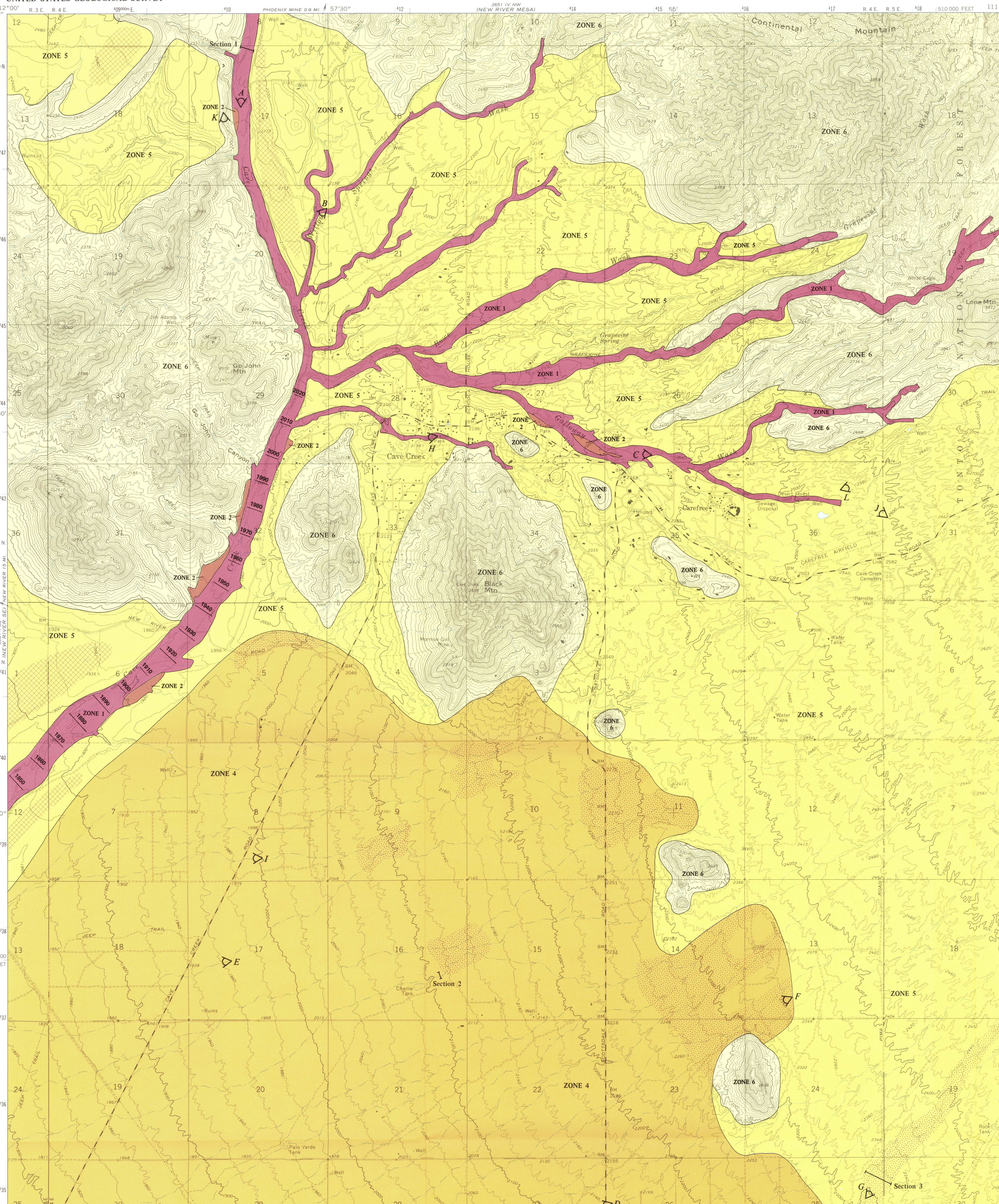


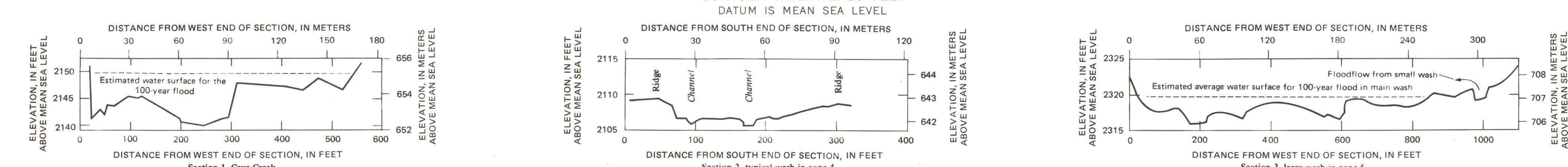
Base from U.S. Geological Survey
10,000-foot grid based on Arizona coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12 shown in blue

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Interior—Geological Survey, Reston, Va.—1978—W77040



Section 1, Cave Creek — Section 2, typical wash in zone 4 — Section 3, large wash in zone 5

CROSS SECTIONS OF CAVE CREEK AND SELECTED WASHES SHOWING ESTIMATED POSITION OF WATER SURFACE FOR THE 100-YEAR FLOOD AND GROUND RELIEF

QUADRANGLE LOCATION

DELINEATION OF FLOOD HAZARDS IN THE CAVE CREEK QUADRANGLE, MARICOPA COUNTY, ARIZONA

By
H. W. Hjalmarson
1978

EXPLANATION

Zone 1

Extent of the 100-year flood on Cave Creek and selected tributaries. Number (2010) indicates the altitude, in feet, of the peak water surface during a 100-year flood using 1964 and 1975 channel conditions. Areas of narrow width are not shown

Zone 2

Part of flood plain that may be inundated by rare large floods or eroded by frequent small floods

Zone 3

Flooding from sheetflow, standing water, and water that collects in depressions. No areas on this map are in zone 3

Zone 4

Flooding in channels and sheetflow on slightly dissected alluvial plains. Greater than average chance of sediment deposition during flooding. Stippled pattern in zone 4 indicates areas of greater than average flood hazard

Zone 5

Flooding confined to defined channels of small tributary streams. Crosshatched pattern in zone 5 indicates areas that are potentially hazardous mainly because of poor drainage. Stippled pattern in zone 5 indicates area of greater than average flood-hazard potential

Zone 6

Steep mountainous terrain with minimal potential flood hazard except in defined channels

Location and view angle of photographs

INTRODUCTION

