WYOMING
Floods and Droughts

Certain geographic aspects of Wyoming—mountain ranges, valleys, and the inland, northerly location—combine with moisture-laden winds from the west and southwest and cold, dry winds from the north to produce diverse weather and climatic conditions. The mountain ranges are barriers to moisture-laden winds from the Gulf of Mexico and the Pacific Ocean. The location and orientation of the mountain ranges cause winter and spring snows, widespread spring rains, and locally intense summer thunderstorms predominantly in the western and eastern parts of the State. Arid and semiarid conditions prevail in the central part of the State.

The variation of the movement of moist, dry airmasses and the duration of flow along particular paths have resulted in severe flooding and severe drought in Wyoming. The most severe, widespread flooding since the early 1900's occurred in 1923. During that year, peak discharges with recurrence intervals that exceeded 100 years resulted from snowmelt that probably was combined with rainfall runoff in the Laramie River basin during June, thunderstorms in the Bighorn and the Wind River basins during July, and widespread rainfall in the Bighorn, the Powder, and the North Platte River basins during September. These floods caused at least 20 deaths and damage in the millions of dollars (Casper Daily Tribune, October 2, 1923; Follansbee and Hodges, 1925). Although local in nature, one of the most devastating floods in terms of lives lost and property damage was in Cheyenne on August 1, 1985 (Druse and others, 1986). Locally intense thunderstorms produced peak discharges with recurrence intervals that exceeded 100 years on the two main drainages flowing through the city—Crow and Dry Creeks.

Droughts, as determined from decreased streamflow, occurred nearly statewide from 1929 through 1942, from 1948 through 1962, and from 1976 through 1982. Currently (1989), the State is experiencing drought conditions that started as early as 1987 in parts of western Wyoming. Discharge records for some streamflow-gaging stations indicate that the earlier droughts lasted nearly 14 years in some areas, although discharge records for other gaging stations indicate 1 or 2 intervening years of drought relief when the discharge was average or greater than average.

Planning and management responsibilities during floods and droughts are implemented to various degrees in Wyoming. State agencies and the Federal Emergency Management Agency (FEMA) are responsible for flood-plain management and, under certain conditions, for water-use management during droughts. Flood-warning systems have been established in Cheyenne, Lander, and Sheridan, and the National Weather Service (NWS) is establishing a network of 15 flood-forecast points in other parts of the State. The dependence of citizens and major industries on the adequate supply of suitable-quality surface water magnifies the importance of drought management. Only about 8 percent of the water used in Wyoming is obtained from ground-water sources; however, a long-term drought would increase demand for ground-water supplies, which in turn would adversely affect the economy of Wyoming.

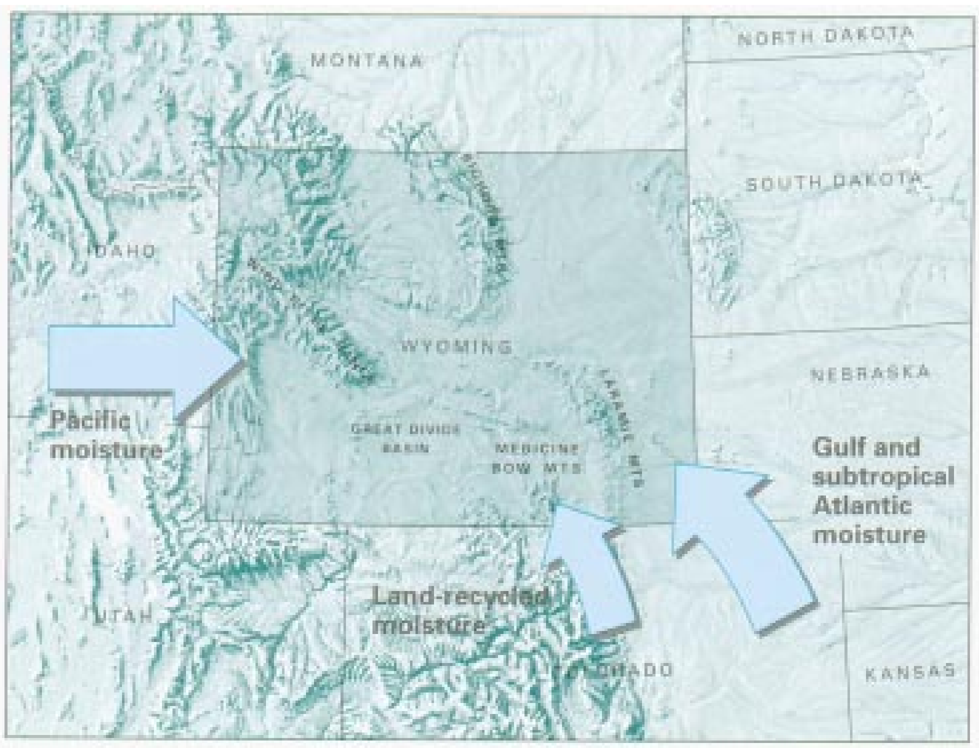

Figure 1. Principal sources and patterns of delivery of moisture into Wyoming. Size of arrows implies relative contribution of moisture from source shown. (Source: Data from Douglas R. Clark and Andrea Lage, Wisconsin Geological and Natural History Survey.)

