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# Peak Discharges and Flow Volumes for Streams in the Northern Plains, 1996–97

## Circular 1185–B

U.S. Department of the Interior
U.S. Geological Survey

Cover photograph: Fire consumes an outbuilding on a farmstead near the Red River of the North in northeastern North Dakota, April 1997. Photograph from North Dakota Water Education Foundation and North Dakota National Guard. Photograph was taken by Tony Mutzenberger.

# Peak Discharges and Flow Volumes for Streams in the Northern Plains, 1996–97

*By* Kathleen M. Macek-Rowland, Michael J. Burr, *and* Gregory B. Mitton

U.S. GEOLOGICAL SURVEY CIRCULAR 1185–B

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# FOREWORD

Floods are a common occurrence on all major streams and rivers of the United States. Many floods are just a minor nuisance when low-lying fields and roads are inundated; however, major floods that result in loss of life and extensive damage occur on a number of the Nation's rivers each year. Knowledge of the flood characteristics of the Nation's streams and rivers is important for preventing the loss of life and mitigating the ever-increasing costs of flood damages.

The U.S. Geological Survey (USGS) plays a critical role in supporting flood mitigation, flood forecasting, and response and recovery efforts during and after floods. The 18,000 streamflow-gaging stations that have been operated by the USGS at some time since 1889 provide much of the base information for assessing flood risk and for designing infrastructure such as dams and levees that minimize flood damages. The streamflow-gaging stations also provide data that are critical to effective management of the Nation's water resources.

The USGS has a current network of 7,000 streamflow-gaging stations. Of these stations, 4,200 are used to provide real-time streamflow data 24 hours a day directly to the public and many organizations, including the National Weather Service, U.S. Army Corps of Engineers, the Bureau of Reclamation, and the Federal Emergency Management Agency. These and other Federal, State, and local agencies use the river-stage data to forecast river conditions, to issue flood warnings and river-conditions statements, to plan flood response and recovery operations, and to plan reservoir releases or water withdrawals. With the advent of the internet, USGS data, real-time and historical, are being disseminated to an even broader range of interested users worldwide.

This report, "Peak Discharges and Flow Volumes for Streams in the Northern Plains, 1996–97," is an example of the type of information produced by the USGS streamflow-gaging network. The report is the second in a two-part series of reports that document the 1997 spring floods in the northern plains. The report presents the magnitude and duration of discharges and volumes, describes the effects of reservoir storage on flood peaks, and summarizes the effects of the 1997 spring floods on the people of the northern plains. U.S. Geological Survey Circular 1185–A, "Precipitation in the Northern Plains, September 1996 through April 1997," is the first in the two-part series of reports and describes precipitation and climatic conditions before and during the 1997 spring floods.

Robert M. Hirsch

Robert M. Hirsch
Chief Hydrologist

# CONTENTS



## FIGURES



## TABLES

## CONVERSION FACTORS

| Multiply | By | To obtain |
|---|---|---|
| inch | 2.54 | centimeter |
| foot | 0.3048 | meter |
| cubic foot per second | 0.02832 | cubic meter per second |
| square mile | 2.590 | square kilometer |
| acre-foot | 1,233 | cubic meter |

Degree Fahrenheit (°F) may be converted to degree Celsius (°C) by using the following equation:

$$°C = 5/9\ (°F - 32)$$

# Peak Discharges and Flow Volumes for Streams in the Northern Plains, 1996–97

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## Abstract

The winter of 1996–97, combined with the 1997 spring floods, was one of the worst natural disasters in recent history on the northern plains. Above-normal snowfall in central and eastern North Dakota, western Minnesota, and central and eastern South Dakota during the winter of 1996–97 and a blizzard on April 5–6, 1997, caused the worst flooding in several areas in more than 100 years. Record peak stages or discharges occurred at 72 of 134 streamflow-gaging stations located in the Red River of the North, upper Mississippi River, and Missouri River Basins. Recurrence intervals for the peak discharges ranged from less than 10 years to 500 years. Grand Forks, N. Dak., and East Grand Forks, Minn., which are located on the Red River of the North, were completely evacuated because of flooding.

The flow volumes for water year 1997 at selected streamflow-gaging stations on the Red River of the North, the Minnesota River, and the James River were 186 to 788 percent of the mean annual volumes for the periods of record for those stations. In 1997, record 3-day maximum mean discharges occurred at 43 of 82 streamflow-gaging stations, and record 120-day maximum mean discharges occurred at 44 of 82 streamflow-gaging stations. Many reservoirs in the region were at capacity or near capacity from April through June 1997. Without flow regulation by the dams and reservoirs, peak stages along the main stem of the Missouri River probably would have been about 4 to 8 feet higher in many areas.

## INTRODUCTION

Above-normal snowfall in central and eastern North Dakota, western Minnesota, and central and eastern South Dakota during the winter of 1996–97, combined with a blizzard on April 5–6, 1997, caused the worst flooding in several areas in the northern plains in more than 100 years. Floodwaters and severe weather forced thousands of people to flee their homes, some permanently, and caused more than $2 billion in damages to the region. This report is the second of two reports that document the 1997 spring floods in the northern plains. The first report[1] describes precipitation and climatic conditions before and during the 1997 spring floods. This report describes peak discharges and flow volumes for streams in parts of the Red River of the North (Red River), upper Mississippi River (including the Minnesota River), and Missouri River (including the James River and Big Sioux River) Basins from March through June 1997 (fig. 1). This report also presents the magnitude and duration of flow volumes and the recurrence interval at selected streamflow-gaging stations, a summary of flood-control and storage characteristics of selected reservoirs and lakes in the region, and statistical data, including Federal assistance received as a result of the flood. The climatic conditions presented in the first report also are summarized in this report.

The U.S. Geological Survey, one of the principal Federal agencies responsible for the collection and interpretation of water-resources data, works with other Federal, State, and local agencies to ensure that accurate and timely data are available for making decisions regarding the public's welfare. This report represents the combined efforts of U.S. Geological Survey personnel and personnel from the U.S. Army Corps of Engineers, Bureau of Reclamation, National Weather Service, State climatological offices, and other State and local offices whose work before, during, and after the 1997 spring floods gives a comprehensive view of one of the worst natural disasters to occur in

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[1]U.S. Geological Survey Circular 1185–A, "Precipitation in the Northern Plains, September 1996 through April 1997," by Kathleen M. Macek-Rowland, Michael J. Burr, and Gregory B. Mitton.

