FEMA-165
MAY 1989

Alluvial Fans:
Hazards and Management

Aerial view of the Magnesia Spring Canyon alluvial fan flood of July 1979, which caused over $7 million in damage, and one death.

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration
Office of Loss Reduction
February 1989

ALLUVIAL FAN HAZARDS IN THE UNITED STATES

Flood hazards in the American West are often greatly underestimated due to the dry conditions, lack of rainfall and absence of defined watercourses. Ironically, western floods are quite severe and powerful, exhibiting unpredictable flow paths and high velocities that usually occur with little advance warning time. These floods can cause considerable erosion in some areas while depositing large amounts of sediment and debris in others.

With rapid growth continuing throughout the West (particularly in many major metropolitan areas) hillside building sites have become more popular as the supply of prime developable land becomes depleted. This has resulted in an increasing amount of development occurring in floodplain areas called *alluvial fans.*

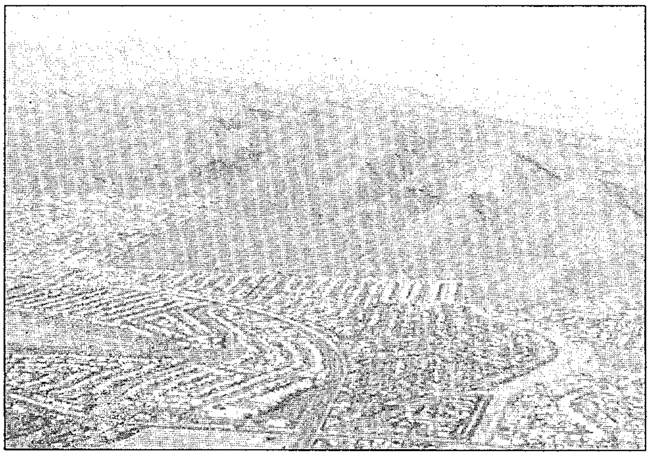


Figure 1.
Dense development on alluvial fans in the South Mountain area of Phoenix, Arizona. Note the numerous branching channels.

Alluvial fans are triangular or fan-shaped, gently-sloping landforms which typify the floodplain management dilemma facing many western states today: **fans provide attractive development sites due to their commanding views and good local drainage, yet harbor all the severe flood hazards which endanger arid western communities.**

Development pressure on alluvial fan areas is intensifying, creating a critical need to provide guidance to communities, developers and citizens on how to safely accommodate growth while protecting life and property from flood hazards. To address this need, the Federal Emergency Management Agency (FEMA) has designed this brochure to increase awareness of alluvial fan flood hazards, and to provide general guidance on the techniques and strategies for minimizing losses from these hazards when building and developing. FEMA is the agency which administers the National Flood Insurance Program (NFIP), which enables property owners within participating communities to purchase insurance to cover flood losses affecting structures and their contents.

Figure 2.
Damaged homes on a fan in Ocotillo Wells, California, which lies in eastern San Diego County. Tropical Storm Kathleen caused extensive flooding September 9-11, 1976, there and throughout Riverside and Imperial counties to the north and east. The channel braiding shown in the photo is typical of alluvial fan flooding, and thus it is difficult to predict the location of floodflows.

Where Are Alluvial Fans Found?

In the United States, alluvial fans are typically found along the base of mountain fronts in the western states of California, Arizona, Nevada, Colorado, Utah, Idaho, New Mexico, Wyoming, Montana, Oregon and Washington. Here, the infrequent but intense storms typical of arid and semi-arid climates combined with abrupt changes in topography create the necessary conditions for fan formation. Differences in climate and geology have produced mostly active fans in regions such as Nevada and California, and inactive fans in southern Arizona. Active fans exhibit braided channels and erratic flowpaths typical of a young fan formation. Fans in southern Arizona tend to exhibit more predictable channels and flood paths due to their geologically older setting. It has been estimated that 15 to 25 percent of the arid West is covered by fans.

How Are Alluvial Fans Formed?

Alluvial fans build up over the course of geologic time through this general sequence:

1. Rock and soil are eroded from the mountain watershed;

2. These sediments are transported through stream channels via storm-generated floodwaters;

3. The floodflow which has been confined in mountain ravines emerges onto the wide, flat valley slope, and progressively loses velocity while depositing sediment as it travels downfan.

The sediment deposits are generally narrow and steep at the head of the valley, broadening as they spread out onto the valley floor in a wedge or conical shape. The natural processes responsible for fan formation have frequently been observed to occur in a specific sequence and range of location along the length of the fan. For the sake of illustration, these processes will be presented in a generalized fashion to portray the formation of the "idealized" alluvial fan. In reality however, wide variations in the physical characteristics of each fan system affect the actual location, extent and severity of these flood processes. Variations occur between areas exhibiting differences in climate and geology, as well as among fans within the same valley.

FORMATION OF AN "IDEALIZED" ALLUVIAL FAN

1. Streamflow from intense rainstorms emanates from the confined channel of a mountain canyon and proceeds onto the relatively flat valley below. The canyon outlet forms the APEX of the fan, which represents the point of highest elevation on the fan.

2. Flow leaving the apex spreads onto the uppermost portion of the alluvial fan surface via a single high-velocity channel. This singular channel will either follow a preexisting path cut from past flood events, possibly deepening the channel in a process called entrenchment, or cut a new path downslope. Flood hazards in this CHANNELIZED ZONE of the upper fan region can be severe due to the high velocity of flow, the presence of debris from the watershed, and the unpredictable location of flowpaths.

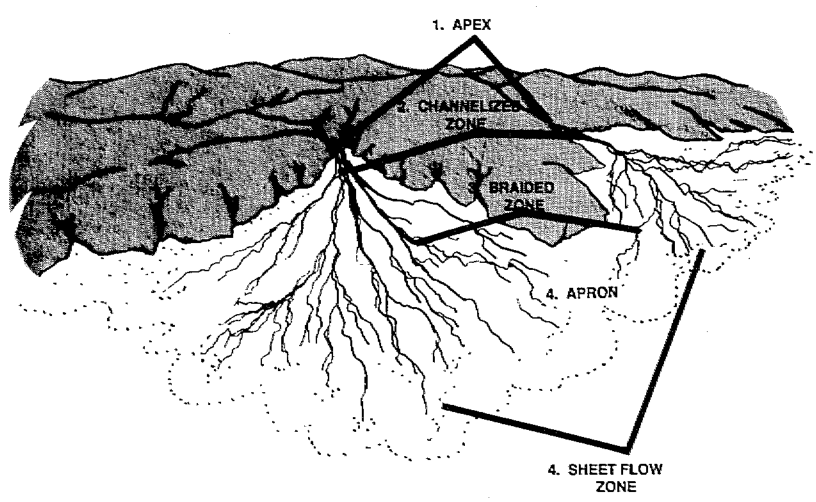


Figure 3

3. As the single channel flow encounters the flatter slope of the mid-fan area, it widens and becomes shallower, losing velocity and depositing sediment and debris. Materials that become deposited into previously-cut channels can backfill the old streambeds, leading to the abrupt development of new channels in a process called avulsion. The erosion/deposition processes include channel braiding, where singular flows split and rejoin as channels are alternately cut and filled with sediment. These BRAIDED ZONE processes occur erratically, creating random, unpredictable flow patterns.

