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OCCURRENCE AND DISTRIBUTION OF FLASH FLOODS IN THE WESTERN REGION

Thomas L. Dietrich
Western Region Headquarters
Hydrology Division
Salt Lake City, Utah
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UNITED STATES DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

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Richard A. Frank, Administrator

National Weather Service
Richard E. Hallgren, Director

This Technical Memorandum has been reviewed and is approved for publication by Scientific Services Division, Western Region.

L. W. Snellman, Chief
Scientific Services Division
Western Region Headquarters
Salt Lake City, Utah

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OCCURRENCE AND DISTRIBUTION OF FLASH FLOODS IN THE WESTERN REGION

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I. INTRODUCTION

Given the right meteorological conditions, a flash flood can occur almost anywhere in the Western Region. However, some areas are much more susceptible to flash floods than others. Of the eight states making up the Western Region, the two states reporting the greatest number of flash floods are Utah and Arizona. Nevada undoubtedly also has a high number of flash floods; however, they probably go unobserved because of the low population density.

The purpose of this report is two-fold. First, it is to describe flash floods that have occurred in the Western Region as reported in the USGS Annual Flood Summaries from 1950-1969. At the same time, it is intended to provide the meteorologist and meteorological technician with a relatively geographical and seasonal distribution of flash flood events in the Western Region.

Data is taken only from the U. S. Geological Survey Annual Flood Summaries since it is not the intent to account for and describe every flash flood that occurred between 1950 and 1969. I am assuming that the sample is representative of the overall occurrence and distribution of flash floods in the Western Region.

II. CLIMATOLOGY OF THE WESTERN REGION BY GEOGRAPHICAL REGIONS

The conterminous United States can be divided into seven physical regions, five of which are represented in the Western Region (Figure 1).

The principal climatic features of the geographical divisions of the Western Region are described below.

a. Pacific Coast

The Pacific Coast Region consists of the coastal plains, the coastal ranges, and the adjacent inland valleys of Washington, Oregon and California (Figure 2).

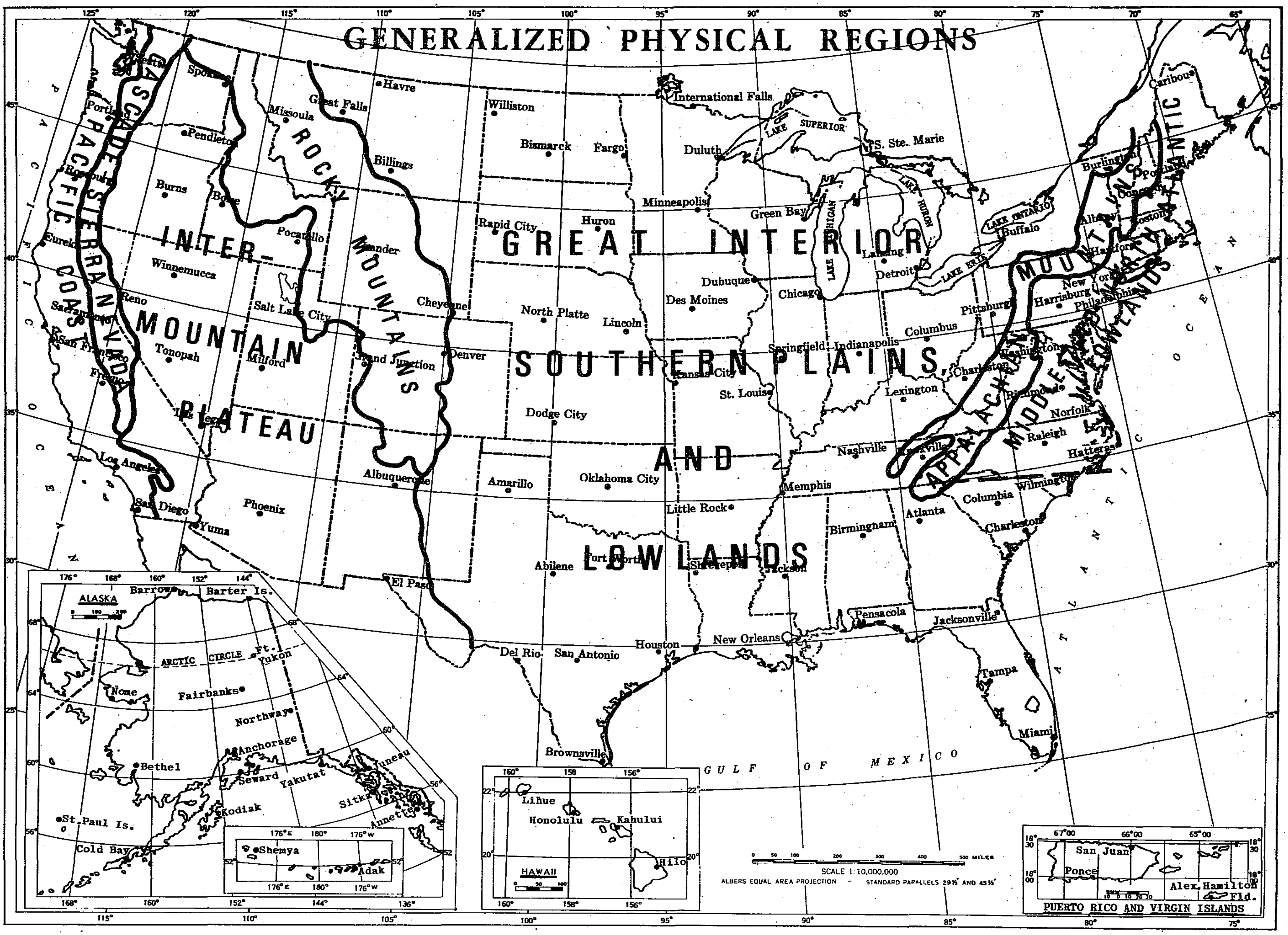

Figure 1. Geographic Regions of the United States (Baldwin, 1973)

- 2 -

Figure 2. Coastal Valley, south of Eureka, California

With a Mediterranean type climate of dry summers and mild wet winters the region has the lowest mean annual number of days with thunderstorms in the United States (Figure 3). During the summer, the strong Pacific high steers storms to the north of the region. When the high weakens in winter, storms of greater areal coverage and intensity hit the coast more frequently.

b. Cascade-Sierra Nevada Mountains

This continuous chain of mountains (Figure 4) varies in width from 20 to 70 miles and is generally 8,000 to 10,000 feet high. It acts as a barrier to the free movement of air masses from both east and west. The region is dominated by the usually mild Pacific air brought in by the prevailing westerlies. Winter storms generally cover large areas, whereas the summers are generally fair, sunny and pleasant.

c. Intermountain Plateau

The Cascade-Sierra Nevada Ranges either modify the mild moist air masses reaching the region from the Pacific or prevents them from entering the region. To the east, the Rocky Mountains shield the region somewhat from incursions of warm moist air from the Gulf of Mexico and from the cold air that sweeps south from Canada onto the Great Plains.

Summer rainfall in southeastern California, Arizona, southern Nevada and southern Utah begins early in July and usually extends through mid-September. Moisture-bearing winds sweep into the area from the southeast, with their source region the Gulf of Mexico. Heavy thundershowers at times cause flash floods that do considerable local damage. This area also reported the greatest number of flash floods.

The heaviest runoff usually occurs in connection with the arrival of tropical air over southern California, Arizona (Figure 5), southern Nevada and southern Utah, which had its origin in hurricanes that dissipated in or off the west coast of Mexico. Heavy rains associated with these systems usually occur during August or September.

Figure 6 shows Heppner, Oregon sitting in the flood plain of Willow and Hinton Creeks where 200 people died in a flash flood in the early 1900's.

d. Rocky Mountain Region

The high ranges of the Rocky Mountains extend southward from Canada into northern, central, and eastern Idaho, western Montana