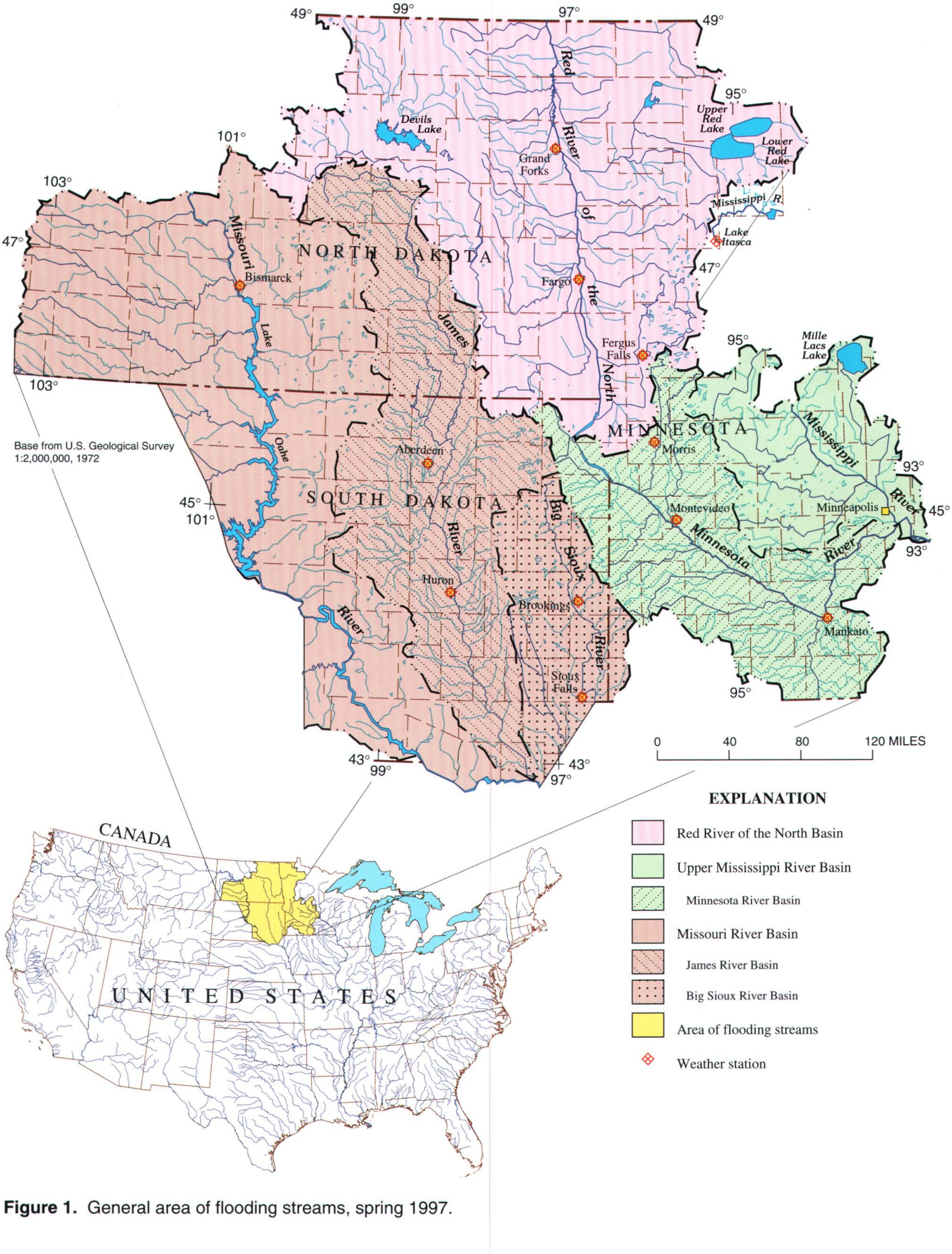



**Figure 1.** General area of flooding streams, spring 1997.

the northern plains in recent history. Appreciation is expressed to those individuals who worked diligently, often under adverse conditions, to collect data. Appreciation also is expressed to Steven K. Sando, Tara Williams-Sether, and Aldo V. Vecchia of the U.S. Geological Survey who refined the recurrence-interval data for this report.

## ANTECEDENT CLIMATIC AND HYDROLOGIC CONDITIONS

Flooding in the northern plains usually is caused by spring snowmelt. Conditions that contribute to flooding include (1) high soil-moisture levels produced by substantial precipitation in the fall and high water levels in numerous surface-water bodies; (2) above-normal snowfall in the winter; (3) frozen saturated soil that prohibits infiltration of moisture; (4) a late spring thaw; (5) above-normal precipitation during the spring thaw; and (6) ice jams (temporary dams of ice) on rivers and streams. Many of these conditions were present in the northern plains before and during the 1997 spring floods.

Annual precipitation in the northern plains averages about 13 inches in the west and about 26 inches in the east. About 9 to 19 inches of the precipitation falls during the growing season, April through September, and about 4 to 7 inches falls during October through March. Many areas in the northern plains received normal to much-above-normal precipitation from 1993 to the fall of 1996 (Owenby and Ezell, 1992a, 1992b, 1992c; U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, 1996–97a, 1996–97b, 1996–97c; Tara Williams-Sether, written commun., 1998). Thus, soils in many areas became saturated, and numerous potholes, sloughs, and small lakes in the region were filled and retained high water levels before the winter of 1996–97. When moisture was added to the water-laden systems in the fall and winter of 1996–97, conditions were set for the 1997 spring floods.

During September through October 1996, precipitation in the flood-affected region generally was between 4 and 8 inches; however, precipitation in east-central South Dakota was more than 10 inches (fig. 2). Most of the region received between 100 and 300 percent of the normal precipitation (based on data for September through October 1961–90), and single-day totals at some weather stations nearly equaled or exceeded the monthly normal (Macek-Rowland and others, 2001).

During November 1996 through March 1997, a series of winter storms moving through the region caused above-normal precipitation (125 to 200 percent of the 30-year normal). The blizzard on April 5–6, 1997, was preceded by wind-driven rain and sleet in many areas; the blizzard brought a severe drop in temperatures, windspeeds as much as 70 miles per hour, and as much as 2 feet of snow, with drifts many feet higher in several areas. The above-normal precipitation during the winter and early spring produced record or near-record snowfalls in much of central and eastern North Dakota, western Minnesota, and central and eastern South Dakota. The largest snowfall totals, exceeding 100 inches, occurred in the southern part of the Red River Basin, the central part of the Missouri River Basin, and the central part of the Big Sioux River Basin (fig. 3). Official and unofficial snowfall totals for the winter of 1996–97 at some cities in the region include 101.3 inches at Bismarck, N. Dak., 117 inches at Fargo, N. Dak., 97.9 inches at Grand Forks, N. Dak., and 105.3 inches at Fergus Falls, Minn. Several other cities had snowfall totals that ranked in the top 10 highest snowfalls for the period of record at that city. Some of those totals include 73.9 inches at Montevideo, Minn., 75.7 inches at Aberdeen, S. Dak., and 48.3 inches at Brookings, S. Dak. Generally, the areas that received the most snowfall were the areas that had the highest river stages and peak discharges in the spring.

