DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

EXPLANATION

[Stippled pattern in zones 3, 4, and 5 indicates areas of greater than average flood hazard]

1990

Zone 1

Extent of a 100-year flood on the Santa Cruz River. Number (1990) indicates the altitude, in feet, of the peak water surface during a 100-year flood using the 1973 channel conditions

Zone 2

Additional part of the flood plain that may be inundated by rare floods; severe hazard exists because of possible erosion

Zone 3

Flooding from local sheetflow and water that collects in depressions

Zone 4

Sheetflood on slightly dissected alluvial slopes

Zone 5

Flooding confined to defined channels of small tributary streams

Zone 6

Steep mountainous terrain with minimal flood hazard

★ A

Location of special hazards

A. *The 100-year flood will overtop Interstate Highway 10 and the Southern Pacific Railroad upstream from the mapped area, and water will flow to the northwest on both sides of the highway and railroad. Areas of high velocity and possible scour may occur at underpasses for Avra Valley Road and the railroad spur leading to the cement plant. Water will flow through Rillito at depths of 1 to 2 feet and continue toward Marana schools along the access road adjacent to Interstate Highway 10. See photograph A.*

B. *A small irrigation ditch along Tangerine Road, which directs floodwater back to the river, may be overtopped.*

C. *Bank erosion is occurring near the Marana residential section. See photograph B.*

D. *Marana schools were damaged by a flood from Cottonwood Wash on Sept. 10, 1962. The peak flow was measured as 5,700 cfs from 8 square miles at a point about 1 mile upstream from the north edge of the map. Large photograph shows how channels of Cottonwood Wash are directed toward the school buildings.*

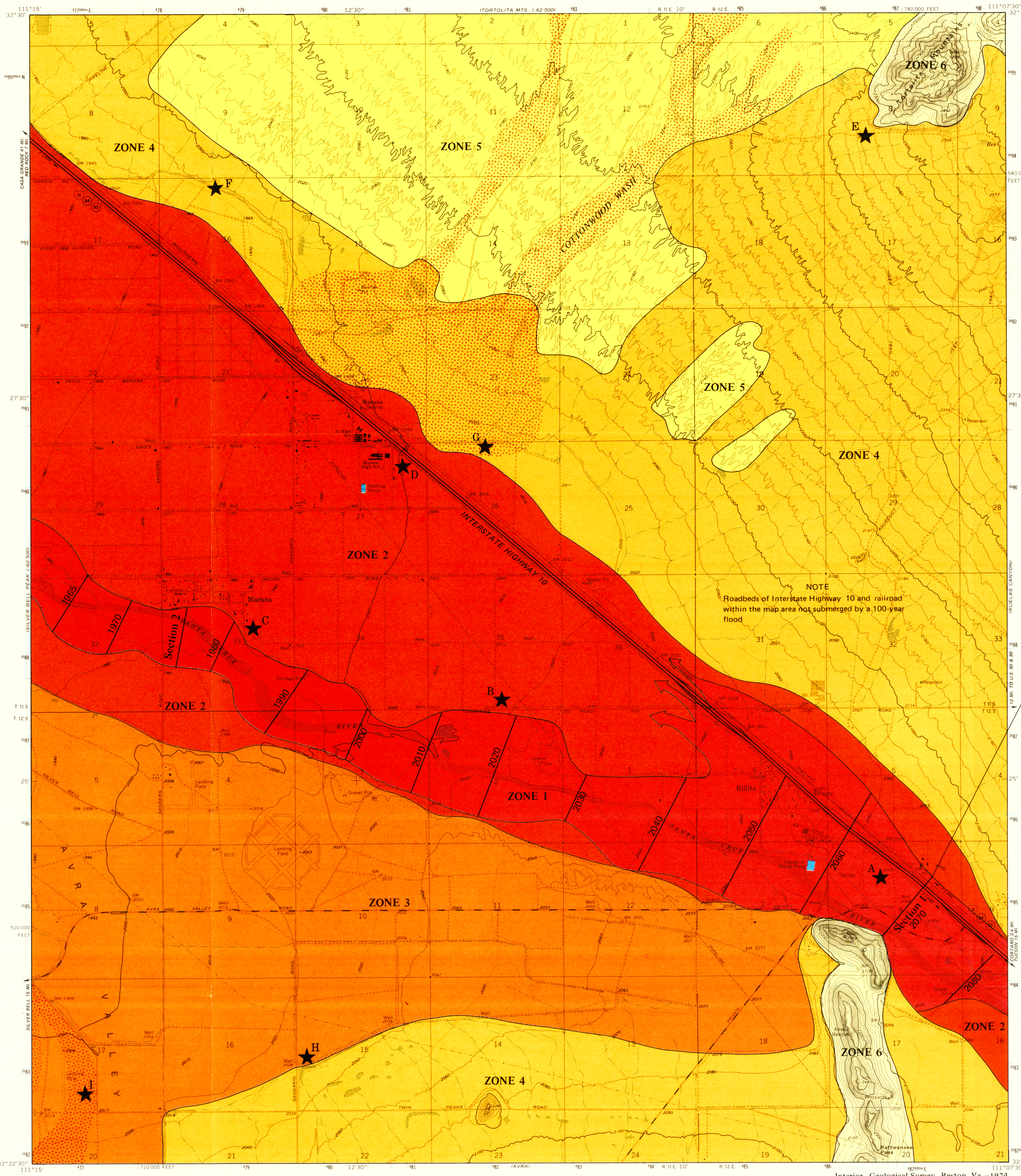
E. *Channel makes right-angle bend below a reach of very steep channel. Distributary channels on large photograph show that floods overtop the bank and flow directly down the general land slope.*

