USE OF PALEOFLOOD INVESTIGATIONS TO IMPROVE FLOOD-FREQUENCY ANALYSES OF PLAINS STREAMS IN WYOMING

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 88-4209

Prepared in cooperation with the
WYOMING HIGHWAY DEPARTMENT

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CONVERSION FACTORS

For use of readers who prefer to use metric (International System) units, rather than the inch-pound terms used in this report, the following conversion factors may be used:

Multiply inch-pound unit	By	To obtain metric unit
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile ($ft^3/s/mi^2$)	0.01093	cubic meter per second per square kilometer
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

USE OF PALEOFLOOD INVESTIGATIONS TO IMPROVE FLOOD-FREQUENCY

ANALYSES OF PLAINS STREAMS IN WYOMING

By Maurice E. Cooley

ABSTRACT

Paleoflood onsite evidence was used to: (1) Develop additional information on historical peak flows, and (2) improve flood-frequency curves of short-term (8 to 22 water years) peak-flow records of ephemeral and intermittent streams in the plains region of Wyoming. The adjusted flood-frequency curves are more representative of long-term conditions. Twenty-one gaged drainage basins were evaluated. Drainage areas upstream from the streamflow-gaging stations range from 0.81 to 515 square miles, but are less than 50 square miles for 18 of the stations.

A reconnaissance was made to relate historical and recorded peak flows to certain conspicuous drainage features. These features include: (1) Geomorphic features, such as bottom land, fluvial terraces, and channel features; (2) flood deposits, such as overbank deposits and point-bars and associated deposits; (3) botanic features, such as wood debris deposited by floods, damage to plants by flood flows, buried root crowns, and vegetation in overflow (frequently inundated) areas; and (4) soils.

Study-area drainages are classified geomorphically into three general types on the basis of distribution of paired and unpaired terraces, and on channel and other bottom-land features. In type-1 drainages, paired terraces predominate and comprise most of the bottom land; channels are usually deep and narrow. In type-2 drainages, unpaired terraces and locally developed paired terraces are present; channels generally are wide, shallow, and contain large sand and gravel bars. In type-3 drainages (recognized only in southwestern Wyoming) a single low terrace comprises most of the wide bottom land. The terrace is bordered by alluvial fans that are adjacent to the valley sides; channels are narrow and shallow.

The recognition of fluvial geomorphic events of the past few centuries has been helpful in relating the geomorphic information to the classification of drainages, and in evaluating large historical floods. The sequence of geomorphic events, including channel trenching and terracing, is recorded best in type-1 drainages. The approximate depth and configuration of the present channels was attained for type-1 drainages during 1850-1900; for type-2 drainages, a few centuries ago; and for type-3 drainages, at least before about 1930, and probably during the late 19th century.

Relative magnitudes of peak flows were classified on the basis of their relation to geomorphic features, especially terraces and channels. This classification allows a comparison of the flows of different drainages, regardless of the size of the drainage basin and the quantity of flow. The peak-flow classification was applied to each drainage type, and generalized models were obtained for each type. In general, in all drainage types, very small and small peak flows are confined to the lower part of the channel;

medium peak flows fill the channel (bankfull stage) and inundate the overflow area; and large to very large peak flows inundate most or all of the bottom land.

Certain selected precipitation characteristics and flood information affect interpretations that are used to extend short-term peak-flow records. Monthly precipitation records indicate that flood-producing storms probably were more frequent from 1900 to 1930 and from 1962 to 1982, than during the intervening period from 1931 to 1961. Similarly, floods along major rivers and reported large flows of streams in the plains region of Wyoming were more numerous during 1900-30, particularly during 1918-27, and also during 1962-82, than from 1931-61. Two droughts occurred during 1931-61—one during the early and mid-1930's, and the other during the early 1950's.

Historical adjustments, based on the time of formation of geomorphic features and the relation of peak flows to the geomorphic features, were made to the short-term records for the 21 stations. Most of the station records were extended to 50 years or less; four were extended to 100 years; one was extended to a maximum of 200 years.

Adjusted flood-frequency values were computed for the 21 study drainages for recurrence intervals as much as twice as long as the historical adjustment. On the basis of historical adjustments, substantial changes in peak flows for most recurrence intervals were made for most of the station records. The peak flow for a recurrence interval of 50 years for one drainage was adjusted upward by 86 percent; for another drainage, the peak flow was adjusted downward by 63 percent. Overall, the estimated 50-year flood was increased for 7 drainages and decreased for 14 drainages.

INTRODUCTION

Floodflow information is necessary for the efficient design of highway bridges, culverts, and other hydraulic structures. The types of information needed include stage-discharge relations, flood-frequency relations based on annual peak flows, and runoff-volume relations. Such information for small drainage basins in Wyoming--particularly for the plains region--was practically nonexistent before 1958. A program was begun in 1958 to collect and analyze floodflow information for small drainage basins, principally in the plains, to fill this information gap. The program, conducted by the U.S. Geological Survey in cooperation with the Wyoming State Highway Department, included establishment and operation of a large number of partial-record streamflow-gaging stations (Druse and others, 1988). There were two types: (1) Crest-stage stations, at which only annual peak flows were monitored, and (2) flood-hydrograph stations, operated seasonally. Most partial-record stations were operated for less than 25 years; in some cases, less than 10 years. Peak-flow data for flood-frequency analyses and interim flood-frequency reports have been collected at about 140 partial-record stations in Wyoming (Lowham, 1976; Craig and Rankl, 1978; Lowham, 1988).

The short-term records of peak flows collected at partial-record stations on ephemeral and intermittent streams in the plains region of Wyoming may not represent long-term conditions accurately because of the extreme variability of peak flows. In the plains region, it is not uncommon for only low flows or no flow to occur for several consecutive years; conversely, a series of high flows occasionally may occur during a single year. The statistical uncertainty of short-term records can be decreased if the record can be extended. Because data collection at crest-stage stations and other types of streamflow-gaging stations is expensive and time consuming, an investigation to determine the feasibility of extending the records using onsite paleoflood techniques was conducted during the 1980's by the Geological Survey in cooperation with the Wyoming Highway Department, as a supplemental part of the program described above.

Purpose and Scope

The purpose of this report is to describe the results of the investigation of paleoflood techniques that were conducted to: (1) Develop additional information pertaining to historical peak flows at selected streamflow-gaging stations, and (2) use the additional information to improve flood-frequency curves at the stations by making the curves more representative of long-term conditions. Paleoflood hydrology is defined as "...the study of the movements of water and sediment in channels before the time of continuous hydrologic records or direct measurements" (Costa, 1986, p. 428). Paleoflood techniques have been used for describing the flood history and for extending flood records. Some pertinent paleoflood investigations include studies by Costa (1978, 1986); Kochel and Baker (1982); and Gregory (1983). A brief discussion of the methods used in paleoflood hydrology and examples of historical adjustments to flood-frequency curves are presented in this report.

Stations Used in the Analysis

After identification of drainage basins in the plains region of Wyoming for which peak-flow data are available, 21 gaged drainage basins were selected for detailed investigations (fig. 1 and table 1). Each drainage basin has an active or discontinued streamflow-gaging station: 17 are crest-stage stations; three are crest-stage stations converted from flood-hydrograph stations; and one is a continuous-record station converted from a flood-hydrograph station. Drainage areas upstream from the 21 stations range from 0.81 to 515 mi^2; however, 18 of the drainage areas are less than 50 mi^2. The maximum length of systematic record is 23 water years (water years 1961-82); the minimum is 8 water years (water years 1965-72). Analytical procedures used in the study are summarized in the following section.

Analytical Procedures

A flood-frequency curve indicates the relation of annual peak flows to their frequency or probability of occurrence at a specified location. The curve is assumed to be based on a random homogenous sample of peak flows. The reliability of a curve depends on how well the sample of peak flows represents the long-term distribution, or population, of annual peak flows at the study site. In general, the longer the record of sample peak flows, the more reliable the estimates of probability of occurrence. Even with a record of 50 to 100 years, the probability of flood occurrences cannot be determined with precision (Wahl, 1970, p. 7); however, for practical purposes, it is assumed that the sample of peak flows represents the population of peak flows.

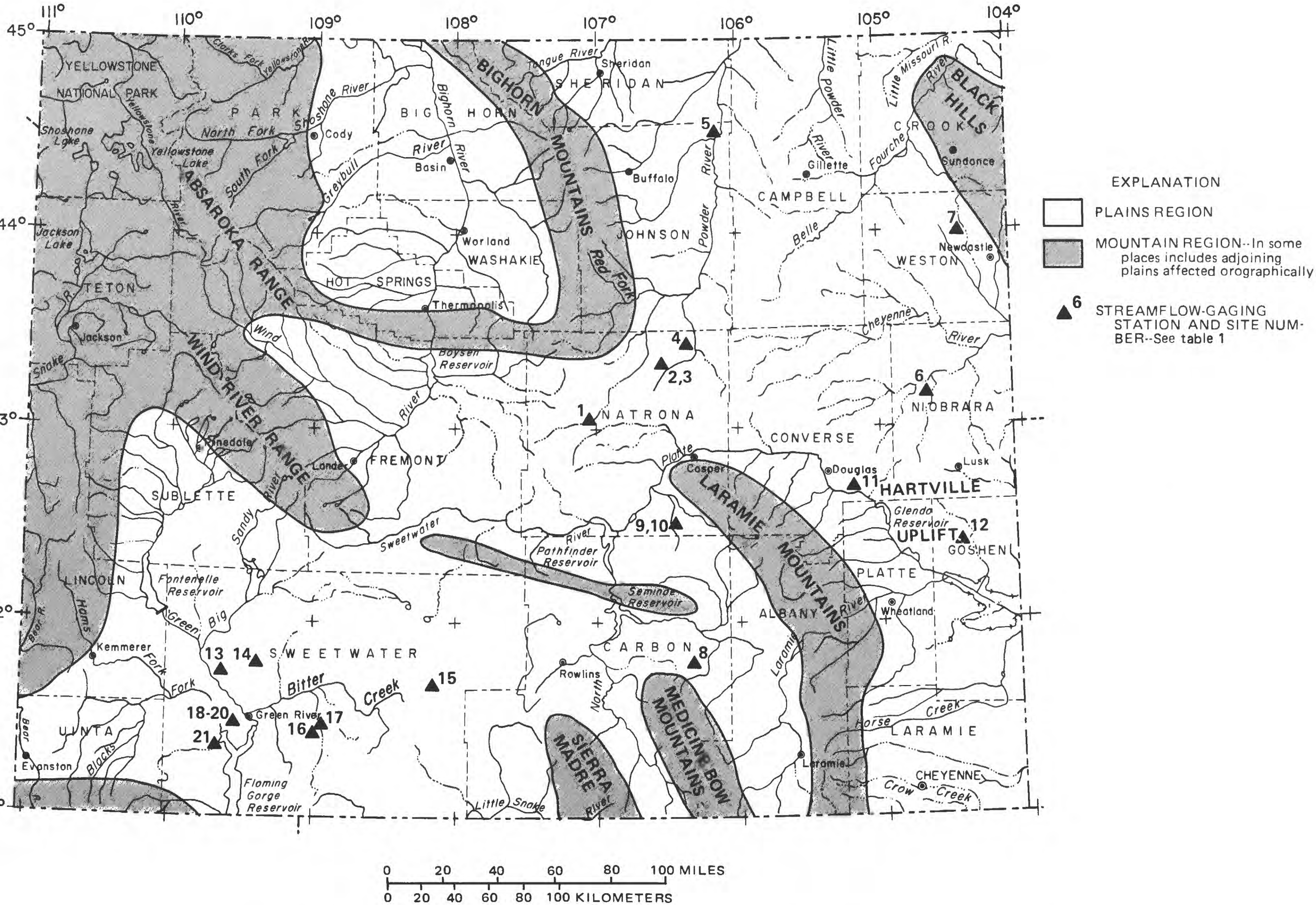


Figure 1.--The plains region of Wyoming and location of streamflow-gaging stations and miscellaneous-observation sites investigated.

Table 1.--Streamflow-gaging stations and records used in investigation

[Station type: CS, crest stage; FH, flood hydrograph; Con, continuous record]

Site number in figure 1	Station number	Station name	Drainage area (square miles)	Records available (water years)	Station type	Geomorphic drainage type
		Powder River basin				
1	06312700	South Fork Powder River near Powder River	262	1961-82	CS	1
2	06312910	Dead Horse Creek tributary near Midwest	1.53	1965-72	CS	1
3	06312920	Dead Horse Creek tributary no. 2 near Midwest	1.34	1965-72	CS	1
4	06313180	Dugout Creek tributary near Midwest	.81	1965-74, 1974-82	FH Con	1
5	06316700	Coal Draw near Buffalo	1.64	1965-73, 1973-82	FH CS	1
		Cheyenne River basin				
6	06382200	Pritchard Draw near Lance Creek	5.1	1964-72, 1972-81	FH CS	1
7	06387500	Turner Creek near Osage	47.8	1959-82	CS	1
		North Platte River basin				
8	06631150	Third Sand Creek near Medicine Bow	10.8	1965-73, 1973-81	FH CS	1
9	06642700	Lawn Creek near Alcova	11.5	1961-82	CS	1
10	06642730	Stinking Creek tributary near Alcova	1.34	1961-71	CS	1
11	06651800	Sand Creek near Orin	27.8	1955, 1961-82	CS CS	2
12	06670985	Dry Rawhide Creek near Lingle	20.0	1969-81	CS	1
		Green River basin				
13	09216290	East Otterson Wash near Green River	16.6	1969-82	CS	1
14	09216350	Skunk Canyon Creek near Green River	15.7	1965, 1971-81	CS CS	3
15	09216537	Delaney Draw near Red Desert	32.8	1961-82	CS	3
16	09216695	No Name Creek near Rock Springs	18.2	1973-81	CS	1
17	09216700	Salt Wells Creek near Rock Springs	515	1959-76	CS	1
18	09224810	Blacks Fork tributary no. 2 near Green River	12.0	1965-81	CS	3
19	09224820	Blacks Fork tributary no. 3 near Green River	3.59	1965-82	CS	3
20	09224840	Blacks Fork tributary no. 4 near Green River	1.26	1965-81	CS	3
21	09224980	Summers Dry Creek near Green River	423	1965-81	CS	2

The flood-frequency curves discussed in this report were developed using procedures recommended by the Interagency Advisory Committee on Water Data (1981). An assumption of the procedures is that the distribution of annual peak flows can be represented by a log-Pearson Type III probability distribution.

Where short-term flow records exist, with large and very large peak flows occurring either during or outside the period of systematic record, the peak-flow data can be used to compute historically adjusted flood-frequency curves (Interagency Advisory Committee on Water Data, 1981). The procedure, in effect, extends the record by filling in the ungaged part of a historical period with an appropriate number of replications of the systematic record less than the magnitude of the historical peak flow(s). This procedure was used in this study.

Key information in the process of making a historical adjustment to a flood-frequency curve, or, in effect, of extending peak-flow data, is the dates and the discharge rates of historical peak flows that occurred outside the streamflow record. Paleoflood investigations can be used to determine the approximate dates and elevations of the historical peak flows. The discharge for a given paleoflood elevation is estimated using applicable methods of open-channel hydraulics.

The following steps were used to determine the dates, elevations, and discharges of historical peak flows, and then to adjust the appropriate flood-frequency curves for each of the 21 study sites:

1. A reconnaissance was made to identify high-water marks for paleofloods, to relate these high-water marks to pertinent physical features at the site and to available streamflow data, and to photograph the pertinent features. These pertinent features include: (1) Geomorphic features used to classify the drainages; (2) flood deposits; (3) botanic features; (4) soils; and (5) cultural features.

2. Local residents were contacted to obtain information about historical floods.

3. Cross sections were developed to show the relation between the geomorphic features, observed high-water marks, and previously recorded peak flows; to classify each drainage as to geomorphic type; and to classify the peak flows for relative magnitudes on the basis of their relations to the geomorphic features.

4. The discharge and date of each peak flow associated with observed historical high-water marks were estimated.

5. The number of years the station records reasonably could be extended was determined based on the established onsite information, coupled with general interpretive information derived from the sequence of geomorphic events and selected precipitation characteristics and flood information of the 20th century.

6. Flood-frequency curves were adjusted using the historical peak flows and the extended record.

PALEOFLOOD INVESTIGATIONS

Paleoflood investigations consisted of a reconnaissance of each drainage basin in order to relate certain drainage features to the recorded and historical peak flows. These features generally are recognized easily and are widely distributed along the selected plains streams investigated. The principal features observed were: (1) Geomorphic features, such as fluvial terraces and channel characteristics; (2) flood deposits, such as overbank deposits and point bars and associated deposits; (3) botanic features, such as wood debris deposited by floods, damage to plants by flood flows, buried root crowns, and vegetation in overflow areas; and (4) soils.

Geomorphic Features

Geomorphic features, sculptured by streamflow, comprise the basic framework for this study, because their type, configuration, and distribution are related to certain streamflow characteristics, such as the magnitude of peak flow and volume of streamflow; they also are related partially to frequency and duration of peak flows. Therefore, the present fluvial geomorphic features may be considered the end product of the cumulative effects of all previous flows in a stream.

Bottom Land

The term bottom land, as used throughout this report, is defined as the part of the valley floor that may be inundated by infrequent, very large peak flows. These very large peak flows may be substantially larger than those listed in the streamflow-gaging records. Many were reported by residents as having occurred during the first few decades of the 20th century. The bottom land consists of the channel and adjoining valley flats, and includes the low terraces and gentle slopes that generally are less than 20 ft above the streambed.

Fluvial Terraces

Fluvial terraces form topographic features such as benches, narrow platforms, or steps along a stream (fig. 2). The summits of the terraces are nearly flat, and the sides are steep. One or more levels of terraces may be present, although the type, number, and distribution of the terraces may vary along different streams and along different reaches of the same stream. Generally, terraces represent former levels of valley floors.

Paired terraces are those terraces present at similar levels along both sides of a stream (fig. 2). Some drainages have two or three sets of paired terraces that can be related to peak flows. Most terraces have been eroded from sandy to silty alluvium that contains little gravel. These terraces are distributed widely along the drainages selected for study, and they may be traceable throughout most of the drainage basin. Characteristically, the heights of paired terraces are consistent in a given reach of a stream, although the heights may vary in different reaches. Generally, a relation exists between the heights of the paired terraces and the width of the valley floor--the terraces are higher along a narrow valley floor and lower along a wide valley floor. A consistent height relation also exists between the levels of the paired terraces and the peak flows; this relation can be

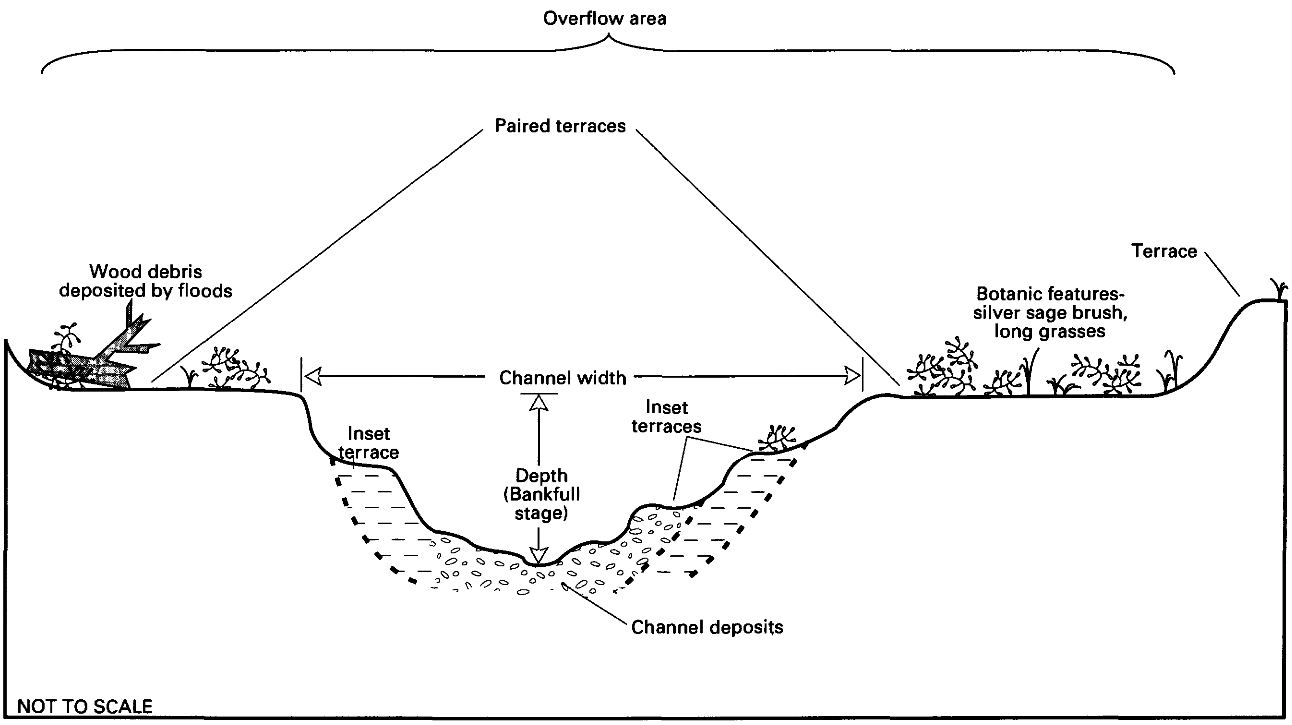


Figure 2.--Fluvial terraces and related channel and botanic features.

determined from the positions of the high-water marks traced along the terraces. This height relation allows comparison of the relative magnitude of peak flows along different drainages with paired terraces even though the discharge of the peak flows may have varied substantially in the different drainages.

Unpaired terraces occur as local features at variable heights above the streambed. A single terrace remnant also may vary considerably in height; usually the upstream end of the remnant is not as high above the streambed as the downstream end. Unpaired terraces usually are formed by streams that have numerous, extremely variable, large and very large peak flows and that transport large quantities of sand and gravel--conditions that favor fluctuations in the depths and widths of channels, and the formation of transitory channel features, such as sand and gravel bars.

Inset terraces (fig. 2) are narrow, alluvial, benchlike features, that may be present along the lower sides of channels of streams that are mainly ephemeral and intermittent. These terraces are formed by small peak flows that inundate only the lower one-half of the channel and that deposit (mainly from suspension) silty to sandy sediments that comprise the terraces. Locally, as many as three distinct levels of inset terraces may be present, although most channels have only one or two levels of inset terraces. Generally, inset terraces are discontinuous, and their heights above the streambed vary considerably along different reaches of a stream. However, in a given reach, the heights above the streambed of the inset terraces are consistent and allow for establishing a consistent height relation between the inset terraces and the peak flows that partially fill the channel.

The presence, condition, or absence of inset terraces help determine the size and relative frequency of recent flows in a channel. Well-formed inset terraces indicate that small peak flows (that form the terraces), rather than medium and very large peak flows, were predominant during one or two decades prior to the time of onsite inspection. Conversely, the lack of well-defined inset terraces indicates that medium, large, and very large peak flows (that have eroded the inset terraces), or very small flows (that are below the level of the lowest inset terrace), have occurred recently. A well-formed inset terrace also indicates that numerous recent flows of sufficient magnitude to have inundated the terrace at a shallow depth have occurred.

Channel Features

The width, depth, configuration, and bed of a channel (fig. 2) were the principal features inspected. The depths of the channels mainly range from 3 to 30 ft. The widths of the channels range from about 10 to 200 ft. Observed low-flow channel depths were from 1 to 3 ft, with observed widths from about 2 to 20 ft. The composition of the bed ranged from mixtures of clay and silt to coarse gravel. Inset terraces, discussed in the preceeding section, also were one of the principal features observed in channels.

Only a general discussion of the main channel features, as related to peak flows, is presented here. Detailed discussions of these features and other features, and their relation to flow conditions, are available in the literature. Two comprehensive texts have been written by Leopold and others (1964) and Picard and High (1973).

The determination of whether a channel is aggrading, degrading, or stable is a help in reconstructing the recent streamflow history of a drainage. Aggrading channels indicate that few large and very large peak flows have occurred recently. Conversely, actively degrading channels indicate that numerous large and very large peak flows (or long-duration flows) have occurred recently. Channels not aggrading or degrading appreciably indicate that either (1) the recent flow sequence consisted principally of larger flows that scoured the channel, followed by a series of smaller flows that filled the scours, or (2) recent flows have not been sufficiently large or numerous to disturb the channel features. Stable channels indicate that the channel is in a condition of equilibrium with the flows, and that large and very large peak flows have not been sufficiently numerous to cause modifications in the channel. Some of the more general features of aggrading, degrading, or stable conditions are presented as follows:

Aggrading channels

1. Depositional features predominate. The channel has a general overall subdued appearance with some "rounded" features, and with some drainages having a trapezoidal cross-sectional profile.

2. The channel bottom has a "filled" appearance, especially in drainages with a wide, shallow, sand-to-gravel channel. Widespread bars are formed, including some well-formed point-bars. Little vegetation is present on the bars.

3. In some drainages, a continuous mantle of vegetation extends across the channel bottom. The vegetation mainly is grass, and small scours may interrupt the vegetation mantle.

4. Generally, inset terraces are widely distributed; few of the inset terraces are well-formed and stabilized by grass.

5. Root crowns of shrubs and trees are buried.

6. Beaver dams and ponds are present in a few places.

Degrading channels

1. Erosional features predominate. The channel has an overall angular and "blocky" appearance, particularly in the lower one-half of the channel, as evidenced by recently eroded benches, scoured banks, and vertical and locally overhanging sides. The channel bottom may be scoured severely.

2. Well-formed low-flow channels and widely distributed inset terraces are absent.

3. Plant roots are exposed along the channel bottom and lower sides of the channel.

Channels not aggrading or degrading appreciably

1. These channels have a combination of those erosional and depositional features listed previously under aggrading and degrading channels. Current conditions of the channels are dependent on the occurrence of the last large or very large peak flow. Geomorphic features and vegetation of the lower channel sides have been modified by recent peak flows.