*A driver makes its way through a 12-foot cut in a snowdrift on a road near Hartford, South Dakota, on January 14, 1997. (Photograph from Argus Leader, Sioux Falls, South Dakota.)*

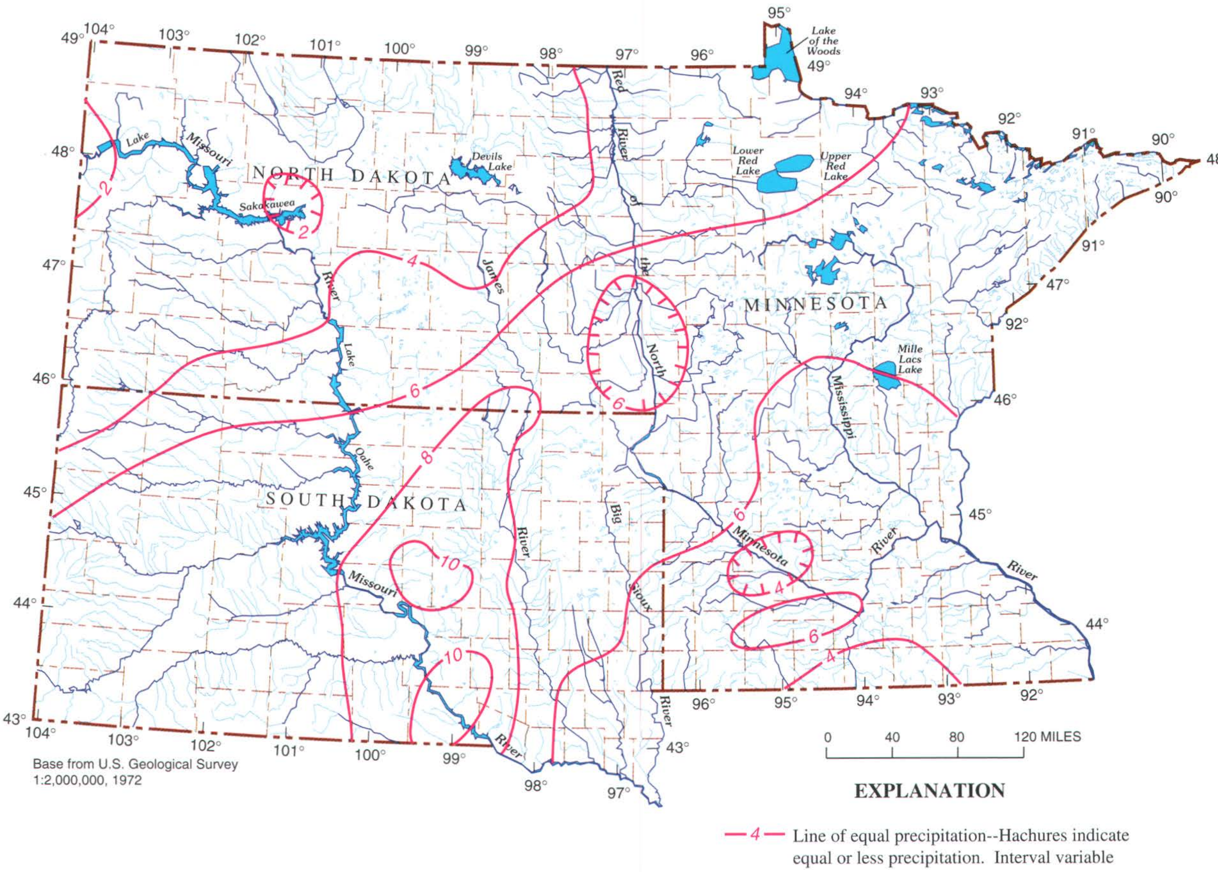



**Figure 2.** Areal distribution of precipitation, in inches, for the northern plains, September through October 1996. (Data from U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, 1996–97a, 1996–97b, 1996–97c.)

Most of the snowfall received during the winter of 1996–97 remained until the spring thaw because temperatures in the northern plains were below normal and few mild days (days with temperatures at or above 32°F) occurred during the winter. The absence of these mild winter days along with frozen moist soils slowed the gradual dissipation of accumulated snowfall through sublimation, evaporation, or infiltration in much of the region.

Generally, snowmelt and warm temperatures begin in the southwestern and western parts of North Dakota and South Dakota and move northeast across both States into Minnesota. By late February 1997, runoff from snowmelt began on some streams in central and southern South Dakota, but widespread flooding in the northern plains did not begin until mid-March when high waters began occurring on rivers and streams in west-central and southeastern North Dakota, southwestern Minnesota, and north-central South Dakota.

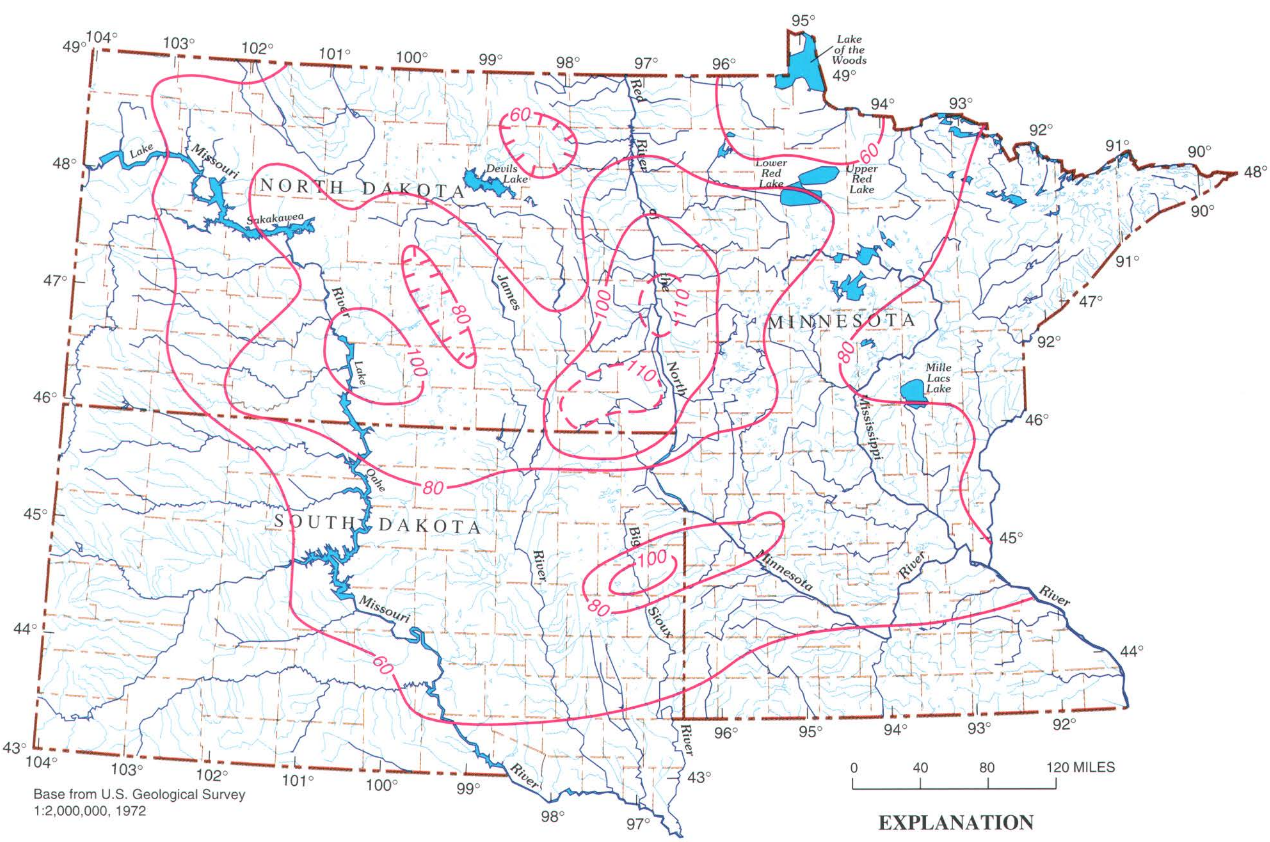
## PEAK STAGES AND DISCHARGES FOR 1997 FLOOD

Peak stages and discharges for 134 streamflow-gaging stations maintained by the U.S. Geological Survey in the area of flooding are listed in table 1 in the "Tabular Information" section at the back of this report. Of the 134 stations, 45 are located in the Red River Basin, 22 are located in the upper Mississippi River Basin, and 67 are located in the Missouri River Basin. Stage is the height of the water surface in a stream above an arbitrarily established datum. Peak stages are reported because they are primary indicators of overbank flooding and are used to define the limits of flooding (Parrett and others, 1993). Because changes can occur in a channel or within a drainage area, the relation between peak stages and discharges may not remain constant.