4. Toward the base of the fan, called the TOE, water velocities are further reduced as the fan surface becomes more uniform, its slope flattens and water infiltrates the soil surface. In this portion of the fan, SHEET FLOW (shallow, overland flow) is common, though flow velocities may remain high. Adjacent fans which have formed along mountain fronts tend to converge near their bases, producing alluvial APRONS, or zones of coalescence.

How Are Alluvial Fans Identified?

The gentle, imperceptible slopes and extensive size of many fans can sometimes make their identification in the field difficult. As a result, many homeowners do not realize that the panoramic views of the valley below are due to their elevated location on an alluvial fan. The initial identification of the presence and extent of fans within the community is therefore

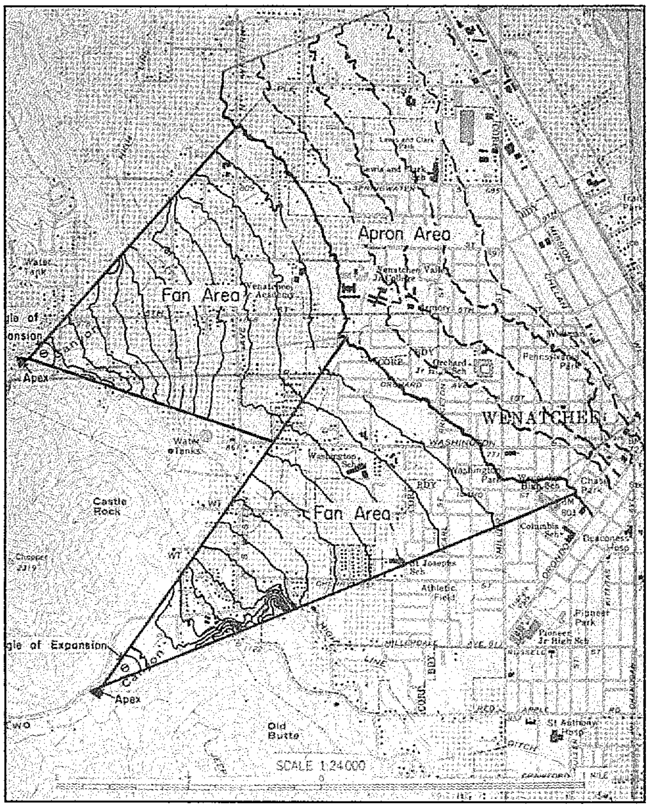


Figure 4.
This U.S. Geological Survey topographic quadrangle map has been enhanced to show the concentric contour pattern typical of alluvial fans. Depicted here are two alluvial fans in Wenatchee, Washington.

best accomplished through the use of topographic maps or aerial photos. Topographic maps (such as those produced by the U.S. Geological Survey) reveal concentric semicircular contours that bow downslope, as shown on the figure above. The use of soil survey maps (such as those developed by the Soil Conservation Service) can also indicate the presence of alluvial (water-transported) soils which often comprise fan formations. In confirming the location and extent of alluvial fans, the final detailed interpretation of maps, air photos and field data should be made by a professional geologist, hydrologist, and/or engineer.

What Are The Flood Hazards Associated With Alluvial Fans?

Alluvial fan floods do not exhibit the more predictable behavior and well-defined boundaries normally found in most riverine floods. The behavior and path of flood water in any individual flood event as it proceeds from the apex to the toe is a direct result of the flood processes previously illustrated. These processes vary as a function of the flow's sediment content and velocity, the fan's slope, soil and vegetative cover, and types and amount of fan development.

Alluvial fan flows are subject to lateral migration and sudden relocation during the course of a flood, and may not even follow the same path in subsequent floods; in any flood event, however, a part of the fan will always be subject to flood hazards. Thus, it is generally not appropriate to utilize the location of past flow paths in the prediction of future hazards. The full range of hazards that may be encountered on fans include:

- high-velocity flow (as high as 15-30 feet per second), producing significant hydrodynamic forces (pressure against buildings caused by the movement of flowing water)
- erosion/scour (to depths of several feet)
- deposition of sediment and debris (depths of 15-20 feet have been observed)
- debris flows/impact forces
- mudflows
- inundation, producing hydrostatic/buoyant forces (pressure against buildings caused by standing water)
- flash flooding (little, if any, warning times)

An often-overlooked "hazard" is the tendency to underestimate both the potential and severity of alluvial fan flood events. The infrequent rainfall, gently-sloping terrain, and often long time spans between successive floods contribute to a sense of complacency regarding the existence of possible flood hazards. Though the intense rainstorms which produce fan floods occur randomly, they nevertheless can develop very rapidly at any time, and can recur with any frequency.

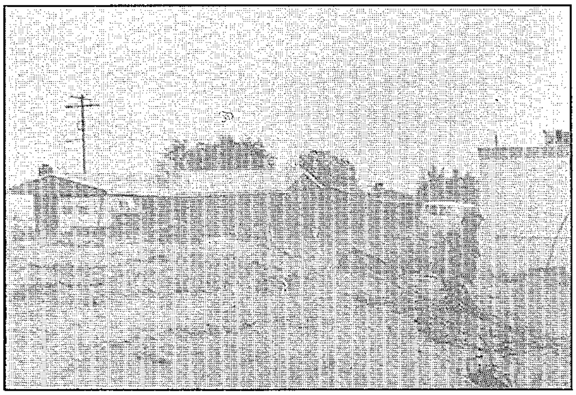
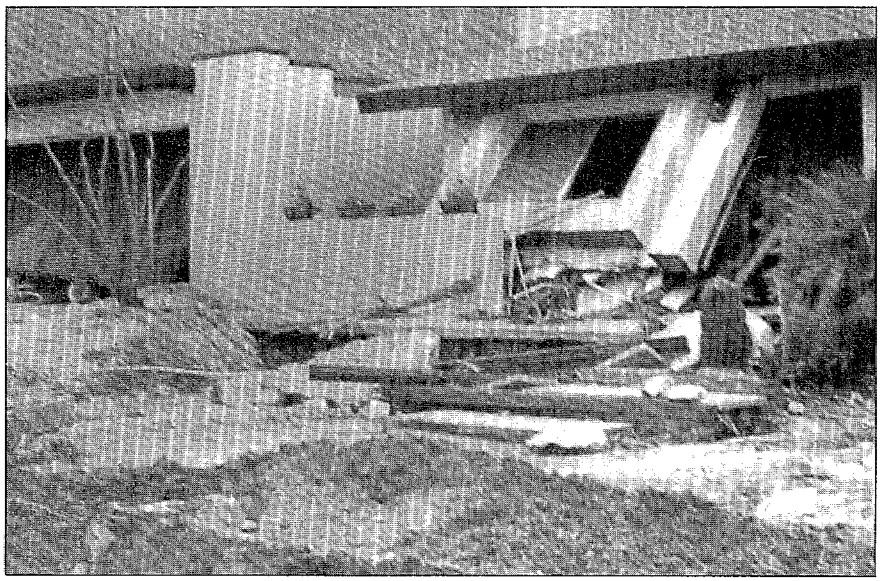


Figure 5.
High-velocity flows battered homes in Ocotillo Wells, California during the September 1976 flood caused by Tropical Storm Kathleen.

Figure 6.
Fast-moving floodwaters caused scour, erosion and structural damage to numerous Rancho Mirage, California homes in September 1976 and in July 1979.