2. Large scours may be partly filled by sediment.

3. Inset terraces generally are poorly formed and have a limited distribution; locally, some are eroded severely.

4. Young vegetation may be established in scours, on the channel bottom, on lower channel sides, and on bars and other channel deposits.

5. Locally, the root crowns of trees and shrubs growing on the channel bottom may be exposed in scours or buried slightly by deposits.

Stable channels

1. The appearance of the channel indicates that it has not been modified recently by large and very large peak flows.

2. A well-formed, low-flow channel, bordered by widely distributed inset terraces, may be present.

3. Large bars or scours are absent.

4. Vegetation mantles the channel sides and much of the channel bottom.

5. Root crowns of vegetation are not exposed from erosion nor buried by sediment.

Relations between peak flows and geomorphic features are determined most reliably for reaches of streams with stable channels, because well-developed channel features, particularly the inset terraces, once formed, tend to be stable and readily discernable. In stable channels, many transitory features are absent, such as large scours and bars that can cause fluctuation in the width and, particularly, in the depth of a channel, and that, therefore, can affect the peak-flow geomorphic relations.

Headcuts may be considered as large eroded scours with nearly vertical sides at the upstream end of a discontinuous channel. They form along ephemeral streams in drainage basins that are only a few square miles in area. A dense mantle of grass growing on the valley floor favors the formation of a headcut with overhanging sides. A plunge basin typically is present at the base of the headcuts. In Wyoming, headcuts generally are 3 to 15 ft deep; locally, they are as much as 50 ft deep. At many places, especially near the Powder River, valleys display as many as three levels of headcuts. Such features represent headward erosion initiated at different times with the uppermost headcut represented by the oldest period of erosion, and the lowermost headcut represented by the youngest period of erosion. Headcuts and accompanying deep gullying in eastern Wyoming were noted in many historical accounts written during early and middle 1800's. In general, since the 1930's, the observed advancement of the headcuts has been slow, with the maximum headward advancement along a few drainages measured in only tens of feet. Also, since the 1930's, erosion along many small headcuts has been retarded by growth of range grass.

The presence of headcuts indicates sporadic flow and uncommon large or very large peak flows or sustained flows in a drainage. The initial formation of headcuts commonly resulted from rapidly moving runoff from large flash floods. Observations by the author indicate that sustained flows are more conducive to active headcutting than short-duration large or very large peak flows. The condition of the sides of the headcut and plunge basin, and of the downstream distribution of the coarse sediment eroded from the headcut and plunge basin may indicate the general magnitude of peak flows that have occurred recently.

The bankfull stage was determined at all channel sites studied during the reconnaissance. Bankfull stage (fig. 2) is definable best in stream reaches, where paired terraces are present, or in reaches where remnants of the lowest paired terrace are present, so that the height of the terrace can be estimated reasonably. As defined in this study, the bankfull stage is the level of the rim of the lowest paired terrace that borders the channel.

A knowledge of bankfull stage is helpful for determining the general magnitude and frequency of recent peak flows that have affected the channel. Flows of bankfull, or near bankfull stage (usually medium peak flows), generally cause the maximum erosion in a channel (Andrews, 1980, p. 22). At places, the author has observed that peak flows larger than bankfull stage may deposit more sediment in the channel than peak flows of about bankfull stage.

Flood Deposits

The flood deposits most useful for analysis in this study were those present in the channel and on slopes and terraces adjoining the channel (fig. 3). These deposits include overbank deposits, point-bar deposits--including high-level point-bar deposits, old bars, and channel deposits. Deposits on the bottom land away from the channel generally are thin, and they are not recognized easily many years after their emplacement. Flood deposits emplaced by large or very large peak flows were recognized along only a few of the drainages studied.

At places where flood deposits were recognized, they indicated conclusive evidence of a past flood. The distribution of these deposits was used to help determine the area inundated, and, therefore, the magnitude of a historical flood. The upper limit of the deposits above the streambed generally was considered to be about 0.5 ft below the level of the peak flow that emplaced them. An estimate of the age of the deposits, or the age of the peak flow that emplaced the deposits, can be made from: (1) The preservation of the deposits, as affected by subsequent erosion of the deposit or burial of the deposit by other sediment; (2) the condition of the vegetation growing on the deposits; and (3) the condition of any wood flood debris that may be associated with the deposits.

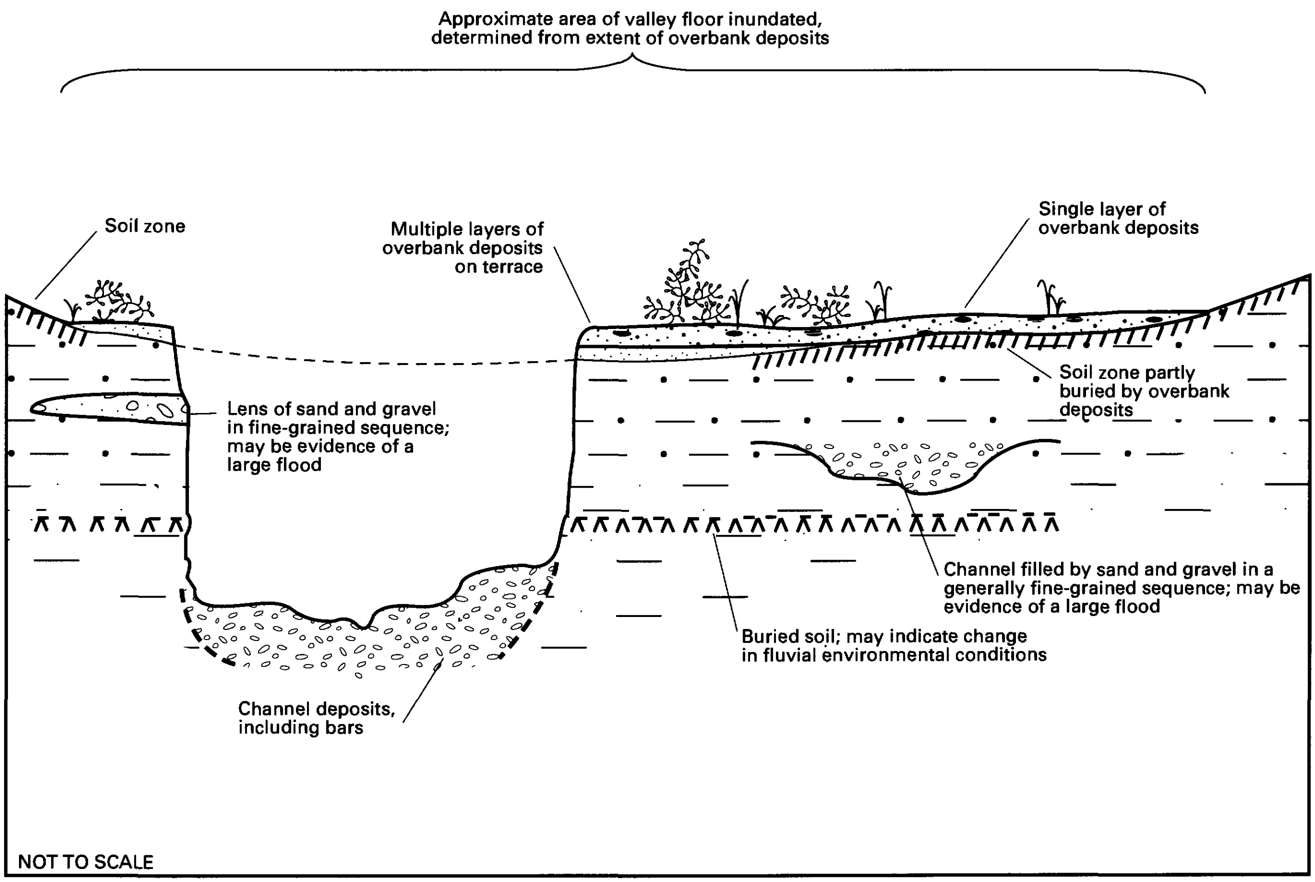


Figure 3.--Flood deposits and soils.

Overbank Deposits

Overbank deposits are formed by peak flows that exceed bankfull stage (fig. 3). They are the type of flood deposits most frequently used in this flood study. They are present on terraces and slopes along the channel, and they may be distributed extensively as a thin layer over the bottom land. Most overbank deposits consist mainly of mixtures of silty sand and sandy silt transported as suspended sediment by flood flows. Most of the sand is very fine to fine grained. Some deposits contain abundant, minute mica (muscovite) flakes. Thickness of the deposits emplaced by a single flood ranges from a few inches to about 1 ft.

Multilayered overbank deposits result from a series of flood flows. Usually, they indicate that flows large enough to have emplaced the deposits occur rather frequently, and that deposition has occurred intermittently during a long period. This indication is especially apparent if the individual layers are separated by: (1) Root crowns of plants (particularly trees) located along the common contact of successive overbank deposits or along the contacts between the overbank deposits and other deposits; (2) other types of deposits, such as locally derived sediments transported by overland flow from the valley sides; (3) accumulations of plant debris, especially if the plant debris has been appreciably weathered; and (4) soil zone(s).

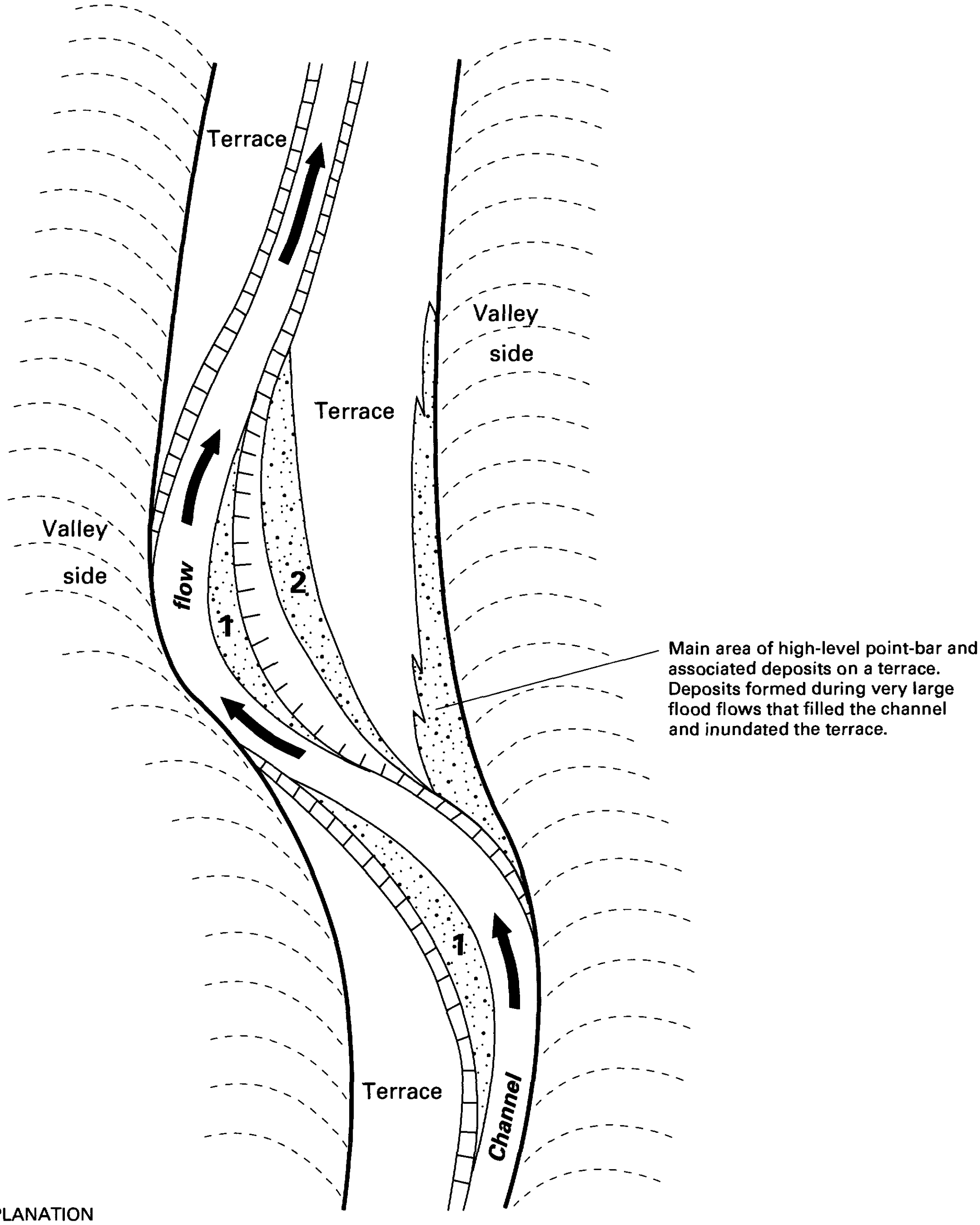
Point-Bar Deposits

Point-bar deposits of sand and gravel are common channel features, especially along the inside margins of, and downstream from, bends in the channel (fig. 4). They form steplike features that represent the peak and the declining stages of a flow. These transitory features are modified or re-formed by different size peak flows. Point bars and their associated deposits provide information mainly on the size and frequency of peak flows less than bankfull stage that inundate only part of the channel.

Other deposits of sand and gravel referred to as high-level point bars indicate the occurrence of a large or very large peak flow. They form on terraces or slopes adjacent to and extending downstream from the rim of the channels, particularly downstream from sharp bends (fig. 4). These deposits are similar to point-bar deposits lower in the channel, except they usually are smaller and have a much more limited distribution. Old high-level point-bar deposits have been modified by erosion and may be concealed by actively growing vegetation, by a thin mantle of decaying vegetation, or by deposits locally derived from nearby valley sides. Favorable locations for recognizing old high-level point-bar deposits are places where the underlying deposits consist mainly of silty material, which has a lithology that is markedly different than the generally coarse high-level point-bar deposits.

Old Bars, Channel Fill, and Sheet Flood Deposits

Remnants of old bars, channel fill, and thin deposits, herein referred to as sheet flood deposits, are present along only a few drainages in Wyoming. These deposits consist of sand and varying proportions of gravel. In places, the old bars and channel fill also may include large boulders. These deposits are indicative of extraordinary floods that transported a large quantity of



EXPLANATION

1 POINT-BAR ALONG LOWER PART OF CHANNEL--Formed either by small flows or during waning stage of large flows

2 POINT-BAR ALONG UPPER PART OF CHANNEL AND ALONG SIDE OF TERRACE--Formed during large flood flows

Figure 4.--Point bars in the channel, and high-level point bars and associated deposits emplaced by large peak flows on a terrace.

coarse bedload material. At places, the bedload material completely filled the old channel, as indicated in an exposure along Coal Creek near Goose Egg about 0.5 mi upstream from the crest-stage station on Coal Creek (site M-1, fig. 1). Along streams with shallow channels, the flow spread out as sheet flow over much of the valley floor and deposited a mantle of coarse detritus about 0.5 to 2 ft thick that generally is much coarser than the underlying deposits. One such sheet flood deposit is present along a small, west-flowing tributary to Salt Wells Creek, a short distance downstream from the crest-stage station on Salt Wells Creek near South Baxter (site M-2, fig. 1). The severe storm in 1981 that caused the very large peak flow at Lawn Creek near Alcova (site 9, fig. 1) also deposited bars consisting primarily of boulders and other accumulations of boulders along several other tributaries of Stinking Creek to the south of Lawn Creek (site 9, fig. 1) in a short reach where those streams debouch from their canyons in the Laramie Mountains. Many boulder deposits overlie other boulder deposits that had been emplaced by previous floods. Accumulations of old boulder deposits commonly are present along reaches of other streams that have their origins in mountain regions.

Botanic Features

The type and condition of vegetation in the channels, on terraces, and on slopes of the bottom land are affected considerably by the magnitude and frequency of peak flows. Medium to very large peak flows usually damage the vegetation and may emplace flood deposits around root crowns. The vegetation type can be used to delineate the area of the bottom land that is inundated frequently from that part that is inundated infrequently.

Typically, vegetation is damaged during floods. Damage to trees especially is observable. Trees may be uprooted and limbs or trunks may be bent or broken; this damage may last for their entire lifetime, which for cottonwoods may be more than a century. The lifespan of a willow is substantially less and may be no longer than about 50 years. Cottonwood and willow are the most common trees bordering the plains streams. Old photographs and historical accounts indicate that generally there were few groves of cottonwoods and willows and no other species of deciduous trees along plains streams in Wyoming during the late 19th century; the present (1982) prolific growth of riparian tree vegetation along the streams has occurred mainly during the 20th century. Although flood damage to most shrubs usually is difficult to recognize after about 10 years, flood damage to sagebrush may be apparent for 20 to 25 years.

Just as observations of damage to vegetation can provide information concerning floods, so can observations of buried root crowns. Root crowns of trees and shrubs commonly are buried in overbank and other deposits emplaced by flood flows. On some terraces and slopes, root crowns of big sagebrush and silver sagebrush were buried to depths of as much as 0.5 ft, and root crowns of 1-to-3-ft diameter cottonwoods were buried as deep as 1 ft. At places, large tree root crowns were buried by as much as 3 ft of sediment. However, the root crown of one large cottonwood, 4 ft in diameter, along Cow Creek near Weston (site M-3, fig. 1), had been buried by 5 ft of sediment, and only recently had been exhumed by the lateral cutting by the creek.

Overflow Area

The overflow area consists of the channel and adjoining low terraces and slopes (fig. 2). This area is the part of the bottom land that frequently is inundated, and it contains vegetation that needs a dependable supply of soil moisture to sustain growth—long grasses, broad-leaf shrubs, weeds, and reedy plants. Silver sagebrush is a particularly common plant in the overflow area of some Wyoming streams. In many drainages of southwestern Wyoming, dense stands of big sagebrush, rabbitbrush, and greasewood grow in the overflow area. Along most drainages, a change in vegetation type is easy to identify along the boundary between a relatively moist overflow area and an adjoining semiarid range land. Identification of an overflow area is useful in studying the flood hydrology of a drainage, because it indicates the area of the bottom land that is inundated by frequent, medium peak flows.

Weathering of Wood Debris Deposited by Floods

Observations of the degree of weathering of wood debris deposited by floods were used to estimate the date of historical floods. The observed wood debris primarily consisted of cottonwood and sagebrush. Excellent examples of cottonwood debris with varying degrees of weathering resulting from different periods of exposure were observable in the more humid eastern part of the State in the Shawnee Creek (site M-4, fig. 1), Dry Rawhide Creek (site 12, fig. 1), and Cottonwood Draw (site M-5, fig. 1) drainages (table 2). Wood debris was deposited in the Shawnee Creek drainage in 1978, from one of the large floods that occurred that year (Parrett and others, 1984). In 1982, large logs and limbs showed little if any weathering. Some weathering was observed of fine woody material (less than 0.1 in. in diameter) and of leaves in piles of flood debris. Wood debris observed in the Dry Rawhide Creek drainage was deposited by a large peak flow that occurred in 1969. Logs and limbs were slightly weathered. The smallest limbs preserved in 1982 were 0.25 to 0.5 in. in diameter. Debris observed in the Cottonwood Draw drainage was deposited by a very large peak flow that occurred in 1955. In 1982, large logs and limbs were strongly weathered. The smallest limbs still present were about 1 in. in diameter. Based on these observations, and other observations by the author, cottonwood debris deposited by floods is assumed to be preserved in eastern Wyoming for about 50 years.

Differences in the degree of weathering of sagebrush debris deposited by floods are readily apparent in debris piles on bottom lands throughout Wyoming; however, observations were made of numerous drainages only in the dry southwestern part of the State (table 3). In southwestern Wyoming, fine woody material (less than 0.1 in. in diameter) is present in debris deposited since about 1955. Trunks and limbs exist much longer. A particularly observable weathering characteristic of sagebrush is the breaking up of large fragments (especially of big sagebrush) into angular, rod-like fragments (fig. 5). This characteristic is referred to as flaking. Flaking occurs during the later part of the weathering process. On the basis of onsite observations, sagebrush trunks are assumed to be preserved in recognizable form for at least 50 years. Sagebrush probably is preserved for a considerably longer period, but lack of information about historical floods in this sparsely settled region precludes an accurate estimation of the length of time necessary for the complete decay of sagebrush.

Table 2.—*Weathering of cottonwood debris deposited by peak flows occurring in 1978, 1969, and 1955 on streams in east-central Wyoming (observations made in 1982)*

Year of peak flow	Stream name and site number in figure 1	Brief description of weathering
1978	Shawnee Creek near Orin (site M-4)	Logs and limbs virtually unweathered; all fine woody material present; some weathered leaves present.
1969	Dry Rawhide Creek near Lingle (site 12)	Logs and limbs slightly weathered; limbs 0.25 to 0.5 inch in diameter present.
1955	Cottonwood Draw near Guernsey (site M-5); Sand Creek near Orin (site 11)	Logs and limbs considerably weathered; smallest limbs present were 1 inch in diameter.

Figure 5.--Extreme state of flaking of weathered sagebrush debris deposited by a historical flood along Delaney Draw. Date of photograph: August 20, 1982.

Table 3.--Weathering of sagebrush debris deposited by floods in southwestern Wyoming (observations made in 1982)

Year of peak flow	Site number in figure 1	Streamflow-gaging station name	Fine, woody material less than 0.1 inch diameter	Limbs and trunks	Flaking
1976	15	Delaney Draw near Red Desert	Slightly weathered.	Almost unweathered.	None.
1969	13	East Otterson Wash near Green River	Slightly weathered.	Slightly weathered.	None.
1965	14	Skunk Canyon Creek near Green River	Moderately weathered.	Slightly weathered, especially small limbs.	None.
1965	15	Delaney Draw near Red Desert	Not recognizable in small accumulations of flood debris.	Small limbs slightly weathered.	None.
1960-65[1]	13	East Otterson Wash near Green River	Moderately to considerably weathered.	Small limbs slightly weathered.	None.
1950-55[1]	14	Skunk Canyon Creek near Green River	Considerably weathered, not present in all debris piles.	Small limbs moderately weathered; few limbs less than 1 inch in diameter.	None.
1950-55[1]	13	East Otterson Wash near Green River	Not present in small debris piles.	Considerably weathered.	None.
1950-55[1]	18	Blacks Fork tributary no. 2 near Green River	Considerably weathered; fine materials present.	Considerably weathered; few limbs 1 inch in diameter.	None.
Pre-1950-55[1]	20	Blacks Fork tributary no. 4 near Green River	None.	Considerably weathered; few limbs 1 inch in diameter.	Considerable.
Pre-1930[1]	15	Delaney Draw near Red Desert	None.	Considerably weathered; only trunks 5 to 6 inches in diameter.	Considerable.

[1]Historical peak flow.

Soils

Soils, mostly formed more than a century ago, are present on some of the terraces and slopes of the valley floors or are buried in alluvial deposits exposed in terraces (fig. 3). Soils on the bottom land are from 0.5 to 1 ft thick, are immature, and generally do not have zoning caused by accumulations of clay or concentrations of limy material. Soils are excellent environmental marker beds because: (1) They indicate areas of a stable fluvial environment, not aggrading or degrading appreciably, and infrequent large and very large peak flows; (2) they are formed slowly—even the formation of immature soils takes several decades to a few centuries; and (3) they, particularly buried soils, also indicate fluctuations in the bottom-land fluvial environment during the past several centuries. As an example, coarse fluvial sediments deposited on a soil may represent a change in the fluvial environment and possibly a single large or very large peak flow.

CLASSIFICATION OF DRAINAGES

Drainages can be classified into different types on the basis of streamflow characteristics; channel and basin characteristics, such as size, shape, slope and other characteristics; or geomorphic features, such as those described in this report (see section on geomorphic features). The 21 drainages studied are classified geomorphically into three general types:

Type 1

South Fork Powder River near Powder River
Dead Horse Creek tributary near Midwest
Dead Horse Creek tributary no. 2 near Midwest
Dugout Creek tributary near Midwest
Coal Draw near Buffalo
Pritchard Draw near Lance Creek
Turner Creek near Osage
Third Sand Creek near Medicine Bow
Lawn Creek near Alcova
Stinking Creek tributary near Alcova
Dry Rawhide Creek near Lingle
East Otterson Wash near Green River
No Name Creek near Rock Springs
Salt Wells Creek near Rock Springs

Type 2

Sand Creek near Orin
Summers Dry Creek near Green River

Type 3

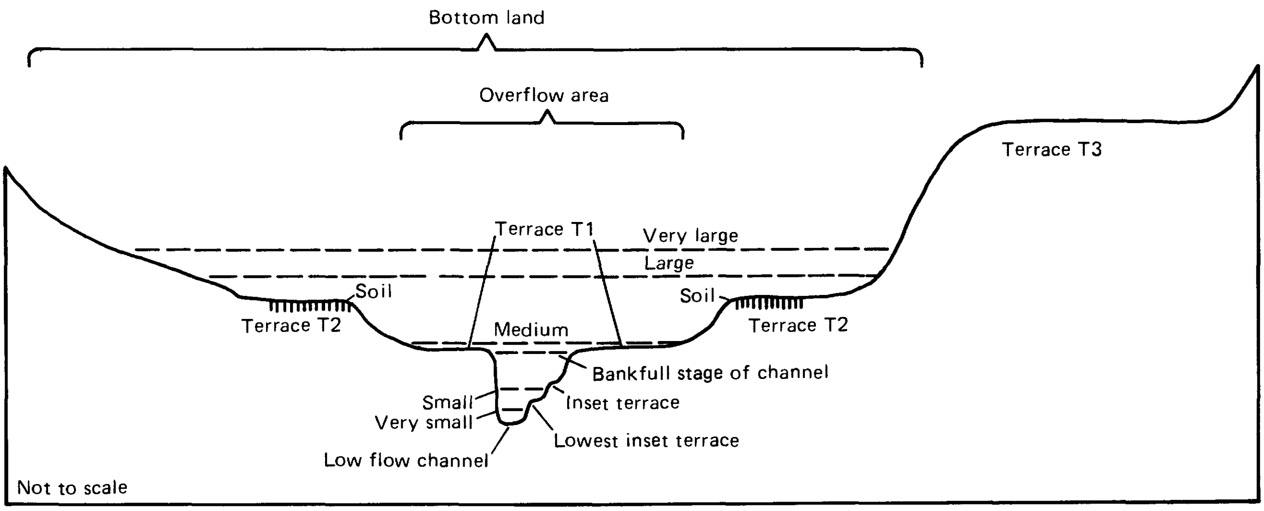
Skunk Canyon Creek near Green River
Delaney Draw near Red Desert
Blacks Fork tributary no. 2 near Green River
Blacks Fork tributary no. 3 near Green River
Blacks Fork tributary no. 4 near Green River

This three-fold classification of drainages is based on the distribution of paired and unpaired terraces, and on channel and other bottom-land features. Generalized cross sections of the three drainage types are shown in figures 6-8.