Locations of the 134 streamflow-gaging stations are shown in figure 4. The site numbers in the figure correspond to the site numbers listed in table 1, which also includes the streamflow-gaging station name and number. The station name and number, which was assigned according to downstream order, can be used to obtain additional data stored in U.S. Geological Survey data bases and published in U.S. Geological Survey annual water-data reports for each State.

Peak discharges during a flood are best defined by direct measurements. However, measurements sometimes cannot be made because of limited access to a gage or safety concerns or because the flood events are short in duration and cause unstable conditions that make measuring extremely difficult or impossible. If measurements are not made, peak discharges may be extrapolated from rating curves extended to known peak stages. A rating curve is a unique relation between measured stage and discharge at a site on a stream. A rating curve may not be well defined at extreme high discharges. Therefore, additional data, such as the rate of change in stage, the fall in a reach between gages, hydrologic conditions upstream and downstream from the measurement site, and weather conditions at the time of measurement, also may be considered when determining peak discharges (Kennedy, 1984).

Peak discharges also may be determined from indirect measurements after a flood. Indirect measurements are made using slope-area, contracted-opening, flow-over-dam, or flow-through-culvert methods. Field data obtained by site surveys are required for the computation of peak discharges by these methods. The surveys include the locations and elevations of high-water marks that correspond to peak stage, the cross sections of the channel, the determination of the roughness coefficient for the channel site, and the descriptions and measurements of structures (for example, dams and culverts) that influence the discharge (Benson and Dalrymple, 1967).




**EXPLANATION**

—100— Line of equal snowfall—Dashes indicate snowfall of at least 110 inches but less than 120 inches. Hachures indicate equal or less snowfall. Interval variable

**Figure 3.** Areal distribution of snowfall, in inches, for the northern plains, November 1996 through April 1997. (Data from U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, 1996–97a, 1996–97b, 1996–97c.)

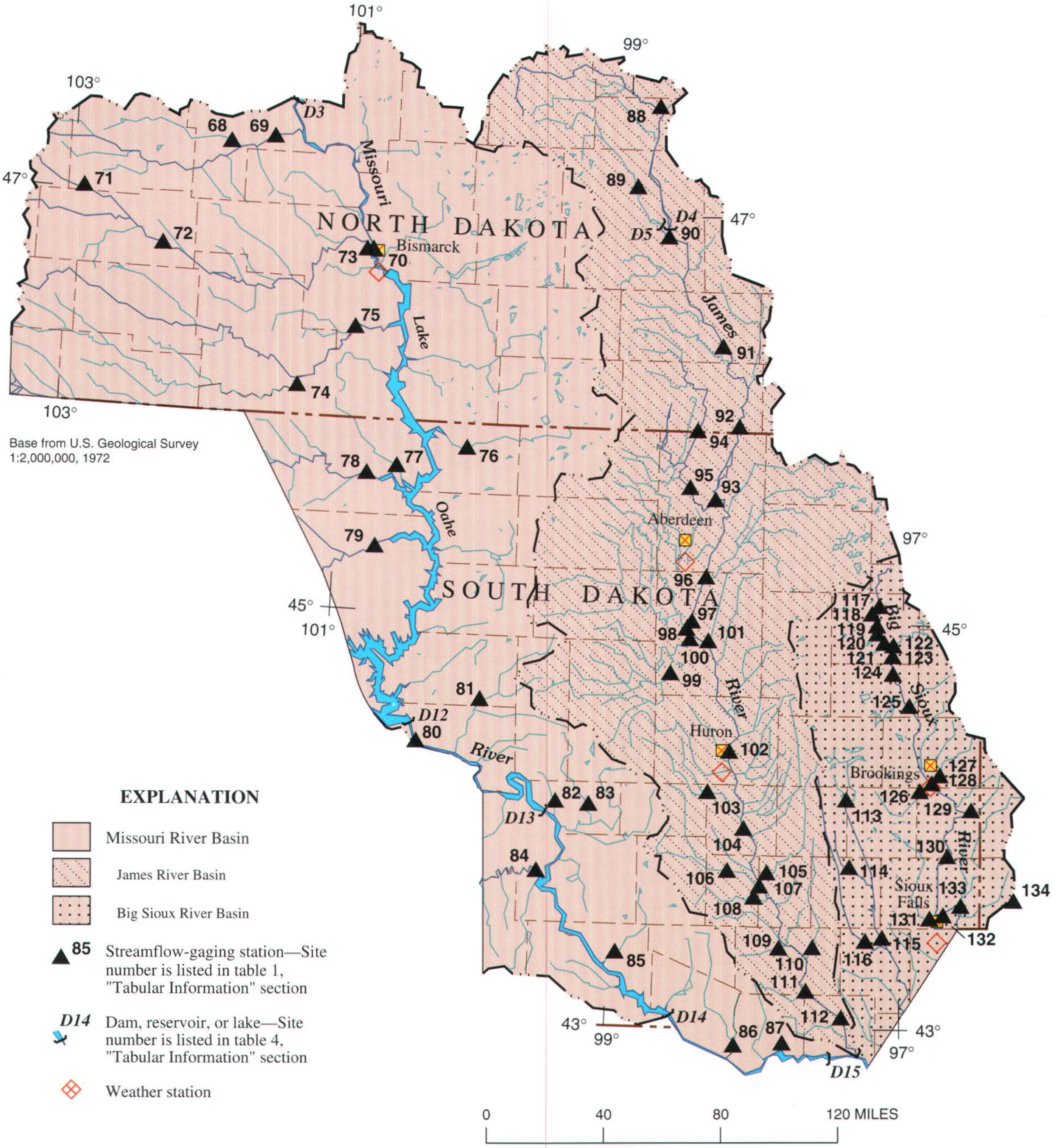



**Figure 4.** Locations of selected streamflow-gaging stations, dams, reservoirs, and lakes in the northern plains.

Peak discharges are used to determine the probability, often expressed in recurrence intervals, that a given discharge will be exceeded. For example, a flood that has a 1-percent chance of exceedance in any given year would, on the long-term average, be expected to occur only about once a century; therefore, the flood would be termed the "100-year flood." However, an equal chance (1 percent) exists for the flood to occur in any given year. Thus, a 100-year flood can occur in successive years at the same location. In some instances, recurrence-interval estimates can be based on periods of regulated discharge or made with historical adjustments when historical data are available. Because it is difficult to accurately determine recurrence intervals, particularly for sites that have short periods of record, ranges within