Floods in the map area result from large amounts of intense rainfall in the areas drained by Cave Creek. The normally dry channels can suddenly host dangerous torrents. Typical floods in the normally dry channels are characterized by a rapid rise in water surface, a short period of peak flow, and a gradual decline in water surface; they are commonly referred to as flash floods because of the suddenness with which they occur and because they are short lived. Floodflow often is decreased by infiltration as the water moves downstream over the dry alluvial channels. Large amounts of debris are carried down the channels, and the shapes of the channels often change during flooding. Channel banks wetted by floodwater often cave after or during flooding.

The principal potential flood hazard in the map area is along the defined channels of Cave Creek and its tributaries. The velocity of floodwater in the channels is high, and the erosion potential is great. The most overlooked potential flood hazard in the map area is along the small washes on the alluvial plains. The water-carrying capacity of the small washes is a small fraction of the amount of floodwater expected once every 100 years. The potential hazards range from floodwater in sheets a few inches deep to floodwater concentrated in channels having high-flow velocities. The potential flood hazard is caused, in part, by the suddenness and unexpected nature of the floodflow.

The possible degree of hazard resulting from floods along Cave Creek and its tributaries varies with depth of flooding, velocity of floodflow, and the frequency with which an area is flooded; on the surrounding slopes, the possible degree of hazard depends mostly on the physical features of the terrain. The zones of potential flood hazard on the map are based on the source of flooding, frequency of inundation, and degree of hazard related to physical features. The zones generally represent areas of definable potential flood hazards with homogeneous characteristics.