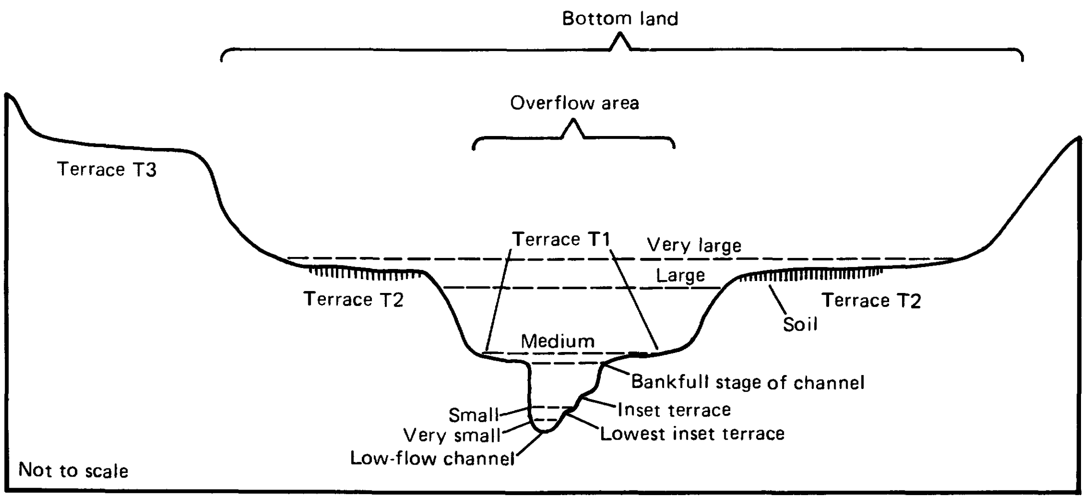
In type-1 drainages, conspicuous paired terraces comprise most of the bottom land. In Wyoming, most type-1 drainages have three paired terraces that are designated in ascending order above the streambed, as terraces T1, T2, and T3 (figs. 6A and 6B). Well-formed inset terraces may be present in the channel (below the level of terrace T1). Terrace T1 borders the channel, may form much of the overflow area, and is inundated frequently. Terrace T2 is the principal terrace of the bottom land, and, depending on its height above the streambed, is not inundated, or is inundated infrequently. Terrace T3 forms the boundary of the bottom land, and, in the drainages inspected, probably has not been inundated since its time of formation several centuries ago. In type-1 drainages having only two paired terraces, terrace T3 is not present, and the deposits equivalent to those of terrace T3 are overlain by deposits of terrace T2. Channels of type-1 drainages generally form deep and narrow trenches; they have been eroded in clayey to sandy alluvium that contains small quantities of gravel.

Type-2 drainages are widely distributed and have paired and unpaired terraces. One or two paired terraces and numerous unpaired terraces may be present. At places, three or four levels of unpaired terraces are present. In some drainages, a conspicuous paired terrace, probably equivalent to terrace T3 of type-1 drainages, borders the bottom land, and a low paired terrace, designated as terrace T1, is in most reaches of type-2 drainages. However, the terrace designated as terrace T2 in type-1 drainages is not present. Much variation occurs in the types and distribution of the terraces, channels, and bottom lands of type-2 drainages (fig. 7).

Channels of type-2 drainages generally are comparatively wide and shallow in relation to those of type-1 drainages. Large sand and gravel bars commonly are present. The channel deposits and much of the sediment forming the terraces consist of sand and gravel. The channel width is not stable, but fluctuates according to the volume of streamflow associated with large and very large peak flows, and because of encroachment of riparian vegetation along the channel during times of medium or lesser peak flows. A single large or very large peak flow may uproot much of the riparian vegetation and considerably widen the channel. Such flows occurred in 1973 along Summers Dry Creek near Green River (site 21, fig. 1) (H.W. Lowham, U.S. Geological Survey, oral commun., 1982) and along Spring Creek near Glendo (site M-6, fig. 1) (G.S. Craig, Jr., U.S. Geological Survey, oral commun., 1982). However, flood flows along type-2 drainages generally cause only slight fluctuations in the depth of the channel.



A



B

Figure 6.--Generalized cross sections of type-1 drainages showing the relative magnitude of peak flows to the characteristic geomorphic features: A, Terrace T2, less than 8 feet above the streambed; and B, Terrace T2, more than 8 feet above the streambed. Relative magnitude of peak flows is classified as very small, small, medium, large, and very large.

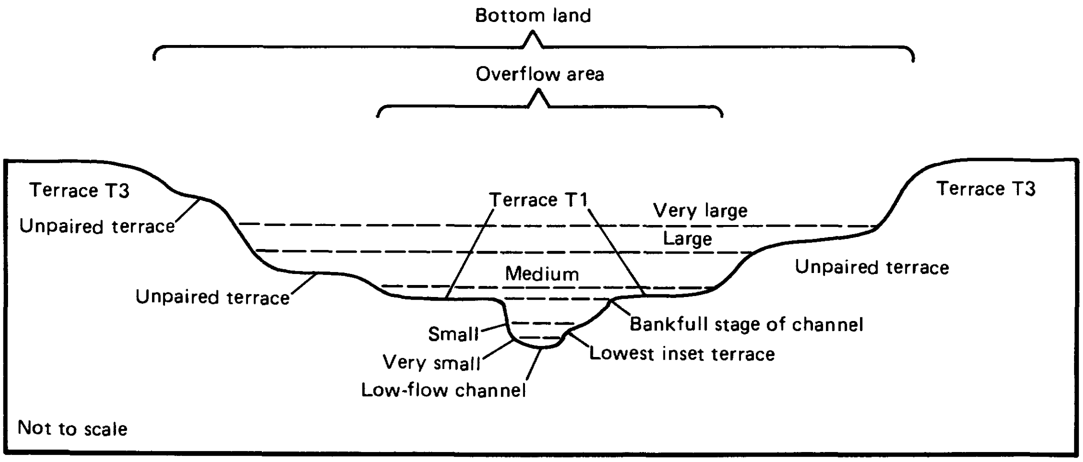


Figure 7.--Generalized cross section of type-2 drainages showing the relative magnitude of peak flows to the characteristic geomorphic features. Relative magnitude of peak flows is classified as very small, small, medium, large, and very large.

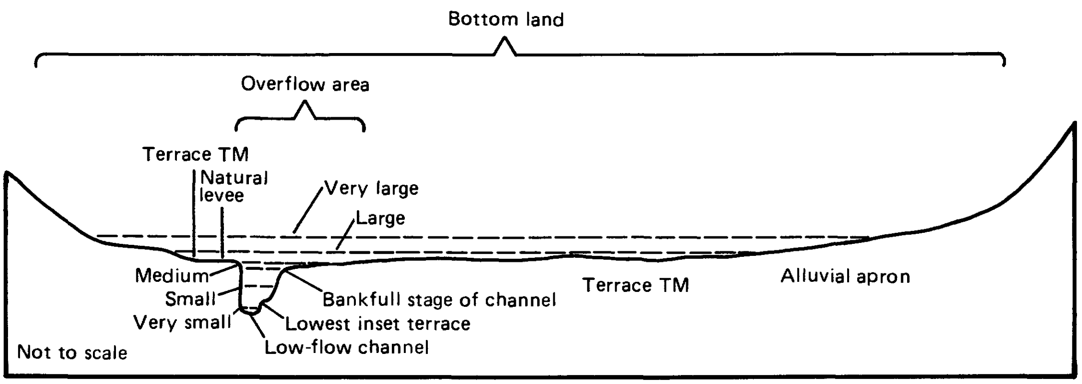


Figure 8.--Generalized cross section of type-3 drainages showing the relative magnitude of peak flows to the characteristic geomorphic features. Relative magnitude of peak flows is classified as very small, small, medium, large, and very large.

Type-3 drainages are recognized only in the dry southwestern part of Wyoming. These drainages are characterized by a single terrace, designated as terrace TM, that borders the channel and forms most of the wide, nearly flat bottom land; they also are characterized by a series of alluvial fans that coalesce to form an alluvial apron in the part of the bottom land that is adjacent to the valley sides (fig. 8). In some drainages, the channel is discontinuous and begins below a sharply formed headcut, which is eroding actively headward during times of the sporadic streamflow. The channel is generally shallow and narrow, and is trenched mainly into silty to sandy alluvium, usually containing small amounts of gravel.

DATING OF FLUVIAL GEOMORPHIC EVENTS

Dating of recent fluvial geomorphic events is essential in relating the geomorphic information to the classification of drainages, and also to the historical occurrence of large and very large peak flows. In Wyoming, Leopold and Miller (1954) recognized sequences of erosion and deposition along different drainages. The present study indicates that the sequence of geomorphic events is recorded best in type-1 drainages, where the erosion, including channel trenching and terracing, and depositional sequences also are well developed. Correlation of geomorphic events in the three drainage types is explained in table 4.

The oldest geomorphic event pertaining to this study is the erosional episode that initiated the present bottom-land configuration along the drainages described in this report. During this episode, valley floors were degraded, at many places to bedrock, and terrace T3 was formed from previously deposited flood-plain alluvium along most type-1 drainages and some type-2 drainages. This erosional episode is not dated in Wyoming, but from relations with the succeeding erosional and depositional sequence, it occurred probably 1 or 2 thousand years ago.

After this erosional episode, valley floors were aggraded; alluvium deposited during this time is now exposed in terrace T2 (type-1 drainage) and in terrace TM (type-3 drainage). However, fluctuations of minor erosional and depositional events took place along type-2 drainages. In most type-1 drainages, the upper level of deposition of the flood-plain alluvium attained a height within several feet of the rim of terrace T3. In a few type-1 drainages, deposits equivalent to the deposits of terrace T3 were buried during this time. Deposition continued until the present channel trenching occurred. One key process during the late part of the episode was the development of soil on the valley floors underlain by terrace T2 deposits.

The present erosional episode, often referred to as a channel-trenching episode (including the formation of terrace T2), markedly affected type-1 drainages in Wyoming. This channel trenching began at slightly different times along various type-1 drainages during the middle to late parts of the 19th century. Accelerated channel trenching, gullying, terrace formation, and widespread sheet erosion were common during this episode. Early accounts and photographs indicate that deep channels similar to the modern channels at several places already were present along many type-1 drainages during the 1870's and 1880's; the initial trenching of these channels probably began in or slightly before the 1860's. By about 1870, many channels in the study

Table 4.—*Correlation of principal geomorphic features and events*

Years	Type-1 drainages (two or three conspicuous paired terraces)	Type-2 drainages (combination of paired and unpaired terraces)	Type-3 drainages (one discontinuous terrace, other terraces inconspicuous or absent; conspicuous alluvial fans)
1982	Formation of present (1982) detailed channel configuration, terrace T1, and inset terraces; some aggradation of channels in many drainages.	Formation of present (1982) detailed channel configuration, inset terraces, and, where present, terrace T1.	Formation of present (1982) detailed channel configuration, inset terraces, and deposition of some overbank deposits on terrace TM by large and very large peak flows.
1930			Terrace TM and channel formed to approximate present proportions.
About 1900	Terrace T2 and channel formed to approximate present proportions.		
	Initial formations of terrace T2[1] and present channel.		Initial formation (?) of terrace TM[1] and present channel.
About 1850		Large fluctuations in channel width; slight fluctuations in channel depth.	
	Formation of a soil at top of terrace T2 deposits.	Erosion with formation of lower unpaired terraces, including the Lightning terrace (Leopold and Miller, 1954) in many drainages.	Accumulation of main part of deposits comprising terrace TM and alluvial fans forming alluvial apron.
		Initial formation of present channel, with channel eroded to approximate present depth.	
1300	Accumulation of deposits comprisng terrace T2.		---
	Erosion with formation of terrace T3.	Erosion with formation of higher unpairred terraces and (where present) Terrace T3.	Erosion with formation of a wide valley floor; deposits older than terrace TM deposits not exposed.
	Deposition of sediments comprising terrace T3.	Where present, deposition of sediments comprising terrace T3.	

[1]Terraces T2 and TM represent the approximate level of valley floor prior to the late 19th century.

drainages were eroded to their approximate present size, and terrace T2 had attained its approximate present height; by 1900 in all of the type-1 drainages, the channels and terrace T2 had attained their approximate present configurations. Terrace T2 is an excellent marker terrace, because its summit represents the level of the 19th century flood plain. Since 1900, lateral erosion has considerably widened many channel reaches, but in other reaches, the channel has remained narrow. Also, since about 1930, as indicated by depth relations to bridges and other structures, and from accounts of local residents, many channels have been aggraded slightly, including the formation of terrace T1 to its present extent.

The present erosional episode slightly affected the two type-2 drainages described in this report, because type-2 channels already had attained their present approximate depths and general configuration, possibly centuries before the late 19th century. Probably all of the erosion of type-3 channels can be attributed to the present erosional episode (since 1850), even though specific information concerning the time of the initial trenching is lacking. The channel and terrace at the streamflow-gaging stations had attained their present proportions no later than about 1930.

RELATION OF PEAK FLOWS TO GEOMORPHIC FEATURES (DRAINAGE TYPES)

In relating peak flows to geomorphic features, the peak flows were classified as to their relative magnitudes, to help determine which geomorphic features along a drainage were inundated by peak flows of different relative magnitudes. This classification allowed a comparison of peak flows in different drainages, regardless of the size of the drainage basin and the quantity of flow. The peak flows were classified as very small, small, medium, large, and very large. This peak-flow classification was applied to each drainage type, and generalized models were obtained for each drainage type (figs. 6-8).

Very small peak flows in all drainage types are confined to the channel and occur below the level of the lowest inset terrace. In general, small peak flows in all drainage types are confined to the channel and are associated with the formation of the inset terraces. Medium peak flows have formed terrace T1 in type-1 and type-2 drainages; they inundated the overflow area that consists mainly of the channel and terrace T1. In type-3 drainages, medium peak flows may fill the channel but only larger peak flows inundate the adjoining terrace TM or other parts of the bottom land.

The height of terrace T2 above the streambed is an important factor in the classification of peak flows in type-1 drainages (figs. 6A and 6B). In most type-1 drainages, where terrace T2 is less than about 8 ft above the streambed, large to very large peak flows inundate most of the bottom land including terrace T2 (fig. 6A). In drainages where terrace T2 is more than about 8 ft above the streambed, even very large peak flows may be confined below the level of terrace T2 (fig. 6B). At the localities inspected, where terrace T2 was inundated, the entire terrace was inundated to only a shallow depth.

Large peak flows in type-2 drainages inundate a large proportion of the bottom land including the lower unpaired terraces (fig. 7). The very large peak flows inundate most of the bottom land and all but the highest unpaired terraces, but terrace T3 appears not to have been inundated by any recent flooding. In type-3 drainages, only large to very large peak flows inundate the broad bottom land formed by terrace TM (fig. 8). Very large peak flows also may inundate the lower toe slopes of the alluvial apron adjacent to the valley sides.

SELECTED PRECIPITATION CHARACTERISTICS AND FLOOD INFORMATION AFFECTING INTERPRETATION OF SHORT-TERM PEAK-FLOW RECORDS

The precipitation characteristics discussed in this section indicate conditions that tend to be either more favorable or less favorable for occurrence of large to very large peak flows. These characteristics include the general distribution of annual and seasonal precipitation that has affected the distribution of flood-producing storms in different parts of Wyoming during the 20th century. Information about geographic and time distribution of large and very large peak flows helps in the interpretation of short-term peak-flow records. The location of the precipitation stations used in this investigation is shown in figure 9.

Mean annual and mean summer (May to September) precipitation decreases westward and southwestward across the plains region of Wyoming:

Plains region	Mean annual precipitation (inches)	Mean summer precipitation (inches)
Eastern Wyoming	12 - 19	7 - 12
Southwestern Wyoming	7 - 10	4 - 5

Similarly, summer monthly totals of precipitation are small in southwestern Wyoming. For example, more than 3 in. of precipitation was recorded at Green River in only 3 summer months during 1931-82; whereas, during the same period in eastern Wyoming, more than 3 in. of precipitation was reported for 44 months at Gillette, for 43 months at Douglas, and for 27 months at Cheyenne. The minimal precipitation, therefore, limits (but does not preclude) the occurrence of large flood-producing storms in southwestern Wyoming. This limitation on floods is evident in records of peak flows in the two areas.

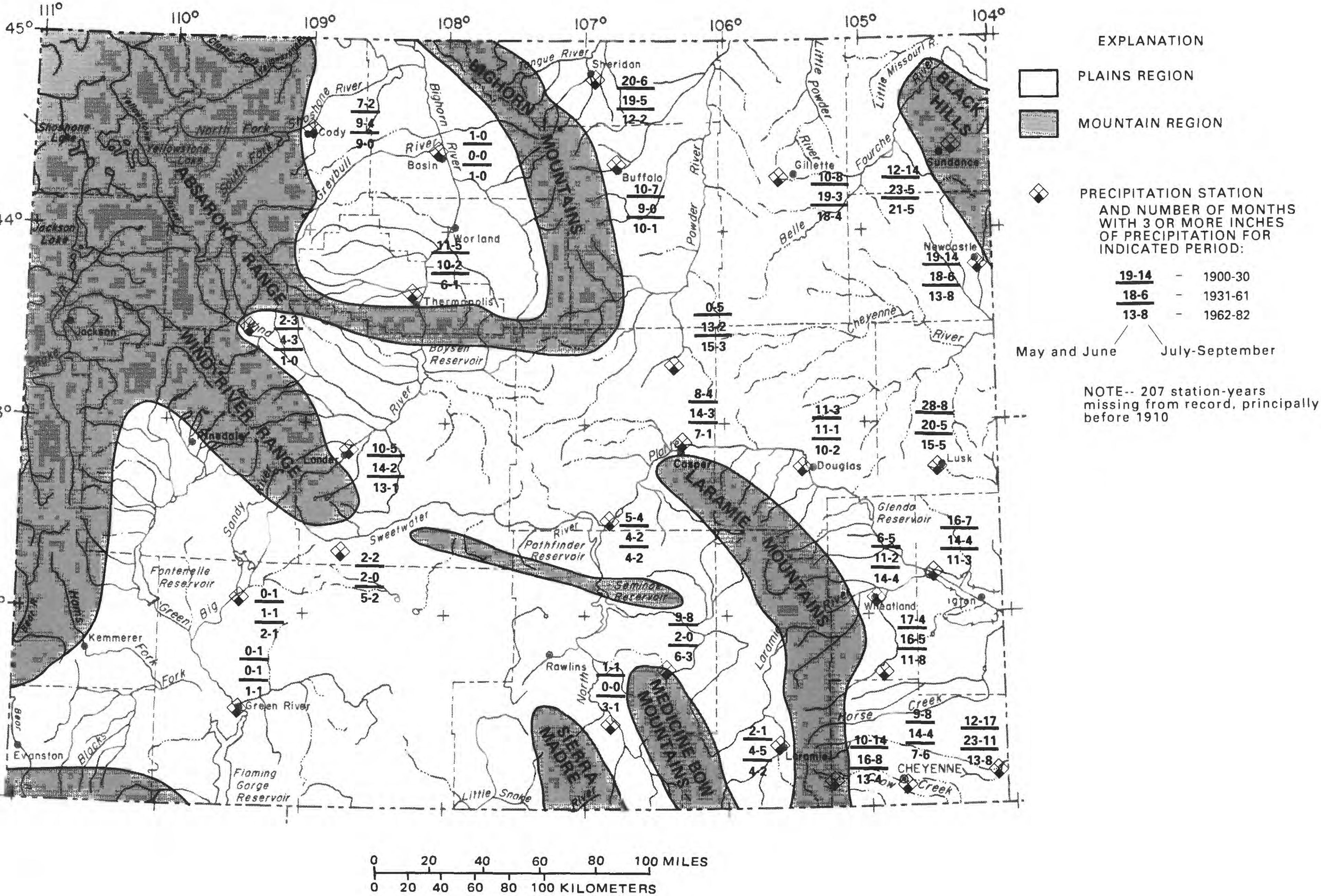


Figure 9.--Location of precipitation stations, and number of months with 3 or more inches of precipitation during May and June and July through September for 1900-30, 1931-61, and 1962-82.

The geographic differences in magnitude of peak flows can be defined graphically by envelope curves of unit peak flow as a function of drainage area. All available data for a given region are used to plot the curves. A summary of unit peak flows obtained from the envelope curves for the two regions (Lowham, 1988) is given in the following table:

Drainage area (square miles)	Approximate maximum unit peak discharge (cubic foot per second per square mile)	
	Eastern Wyoming	Southwestern Wyoming
1	4,600	3,900
5	2,200	1,600
10	1,700	1,150
50	720	450
100	500	360
200	360	250

On the basis of the differences in precipitation and peak flows, a large peak flow in southwestern Wyoming could have a much larger recurrence interval (smaller probability of occurrence) than the same size flow in the eastern part of the State.

Precipitation data were examined to determine any long-term differences in the distribution of precipitation during the 20th century that would indicate possible similar differences in peak flows. Two characteristics of monthly totals of precipitation were detected that affect the occurrence and distribution of peak flows. One characteristic indicates that a noticeable shift has taken place in the monthly distribution of summer precipitation. The monthly precipitation records indicate that around 1930 a shift occurred in the precipitation in May and June and in July through September. During 1900-30, the number of months with 3 in. or more of precipitation during May and June were almost equal to those during July through September. Since 1930, May and June precipitation has been dominant. In part of eastern Wyoming, the number of months having 3 in. or more of precipitation during May and June is more than four times larger than the number of months during July through September (fig. 9). Greater precipitation during July through September (months that have thunderstorm-type precipitation) favors more frequent occurrence of storms producing flash floods and large to very large peak flows that affect the small plains drainages.

Another characteristic indicates that months having larger precipitation were more numerous after 1961 (1962-82) than during 1931-61. Some stations had more months with 3 in. or more of precipitation during the 21-year period (1962-82) than during the previous 31-year period (1931-61) (fig. 9). The total number of summer months with 3 in. or more of precipitation during the two periods for the weather stations located in figure 9 are 163 months during 1931-61 and 148 months during 1962-82. The increase in the number of months with more than 3 or 4 in. of precipitation indicates that more large flood-producing storms have occurred during the 21-year period (1962-82) than during the preceding 31-year period (1931-61).

Flood information from U.S. Geological Survey files, many published historical accounts, and recollections of local residents indicate that, during the 20th century, major floods in the plains region of Wyoming were more numerous and generally more widespread before 1931 and during 1962-82. More large floods occurred during 1918-27 than during any other decade in the history of Wyoming. The most severe floods in the history of Wyoming since at least 1880 were in 1923 (Follansbee and Hodges, 1925). Many record-high peak flows in the plains streams occurred during the July and September storms of that year. The years of major floods resulting from precipitation in May through September during the 20th century, involving the Powder, Cheyenne, Belle Fourche, and Little Missouri Rivers and many the many small drainages throughout large parts of the State, are summarized as follows:

1900-30 Widespread flooding occurred during 1918-27, with major floods in 1918, 1920, 1922, 1923, 1924, 1925, and 1927. Floods of July and September in 1923 were the largest and most severe in history of Wyoming. Floods of 1923 and probably 1918 were statewide; floods in the other years were mainly in northeastern Wyoming. Other years known to have had severe local floods include 1904, 1908, 1912, and 1929.

1931-61 Major floods in 1935, 1944, 1952, and 1955. Floods of 1935 and 1955 affected mainly southeastern Wyoming. Floods of 1944 affected mainly northeastern Wyoming, and floods of 1952 affected mainly the Powder River drainage basin.

1962-82 Major floods in 1962, 1963, 1965, 1967, 1970, and 1978. Floods of 1962, 1963, 1965, and 1978 affected drainages in areas comprising about one-half of Wyoming.

During the late 19th century, generally few floods or very large peak flows were reported in Wyoming. Little flood information is available in the historical accounts, especially before about 1880, when cattle ranching and settlement began in the State. Many historical accounts refer to floods as "high flows"; some accounts indicate the flows were of approximate bankfull size. Many of the flows resulted from rapid melting of snow caused by warm winds (chinooks), which seem to have been much more common then than at present. The historical accounts indicate that floods at different places during the early part of the 20th century (before 1931) were the largest since settlement began about 1880. Years before 1900 known to have had large flows that affected numerous plains streams were 1876, 1878, 1883, 1884, 1886, 1895, and 1896. Major flows—some of the largest known peak flows—occurred on the North Platte River in 1844 (a year of exceptionally large floods in north-central Colorado), possibly the North Platte and Laramie Rivers in 1883, possibly the North Platte and Little Snake Rivers in 1884, and on the Snake and Bighorn River in 1894.

Streamflow records also indicate that annual peak flows and volumes of flow for all streams in Wyoming generally were larger during 1900-30 and 1962-82 than during 1931-61. Peak flows not only were smaller for the drought years of the 1930's and 1950's but also generally were smaller for the other years during 1931-61. Streamflow records and historical information of the largest peak flows known to have occurred during the 20th century are available for 49 plains streams distributed throughout Wyoming. Twenty-two of these streams had maximum peak flows during 1900-30, 10 of these streams had maximum peak flows during 1931-61, and 17 of these streams had maximum peak flows during 1962-82. Most of the maximum peak flows before 1931 occurred during 1918-27.

