UTAH
Floods and Droughts

Moisture-delivery systems and topography interact to produce great spatial and seasonal variability in precipitation and, thus, floods and droughts in Utah. Annual precipitation ranges from about 5 inches on the Great Salt Lake Desert to about 60 inches on the highest mountains. Most of the moisture received in Utah originates either in the Pacific Ocean or in the Gulf of Mexico (fig. 1).

Variability in precipitation quantities has resulted in both severe floods and severe, multiyear droughts. The five major floods of record occurred in 1952, 1965, 1966, 1983, and 1984. The largest and most widespread of these floods was April 10–June 25, 1983. Peak discharges on several streams set new records and had recurrence intervals that exceeded 100 years. When a landslide dammed Spanish Fork on April 16, the community of Thistle was completely inundated. The town of Deseret was inundated by as much as 5 feet of water when a dam on the Sevier River failed June 23. Damage due to the April 10–June 25 flooding was $621 million.

Three multiyear droughts have occurred: 1930–36, 1953–65, and 1974–78. Only the 1930–36 drought was severe statewide. During this drought, water was in short supply for all human needs. In 1934, crop yields per acre were 59 percent of the 1921–30 average yield.

Flood-plain management in Utah is administered through the National Flood Insurance Program by the Federal Emergency Management Agency in Denver, Colo. Local coordination is managed by the Utah Division of Comprehensive Emergency Management.

Flood-warning systems are used in the Ogden-Salt Lake City area. Other urban areas in the State rely on flood-warning systems that are limited mostly to flood-stage and weather forecasts provided by the National Weather Service (NWS).

State water-use management during droughts is limited to reallocating water for domestic use. However, the State communicates with various local government agencies to coordinate use of the available water supplies.

GENERAL CLIMATOLOGY

Extreme contrasts in topography across Utah result in considerable spatial variability in precipitation. Annual precipitation ranges from about 5 inches on the Great Salt Lake Desert (fig. 1) to about 60 inches on the highest mountains (Butler and Marsell, 1972, p. 6). Spatial and seasonal distribution of precipitation is largely associated with three general atmospheric conditions that account for most of Utah's precipitation: Pacific frontal systems, upper-level low-pressure systems called cutoff lows, and thunderstorms. Precipitation from Pacific frontal and cutoff low-pressure systems increases with increasing altitude; most precipitation from thunderstorms occurs in areas below 8,000 feet (Woolley, 1946, p. 5).