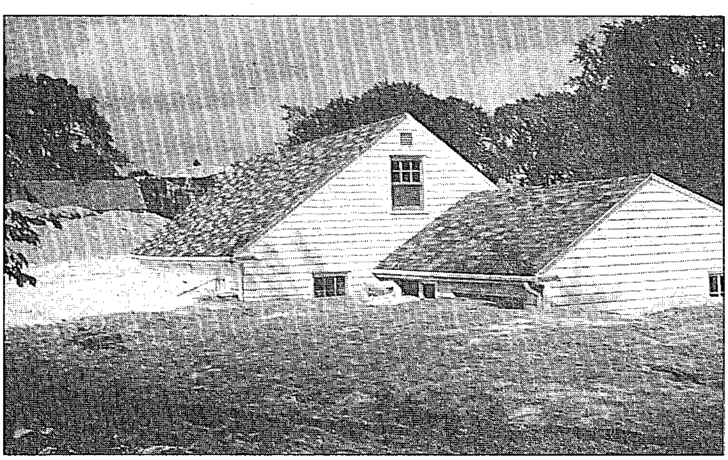


Figure 7.
Large volumes of sediment can be deposited by floodwater during the course of an alluvial fan flood event.

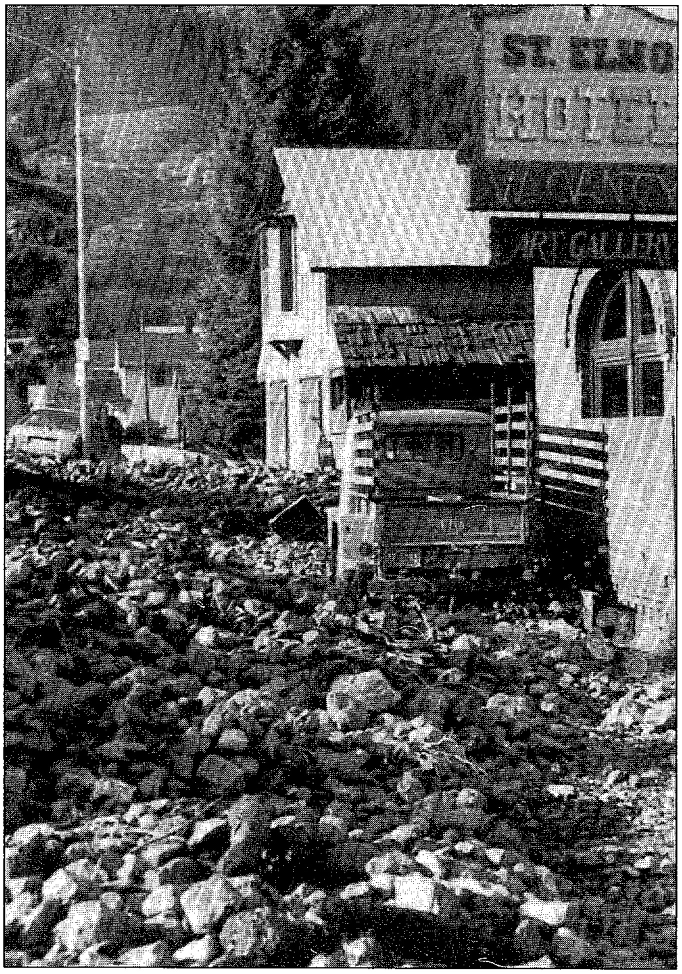


Figure 8.
Four successive days of flooding in August 1982 caused debris and water damage in Ouray, Colorado. Thirty-five homes and businesses were damaged, and numerous bridges were destroyed. Shown here is debris deposited by Portland Creek. (Courtesy of Dave Vince, City of Ouray)

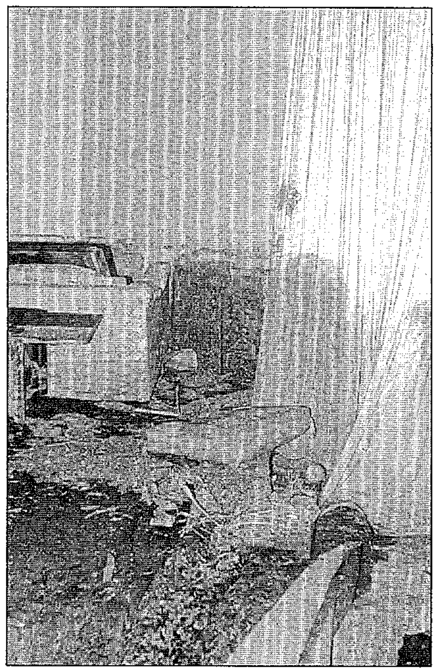


Figure 9.
Inundation of homes by shallow flooding can cause extensive interior damage.

Active vs. Inactive Fans

In the case of geologically younger, or *active* fans, the natural processes which, over time, formed the fan continue to act upon its surface in a somewhat random fashion. Thus, the entire fan surface represents a potential site for flood, sediment and debris deposition and scour, and is a dangerous location upon which to build.

In geologically older regions, alluvial fan processes tend to follow more predictable patterns, and floodflows may remain within defined channels as they discharge downslope. Fans or portions of fans which are no longer subject to these flows are considered *inactive*, and may be regarded as less hazardous construction sites.

Regardless of whether a fan is active, inactive, or both, there is always some degree of unpredictability of the flood hazard on all fans.

A Word About Debris Hazards . . .

Debris flows can result from the presence of a large percentage (up to 70-90% of flow by weight) of fine sediment such as silt and clay in steeply-flowing floodwaters. This enables the muddy flow to transport sand, gravel, boulders, and dislodged timber and brush from the mountain watershed onto a fan's surface. Conditions favoring the formation of debris flows are: available unconsolidated silt, clay and larger rock in the basin watershed (due to minimal vegetation), heavy or sustained rainfall in the basin, and the presence of steep basin and fan slopes. Fans which have been created from repeated debris flow activity are called *debris fans*, and are composed of deposits of rock, soil and vegetation from the upstream watershed. Debris fans are found in areas where mountain systems are subject to tectonic forces of uplift. Colorado, Utah, Wyoming, Montana, and parts of California, Nevada and Arizona contain the bulk of debris fans and flows.