EXTENSION OF SHORT-TERM PEAK-FLOW RECORDS

When this study was initiated, it was assumed that the periods of the flood records could be extended to as much as 100 or 200 years. However, based on onsite investigations, historical accounts (including examination of old photographs taken since 1868), and the general lack of definitive hydrologic information on conditions in Wyoming prior to 1895, it was decided that flood records for most of the stations studied could be extended only to 100 years or less. All the historical extensions are based on periods ending before 1982. No significant floods occurred on any of the 21 study drainages during 1982 through 1988.

The 21 drainages discussed in this report have had peak flows that are related to geomorphic features, and have records that can be extended substantially. Each drainage was inspected to determine the geomorphic and botanical features pertinent to that drainage and to classify the drainages geomorphically into general types. The area near the streamflow-gaging station was examined for evidence of historical peak flows that may have occurred before the peak-flow records. All peak flows were related to geomorphic features, and the peak flows were classified as to their relative magnitudes. The peak flows of historical floods were estimated by standard methods of estimation (table 5).

Type-1 Drainages

Type-1 drainages had been selected as sites for most of the crest-stage stations used in the hydrologic evaluation of small drainage basins in Wyoming. They were chosen because type-1 drainages generally have well-defined stable channels, making them suitable for gaging peak flows, and because type-1 drainages have a wide distribution throughout the plains region of Wyoming.

Relating peak flows to geomorphic features is easier in type-1 drainages than in type-2 and type-3 drainages because considerable information is available on the formation of channels and terraces of the type-1 drainages (figs. 6A and 6B). Most channels are known to have been generally stable from about 1870 to 1900 with little aggradation or degradation occurring since that time. The presence of well-formed terraces, particularly terrace T2, that also was formed to its approximate height and extent by about 1870 to 1900, and terrace T1 (formed mainly since about 1930) indicates geomorphic marker units that easily can be related to the relative magnitudes of peak flows. Thus, infrequent large to very large peak flows are associated with the level of terrace T2, and frequent smaller peak flows are related to terrace T1, including the overflow area and the channel.

Table 5.--*Methods used to estimate peak flows of station records or of historical floods at study sites*

Station number	Station name and site number in figure 1	Date	Peak flow (cubic feet per second)	Method used to estimate peak flow
06312700	South Fork Powder River near Powder River (site 1)	1918	19,000	Area-velocity computation, based on reported elevations of the 1918 and 1921 floods.
		1921	10,300	Indirect determination at culvert, based on reported depth of water over railroad-culvert headwall.
06642700	Lawn Creek near Alcova (site 9)	1981	5,000	Rating curve extended above 4,800 cubic feet per second on basis of step-backwater computation.
06642730	Stinking Creek tributary near Alcova (site 10)	1981	2,000	Rating curve extended above 580 cubic feet per second on basis of culvert backwater with flow over road; transfer of backwater-free rating at downstream side of culvert (at station) to natural channel at study site.
06670985	Dry Rawhide Creek near Lingle (site 12)	1969	3,800	Area-velocity and slope-conveyance computations.
09216290	East Otterson Wash near Green River (site 13)	1950-55	1,200	Rating curve extended above 800 cubic feet per second.
09216350	Skunk Canyon Creek near Green River (site 14)	1950-55	1,100	Rating curve based on step-backwater computation.
09216537	Delaney Draw near Red Desert (site 15)	Pre-1930	1,700	Rating curve extended above 610 cubic feet per second on basis of step-backwater computation.
09216695	No Name Creek near Rock Springs (site 16)	1962-67	950	Rating curve extended above 377 cubic feet per second.
09224810	Blacks Fork tributary no. 2 near Green River (site 18)	1950-55	1,000	Rating curve extended above 60 cubic feet per second on basis of step-backwater and slope-conveyance computations.
09224820	Blacks Fork tributary no. 3 near Green River (site 19)	1950-55	600	Rating curve extended above 110 cubic feet per second on basis of slope-conveyance computations.
09224840	Blacks Fork tributary no. 4 near Green River (site 20)	Pre-1950	600	Rating curve extended above 30 cubic feet per second on basis of slope-conveyance computations.

South Fork Powder River near Powder River
(Streamflow-gaging station 06312700)

Data collected in the reach of the South Fork Powder River near the site of the streamflow-gaging station (site 1, fig. 1) indicate two historical peak flows, a larger one in 1918, and a smaller one in 1921. Peak flows were estimated to be 19,000 and 10,300 ft^3/s. Few peak flows larger than 15,000 ft^3/s have been recorded for the ephemeral plains streams of Wyoming. The 1918 peak flow inundated terrace T2; in this reach, terrace T2 is inundated rarely, and the 1921 peak flow was slightly below the rim of this terrace (fig. 10). Both peak flows are classified as very large. The peak flow of record, 1,940 ft^3/s, classified as a medium peak flow, occurred in 1982. The 1982 peak flow inundated only the overflow area and terrace T1 to a shallow depth.

The peak flow of 1918 is classified as a very large peak flow; it is assumed to be the largest peak flow in about 100 years or perhaps longer, because:

1. Information obtained from J.B. Eccles, Sr. (born 1901), of Eccles Ranch, was used to determine the area inundated by the 1918 peak flow; he said that this peak flow was the largest flood, since the Eccles Ranch was established in 1900. He also said that the depth and general configuration of the channel had not changed during his lifetime. Posts of abandoned railroad trestles (rebuilt after the 1918 flood) also indicate that the channel had not been deepened, but that it had been aggraded slightly locally, since the piers had been constructed.

2. Terrace T2 near the station and Eccles Ranch is rarely inundated; it may not have been inundated since its formation during the late 19th century. This is indicated from the absence of flood deposits and the presence of unaltered range grass and sagebrush on the terrace. The height of terrace T2 (13 ft at Eccles Ranch) also indicates that terrace T2 seldom is inundated, since its height is more than 8 ft above the streambed.

Dead Horse Creek Tributary near Midwest
(Streamflow-gaging station 06312910)

Data collected in the reach of Dead Horse Creek tributary near the site of the discontinued streamflow-gaging station (site 2, fig. 1) indicate no historical peak flow above the peak flow of record for at least the last 50 years. The peak flow of record, 3,020 ft^3/s, occurred in 1969. This peak flow for a drainage area of 1.53 mi^2 is one of the largest unit peak flows known for Wyoming. The 1969 peak flow was slightly below the rim of terrace T3 (fig. 6); it inundated all the bottom land including terrace T2 (fig. 11).

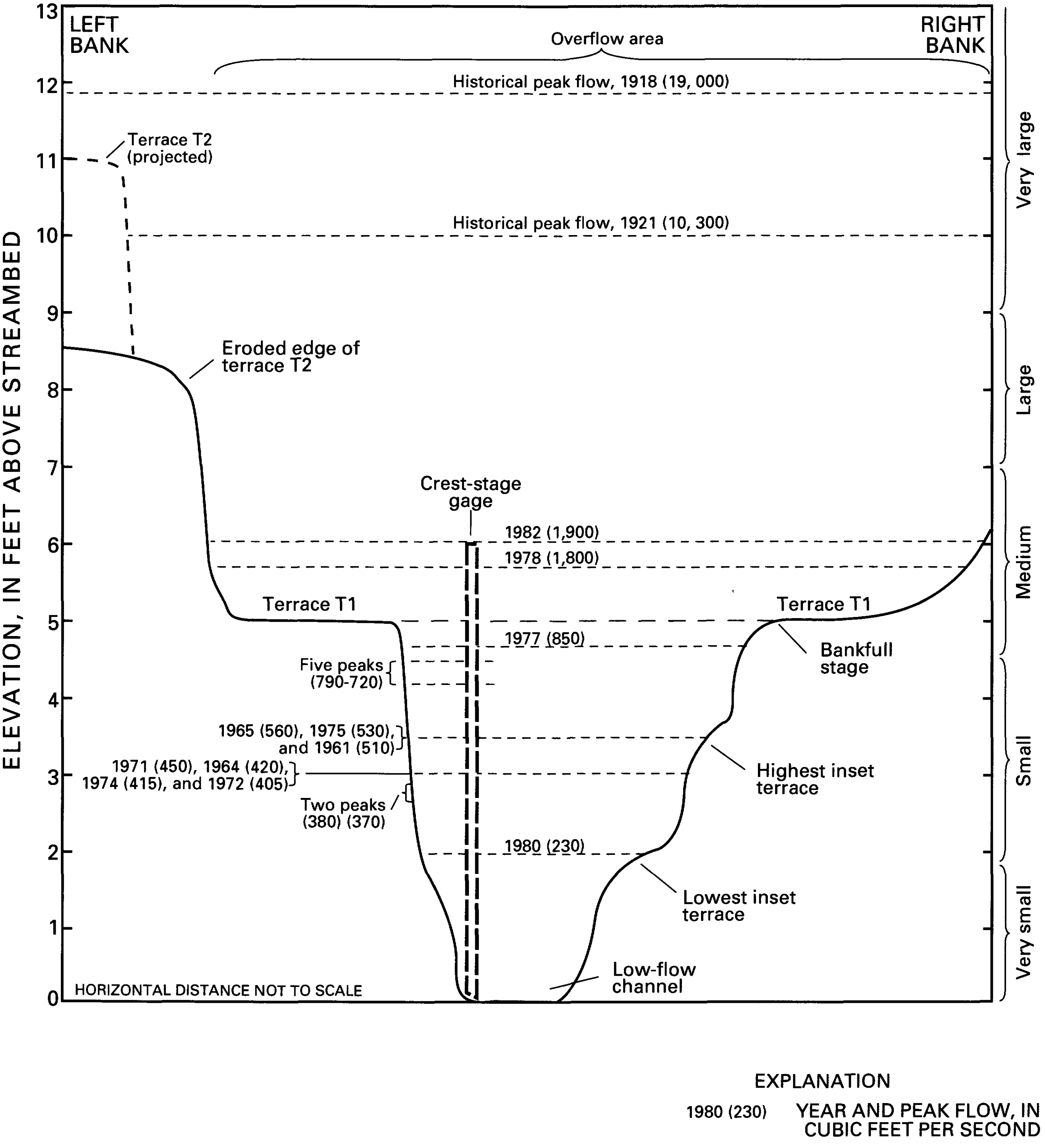


Figure 10.--Cross section of South Fork Powder River near Powder River, showing relation of historical and systematic-record peak flows to the principal geomorphic features.

The peak flow of 1969 is classified as a very large peak flow; it is assumed to be the largest peak flow for at least 50 years, and possibly more than 100 years because:

1. The level of the peak flow was near the rim of terrace T3, a terrace rarely inundated, or that has not been inundated since its formation.

2. The upper sides and top of terrace T3 support range-type vegetation; terrace T2 supports a mixed stand of vegetation, consisting of range and vegetation types present in the overflow area. The vegetation indicates that the upper sides of terrace T3 seldom are inundated, and that terrace T2 is more frequently inundated, but not as frequently as the overflow area.

3. Terrace T2 has a "rounded-subdued" appearance of having been modified by flood flows, which contrasts with some angular erosional features along the upper sides of terrace T3, formed from overland flow across the terrace. Terrace T2 is only 7 ft above the streambed indicating that this terrace is inundated frequently.

4. Evidence of peak flows higher than the 1969 peak flow was not observed.

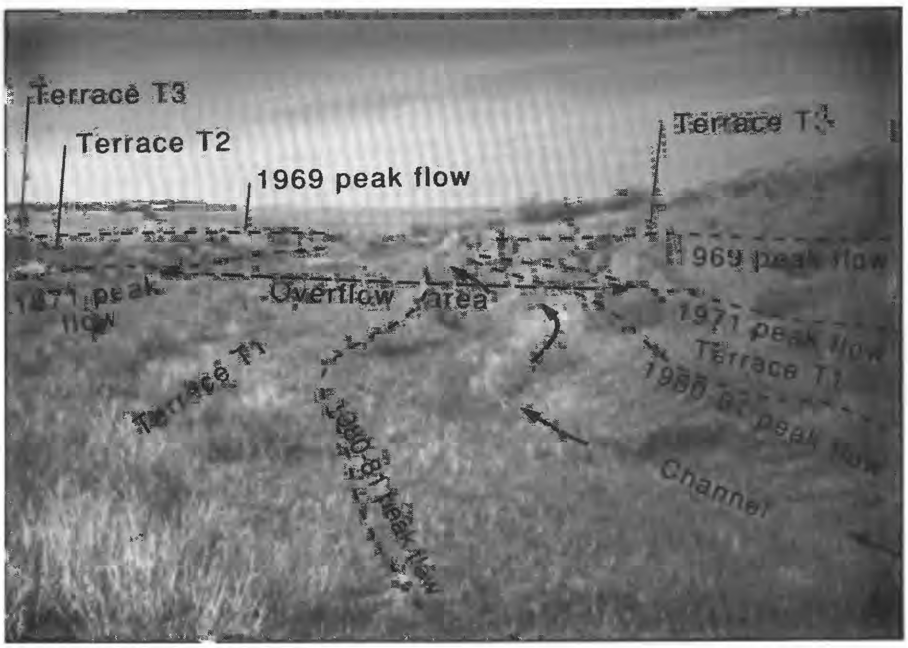


Figure 11.--Downstream view of Dead Horse Creek tributary near Midwest, showing the relation of selected peak flows to geomorphic features. Peak flows, in cubic feet per second, were as follows: 1969, 3,020; 1971, 400; 1980 or 1981, 170 (estimated). Date of photograph: April 28, 1982.

Dead Horse Creek tributary no. 2 near Midwest
(Streamflow-gaging station 06312920)

Data collected in the reach of Dead Horse Creek tributary no. 2 near the site of the discontinued streamflow-gaging station (site 3, fig. 1) indicate no historical peak flow above the peak flow of record for at least 25 years. The peak flow of record, 1,470 ft^3/s, occurred in 1972. The 1972 peak flow inundated terrace T2 (fig. 12) at a moderate depth.

The peak flow of 1972 is assumed to be the largest peak in about 25 years (possibly for as long as 50 years) because:

1. Terrace T2 is 8 ft above the streambed; this height indicates that the terrace may be inundated frequently. Sharply eroded vertical sides of this terrace indicate that numerous flows near the height of the terrace have occurred during recent years. These flows also may have caused a slight deepening of the channel.

2. Some overbank deposits overlie a soil at the top of terrace T2 deposits, indicating previous inundation(s) of the terrace.

3. Vegetation on terrace T2 is a mixed type, including types common to the overflow area and to the adjacent rangeland. Range-type vegetation is on the upper sides and on the summit of terrace T3. The combination of vegetation types common to the overflow area and to the rangeland indicates that terrace T2 may be inundated frequently, and that the upper sides of terrace T3 are seldom inundated.

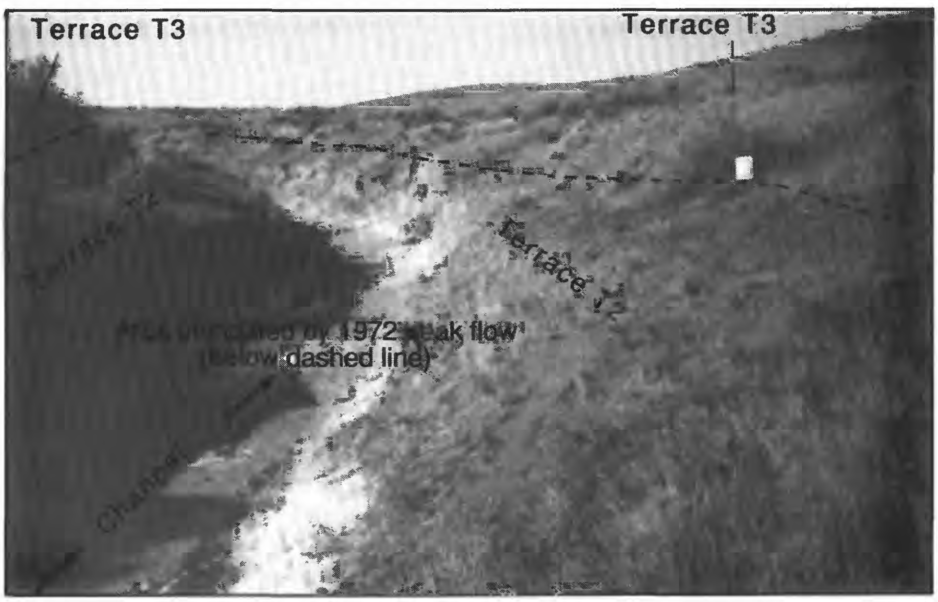


Figure 12.--Downstream view along Dead Horse Creek tributary no. 2 near Midwest, showing the relation of the 1972 peak flow to geomorphic features. The peak flow was 1,470 cubic feet per second. Date of photograph: April 28, 1982.

4. Evidence of peak flows higher than the 1972 peak flow was not found in the reach inspected. However, small fragments of slightly weathered sagebrush forms most of the flood debris.

Dugout Creek tributary near Midwest (Streamflow-gaging station 06313180)

Data collected in the reach of Dugout Creek tributary near the site of the streamflow-gaging station (site 4, fig. 1) indicate that the 1967 peak flow of 1,590 ft^3/s, the largest peak flow of record, is the largest peak flow for which there is evidence in the drainage area. This is the largest peak flow recorded in Wyoming for a drainage area that is less than 1 mi^2. The level of the 1967 peak flow was along the rim of terrace T2 and inundated some of its low areas (fig. 13). This peak flow inundated all the narrow bottom land between the rims of terrace T2, 9 ft above the streambed.

The 1967 peak flow is classified as a very large peak flow; it is assumed to be the largest peak flow to have occurred for the last 50 years, and possibly for at least 80 years, because:

1. Overbank deposits and flood features above the level of the 1967 peak flows were not recognized on the immature soil that forms the top layer of terrace T2.

2. Flood debris was not observed above the level of the 1967 peak flow. However, small sagebrush fragments comprise the flood debris, and it is difficult to recognize—even the debris deposited by the 1967 peak flow.

3. Terrace T2 is 9 ft above the streambed, indicating that, because terrace T2 is more than 8 ft above the streambed, this terrace seldom is inundated. Possibly terrace T2 has not been inundated since the channel was eroded to its approximate present depth. The abutments of a wood bridge built in 1932 (J.G. Rankl, U.S. Geological Survey, oral commun., 1982) near the streamflow-gaging station indicate that the channel has been relatively stable since that time (fig. 13).

4. Presence of range-type grass and sagebrush along the upper sides and on the summit of terrace T2 indicates that these areas seldom have been inundated.

Coal Draw near Buffalo (Streamflow-gaging station 06316700)

Data collected in the reach of Coal Draw near the site of the streamflow-gaging station (site 5, fig. 1) indicate that the 1965 peak flow (2,290 ft^3/s), the largest peak flow of record, inundated nearly all the bottom land between the steep valley sides. The 1965 peak flow inundated terrace T2 and much of the alluvial slopes adjacent to this terrace (fig. 14). Terrace T2 is only 6.5 ft above the streambed and is in the overflow area. The shape of terrace T2 has been modified, particularly by deposition of overbank sediments

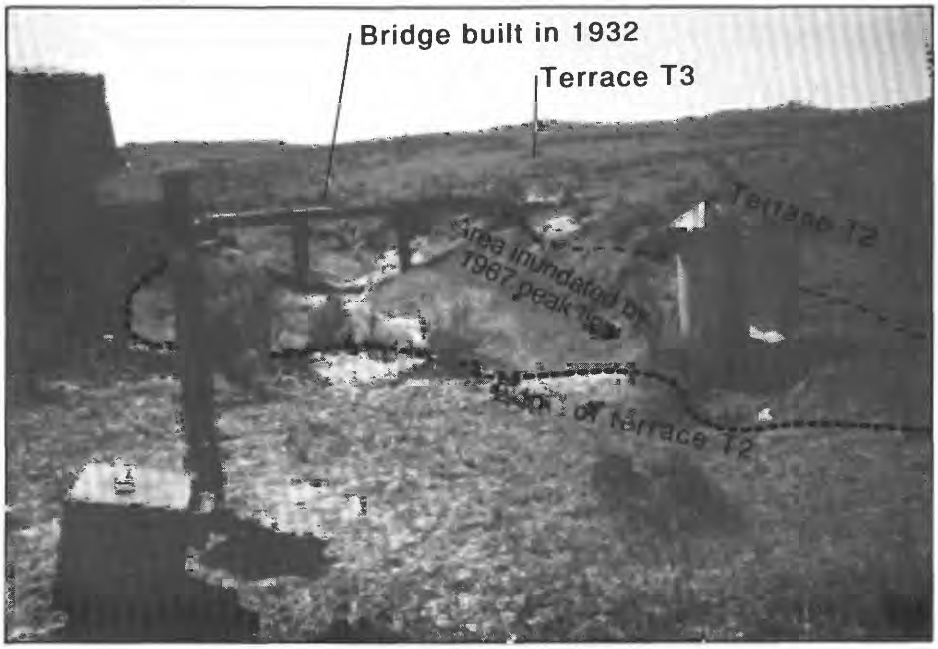


Figure 13.--Upstream view of Dugout Creek tributary near Midwest, showing the relation of the 1967 peak flow to the rim of terrace T2. The peak flow was 1,590 cubic feet per second. Date of photograph: April 28, 1982.

Figure 14.--Upstream view of Coal Draw near Buffalo, showing the relation of the 1965 peak flow to the principal geomorphic features. The peak flow was 2,290 cubic feet per second. Date of photograph: July 13, 1982.

on the summit and along the sides of the terrace. A peak flow (1,640 ft^3/s) that occurred in 1969, also inundated terrace T2. Another peak flow may have occurred in 1962, the year local residents reported large floods in drainages near Coal Draw.

The 1965 peak flow is classified as a very large peak flow; it is assumed to be the largest peak flow since probably 1930 (possibly 1923) because:

1. The 1965 peak flow inundated terrace T2 and nearly all the bottom land.

2. Flood features, such as wood debris, overbank deposits, and shallow channels formed by Coal Draw, were not recognized on slopes above the level of the 1965 peak flow.

3. A conspicuous boundary is recognized between the area mantled by overbank deposits and the adjacent alluvial slopes that are dissected slightly by rills and small gullies from tributary flow. High-water marks of the 1965 peak flow were not recognized specifically, but, based on the gage height of the 1965 peak flow, the level of this peak flow was along the upper boundary of, or slightly above, the overbank deposits. This height indicates that the 1965 peak flow was the largest peak flow during recent years, and probably larger than any peak flow that may have occurred in 1962, or for the last few decades.

4. A dense stand of silver sagebrush growing in the area of the overbank deposits also indicates that terrace T2 and most of the bottom land have been inundated frequently.

5. As reported by a local resident, Mrs. Al Kuhn, the large storm of 1962 produced the largest flows during the preceding 30 to 70 years in drainages from near Coal Draw north to the Wyoming-Montana State line. Partial substantiation of the intensity of that storm is from Deadman Creek (site M-7, fig. 1), at which a peak flow of 16,600 ft^3/s occurred from a drainage area of only 12 mi^2.

6. Very large peak flows, some of the largest peak flows of the 20th century, occurred in 1923 along many small drainages of the northern Powder River basin in Wyoming. Possibly a large peak flow also occurred along Coal Draw in that year.

7. The 1965 peak flow probably has been the largest peak flow of recent years, but only slightly larger than the 1969 peak flow and a peak flow that may have occurred in 1962. All these peak flows probably were larger than peak flows that had occurred during the three or four decades before the 1960's--possibly since about 1910.

Pritchard Draw near Lance Creek
(Streamflow-gaging station 06382200)

Data collected in the reach of Pritchard Draw near the site of the streamflow-gaging station (site 6, fig. 1) indicate that the 1968 peak flow (4,050 ft^3/s—the largest peak flow of record) also has been the largest peak flow of recent decades along this drainage. This peak flow inundated terrace T2, 15.5 ft above the streambed at the station, and all the bottom land (fig. 15). Upstream from the station, terrace T2 decreases in height to 11 ft. In this area, the 1965 peak flow (2,100 ft^3/s—the second largest peak flow of record) inundated terrace T2. Because high-water marks of the 1965 and 1968 peak flows were not observed, the relation of these peak flows to terrace T2 is based on their gage heights. The 1968 peak flow is classified as a very large peak flow, and the 1965 peak flow is classified as a large peak flow.

Recent deepening of the channel, now bordered by a conspicuous bench referred to as terrace T1, is indicated from scoured, nearly vertical, channel sides. This deepening probably occurred a few years before the gaging station was installed in 1964. Since 1964, the depth of the channel has remained stable. The deepening has been about 4 to 5 ft, and the newly formed terrace T1 is between 5 and 6.5 ft above the streambed. The largest recent flood along Lance Creek reported by local residents in 1954. Also, several large peak flows along different drainages in east-central Wyoming took place during 1952, 1953, and 1955. Deepening of the channel along Pritchard Draw may have resulted during that time (1952-55).

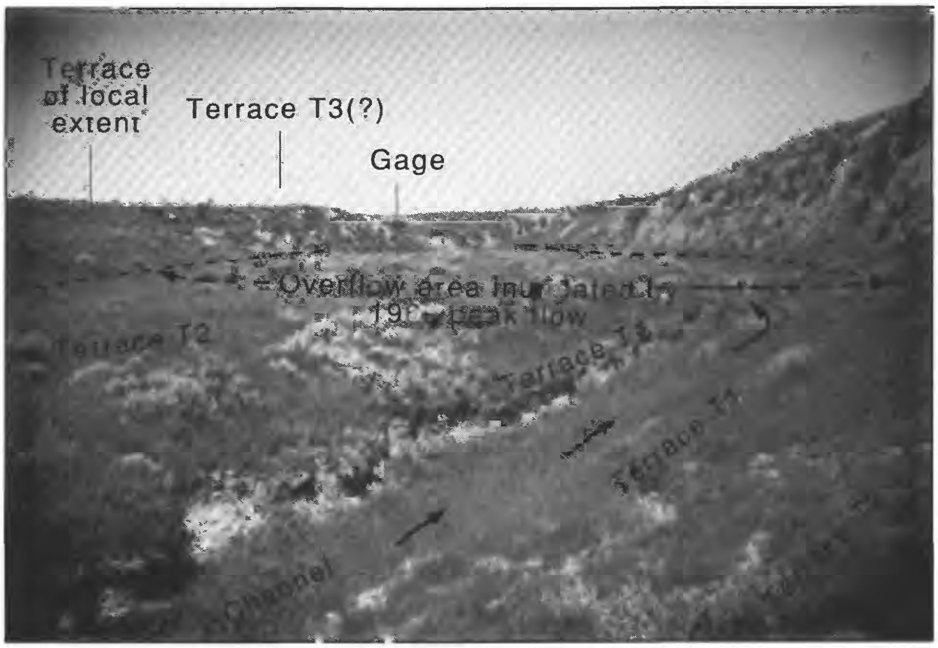


Figure 15.--Downstream view along Pritchard Draw near Lance Creek, showing the relation of the 1968 peak flow to terrace T2 and the bottom land. The peak flow was 4,050 cubic feet per second. Date of photograph: July 16, 1982.