GENERAL CLIMATOLOGY

Mountain ranges, valleys, and basins partition Wyoming into a geographic mosaic of diverse weather conditions and contrasting climates. Martner (1986) describes Wyoming as being within the range of southward winter movement of the polar jetstream in the upper atmosphere. The jetstream energizes storms in the lower atmosphere. During the winter, the path of the jetstream commonly is across or slightly south of Wyoming, subjecting the State to strong winds, frigid arctic airmasses, and frontal systems that occur when airmasses of differing warmth and moisture content collide. During the summer, the path of the jetstream commonly is north of Wyoming, resulting in generally mild weather.

Local topography markedly modifies Wyoming's regional weather and climate (Martner, 1986, p. 3). Topography largely governs the quantity and distribution of precipitation within the State. Most of Wyoming's mountain ranges, which trend northward, create barriers to the prevailing westerly winds. The winds force moist, low-level airmasses to rise along the mountain slopes; condensation and precipitation occur as the air reaches cooler altitudes. Consequently, much more precipitation falls on the mountains than on the plains. The high average altitude (about 6,700 feet) and northerly latitude ensure that the weather will be cool most of the year and that much of the annual precipitation will fall as snow. The midcontinent location also results in air that is relatively dry. Because of the effects of topography, the plains and basins throughout the State are arid to semiarid. Martner (1986) notes that average annual precipitation across Wyoming ranges from 6 inches in parts of the Bighorn River basin and the Great Divide basin to about 60 inches in some of the mountain ranges.

The principal sources of the moisture for Wyoming are the Gulf of Mexico (Martner, 1986, p. 82, 128; Miller and others, 1973, p. 8) and the Pacific Ocean (fig. 1). Most of this moisture falls as snow; at least 70 percent of the State's water supply originates as snow (Martner, 1986, p. 78, 104). The eastern two-thirds of Wyoming receives most of its moisture during the spring from a general pattern of easterly upslope winds that carry moist air from the Gulf of Mexico. This pattern of spring snowfall ends abruptly in central and southern Wyoming at the Medicine Bow, Wind River, and Bighorn Mountains, which are barriers to the moist airflow from the east. The area west of these mountains receives most of its snowfall during midwinter; the source of this moisture is the Pacific Ocean.

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.

Moisture delivered by summer thunderstorms occurs predominantly in the eastern and western parts of Wyoming; thunderstorms are not common in the central part of the State. In eastern Wyoming, thunderstorms are caused primarily by abundant humid air, and also by the warm land surfaces of the relatively lower altitudes. The moist air generally originates in the Gulf of Mexico and subtropical Atlantic Ocean and moves northwestward across the Central States, but commonly is at too low an altitude to cross the Laramie and Bighorn Mountains. Because of these topographic barriers, airmasses are drier on the west side of the mountains than on the east, and thunderstorms are less common on the west. In western Wyoming, thunderstorms deliver moisture that originated primarily in the Pacific Ocean; topographic barriers to the low-altitude, moist airflow protect the middle one-third of the State from these thunderstorms (Martner, 1986, p. 128).

The extent and severity of floods or droughts in Wyoming are influenced by the interrelations of moist air flow, topography, temperature, winds, and other climatic factors. Floods generally occur during the spring and summer as a result of snowmelt, widespread rain, rain combined with snowfall, or intense thunderstorms. The severity of the floods can be increased by: antecedent rainfall on ground that is sufficiently frozen to limit the quantity of moisture that can be absorbed, dam failures, blockage of the stream channels with debris or ice, or emergency releases of water from reservoirs. Some of the more severe floods occur when rain from either isolated thunderstorms or widespread storms falls on mountain snowpack. Even during periods of general drought, when the moisture flow into the State is less than average, flooding can be extreme owing to conditions such as rain on snow or intense thunderstorms. However, these conditions generally are local and result in a short period of greater than average runoff.