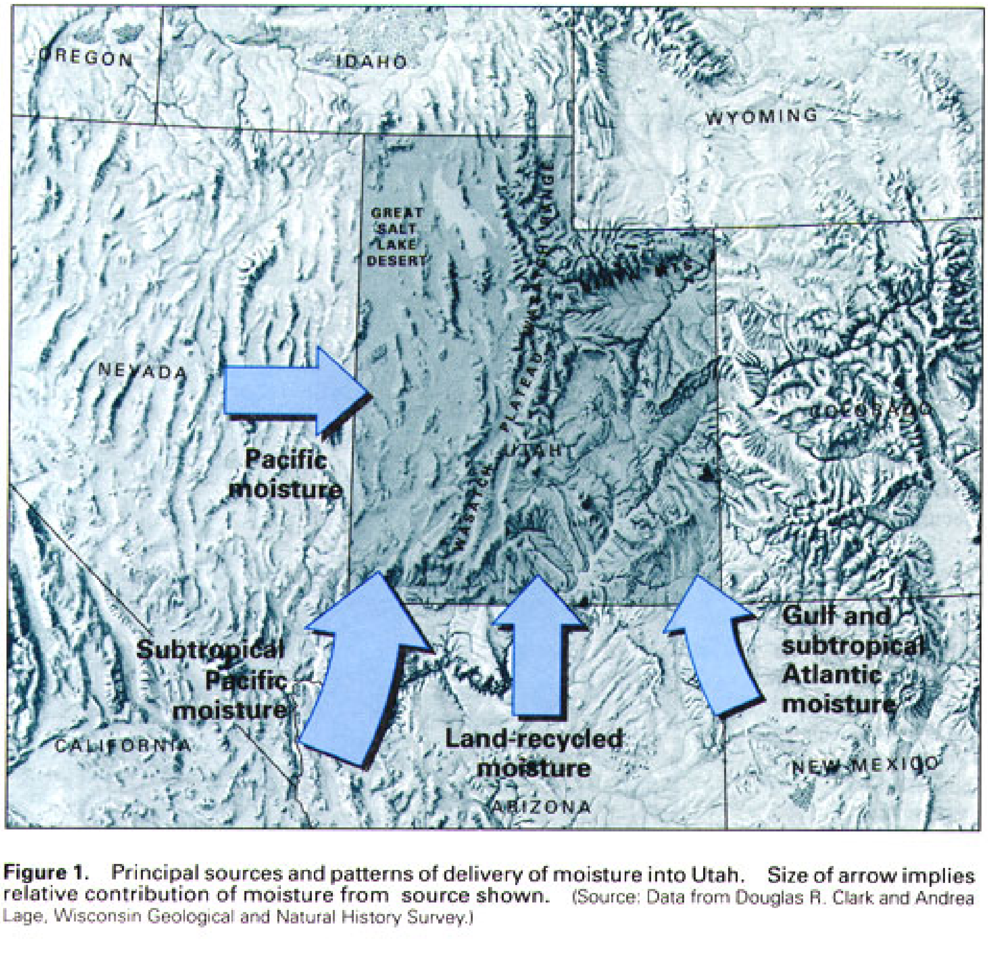


Figure 1. Principal sources and patterns of delivery of moisture into Utah. Size of arrow implies relative contribution of moisture from source shown. (Source: Data from Douglas R. Clark and Andrea Lage, Wisconsin Geological and Natural History Survey.)

Frontal systems are most frequent in the winter and early spring; consequently, they account for much of the mountain snowpack. Although frontal systems generally move into Utah from the Pacific Northwest, the moisture in the southerly flow ahead of the cold fronts originates in the subtropical Pacific Ocean. The storms may move across the State in a storm track from northwest to southeast, from west to east, or from southwest to northeast, depending on the direction of upper level winds.

Frontal systems frequently follow the west-to-east track across Utah, and the area beneath that track may accumulate a deep snowpack. In the spring, rapid snowmelt can result in flooding. When winter storms follow several different tracks, snow is distributed more uniformly over the State. During some winters, a high-pressure ridge is dominant over the western United States, and the storm track is pushed northward. A statewide winter drought can result.

Cutoff low-pressure systems tend to dominate the weather in the spring (late April and May) and fall (generally October). They move slowly and often produce large quantities of rain over an extended time. Occasionally, dissipating tropical cyclones, including tropical storms and hurricanes, cause intense precipitation in Utah (Smith, 1986). The moisture from the tropical cyclones may be transported into the State by the cutoff low-pressure systems.

Thunderstorms are most frequent during the summer, when intense heating of the Earth's surface produces strong thermals. When the air contains a considerable quantity of moisture from the subtropical Pacific and Atlantic Oceans or the Gulf of Mexico, these thermals develop into thunderstorms that can produce intense precipitation.

In addition to the oceans, important moisture sources include local and upwind land surfaces, as well as lakes and reservoirs, from which moisture evaporates into the atmosphere. Typically, as a moisture-laden ocean airmass moves inland, it is modified to include some water that has been recycled one or more times through the land-vegetation-air interface.

MAJOR FLOODS AND DROUGHTS

Major floods and droughts are those that were areally extensive and have large recurrence intervals—greater than 25 years for floods and greater than 10 years for droughts. These major events and additional floods of a more local nature are listed chronologically in table 1; rivers and cities are shown in figure 2. Major floods and droughts in Utah are depicted by streamflow records from six streamflow-gaging stations (figs. 3 and 4). The selected gaging stations are on streams that represent natural runoff in Utah's principal river basins. Data from the gaging stations are collected, stored, and reported by water year (a water year is the 12-month period from October 1 through September 30 and is identified by the calendar year in which it ends).

Many other floods and droughts in Utah have been severe locally and have affected considerably smaller areas than the areas of those floods and droughts identified in table 1. Some of these local floods have caused substantial loss of life and property damage, and local droughts have caused water shortages.

FLOODS

The five major floods of record occurred in 1952, 1965, 1966, 1983, and 1984. The areal extent and severity of these floods, as determined from 81 gaging stations, and the magnitude of annual peak discharges at the six selected gaging stations are shown in figure 3. Also shown are the peak-discharge values having recurrence intervals of 10 and 100 years at each station, the peak discharges associated with major floods, and areas of flooding where the recurrence interval is 25–50 years and greater than 50 years.

The April 28, 1952, flooding on Chalk Creek at Coalville (fig. 3, site 1) and other flooding during the extensive April 28–June 11, 1952, floods were caused by melting of maximum-of-record snowpack for April 1 (U.S. Soil Conservation Service, 1983). Flooding was severe in central and north-central Utah (fig. 3), and a flood disaster was declared. Two lives were lost in boating accidents on the swollen Ogden River (Wells, 1957, p. 597–613). Flood damage was $8.4 million, of which $1.9 million was in Salt Lake City.

Rainfall on melting snowpack caused the June 11, 1965, flood on Ashley Creek near Vernal (fig. 3, site 2) and the June 10–11, 1965, floods in northeastern Utah. Flooding also was severe on several other streams in the Uinta Mountains (fig. 1) near Vernal and Manila. Areas at altitudes above 9,200 feet contributed most to the flooding. During the flood, the snowline receded from about 9,200 to 9,900 feet. Peak discharges were greater than the discharge expected to recur once in 100 years on Ashley Creek on the southern slope of the Uinta Mountains and on streams on the northern slope. On a creek southwest of Manila, floodwaters that were the most severe in 40 years swept away and killed seven campers during the night. Within the storm area, flooding caused estimated damage of $814,000 to roads, bridges, irrigation canals, fences, and crops (Rostvedt and others, 1970, p. E54–E57).