At the present time (1975), the dominant land use is low-density single-family residential mainly around the communities of Cave Creek and Carefree in the center of the map area. Future land use is expected to remain mostly single-family residential in most of the area.

The flood-hazard zonation indicates the magnitude of flood that can be expected and the area that would be inundated. The necessary information is based on flood-frequency analyses of recent streamflow data and on the hydraulic characteristics of the stream channels. The predicted extent and type of flooding were estimated by a field investigation, which included the surveying of sections across channels, and by the interpretation of maps and photographs. The information given regarding flooding along Cave Creek downstream from Rowe Wash is from an earlier study by the U.S. Army Corps of Engineers (1964).

The estimated peak discharge for floods of different frequencies of occurrence is given in table 1 for most of the area. The data in table 1 may not be applicable to sites in zone 4 more than about 0.2 mi (0.3 km) downstream from zones 5 or 6 because the amount of rainfall that runs off the land surface in zone 4 is less than that in other zones. Also, floodwater that enters zone 4 from zones 5 and 6 is lost to the subsurface, and the magnitude of the flood peak often diminishes as floodwater moves downstream.

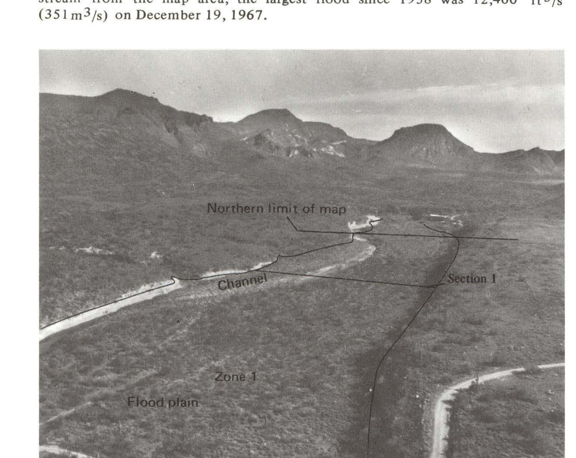
Table 1. – *Estimated peak discharge for the 10-, 50-, and 100-year floods*[1]
[Estimates based on computations using methods described by Patterson and Somers (1966)]

Drainage area, in square miles	Peak discharge, in cubic feet per second		
	10-year flood	50-year flood	100-year flood
0.1	200	400	500
.5	500	1,000	1,400
1.0	750	1,500	2,100
5.0	2,000	4,000	5,500
10.0	3,000	6,000	8,400
20.0	4,500	9,000	13,000

[1] Discharge subject to change as a result of the continuing statewide flood-frequency analysis.

FLOODING FROM CAVE CREEK AND LARGE WASHES

The peak discharge of the 100-year flood – the discharge that will be equaled or exceeded on an average of once every 100 years – is about 30,000 ft^3/s (850 m^3/s) for Cave Creek upstream from Willow Springs Wash and about 35,000 ft^3/s (991 m^3/s) for Cave Creek downstream from Rowe Wash. Floodflow velocities will exceed 15 ft/s (4.6 m/s), and flow depths will be as much as 15 ft (4.6 m). The largest known peak discharge in Cave Creek was about 30,000 ft^3/s (850 m^3/s) in August 1921; the peak occurred at a downstream site near the Phoenix Mountains, where the area drained is about twice the area drained by Cave Creek where it leaves the west edge of the map area. At the U.S. Geological Survey streamflow-gaging station on Cave Creek 0.6 mi (1.0 km) downstream from the map area, the largest flood since 1958 was 12,400 ft^3/s (351 m^3/s) on December 19, 1967.



Photograph A. – Looking north and upstream along Cave Creek. The extent of the 100-year flood (zone 1) is between the defined banks as shown.