F. *A well-constructed dike and diversion channel collect sheetflow and divert moderate floods around fields. Deposits of gravel in channel during a major flood may cause the dike to be overtopped and breached.*

G. *A low earth berm, which prevents damage to fields during minor floods, will have no effect on large floods.*

H. *Floodwater is impounded in a detention basin behind a high earth dike that could fail and release large amounts of water during a major flood.*

I. *A small area is flooded by overflow from Brawley Wash.*



Base from U.S. Geological Survey, 1:24,000, 1967

10,000-foot grid based on Arizona coordinate system, central zone

1000-meter Universal Transverse Mercator grid ticks, zone 12 shown in blue

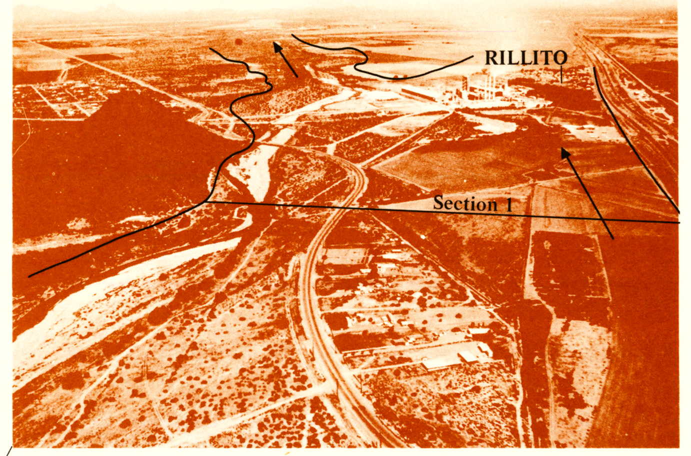
APPROXIMATE MEAN DECLINATION, 1974

SCALE 1:36 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ARIZONA

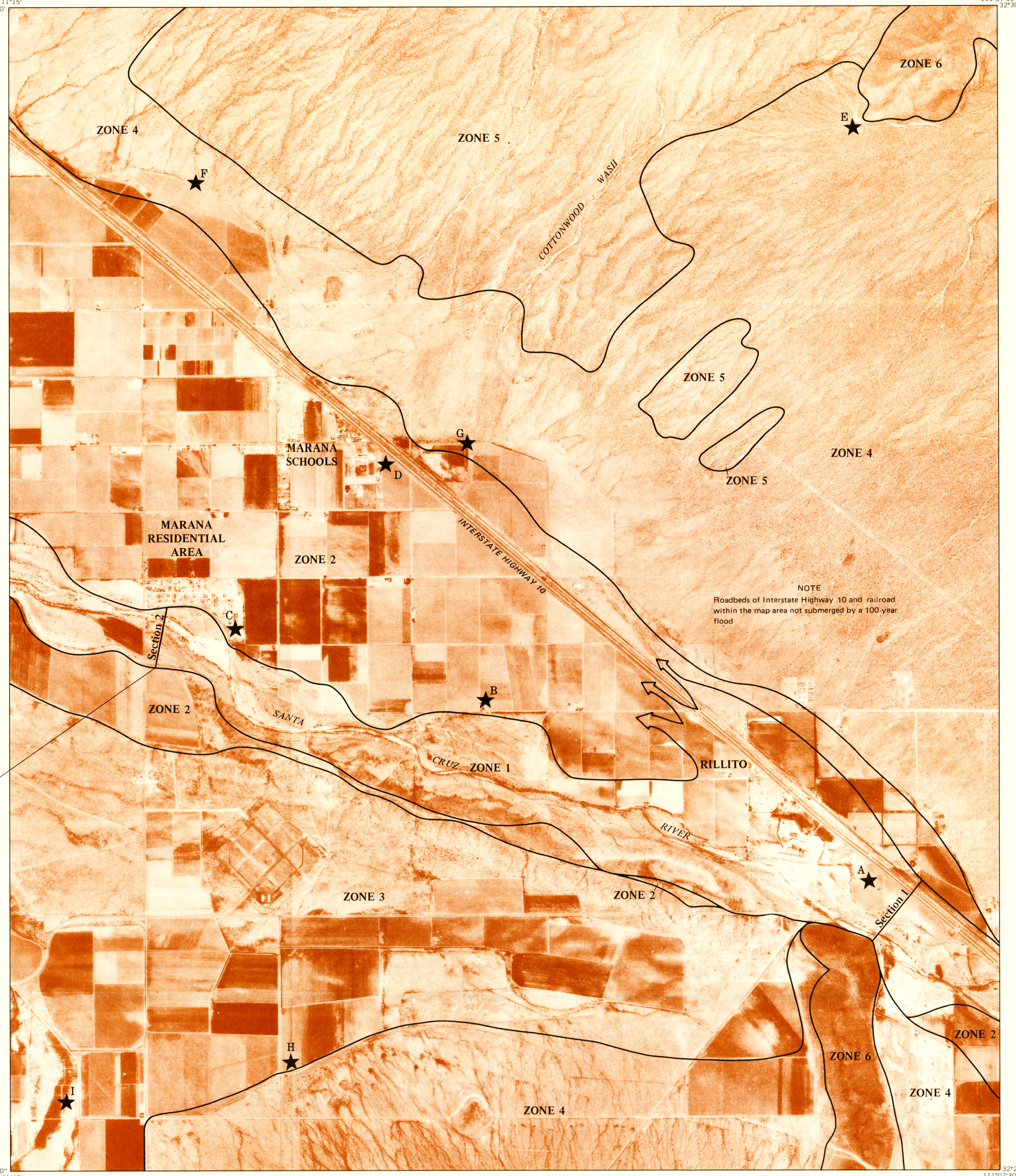
QUADRANGLE LOCATION



A. Looking downstream toward Rillito. Water flowing along Interstate Highway 10, during the 100-year flood, will follow the natural ground slope through Rillito. The limits of overflow are indicated by the solid line. Floodwaters overtopped the northwest bank just downstream from Rillito in 1967. See cross-section 1.