The December 6, 1966 (water year 1967), flood on the Santa Clara River near Pine Valley (fig. 3, site 4) occurred during the December 6–7, 1966, floods. A rainstorm during December 3–6 was of unprecedented areal coverage and intensity for extreme southwestern Utah. Rainfall in the storm area ranged from about 1 to 12 inches. Peak discharges on the Virgin and Santa Clara Rivers (fig. 2) and other streams in the storm area had recurrence intervals that exceeded 100 years. Areal extent of the flooding is shown in figure 3. Total damage to crops, fences, roads, bridges, diversion structures, cropland, and forest lands and improvements was about $1.4 million (Butler and Mundorff, 1970, p. A–19).

The floods of April 10–June 25, 1983, affected 22 counties, or more than three-fourths of the State. On April 10, a landslide caused by precipitation dammed the Spanish Fork, which then inundated the community of Thistle. The landslide, which resulted in damage of about $200 million and a Presidential disaster declaration, was the most costly geologic phenomenon in Utah's history (Utah Division of Comprehensive Emergency Management, 1985, p. 40).

Rapid melting of snowpack that had maximum-of-record water content for June 1 (U.S. Soil Conservation Service, 1983) resulted in the largest and most widespread flooding in the State's history; peak discharges had recurrence intervals that exceeded 100 years on several streams. New discharge records were set on many others, such as Chalk Creek at Coalville (fig. 3, site 1). On June 23,

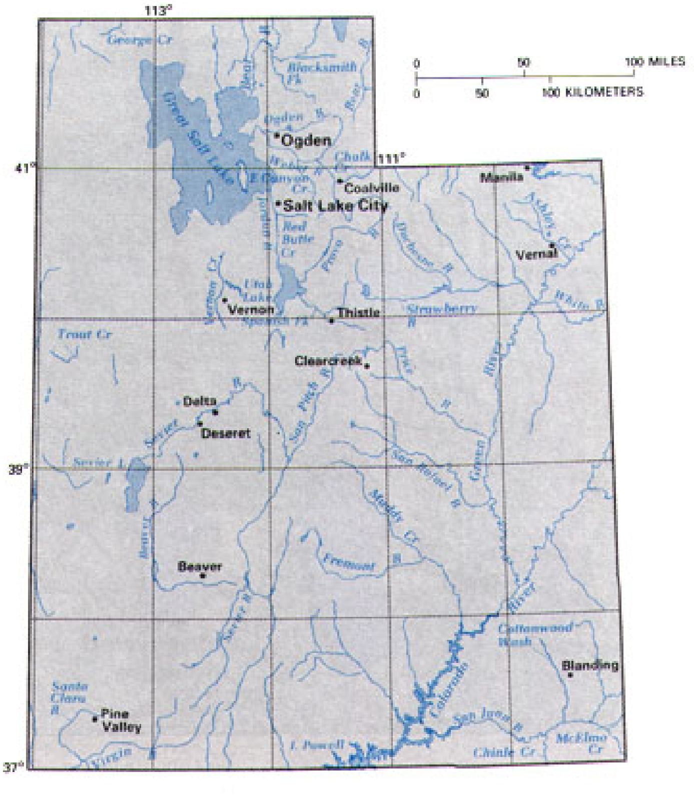


Figure 2. Selected geographic features, Utah.

the Delta-Melville-Abraham-Deseret Dam on the Sevier River near Delta (fig. 2) failed as a result of the flooding on June 23, 1983, and released 16,000 acre-feet of water down the river. Two bridges were washed away, and the town of Deseret was inundated by as much as 5 feet of water (Utah Division of Comprehensive Emergency Management, 1985, p. 41).

Overall damage from the April 10–June 25, 1983, floods totaled $621 million (Stephens, 1984, p. 20–36). No deaths were attributed to the floods.

The May 24, 1984, flood on the Beaver River near Beaver (fig. 3, site 5) and other flooding during the April 17–June 20, 1984, floods caused damage second in magnitude only to damage in 1983. The major cause of the flooding was much greater than average snowpack and greater than normal precipitation that continued throughout the spring. Peak discharges exceeded those in 1983 at some sites on the White, Bear, Jordan, and Beaver Rivers. Owing to severe flooding in 12 counties, a disaster was declared by the President. On May 14, rainfall caused a mudslide near the coal mining town of Clearcreek that killed one person and injured another. The direct impact on people was considerably less in 1984 compared to 1983 because of mitigation measures implemented during the previous year. Total damage for floods and landslides was estimated to be $41 million (Utah Division of Comprehensive Emergency Management, 1985, p. 15).