ZONE 1

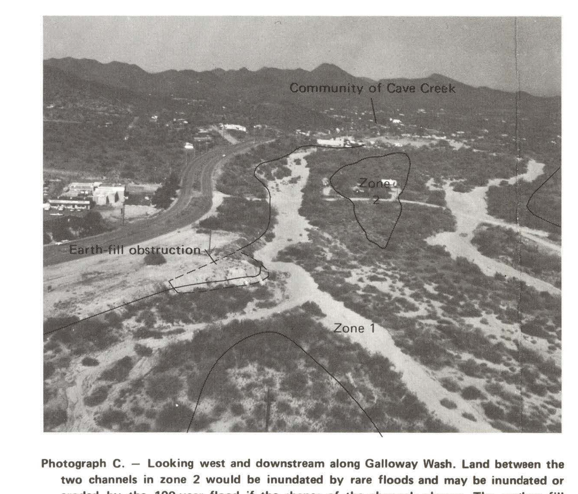
Zone 1 is the area that would be inundated by the 100-year flood on Cave Creek and (or) its larger tributaries if the 1975 channel conditions remain stable. This zone has a high potential flood hazard because floodflows are concentrated in defined channels and parts of the land that adjoin the channels. The velocity of flows in the channels is high, and the land in and adjacent to them is susceptible to erosion. Zone 1 includes the channel and the parts of the flood plain that would be flooded (see photograph A and cross section 1). The channels and flood plains in zone 1 are unstable and are susceptible to scour and fill. The alluvium of the channels is composed of sand, gravel, and boulders that are easily moved by floodwater. The erosion, deposition, and movement of the alluvium causes varying amounts of obstruction to floodwater; the effects of this and other obstructions, such as uprooted trees, on flood depths and velocities are unpredictable. The obstructions occur during major floods, and large changes in flow pattern in the flood plains can result (see photograph B).

Photograph B. – Looking southwest from the center of Willow Springs Wash. Channel is cutting into the terrace bank on the east side of the wash. The bank is about 5 ft (1.5 m) high. Floodwater continually erodes low terraces like that shown in the photograph. Most of the low terraces in zone 1 will be inundated by the 100-year flood. The potential hazard to development on low terraces is great because of the high velocity, substantial depth of flow, and high erosion potential of the terraces.

Water-surface elevations for the 100-year flood and the limits of zone 1 along Cave Creek below Rowe Wash have been defined by the U.S. Army Corps of Engineers (1964) and are based on detailed engineering studies using channel cross sections and step-backwater computations. Because the flood plains would be completely inundated by the 100-year flood, and because they are bounded by steep banks, the remaining limits of zone 1 can be approximated quite closely. Water-surface elevations have not been computed precisely for the reaches of channel upstream from those studied by the Corps of Engineers. The depth of flow in the flood plains generally will be more than 1 ft (0.3 m) and in places may be as much as 5 ft (1.5 m).

ZONE 2

A few small areas of flood plain along Cave Creek and Galloway Wash that are not included in zone 1 have been designated as zone 2. If the 1975 channel conditions remain stable, these areas would not be flooded except by rare floods that are larger than the 100-year flood; however, the areas could be cut away by streamflow and their flood-hazard potential is only slightly less than the areas in zone 1. The parts of zone 2 that are immediately adjacent to the main channels have a particularly high flood-hazard potential (see photograph C).



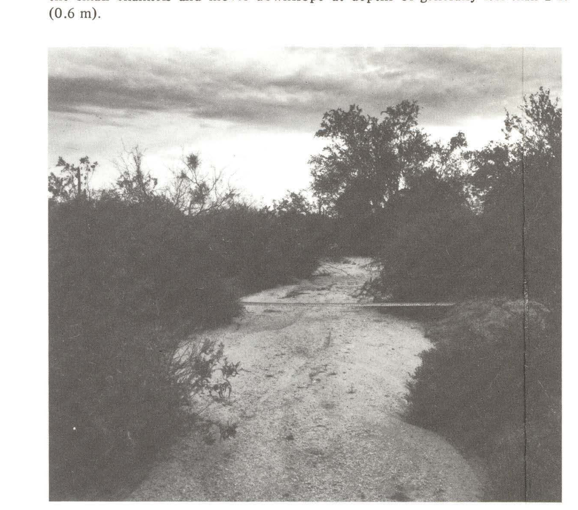
Photograph C. – Looking west and downstream along Galloway Wash. Land between the two channels in zone 2 would be inundated by rare floods and may be inundated or eroded by the 100-year flood if the shapes of the channels change. The earthen fill encroaching into the south channel of the wash forms an obstruction to floodwater. Obstructions often reduce the ability of the channel to carry floodwater and thereby increase the height of floods. Lateral migration of a channel also can result from obstructions.