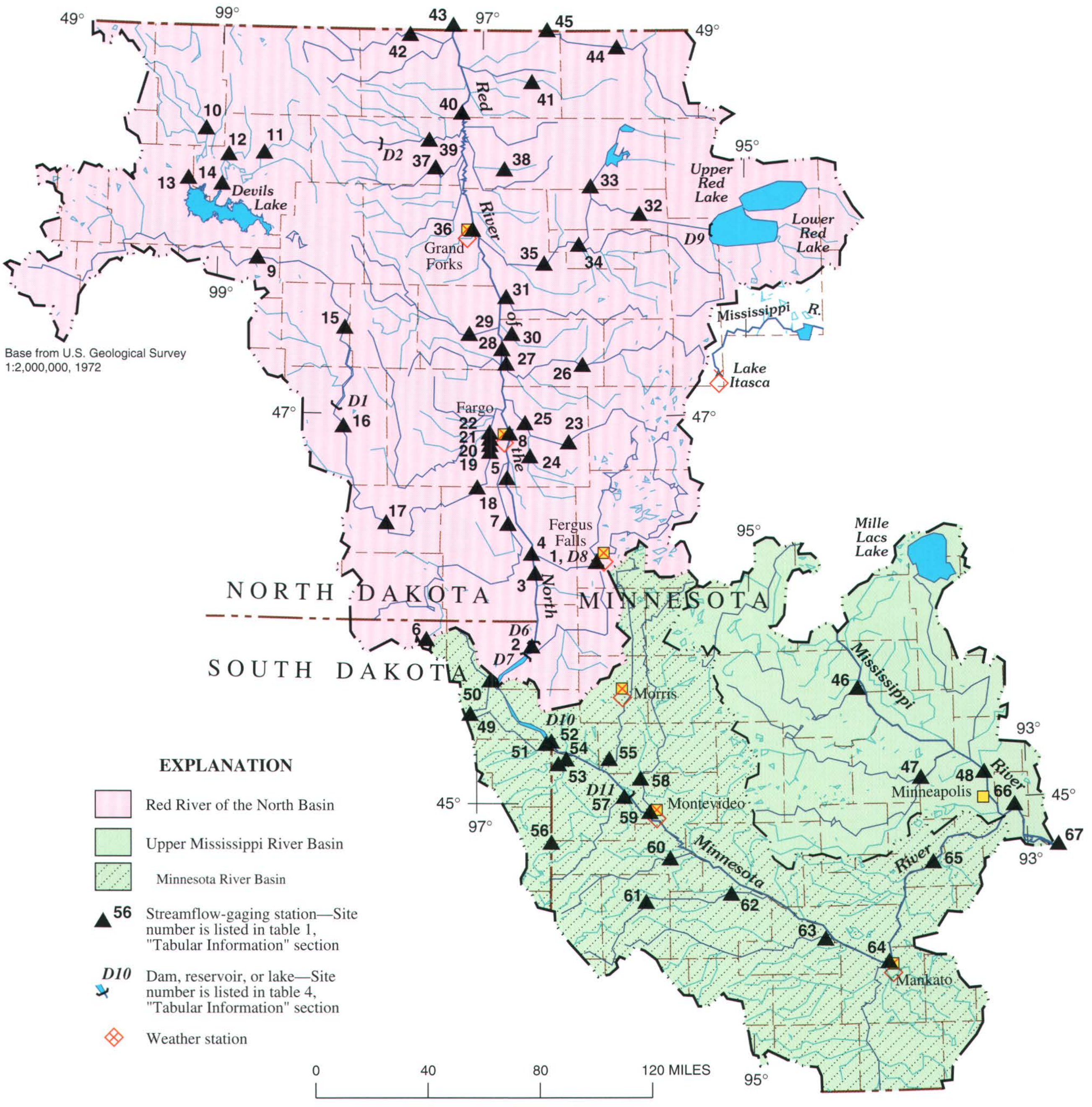



**Figure 4.** Locations of selected streamflow-gaging stations, dams, reservoirs, and lakes in the northern plains—Continued.

which the recurrence intervals for the 1997 spring floods are estimated to fall are given for many of the streamflow-gaging stations listed in table 1 ("Tabular Information" section). Recurrence intervals given in this report for the 1997 peak discharges generally are determined by using the most current techniques published in U.S. Geological Survey flood-frequency reports for States in the area of flooding and procedures described in Bulletin 17B of the Interagency Advisory Committee on Water Data (1982).

Stages and discharges were measured at all active streamflow-gaging stations in the area of flooding. More measurements were made at selected streamflow-gaging stations than at other stations to better track the volumes of water through the individual basins and to better define stage-discharge relations at high discharges. Because of the magnitude of the 1997 spring floods, additional data were collected at crest-stage gages, miscellaneous-measurement sites, and inactive sites within each basin. The streamflow-gaging stations listed in table 1 were selected on the basis of period of record, location, or recurrence interval.

## Red River of the North Basin

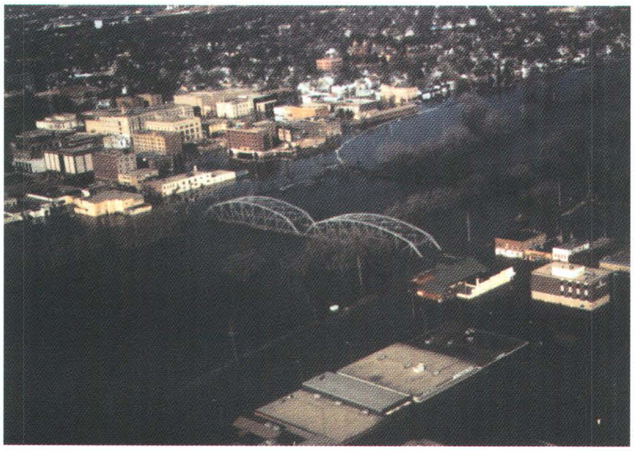
In 1997, record peak stages or discharges occurred at 28 of the 45 streamflow-gaging stations in the Red River Basin. The Red River Basin is located in eastern and north-central North Dakota, western Minnesota, and a small part of northeastern South Dakota (fig. 4). The headwaters of the Red River are in west-central Minnesota, and the river flows into Lake Winnipeg, Manitoba, Canada. At Emerson, Manitoba, near the Canada-United States boundary, the drainage area for the Red River Basin is about 40,200 square miles. The basin is relatively flat and has a shallow river channel. The Red River is one of the few rivers in the United States to flow directly north. Because of the flatness of the basin, the shallow river channel, and the northerly flow, the timing of spring thaw and snowmelt can greatly aggravate flooding. Snow in the headwaters of the Red River Basin begins to melt first, when areas downstream remain largely frozen. This melt pattern can cause ice jams to form, and substantial backwater (water that is retarded, backed up, or turned back in its course because of an obstruction or an opposing current) can occur as flow moves north.