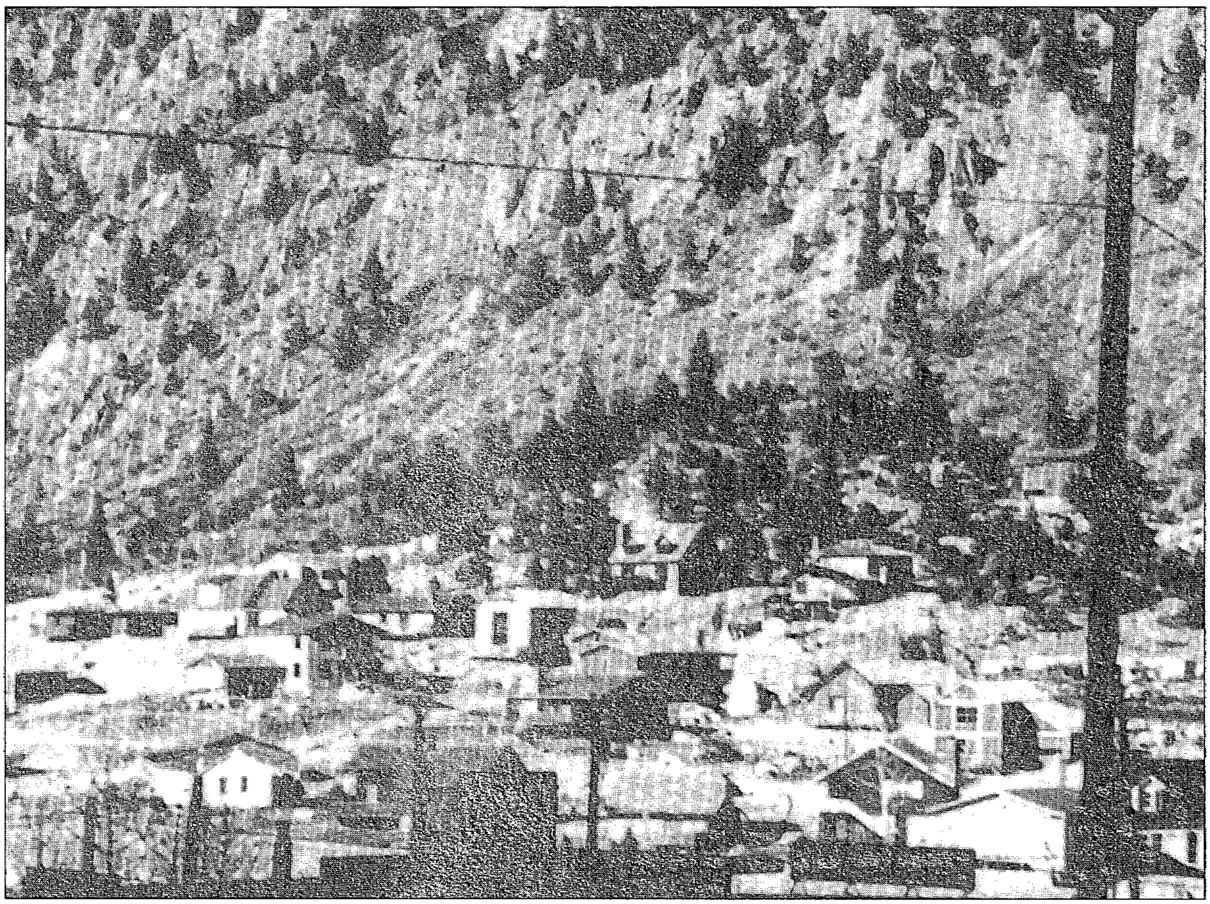


Figure 10.
Development on a debris fan in Georgetown, Colorado. Note the structures' proximity to the steep mountain slope above. (Courtesy of the Colorado Geological Survey)

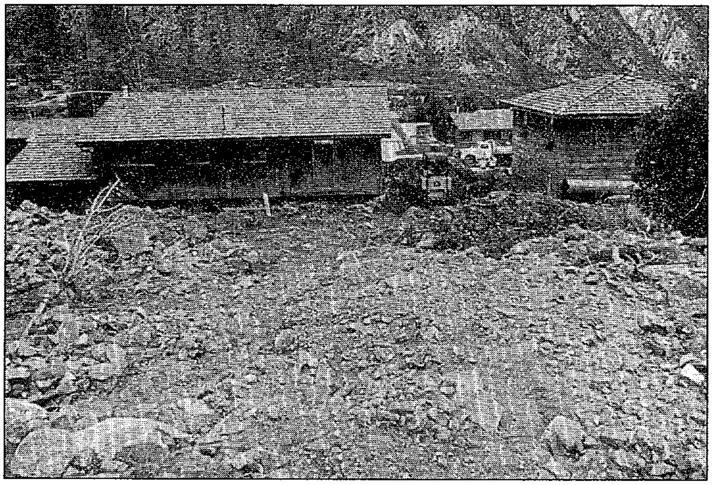


Figure 11.
Debris flow damage in Glenwood Springs, Colorado in July 1977. Property damage to homes and public facilities and cleanup costs totalled approximately $2 million. (Courtesy of the Colorado Geological Survey)

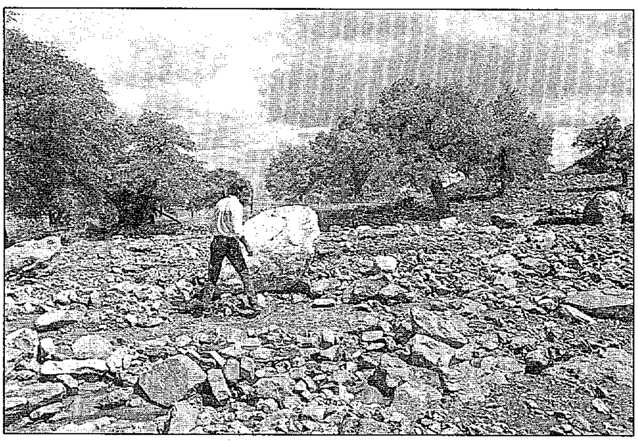


Figure 12.
Boulders several feet in diameter may be transported by sediment-laden flood flows. This debris was deposited south of Sierra Vista, Arizona in June 1988 following heavy rains in the Huachuca Mountains.

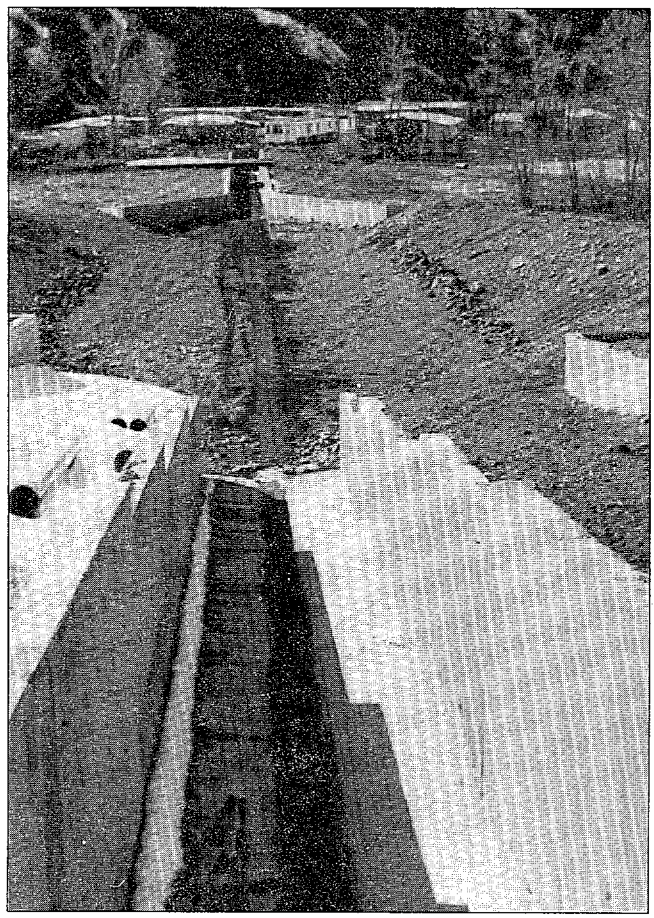
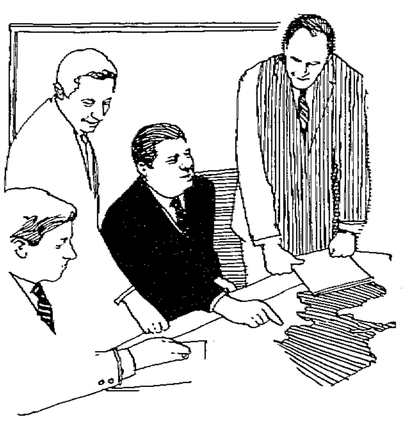