The 1968 peak flow is classified as a very large peak flow; it is assumed to be the largest peak flow since at least 1952-55, and possibly since about 1930 because:

1. The 1968 peak flow inundated all of terrace T2 and the bottom land. Terrace T2 has a rounded appearance, as if it has been inundated frequently, and some overbank deposits are present.

2. Flood features were not recognized above the level of terrace T2 (where terrace T2 is 15.5 ft above the streambed). Slopes above the highest level of terrace T2 display a few rills and small gullies formed by tributary flow.

3. Flood debris of the 1968 or 1965 peak flows, or peak flows possibly larger than the 1968 peak flow, were not identified. However, the flood debris consists of small sagebrush fragments, which do not accumulate readily as piles on the grassy slopes of the bottom land.

4. A scattered stand of silver sagebrush indicates that terrace T2 is inundated at least occasionally.

5. Because of recent deepening of the channel, peak flows that could inundate terrace T2 before the establishment of the gaging station would not need to be as large as the 1968 peak flow.

Turner Creek near Osage
(Streamflow-gaging station 06387500)

Data collected in the reach of Turner Creek near the site of the streamflow-gaging station (site 7, fig. 1) indicate that the 1979 peak flow (5,660 ft^3/s), the largest peak flow of record, inundated the widespread terrace T2 and nearly all the bottom land (fig. 16). The 1981 peak flow (4,700 ft^3/s), the second largest peak flow of record, was only slightly smaller than the 1979 peak flow. Both peak flows are classified as very large peak flows.

The 1979 peak flow is the largest peak flow since at least 1918 because:

1. As reported by a local resident (Milton Holwell, oral commun., 1982), the 1979 peak flow has been the largest peak flow since at least 1918. This peak flow may have been the largest peak flow since the area was settled during the early 1880's, because few large floods are known to have occurred in this region.

2. The 1979 peak flow inundated nearly all the bottom land, including all of terrace T2. Flood debris above the level of the 1979 peak flow was not recognized.

3. Flood features, such as scouring or overbank deposits, were not recognized on alluvial slopes above the level of the 1979 peak flow. Rills and small channels formed by tributary flow were recognized on slopes not inundated by the 1979 peak flow.

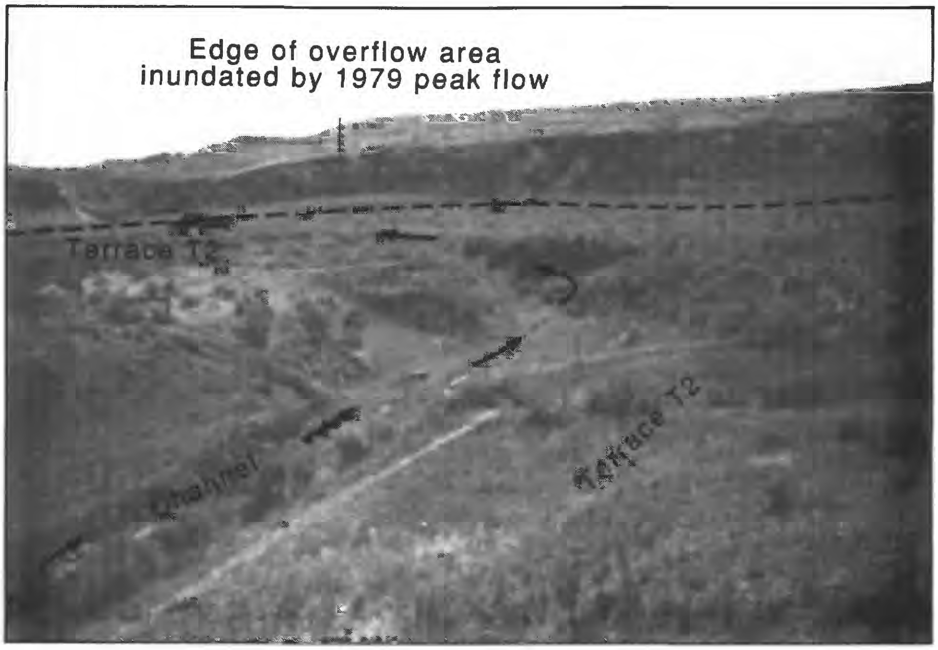


Figure 16.--Downstream view along Turner Creek near Osage, showing the relation of the 1979 peak flow to the widespread terrace T2 and the bottom land. The peak flow was 5,660 cubic feet per second. The channel in the foreground has been modified from construction of the bridge on U.S. Highway 85. Date of photograph: July 15, 1982.

4. Considerable overbank deposits on terrace T2 indicate that this terrace is inundated frequently; this also is indicated by the gaging-station record, which indicates the terrace was inundated six times during the period of record, water years 1959-81.

Third Sand Creek near Medicine Bow
(Streamflow-gaging station 06631150)

Data collected in the reach of Third Sand Creek near the site of the streamflow-gaging station (site 8, fig. 1) indicate that historical peak flows (before 1965) approximately the magnitude of the two largest peak flows of record—1,580 ft^3/s in 1977, and 1,540 ft^3/s in 1979—have occurred from time to time during the last several decades. Relations between all the peak flows and terrace T2 were obtained in the reach upstream from the station (fig. 17). The channel at the gaging site and downstream appears to have been deepened recently, mainly by construction activity along a county road that crosses the creek downstream from the gage. The pre-1965 historical peak flows are indicated by a buried mantle of sandy and silty overbank deposits on terrace T2. The overbank deposits are between 1 and 1.5 ft thick and are distributed over all of terrace T2; terrace T2 is 7 ft high and forms nearly all the bottom land. Root crowns of big sagebrush, buried at depths of 0.5 and 0.7 ft between layers of overbank deposits indicate that: (1) These plants have been affected during floods caused by the two largest peak flows of record and at least one historical peak flow; and (2) at least two historical peak flows emplaced most of the overbank deposits. All the peak flows are classified as large peak flows. The overbank deposits and the dense stand of silver sagebrush indicate terrace T2 is in the overflow area and has been inundated frequently since its formation.

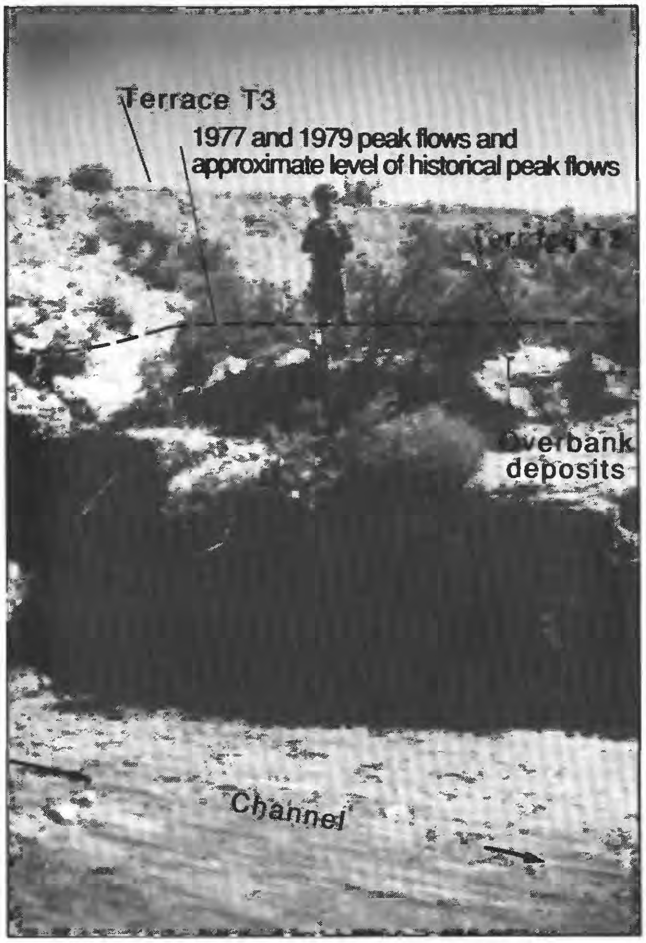


Figure 17.--View across the channel of Third Sand Creek near Medicine Bow, showing the relation of the 1977 and 1979 peak flows to the principal geomorphic features and overbank deposits emplaced by the 1977 and 1979 peak flows, and by the historical peak flows (pre-1965) on terrace T2. Peak flows, in cubic feet per second, were as follows: 1977, 1,580; 1979, 1,540. Date of photograph: June 29, 1982.

The 1977 peak flow is assumed to be the largest peak flow for at least 30 years because:

1. The overbank deposits emplaced by the 1977 and 1979 peak flows are thinner and not as widespread as the underlying overbank deposits laid down by the pre-1965 historical peak flows. In the reach inspected upstream from the station, buried root crowns of large trees show the channel has been aggrading slightly for at least the past few years.

2. Wood flood debris deposited by the 1977 and 1979 peak flows is the oldest flood debris observed, indicating that, because of the lack of preservation of flood debris from the historical peak flows, the historical peak flows occurred at least a few decades ago.

3. The relation of the buried root crowns of big sagebrush to the overbank deposits indicates that these plants have been affected during floods caused by the 1977 and 1979 peak flows, and at least one historical peak flow. Based on the condition of the overbank deposits, the historical peak flows probably occurred three decades ago or longer.

Lawn Creek near Alcova
(Streamflow-gaging station 06642700)

Data collected in the reach of Lawn Creek near the site of the streamflow-gaging station (site 9, fig. 1) indicate that a historical peak flow occurred during the middle or late 1800's. The peak flow is estimated to have been 5,000 ft^3/s and is classified as a very large peak flow. Also, this peak flow emplaced gravel deposits forming a 10.5-ft-high terrace (fig. 18). The peak flow of record, 4,760 ft^3/s, also classified as a very large peak flow, occurred in 1981. As reported by R.A. Boyd of Boyd Ranch (oral commun., 1982), this peak flow has been the largest peak flow since about 1930. The 1981 peak flow barely inundated the 10.5-ft-high terrace formed by the historical peak flow; thus, the 1981 peak flow probably has been the largest peak flow to have occurred since the historical peak flow.

The historical peak flow is classified as a very large peak flow; it is assumed to be the largest peak flow for at least 100 years (perhaps for as long as about 130 years) because:

1. Historical accounts indicate that some streams, such as the type-1 Red Fork Powder River, in similar physiographic positions along mountain fronts as Lawn Creek, had channels with vertical sides during the 1870's.

2. An immature soil about 0.5-ft thick has developed at the top of the 10.5-ft-high terrace. The 10.5-ft-high terrace is believed to have been formed originally as a huge bar because the gravelly deposits of this terrace are similar to the gravelly deposits of a large bar emplaced during the 1981 peak flow. The bar formed in 1981 has a maximum height of 7 ft and is about 0.3 mile upstream from the 10.5-ft-high terrace. The soil at the top of the 10.5-ft-high terrace is less developed than the soil at the top of terrace T2, that had formed during a few centuries prior to the late 19th century. Based on differences in the development of both soils, the length of time necessary for the development of the soil on the 10.5-ft-high terrace would be about 100 years or slightly longer. Therefore, the flood that formed the deposits of the 10.5-ft-high terrace probably occurred about 100 years ago.

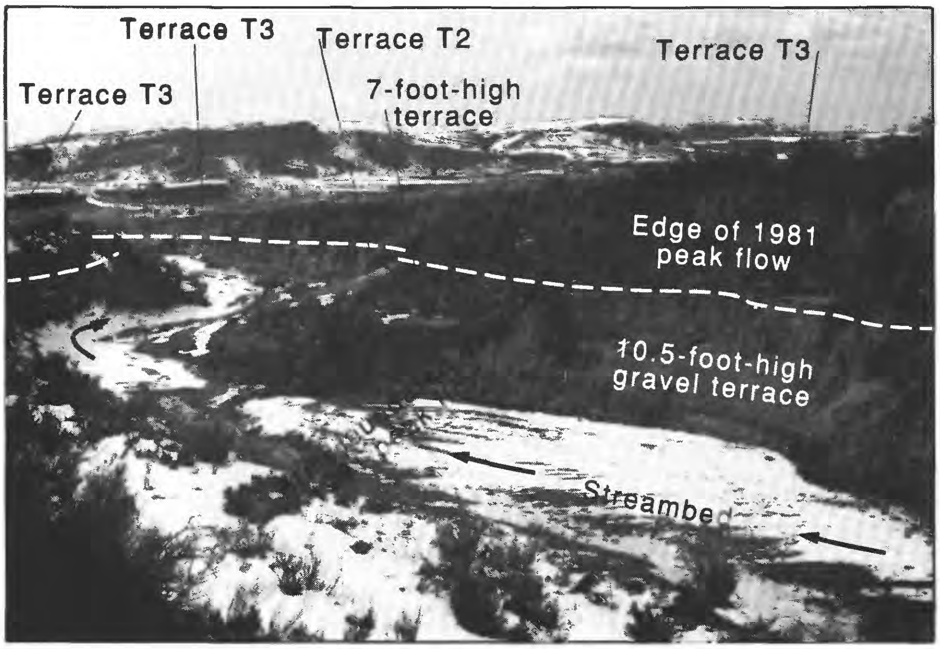


Figure 18.--Downstream view along Lawn Creek near Alcova, showing the relation of the 1981 peak flow to the principal geomorphic features. The peak flow was 4,760 cubic feet per second. The gravel of the 10.5-foot-high terrace is believed to have been deposited by a large historical flood with a peak flow estimated to be 5,000 cubic feet per second, because the 1981 peak flow inundated only the lower part of this terrace. Date of photograph: March 23, 1982.

Stinking Creek tributary near Alcova
(Streamflow-gaging station 06642730)

Data collected in the reach of Stinking Creek tributary near the site of the discontinued streamflow-gaging station (site 10, fig. 1) indicate the 1981 peak flow far exceeded the peak flow of record. The 1981 peak flow was estimated to be 2,000 ft^3/s. The 1981 peak flow inundated terrace T2 (fig. 19) at a shallow depth. The peak flow of record, 561 ft^3/s, occurred in 1961; this peak flow inundated only the lower part of the channel.

The peak flow of 1981 is classified as a very large peak flow; it is assumed to be the largest peak flow for at least 100 years and possibly for more than 100 years because:

1. Based on information reported by R.A. Boyd of Boyd Ranch (oral commun., 1982), the 1981 peak flow in the adjacent drainage of Lawn Creek near Alcova (site 9, fig. 1), which occurred at the same time as the peak flow on Stinking Creek tributary, probably was the largest peak flow to have occurred since at least 1930.

2. A comparison of the relation of the peak flow to terrace T2 in this drainage with that in the Lawn Creek drainage indicates that the peak flow was larger in this drainage, where the peak flow inundated terrace T2, than that in the Lawn Creek drainage, where the peak flow did not inundate terrace T2 (see preceding section on Lawn Creek near Alcova).

Figure 19.--Downstream view of Stinking Creek tributary near Alcova, showing the relation of the 1981 peak flow to terrace T2. The peak flow was estimated to be 2,000 cubic feet per second. This terrace was inundated at a shallow depth--just above the boy's ankle (left bank), and is at the base of the notebook (right bank). The peak flows of the systematic record were confined to the lower one-third of the channel. Date of photograph: July 1, 1982.

3. The absence of overbank deposits and presence of range type vegetation on terrace T2 indicate that this terrace rarely has been inundated, or never had been inundated since its formation until 1981.

4. The height of terrace T2 is 14.5 ft above the streambed, indicating that this terrace is inundated rarely.

Dry Rawhide Creek near Lingle
(Streamflow-gaging station 06670985)

Data collected in the reach of Dry Rawhide Creek near the site of the discontinued streamflow-gaging station (site 12, fig. 1) indicate a historical peak flow larger than the peak flow of record has not occurred for at least 50 years. The peak flow of record (4,180 ft^3/s) occurred in 1969. The peak flow inundated terrace T2 (fig. 20), nearly all the bottom land, and overtopped a high embankment of U.S. Highway 85. The highest known peak flow prior to 1969 was reported by an area rancher in 1946. Discharge for the 1946 peak flow was estimated by slope-conveyance methods to be 3,800 ft^3/s.

The peak flow of 1969 is classified as a large peak flow; it is assumed to be the largest peak flow in at least the last 50 years (possibly for as long as 100 years) because:

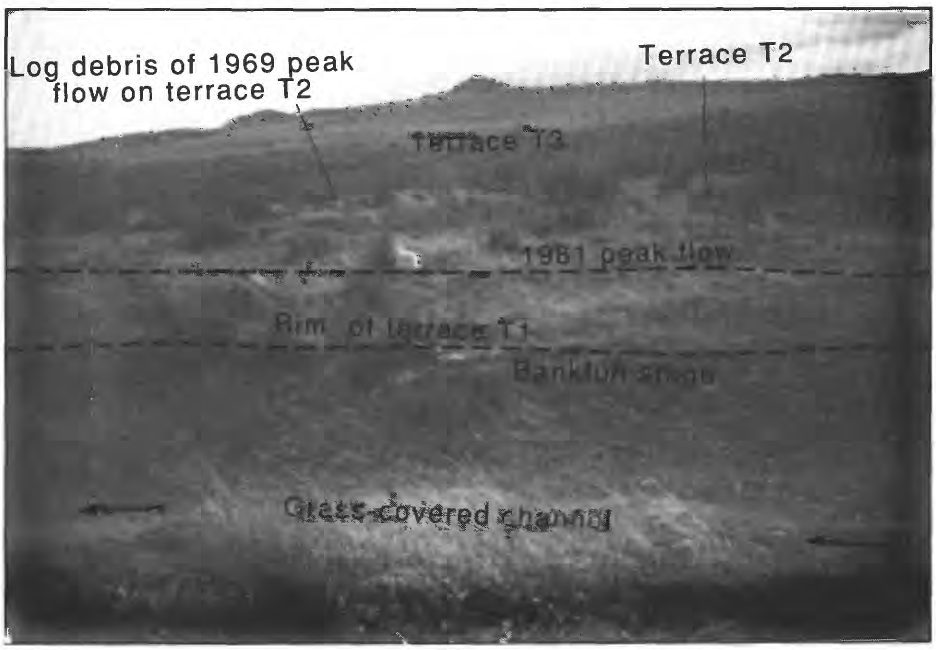


Figure 20.--View across the channel of Dry Rawhide Creek near Lingle, showing wood debris deposited by the 1969 peak flow on terrace T2. The peak flow was 4,180 cubic feet per second. The much smaller 1981 peak flow (710 cubic feet per second) inundated only terrace T1. Date of photograph: March 31, 1982.

1. Flood debris of the 1969 peak flow consists mostly of slightly weathered logs and large limbs of cottonwoods. A grove of large cottonwoods is located upstream from the reach inspected. The time estimated for complete decay of large cottonwood logs and limbs is more than 50 years (table 2). Because cottonwood flood debris was not found above the level of the 1969 peak flow, this peak flow is assumed to be the highest peak flow to have occurred for at least 50 years.

2. The height of terrace T2 is 8.5 ft above the streambed, indicating that this terrace is seldom inundated.

3. The absence of recognizable overbank deposits on terrace T2 also indicates that this terrace is seldom inundated.

4. A well-preserved shallow channel is present on terrace T2; it was the channel of Dry Rawhide Creek before the present channel was entrenched. If terrace T2 had been inundated frequently, this channel would have been filled with sediment, and its presence would not be recognized easily.

East Otterson Wash near Green River
(Streamflow-gaging station 09216290)

Data collected in the reach of East Otterson Wash near the site of the streamflow-gaging station (site 13, fig. 1) indicate two historical peak flows, one that occurred about 1950-55 (classified as a large peak flow) and the other that occurred about 1960-65 (classified as a medium peak flow). The peak flows are estimated to have been 1,200 ft^3/s in 1950-55 and 950 ft^3/s in 1960-65. The level of the 1950-55 peak flow was along the rim of terrace T2; however, where it was inspected, no evidence existed that this terrace was flooded. The 1960-65 peak flow inundated terrace T1 at a moderate depth. The peak flow of record, 791 ft^3/s, occurred in 1969. This peak flow covered terrace T1 at a shallow depth; it is classified as a medium peak flow (fig. 21). The approximate dating of the two historical peak flows is based on the degree of weathering of the sagebrush flood debris (table 3).

The historical peak flow of 1950-55 is classified as a large peak flow; it is assumed to be the largest peak flow since at least 1930 because:

1. The absence of sagebrush debris deposited by floods higher than the level of this peak flow indicates this peak flow was the largest for at least 50 years, because a complete decay process for sagebrush debris deposited by floods in southwestern Wyoming is estimated to take more than 50 years.

2. Features formed during peak flows were not recognized on terrace T2 or on slopes higher than the area inundated by the 1950-55 peak flow, indicating those areas have not been inundated recently.

3. The abutments of a wood bridge near the station, of the type built during the 1920's or 1930's, indicate that the depth of the channel has not changed appreciably since the construction of the bridge.

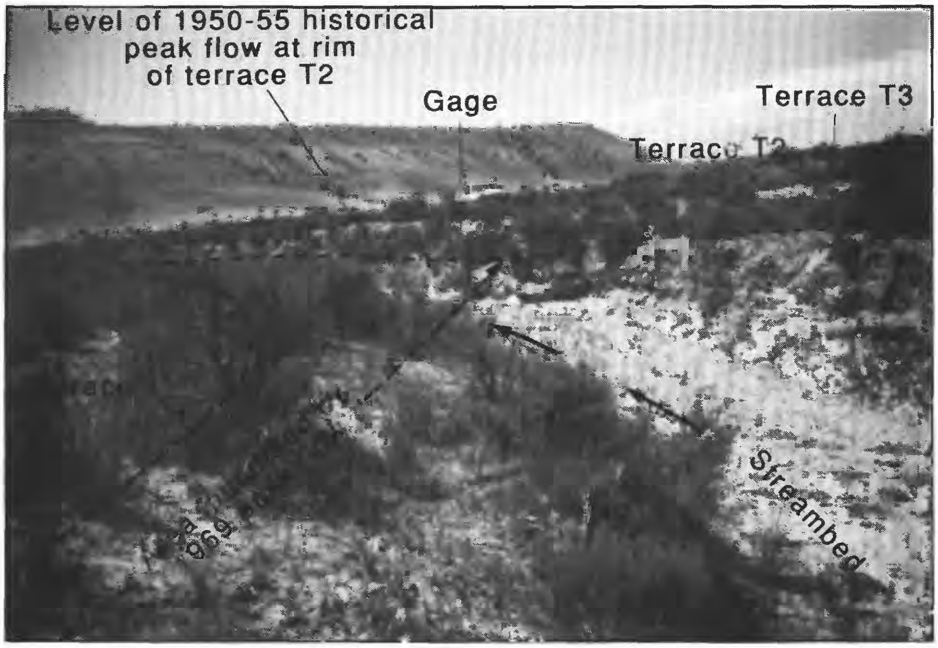


Figure 21.--Downstream view along East Otterson Wash near Green River, showing the relation of the 1950-55 historical peak flow and the 1969 peak flow (the largest peak flow of the systematic record) to the principal geomorphic features. Peak flows, in cubic feet per second, were as follows: 1950-55, 1,500 (estimated); 1969, 791. Date of photograph: August 19, 1982.

No Name Creek near Rock Springs
(Streamflow-gaging station 09216695)

Data collected in the reach of No Name Creek near the site of the abandoned streamflow-gaging station (site 16, fig. 1) indicates a historical peak flow occurred a short time before 1973. The historical peak flow inundated terrace T1, which is 4 ft below the level of terrace T2 (fig. 22). The peak flow is estimated to have been 1,000 ft^3/s. The 1973 peak flow of 377 ft^3/s, the largest peak flow of record, is classified as a small peak flow; it did not inundate terrace T1.

The historical peak flow is classified only as a medium peak flow, even though it is assumed to be the largest peak flow to have occurred during at least the past 15 to 20 years because:

1. Some trunks and large limbs of sagebrush were bent in the downstream direction, but flood debris was not observed in the inspected reach. This bending of the sagebrush indicates that a peak flow occurred probably not more than 20 years ago.