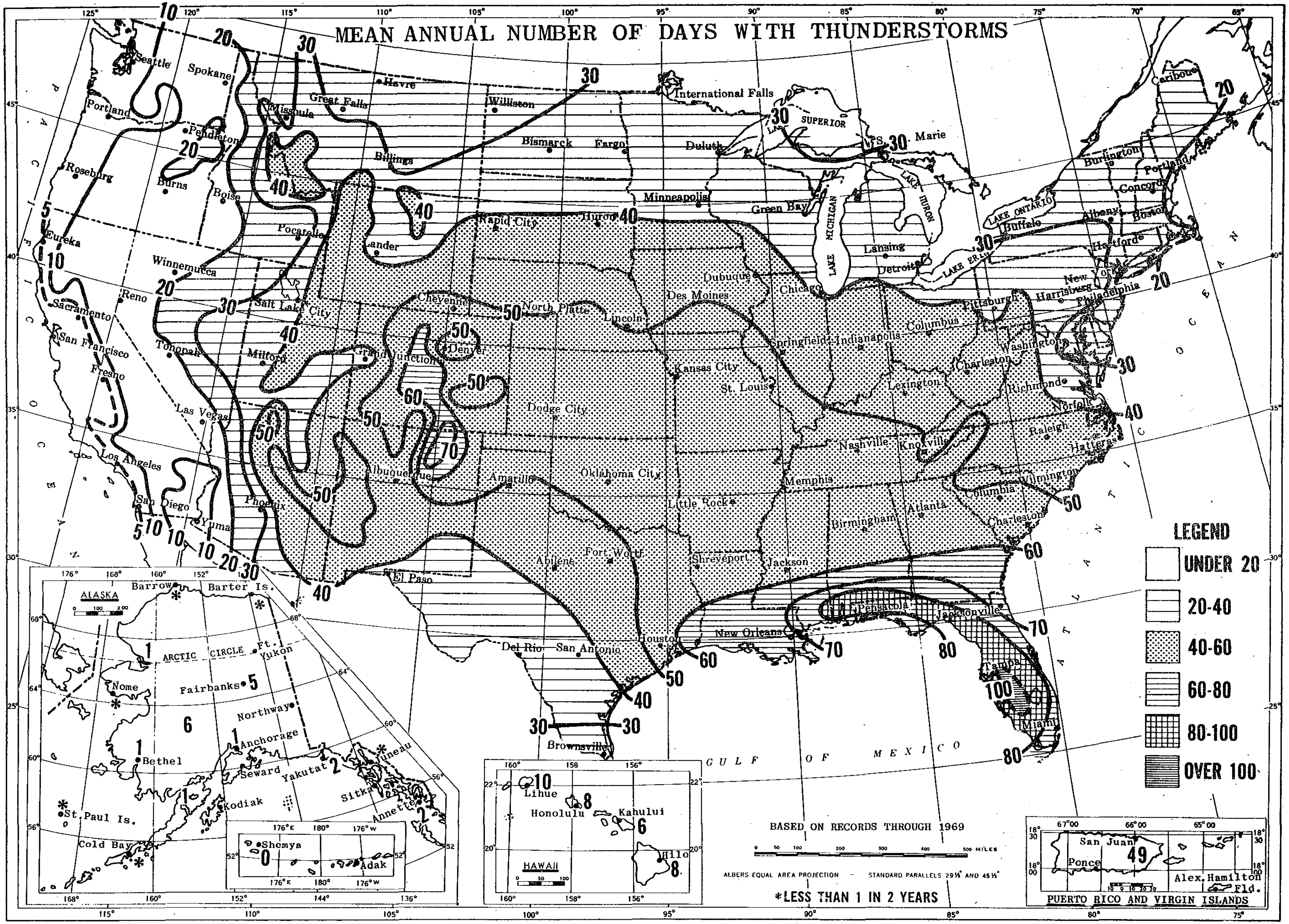

Figure 3. Mean Annual Number of Thunderstorm Days (Baldwin, 1973)

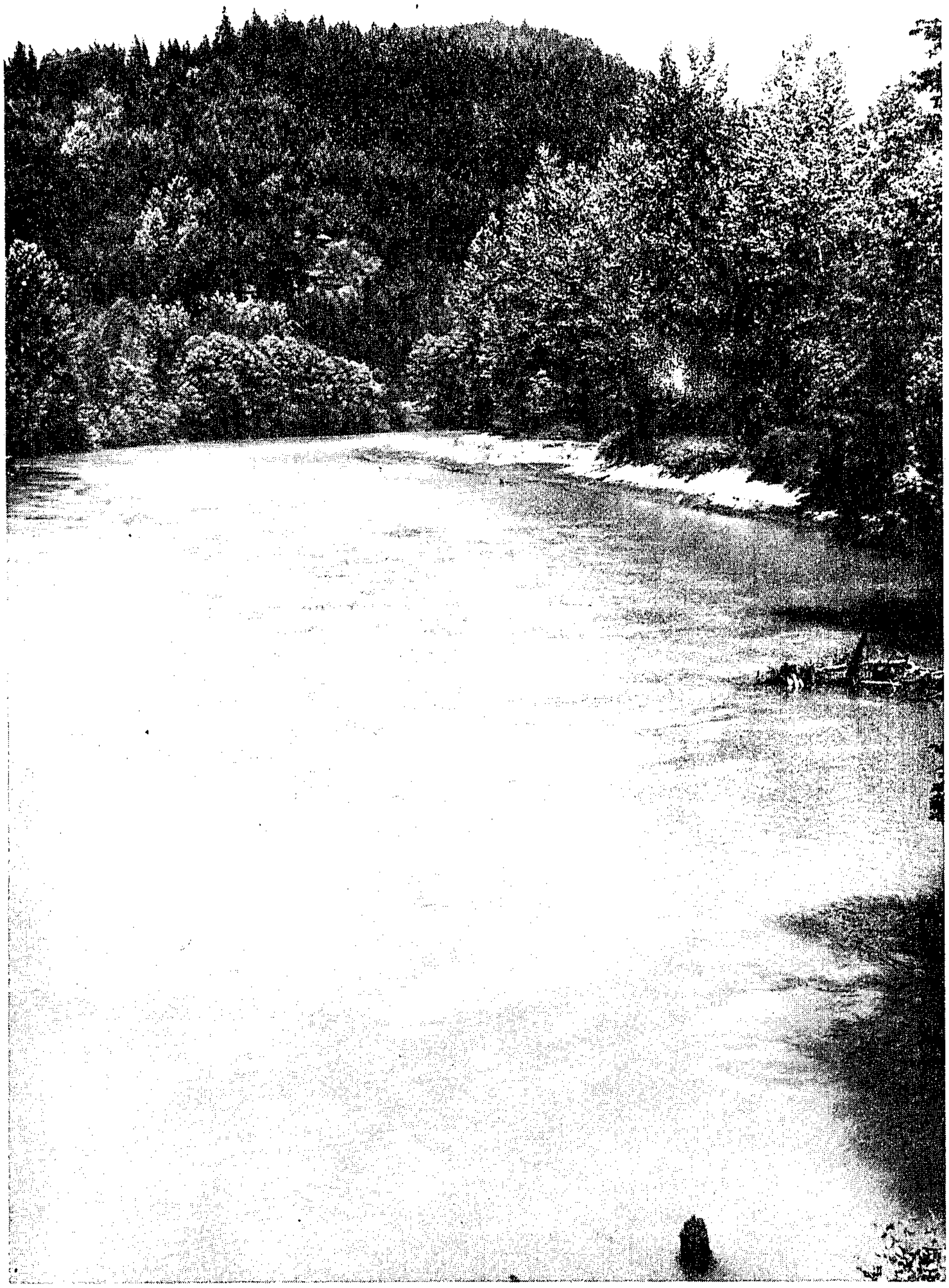

Figure 4. Cascade Range, Western Washington

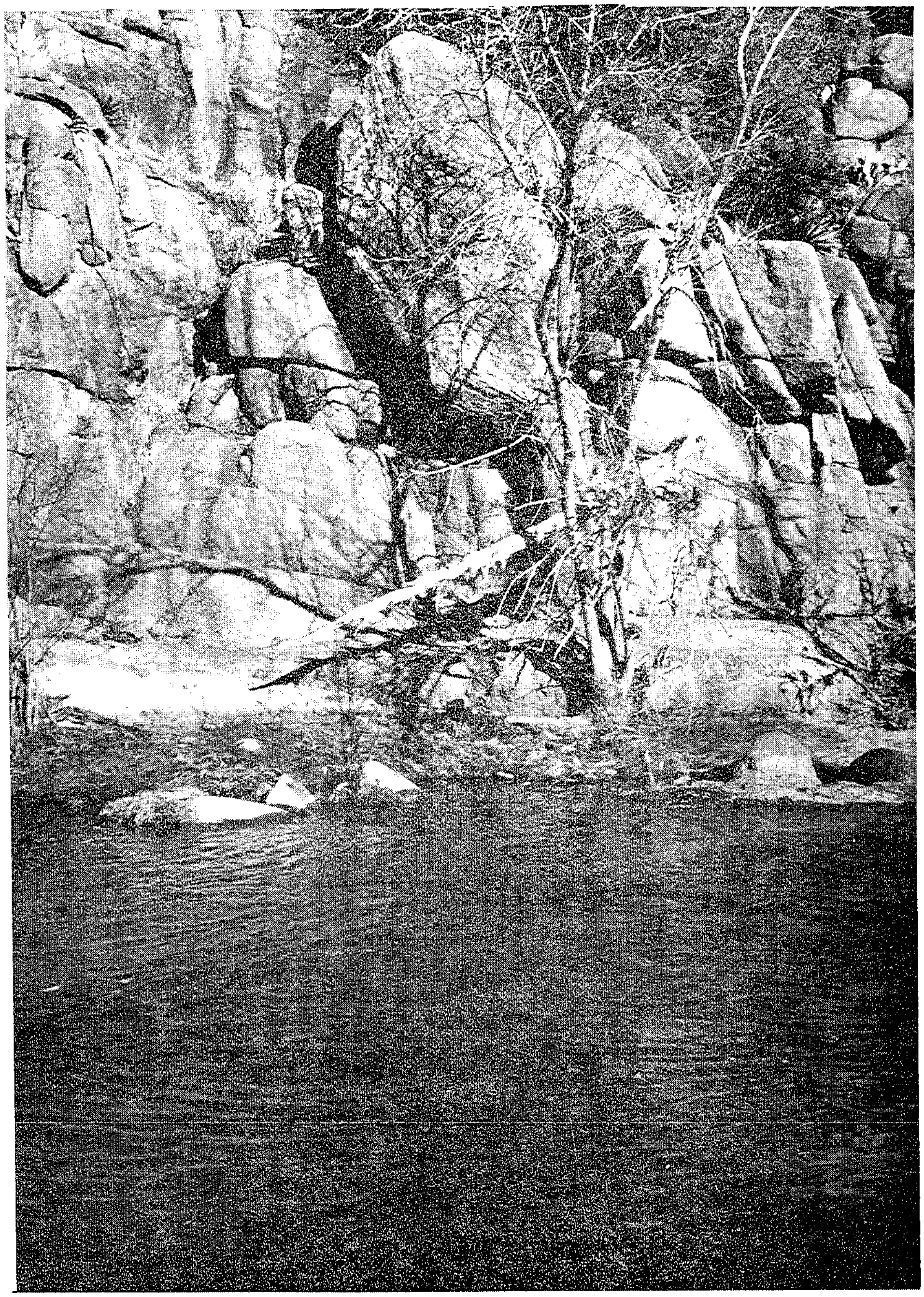

Figure 5. Flood Debris lodged in Tree from Floodwaters in the East Verde River, Arizona

(Figure 7), western and central Wyoming, northeastern Utah, western and central Colorado and north central New Mexico.

Variations in precipitation occur over the rather wide range in latitude. Predominantly, the climate is associated with Pacific Ocean air masses which move inland from the west, carrying much of the region's precipitation. In the southern portion of the region the maximum monthly precipitation often occurs during July, August and September as a result of the summer thunderstorms that sweep in from the Gulf of Mexico.

e. Great Plains (eastern Montana)

Circulation around low-pressure areas moving toward the east or northeast across the central U. S. or across southern Canada is one of the causes of the northward flow of warm gulf air into eastern Montana. The wind around the western side of the Bermuda high-pressure area intensifies in summer, contributing to the northward flow of moisture.