ZONE 3

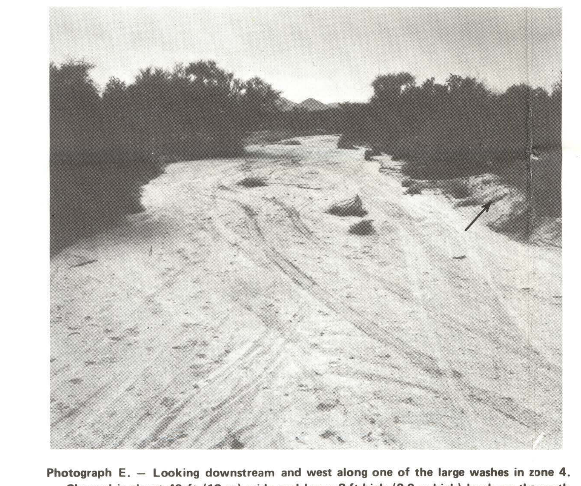
Zone 3 is used to define sheetflow, standing water, and water that collects in depressions. In the map area no area is large enough to be so defined.

ZONE 4

The slightly dissected alluvial slopes in zone 4 have an extreme and often overlooked flood potential. Streams debouching into zone 4 transport large amounts of sand and gravel, and floodwater spreads out in many directions. Generally, the well-defined channels in zones 5 and 6 branch and rebranch downstream in zone 4 into many unstable distributary channels, and the flow from several streams may combine. The channels generally are less than 3 ft (0.9 m) deep at bankfull stage, are embedded in fairly coarse sand and gravel, erode easily, and can change direction and location (see photographs D and E). Generally, the ground relief between channels is less than 5 ft (1.5 m). (See cross section 2.) Much of the floodflow spreads out over the land adjacent to the small channels and moves downslope at depths of generally less than 2 ft (0.6 m).



Photograph D. – Looking downstream along a small unnamed wash in zone 4. The channel is about 12 ft (3.7 m) wide, and the banks are from 1 to 1½ ft (0.3 to 0.5 m) high. The capacity of the channel is about 10 percent of the potential peak discharge of the 100-year flood. The hydraulic characteristics and general appearance of many small washes in zone 4 are similar to those of the wash in the photograph. Floodwater may spread over the adjoining land as much as 2 ft (0.6 m) deep and as much as 100 ft (30 m) from the channels.



Photograph E. – Looking downstream and west along one of the large washes in zone 4. Channel is about 40 ft (12 m) wide and has a 3-ft-high (0.9-m-high) bank on the south and a 1-ft-high (0.3-m-high) bank on the north. The capacity of the channel is a small fraction of the potential 100-year flood. Land adjacent to large washes is susceptible to inundation, erosion, and deposition of sediment. Floodwater can spread out from the washes to depths of more than 3 ft (0.9 m). The floodflow on land adjacent to the channels generally is less than 2 ft (0.6 m) deep; the floodflow in the channels may be as much as 5 ft (1.5 m) deep, and velocities may be more than 10 ft/s (3.0 m/s). The small manmade mound of sediment indicated by the arrow in the right foreground of the photograph is adjacent to a subdivision lot to the north.

Water 2 ft (0.6 m) deep flowing over clean smooth slopes may attain a velocity of 10 ft/s (3.0 m/s); however, such a depth would seldom occur unless the water is impeded by a rougher surface (table 2). The average velocity generally is about half the maximum velocity shown in table 2.