2. The historical peak flow inundated only terrace T1, which is frequently inundated in most type-1 drainages.

3. Evidence of floods larger than the historical peak flow was not observed in the inspected reach.

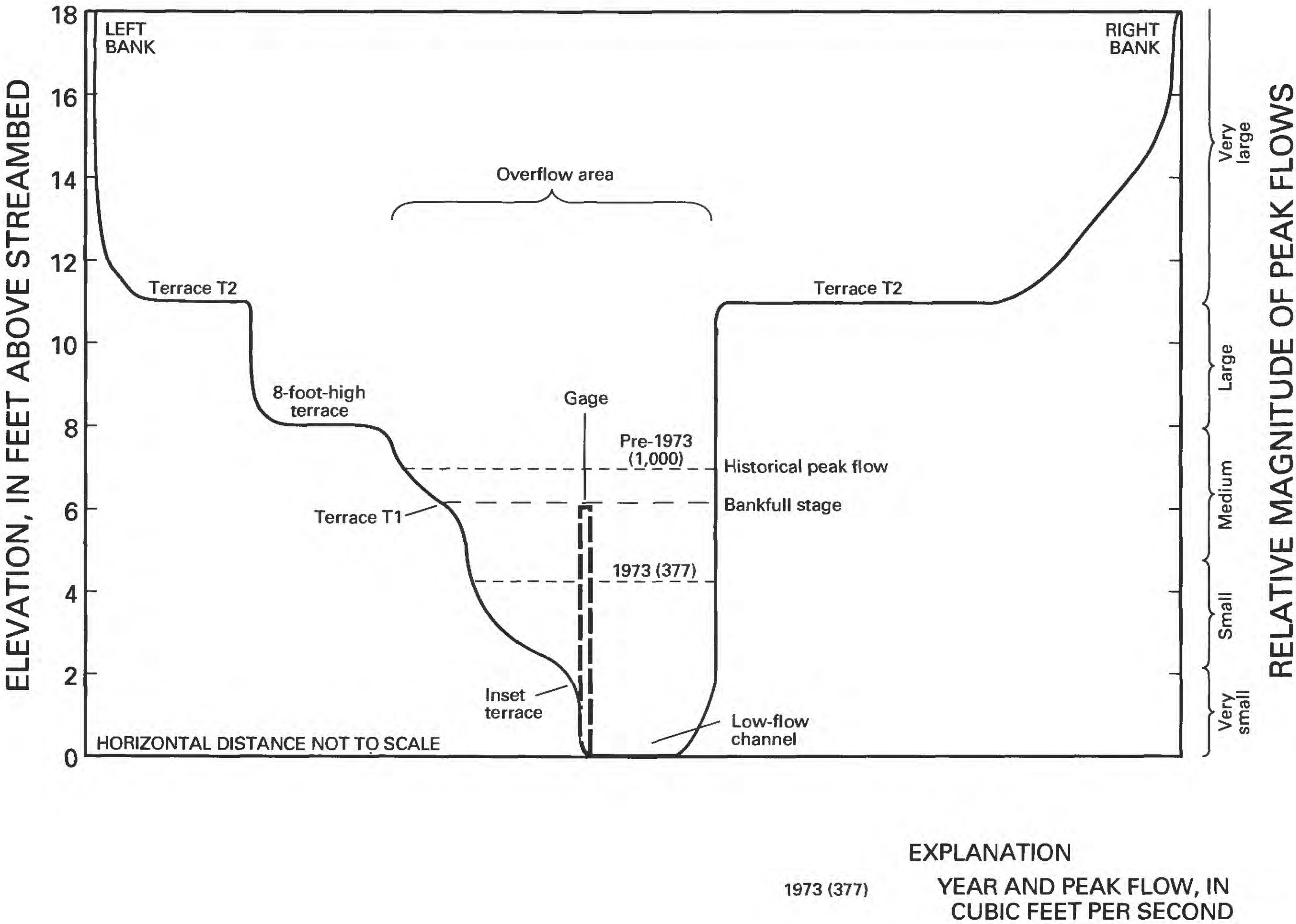


Figure 22.--Cross section of No Name Creek near Rock Springs, showing the relation of the historical peak flow and the 1973 peak flow (the largest peak flow of the systematic record) to the principal geomorphic features. Peak flows, in cubic feet per second, were as follows: historical, 1,000 (estimated); 1973, 377.

Salt Wells Creek near Rock Springs
(Streamflow-gaging station 09216700)

Data collected in the reach of Salt Wells Creek near the site of the discontinued streamflow-gaging station (site 17, fig. 1) indicated no evidence of a historical peak flow above the peak flow of record since the 1930's. The peak flow of record (3,750 ft^3/s) occurred in 1962. The 1962 peak flow, resulting mainly from the melting of snow by a chinook, inundated terrace T1 (fig. 23) and was at a level of about 1 ft below the rim of terrace T2.

The peak flow of 1962 is classified as a large peak flow; it is assumed to be the largest peak flow since at least 1937 (45 years before 1982) because:

1. Evidence of floods was not found above the level of the 1962 peak flow.

2. Overbank deposits were emplaced by the 1962 peak flow (and possibly older peak flows) on the 7-ft-high terrace. Overbank deposits were not observed on terrace T2.

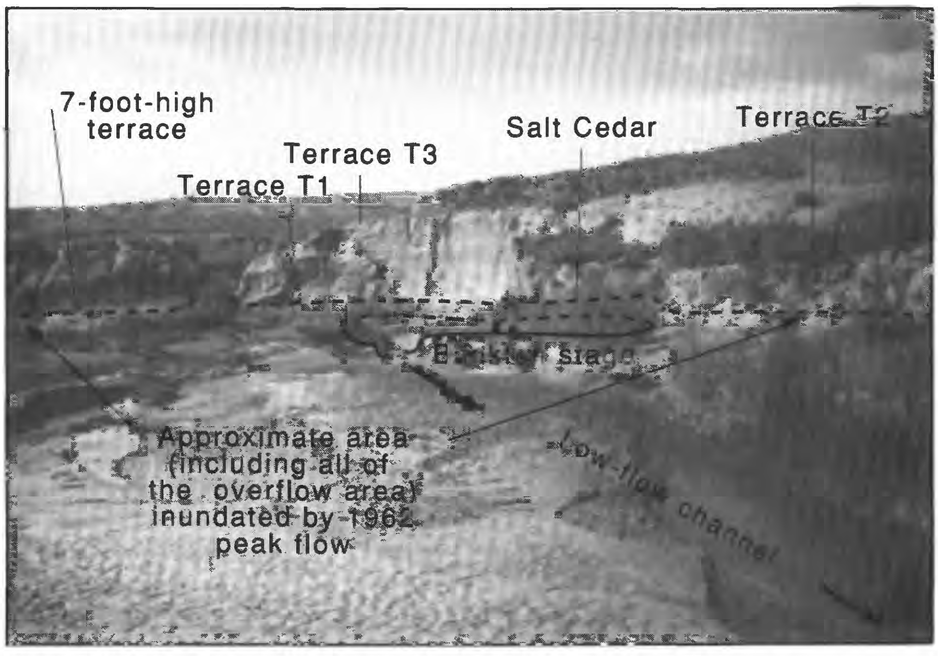


Figure 23.--Upstream view along Salt Wells Creek near Rock Springs, showing the relation of the 1962 peak flow to the principal geomorphic features. The peak flow was 3,750 cubic feet per second. Date of photograph: August 17, 1982.

3. Terrace T2 is 9 ft high and supports range-type vegetation. Because this terrace is more than 8 ft high and supports range-type vegetation, is it seldom inundated.

4. The 7-ft-high terrace supporting range-type vegetation is not in the overflow area; therefore, this terrace is seldom inundated.

5. In 1937, the largest known peak flow (9,700 ft^3/s) on Bitter Creek during the 20th century occurred in the reach downstream from the mouth of Salt Wells Creek. Large-scale flooding also may have occurred along Salt Wells Creek during that year.

Type-2 Drainages

Type-2 drainages are distributed mainly along the flanks of some of the upland parts of the plains region in Wyoming. These drainages generally have not been selected for streamflow-gaging-station sites because their channels are unstable. The channels may be filled with sand and gravel bars, in contrast to the channels of drainage types 1 and 3. The width of the channels may change with every large or very large peak flow, even though the depth of the channels only have fluctuated slightly during the past few centuries. Unpaired terraces and short reaches with local paired terraces characterize the type-2 drainages (fig. 7). In some drainages, a low paired terrace in the overflow area is referred to as terrace T1, and a high terrace is referred to as terrace T3. Terrace T3 forms the boundary of the bottom land in some type-2 drainages (fig. 7). Terrace T2, a conspicuous geomorphic marker unit in type-1 drainages, is not present in the type-2 drainages. Because of the local distribution of most terraces and the relatively unstable channels, it is much more difficult to relate the magnitude of the peak flows to the terraces in type-2 drainages than in type-1 drainages.

Sand Creek near Orin
(Streamflow-gaging station 06651800)

Data collected in the reach of Sand Creek near the site of the streamflow-gaging station (site 11, fig. 1) indicate that the 1955 peak flow, the largest peak flow of record, was a very large peak flow of 20,700 ft^3/s. This peak flow is one of the largest peak flows recorded for the small ephemeral plains streams in Wyoming. Substantially larger peaks have occurred only along the much larger major rivers, such as the Cheyenne and Powder Rivers. The 1955 peak flow inundated most of the bottom land and about the lower one-half of the sides of terrace T3 (fig. 24). It inundated terrace T1 to a maximum depth of 7 ft and also flooded most of the unpaired terraces in this reach of Sand Creek.

The 1978 peak flow of 5,460 ft^3/s is the second largest peak flow of record. The 1978 peak flow covered only some of the unpaired terraces and part of bottom land in the area near the station. However, high embankments along Interstate Highway 25 (not present in 1955), 0.25 mi upstream from the station and an access road, dammed the 1978 peak flow and may have decreased the peak flow substantially in the reach downstream from the interstate highway. The 1978 peak flow in the reach near the station is classified as a medium to large peak flow; in the reach upstream from Interstate Highway 25, it probably would be classified at least as a large peak flow.

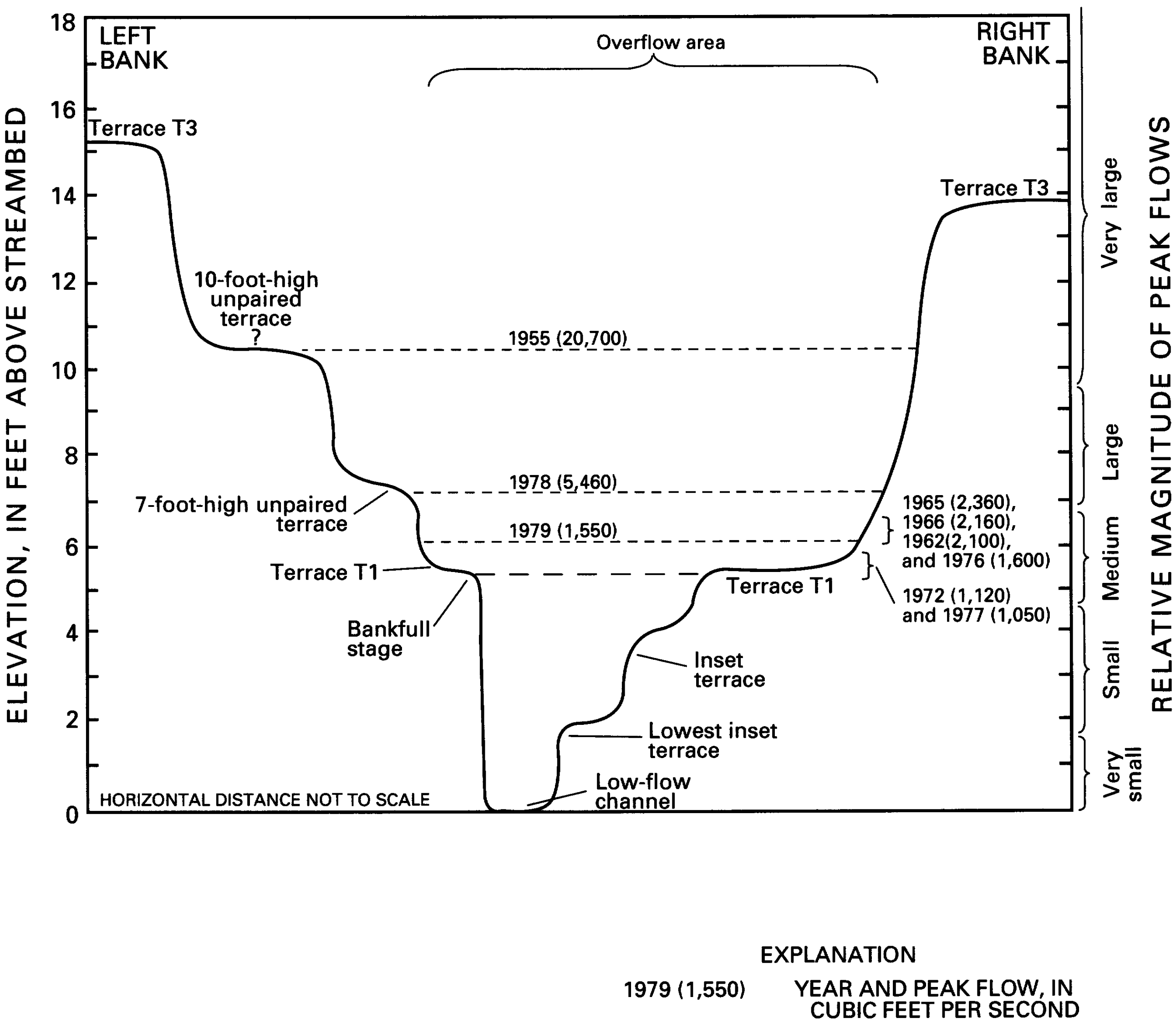


Figure 24.--Cross section of Sand Creek near Orin, showing the relation of selected peak flows to the principal geomorphic features.

The 1955 peak flow is classified as a very large peak flow; it is assumed to be the largest peak flow since at least 1930 and possibly for 200 years because:

1. Mr. and Mrs. George Carmin of Carmin Ranch (near the station) reported that the 1955 peak flow was the largest peak flow since at least 1930.

2. Flood debris deposited above the level of the 1955 peak flow was not observed in the inspected area. Flood debris of the 1955 peak flow consisted chiefly of cottonwood logs, bridge planks, and other boards. Cottonwood logs are preserved from weathering for about 50 years in eastern Wyoming (table 2); however, bridge planks and boards withstand weathering for a much longer period of time--some for more than a century. If bridge planks and other boards were available for flood debris before 1955, then a historical peak flow larger than the 1955 peak flow has not occurred for at least more than a century. (Historical accounts indicate the area was first settled around 1880, and considerable traveling through the area by the U.S. Army and private individuals occurred as early as the 1860's.)

3. Features such as overbank deposits, bars, or small channels formed by peak flows were not observed above the level of the 1955 peak flow.

4. Range-type grass and sagebrush distributed on the slopes and terraces above terrace T1 indicate those areas are seldom inundated.

5. The presence of an immature soil at the top of a locally developed 7-ft-high terrace indicates that this terrace was formed many decades ago. A thin layer (less than 0.5-ft thick) of silty sand, which is a combination of overbank deposits and wind-blown sand, overlies the soil. The thin layer containing overbank deposits indicates that this terrace has been overtopped by few peak flows. The 1955 peak flow inundated this terrace at a depth of less than 1 ft, and it may have deposited most or all of the overbank deposits. The 1978 peak flow did not inundate this terrace. The 7-ft-high terrace also is in an exposed position where lateral erosion by Sand Creek during flood flows has been progressively eroding the terrace. If many large peak flows, as large or larger than the 1978 peak flow, have occurred during recent decades, this terrace probably would have been removed by erosion.

Summers Dry Creek near Green River
(Streamflow-gaging station 09224980)

Data collected in the reach of Summers Dry Creek near the site of the streamflow-gaging station (site 21, fig. 1) indicate that the 1973 peak flow may have been the largest peak flow for the past few centuries. The 1973 peak flow was by far the largest peak flow of record--a discharge of 13,900 ft^3/s--nearly four times larger than the second largest peak flow of 1968 (3,830 ft^3/s and classified as a medium peak flow). The 1973 peak flow also is the largest known peak flow of any plains stream tributary to the Green River in southwestern Wyoming. The second largest peak flow known to have occurred in a plains stream in southwestern Wyoming was 9,700 ft^3/s. This peak flow occurred in 1937 along Bitter Creek, which has a much larger drainage area than does Summers Dry Creek. The 1973 peak flow extended over nearly all the bottom land, including all the terraces and most of the alluvial slopes along the sides of the valley (fig. 25). By comparison, the 1968 peak flow inundated only the area of a locally developed lower paired terrace.

The 1973 peak flow is classified as a very large peak flow; it is assumed to be the largest peak flow for the last 100 years, probably for at least the last 200 years, and possibly for the last 500 years because:

1. Flat surfaces of sandstone boulders (composed of medium to fine-grained sand particles and not inundated by 1973 peak flow) along the edge of the area inundated by the 1973 peak flow are overlain by a discontinuous mantle of thin sandstone flakes that have weathered from the sandstone boulders (fig. 26). The time taken for the weathering and accumulation of the flakes must be in terms of many decades to a few centuries. If peak flows larger than the 1973 peak flow had occurred in recent decades, the surging action of the flood water would have removed the flakes from the boulders.

2. Flood features such as shallow channels, bars, or flood debris were not observed on slopes outside of the area inundated by the 1973 peak flow.

3. Overbank sediments deposited by the 1973 peak flow have a more widespread distribution and are at higher elevations above the streambed than are other older overbank deposits, emplaced by some historical peak flows, that were recognized in the inspected reach. These overbank deposits are exposed in a locally developed upper paired terrace, that is 7 to 8 ft above the streambed and about 2,000 ft downstream from the gaging station. The deposits (including the overbank deposits) in this terrace are at least a few centuries old. The top of this terrace is shown in figure 26.

4. The presence of range-type vegetation on the lower paired terrace (terrace T1 not present in reach investigated), higher terraces, and slopes indicates these areas are seldom inundated.

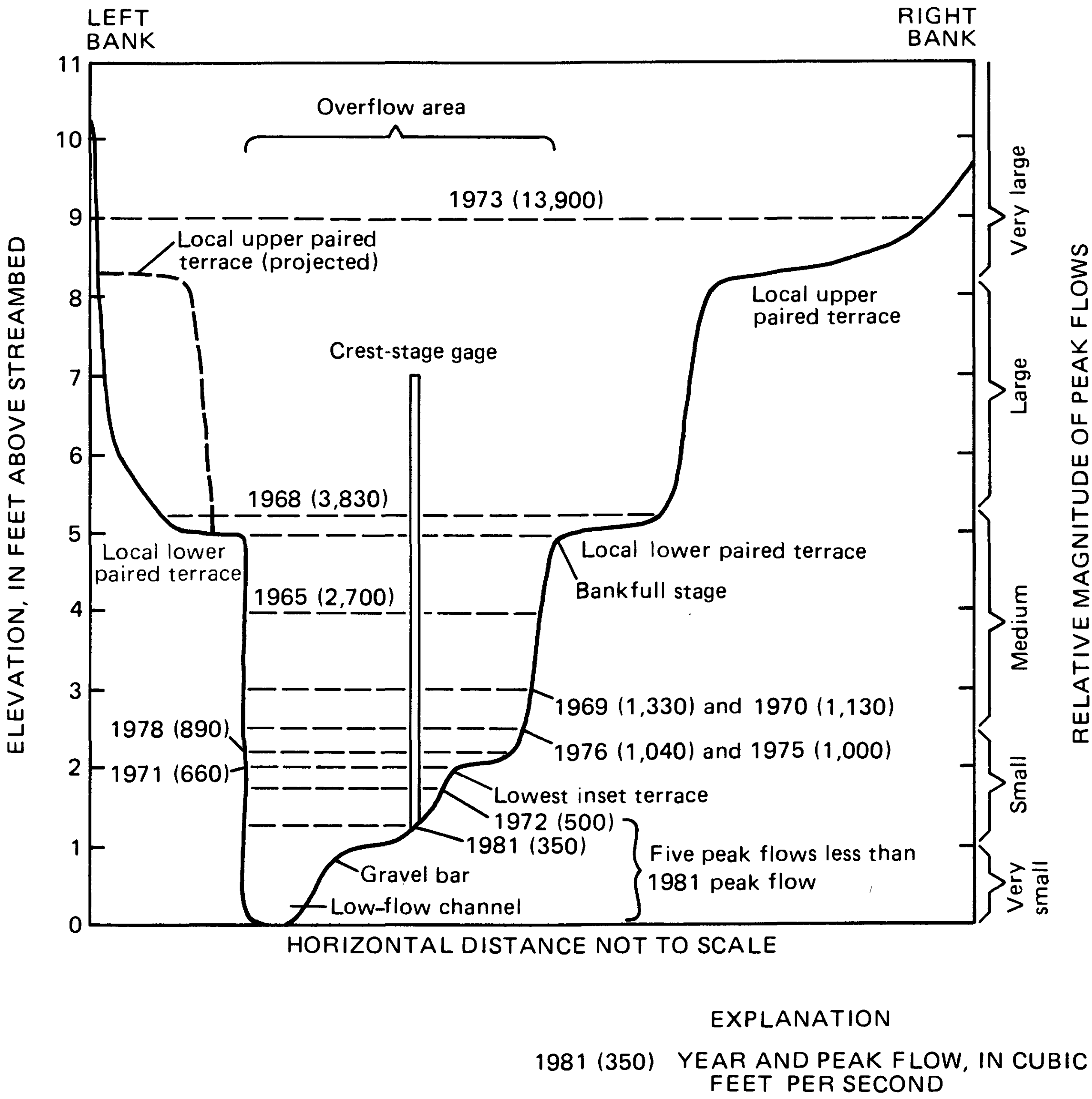


Figure 25.--Cross section of Summers Dry Creek near Green River, showing the relation of peak flows to the principal geomorphic features.

Figure 26.--View across a locally developed paired terrace along Summers Dry Creek near Green River, about 2,000 feet downstream from the streamflow-gaging station. The surface of the large sandstone slab (foreground) consists of thin sandstone flakes that have weathered from the main sandstone slab. The 1973 peak flow (13,900 cubic feet per second) did not inundate the sandstone slab but was along its lower edge. Date of photograph: August 16, 1982.

Type-3 Drainages

Type-3 drainages are known to be present only in southwestern Wyoming. They are in valleys dominated by the broad terrace TM, which comprises the nearly flat valley floor (fig. 8). The valley floor merges into the gentle lower slopes of an alluvial apron distributed along the sides of the valleys. The channel forms a sharp narrow notch below the surface of terrace TM. The channel may be discontinuous with headcuts actively eroding during times of flow. The channels are stable downstream from the headcuts, and these reaches have been selected as favorable sites for streamflow-gaging stations. Peak flows of more than 1,000 ft^3/s are not common for the five type-3 drainages investigated during this study.

Skunk Canyon Creek near Green River (Streamflow-gaging station 09216350)

Data collected in the reach of Skunk Canyon Creek near the site of the streamflow-gaging station (site 14, fig. 1) indicate the occurrence of a pre-1965 historical peak flow. The peak flow was an estimated 1,100 ft^3/s. The historical peak flow inundated terrace TM (fig. 27), which forms most of the bottom land and the lowest part of the alluvial apron. The peak flow of record, 600 ft^3/s, classified as a medium to large peak flow, occurred in 1965. The 1965 peak flow filled the channel and inundated only low parts of terrace TM.

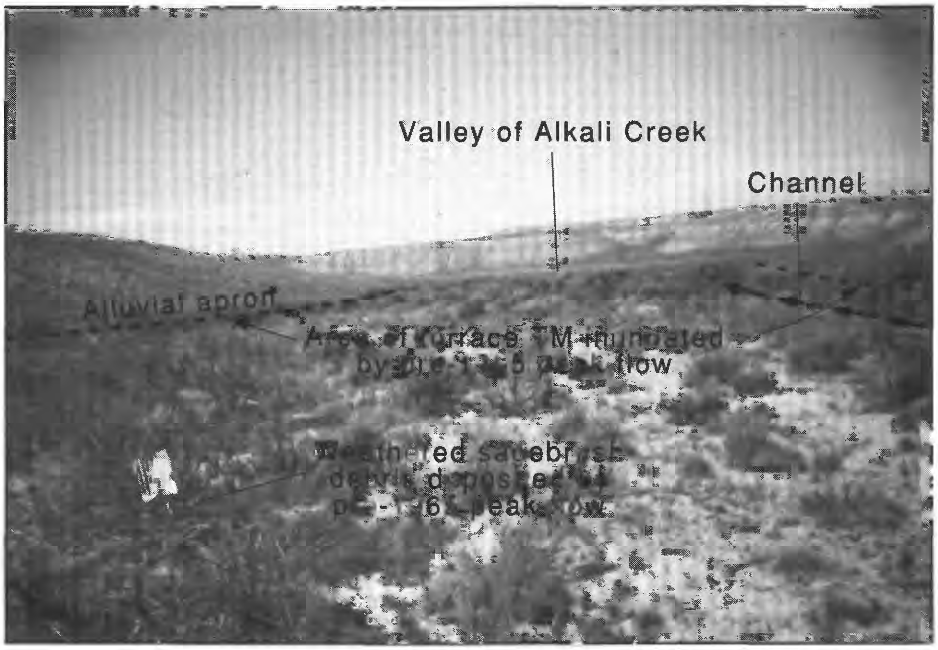


Figure 27.--Downstream view of the valley of Skunk Canyon Creek near Green River, showing the relation of the historical peak flow to the principal geomorphic features. The peak flow was estimated to be 1,100 cubic feet per second. Date of photograph: August 19, 1982.

The historical peak flow, classified as a large peak flow, is assumed to be the largest peak flow in the last 50 years because:

1. The historical peak flow occurred about 30 years ago as indicated by weathering of sagebrush debris deposited by the peak flow (table 3).

2. Wood flood debris or erosional or depositional features emplaced by other peak flows were not observed above the level of the historical peak flow.

Delaney Draw near Red Desert
(Streamflow-gaging station 09216537)

Data collected in the reach of Delaney Draw near the site of the streamflow-gaging station (site 15, fig. 1) indicate that a historical peak flow occurred prior to 1930. The peak flow was estimated to be 1,700 ft^3/s. The peak flow inundated terrace TM, which underlies most of the wide bottom land (fig. 28) and the lowest slopes of the alluvial apron. The peak flow of record (1,260 ft^3/s), which is classified as a large peak flow, occurred in 1965. This peak flow covered only part of terrace TM at a shallow depth.