III. METEOROLOGY OF FLASH FLOODS (Maddox and Chappel, 1978)

Maddox and Chappel (1978) identified a number of meteorological parameters common to flash flood events in the western United States. Detailed analyses of three-hourly surface charts, standard level charts for 850, 700, 500 and 300 mb, hourly radar-summary charts and upper-air sounding data revealed that a number of large scale patterns, mesoscale features, and meteorological parameters were common to many events.

For flash floods in the western U. S. the following features were found to be fairly common:

1) Storm area is very near large-scale ridge position.

2) A weak mid-level short-wave trough moving through or around ridge helps to trigger and focus storms.

3) Storms usually occur during the afternoon hours.

4) Rain amounts tend to be lighter than elsewhere in the U. S.

5) Severe thunderstorm phenomena are often associated with the heavy rainstorms.

Generally western type events are confined to a region west of the continental divide and east of the Pacific Coast Ranges. The thunderstorms responsible for the flooding quite often produce hail and high winds as well as heavy rain. Small-scale terrain features, local heating anomalies, and thunderstorm-scale motions interact in these western events to maximize rainfall in particular locations.

Figure 6. Heppner, Oregon

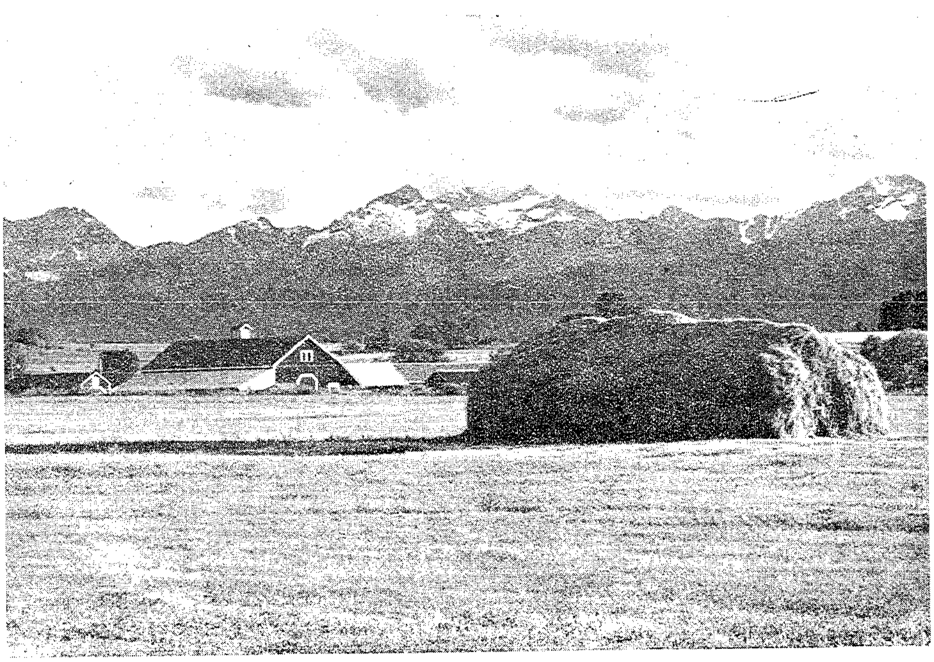

Figure 7. Bitterroot Valley, near Hamilton, Montana

The general threat area can be best delineated by the high moisture contents (surface through at least 500 mb), weak vertical wind-shear, and large conditional instability that lies ahead of the advancing middle-level short wave.

Events outside the intermountain region can either be frontal, east slope (of the Rocky Mountains), synoptic or mesohigh. Generally speaking, these types of events occur east of the continental divide or on the windward side of the Pacific Coast Ranges. Most flash floods in the western U. S. are classified under the general category of western type events.

Throughout the West, precipitation is extremely variable with respect to time and place, with meteorological conditions, in general, dictating when and where flood-producing precipitation will occur. The combination of the magnitude and intensity of precipitation and the effect of the basin's physiographic features on runoff determine the magnitude of the flash flood.

IV. GEOGRAPHICAL PROPERTIES INFLUENCING FLASH FLOODS

a. Topography, Soils and Surface Cover

In the Western Region topography plays a very important role in the generation of flash floods. The steep slopes and cliffs (Figure 8) provide a strong orographic lifting mechanism intensifying the precipitation. The intense, short duration precipitation in turn produces rapid runoff and very high peaks for small amounts of rainfall.

Along with topography the nature of the soils and surface-cover affects the timing and amount of runoff. Rock outcrops, shallow soils and sparse vegetation all interact to generate rapid runoff and high peaks for the relatively small amounts of rainfall.

b. Urbanization

Many of the cities and towns in the Western Region are expanding at a phenomenal rate. At the same time flood damages are skyrocketing because these same communities are expanding and building in the flood plains.

Urbanization (Figure 9), with more roads, parking lots and buildings, produces increased runoff amounts and quicker response times (Figure 10) over what would occur in the natural landscape.

V. DATA ANALYSIS

Plotting each of the flash flood events (Figure 11) on a map of the western United States, the flash floods were categorized by geographical divisions (Table 1 and Figure 12).