MAJOR FLOODS AND DROUGHTS

Floods and droughts can have a pronounced effect on the agricultural, mineral-development, and tourist industries, as well as on the general population. Surface-water sources comprise about 92 percent of the water used in Wyoming and about 51 percent of public supply (U.S. Geological Survey, 1990), although most towns have wells as alternative sources for water. Any disruption of the source or quality of water supplies has adverse effects throughout the State. Floods can damage any structure within their paths, temporarily disrupt transportation routes, and degrade water quality. Droughts decrease the supply of available surface and ground water, adversely affect water quality and fisheries, and commonly result in increased ground-water withdrawals.

Major floods and droughts, described herein, are those that were areally extensive and had significant recurrence intervals—greater than 25 years for floods and greater than 10 years for droughts. These major events, and those of a more local nature, are listed chronologically in table 1; rivers and cities are shown in figure 2. The evaluation of floods and droughts, as determined from streamflow records, is limited to the period starting about 1900 when the systematic operation of streamflow-gaging stations began. Five memorable floods (fig. 3) and three memorable droughts (fig. 4) in Wyoming are shown by maps prepared from records collected at about 25 gaging stations and by graphs prepared from records collected at six gaging stations. The selection of stations was based on areal distribution, diversity of basin size and hydrologic setting, and lack of substantial regulation to reflect natural runoff characteristics. Data from most gaging stations are indicative of runoff conditions from the various mountain ranges; however, data from the Powder River at Arvada (fig. 3, site 3) mainly reflect runoff from

Figure 2. Selected geographic features, Wyoming.

the plains areas. Streamflow data 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 Wyoming have been severe locally and have affected considerably smaller areas than the areas of those floods and droughts classified as major. However, some of these local floods have caused substantial loss of life and property damage, and local droughts have caused crop failures and water shortages. These floods and droughts are listed in table 1.

FLOODS

The areal extent and severity of major floods, as determined from the statewide network of gaging stations, and the magnitude of annual peak discharges at selected stations are shown in figure 3. The approximate areas affected by floods that had recurrence intervals of 25 to 50 years and greater than 50 years are shown on the maps. The magnitudes of discharges having recurrence intervals of 10 and 100 years and the dates of memorable floods are shown on the graphs and maps.

Although the extent is not as great as for some other floods, the flood of Clear Creek on June 11, 1912, was particularly noteworthy because it caused considerable damage. The flood, which had a peak discharge of 16,000 ft^3/s (cubic feet per second) and inundated numerous businesses and residences, resulted from an intense thunderstorm that was centered west of Buffalo (fig. 5).

The floods of June 12–18, 1918, affected most of the upper Yellowstone River and the upper Snake River basins and adjacent basins in northwestern Wyoming (fig. 3). The peak discharge of the flood at the gage on the Yellowstone River at Corwin Springs, Montana (fig. 3, site 1) exceeded the 100-year recurrence interval.

"The big floods of 1923" probably are the floods most mentioned by long-term residents when speaking of severe floods. Flooding was severe in 1923 between June 9 and 13 in the Laramie River basin (fig. 3), July 23 and 25 in the Bighorn and Wind River basins (fig. 3), and September 27 and 30 in the Bighorn, Powder, and North Platte River basins. At several gaging stations operated in the flooded areas during 1923, peak discharges had recurrence intervals that exceeded 100 years. On September 29, 1923, the Powder River at Arvada (fig. 3, site 3) had a peak discharge of 100,000 ft^3/s—more than twice that of any other discharge for the period of record.

Damage during the flood in July 1923 was most extensive along tributaries to the Bighorn and Wind Rivers north of Shoshoni. Two lives were lost, and the Chicago and Northwestern Railway alone had $1 million in damage (Follansbee and Hodges, 1925, p. 110). The July flood resulted from widespread severe thunder-

Table 1. Chronology of major and other memorable floods and droughts in Wyoming, 1912–88