Figure 13.
This small debris basin was constructed in 1984 on Cascade Creek in Ouray, Colorado after several instances where debris blocked the channel and worsened flooding conditions. The basin allows debris to settle out of moving floodwaters. (Courtesy of Dave Vince, City of Ouray)

It must be stressed that any development activity sustained on the active portion of an alluvial fan disrupts and alters the natural flood processes which perpetuate its formation, and subjects any structure situated on the fan to unpredictable, erratic hazards during flood events. Furthermore, any new construction can redirect flood and debris flow to adjacent properties and thereby increase flood hazards in other areas. A comprehensive approach is therefore needed to manage development on fan areas such that the entire fan's natural flood processes and resulting hazards are taken into account. The development and implementation of a comprehensive approach is best handled on the local government level through planning, zoning and building permit processes. Through these processes, future development can be planned and its effects on flood hazards adequately addressed.

How Should a Community Manage Development on Alluvial Fans?

A comprehensive or master planning approach to managing growth on an alluvial fan considers fan conditions from apex to toe while guiding future development in a coordinated manner. The keystone of this planning process is the community's selection of flood/debris hazard management tools. The choice of tools will depend upon the nature and location of the hazards, and the location, timing, size and density of existing and future development. These tools can be structural (levees, basins, channels) or nonstructural (zoning, public acquisition, subdivision regulations, building standards). The fan management plan may be incorporated as a separate element within the community's existing comprehensive plan, or may stand alone as a separate document. The planning process incorporates the following steps:



1. **IDENTIFY THE HAZARDS.** Using qualified geologists, hydrologists and engineers, conduct a detailed study of individual watershed and fan characteristics in order to determine the severity and location of hazards to be expected on each fan. Where appropriate, active and inactive portions of the fan should be mapped, as should the location of previous and potential debris flow paths. If the community has had its alluvial fan areas studied and mapped while preparing its Flood Insurance Rate Map (FIRM), some of this data may already be available. The FIRM will delineate the flood having a one percent chance of occurring in any given year (the 100-year flood), which can serve as the basis of more detailed hazard analysis and mapping.

2. **PLAN FUTURE DEVELOPMENT.** Identify the areas of the fan which require immediate flood protection, taking into account the location and density of **existing** development. Establish the location, timing, and amount of **future** development in light of the delineated hazards. Development in the most hazardous portions of the fan should be restricted.

3. **CHOOSE FLOOD MITIGATION TOOLS.** Analyze the range of flood management/control tools available in consideration of identified hazards, present and planned density and location of development, cost to locality, and public acceptance. This is accomplished through the establishment of community goals, and through coordination among local government officials, planners, engineers, residents, and the development community. The most widely-used alluvial fan flood management tools are presented in the next table.

4. **ENFORCE REGULATIONS.** Ensure the effective application and operation of the selected flood management tools by adopting and enforcing regulatory controls:

   a. Zoning ordinances, subdivision regulations and open space/land acquisition plans can be used to prohibit or otherwise limit growth in high hazard areas, and would allow the safe passage of flood waters;

   b. Building codes can help ensure safe residential construction;

   c. Maintenance/inspection requirements can help guarantee the effective operation of structural flood control measures;

5. **EDUCATE CITIZENS.** Communities should initiate public awareness programs on alluvial fan hazards, install flood warning systems (where practical), and encourage the purchase of federal flood insurance.

This comprehensive planning approach is most effective when implemented as early as possible during fan development. A community can then exercise maximum control over future desired density levels and have the most flexible choice of flood management tools. It is also best utilized on a multi-community or regional scale, especially when multiple fans occupy range-fronts which may span several jurisdictions.

ALLUVIAL FAN FLOOD MANAGEMENT TOOLS
(Based on Size and Density of Planned Development)

Whole Fan Protection

- Levees
- Channels
- Detention basins
- Debris basins/fences/deflectors/dams

Design Considerations: Whole-fan protection includes large-scale structural measures appropriate for use on extensively-developed fans, and which are most cost-effective in high-density situations. Structures must be designed to intercept upstream watershed flow and debris at the apex and to transport water and sediment around the entire urbanized fan. Structures must be designed to withstand scour, erosion, sediment deposition, hydrostatic forces, impact and hydrodynamic forces, and high flow velocities. Continual maintenance is essential for optimal operation, and can be costly. These structures are most often funded through federal and state sources, but can also be financed through special regional districts, local governments, or developers.

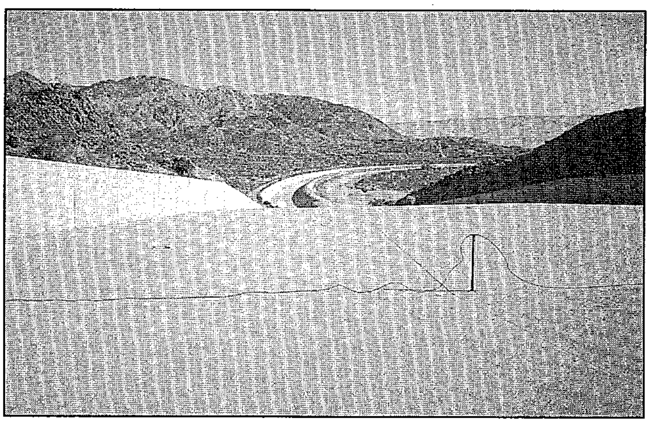


Figure 14.
This concrete channel was designed to carry floodwater downslope in Palm Desert, California.

Subdivision or Localized Protection

- Drop structures to reduce flow velocity
- Debris fences
- Local dikes, channels
- Site plans to convey flow
- Street design/alignment to convey flow
- Elevation on armored fill

Design Considerations: These are smaller-scale measures that can be used throughout moderate-density fans to safely trap debris, and to route water and sediment around or through individual residential developments. Protection elements must prevent formation of new flow paths and/or the relocation of existing paths; flood control structures must resist high velocities, erosion, deposition, hydrodynamic and hydrostatic forces. The most effective strategy includes a combination of elements; the entire protection plan must be coordinated with other similarly-scaled efforts to avoid adverse impacts to adjacent property. These measures can be financed privately by developers.

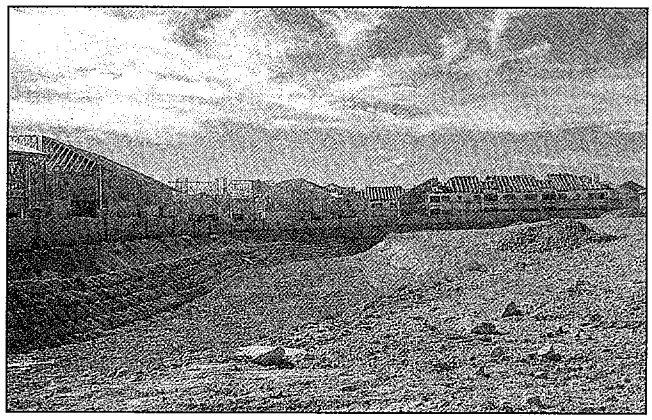


Figure 15.
Shown here is the channelization of Flamingo Wash adjacent to new construction near Las Vegas, Nevada. Gabions (rock-filled baskets enclosed with wire mesh) help stabilize the channel sideslopes. Walls provide some additional flood protection.