Recurrence intervals for 1997 peak discharges on the main stem of the Red River ranged from 50 to 200 years (table 1). On April 6, 1997, the first of two peak stages occurred on the Red River at Wahpeton, N. Dak. (site 4, fig. 4, table 1). The peak stage was 19.42 feet, which is 1.47 feet higher than the record set in 1989. The peak stage was caused by backwater from ice. Before the peak stage, Wahpeton received additional moisture in the form of rain, sleet, and snow from the blizzard on April 5–6, 1997. This additional moisture resulted in the flooding of a several-block residential area in Wahpeton when dikes broke. Meanwhile, the northern part of Wahpeton's sister city, Breckenridge, Minn., was being flooded by flow from the Otter Tail River (site 1, fig. 4, table 1). Hundreds of people in both cities were evacuated.

On April 8, 1997, most of the 1,700 people in Ada, Minn., were forced to flee their homes when overland flow from the flooding Marsh and Wild Rice Rivers (sites 26, 27, and 30, fig. 4, table 1) inundated the town. Freezing temperatures from the April 5–6 blizzard caused a layer of ice to form over the flooding waters in this area, hampering flood and rescue operations and slowing the melting process. The suddenness of the blizzard caught many farmers unaware, and they were unable to move livestock to shelter and food. Many livestock were lost because of the colder temperatures and floodwaters.

On April 15, 1997, the second peak stage occurred on the Red River at Wahpeton, N. Dak. This peak stage was 19.25 feet, which is 0.17 foot less than the peak stage on April 6. The peak discharge was 12,800 cubic feet per second. The recurrence interval for this peak discharge was between 50 and 150 years. As temperatures rose, flow from the Red River broke through a levee protecting Wahpeton and more of the city was flooded. In Breckenridge, Minn., hundreds more people were evacuated as overland flooding from the Bois de Sioux River (sites 2 and 3, fig. 4, table 1) inundated the southern part of the city.

*Sandbag dikes were common in the Red River of the North Valley in the spring of 1997. (Photograph from North Dakota Water Education Foundation and North Dakota National Guard.)*



*Floodwater inundated Grand Forks, North Dakota, and East Grand Forks, Minnesota, in April 1997. (Photograph from North Dakota Water Education Foundation and North Dakota National Guard.)*

On April 17, 1997, the peak stage of the Red River at Fargo, N. Dak. (site 8, fig. 4, table 1), was 39.57 feet, and the peak discharge was 28,000 cubic feet per second. The recurrence interval for this peak discharge was between 50 and 100 years. In the southern part of Fargo, a section of a dike gave way, sending floodwaters into a nearby neighborhood and causing the evacuation of area residents. On April 18, 1997, the peak stage was 39.72 feet, which is 0.62 foot higher than the record set 100 years earlier, and the peak discharge was 27,700 cubic feet per second. A decision was made to build a massive dike around the southern part of the city to prevent widespread flooding from overland flows coming from the south and west.

High flows continued moving downstream on the Red River. On April 18, 1997, the peak stage of the Red River at Grand Forks, N. Dak. (site 36, fig. 4, table 1), was 52.04 feet, which is 1.84 feet higher than the record set in 1897, and the peak discharge was 137,000 cubic feet per second. This peak discharge was unusual in that it resulted from the convergence of flows from the Red Lake River in Minnesota, flows from the main channel of the Red River, and breakout flows from the Red River that were conveyed by the old Red River oxbows. Breakout flows occurred upstream from Grand Forks when plugs in the upstream end of the oxbows either were overtopped or washed away, allowing about 25,000 cubic feet per second of discharge to arrive at the confluence of the Red Lake River and the Red River. The daily mean stage for March through June 1997 and the previous peak stage for the Red River at Grand Forks, N. Dak., are shown in figure 5, and the daily mean discharge for March through June 1997 and the previous peak discharge are shown in figure 6. On April 19, 1997, a fire demolished several buildings in the flooded downtown area of Grand Forks, N. Dak. The flooding made it extremely difficult for firefighters to reach the fires and put them out. Except for emergency personnel, Grand Forks and its sister city, East Grand Forks, Minn., were completely evacuated by this time.

On April 24, 1997, the peak stage of the Red River at Drayton, N. Dak. (site 40, fig. 4, table 1), was 45.55 feet, which is 1.89 feet higher than the record set in 1979, and the peak discharge was 124,000 cubic feet per second. The recurrence interval for this peak discharge was between 100 and 200 years. On April 26, 1997, the peak stage of the Red River at Emerson, Manitoba (site 43, fig. 4, table 1), just north of the international boundary between the United States and Canada, was 792.41 feet, which is 1.22 feet higher than the record set on May 1, 1979, and the peak discharge was 133,000 cubic feet per second. The April 26 peak discharge surpassed the previous peak discharge of 95,500 cubic feet per second that occurred on May 13, 1950. The recurrence interval for the April 26 peak discharge was between 100 and 200 years.

Record peak discharges during the 1997 spring floods also occurred on many tributaries to the Red River. The recurrence intervals for these peak discharges ranged from less than 10 years to 200 years. The recurrence interval for the peak discharge on the Bois de Sioux River near White Rock, S. Dak. (site 2, fig. 4, table 1), was between 100 and 200 years, and the recurrence interval for the peak discharge on the Wild Rice River at Twin Valley, Minn. (site 26, fig. 4, table 1), was between 100 and 200 years. The recurrence interval for the peak discharge on the Red Lake River at Crookston, Minn. (site 35, fig. 4, table 1), was between 30 and 100 years. The Red Lake River normally accounts for almost 35 percent of the Red River flow.

Devils Lake Basin is a 3,810-square-mile closed subbasin within the Red River Basin. Devils Lake discharges no water until the lake level reaches 1,459 feet above sea level, the lowest outlet elevation. Since 1993, the lake level has risen rapidly in response to above-normal precipitation and runoff. The rising water has inundated homes, businesses, and agricultural lands and has caused roads to be closed. On April 16, 1997, Devils Lake reached 1,438.40 feet above sea level, equaling the previous record set in 1867. Because of the heavy runoff during the spring of 1997, the lake level continued rising to 1,442.97 feet above sea level on July 26, 1997, the highest level in at least 130 years. In 1997, record peak stages or discharges occurred at several streamflow-gaging stations (sites 10 through 14, fig. 4, table 1) in the Devils Lake Basin.

## Upper Mississippi River Basin

In 1997, record peak stages or discharges occurred at 10 of the 22 stations in the upper Mississippi River Basin. The upper Mississippi River Basin, including the Minnesota River Basin, is located in Minnesota and northeastern South Dakota (fig. 4). The Mississippi and Minnesota Rivers generally flow from the northwest to the southeast. The drainage area for the upper Mississippi River Basin is about 37,000 square miles, and the drainage area for the Minnesota River Basin is about 16,900 square miles.