Figure 8. Little Cottonwood Canyon, near Salt Lake City, Utah

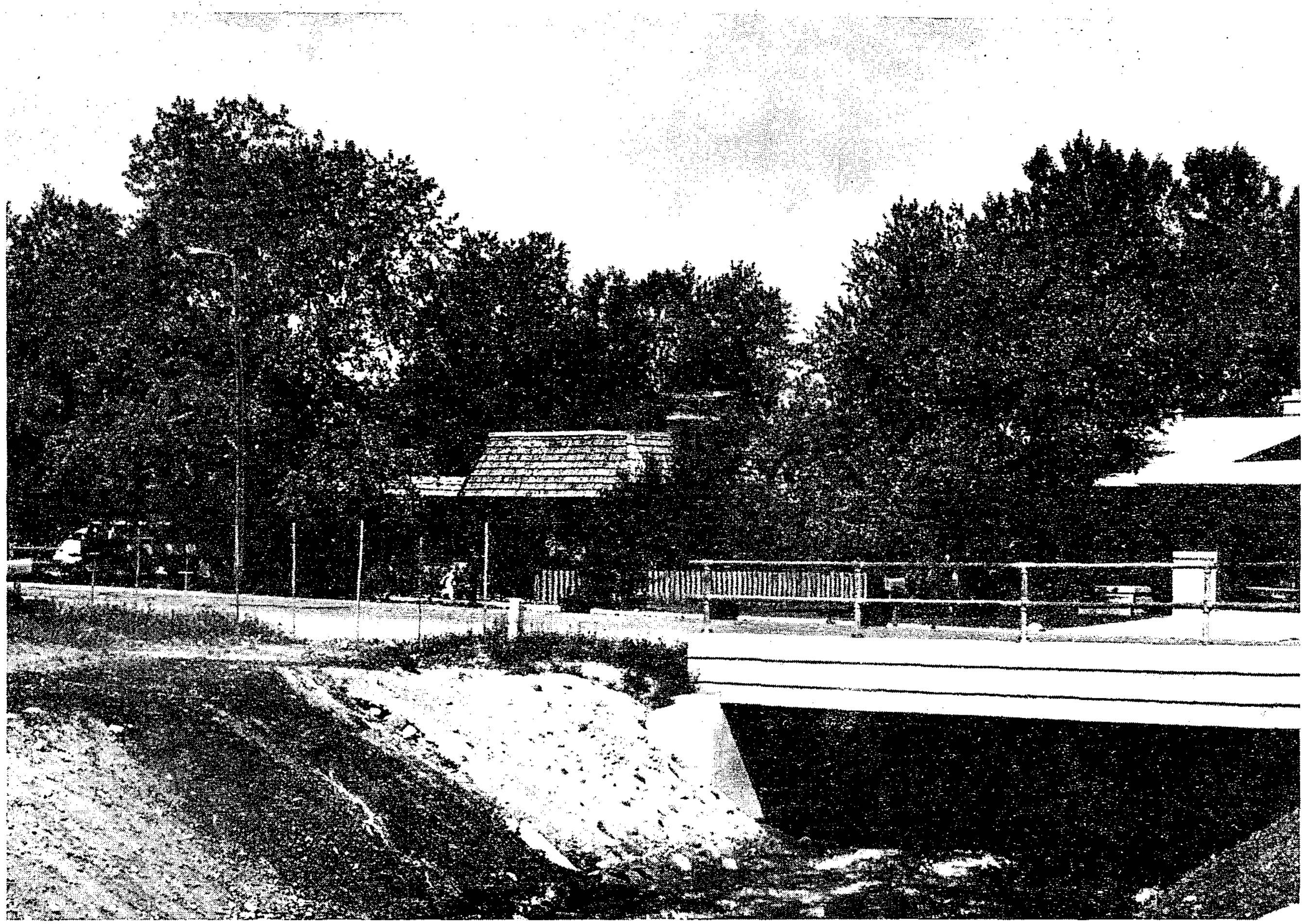

Figure 9. Big Cottonwood Creek, Salt Lake City, Utah

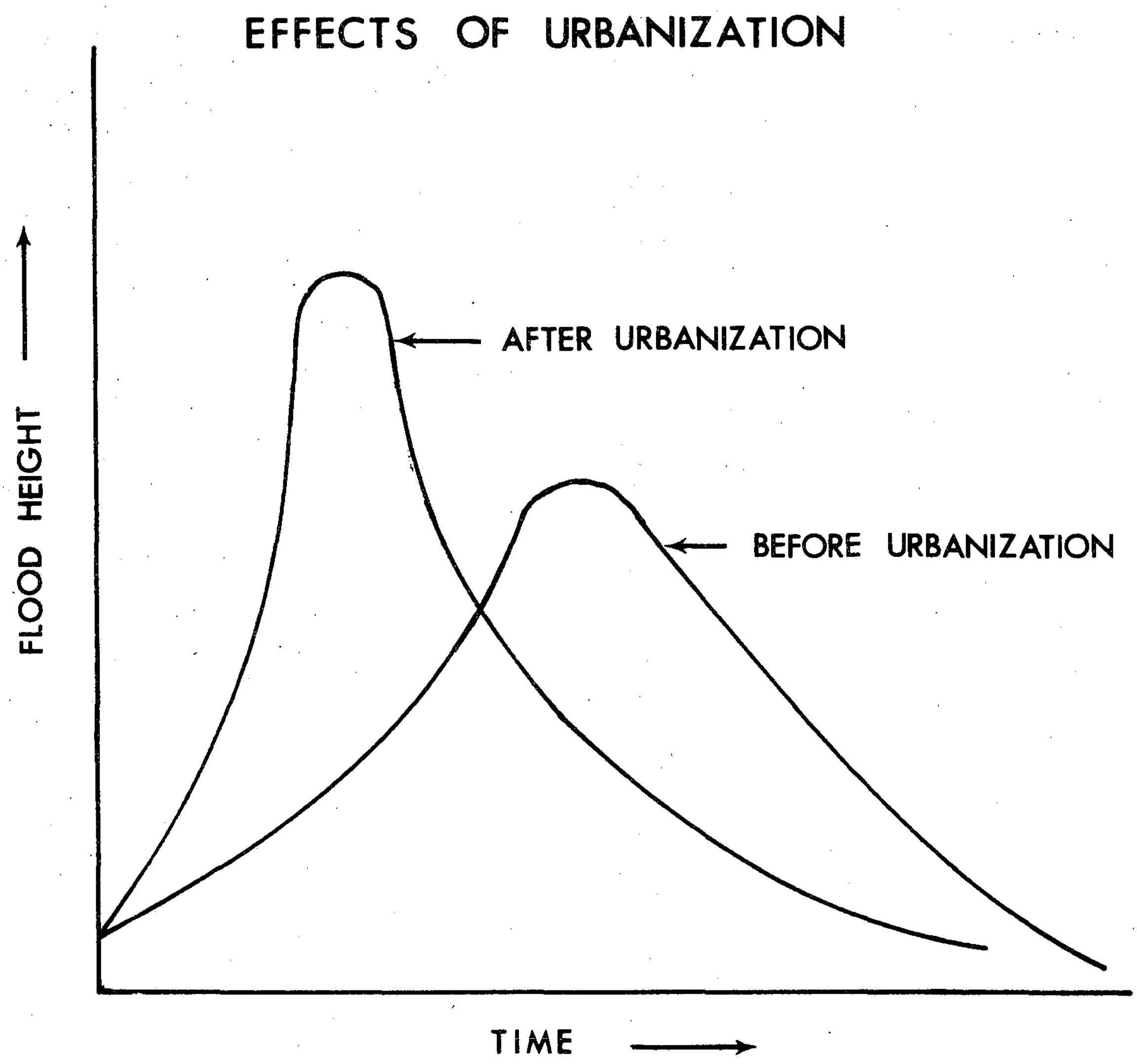

Figure 10. Effects of Urbanization on Flood Heights

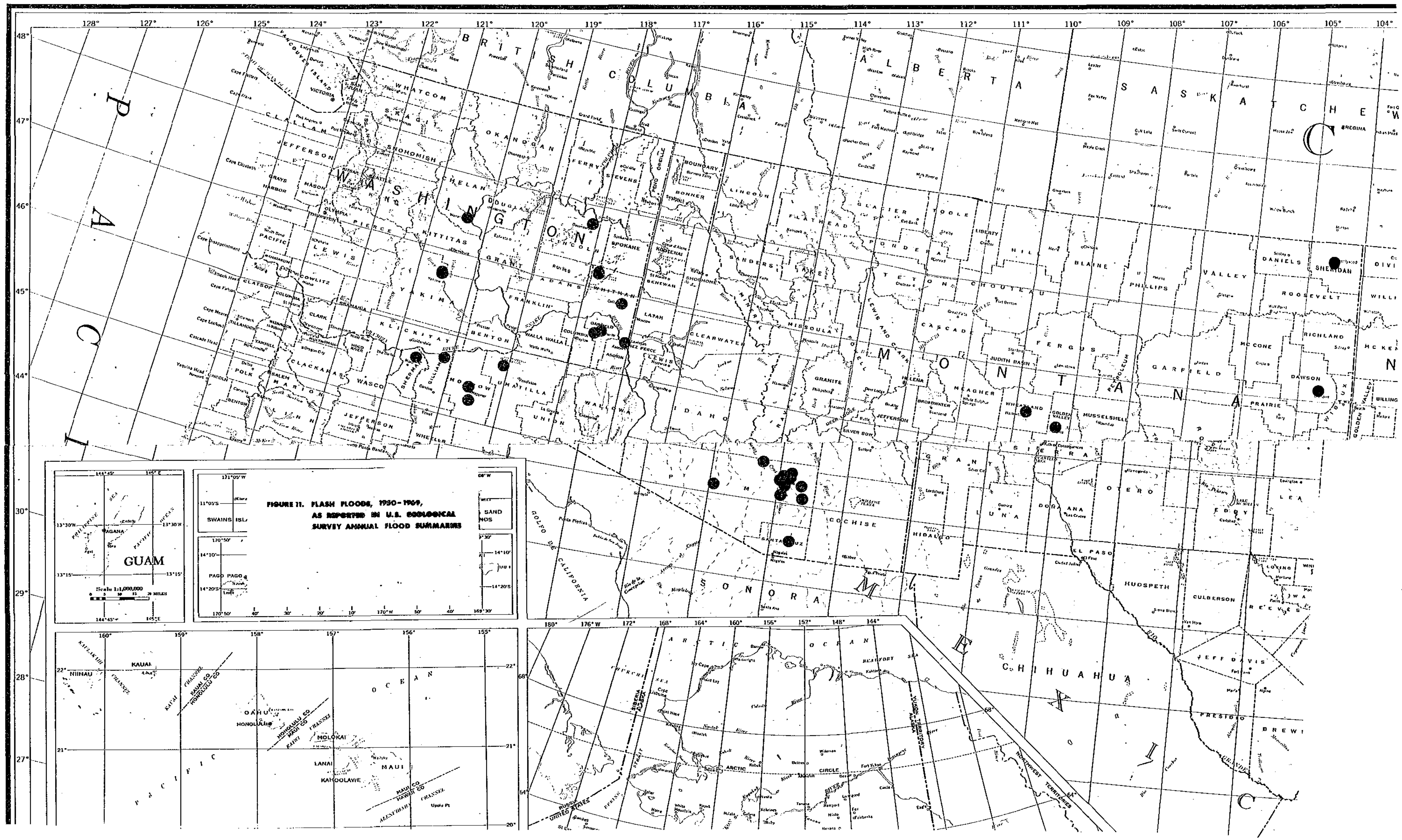

FIGURE 11. FLASH FLOODS, 1950-1969, AS REPORTED IN U.S. GEOLOGICAL SURVEY ANNUAL FLOOD SUMMARIES

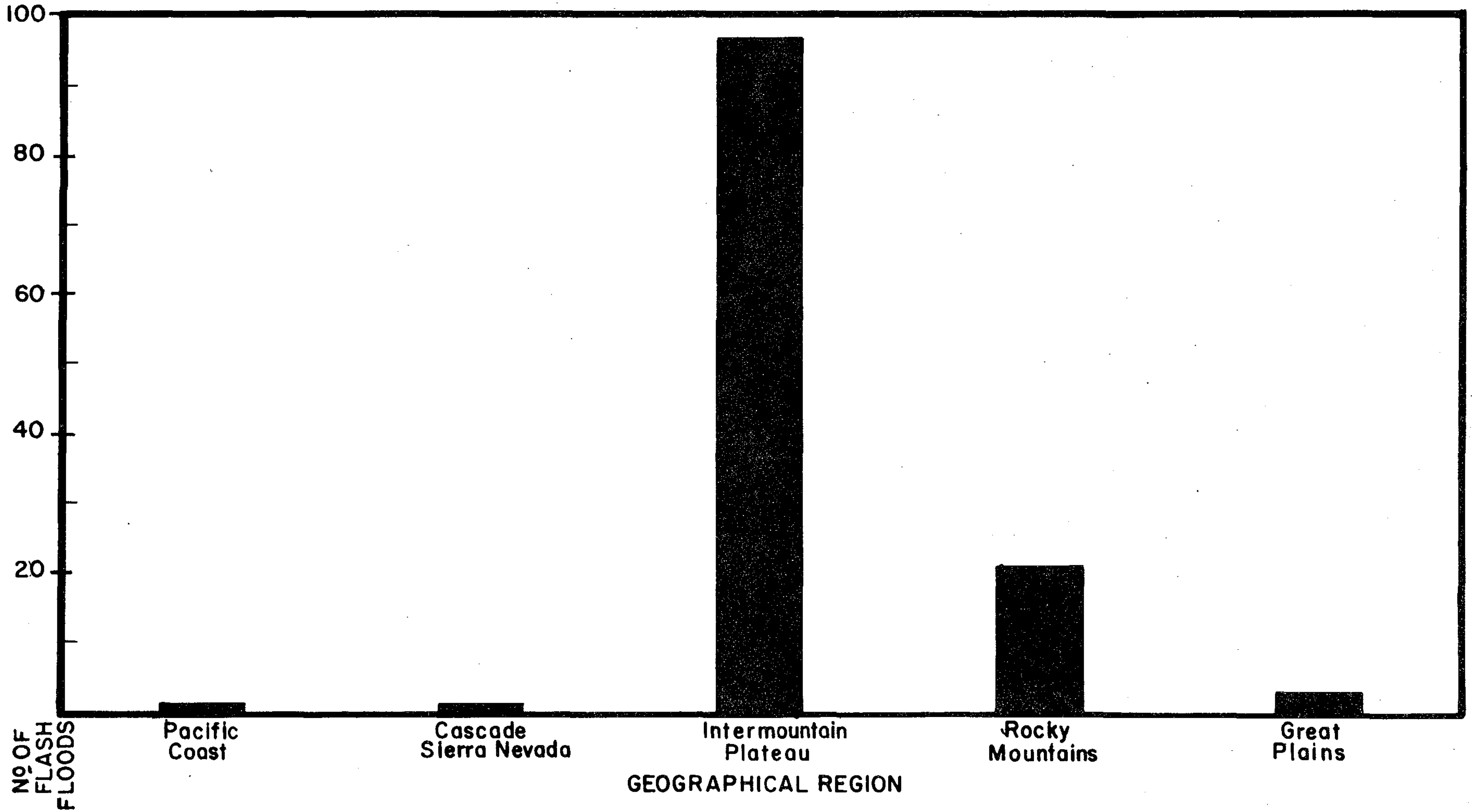

Figure 12. Flash Floods by Geographical Region

The Intermountain Plateau has by far the most flash floods, with Arizona and Utah reporting the greatest number. Together, Arizona and Utah reported 72% of the flash floods that were observed in the Intermountain Plateau and 57% that were observed in the Western Region.