Single Lot/Structure Protection

- Elevation on properly designed foundations (piles, columns or armored fill)
- Floodwalls and berms
- Reinforcement of uphill walls, windows and doors against debris impact

Design Considerations: These measures are most cost-effectively implemented at low development densities, but should be considered for all structures on fans. Owners of existing structures should consider retrofitting their homes to protect against future flood hazards; new lots should be planned with adequate open space to accommodate flow paths. Velocity/scour, sedimentation and debris impact must be addressed in the design of elevated foundations and of floodwalls. Floodwalls should not be solely relied upon for protection, but as a supplement to elevated foundations. These measures are usually financed by the homeowner.

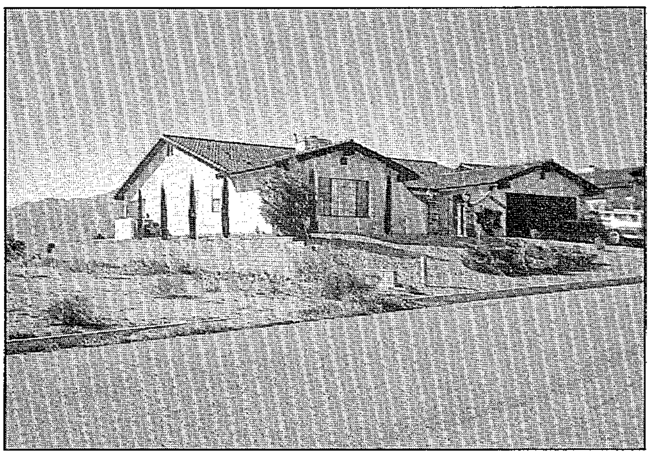


Figure 16.
This home in Palm Desert, California has been elevated on fill. Utilities (shown against the left side of the house) have also been raised to minimize potential flood damage.

The choice of the appropriate measure(s) will ultimately depend upon the community's development plan and the level and extent of protection desired.

What Factors Should Be Considered When Building On A Single Lot?

It is recommended that single lot development only proceed within the framework of a comprehensive plan for the alluvial fan, which has identified the fan's flood hazards, design requirements for the safe construction of individual sites, and how each site would fit into a coordinated approach. If such a comprehensive plan has not been developed, then the following general steps should be undertaken to minimize the potential flood risk for any proposed structure:

1. AVOID THE MOST HAZARDOUS AREAS OF THE FAN.
2. Consult with local planning, building, and engineering officials to discuss the potential hazards specific to the site, regulations in effect which would specify methods of construction, and any permits required for building in a flood hazard area.
3. Using the expertise of local engineers, determine the depth and velocity of the 100-year flood flow which would affect the site, including the possible effects of any debris hazards.
4. ELEVATE THE STRUCTURE so that the lowest floor (including basement) is at (or preferably above) the determined flood depth. The most effective methods of elevating structures on fans are to use piles or columns, or to elevate on armored fill.
5. Flood walls can also be used to divert flow around elevated structures where expected flood flows are of minimal depth and velocity, where there is no potential for debris hazards or increased damage to adjacent structures.
6. Avoid the placement of windows and doors on the uphill side of the structure to keep debris and flood water from entering the building. If such openings must be used, they should be reinforced to strengthen resistance against debris and hydrodynamic forces.

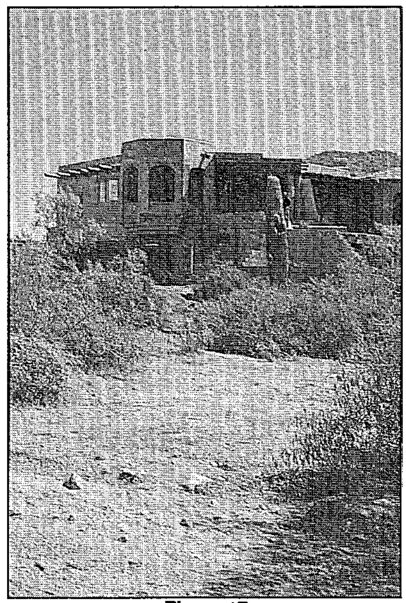


Figure 17.
This home is under construction on an active alluvial fan below the McDowell Mountains in Scottsdale, Arizona.

SINGLE STRUCTURE PROTECTION

Piles, Columns, or Posts:

- Minimize the structure's exposure to flood hazards
- Eliminate obstructions to natural flow paths
- Do not significantly affect flood flow hydraulics
- Size and number of piles must be adequate to provide structural support to building; must be embedded to sufficient depth, and be adequately anchored to both the structure and to subsoil/bedrock to withstand scour and erosion

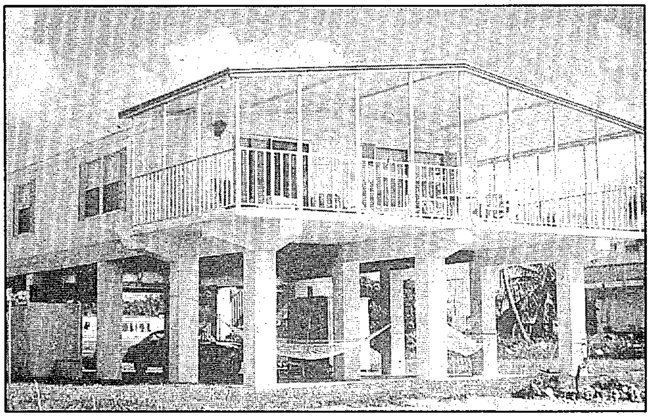


Figure 18.
A home elevated on columns, illustrating how the area below the first floor should be limited to parking, access, or storage. Utilities and mechanical equipment should also be elevated above ground at least to the depth indicated on the FIRM.

Fill:

- Should only be used in low to moderate velocity/depth conditions
- Must be armored above and below grade to withstand scour, erosion, and debris impact and to protect the structure's foundation
- Should be oriented parallel to expected flood flow to reduce debris damage, to avoid deflecting flow to adjacent or downstream property, and to minimize obstruction to flow
- Can be landscaped

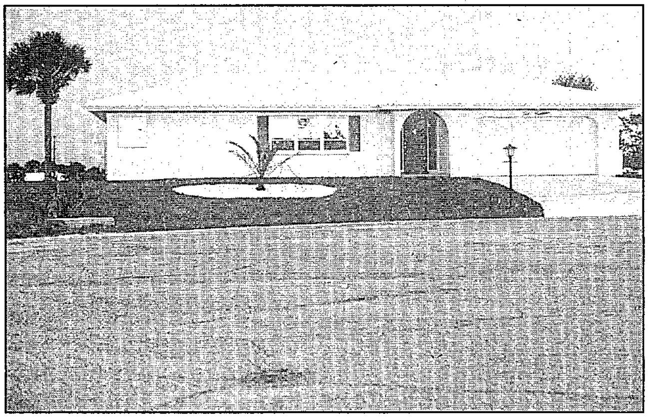


Figure 19.
This home has been elevated on earth fill and landscaped. The vegetation helps to stabilize the fill to protect it from erosion.