The historical peak flow, classified as a large to very large peak flow, is assumed to have been the largest peak flow since at least 1930 because:

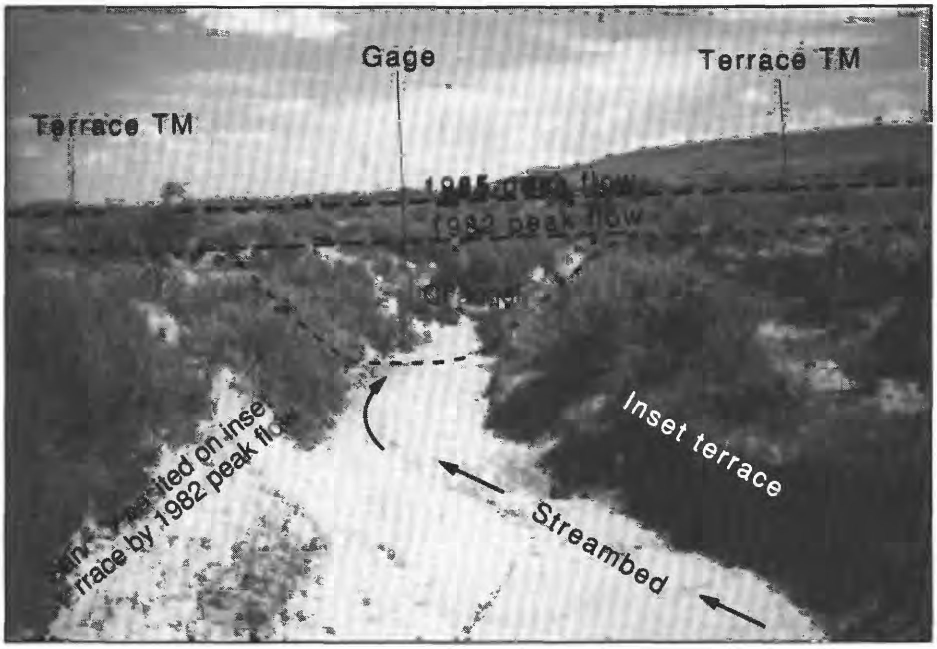


Figure 28.--Downstream view along Delaney Draw near Red Desert, showing the relation of the 1965 and 1982 peak flows, and the historical peak flow to the principal geomorphic features. Peak flows, in cubic feet per second, were as follows: 1965, 1,260; 1982, 350; historical peak, 1,700 (estimated). Date of photograph: August 15, 1982.

1. The extreme flaking (weathering) of the sagebrush flood debris indicates the peak flow occurred at least 50 years ago; this sagebrush flood debris was the most weathered observed in the study (fig. 5).

2. Wood debris deposited by, or erosional or depositional features formed by, other peak flows were not observed above the level of the historical peak flow.

3. Only wood debris deposited by the historical and the 1965 peak flows was recognized in the bottom land.

Blacks Fork tributary no. 2 near Green River
(Streamflow-gaging station 09224810)

Data collected in the reach of Blacks Fork tributary no. 2 near the site of the discontinued streamflow-gaging station (site 18, fig. 1) indicate the occurrence of a pre-1965 historical peak flow. The peak flow was estimated to be 1,000 ft^3/s. The peak flow inundated terrace TM (fig. 29) and the lowest slopes of the alluvial apron. The peak flow of record, 180 ft^3/s, which is classified as a small peak flow, was in 1976. This peak flow filled only about one-half of the channel.

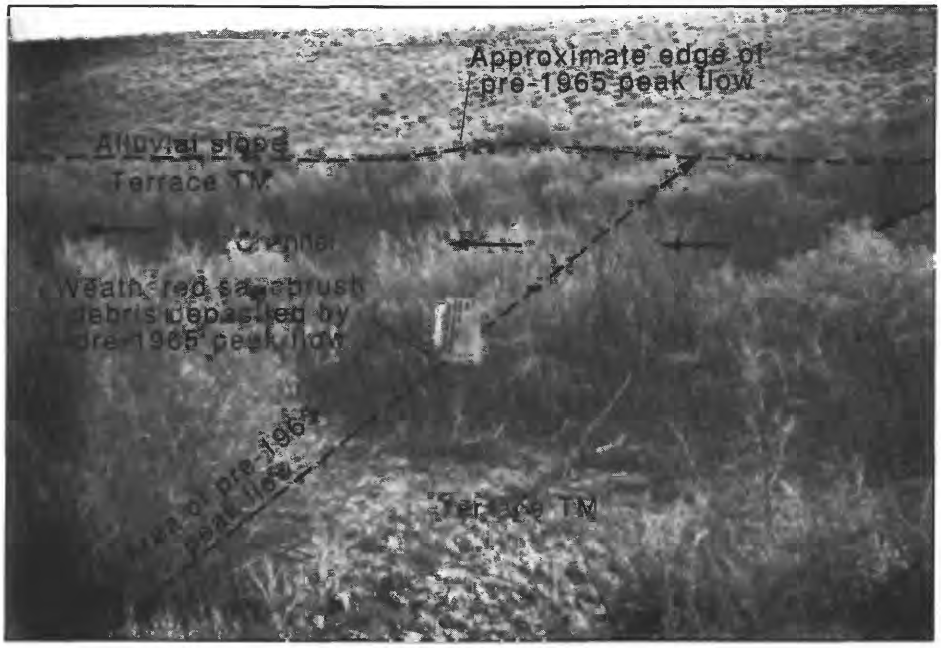


Figure 29.--View across the channel of Blacks Fork tributary no. 2 near Green River, showing the relation of the historical peak flow to the principal geomorphic features. The peak flow was estimated to be 1,000 cubic feet per second. Date of photograph: August 19, 1982.

The pre-1965 peak flow, which is classified as a large peak flow, is assumed to be the largest peak flow in the last 50 years because:

1. Fine, woody sagebrush material is present in some of the debris deposited by the pre-1965 peak flow, indicating that this peak flow occurred about 30 years ago; flaking of the larger sagebrush fragments was not observed.

2. Wood debris deposited by, or depositional or erosional features formed by, peak flows were not observed above the level of the pre-1965 peak flow, indicating that this peak flow probably was the largest during the past 50 years.

Blacks Fork tributary no. 3 near Green River
(Streamflow-gaging station 09224820)

Data collected in the reach of the Blacks Fork tributary no. 3 near the site of the streamflow-gaging station (site 19, fig. 1) indicate the occurrence of a pre-1965 historical peak flow. The peak flow was estimated to be 600 ft^3/s. The level of the peak flow was at the rim of terrace TM (fig. 30). The peak flow of record, 170 ft^3/s, occurred in 1973. This peak flow, which is classified as a small peak flow, filled about one-half the channel.

The pre-1965 peak flow, which is classified as a medium to large peak flow, is assumed to be the largest peak flow in the last 50 years because:

1. The moderate weathering of the sagebrush flood debris with no flaking or fine woody material indicates that the peak flow occurred about 30 years ago. However, because the flood debris is in bushes above ground level, much of the fine woody material may have fallen from the debris accumulations.

2. Evidence of flooding was not observed on terrace TM or on the slopes of the alluvial apron above the level of the historical peak flow.

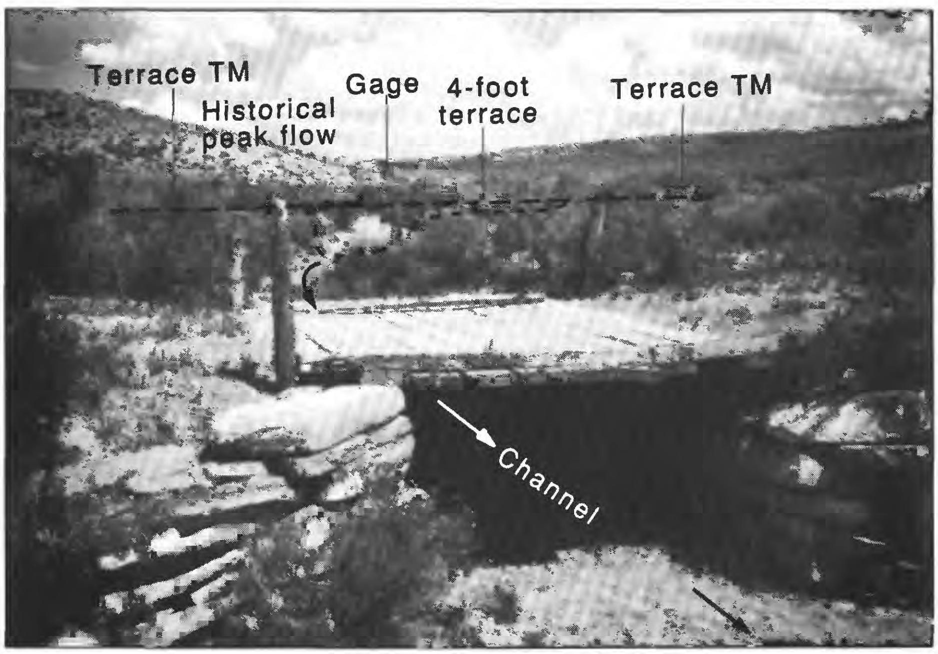


Figure 30.--Upstream view of Blacks Fork tributary no. 3 near Green River, showing the relation of the historical peak flow to the principal geomorphic features. The peak flow was estimated to be 600 cubic feet per second. The wood bridge and stonework are typical of construction of the 1920's and 1930's, indicating that only minor changes have occurred in the channel. Date of photograph: August 19, 1982.

Blacks Fork tributary no. 4 near Green River
(Streamflow-gaging station 09224840)

Data collected in the reach of Blacks Fork tributary no. 4 near the site of the discontinued streamflow-gaging station (site 20, fig. 1) indicate the occurrence of a pre-1965 historical peak flow with an estimated peak discharge of 600 ft^3/s; this peak flow for a drainage area of 1.26 mi^2 is the largest unit discharge known for southwestern Wyoming. The peak flow inundated terrace TM (fig. 31) and the lower slopes of the alluvial apron. The peak flow of record, 47 ft^3/s, was in 1977. This peak flow, which is classified as a small peak flow, filled only the lower part of the channel.

The pre-1965 peak flow, which is classified as a large peak flow, is assumed to be the largest in about 50 years because:

1. The presence of flaking of the sagebrush flood debris with the absence of fine woody material indicates that the peak flow occurred more than 30 years ago.

2. Wood debris deposited above the level of the historical peak flow was not observed, indicating that this peak flow probably was the highest during at least the past 50 years.

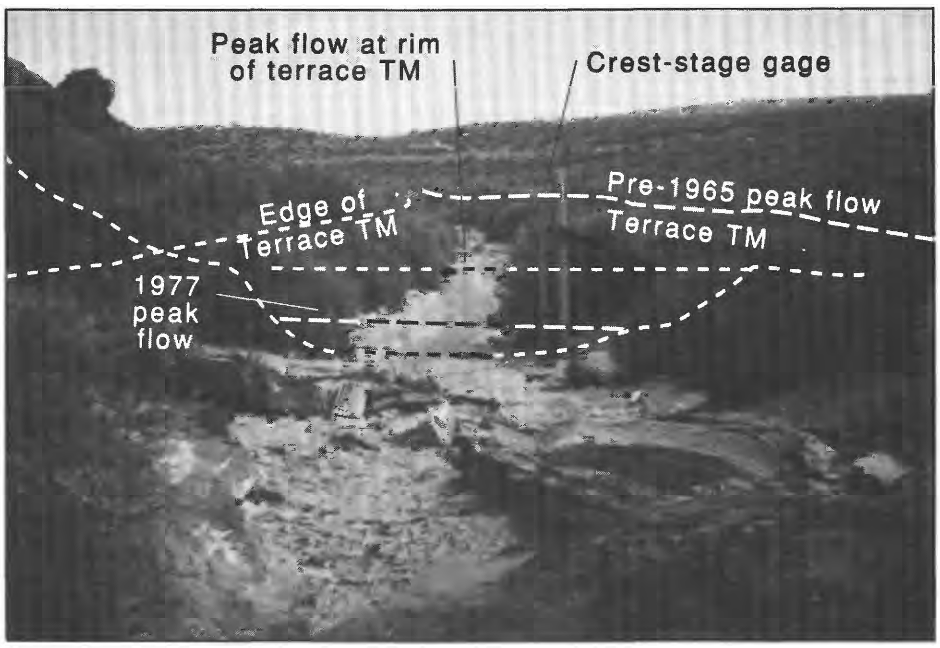


Figure 31.--Upstream view along Blacks Fork tributary no. 4 near Green River, showing the relation of the historical peak flow and the 1977 peak flow (the largest peak flow of the systematic record) to the principal geomorphic features. Peak flows, in cubic feet per second, were as follows: Historical, 600 (estimated); 1977, 47. Date of photograph: August 19, 1982.

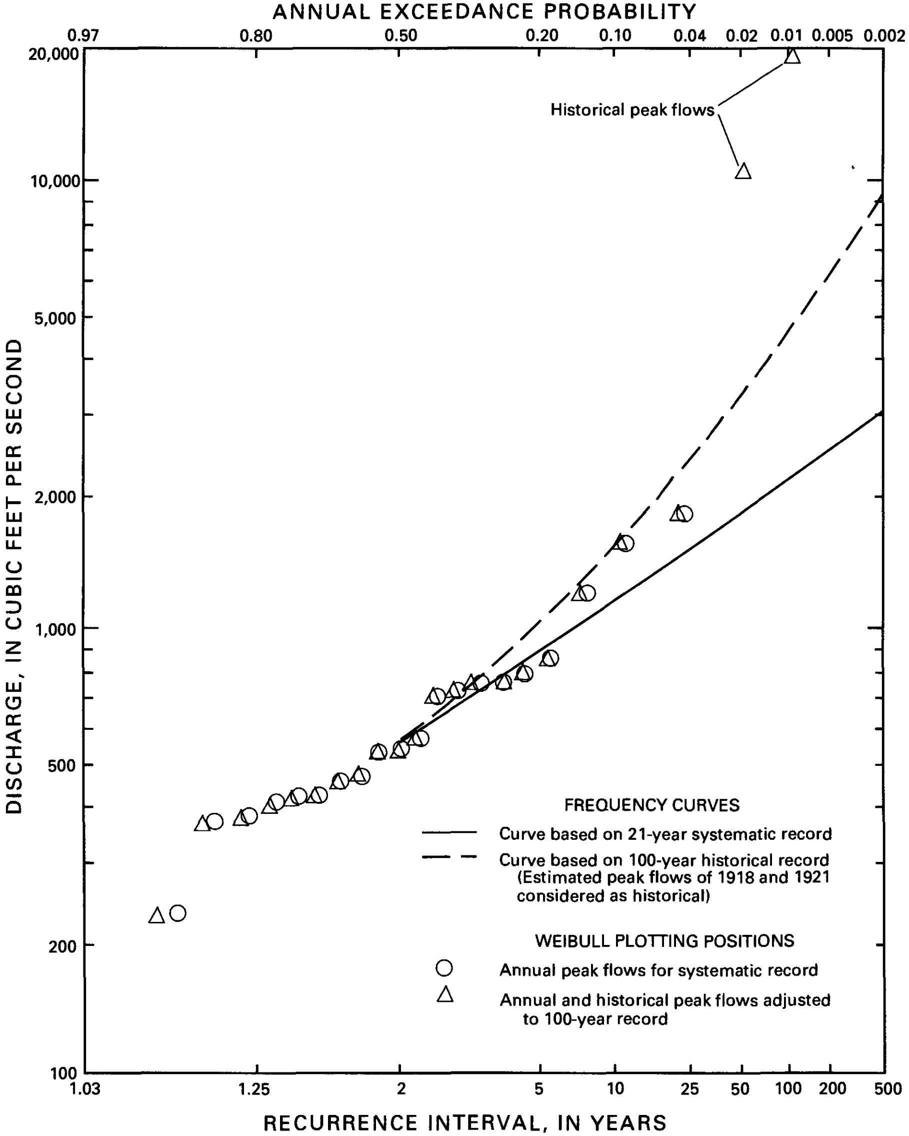
3. Erosional or depositional features were not observed on the slopes of the alluvial apron above the level of the historical peak flow. However, these slopes are underlain by gravelly material that would retard erosion by short duration flood flows.

ADJUSTMENT OF FLOOD-FREQUENCY CURVES

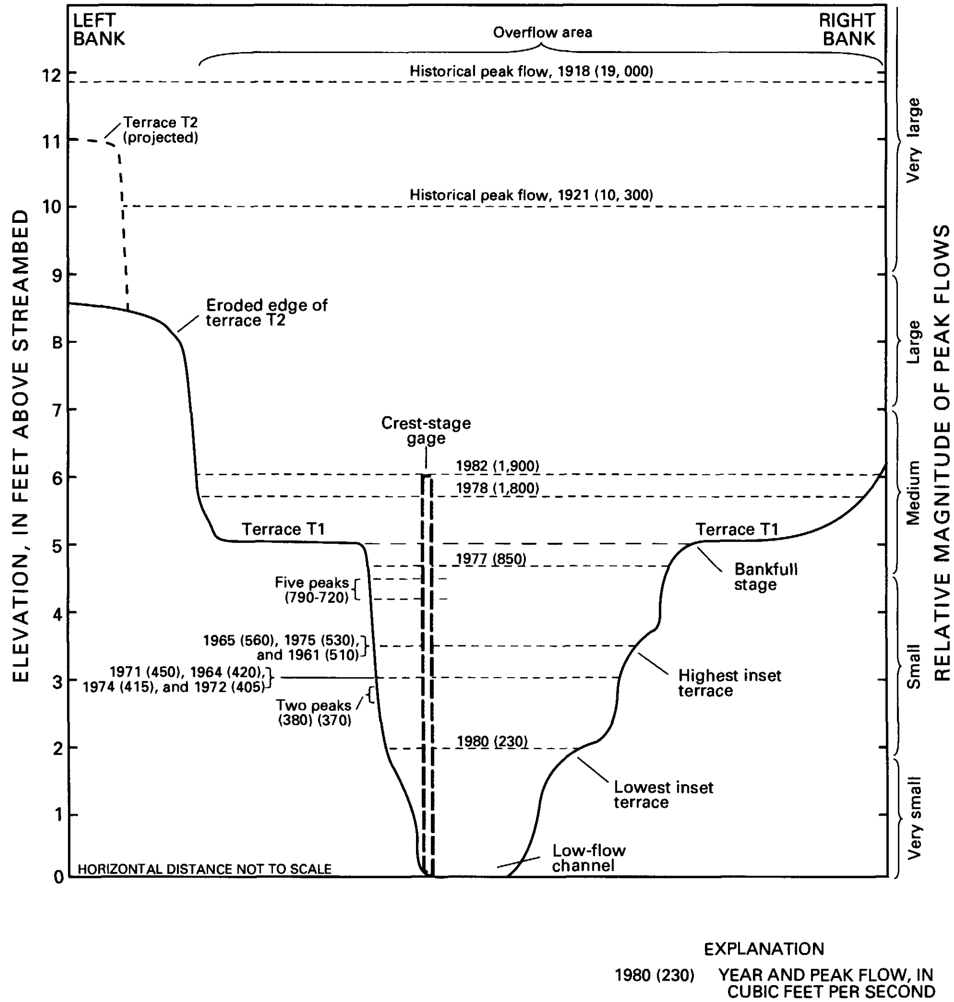
Adjustments were made to the flood-frequency curves for the short-term systematic records of the previously described 21 drainages for which extensions of the records were determined. Six of the flood-frequency curves, accompanied by a cross section showing elevations of the peak flows obtained from the systematic records, were selected to illustrate the differences between the curves derived using only systematic records and curves derived using the historical adjustments (figs. 32-37). The adjustments of the flood-frequency curves based on historical peaks are considered to be conservative estimates, and may not necessarily be the maximum amount of possible adjustment discussed in the previous section. However, greater adjustments for the very large peak flows cannot be substantiated, owing to the absence of definitive onsite evidence, even though the relatively large size of these peak flows would tend to support greater adjustments. The flood-frequency curves were developed using procedures recommended by the Interagency Advisory Committee on Water Data (1981) (see discussion in section on analytical procedures).

The very large peak flows of some of the systematic records were not determined to be representative of the short period of the station records; generally these peak flows were representative of a time that may be several times longer than the systematic record. In many drainages where a historical peak flow was determined, the annual peak flows of the systematic record only represent the medium and small peak flows of the drainages. For 13 of the drainages studied, the maximum peak flow of the systematic record was the largest known peak flow; for the remaining 8 drainages, a historical peak flow was the largest known peak flow. Historical peak flows were determined for all of the type-3 drainages and for a few type-1 drainages; whereas, the maximum peak flow of the systematic record was the largest known peak flow for the majority of the type-1 drainages and for the two type-2 drainages. Evidence of historical peak flows is more common along drainages in southwestern Wyoming than in other parts of the State, because few large peak flows have occurred in that area during the time of the systematic records (since about 1965) and because of generally excellent preservation of the sagebrush debris deposited by the peak flows.

The flood-frequency curves indicate that adjustments of the systematic records can be made for all 21 drainages that were studied. Typical adjustments of flood-frequency curves are shown in figures 32 to 35 for type-1 drainages, figure 36 for type-2 drainages, and figure 37 for type-3 drainages. The largest adjustments are for the two type-2 drainages and for some of the type-1 drainages; the smallest adjustments are for the type-3 drainages. Generally, the larger adjustments of the flood-frequency curves are for drainages in the eastern one-half of Wyoming, and the smaller adjustments are for drainages in the southwestern part of the State.



A



B

Figure 32.--South Fork Powder River near Powder River: A, Flood-frequency curves; and B, Cross section showing the relation of the historical and systematic-record peak flows to the principal geomorphic features. (Cross section also shown in fig. 10.) Site no. 1 (fig. 1); station no. 06312700 (tables 1 and 6).

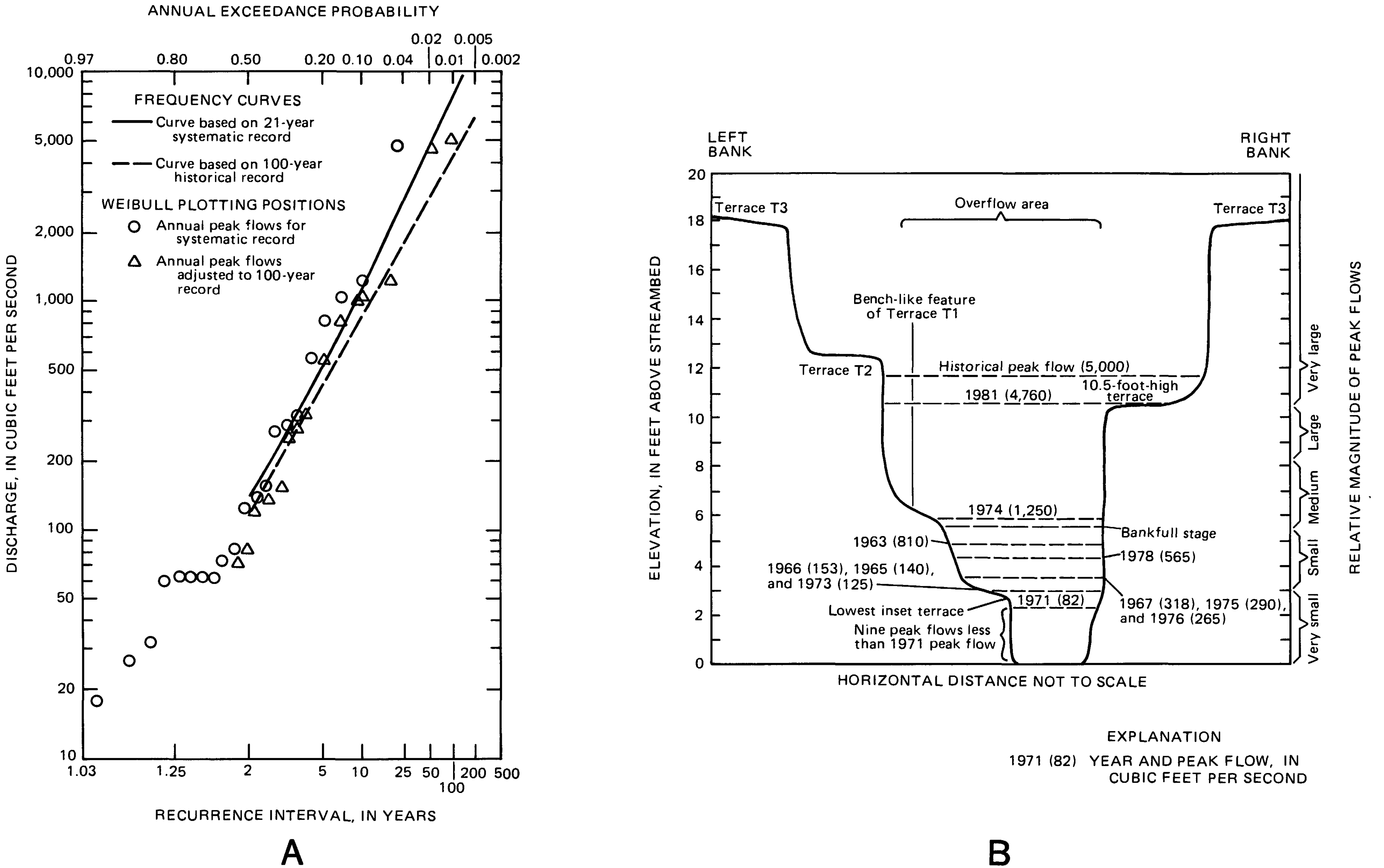


Figure 33.--Lawn Creek near Alcova: A, Flood-frequency curves; and B, Cross section showing the relation of the historical and systematic-record peak flows to the principal geomorphic features. Site no. 9 (fig. 1); station no. 06642700 (tables 1 and 6).