The Pacific Coast and Cascade-Sierra Nevada Regions reported the fewest number, one in each division.

Summarizing by month, the greatest number of flash floods was reported during the month of August (58) with approximately equal numbers in July and September (Figure 13). The monthly breakdown by state is shown in Table 2.

Table 1. Flash Floods by Geographical Region

Geographical Region	Number Reported	
Pacific Coast		
California	1	
Oregon	0	
Washington	0	
Total		1
Cascade-Sierra Nevada		
California	0	
Nevada	1	
Oregon	0	
Washington	0	
Total		1
Intermountain Plateau		
Arizona	31	
California	4	
Idaho	1	
Nevada	5	
Oregon	8	
Utah	39	
Washington	9	
Total		97

Geographical Region (Cont'd.)	Number Reported	
Rocky Mountains		
Idaho	8	
Montana	3	
Utah	10	
Total		21
Great Plains		
Montana	3	
Total		3
Grand Total		123

Table 2. Flash Floods by Month and State

Month	MT	ID	OR	WA	CA	NV	UT	AZ
May								
June	2	1	3	1		1	2	
July	1	2	3		2	2	10	7
Aug.	2	6	2	6	1	1	25	15
Sept.	1			2	2	2	12	9
Oct.								
Total	6	9	8	9	5	6	49	31

VI. GEOGRAPHICAL AREAS OF SIGNIFICANT CONCENTRATIONS OF FLASH FLOOD EVENTS

a. Wasatch Front, Utah

Due to the combination topography and climate, the pioneer settlers of Utah first located along the western edge of the Wasatch Range. As a result, 85% of Utah's citizens live in a narrow strip along the Wasatch Front, extending from Brigham City on the north to Nephi on the south.

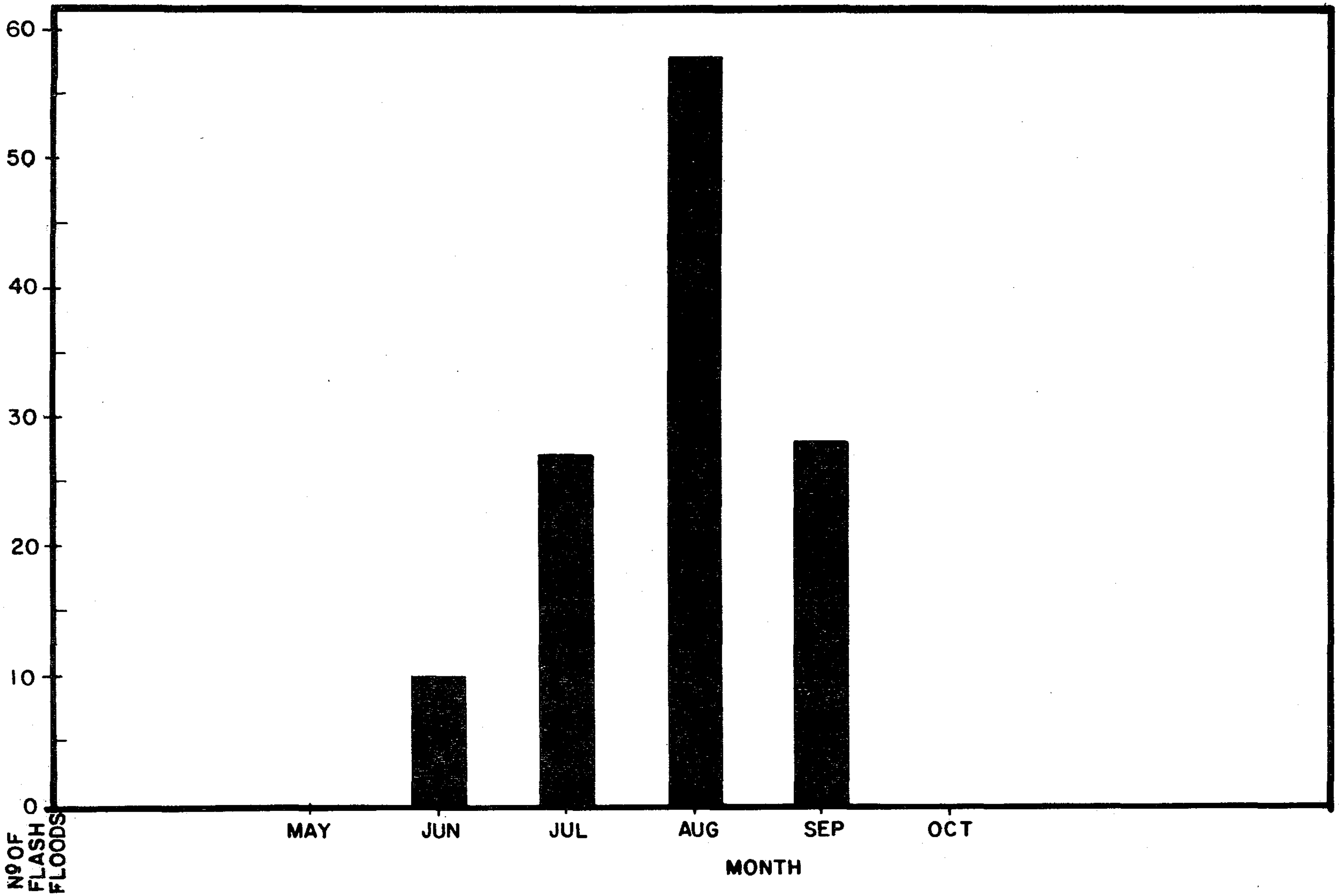

Figure 13. Monthly Distribution of Flash Flood Events as reported in the U. S. Geological Survey Annual Flood Summaries, 1950-1969

The short, steep canyons and large ravines that drain the west-facing slope of the Wasatch Range (Figure 14) are especially vulnerable to flash floods. According to Butler and Marsell (1972), 31% of the flash floods reported in Utah from 1939 to 1969 were in the six counties along the Wasatch Front.

b. Central and Southern Arizona

The Mogollon Rim extends across the eastern half of Arizona and divides the north flowing tributaries of the Little Colorado River from the south flowing tributaries of the Verde, Salt and Gila Rivers. Rising sharply above the surrounding area and generally at elevations between 6,500 and 7,500 feet, the Mogollon Rim serves as the orographic mechanism for the generation of heavy rains and resulting flash flooding in central Arizona (Figure 15). Further east the White Mountains in Arizona and the Gallo and Mangas Mountains in New Mexico form the eastern end of the divide between the Gila and Little Colorado Rivers.

Many flash floods originate along the Mogollon Rim, in the rugged mountainous area south of the Rim, and in the mountains south and east of Tucson. The Catalina, Rincon and Santa Rita Mountains generate many flash floods that cause extensive damage in and around Tucson.

One of the most devastating flash floods to ever occur in Arizona (September 1970) originated along the Mogollon Rim. Intense rains along the Rim caused flash floods in the drainage basins of Tonto and Sycamore Creeks, East Verde River, Oak and Beaver Creeks, and the Agua Fria and Hassayampa Rivers. Twenty-three persons died and property damage was estimated to be several million dollars.

c. Utah--Southern Mountains, Sevier Valley and Cedar City Area

This area is extremely flash flood-prone. Rugged mountains and narrow canyons make this one of the most dangerous flash flood areas in the Western Region. The "Narrows" in Zion National Park (Figure 16) shows well the action of flash floods in the past. In September 1961 five members of a hiking party were drowned when a flash flood caught them in the "Narrows".