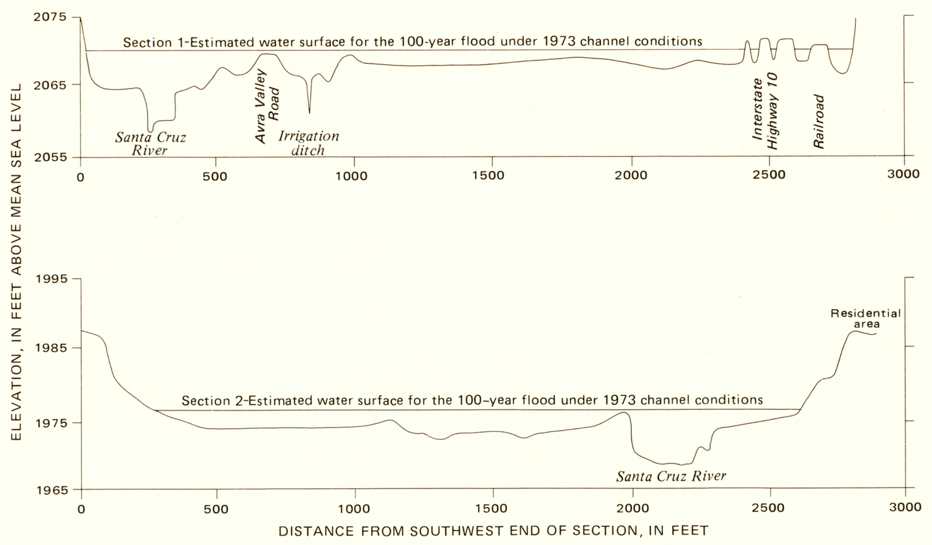
B. Looking downstream toward the Marana residential section. Over a period of years, the Santa Cruz River can be expected to shift back and forth across zone 1 (indicated by solid line) by eroding large sections of its bank in a manner similar to that shown in the center of the picture. The dashed line indicates the approximate location of the channel in 1966. See cross-section 2.

PHOTOGRAPHS OF SANTA CRUS RIVER, MAY 1973



SCALE 1:36 000

High-altitude aerial photography by NASA Ames Research Center, Moffett Field, Calif. 1972



CROSS SECTIONS OF THE SANTA CRUZ RIVER, SHOWING ESTIMATED WATER SURFACE FOR THE 100-YEAR FLOOD

INTRODUCTION

The principal flood hazard in the map area is the Santa Cruz River, but flash floods that occur on the upland slopes as a result of intense rainfall of short duration and small areal extent are also a hazard. Much of the upland area is undeveloped, and flood peaks often dissipate on the alluvial fans; therefore, the potential hazards to proposed urban developments are not readily apparent to the casual observer.

The degree of hazard resulting from floods along the Santa Cruz River varies with depth of flooding and frequency with which an area is flooded; in the upland slopes the degree of hazard depends mostly on the terrain. The six flood-hazard zones on the map are based on the source of flooding, frequency of inundation, and degree of hazard related to the different terrains. Complex drainage patterns and type of land use are shown on the large photograph, which is at the same scale as the topographic map.

The information given regarding flooding along the Santa Cruz River is a refinement of similar information given on the 1970 flood-prone map of the Marana quadrangle. For this presentation, the extent of flooding was defined by a detailed study in which sections were surveyed across the flood plain, and water-surface profiles along the river were computed. In the previous study the extent of flooding was estimated from regional stage-frequency relations and an interpretation of maps and photographs.