[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	June 11, 1912	Clear Creek	>100	Locally intense thunderstorm. Widespread damage in Buffalo.
Flood	June 12–18, 1918	Northwest and west-central Wyoming.	30 to >100	Snowmelt, probably combined with rainfall runoff.
Flood	June 9–13, 1923	Laramie River	25 to >100	Snowmelt, probably combined with rainfall runoff.
Flood	July 23–25, 1923	Bighorn and Wind Rivers	20 to >100	Widespread thunderstorms. Deaths, 2; damage to Chicago and Northwestern Railway alone was $1 million.
Flood	Sept. 27–30, 1923	Bighorn, Powder, and North Platte Rivers and North Platte River tributaries near Casper.	60 to >100	Five days of widespread rainfall. Railroad bridge washed out east of Casper; 18 deaths resulted.
Flood	June 1–5, 1929	Crow Creek	Unknown	Rainfall combined with snowmelt runoff. Damage in Cheyenne along Crow Creek.
Drought	1929–42	Statewide	10 to >25	Regional.
Flood	May–June, 1935	North Platte River tributaries near Glendo.	10 to >100	Snowmelt and locally intense thunderstorms.
Drought	1948–62	Statewide	>25	Regional.
Flood	Feb., May, and June 1962	Bighorn and North Platte Rivers—Feb.; Powder and Tongue Rivers—May and June; and Beaver Creek—June.	25 to >100	Snowmelt from warm chinook winds (Feb.). Rainfall runoff or snowmelt or both (May and June).
Flood	June 15–17, 1963	Goose and Clear Creeks	20 to >100	Widespread and locally intense rainfall combined with snowmelt runoff. Deaths, 1 in Sheridan.
Flood	May–June 1965	North Platte River tributaries near Glenrock and Douglas—May; upper Green River—June; and Laramie River—June.	30 to >100	Widespread rainfall combined with snowmelt runoff.
Flood	June 1965	North Platte River tributaries near Glendo.	>50	Locally intense thunderstorms.
Drought	1968–70	Statewide	5 to 25	Less than average streamflow for 1 to 3 consecutive years in most streams.
Drought	1976–82	Statewide	10 to >25	Less than average streamflow for 2 to 4 consecutive years in most streams.
Flood	May 18–20, 1978	Bighorn River tributaries near Worland and Powder River and tributaries.	20 to >100	Widespread rainfall combined with snowmelt runoff.
Flood	June 9, 1981	Shoshone and upper Snake Rivers.	40 to >100	Widespread rainfall combined with snowmelt runoff. Damage to rural property.
Flood	May 12–17, 1984	North Platte River and tributaries near Saratoga and Little Snake River.	>100	Rainfall combined with snowmelt runoff. Augmented on Little Snake River when dam was breached. Damage to rural property and Baggs.
Flood	Aug. 1, 1985	Crow Creek and tributaries at Cheyenne.	>100	Locally intense thunderstorms. Deaths, 12; damage to Cheyenne, $61.1 million.
Flood	June 2–11, 1986	West-central, southwest, and south-central Wyoming.	20 to >100	Rainfall combined with snowmelt runoff. Damage to rural property.
Drought	1987–present	Statewide except southeastern Wyoming.	Unknown	Primarily affected western Wyoming in 1987; area increased to nearly statewide in 1988.