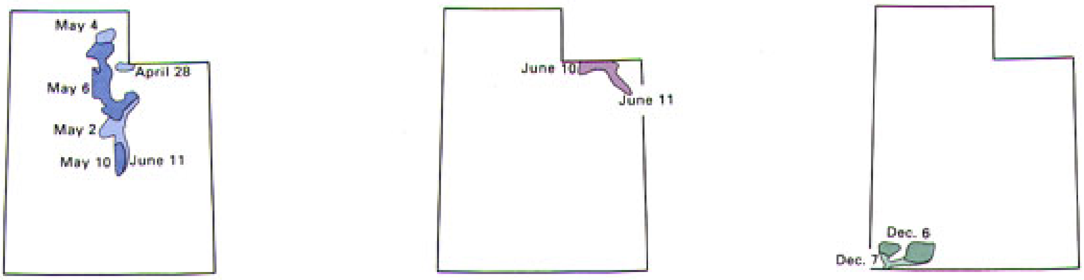
Floods not only can cause direct loss of life and property, but also can adversely affect the use and quality of surface water, resulting in economic and environmental costs that are not apparent until the floodwaters recede. For example, floods transport large quantities of sediment and debris from eroding channels, then deposit the material on cropland and streets and in homes, reservoirs, and stock ponds. Also, waterfowl nesting can be disrupted when areas adjacent to lakes become flooded.

Table 1. Chronology of major and other memorable floods and droughts in Utah, 1884–1988

[Recurrence interval: The average interval of time within which streamflow will be greater than a particular value for floods or less than a particular value for droughts. Symbol: >, greater than. Sources: Recurrence intervals calculated from U.S. Geological Survey data; other information from U.S. Geological Survey, State and local reports, and newspapers]

Flood or drought	Date	Area affected (fig. 2)	Recurrence interval (years)	Remarks
Flood	July 4, 1884	Colorado River	>100	Probably snowmelt combined with rainfall.
Flood	Aug. 13, 1923	Tributaries to Great Salt Lake between Ogden and Salt Lake City.	Unknown	Locally intense thunderstorms. Deaths, 7; damage, $300,000.
Drought	1930–36	Statewide	>25	Regional.
Flood	Apr. 28–June 11, 1952	Strawberry, upper Price, upper San Rafael, Ogden, Weber, Provo, and Jordan Rivers; Blacksmith Fork and Spanish Fork; upper Muddy and Chalk Creeks.	25 to >100	Melting of snowpack having maximum-of-record water content for Apr. 1. Disaster declared. Deaths, 2; damage, $8.4 million.
Drought	1953–65	Statewide	10 to >25	Regional.
Flood	June 16, 1963	Duchesne River	>100	Dam failure.
Flood	June 10–11, 1965	Ashley Creek and other streams between Manila and Vernal and west of Manila.	>100	Three days of intense rainfall on thick snowpack above altitude of 9,200 feet. Deaths, 7; damage, $814,000.
Flood	Dec. 6–7, 1966	Virgin and Santa Clara Rivers	25 to >100	Four days of light to intense rainfall of as much as 12 inches. Damage, $1.4 million.
Flood	Aug. 1–2, 1968	Cottonwood Wash and other nearby tributaries to San Juan River.	50 to >100	Locally intense thunderstorms following 11 days of rainfall. Damage, $34,000.
Flood	Sept. 5–7, 1970	San Juan River and tributaries from McElmo Creek to Chinle Creek.	25 to >100	Record-breaking rainfall. Deaths, 2; damage $700,000.
Flood	Aug. 27, 1972	Vernon Creek	>100	Locally intense thunderstorms.
Drought	1974–78	Statewide	10 to >25	Regional.
Flood	Apr. 10–June 25, 1983	Lower Duchesne and Jordan Rivers and tributaries (including Spanish Fork); upper Price, Bear, Sevier, and San Pitch Rivers; Chalk, East Canyon, Trout, and George Creeks; Great Salt Lake and tributaries between Ogden and Salt Lake City.	25 to >100	Rapid melting of snowpack having maximum-of-record water content for June 1. Disaster declared by President. Damage, $621 million.
Flood	Apr. 17–June 20, 1984	White, upper Price, and Fremont Rivers; lower Bear and Sevier Rivers and tributaries; Beaver River; Red Butte Creek; Spanish Fork; Jordan River.	25 to >100	Runoff from greater than average snowpack for Apr. 1 and spring precipitation. Deaths, 1; damage, $41 million.
Flood	May 22, 1984	Sevier Lake	Unknown	Runoff in Sevier River from Nov. 1982 through June 1984 exceeded upstream reservoir capacity; about 1.5 million acre-feet of water conveyed to Sevier Lake. On May 22, 1984, lake reported to be as much as 35 feet deep after being dry or nearly dry since about 1880.
Flood	June 15, 1984	Utah Lake	Unknown	Runoff from greater than normal precipitation since Sept. 1982 increased lake level to 101-year record of 5.46 feet above compromise level on June 15, 1984. Damage, $5.9 million.
Flood	June 3, 1986	Great Salt Lake	Unknown	Large runoff from greater than normal precipitation since Sept. 1982 increased lake level to 140-year record altitude of 4,211.85 feet on June 3, 1986. Damage, $268 million.