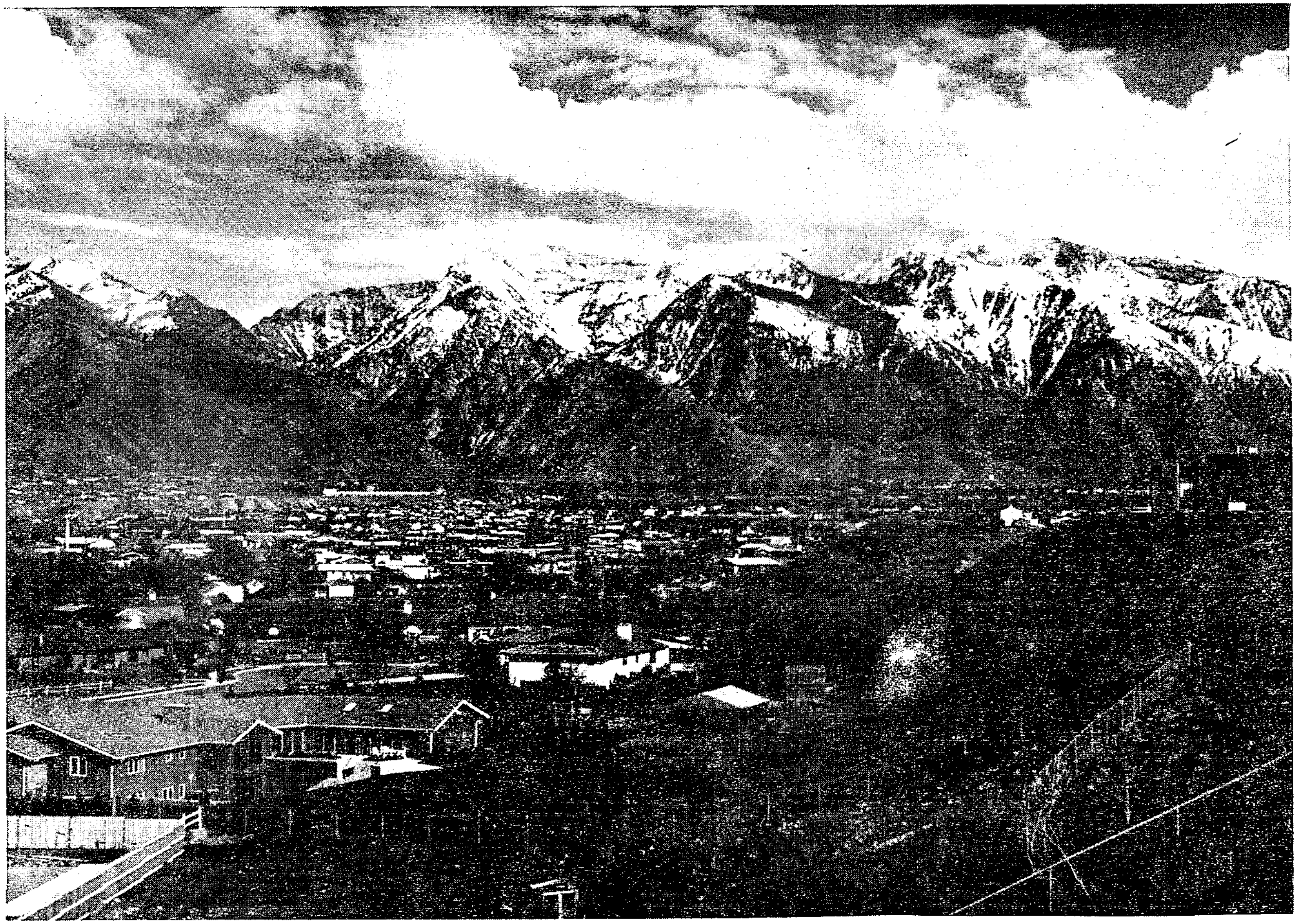

Figure 14. Wasatch Front, Salt Lake City, Utah

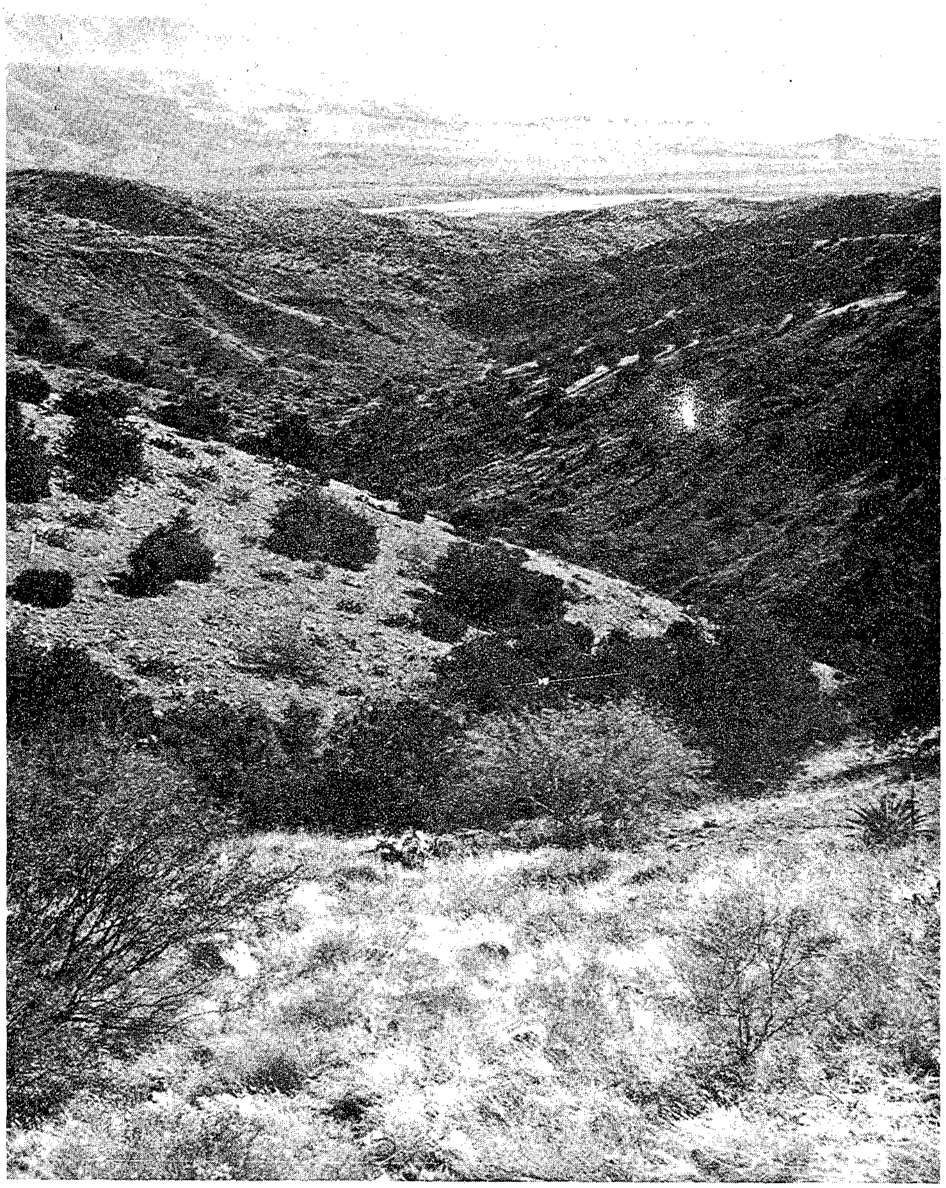

Figure 15. Central Arizona Mountains, near the Mogollon Rim

VII. BRIEF DESCRIPTION OF FLASH FLOODS IN THE WESTERN REGION, 1950 - 1969 AS REPORTED IN THE USGS ANNUAL FLOOD SUMMARIES

Date	Location	Remarks
		- 1950 -
6/17/50	Antelope Creek, Wheatland County near Harlowton, Mont.	On June 17 a cloudburst caused flooding of Antelope Creek, in Wheatland County in southcentral Montana. One life was lost. Damage in and near Harlowton consisted of 1 mile of railroad track destroyed and some highways and homes damaged.
6/17/50	Morrow County, east of Hardman, south of Heppner, Oregon	On June 17 at about 6:00 p.m., a cloudburst caused flash flooding in an area of Morrow County east of Hardman and south of Heppner, in northcentral Oregon. Considerable damage was done to hay and grain when Rhea Creek overtopped its banks and covered crops with mud and debris. Fences, bridges, and roads were also damaged, and one barn was reported as a total loss. Much of the runoff in Rhea Creek was contributed by Balm Canyon, which is practically dry most of the time.
6/11-18/50	Linfield Gulch near Pomeroy Eastern Washington	During the period June 11-18, thunderstorms accompanied by torrential rains swept over parts of eastern Washington. These storms caused several flash floods in small areas.
7/30/50	Sonoita Creek near Patagonia, Arizona	Peak discharge 7,300 cfs. Associated precipitation 0.78 in.
		- 1951 -
7/28/51	Palm Springs area, California	Severe local thunderstorms in the Palm Springs area.
7/28/51	Coyote Creek near Borrego Springs, California	Associated precipitation 1.87 inches
		- 1952 -
8/10/52	Roza Canal, Wenas Creek basins in Yakima County, Wash.	A flash flood occurred in the Roza Canal--Wenas Creek basins in Yakima County.

Date	Location	Remarks
		Two persons died, and considerable damage was caused to farm buildings and lands.
		- 1953 -
8/ 1/53	Boxelder Creek Plentywood, Montana	Plentywood was flooded in the early morning of August 1, following a heavy rain that began shortly before midnight. Rainfall at Plentywood totaled 1.28 inches in 40 minutes but was less in the upper part of Boxelder Creek.
8/26/53	Bull Run Canyon near Klondike, Oregon	On August 26, as a result of a cloudburst-type storm, a flash flood occurred in Bull Run Canyon near Klondike. No Weather Service rain gages in the area, but a rancher in Bull Run Canyon reported that 0.82 inch of rain fell in 20 minutes.
8/28/53	Willow Creek basin between Lexington and Heppner, Oregon	On August 28, a cloudburst occurred in a small part of Willow Creek basin. The storm passed between Lexington and Heppner in a belt about 6 miles wide.
		- 1954 -
7/20/54	Miami, Superior, Globe, Arizona	A thunderstorm on July 20 produced 1.70 inches of rain at Miami, 1.20 inches at Superior, 0.61 inch at Pinal Ranch, and 0.48 inch at Globe during the evening of July 20 and caused a flash flood in Bloody Tanks Wash in Miami.
7/29/54	Pinal Creek near Globe, Arizona	Heavy rains south of Globe and 1.1 inches in Globe caused a flash flood in Pinal Creek near Globe on the evening of July 29.
8/4-5/54	Santa Rita Mountains west to Santa Cruz River between Amado and Sahuarita, Arizona	Heavy thunderstorms occurred August 4 and 5 in the Santa Rita Mountains and extended west to the Santa Cruz River where severe flooding occurred in the reach between Amado and Sahuarita.