The potential flood hazard at a particular site in zone 4 is difficult to estimate by any procedure and is largely dependent on physical examination of the site. The flood-hazard potential commonly is underestimated because of the small size of the channels, and the total area that contributes runoff to a particular site often cannot be determined. Unfortunately, the area drained by a wash is difficult to estimate because the washes divide and combine. Large amounts of water infiltrate into the sand, and peak flows during most floods are reduced as the flood moves downstream. A reliable prediction cannot be made of flood discharge at most sites. The evaluation of the flood-hazard potential at a site must take into account the site elevation, the cross-sectional configuration, the gradient of the terrain, the distance from the site to defined washes, and the location and possible amount of overflow upstream.

Table 2. – *Estimated maximum flow velocity for different flow depths over clean smooth slopes in zone 4*
[Velocity computed using the Manning (in Linsley and others, 1949, p. 272) formula]

Depth, in feet	Velocity, in feet per second
0.1	1.5
.5	4
1.0	7
2.0	10

In zone 4 the flood-hazard potential is particularly great in areas shown by the stippled pattern, where large washes are confined between mountains and where large washes combine and branch. The distance and the ground relief between channels is small in the areas where the large washes combine and branch; therefore, land in these areas is subject to extensive inundation by fast-moving floodwater from one or more washes. The peak discharge for the 100-year flood in the large stippled area between the two mountains in parts of secs. 13, 14, 23, and 24, T. 5 N., R. 4 E., is about 8,000 ft^3/s (227 m^3/s). The discharge greatly exceeds the capacity of the channels, and floodwater will spread over large areas (see photograph F).

Photograph F. – Looking southwest at the area in zone 4 where the flood-hazard potential is great. Most of the land near the center and in the foreground of the photograph is subject to flooding.

ZONE 5

The greatest potential hazard in zone 5 is from the flooding confined in the channels and narrow flood plains that occupy the lowlands between the defined ridges. Marked scouring occurs along some of the channels and flood plains, and floods carry large amounts of sediment. In many channels the depth of flooding depends on the amount of erosion and deposition that takes place during the flood. The depth of flooding generally does not exceed 10 ft (3.0 m) except where channels are obstructed or are on the outside of sharp bends. The depth of floodwater also increases behind debris jams and manmade obstructions. The degree of potential hazard of the larger washes in zone 5 is similar to that in zone 1; however, a zone 1 classification for these washes cannot be clearly delineated on the map because of the narrow width of the areas inundated by the 100-year flood.

The areas shown by the crosshatched pattern are susceptible to flooding from local sheetflow. Only a few small defined channels are present in these areas, and water moves in a shallow sheet over the fairly flat land surface.

The area in zone 5 shown by the stippled pattern is susceptible to extensive sheetflooding and flooding in small defined channels. The potential hazard in this area is nearly equal to that in zone 1. The area drained above cross section 3 is 8.5 mi^2 (22 km^2) and has a 100-year flood of about 7,500 ft^3/s (212 m^3/s). Floodwater spreads over large areas, and the elevation of the water surface varies along cross section 3 perpendicular to the flow. The main channel of the wash is deceptively small and carries only a small part of the floodwater (see photograph G).

Photograph G. – Looking upstream from the center of a large wash in zone 5. The channel is from 40 to 50 ft (12 to 15 m) wide and has banks about 2 ft (0.6 m) high, as indicated by the surveying rod in the right center of the photograph. The maximum capacity of the channel at bankfull stage is about 1,000 ft^3/s (28.3 m^3/s) or only 13 percent of the peak discharge of the 100-year flood. The area that would be inundated by the 100-year flood is several hundred feet wide.

Zones 4, 5, and 6 are related to major physical features. For example, in many places the boundary between zones 4 and 5 is the boundary between an alluvial plain and an eroded bedrock surface thinly covered by alluvium; the boundary between zones 5 and 6 is a function of the slope of the land surface and in places may be the boundary between unconsolidated alluvium and consolidated rocks of the mountains.

ZONE 6

Zone 6 contains well-drained areas of steeply sloping hills and mountains, and most of the zone has a low flood-hazard potential. The dominant hazard is along the defined channels where flood velocities are high; in the large channels velocities may be as much as 15 ft/s (4.6 m/s). Sheetflow may occur along some steep slopes possibly accompanied by landslides and rolling boulders. Areas drained by defined channels commonly are only a few tenths of a square mile. Peak discharge rates of as much as 500 ft^3/s (5.5 m^3/s) from a 0.1-mi^2 (0.1-km^2) area can be expected on an average of once every 100 years (table 1). A large part of the flood-hazard potential in this zone is attributable to the possibility of sudden flooding and the high velocity of flow.