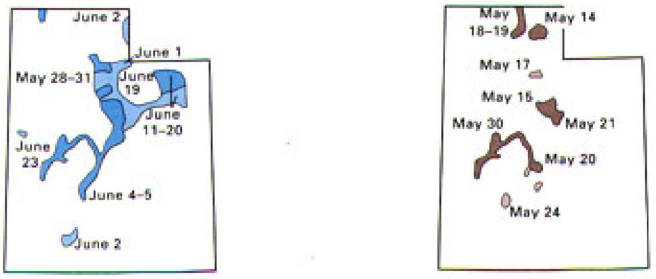
Areal Extent of Floods



April 28-June 11, 1952

June 10-11, 1965

December 6-7, 1966



April 10-June 25, 1983

April 17-June 20, 1984

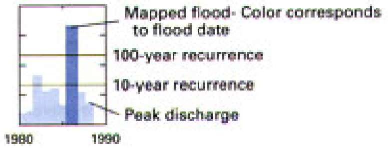
EXPLANATION

Areal extent of major flood

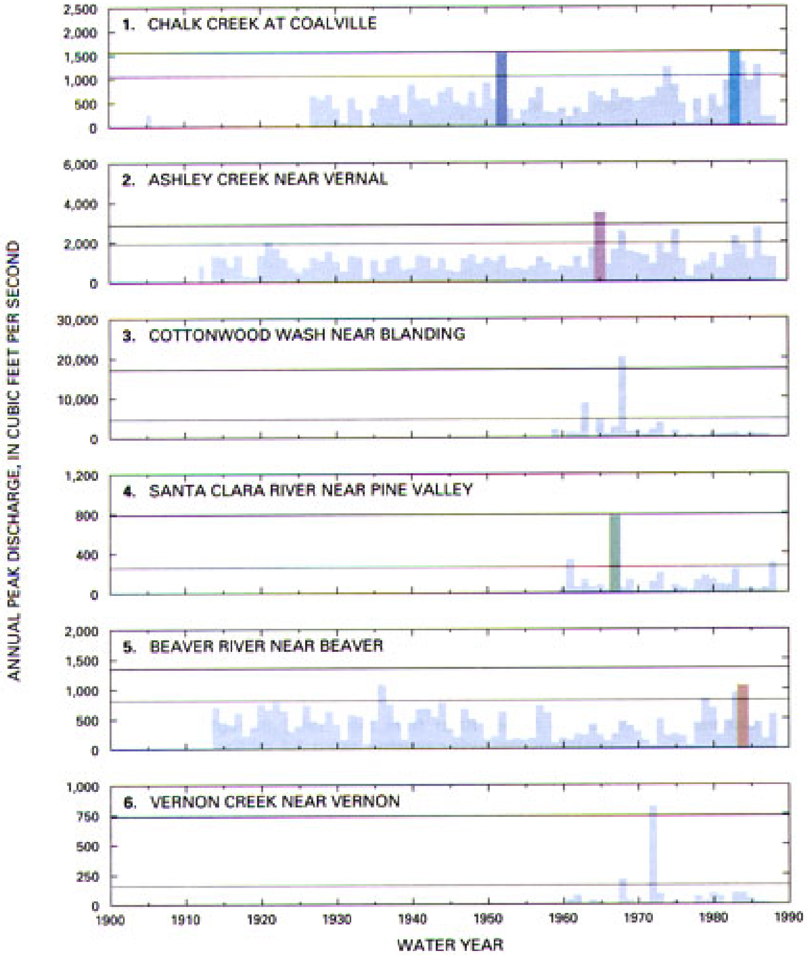
Recurrence interval, in years

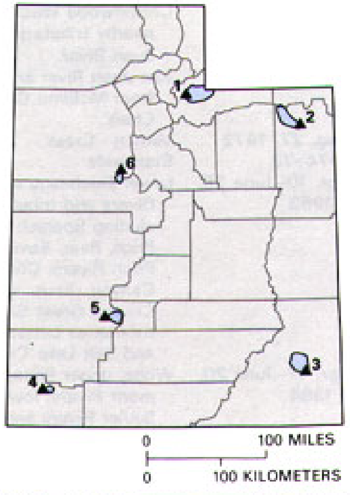
25 to 50	More than 50	
▨	▨	April 28-June 11, 1952 (water year 1952)
NONE	▨	June 10-11, 1965 (water year 1965)
▨	▨	December 6-7, 1966 (water year 1967)
▨	▨	April 10-June 25, 1983 (water year 1983)
▨	▨	April 17-June 20, 1984 (water year 1984)

Annual stream peak discharge



Peak Discharge





U.S. Geological Survey streamflow-gaging stations and corresponding drainage basins — Numbers refer to graphs