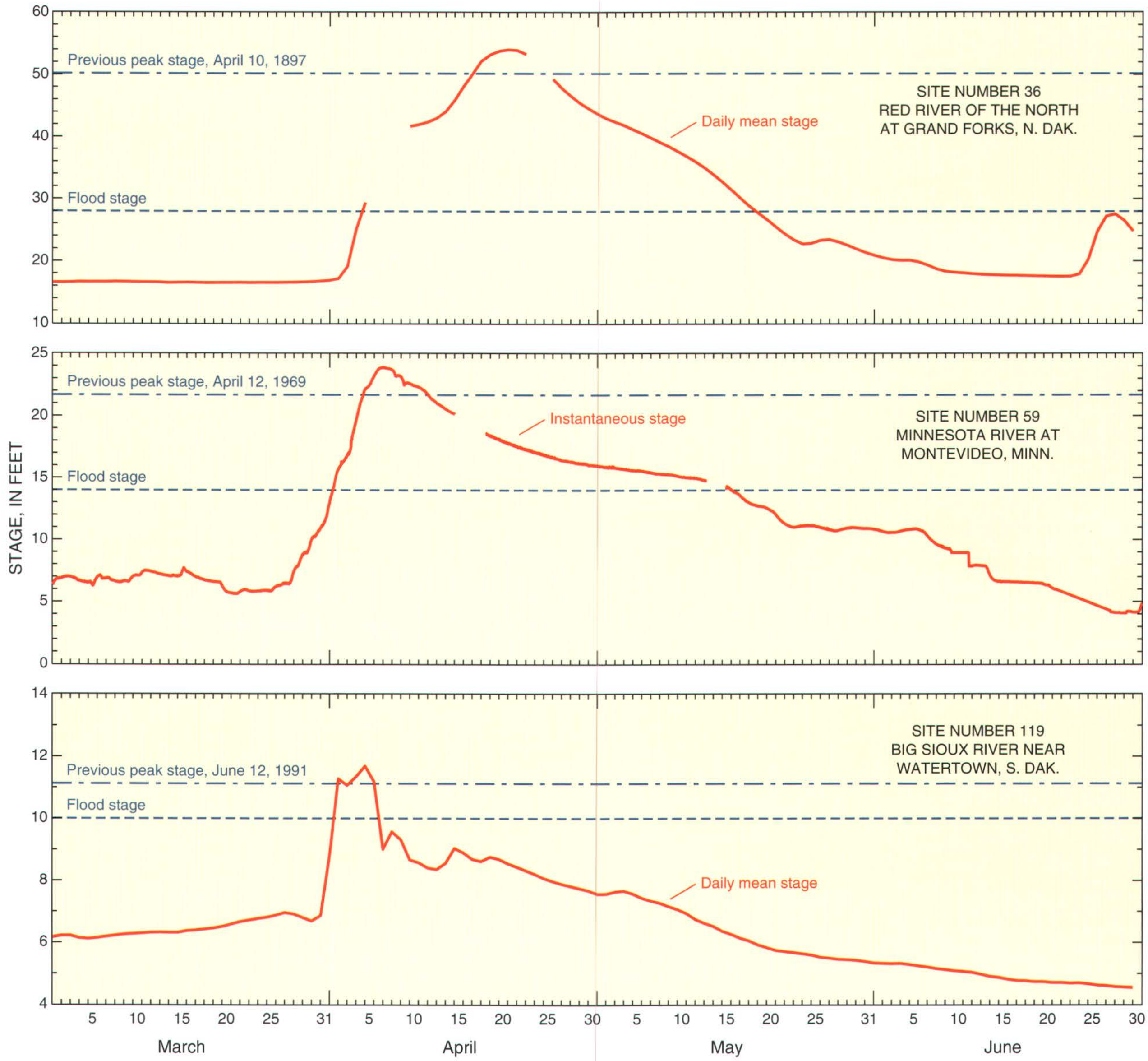



**Figure 5.** Daily mean stage or instantaneous stage for March through June 1997, previous peak stage, and flood stage at three streamflow-gaging stations in the northern plains. (Broken lines indicate periods of missing data for 1997. Instantaneous stage data for the Minnesota River at Montevideo, Minn., are considered preliminary.)

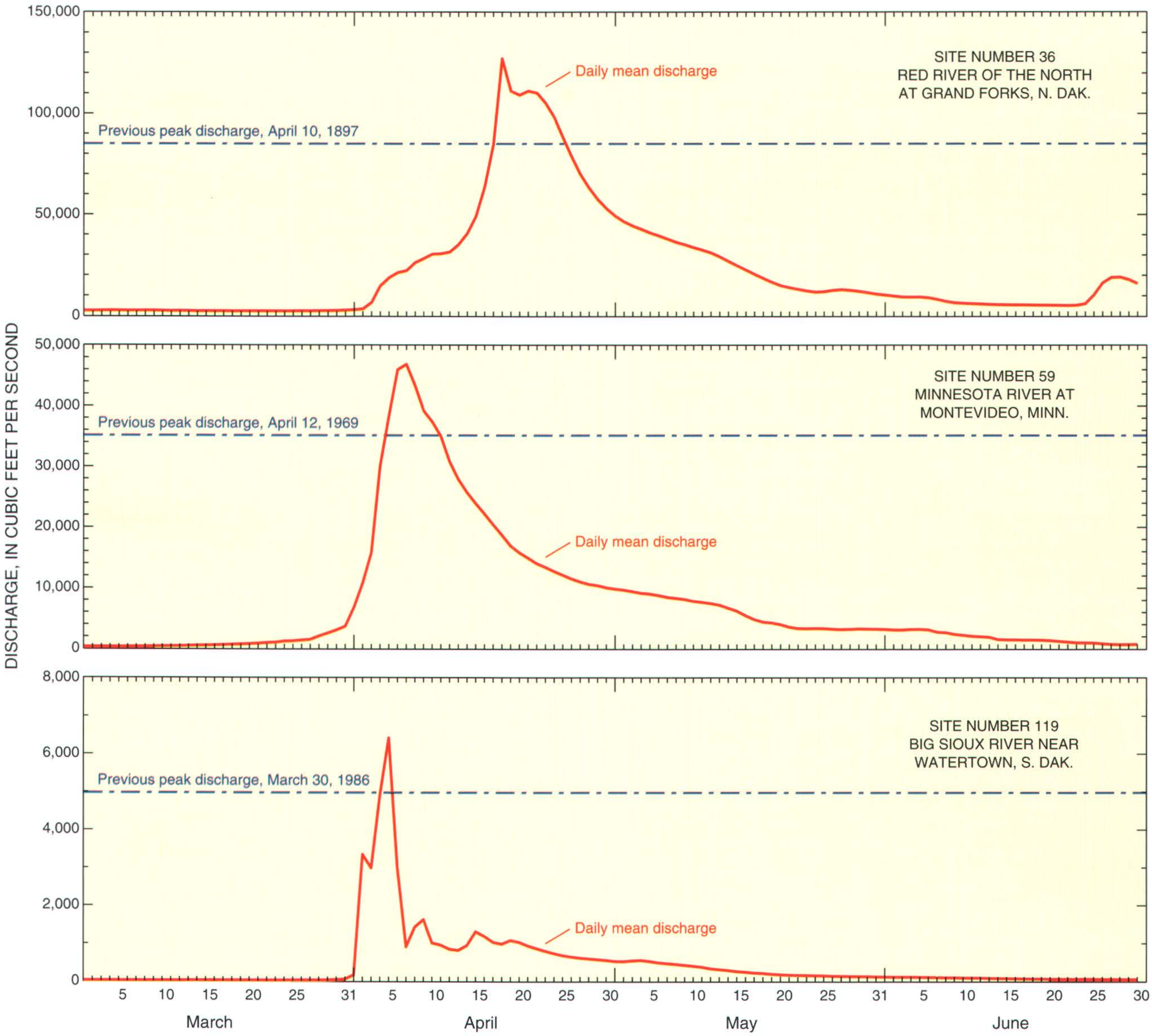



**Figure 6.** Daily mean discharge for March through June 1997 and previous peak discharge at three streamflow-gaging stations in the northern plains.