FLOOD-HAZARD POTENTIAL AND EFFECTS OF URBANIZATION

At present (1975), much of the area is undeveloped, but urbanization is spreading rapidly. The area is topographically desirable, has many scenic features, and is close to the Phoenix metropolitan area; therefore, a considerable amount of future growth is expected. Most of the urbanization is centered around the communities of Cave Creek and Carefree, and new development radiates outward, mostly toward the north and south.

New development should be compatible with potential flood hazards; unplanned and unregulated urbanization in other areas has resulted in development that is highly susceptible to flood damage. Flood-damage prevention, such as dams, levees, and channel changes, often is costly and can be unsightly. Awareness of potential flood hazards, as shown in recent zoning ordinances, building codes, development policies, and other flood-damage-prevention measures, has yielded favorable economic and esthetic benefits.

Urban developments will be subject to the potential flood hazards described above, and extensive development may create additional hazards. The effects of urbanization will depend on the type and extent of development. Extensive urbanization often increases the potential for flooding and related hazards within and downstream from the urbanized area.

ZONES 1 AND 2

Structures in zone 1 would be highly susceptible to damage from inundation, erosion, and high-velocity floodflow. Encroachment of structures and earthen fill may cause the flood level to rise appreciably. Extensive urbanization in zones 4, 5, and 6 could increase the magnitude and frequency of flooding in zone 1. Development in zone 2 would be subject to hazards similar to those in zone 1; however, the hazards would be of lesser magnitude and frequency. Obstructions in zone 1 could significantly raise the flood level and cause flooding in other zones (see photographs C and H).

ZONE 4

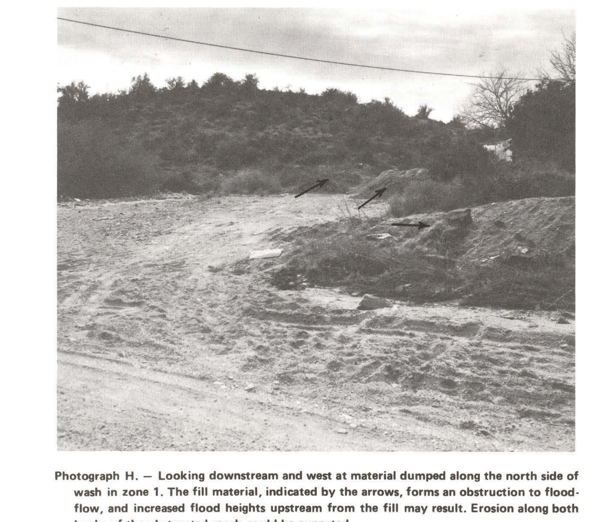
Structures in and near channels in zone 4 would be susceptible to damage from fast-moving floodwater and erosion. Structures in low-lying areas would be subject to inundation. Encroachment in the low-lying and channel areas could cause increased flood depths (see photograph I) and change the location of the fast-moving floodflow. Erosion of desert land owing to rooftop and paved-area runoff can be expected, particularly along uncurbed streets, collector channels, and below the outlets of collector channels. Runoff that enters zone 4 may increase owing to urbanization in zones 5 and 6.

The runoff that originates in zone 4 may increase if extensive areas of the land surface become impervious because of the construction of buildings and the paving of driveways and roads. By comparison with other areas, the magnitude of small floods may increase by a factor of two or more owing to paving. The construction of lined channels to carry floodwater also has significantly increased the magnitude of flood peaks in other areas. Lined channels that drain floodwater from an area can create flood hazards in downstream areas.