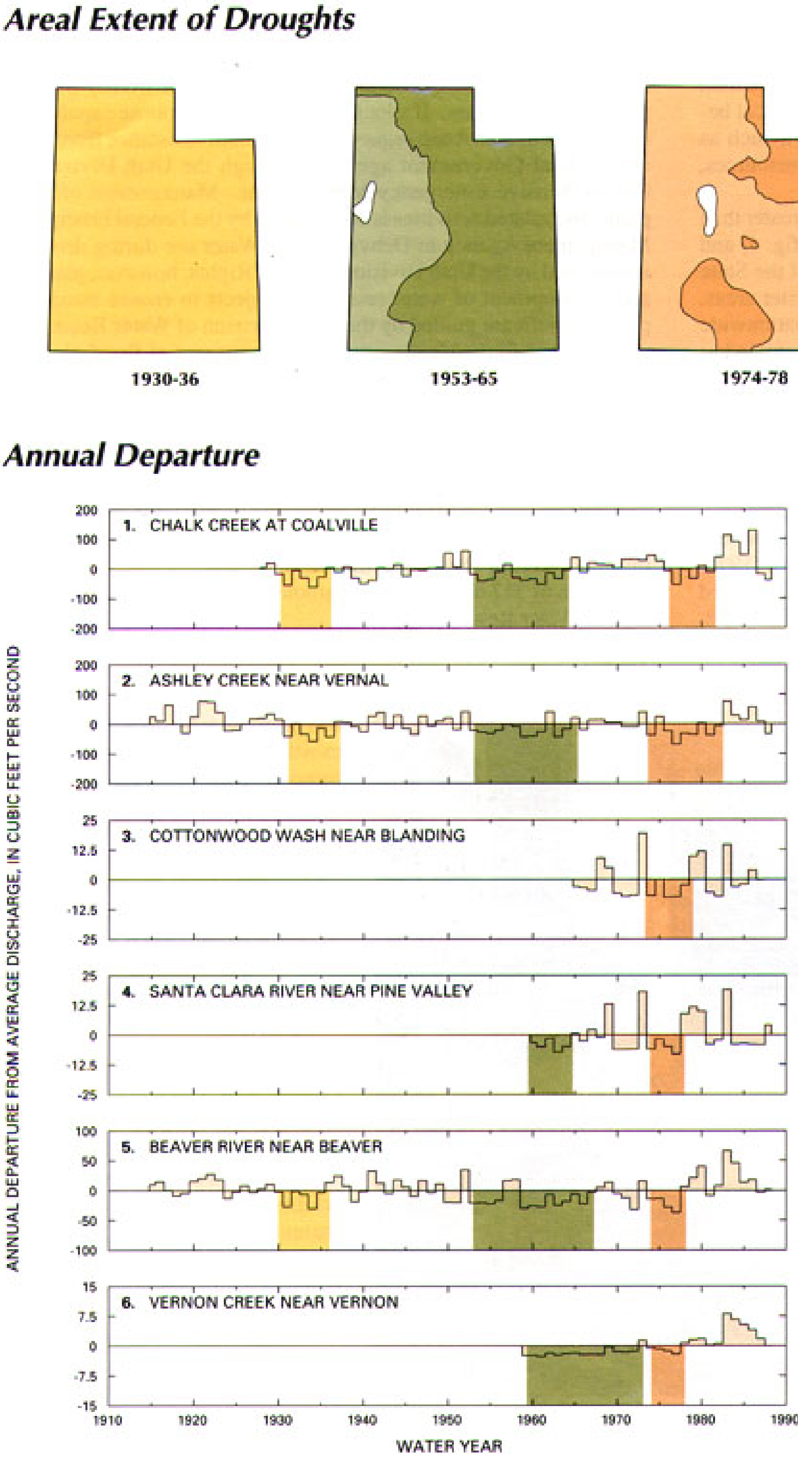
Figure 3. Areal extent of major floods with a recurrence interval of 25 years or more in Utah, and annual peak discharge for selected sites, water years 1905, 1914–88. (Source: Data from U.S. Geological Survey files.)