FLOODING FROM THE SANTA CRUZ RIVER

The flood plain of the Santa Cruz River is subject to damage from inundation and erosion. The river overflows its banks on an average of about once every 10 years; bank erosion occurs during each flood as the channel of the Santa Cruz River continually changes its size and shape in adjustment to the amount of water it carries. Major floods have not occurred in the Santa Cruz River for many years, and the channel is adjusted to relatively low flows. Near Rillito, the channel capacity is about 17,000 cfs (cubic feet per second), which is significantly less water than can be expected from the 3,600-square-mile drainage of the Santa Cruz River. For example, the peak discharge of the 100-year flood—the discharge that will be exceeded on an average of once every 100 years—is 40,000 cfs for this reach of river. Flows measured at other points on the river, and in adjacent basins, indicate that such a discharge is not unreasonable. Examples are peak discharges of 98,000 cfs from 1,219 square miles in the San Pedro River basin to the east, 38,000 cfs from 1,077 square miles in Brawley Wash to the west, and 28,000 cfs from 1,178 square miles in the upper part of the Santa Cruz River basin.

ZONES 1 AND 2

Zones 1 and 2 are areas that may be inundated by overflow from the Santa Cruz River. Zone 1 will be inundated by the 100-year flood if the existing (1973) channel remains stable; zone 2 shows the additional area that may be inundated by greater floods. In much of zone 2 the potential hazard from erosion, especially the development of new channels, is greater than the potential hazard from inundation.

Three existing centers of urban development—Rillito, the Marana schools area, and the Marana residential area—are in hazardous locations. The community of Rillito is directly in the path of overflow from the Santa Cruz River. During major floods, water flowing through Rillito may reach the Marana schools area. (See photograph A and notes on special hazards.) Specific sites that will be inundated and depths of floodwater northwest of Tangerine Road cannot be predicted because water may follow several different routes, as indicated by arrows northwest of Rillito. Any effort to confine the 100-year flood to the existing channel past Rillito would require enlargement of the bridge at Avra Valley Road.

Bank erosion constitutes the principal hazard to the Marana residential section, which is above a steep bank along the north side of the Santa Cruz River. (See cross-section2.) Photograph B shows the progress of bank erosion since 1966. In time, a new channel may develop through the residential area. Barring drastic channel changes, the residential area probably will not be flooded except by extremely rare floods; however, it may be surrounded by water flowing between the residential area and the Marana schools area. The extent of flooding between the two areas will depend on the amount and location of overflow at upstream points.

PROBABLE CHANGES IN CHANNEL AND FLOOD PLAIN

The flood limits of the 100-year flood are shown for the existing (1973) channel of the Santa Cruz River. Channel changes as a result of bank erosion, channel cutting, sediment deposition, and vegetal growth may cause additional areas to be flooded. Observations of other reaches of the Santa Cruz River and of similar streams indicate that changes will occur and that the degree of change will depend on the time between large floods. Exact areas that may be covered by the 100-year flood cannot be determined because it is impossible to predict the channel conditions that will exist at the time the flood occurs. The changes that can be expected are as follows:

1. *Bank erosion.* Floodwater continually erodes many acres of land from the Santa Cruz River flood plain. In subsequent years, the stream channel can be expected to shift back and forth across most of zone 1 and parts of zone 2. During periods of dominantly low flows, the stream will develop a small meandering channel; during periods of dominantly high flows, the channel will be widened.

2. *Channel cutting.* In places the erosion may be severe enough to develop new channels through zone 2, as overflow from the Santa Cruz River moves north and west away from the river. One likely place for the development of a new channel is along Interstate Highway 10, but channels may develop in any part of the zone.

3. *Sediment deposition.* In recent years large amounts of sediment have been deposited in the streambed upstream and downstream from the mapped area. A few miles upstream from Rillito about 5 feet of sediment has been deposited since 1964; this deposition has been accompanied by a rapid growth of brush. Large amounts of brush and other vegetation now grow on what was formerly a clean sand bed. The vegetation receives its water from the perennial flow of sewage effluent from the sewage-treatment plant near Tucson, and the vegetation has become well rooted in the channel; the channel in the mapped area can be expected to become overgrown with vegetation. Large amounts of deposition accompanied by a dense growth of vegetation may cause the channel to overflow more frequently, thus increasing the flood hazard.