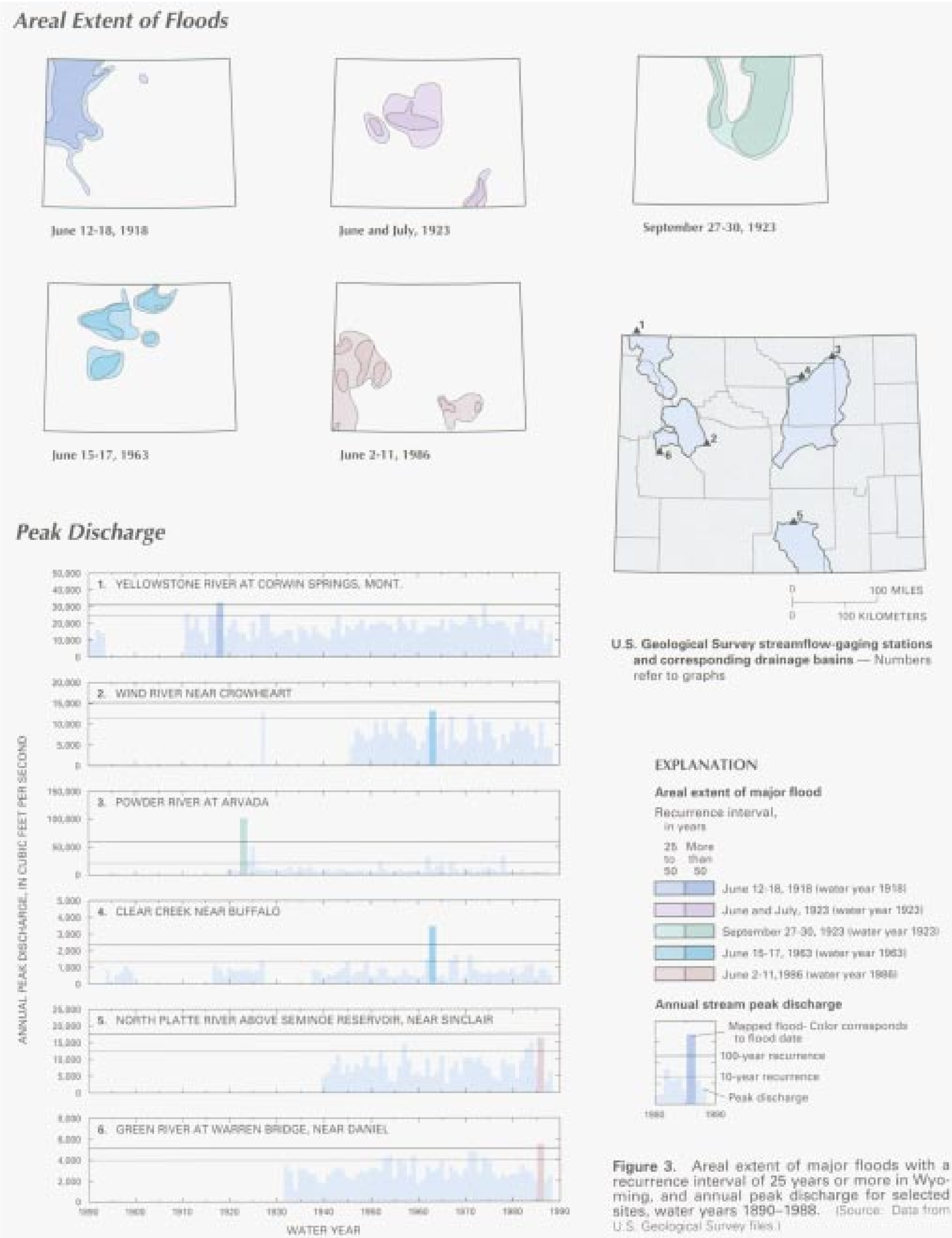

Figure 3. Areal extent of major floods with a recurrence interval of 25 years or more in Wyoming, and annual peak discharge for selected sites, water years 1890–1988. (Source: Data from U.S. Geological Survey files.)

Main street of Buffalo following June 11, 1912, flood in Clear Creek, Wyo.; maximum discharge was about 16,000 cubic feet per second. (Photograph from U.S. Geological Survey files.)

storms that were preceded by several days of moderate rainfall. The floods in September 1923 also resulted from widespread rainfall; Follansbee and Hodges (1925, p. 117) note that "The flood on the Powder River was the largest that has occurred in the 40 years that . . . settlers have lived in the valley." The September flood on Cole Creek, east of Casper, collapsed a railroad bridge, causing a locomotive and passenger cars to fall into the floodwater. The Casper Daily Tribune (October 2, 1923) reported 5 people known dead and 21 missing; subsequent newspaper accounts reported 18 dead.

The floods of June 15–17, 1963, affected most basins in north-central Wyoming. Peak discharges on several streams were similar in severity to those on Clear Creek near Buffalo (fig. 3, site 4). On Clear Creek near Buffalo, runoff from snowmelt that began in early June was thought to have peaked between June 3 and 5 and was receding when rain began on June 14 (Rennick, 1968, p. 80–84). The rainfall caused rapid melting of the remaining snowpack and resulted in flooding that caused one death in Sheridan and extensive damage to homes and businesses in Lander and Sheridan and near Greybull.

Flooding of the Little Snake River, caused by extensive snowmelt during May 12–17, 1984, inundated most of the town of Baggs for several consecutive days. The flooding was augmented on May 16, when the dam on Grieve Reservoir, about 30 miles upstream, was breached.

Baggs, Wyo., during May 12–17, 1984, flood of the Little Snake River; maximum discharge was about 13,000 cubic feet per second. (Photograph from U.S. Geological Survey files.)