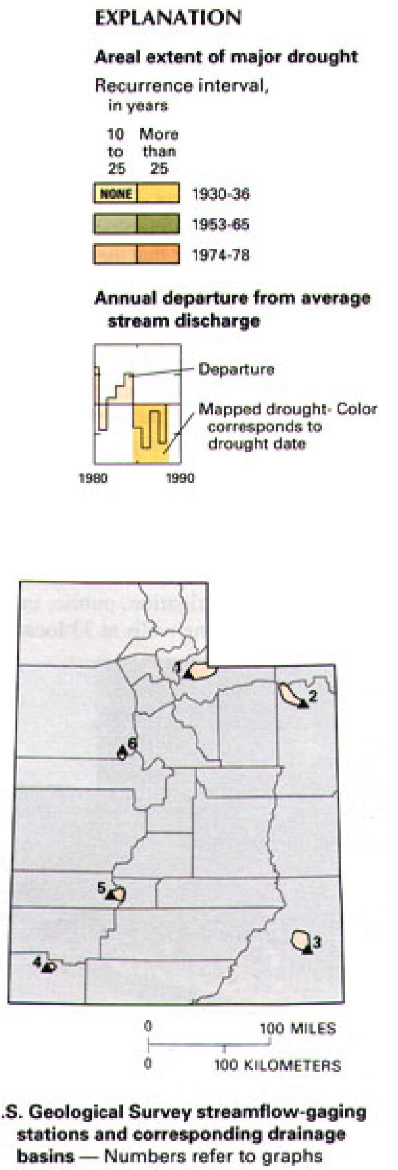
DROUGHTS

The drought analysis for Utah, as determined from 33 gaging stations, indicates that a localized drought has occurred on at least one stream in Utah every year since 1924. Drought duration tends to be longest in basins where runoff is mainly from snowmelt. The frequency of occurrence of major droughts is greater for areas in the Wasatch Range than in the Uinta Mountains, Wasatch Plateau, or the mountains in southwestern Utah (fig. 1).

Annual-departure graphs are shown in figure 4 for six selected gaging stations that are representative of Utah streams having natural runoff. Each graph represents the annual departure from the average stream discharge for the period of record. Major droughts occurred in 1930–36, 1953–65, and 1974–78. The drought duration at the six representative gaging stations is shown on the graphs. Other droughts evident on the graphs were not selected as major droughts because they were less significant in terms of areal coverage, duration, and severity. The areas affected by drought having recurrence intervals of 10–25 years and greater than 25 years also are shown in figure 4.

The drought of 1930–36 had a recurrence interval greater than 25 years throughout the State (fig. 4). Annual streamflow during





U.S. Geological Survey streamflow-gaging stations and corresponding drainage basins — Numbers refer to graphs

Figure 4. Areal extent of major droughts with a recurrence interval of 10 years or more in Utah, and annual departure from average stream discharge for selected sites, water years 1915–88. (Source: Data from U.S. Geological Survey files.)

water year 1934 was severely deficient—less than 50 percent of mean annual discharge—in Utah, in parts of adjacent Western and Southwestern States, and in Midwestern States (Nace and Pluhowski, 1965, fig. 17, p. 37). Crop yields per acre that year were 59 percent of the 1921–30 average (Hoyt, 1936, p. 56–61). The drought caused water-supply shortages for irrigation, domestic, stock, recreation, wildlife, power, and industrial uses.

The drought of 1953–65 had a recurrence interval greater than 25 years in the eastern three-fourths of the State and a recurrence interval of 10–25 years in most of the remaining area (fig. 4). Most of Utah was declared a disaster area (Matthai, 1979, p. 4). Through 1956, the drought in Utah was a part of the regional drought of the 1950's, which extended nationally from the Southwest to the southern Great Plains (Nace and Pluhowski, 1965, fig. 22, p. 48). The effects of the 1953–65 drought in local areas were more severe than the drought of 1930–36, but the overall effects were less critical because of protective procedures that had been undertaken, such as construction of reservoirs, development of ground-water resources, and improved land management.

The drought of 1974–78 had a recurrence interval greater than 25 years mainly in northeastern and south-central Utah (fig. 4) and a recurrence interval of 10–25 years in most of the rest of the State (fig. 4). Several counties in the State were declared disaster areas. Matthai (1979, p. 3) reported that the drought had spread nationwide in 1976–77 and had more severely affected the Nation than any other drought during the 20th century.

Current water use in the State relies mainly on surface-water supplies, which can be greatly decreased by multiyear droughts. Surface water provides about 81 percent of the State's offstream water use, and about 35 percent of the population relies on surface water for domestic supply (U.S. Geological Survey, 1990). Because of this dependency on surface-water supplies in Utah, a drought can severely affect the State's people and industries. For example, Matthai (1979, p. 41–53) reported that, during the drought of 1976–77, record minimum annual discharge in streams caused severe water shortages. Some cities and towns were forced to ration water. In Utah, emergency water needs for irrigation, public, industrial, domestic, and stock uses required drilling wells at 33 locations in 17 counties.

Droughts not only reduce water supplies but can adversely affect water quality as well. During droughts, the inability of streamflow to flush and dilute chemical constituents can cause concentrations to increase to the point that the water is not usable for many purposes. An increase in temperature and a decrease in dissolved oxygen during low streamflow can cause fishkills. Less than average snowpack, low streamflow, and lowered water levels in reservoirs restrict snow- and water-based recreation, a major activity in Utah.