Large changes in the size or location of the Santa Cruz River channel may cause filling or scouring to extend several miles upstream along tributary channels. Deeply incised tributary channels may develop in areas that now have little relief, or channels that are deeply incised may be filled sufficiently to cause frequent overbank flooding and possible sheetflow. The construction of artificial drainage channels in zones 2 or 3 also may cause changes in the adjacent zones.

ZONE 3

Zone 3 is a former flood plain but is no longer subject to overflow from the Santa Cruz River. Flooding in zone 3 mainly is the result of runoff from the foothills to the south. Floodwater leaving the foothills collects in the southern half of the zone and flows toward Brawley Wash. Although the Brawley Wash channel is 3 miles west of the area shown on the map, the overflow during floods extends into the southwest corner of zone 3 in the mapped area. Numerous earthen dikes and drainage ditches have been constructed in zone 3 and along the adjacent edges of zone 4 to protect and drain the farmland, but severe floods may cause dike failures, channel overtopping, and flooding to depths of as much as 2 feet over the entire area; flooding to depths of 4 feet may occur in some depressions. Direct precipitation on zone 3 may produce sheetflow that is a few inches deep in the northern half of the zone, and some erosional hazard may exist along short incised tributary channels that extend from zone 3 into zone 2.

UPLAND HAZARDS

Flash floods occur in the upland areas as a result of intense rainfall of 1 to 5 inches per hour over small areas. These floods transport large amounts of sand, gravel, and boulders. The degree of flood hazard in the uplands is determined mainly by the terrain. Zones 4–6 on the map are related to the three dominant types of terrain—slightly dissected alluvial slopes that have undefined channels and sheet runoff, moderately dissected alluvial slopes that have defined channels, and steep mountains. Topographically, there are gradual transitions from the slightly dissected slopes to the moderately dissected slopes.

ZONE 4

The slightly dissected alluvial slopes in zone 4 have an extreme, but often overlooked, flood potential. Most well-defined channels that leave zones 5 and 6 branch and rebranch into many unstable distributary channels in zone 4 and eventually become discontinuous. Flow from several streams may combine. No reliable estimate can be made of flood discharges at specific sites. The channels generally are less than 3 feet deep at bank-full stage, are embedded in fairly coarse sand and gravel, erode easily, and frequently change direction and location. Generally, the ground relief between channels is less than 5 feet. Much of the floodflow is unconfined and moves downslope as sheetflow that has a maximum depth of less than 2 feet. Streams debouching into zone 4 deposit large amounts of sand, gravel, and boulders, and floodwater spreads out in many directions. Large amounts of water infiltrate into the sand, and peak flows are reduced greatly as the flood moves downstream.

ZONES 5 AND 6

In contrast to the undefined drainage basins in zone 4, drainage basins of most streams in zones 5 and 6 can be defined on topographic maps or aerial photographs, and the magnitude of a flood at a specific site can be predicted. Flash floods rise several feet in a few minutes and are highly destructive. The peak discharges of the 10-, 50-, and 100-year floods for selected sizes of drainage area are given in table 1.

TABLE 1. – Peak discharges for the 10-, 50-, and 100-year floods

[Computed using methods described by Patterson, J. L., and Somers, W. P., 1966, Magnitude and frequency of floods in the United States, Pt. 9, Colorado River basin: U.S. Geol. Survey Water-Supply Paper 1683, 475 p]

Drainage area (sq mi)	Peak discharge (cfs)		
	10–yr flood	50–yr flood	100–yr flood
0.1	200	400	500
.5	400	800	1,000
1.0	500	1,000	1,200
5.0	1,000	2,000	2,500
10.0	1,300	2,700	3,400

