flood are delineated on the accompanying maps. In general, the flood plains studied include only those along streams whose watersheds are greater than 2 square miles. Areas contiguous to the ocean and bay that have a potential flood hazard associated with high tides are delineated with respect to the 100-year high tide. However, inundation resulting from tsunamis, or earthquake-generated ocean waves, is not considered in this study; maps prepared by Ritter and Dupre (1972) delineate areas in the region that are subject to damage by tsunamis. Inundation resulting from ponding of locally heavy rainfall—not overbank streamflow—into depressions or low-lying, poorly-drained areas, is not considered. The flooding of basements, underpasses, and other street depressions by local runoff is a common occurrence in urban areas. The frequency of such flooding depends in part on the criteria used in the design of the storm-drainage facilities and on the effect of obstructions from leaves or other debris.

FLOOD-PRONE AREA MAPS

Preparation of the Maps

The development of the accompanying flood-prone area maps for the San Francisco Bay region involved the following five-step procedure:

1. Determination of the 100-year peak discharge for each stream using a flood-frequency relation adapted from Rantz (1971).
2. Determination of the elevation, or stage, for the 100-year peak discharge at selected sites on each stream from stage-discharge relations derived by plotting the results of streamflow measurements against corresponding stage, or from empirical formulas relating stream geometry, including stage, to discharge.
3. Determination of 100-year stage at other sites on each stream. Where the step-backwater technique, a standard procedure described in most textbooks on hydraulics, had been used in previous studies to develop profiles from the 100-year flood, the stage was obtained from those profiles. [Otherwise, step 3 was not used.]
4. Transfer of computed stages or water-surface elevations from either step 2 or step 3 to corresponding locations on 7½-minute topographic maps (scale 1:24,000, about 2 5/8 inches per mile) and joining the plotted points by lines that paralleled topographic contours of the land surface.
5. Transfer of the areas of potential inundation that were delineated on the 7½-minute topographic maps to the flood-prone area map at a scale of 1:125,000 (about 1/8 inch per mile).

To provide flood-prone area maps of manageable size, it was necessary to divide the region into three parts:

Map 1 covers the northwestern part of the region and includes parts of Marin and Sonoma Counties. Map 2 covers the northeastern part of the region and includes parts of Marin, Sonoma, and Contra Costa Counties and all of Napa and Solano Counties. Map 3 covers the southern part of the region and includes part of Contra Costa County and all of Alameda, Santa Clara, San Mateo, and San Francisco Counties.

Use and Limitations of the Maps

Flood-prone areas have been delineated by use of readily available information rather than by detailed field surveys and inspections. The maps are intended only to provide information for regional planning aimed at the judicious use or management of flood-plain lands, and to indicate areas of potential flood hazard, when construction is planned in, or adjacent to, the flood-prone areas shown by the maps, more rigorous description of flood potential should be established by comprehensive flood studies. Sources for some additional information on flood-prone areas are provided in the next section.

FLOOD-PRONE AREA MAPS AND STUDIES

Flood-prone area maps and flood studies have been made by the Geological Survey and by other agencies for many parts of the San Francisco Bay region. Information on floods and flood hazards has been presented in the following reports:

1. *Maps of flood-prone areas.*--Maps have been compiled by the Geological Survey to identify flood-prone areas and to alert owners, planners, or developers to the areal extent of flood hazards. In 1969, 24 maps of flood-prone areas for various parts of the region were prepared on topographic maps at a scale of 1:24,000 (2 5/8 inches per mile). Those maps show areas "occasionally" flooded, the delineated areas generally being those inundated by the greatest recent floods. During 1971 and 1972, 51 maps of similar scale (2 5/8 inches per mile) were prepared to show the approximate limits of flooding for the 100-year flood. Included among the 51 maps were the used in compiling the flood-prone area maps that accompany this report. Copies of maps showing flood-prone areas are available from the U.S. Geological Survey, Menlo Park, Calif.
2. *Flood-insurance studies.*--Flood studies have been made for communities in the San Francisco Bay region that are eligible for flood insurance under provisions of the National Flood Insurance Act of 1968, as amended. Reports summarizing those studies include maps showing areas that may be inundated by 100-year and 500-year floods. The reports were prepared by public and private agencies for use by the U.S. Department of Housing and Urban Development for insurance purposes. Copies of the flood-insurance maps issued by that Department are distributed to insuring agencies and the local communities.
3. *Hydrologic-investigations atlases.*--Hydrologic-investigations atlases have been prepared by the Geological Survey to describe the hydrology of notable flood events for limited geographic areas. The atlases usually include maps of flood-inundated areas, a brief text discussing flood occurrence, water discharge, flood frequency, and other pertinent hydrologic data. Illustrations may include hydrographs, frequency curves, annual flood-distribution graphs, maps, and photographs. Hydrologic-investigations atlases for areas in the San Francisco Bay region were prepared by Young (1962), and Limerinos (1970). Copies of those atlases may be purchased through the Geological Survey Public Inquiries Office in San Francisco, Calif.
4. *Flood-plain information reports.*--Public Law 86-645, dated July 14, 1960, authorized the U.S. Army Corps of Engineers to compile and disseminate information on floods and flood-damage potential, and to develop general criteria for use of flood-plain areas. Eight studies (U.S. Army Corps of Engineers, 1970, 1972a, 1972b, 1973a, 1973b, 1973c, 1973d, 1973e) have been completed for selected streams in the San Francisco Bay region, and other studies are in progress.
5. *Flood-plain mapping by local agencies.*--The flood plains of many streams in Santa Clara County have been mapped to show the boundaries of areas subject to inundation. The boundaries shown are those for historic floods and for the 100-year flood. These maps are available from the Santa Clara County Flood Control and Water District, San Jose, Calif. Limited information on the flood hazard in other areas of the San Francisco Bay region is available at appropriate city and county offices.

REFERENCES CITED

- Limerinos, J. T., 1970 Floods on Napa River at Napa, California: U.S. Geol. Survey Hydrol. Inv. Atlas HA-348.
- Rantz, S. E., 1971, Suggested criteria for hydrologic design of storm-drainage facilities in the San Francisco Bay region, California: U.S. Geol. Survey open-file report, 69 p.
- Ritter, J. R., and Dupre, W. R., 1972, Map showing areas of potential inundation by tsunamis in the San Francisco Bay region, California: U.S. Geol. Survey Misc. Field Studies map MF-480.
- Corps of Engineers, U.S. Army, 1970, Flood plain information, Coyote Creek, San Francisco Bay to Anderson Reservoir, Santa Clara County, California: San Francisco District, Jan. 1972, 22 p.
- 1972a, Flood plain information, Guadalupe River, Santa Clara County, California: San Francisco District, Feb. 1970, 26 p.
- 1972b, Flood plain information, Green Valley, Dan Wilson, and Sismum Creeks, Cordelia [Solano County], California: Sacramento District, June 1972, 37 p.
- 1973a, Flood plain information, Uvas-Carnadero Creek, Pajaro River to Uvas Reservoir, Santa Clara County, California: San Francisco District, May 1973, 19 p.
- 1973b Flood plain information, Alamoitos Creek, including Guadalupe Creek, Arroyo Calero, and Santa Teresa Creek, Santa Clara County, California: San Francisco District, July 1973, 22 p.
- 1973c, Flood plain information, Fisher Creek, Santa Clara County, California: San Francisco District, July 1973, 18 p.
- 1973d, Flood plain information, San Felipe Lake and Pacheco Creek, San Benito County, California: San Francisco District, July 1973, 17 p.
- 1973e, Flood plain information, Alamo and Ulatas Creeks, Vacaville [Solano County], California: Sacramento District, June 1973, 44 p.
- Young, L. E., 1962, Floods at Fremont, California: U.S. Geol. Survey Hydrol. Inv. Atlas HA-54.

EXPLANATION

- Area that may be inundated by a 100-year flood
- Boundary of San Francisco Bay region