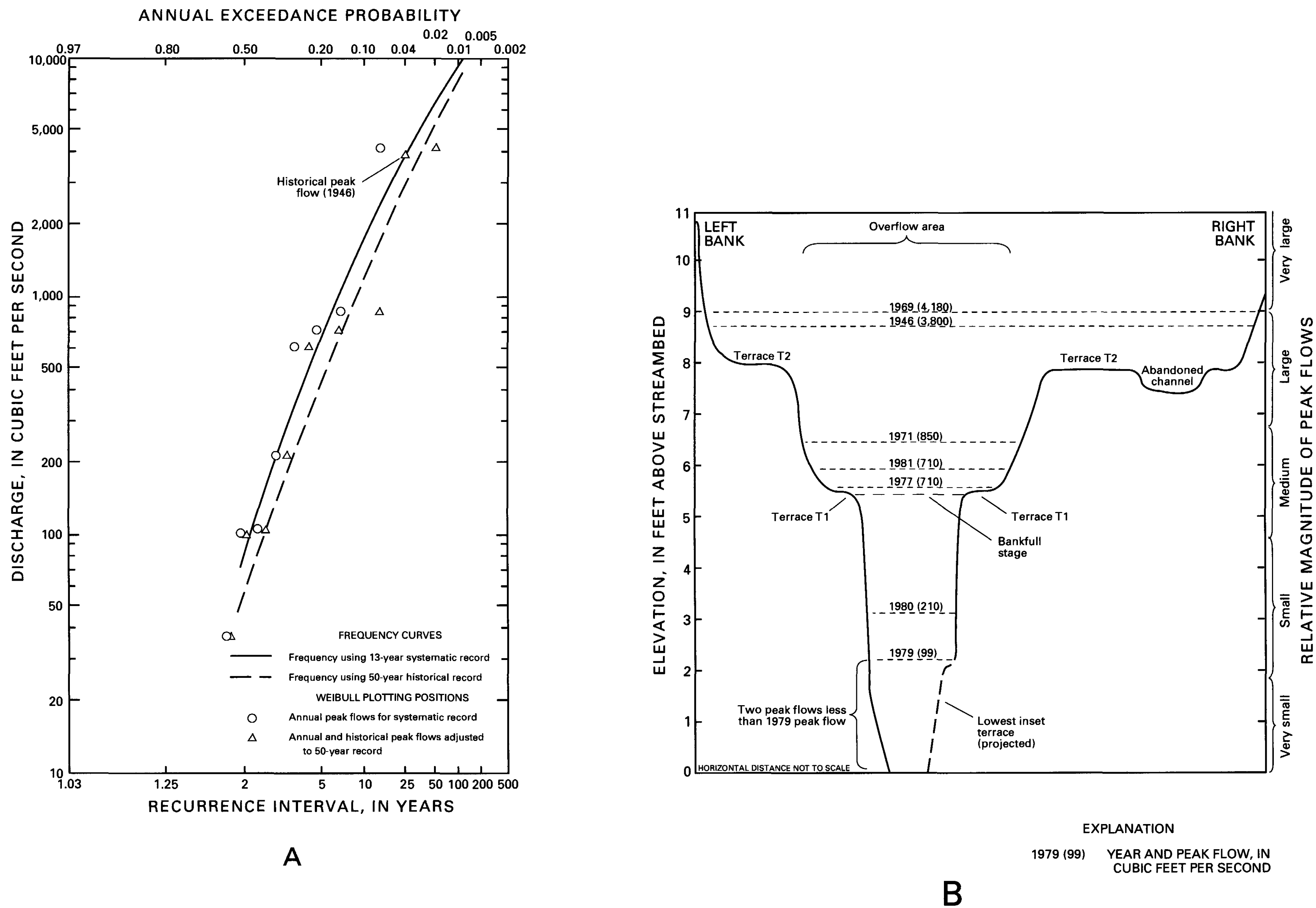


Figure 34.--Dry Rawhide Creek near Lingle: A, Flood-frequency curves; and B, Cross section showing the relation of the historical and systematic-record peak flows to the principal geomorphic features. Site no. 12 (fig. 1); station no. 06670985 (tables 1 and 6).

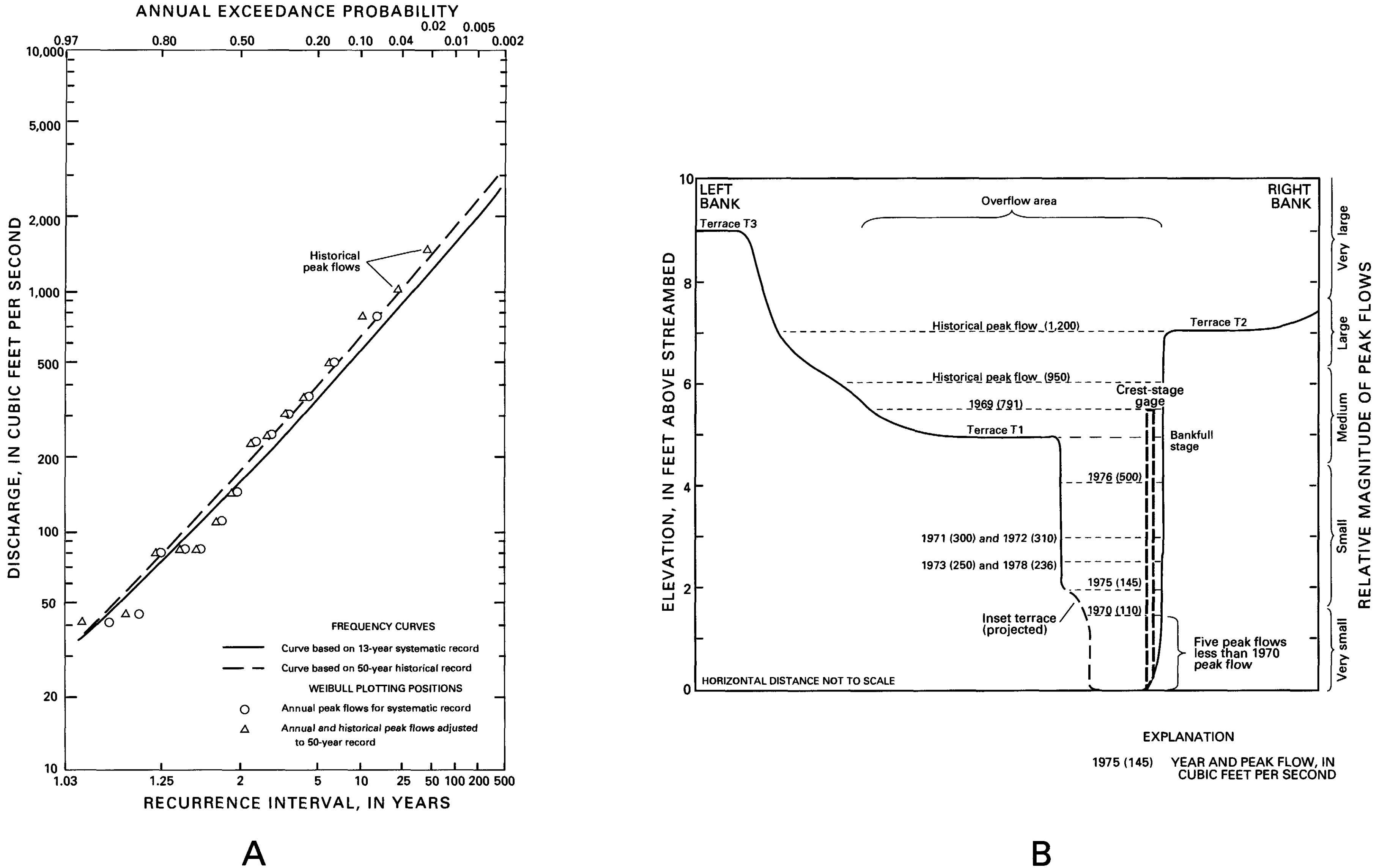


Figure 35.--East Otterson Wash near Green River: A, Flood-frequency curves; and B, Cross section showing the relation of the historical and systematic-record peak flows to the principal geomorphic features. Site no. 13 (fig. 1); station no. 09216290 (tables 1 and 6).

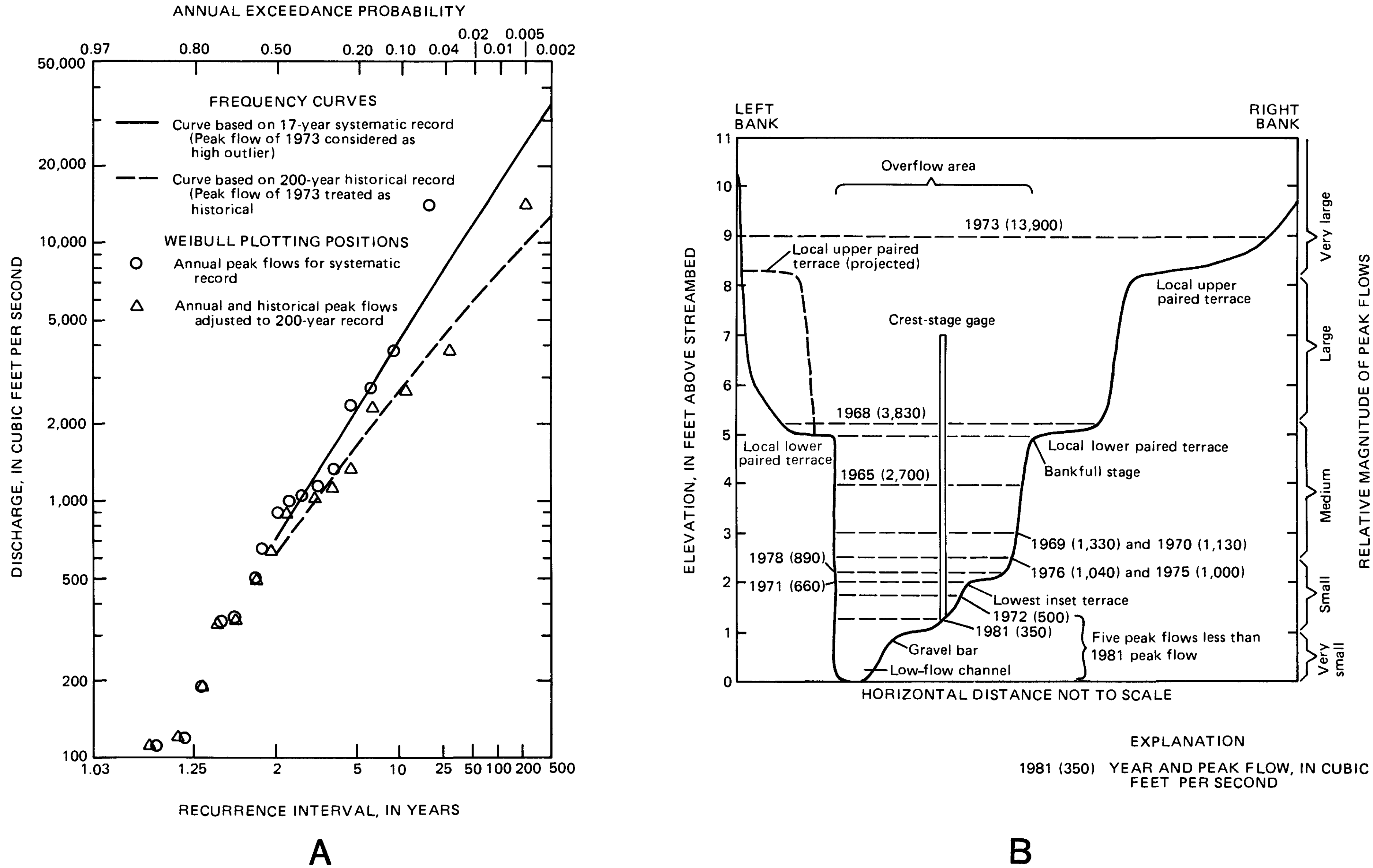


Figure 36.--Summers Dry Creek near Green River: A, Flood-frequency curves; and B, Cross section showing the relation of the systematic-record peak flows to the principal geomorphic features. (Cross section also shown in fig. 25.) Site no. 21 (fig. 1); station no. 09224980 (tables 1 and 6).

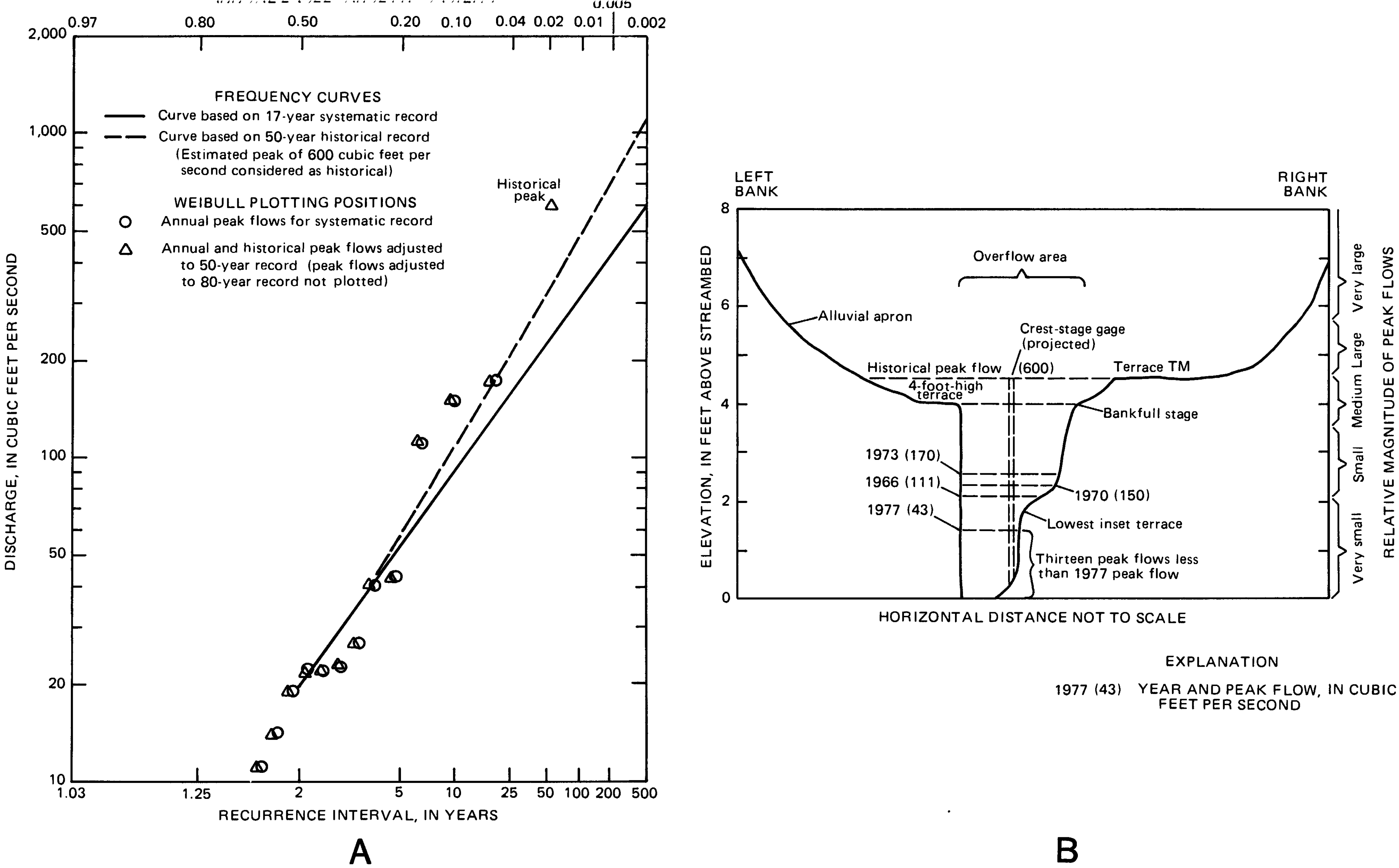


Figure 37.--Blacks Fork tributary no. 3 near Green River: A, Flood-frequency curves; and B, Cross section showing the relation of the historical and systematic-record peak flows to the principal geomorphic features. Site no. 19 (fig. 1); station no. 09224820 (tables 1 and 6).

Adjusted flood-frequency values were computed for recurrence intervals as much as twice the length of historical adjustment (table 6). The length of adjustment for the 21 drainages was determined on the basis of information presented in the previous section of the report. A maximum extension to 200 years was made to records for one station; records for four stations were extended to 100 years. Most of the records were extended to 50 years; three were extended only to 20 to 30 years. For the 21 stations, the peak flows of eight stations were adjusted upward, and the peak flows of 13 stations were adjusted downward.

Significant changes were made in the flood-frequency curves for most of the 21 stations. For example, the peak flow for a recurrence interval of 50 years for the South Fork Powder River near Powder River (fig. 32) was adjusted upward from 1,840 to 3,430 ft^3/s, an 86-percent change. The flow for the same recurrence interval for Dry Rawhide Creek near Lingle (fig. 34) was adjusted downward by 63 percent from 18,800 to 6,990 ft^3/s. Long-term adjustment of the record of Summers Dry Creek near Green River (fig. 36) indicates that for a 200-year recurrence interval, based only on the systematic record, the discharge would be 23,700 ft^3/s; whereas, based on the 200-year historical adjustment the discharge would be 9,770 ft^3/s. If a 500-year historical adjustment were used, the discharge would be adjusted slightly downward to 9,040 ft^3/s. Overall, the estimated 50-year flood was increased for 7 drainages and decreased for 14 drainages. The adjusted flood-frequency curves for 10 of the 21 stations evaluated were used in the most recent regionalized statewide flood-frequency analysis (Lowham, 1988).

Table 6.--*Flood-frequency information based on systematic record and historical adjustment*

[ft³/s, cubic feet per second]

Site number in figure 1	Streamflow-gaging station number and name	Period of record (through water year 1981(	Historical adjustment (years)	Peak flows, in cubic feet per second, for indicated annual exceedance probability-recurrence interval 0.5/2	0.2/5	0.1/10	0.04/25	0.02/50	0.01/100	Remarks
1	06312700 South Fork Powder River near Powder River	1961-81	(1)	578	912	1,170	1,530	1,840	2,170	
			100	570	1,060	1,560	2,470	3,430	4,690	Estimated 1918 peak flow (19,000 ft³/s) and estimated 1921 peak flow (10,300 ft³/s) treated as historical.
2	06312910 Dead Horse Creek tributary near Midwest	1965-72	²17	368	1,911	1,520	2,710	4,010	5,760	Peak flow of record (3,020 ft³/s) treated as historical.
			50	331	766	1,250	2,210	3,260	4,690	Peak flow of record (3,020 ft³/s) treated as historical.
3	06312920 Dead Horse Creek tributary no. 2 near Midwest	1965-72	²17	210	435	648	1,000	1,340	(3)	Peak flow of record (1,470 ft³/s) treated as historical.
			25	203	403	585	881	1,150	(3)	Peak flow of record (1,470 ft³/s) treated as historical.
4	06313180 Dugout Creek tributary near Midwest	1965-81	(1)	193	556	941	1,620	2,270	3,050	
			50	181	477	760	1,210	1,610	2,070	Peak flow of record (1,590 ft³/s) treated as historical.
5	06316700 Coal Draw near Buffalo	1965-81	(1)	157	650	1,330	2,810	4,510	6,850	
			50	143	538	1,040	2,030	3,090	4,470	Peak flow of record (2,290 ft³/s) treated as historical.
6	06382200 Pritchard Draw near Lance Creek	1964-81	(1)	638	1,620	2,610	4,310	5,930	7,880	
			50	610	1,440	,210	3,410	4,470	5,670	Peak flow of record (4,050 ft³/s) treated as historical.
7	06387500 Turner Creek near Osage	1959-81	(1)	1,360	2,520	3,490	4,960	6,240	7,670	
			64	1,310	2,340	3,160	4,350	5,350	6,440	Peak flow of record (5,660 ft³/s) treated as historical.
8	06631150 Third Sand Creek near Medicine Bow	1965-81	(1)	294	674	1,050	1,700	2,320	(3)	
			30	264	572	869	1,370	1,860	(3)	Peak flows of record (1,540 and 1,580) treated as historical.
9	06642700 Lawn Creek near Alcova	1961-81	(1)	121	533	1,160	2,650	4,520	7,320	Peak flow of record (4,760 ft³/s) treated as high outlier.
			100	114	440	872	1,780	2,810	4,190	Peak flow of record (4,760 ft³/s) and estimated peak flow (5,000 ft³/s) treated as historical.
10	06642730 Stinking Creek tributary near Alcova	1961-71	(1)	112	332	561	950	1,310	1,730	
			100	119	335	540	861	1,140	1,440	Estimated 1981 peak flow (2,000 ft³/s) treated as historical.
11	06651800 Sand Creek near Orin	1955, 1961-81	²27	688	2,000	3,680	7,330	11,700	18,100	Peak flow of record (20,700 ft³/s) treated as historical.
			100	648	1,630	2,740	4,890	7,220	10,400	Peak flow of record (20,700 ft³/s) treated as historical.
12	0670985 Dry Rawhide Creek near Lingle	1969-81	(1)	52.1	622	2,190	8,150	18,800	39,300	Peak flow of record (4,180 ft³/s) treated as high outlier.
			50	51.5	468	1,330	3,740	6,990	11,900	Peak flow of record (4,180 ft³/s) treated as high outlier.

Table 6.—*Flood-frequency information based on systematic record and historical adjustment*—Continued

Site number in figure 1	Streamflow-gaging station number and name	Period of record (through water year 1981(	Historical adjustment (years)	Peak flows, in cubic feet per second, for indicated annual exceedance probability-recurrence interval 0.5 / 2	0.2 / 5	0.1 / 10	0.04 / 25	0.02 / 50	0.01 / 100	Remarks
13	09216290	1969-81	(1)	163	348	514	774	1,000	1,270	
	East Otterson Wash near Green River		50	171	384	588	931	1,260	1,650	Estimated peak flows of 950 and 1,200 ft³/s treated as historical.
14	09216350 Skunk Canyon Creek	1965, 1971-81	[2]17	16.5	50.5	93.7	186	294	449	Peak flow of record (600 ft³/s) treated as hsitorical.
	near Green River		50	15.1	43.5	80.7	164	266	420	Peak flow of record (600 ft³/s) and estimated peak flow (1,100 ft³/s) treated as historical.
15	09216537	1961-81	(1)	83.9	237	409	734	1,070	1,510	
	Delaney Draw near Red Desert		50	80.6	227	396	730	1,090	1,570	Peak flow of record (1,260 ft³/s) and estimated peak flow (1,700 ft³/s) treated as historical.
16	09216695	1973-81	(1)	648	165	264	430	585	(3)	
	No Name Creek near Rock Springs		20	72.0	206	357	641	937	(3)	Estimated peak flow (1,000 ft³/s) treated as historical.
17	09216700	1959-76	(1)	1,150	2,190	2,960	4,000	4,790	5,590	
	Salt Wells Creek near Rock Springs		[4]50	1,100	2,020	2,680	3,510	4,130	4,740	Peak flow of record (3,750 ft³/s) treated as historical.
18	09224810	1965-81	(1)	20.4	66.8	115	192	259	334	
	Blacks Fork tributary no. 2 near Green River		50	22.0	71.3	130	242	361	513	Estimated peak flow (1,000 ft³/s) treated as historical.
19	09224820	1965-81	(1)	21.7	56.6	93.9	162	230	316	
	Blacks Fork tributary no. 3 near Green River		50	22.1	62.9	112	215	331	493	Estimated peak flow (600 ft³/s) treated as historical.
20	09224840	1965-81	(1)	11.5	24.5	34.9	49.2	60.3	71.7	
	Blacks Fork tributary no. 4 near Green River		50	16.0	31.0	45.5	70.6	95.4	126	Estimated peak flow (600 ft³/s) treated as historical.
21	09224980 Summers Dry Creek	1965-81	(1)	721	2,300	4,180	7,880	11,800	17,000	Peak flow of record (13,900 ft³/s) treated as high outlier.
	near Green River		200	627	1,640	2,640	4,310	5,860	7,670	Peak flow of record (13,900 ft³/s) treated as historical.

[1]No adjustment; systematic record used to compute estimate of flood-frequency relation.

[2]Historical adjustment applied to systematic record, bason on intervening years from end of record to water year 1951, or on intervening water year between periods of record.

[3]Flood-frequency relations not listed for recurrence intervals larger than twice the historical adjustment.

[4]Historical adjustment of 45 years rounded to 50 years.

SUMMARY AND CONCLUSIONS

As the result of a program started in 1958, peak flow-discharge data for use in certain flood-frequency analyses of small plains streams have been collected at about 140 sites in Wyoming. However, the adequacy of the records, which generally are for less than 22 water years in representing long-term conditions, is questionable because of the extreme variability of peak flows. Because of the questionable nature of the short-term records, an onsite paleoflood method was used to extend selected records without collecting additional streamflow data. The collection of paleoflood evidence included the inspection of certain geomorphic features, principally paired terraces and selected channel features, vegetation, and wood debris deposited by floods. Where applicable, the occurrence of floods was discussed with long-term residents. The drainages were classified geomorphically and relations were established between the peak flows and geomorphic and botanical features. The dates and the discharge of historical peak flows that occurred outside of the streamflow record are key information for making a historical adjustment to a flood-frequency curve or extending a streamflow record.

Historical adjustments ranging between 20 and 200 years were made for the streamflow records of the 21 drainages investigated. The main hydrologic factors that affected the determination of the historical adjustments included:

1. The time of formation of the channels and terraces of the three drainage types;

2. Relation of the peak flows to the geomorphic features in each drainage type.

Background information that provided insight into determining the historical adjustments included:

1. Differences in the distribution of annual and monthly precipitation in eastern and southwestern Wyoming;

2. Differences in the quantity of discharge of the peak flows between eastern and southwestern Wyoming;

3. Differences during 1900-82 of the occurrence of precipitation during June through September and the occurrence of major floods and large peak flows in Wyoming.

Adjusted flood-frequency values were computed for the 21 study drainages for recurrence intervals as much as twice the length of historical adjustment. Most of the streamflow records were extended to 50 years or less; four records were extended to 100 years; one record was extended to a maximum of 200 years. The acceptable length of historical adjustment was determined in an analysis relating historical and systematic-record peak flows to the features observed from onsite investigation. All of the historical extensions ended before 1982; however, no significant floods occurred on any of the 21 drainages through 1988.

On the basis of historical adjustments, substantial changes were made in the flood-frequency curves for most of the 21 stations investigated. Curves for 7 stations were adjusted upward, and curves for 14 stations were adjusted downward. For example, the peak flow for a recurrence interval of 50 years for the South Fork Powder River near Powder River was adjusted upward from 1,840 to 3,430 ft^3/s, an 86-percent change. The peak flow for the same recurrence interval for Dry Rawhide Creek near Lingle was adjusted downward by 63 percent from 18,800 to 6,990 ft^3/s.

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