The flood of August 1, 1985, in Cheyenne was one of the most devastating historic floods in Wyoming, even though it did not affect a large area (Druse and others, 1986). This flood was the result of unusually severe thunderstorms that centered over Cheyenne and covered an area of about 50 square miles. Twelve storm-related deaths, numerous injuries, and $61.1 million in damage that resulted from this storm were reported by FEMA (J.D. Swanson, written commun., 1985). The recurrence intervals of the peak discharges (fig. 5) at all sites on Dry Creek and at two downstream sites on Crow Creek exceeded 100 years.

During June 2–11, 1986, snowmelt runoff from mountain areas caused record or near-record peak discharges at several gaging stations in southern and western Wyoming (fig. 3). Druse and others (1987, p. 7) reported peak discharges with recurrence intervals that nearly exceeded 100 years on the North Platte River above Seminoe Reservoir, near Sinclair (fig. 3, site 5), and that were greater than 100 years on the Green River at Warren Bridge, near Daniel (fig. 3, site 6). Damage throughout the flooded areas was limited to bridges and rural property.

Methods to determine the relation of selected features to recorded and nonrecorded historic floods have been investigated by M.E. Cooley (U.S. Geological Survey, retired, written commun., 1987). These features included fluvial terraces and bottom-land channels, flood deposits, vegetation affected by floods, and soils. Additionally, Cooley researched flood information from newspapers, area residents, and agency records. Cooley noted that floods in July and September 1923 were the largest and most severe in the history of Wyoming, and he identified two periods—1918 to 1927 and 1962 to 1982—when floods were more frequent and generally more widespread than normal throughout the State. More large floods occurred during the decade of 1918–27 than during any other decade.