Floodwalls or Berms:

- Should only be used in very low velocities/depths (sheet flow velocity of less than 5 feet per second/depth of less than 3 feet); should only be used near toe of fan or where large sedimentation and debris loads are not likely
- Should be able to resist erosion at base and below grade
- Should be oriented to avoid diversion of hazards to adjacent or down stream property
- Can be effective when used as supplemental protection for elevated structures

Since flood hazards threatening an individual site on an alluvial fan are highly unpredictable, the methods used to safeguard a structure will depend upon conditions unique to the location of the site itself. It is therefore imperative to consult closely with local engineering experts to determine the site's particular physical conditions and expected flood and debris hazards.

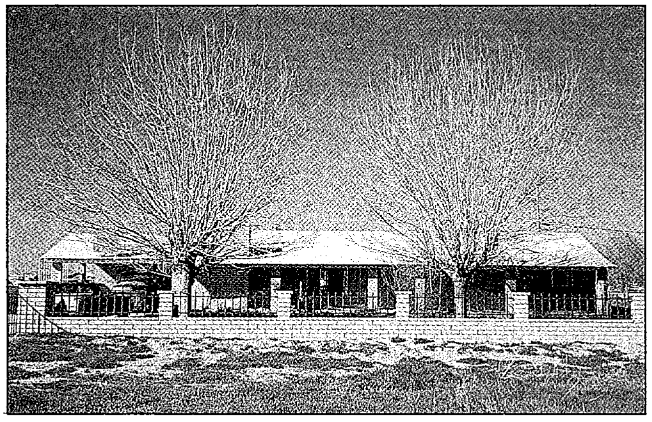


Figure 20.
Floodwalls, such as this example in Phoenix, Arizona, should be constructed parallel to the expected flow direction to minimize the diversion of hazards onto adjacent property.

How Does the NFIP Address Development On Alluvial Fans?

The NFIP identifies alluvial fan hazards on FIRMs as Zone AO and provides information on flood depths and velocities. AO zones are Special Flood Hazards Areas (SFHA) subject to inundation by 100-year sheet-type flow, which are sometimes associated with high velocities. If the community's FIRM identifies AO zones with depths and velocities, construction within those alluvial fan areas are subject to certain regulations (in addition to those which apply to *all* SFHA's) found in Chapter 44 of the Code of Federal Regulations, Part 60.3:

- Elevate lowest floor (including basement) above the highest adjacent grade to *at least* as high as the depth number specified on the FIRM. (It is recommended, however, that the depth of flow assumed for a particular site should take into consideration local topographic anomalies when determining the elevation of any flood protection measure.) Mechanical and utility equipment must also be placed above the depth of flooding.

- Provide adequate drainage paths around structures on slopes, to guide floodwater around and away from proposed structures. Do not deflect floodflow onto adjacent properties.

As part of the FIRM revision process, FEMA will review the development plans submitted by owners of projects who request the removal of their property from the SFHA. To ensure that these projects are in fact protected from alluvial fan flood hazards, FEMA's review criteria require that the construction include elements which: do not cause the disturbance of natural flood processes on the fan; allow for the safe collection, passage, and disposal of flood-related water, sediment and debris without negative impact to adjacent property; address erosion, scour, deposition, impact and hydrostatic forces; provide that the design and maintenance of project elements be coordinated with the local jurisdiction and/or agency responsible for flood control within the community.

With knowledge of local conditions and in the interest of safety, state and community officials may set higher standards for construction in floodplain areas. As with all flooding situations, FEMA encourages local jurisdictions to adopt floodplain management measures which are more tailored to the community's particular flood problems. This is especially important for communities prone to alluvial fan flood hazards, where each fan presents a unique set of flood conditions.

It should be noted that the provisions of Section 60.3 are *minimum* requirements; buildings constructed according to these rules alone will not provide adequate protection against high velocities or debris loads unless additional measures are undertaken.

The unique qualities of each fan formation and its attendant hazards requires individual study and strategic planning using the guidance of government officials, engineers, hydrologists, and geologists. It is hoped that this publication has offered sufficient information regarding the importance of guiding development on alluvial fans to provide the impetus for local knowledge and expertise. Intensified commitment to offset current and future flood losses on fans will greatly complement the work of professional groups and public agencies as they begin to develop management and construction standards for these special arid west flood hazards.

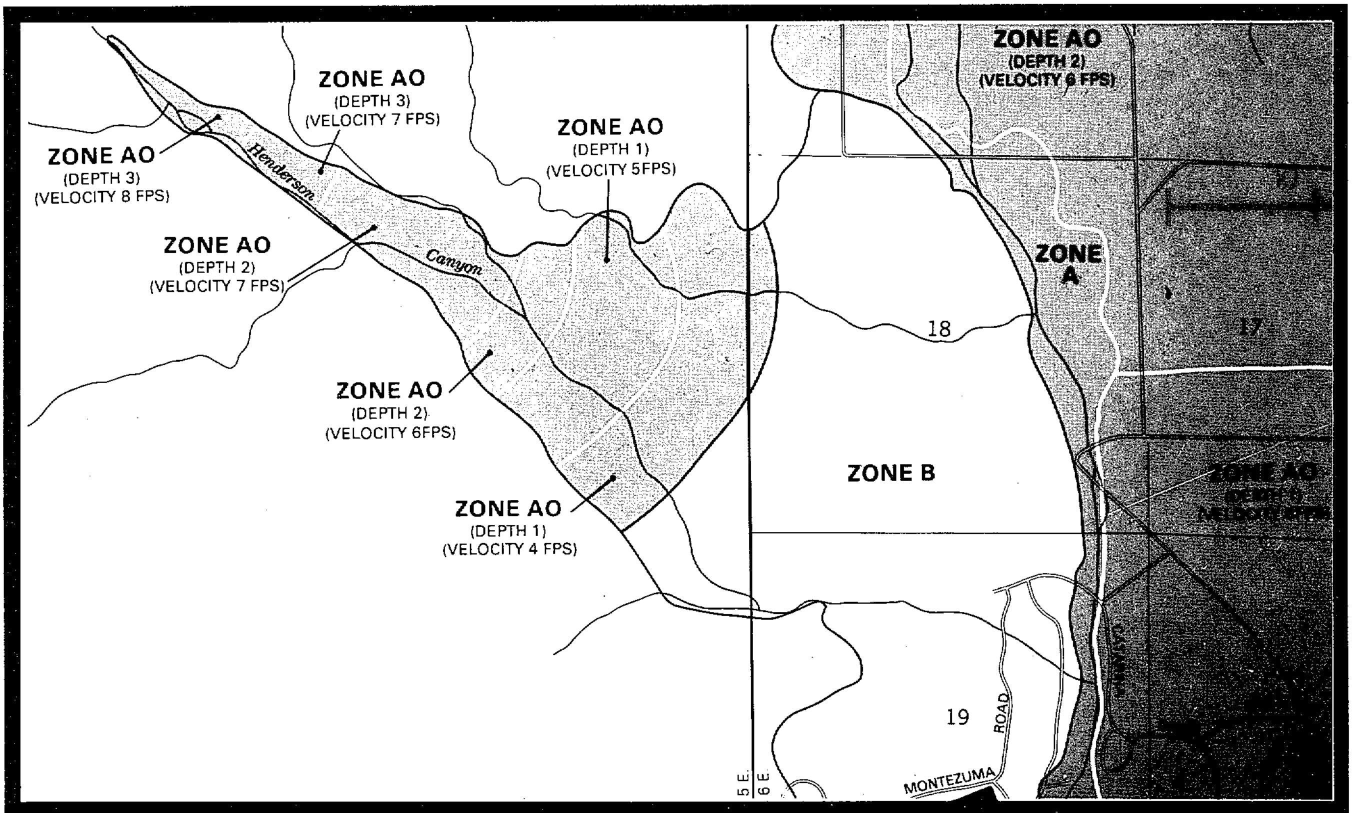


Figure 21.
Portion of a Flood Insurance Rate Map (FIRM) panel for unincorporated San Diego County, California showing areas subject to 100-year flood hazards on the Henderson Canyon alluvial fan.