WATER MANAGEMENT

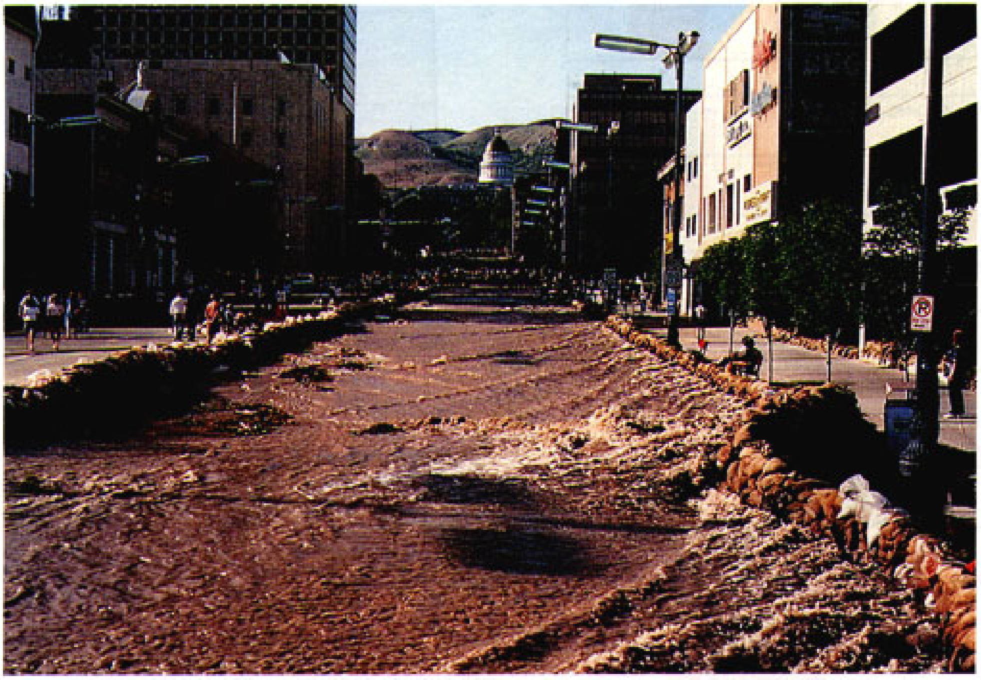
Disaster mitigation and recovery activities following floods and droughts may require direction from State government, but most of the emergency response actions are the responsibility of local government agencies. If a local government's response capabilities are exceeded, then it can request supplemental assistance from State and Federal Government agencies through the Utah Division of Comprehensive Emergency Management. Management of flood plains and related activities is coordinated by the Federal Emergency Management Agency in Denver, Colo. Water use during droughts is regulated by the Utah Division of Water Rights; however, planning and development of water-resources projects to ensure maximum public benefit are guided by the Utah Division of Water Resources.

Flood-Plain Management.—Management of flood plains is administered through the National Flood Insurance Program. In Utah, 182 communities participate in the program. Participating communities regulate development in the identified flood plains by adopting and enforcing flood-damage-prevention ordinances. In exchange for this flood-plain management at the local level, the Federal Government makes flood insurance available for purchase. As of May 1988, 1,002 policies insure buildings valued at about $56 million. During the floods that ravaged Utah in 1983 and 1984, payments of 317 damage claims amounted to $957,248 (Utah Division of Water Resources files).

Flood-Warning Systems.—Davis and Salt Lake Counties, in the Ogden-Salt Lake City area (fig. 2), operate flood-warning systems. Other counties and municipalities in the State rely on flood-warning systems that are limited mostly to flood-stage and weather forecasts provided by the NWS.

Davis County, in cooperation with the NWS, has installed a flood-warning system. This system presently (1988) includes nine stations; five additional stations are planned for installation. Each station consists of a realtime rain and stage recorder interfaced to a radio transmitter. The rain and stage data are received by computers and transmitted to the County Flood Control Office and Sheriff's Dispatch Office, which monitor the system 24 hours a day. If the rainfall or stage values exceed predetermined limits, an alarm alerts law enforcement and maintenance personnel. The NWS also monitors the system and when required issues warnings through its emergency broadcast system.

Salt Lake County operates 11 rainfall stations and 22 streamflow-gaging stations, some of which are used in an early flood-warning system. Recorders at three of the



Flooding along State Street in Salt Lake City, Utah, May 1983. (Photograph by Rulon Christensen, U.S. Geological Survey.)

rainfall sites are connected to a computer by a low-power radio transceiver. Realtime stage data are transmitted in 5-minute increments. If the rainfall exceeds 0.3 inch during any 15-minute period, the Flood Control Division is notified.

Water-Use Management During Droughts.—Water storage in the arid West is essential to the maintenance of adequate supplies during a dry summer season or a drought lasting more than 1 year. Most communities have enough water to endure a 1-year drought. In anticipation of a dry period continuing beyond 1 year, communities can impose restrictions on outside watering, waste due to careless handling of water systems, and domestic water use. Water for irrigation is allocated according to established water rights. Water users without reservoir-storage rights are affected the most during a drought. Municipal and industrial water users depend mostly on ground water and stored water during a drought. When springs and surface flows diminish, ground-water pumping is expected to be used to its maximum capacity.

Emergency water measures are available first to protect domestic uses and second to provide for livestock. No emergency measures are available for other uses such as irrigation, instream flows, boating, and wetlands. The State has regulatory authority only to reallocate water for domestic use. However, the State communicates with various local agencies to coordinate the best and most efficient use of the available water.

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