Droughts

Droughts in Wyoming, as determined from streamflow records collected since the early 1900's, were most notable during three periods—1929–42, 1948–62, and 1976–82. The areal extent and severity of these major droughts, as determined from records for 22 long-term gaging stations, are shown on the maps in figure 4. Annual departure from long-term average stream discharge at six gaging stations is shown in figure 4. Departures from long-term average monthly streamflow were used to determine recurrence intervals of the droughts. Records for some gaging stations indicate an almost continuous deficiency of monthly discharge throughout a given drought, whereas records for other gaging stations have 1 or more years when monthly flows were average or greater. Such short-term reversals may indicate two separate droughts or a temporary variation within the longer drought. Generally, recurrence intervals were computed for each individual drought within the longer drought period.

The graphs in figure 4 illustrate how the droughts affected streamflow at the gaging stations. The statewide drought of 1929–42 had a recurrence interval greater than 25 years in all parts of the State except the Powder River basin, where the recurrence interval was 10–25 years. The annual-departure graph for the Yellowstone River at Corwin Springs, Montana (fig. 4, site 1), indicates that streamflow at that site was less than average most of the time from

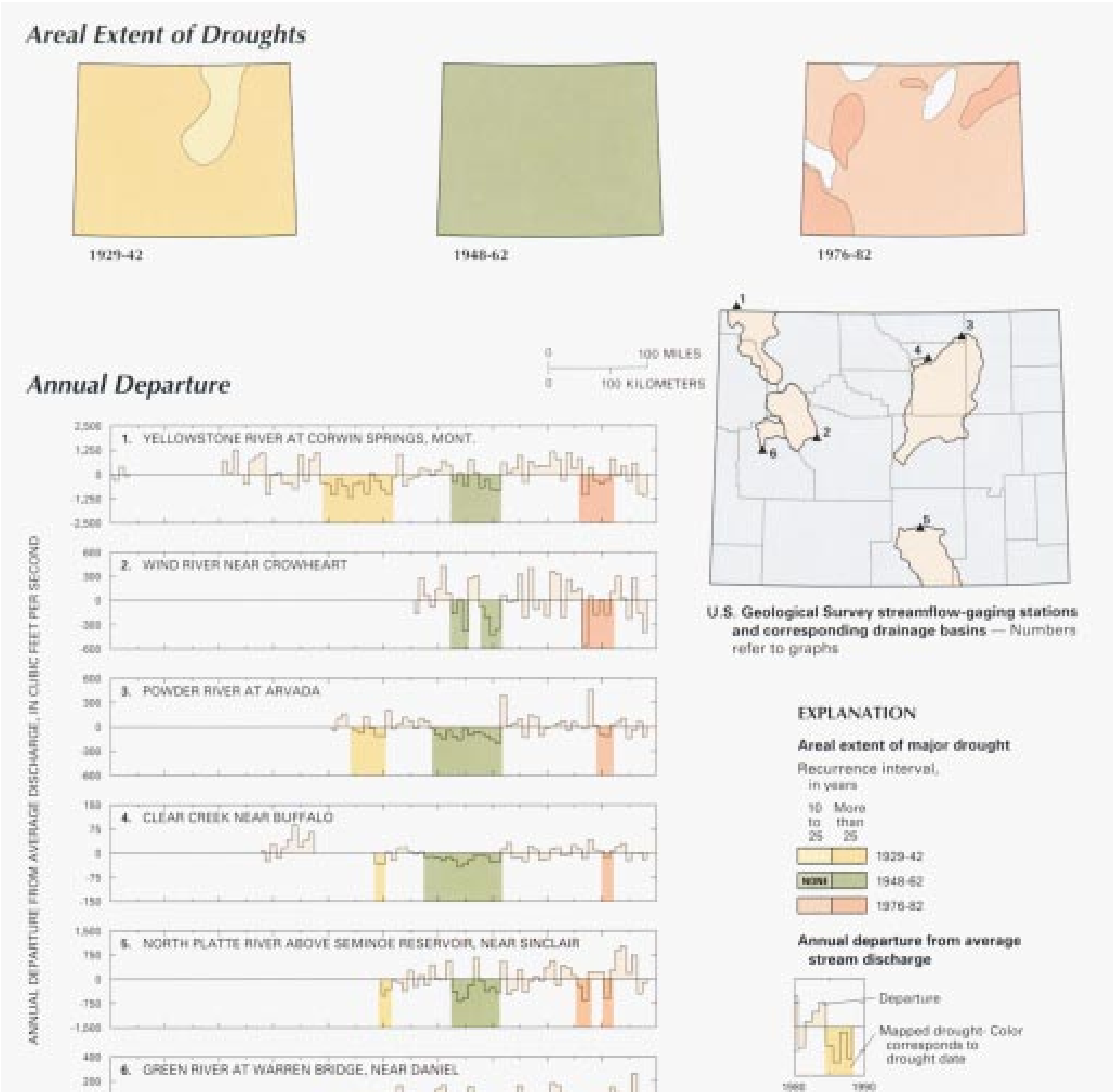

Figure 4. Areal extent of major droughts with a recurrence interval of 10 years or more in Wyoming, and annual departure from average stream discharge for selected sites, water years 1890–1988. (Source: Data from U.S. Geological Survey files.)

1929 to 1942; the drought had a recurrence interval that exceeded 25 years. The drought of 1929–42 also was severe on the Green River at Warren Bridge, near Daniel (fig. 4, site 6). There, the drought recurrence interval also exceeded 25 years, even though the site had intermittent periods of greater than average flow.

During 1948–62, more gaging stations were in operation in the State than during the 1929–42 drought. As a result, a more refined determination of the areal extent of the drought was possible. The drought of 1948–62 was regional and had a recurrence interval exceeding 25 years statewide (fig. 4); the Powder, Wind, and Green River basins were the most severely affected. Streamflow records for the Powder River at Arvada (fig. 4, site 3) and Clear Creek near Buffalo (fig. 4, site 4) indicate less than average annual flow for the entire 1948–62 period. Records for the other sites indicate fewer years of drought, even though the drought may have been equally severe in terms of recurrence interval and streamflow deficit from the beginning to the end of the drought.

A drought during 1968–70 was apparent at most gaging stations in the State, but recurrence intervals were less than 10 years for most sites. The duration of less than average annual flow was 1 to 3 years.

The drought of 1976–82 was less severe than the droughts of 1929–42 and 1948–62; in most of the State the recurrence interval was 10–25 years (fig. 4). The most severely affected areas were the upper Yellowstone (site 1), Wind (site 2), upper Green (site 6), Bear, and Belle Fourche River basins, where the drought had a recurrence interval of greater than 25 years or was continuous. The rest of the State had only short or interrupted periods of drought.

The State was affected by locally intense drought conditions during 1988. Only in extreme southeastern Wyoming were streamflow and precipitation about average. The severity of this drought has not yet been determined. Four of the gaging stations (fig. 4, sites 1, 2, 5, and 6) indicate less than average annual flow starting in 1987.