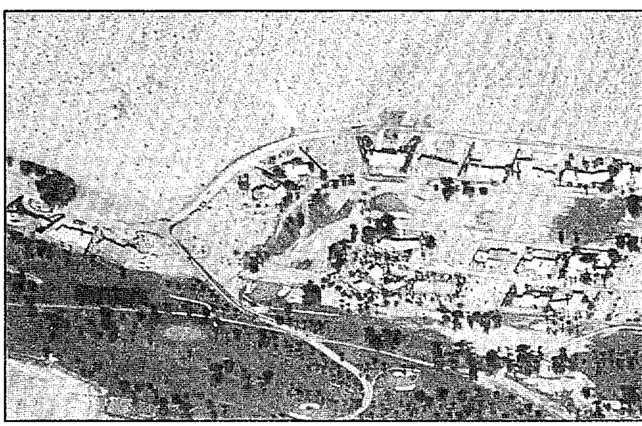


Figure 22.
Flooding hit the community of Borrego Springs near the base of the Henderson Canyon alluvial fan in northeastern San Diego County when Tropical Storm Doreen crossed the area in 1977. This photo faces southward across Montezuma Road, and shows the large amounts of sediment deposited during this flood. The location of this damage is shown in the FIRM, Figure 21. In consideration of the frequency of flood events and the potential for development in the larger Borrego Valley area, a flood management plan is being finalized by San Diego County which will prescribe structural and nonstructural flood control measures for alluvial fans in the county.

APPENDIX A

For Further Information:

For information pertaining to hazard identification mapping and floodplain management, contact the Natural and Technological Hazards Division of the appropriate FEMA Regional Office, or the state NFIP coordinators listed below:

FEMA REGIONAL OFFICES

Region VI: (Arkansas, Louisiana, New Mexico, Oklahoma, Texas)
Federal Regional Center
Room 206
800 N. Loop 288
Denton, TX 76201-3698
(817) 898-9127

Region VIII: (Colorado, Montana, N. Dakota, S. Dakota, Utah, Wyoming)
Federal Regional Center
Building 710
P.O. Box 25267
Denver, CO 80225-0267
(303) 235-4830

Region IX: (Arizona, California, Hawaii, Nevada)
Building 105
Presidio of San Francisco
San Francisco, CA 94129
(415) 923-7175

Region X: (Alaska, Idaho, Oregon, Washington)
Federal Regional Center
130 228th Street, Southwest
Bothell, WA 98021-9796
(206) 487-4682

NFIP STATE COORDINATORS

ARIZONA
Arizona Department of Water Resources
Engineering Division
15 South 15th Avenue
Phoenix, AZ 85007

Ms. Terri Miller
(602) 255-1566

CALIFORNIA
California Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001

Mr. A. Jean Brown
(916) 445-6249

COLORADO
Colorado Water Conservation Board
State Centennial Building, Room 721
1313 Sherman Street
Denver, CO 80203

Mr. Brian Hyde
(303) 866-3441

IDAHO
Idaho Department of Water Resources
Engineering Division
1301 N. Orchard
Boise, ID 83706

Mr. Lotwick Reese
(208) 334-7887

MONTANA
Montana Department of Natural Resources and Conservation
Floodplain Management Section
1520 East 6th Avenue
Helena, MT 59620

Mr. John Hamill
(406) 444-6646

NEVADA
Nevada Division of Emergency Management
2525 South Carson
Capitol Complex
Carson City, NV 89710

(702) 885-4240

NEW MEXICO
New Mexico State Engineer's Office
Design and Construction Section
Bataan Memorial Building
Santa Fe, NM 87503

Mr. Don Lopez
(505) 827-6140

OREGON
Oregon Department of Land Conservation and Development
1175 Court Street, N.E.
Salem, OR 97310

Mr. Jim Kennedy
(503) 378-2332

UTAH
Utah Office of Comprehensive Emergency Management
1543 Sunnyside Avenue
Salt Lake City, UT 84108-0100

(801) 533-5271

WASHINGTON
Washington Department of Ecology
Shorelands and Coastal Zone Management Program
Mail Stop PV11
Olympia, WA 98504

Mr. Jerry Louthain
(206) 459-6791

WYOMING
Wyoming Emergency Management Agency
P.O. Box 1709
Cheyenne, WY 82003

Mr. Grant Sorenson
(307) 777-7566

APPENDIX B

FEMA Publications:

The following publications are free of charge and can be obtained by writing to:

Federal Emergency Management Agency
P.O. Box 70274
Washington, D.C. 20024
ATTENTION: Publications

FEMA-13, **Flood Emergency and Residential Repair Handbook**—Outlines for the homeowner actions that can be taken before and after a flood to help reduce damage and speed repairs.

FEMA-15, **Design Guidelines for Flood Damage Reduction**—General information on flooding and how to properly design and build in floodplain areas.

FEMA-54, **Elevated Residential Structures**—Proper design and construction methods for elevated buildings.

FEMA-114, **Design Manual for Retrofitting Flood-prone Residential Structures**—Presents floodproofing techniques that can be used for existing residential structures.

FEMA-116, **Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials**—A guidebook to help local governments improve their floodplain management programs for high risk flood hazard areas.

FIA-2, **Questions and Answers on the National Flood Insurance Program**—This pamphlet is intended to acquaint the public with the National Flood Insurance Program. It is designed for readers who do not need a detailed history or refined technical or legal explanations, but do need a basic understanding of the Program and the answers to some frequently asked questions.

FIA-14, **Guide to Flood Insurance Rate Maps**—This guide will help you read and understand a Flood Insurance Rate Map (FIRM). It contains illustrations and a step-by-step example of how to use a FIRM.

ACKNOWLEDGEMENTS

The Office of Loss Reduction wishes to thank the following for their information, advice and photographic materials used during the preparation of this publication:

Arizona Department of Water Resources
Association of State Floodplain Managers
California Department of Transportation
Cochise County, Arizona Department of Public Works
Colorado Water Conservation Board
Colorado Geological Survey
Federal Emergency Management Agency-Federal Insurance Administration-Office of Risk Assessment
Federal Emergency Management Agency-Natural and Technological Hazards Division-Regions 6, 8, 9, and 10
Michael Baker, Jr. Engineers
City of Ouray, Colorado
Pima County, Arizona Transportation and Flood Control District
San Diego County, California Flood Control District
Tudor Engineering Company