Station	Rainfall (Inches)
Casa Grande 3 SE	0.74"
Tucson AP	.90"

Date	Location	Remarks
		Rainfall (Inches) (Cont'd.) University of Arizona .77" N Lazy H Ranch 1.40" Tucson Magnetic Observatory .76" Beach Ranch 1.34" Amado 3.06" Bear Valley 3.12" Nogales 1.26" San Rafael Ranch 1.13"
8/19/54	Upper Queen Creek basin near Superior, Arizona	Heavy rains of from 4 to 6 inches fell in a few hours over the Upper Queen Creek basin on the morning of August 19. Weather Bureau rain gages at Superior and at Superstition Mountain recorded 2.47 inches and 4.93 inches, respectively, for August 19. A flash flood of 42,900 cfs. from an area of 144 square miles occurred at 10:00 a.m., at the gaging station at Whitlow Dam site, near Superior.
8/19/54 8/24/54	North of Davenport and near Lamont, Washington Clayton Gulch, Wash.	On August 19, two cloudbursts occurred--one about 15 miles north of Davenport and one near Lamont--and on August 24 a cloudburst occurred in Clayton Gulch near Clarkston. No data available on precipitation.
9/ 5/54	Little Beaver Creek, southeast of Baker, Montana	A cloudburst centered over an unnamed tributary of Little Beaver Creek, 7.5 miles southeast of Baker at about 5:45 p.m., on September 5. Residents within 5 miles of the area reported rainfall intensities ranging from 2.5 inches in 30 minutes to 4.5 inches in 45 minutes.
		- 1955 -
8/ 3/55	30 miles south of Tucson, Arizona Santa Catalina Mtns. to north and Rincon Mtns. to east. Sabino Creek and Rincon Creek	Precipitation occurred over the entire flood area on August 3 but varied greatly in amounts. The total precipitation for the day, in the area extending from the south edge of Tucson south for approximately 30 miles ranged from 2 to 2.5 inches. Heavy precipitation, as much as 2 inches, in the Santa Catalina Mountains to the north and in the Rincon Mountains

Date	Location	Remarks
		to the east caused flooding of Sabino Creek and Rincon Creek.
		- 1956 -
7/10/56	Mt. Vernon, Oregon	A severe thunderstorm with torrential rains, high winds, and hail struck Mt. Vernon about 5:45 p.m. on July 10 and lasted about 45 minutes. Indications were that about 3 to 3-1/2 inches of precipitation occurred in about 1-1/4 hours. Two-thirds of Mt. Vernon residents were forced to evacuate.
7/13/56	Mitchell, from Bridge Creek, Oregon	A little before 5:00 p.m. on July 13 the town of Mitchell was badly battered by floodwaters from Bridge Creek, which had risen rapidly as a result of torrential rains. Information available from catches in tubs indicated that 3-1/2 to 4 inches of precipitation fell. Although the storm lasted for 2 hours, a large part of the precipitation apparently occurred in 30 minutes.
7/ -/56	Galena Creek near Mt. Rose, 10 miles southwest of Reno, Nevada	High intensity rains fell on the headwaters of Galena Creek near the summit of Mt. Rose, about 10 miles southwest of Reno. The resulting flash flood drowned 4 persons who were swept from Nevada Highway 27 by the floodwaters. No precipitation gages in the area.
8/15/56	Knapp Coulee, north-central Washington	Two severe and independent thunderstorms occurred in a 10-day period in areas of north-central Washington. About 1-1/2 inches of rain fell in a few minutes on August 15 in the Knapp Coulee.
8/25/56	Between Monitor and Wenatchee, Washington	The severe thunderstorm of August 25 covered an area between Monitor and Wenatchee. The resulting floods near Monitor destroyed buildings, automobiles and orchards.
		- 1957 -
		None reported.
		- 1958 -

Date	Location	Remarks
7/18/58	Ryegate, Montana	Heavy thunderstorms, which started about 4:30 p.m., July 18, centered over the town of Ryegate, and caused a flash flood of rare occurrence in a small stream in the northwest corner of Ryegate. At Ryegate, about 2-1/2 inches of rain fell in half an hour. Another resident estimated that 3 inches of rain fell.
7/30/58	Beaver Dam and Collinston, Utah	Two severe small area storms occurred about 50 miles apart near the Great Salt Lake. The first storm, on July 30, produced heavy rain over an area of approximately 36 square miles in the vicinity of Beaver Dam and Collinston. Bucket surveys indicated that from 1.5 to 2.5 inches of rain fell in 40 to 60 minutes.
8/16/58	8 square miles, east of Morgan, Utah	Thunderstorm on August 16 caused considerable flood damage in an area about 8 square miles, east of Morgan. Precipitation data from a bucket survey showed rainfall amounts of 4 to 6 inches in less than 1 hour.
		- 1959 -
8/1-2/59	Bryce Canyon, Utah Upper Valley Creek Rock Canyon	Severe thunderstorm activity on August 1 and August 2 caused flash floods on two streams near Bryce Canyon. At Hatch, only 0.08 inch was recorded on August 2, and at Bryce Canyon 1.79 inch fell on August 1.
8/17/59	Near Needles, California	A series of thunderstorms occurred in the Colorado Desert near Needles, on the afternoon and evening of August 17. Precipitation was centered in the basin of Sacramento Wash west of Needles. The nearest rain gage to the storm center, Needles, reported 1.23 inches of rain in 11 hours, with 0.60 inch in 1 hour. Flash floods occurred on several ungaged desert arroyos. These floods were of short duration, and resulted in three deaths.
8/20/59	Boise, Idaho	Damaging floods carrying large quantities of mud, rocks and other debris poured into

Date	Location	Remarks
		Boise from the foothills to the east early in the morning of August 20. The flood of water and debris was the result of moderate rains on August 19, followed by thunderstorms, accompanied by heavy rainfall on steep slopes denuded by recent fires.
		Weather Service records for August 19-21 show that 2.10 inches fell at Deer Point (6 miles north of the flood area), 1.26 inches fell at Lucky Peak Dam (8 miles east of Boise), and 0.40 inch fell at the Boise airport. About 4:15 a.m., August 20, a severe thunderstorm moved into the area; the storm was most intense over the hills east and northeast of Boise.
9/18/59	Near Redding, California Calaboose Creek and its Tributaries	On the afternoon of September 18, a cloudburst occurred near Redding, and caused major flooding on streams in and just north of the city. The localized high-intensity rainfall resulted from a series of thunderstorm cells moving northeasterly through the affected area. In the city of Redding, 3.2 inches of rain fell in a 4-hour period on September 18.
		- 1960 -
7/31/60 8/ 1/60	One-Mile Creek, Jenkins Canyon basin near Topaz, Idaho	Localized flooding from cloudbursts--severe damage to grain and other crops as well as roads.
9/ 2/60	Near Hanna and Duchesne, Utah	Rainfall which fell in less than 1 hour at Hanna, 5 miles northwest of Farm Creek, was 1.27 inches.
9/ 5/60	Mill Canyon near Glenwood, Utah	From intense thunderstorms, a bridge on U-119 was destroyed, and U-24 was damaged.
	Peterson Creek southeast of Sigurd, Utah	
9/ 6/60	Ten-mile Creek near Marysvale, Utah	Thunderstorm flooded U.S. 89 and delayed traffic.

Date	Location	Remarks
		- 1961 -
8/25/61	Pleasant Creek near Mt. Pleasant, Utah	Rainfall reports by SCS in the basin: Upper Twin Creek T Lower Twin Creek 0.10" Upper Coal Creek 0 Lower Coal Creek 0.50" Upper Straight Fork 0.37" Middle Straight Fork 0.65" Lower Straight Fork 0.44" The precipitation at Middle Straight Fork was at the rate of 3.90 inches/hour. Qp (gage) = 200 cfs.
8/12/61	Tributary to Battle Creek near Banida, Idaho	Qp = 1600
8/25/61	Little Danish Canyon near Malad City, Idaho	Qp = 1700
8/25/61	Little Malad River below Sand Ridge dam site near Malad City, Idaho	Qp = 706
8/12/61	Tributary to Green Canyon near Inkom, Idaho	According to local residents, Battle Creek tributary and Green Canyon tributary were the highest in more than 40 and 50 years. Qp = 3060
8/22-23/61	Tucson, Arizona	Weather Service reported 2.48 inches of rain at the Tucson Airport during a 4-hour period; 2.22 inches in 1 hour and 1.17 inches in 15 minutes. Thunderstorm activity was widespread over much of Arizona following inflow of a deep moist current of air, originating over the Gulf of Mexico. The heavy runoff following the cloudburst rapidly filled all of the arroyos in the city, flooded many streets, and filled underpasses with water.

Date	Location	Remarks
		Many businesses and residences were flooded to a depth of 2-3 feet.
9/ 8/61	Farley Canyon near Hite, Utah	At Hite, 0.81 inch of precipitation was recorded on 9/8/61. The floodwater was about 2 feet deep in the store, Post Office, and residence. Qp = 7,350 cfs. D.A. = 12.5 sq. miles
8/ 4/61	Henrieville Creek at Henrieville, Utah	Qp = 7,360 cfs.
8/ 3/61	Paria River at Cannonville, Utah	Qp = 4,830 cfs.
8/25/61	Muddy Creek near Mt. Carmel, Utah	On August 24, rainfall at Zion National Park totaled 1.37 inches, but only 0.38 inch was measured at Orderville, less than 3 miles from Mt. Carmel. Qp = 8,190 cfs.
9/17/61	North Fork Virgin River near Springdale, Utah	The flash flood trapped a party of 26 hikers in the Narrows, and 5 were drowned. A part of the park highway, a tractor, fencing, and 3 diversion structures were destroyed. Qp = 5,880 cfs.
9/17/61	Virgin River at Virgin, Utah	Qp = 13,500 cfs.
7/ 4/61	Hog Canyon near Kanab, Utah	0.58 inch of rain recorded at Kanab. D.A. = 18.5 $mi.^2$ Qp = 6,580 cfs.
8/ 8/61	Blacks Canyon at Springdale, Utah	Water overtopped State Highway 15 at Springdale and flooded the yards of several homes. Qp = 1,030 cfs.
9/17/61	Coalpits Wash near Rockville, Utah	Qp = 8,350 cfs.