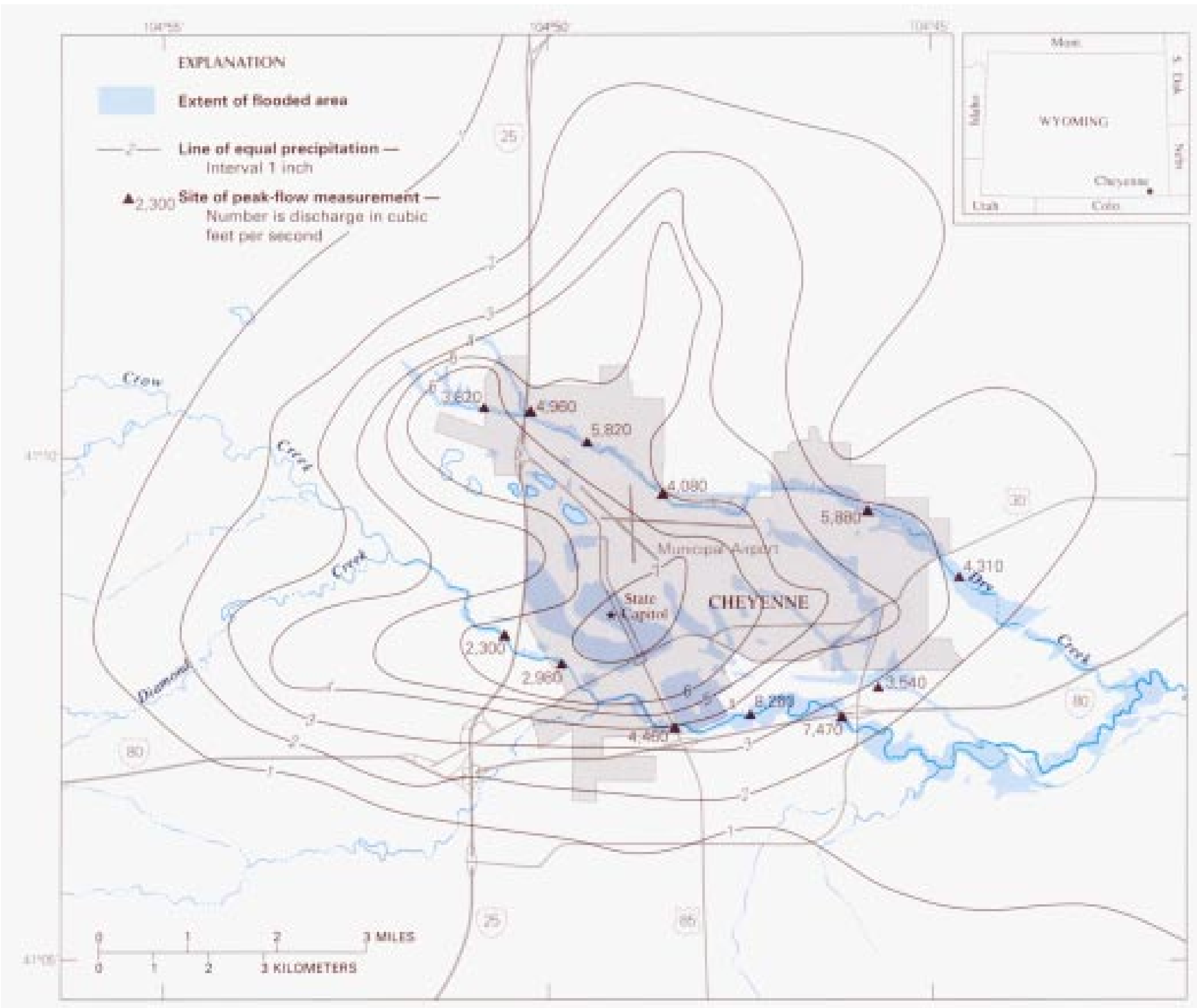

Figure 5. Precipitation and peak flows of Dry Creek, Crow Creek, and an unnamed tributary of Crow Creek resulting from the storm of August 1, 1985, Cheyenne, Wyoming. (Source: Precipitation data compiled by National Weather Service on U.S. Geological Survey base map, Cheyenne, 1981, scale 1:100,000; peak-flow data from U.S. Geological Survey files.)

WATER MANAGEMENT

Contingency planning for floods or droughts and responses during floods or droughts are coordinated at all levels of government—Federal, State, county, and local. Responsibilities for flood-plain management, flood-warning systems, and water-use management during droughts are divided among several agencies.

Flood-Plain Management.—Flood-plain management programs in Wyoming have been implemented by FEMA through the National Flood Insurance Program (Grant Sorensen, Wyoming Emergency Management Agency, written commun., 1987). The State Assistance Program, which began about 1980 and ended in 1985, was developed to enhance State and local roles in flood-plain management, flood-hazard mitigation, and the National Flood Insurance Program. That program was instrumental in helping FEMA to implement the National Flood Insurance Program. As of April 1986, FEMA had identified 82 communities in Wyoming as having "Special Flood Hazard Areas." Of the 82 communities, 49 are in the regular phase of the National Flood Insurance Program, 15 are in the emergency phase, 2 are in the application phase, and the others have not yet applied.

Flood-Warning Systems.—Flood-warning systems that have various degrees of sophistication are operated in Cheyenne, Lander, and Sheridan (Brenda Brock, National Weather Service, oral commun., 1987). Cheyenne has a network of streamflow and precipitation gages in upstream areas that are linked by radio to receiving stations at local NWS and Civil Defense offices. Lander has installed an electronic device that sounds an alarm at one of the local government offices when a critical stream stage is reached. Sheridan has a rainfall- and flood-observer network. On a statewide basis, the NWS in 1987 was establishing 15 flood-forecast points.

The Wyoming Emergency Management Agency, in cooperation with the NWS, provides technical assistance to any local community interested in developing and implementing any type of flood-warning system (Grant Sorensen, Wyoming Emergency Management Agency, written commun., 1987). Flood-warning systems generally are viewed as "local self-help programs."

Water-Use Management During Droughts.—Water-use management during droughts is considered to be primarily a local responsibility, although there are contingencies to involve State agencies (John Shields, Wyoming State Engineer's Office, written commun., 1987). Requests for State assistance originate at the county level, and local officials coordinate onsite action. The Governor has authority to declare a State emergency and to designate disaster areas. Planning responsibilities are delegated to the Wyoming Emergency Management Agency. The State Planning Coordinator is designated to oversee State and Federal response actions. As droughts develop, monitoring of water supplies and dissemination of water data are intensified. Water conservation is fostered by the State Engineer through strict regulation of water rights.

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