Zone 5 includes moderately to highly dissected alluvial slopes. In much of the zone, stream channels are only a few hundred feet apart and are separated by well-defined alluvial ridges that rise more than 10 feet above the channels. Flooding mainly is confined to the channels and narrow flood plains that occupy the lowlands between the ridges. Marked scouring occurs along these channels and flood plains, and floods carry large amounts of rock debris. In most channels the depth of flooding will depend on the amount of erosion and deposition that takes place during the flood. The depth usually will not exceed 10 feet, except where water is ponded behind debris jams or manmade obstructions. The flood hazard is particularly great in the areas shown by the stippled pattern along the flood plains of Cottonwood Wash and the unnamed stream half a mile to the west. The flood hazard extends for a considerable distance into the alluvial fan downstream from the defined flood plain. Floods may erode large areas of the flood plains along these streams and deposit rock and debris in a thick layer in zone 4.

In the area east of Cottonwood Wash the terrain has characteristics that could place it in either zone 4 or zone 5. Sheetflow from the upper slopes re-collects into defined channels between definable ridges, but the area drained by any one channel cannot be defined. The defined channels extend only a short distance before spreading out again. The stream pattern is shown on the large photograph.

Zone 6 is composed of steeply sloping hills and mountains. The dominant flood hazard is along the definable channels, where flood velocities may be as much as 15 feet per second. Sheetflow may occur along some steep slopes, and landslides and rolling boulders may occur during or following periods of heavy rain. Streams in the parts of zone 6 shown on the map generally drain an area of less than half a square mile, and maximum flow depths seldom exceed 7 feet except when the channel is blocked by boulders and rock debris. When channel blockage occurs, flood depths are unpredictable.

HAZARDS AND EFFECTS OF URBANIZATION

At the present time (1973), zones 2 and 3 and the fringes of zone 1 are used mainly for agriculture, and zones 4, 5, and 6 are virtually in a virgin state; however, all zones are subject to extensive urban development. Urban developments will be subject to the existing hazards described above, and extensive development may create additional hazards.

Traditionally, urban developments have encroached on the frequently inundated parts of flood plains; similar encroachment may be anticipated along the Santa Cruz River unless growth is controlled by local zoning ordinances. Areas of shallow flooding along the fringes of zone 1 possibly can be blocked without causing the flood level to rise appreciably in the rest of the zone; however, conventional flood-proofing measures—such as raising floor levels above the 100-year flood and constructing levees—may be ineffective here because of the tendency of the Santa Cruz River to scour new channels and move within its flood plain.

Extensive urban development will alter the surface-water drainage systems. In general, urbanization will increase the runoff from small amounts of precipitation, thus causing small floods to occur more frequently. In zones 2 and 4 the effect of urbanization may be intensified by the fact that water entering the zone from upstream can no longer be dissipated through infiltration and evaporation. The problem will be especially acute in zone 4 because the distributary channels probably will be eliminated during the process of development, and floodflows will be carried directly downslope by streets or will be forced into drainage channels that quickly concentrate runoff. Below an urban area in zone 4, peak discharges for floods of low recurrence interval may be 5 to 10 times greater than the natural flow at the same point. Extensive developments in zone 4, north of Interstate Highway 10, or in zone 2 near Rillito may create an extreme hazard in the Marana schools area if water is allowed to flow freely into that area.

The effects of urbanization in zones 5 and 6 will depend on the type of development. As in the other zones, small peaks will occur more frequently, but the frequency of major floods—floods that occur less than once every 50 years—probably will not be changed appreciably except in areas of dense development and extensive amounts of paving. Very little urban development is expected in zone 6 because of the steep rocky slopes. Scattered homes—the type of development that generally takes place in steep rocky areas—probably will have little effect on the magnitude of floods.

DELINEATION OF FLOOD HAZARDS IN THE MARANA QUADRANGLE, PIMA COUNTY, ARIZONA

By
B. N. Aldridge and D. E. Burkham

1974

For sale by U. S. Geological Survey
Denver, Colo. 80225 and Reston, Va. 22092, price 75 cents