Date	Location	Remarks
8/25/61	Phelps Canyon near Alpine, Utah	At Alpine, 2-1/2 miles southwest, 0.60 inch of rain was recorded. Qp = 1,500 cfs.
8/25/61	Deep Creek near Ibapah, Utah Bar Creek near Ibapah, Utah	Caused by cloudburst north of Ibapah. The greatest intensity of rainfall took place over Bar Creek. Official weather stations at Ibapah and at Wendover, 50 miles north of Ibapah, recorded 0.02 and 0.01 inch of precipitation, respectively.
9/17/61	Mineral Gulch near Mt. Carmel, Utah	
9/16/61	Crystal Creek near Mt. Carmel, Utah	
8/12/61	Cottonwood Creek near Hoytsville, Utah	
8/12/61	Echo Cliff Wash near Echo, Utah	
7/31/61	Chalk Creek near Fillmore, Utah	
8/25/61	South Fork Coal Creek near Mt. Pleasant, Utah	
8/10/61	Coal Creek near Cedar City, Utah	
		- 1962 -
9/13/62	Marana, Arizona	The small town of Marana and surrounding farmland were flooded with 6 to 18 inches of water as a result of a thunderstorm on the west side of the Tortolita Mountains. <u>Rainfall during a 2-hour period reportedly was 3 or 4 inches</u>; one resident reported 4.6 inches. The flood originated in a 15 sq. mile area, centered about 8 miles northeast of Marana. At several places the runoff was estimated to between 700 and 1,000 cfs./sq. mile. Estimate of discharge - 3,500 cfs.

Date	Location	Remarks
9/21/62	Fry Canyon near Hite Saleratus Wash and its tributaries near Green River and Woodside	Rainfall amounts of 0.30 inch at Green River, 1.67 inches at Price, 0.38 inch at Hite. Floods were in sparsely settled regions; therefore, damage was light.
		- 1963 -
6/16/63	Upper Duchesne River, Utah	Failure of a dam on Little Deer Creek caused a record-breaking flood in Deer Creek. The dam apparently failed before the water reached the spillway crest. The 1,000 acre-feet of water that was estimated to have been impounded at the time of failure was released in a short period of about 20 minutes.
8/16-17/63	Glendale-Maryvale, Arizona	Rain lasted from 10:15 p.m. on August 16 and lasted until 4:20 a.m. on August 17. A recording rain gage near the center of Glendale registered 5.25 inches in the 6-hour period. Five gages located in Glendale and Maryvale recorded more than 3.4 inches of rain.
8/16/63	Prescott, Arizona	Heavy rainfall began with a thunderstorm about noon on August 16. By 1:30 p.m. this storm had drenched most of the west side of Prescott and the surrounding mountains with 3 to 4 inches of rain. Butte and Miller Creeks were out of their banks from 1:30 to 3:30 p.m., and caused the closing of Miller Valley Road and many streets. Manzanita, Aspen, and Willow Creeks also flooded.
8/19/63	Prescott, Arizona	Between 6:30 and 8:45 p.m. on the 19th, several residents of the area west of Granite Creek reported over 3 inches of rain; some reported almost 5 inches. Water from Miller and Butte Creeks flowed over Miller Valley Road for 4-1/2 hours at depths up to 3 feet. Granite Creek ran bankfull through town and flooded several homes below the mouth of Miller Creek. Manzanita Creek flowed over U.S. Highway 89.

Date	Location	Remarks
8/22/63	Rye Creek near Payson, Arizona	Between 12:30 and 6:30 a.m. on August 22, a storm centered over the upper portion of Rye Creek, south of Payson, dropped 3 to 4 inches of rain over an area about 15 miles in diameter. The only major damage occurred along Rye Creek, which washed out 60 feet of a bridge on State Highway 87.
9/17/63	Southwestern Arizona	During the storm on the evening of September 17, rainfall around Yuma ranged from 1.9 to 3.4 inches. The National Weather Service gage at Yuma recorded 2.04 inches in 1 hour. Most of the damage from the resulting floods occurred in a strip along the Colorado River from Blythe, California to Yuma, Arizona.
9/23/63	Near Colfax, Washington	A severe thunderstorm on September 23 in the eastern half of Whitman County in southeastern Washington produced unusually high runoff on 3 streams near Colfax. National Weather Service records at Colfax showed 0.70 inch of rain. Local residents stated that the storm lasted less than 15 minutes.
		- 1964 -
7/30/64	Chinle Wash at Chinle, Arizona	About midnight on July 30, a flash flood of about 20,000 crs. originated in Nazlini Wash, a tributary to Chinle Wash in northeastern Arizona. The flood claimed 8 lives when the bridge that spanned Chinle Wash, which provided access to the Canyon de Chelly National Monument at Chinle was washed away. No precipitation data are available from the Nazlini Wash drainage basin. Weather Service reported 0.34 inch of rainfall on July 30 and 0.33 inch on August 1 at Chinle. Ganado reported 0.64 inch on July 30 and 0.70 inch on August 1.
8/12/64	Ruby Wash at city limits of Winslow, Arizona	Most of the runoff originated in a 20 sq. mile area southwest of Winslow. Weather Service reported 2.04 inches of rainfall at the Winslow airport between 4:00 p.m. and 5:00 p.m. The Corps of Engineers reported rainfall totals of 1.7 inches west of town and 2.41 inches within the city limits.

Date	Location	Remarks
7/14-15/64	Wickenburg, Arizona Powder House Wash	Caused from $50,000 to $75,000 damage to residences and motels on the alluvial fan at the mouth of the wash. A rancher, whose home is in the drainage basin of Powder House Wash, reported 2-1/2 inches of rain in a 45 minute period; NWS reported 1.30 inches of rain at Wickenburg on July 15.
7/30/64	Flagstaff, Arizona	2-1/2 to 3 inches of rain fell in a period of a half-hour during the afternoon of July 30. Many homes and businesses in the city were inundated by overflow from the River de Flag and by direct runoff from the surrounding hills.
7/31/64	Near Snowflake, Arizona	Several sections of State Highway 177 and of the Apache Railway were washed out by floods on July 31 after a rainfall of 3-4 inches in 1 hour. Streets and some businesses in Snowflake were flooded by Little Cottonwood Wash.
8/1-2/64	Phoenix area, Arizona	Damaged streets and roads throughout the metropolitan area; the most damage occurred at grade-level crossings along the Agua Fria and New Rivers. Flood of August 1 originated mainly in Skunk Creek. Flood of August 2 originated in the New River upstream from Skunk Creek. In the valley around Phoenix, cotton growers sustained heavy losses from the floods of August 1 and 2, and large acreages of cotton were damaged by rain. Irrigation works and roads in the Eloy, Casa Grande, and Stanfield areas were damaged by overflow from the Santa Cruz River.
8/1-2/64	West of Sells, Pima County	Floods marooned about 300 persons in a dozen small villages west of Sells in central Pima County. Two persons died.
8/12/64	Casa Grande, Arizona	3.08 inches of rain fell in 2 hours. Sheetflow and ponding in areas that had little or no drainage facilities inundated roads and highways. Several homes in Casa Grande and on the surrounding farms were damaged by floodwater.

Date	Location	Remarks
8/14/64	Gila Bend, Arizona	Bridge on U.S. Highway 80 was washed out by floodwaters from Sand Tank Wash. The flood resulted from a combination of natural run-off and spillage from an irrigation canal that broke because of a large amount of intercepted flow.
9/ 6/64	Tucson, Arizona	From an intense rainstorm, covering about 10 sq. miles; occurred over a subdivision north of Tucson. The storm started shortly after 2:00 p.m. and lasted for 2 to 3 hours. One resident measured 4.9 inches of precipitation in a 2-hour period, and several others reported between 3 and 5 inches of rain in 2 to 3 hours. The Riverside housing development on the northwest corner of La Canada Drive and Roller Coaster Road was badly damaged by water and debris. A few other homes near the mouths of small washes sustained wind, water, and debris damage.
9/13/64	Sabino Canyon near Tucson, Arizona	Flash floods closed highways and stranded about 200 persons.
9/14/64	Phoenix, Arizona	Weather Service reported 1.25 inches of rain in a 30 minute period at Sky Harbor airport. Large amounts of rainfall were recorded in some parts of the city; one observer measured 2.48 inches in 45 minutes. Business establishments were flooded throughout the city. Streets became rivers, and sections of pavement collapsed. Cotton crops in the valley surrounding Phoenix were badly damaged by rain, hail and floodwater.
8/ 1/64	Cottonwood Creek near Orangeville, Utah	Caused by intense thunderstorms during late summer and early fall.
8/ 4/64	Dry Wash at Antimony, Coal Creek and Shurtz Creek near Cedar City, Utah	Caused by intense thunderstorms during late summer and early fall.
8/11-12/64	Little Pinto Creek near Newcastle, Utah	Precipitation ranged from 0.0 inch at St. George to 0.54 inch at Orderville; floodwaters overflowed State Highway 10.

Date	Location	Remarks
	East Fork Virgin River near Orderville, Utah	
	The Gap near St. George, Utah	
8/15/64	Anderson Wash near Sigurd, Utah	NWS precipitation station at Richfield recorded only 0.04 inch and Salina 0.0 inch.
		- 1965 -
6/10-11/65	Sheep Creek area, Utah	The worst flood in 40 years hit the Sheep Creek area, causing damage estimated at $660,000 to roads and bridges. Damage to cultivated land was considerable, and 7 campers at Palisades campground on Sheep Creek were drowned when they were swept away by the floodwaters during the night. Rains of high intensity at high altitudes in the Uinta Mountains on June 9-11, with the melting of the unusually heavy snowpack, caused flooding of several streams. The area that contributed mainly to the flooding was above 9,200 feet, which was the approximate snow line before the flood. After the flood, the snow line had moved up to 9,900 feet. Therefore, the snow on about 14 square miles of the Sheep Creek drainage basin had completely melted during the period of flooding.
7/18/65	American Fork Canyon, Utah	Seven mud slides caused floodwater to overtop the road and wash it out. Many campers were marooned between the mud slides for several hours. The U.S. National Park Service reported 2.18 inches of rain at Timpanogos Cave National Monument between 6:00 and 10:00 p.m. on July 18.
7/22/65	Uinta Basin, Utah	Flash floods occurred on small streams in the Uinta basin. Only 0.30 inch of rain was recorded at Vernal airport, and lesser amounts were recorded at other sites in the area. Because the storms were over small areas and were of high intensity, the reported rainfall figures show no relation to the intensity of the storms.