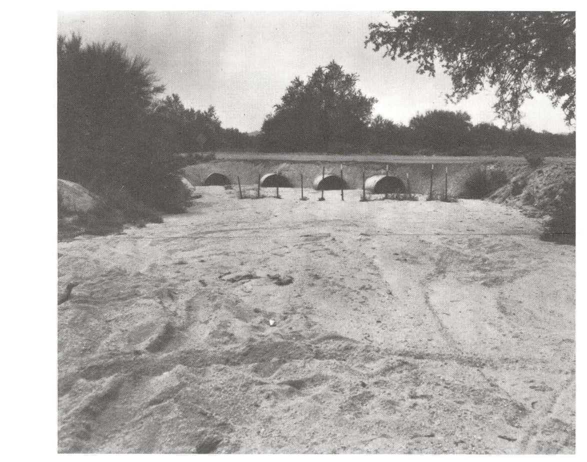
ZONES 5 AND 6

Structures in and near the channels in zones 5 and 6 are susceptible to damage from inundation and high-velocity flow. Development in many channels in zone 5 and in a few channels in zone 6 would be susceptible to damage nearly identical to that in zone 1 (see photograph J). The effect of urbanization on increasing the flood-hazard potential in zones 5 and 6 would depend on the type of development. If urbanization in these zones is extensive, the magnitude and frequency of floodflow probably will increase. Low-density development may have little effect on the magnitude of floods.

The natural system of carrying floodwater in zones 5 and 6 may change significantly if urbanization is extensive. Interception of sheetflow by roads is expected, and erosion along roadways would result (see photographs K and L). Structures may become more susceptible to flood damage owing to the concentration of floodwater in and along roadways.



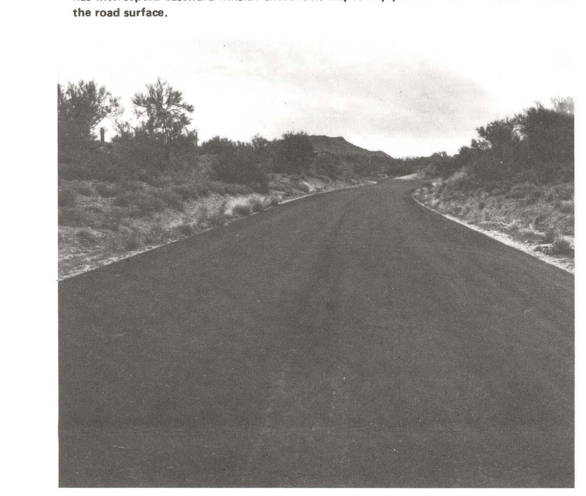
Photograph H. – Looking downstream and west at material dumped along the north side of wash in zone 1. The fill material, indicated by the arrows, forms an obstruction to floodflow, and increased flood heights upstream from the fill may result. Erosion along both banks of the obstructed reach could be expected.



Photograph I. – Looking downstream from center of large wash in zone 4. Culvert pipes under Cave Creek Road are partly filled with sediment, and the capacity has been greatly reduced. During small floods, the culvert effectively carries water under the roadway; however, during large floods, the culvert acts as an obstruction, thus increasing the susceptibility of the surrounding land to flooding. This condition is typical at the few culverts in zone 4.

Photograph J. – Looking northwest at cul-de-sac at the confluence of two washes in zone 5. The end of the street would be inundated by small floods, and much of the nearby land would be inundated by large floods.

Photograph K. – Looking south at erosion along edge of a paved road in zone 6. Roadway has intercepted eastward hillside sheetflow. Exposed pipes are about 2 ft (0.6 m) below the road surface.



Photograph L. – Looking upstream at a residential street in a small wash in zone 5. The street is the main channel for floodwater. The velocity of floodwater in the wash is increased owing to the smooth pavement, and peak rates of floodflow can increase. A significant increase in potential flood hazard can result along washes that drain a large residential area having paved washes. Streets in washes pose a serious potential hazard to travelers because of sudden and unexpected floodflow. Erosion along the edges of the pavement can be expected.

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CONVERSION FACTORS

Multiply English units	By	To obtain metric units
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
feet per second (ft/s)	.3048	meters per second (m/s)
cubic feet per second (ft^3/s)	.02832	cubic meters per second (m^3/s)

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