Recurrence intervals for peak discharges on the main stem of the upper Mississippi River ranged from 25 to 100 years. On April 9, 1997, the peak stage of the Mississippi River near Anoka, Minn. (site 48, fig. 4, table 1), was 16.44 feet, which is 3.09 feet less than the record set on April 17, 1965, and the peak discharge was 69,800 cubic feet per second. The recurrence interval for this peak discharge was between 25 and 50 years. On April 13, 1997, the peak stage of the Mississippi River at St. Paul, Minn. (site 66, fig. 4, table 1), was 22.37 feet, which is 3.64 feet less than the record set on April 16, 1965, and the peak discharge was 134,000 cubic feet per second. The recurrence interval for this peak discharge was between 50 and 100 years.

Recurrence intervals for peak discharges on the main stem of the Minnesota River ranged from 25 to 300 years. On April 10, 1997, the peak stage of the Minnesota River at Ortonville, Minn. (site 52, fig. 4, table 1), was 12.85 feet, which is 0.07 foot less than the record set on April 13, 1952, and the peak discharge was 5,070 cubic feet per second. The recurrence interval for this peak discharge was between 50 and 150 years. On April 6, 1997, the peak stage of the Minnesota River at Montevideo, Minn. (site 59, fig. 4, table 1), was 23.90 feet, which is 2.22 feet greater than the record set on April 12, 1969, and the peak discharge was 47,500 cubic feet per second. The recurrence interval for this peak discharge was between 100 and 300 years. The instantaneous stage for March through June 1997 and the previous peak stage for the Minnesota River at Montevideo, Minn., are shown in figure 5, and the daily mean discharge for March through June 1997 and the previous peak discharge are shown in figure 6. On April 12, 1997, the peak stage of the Minnesota River near Jordan, Minn. (site 65, fig. 4, table 1), was 32.24 feet, which is 2.83 feet less than the record set on April 12, 1965, and the peak discharge was 82,300 cubic feet per second. The recurrence interval for this peak discharge was between 25 and 50 years.

Record peak discharges during the 1997 spring floods also occurred on many tributaries to the Minnesota River. The recurrence intervals for these peak discharges ranged from 10 to 100 years. The recurrence interval for the peak discharge on the Whetstone River near Big Stone City, S. Dak. (site 51, fig. 4, table 1), was between 25 and 50 years, and the recurrence interval for the peak discharge on the Lac Qui Parle River near Lac Qui Parle, Minn. (site 57, fig. 4, table 1), was between 50 and 100 years. The recurrence interval for the peak discharge on the Chippewa River near Milan, Minn. (site 58, fig. 4, table 1), was between 50 and 100 years.

## Missouri River Basin

In 1997, record peak stages or discharges occurred at 34 of the 67 stations located in that part of the Missouri River Basin that is in western and central North Dakota and central and eastern South Dakota. The headwaters of the Missouri River are in Montana and Wyoming, and the mouth is in eastern Missouri. Of the 529,000 square miles in the basin, about 244,600 square miles are located in North Dakota and South Dakota. The Missouri River flows southeastward across North Dakota and South Dakota. Discharges on the river are regulated by a series of dams built on its main stem and tributaries. The dams were built, in part, to control flooding on the Missouri River. One of the dams, built in 1952, is Garrison Dam in North Dakota. Lake Sakakawea, the reservoir behind Garrison Dam, has a maximum capacity of 24.1 million acre-feet and is managed by the U.S. Army Corps of Engineers, which regulates the release of water from the dam.

In 1997, spring runoff began earlier in western and central North Dakota than in eastern North Dakota. Discharge from tributaries to the Missouri River caused the stage of the Missouri River at Bismarck, N. Dak. (site 70, fig. 4, table 1), to continually increase through the spring and early summer. Because of heavy snowpack in the northern Rocky Mountains in Montana and Wyoming and a late spring thaw, high discharges continued through mid-summer. On July 13, 1997, the peak stage at Bismarck was 14.00 feet, which is 0.24 foot less than the post-Garrison Dam record set on December 18, 1979. The peak discharge on July 25, 1997, was 59,500 cubic feet per second, which is the second highest discharge since the completion of Garrison Dam. The recurrence interval for this peak discharge was between 50 and 100 years. To accommodate the higher discharges, the U.S. Army Corps of Engineers released about 59,000 cubic feet per second of water from Garrison Dam for several weeks. The discharge moved downstream on the main stem through a series of dams on the Missouri River in South Dakota. (Additional information on selected dams in the Missouri River Basin and in the Red River and upper Mississippi River Basins is given in the "Elevations and Contents of Selected Reservoirs and Lakes" section of this report.). Although the high discharges on the main stem of the Missouri River caused little damage, the high discharges on tributaries to the Missouri River caused flooding in many communities in North and South Dakota in the early spring.

Record peak discharges during the 1997 spring floods occurred on many tributaries to the Missouri River. The recurrence intervals for these peak discharges ranged from less than 10 years to 500 years. Ice jams on many rivers and streams caused flooding in several areas in western and central North Dakota. On March 23, 1997, the peak stage of the Knife River at Hazen, N. Dak. (site 69, fig. 4, table 1), was 26.92 feet, which is 0.09 foot less than the record set in 1966, and the peak discharge was 20,500 cubic feet per second. The recurrence interval for this peak discharge was between 25 and 50 years. On March 24, 1997, the peak stage of Cedar Creek near Raleigh, N. Dak. (site 74, fig. 4, table 1), was 17.05 feet, which is 3.35 feet greater than the record set in 1978, and the peak discharge was 14,600 cubic feet per second. The recurrence interval for this peak discharge was between 50 and 100 years. On March 25, 1997, the peak stage of the Cannonball River at Breien, N. Dak. (site 75, fig. 4, table 1), was 20.82 feet, which is 1.48 feet less than the record set in 1950, and the peak discharge was 31,100 cubic feet per second. The recurrence interval for this peak discharge was between 10 and 25 years. Flooding from the Cannonball River in Mott, N. Dak., affected about 200 people. Many homes were flooded in this small community. On March 27, 1997, the peak stage of Oak Creek near Wakpala, S. Dak. (site 77, fig. 4, table 1), was 19.83 feet, which is 1.21 feet greater than the record set on March 14, 1995, and the peak discharge was 7,500 cubic feet per second. The recurrence interval for this peak discharge was between 10 and 50 years. The high discharge inundated most of the community of Wakpala (Teller and Burr, 1998).

*Ice and snow outline the actual James River channel in northeastern South Dakota on April 1, 1997. (Photograph by John Davis, Aberdeen American News, Aberdeen, South Dakota.)*

The James River is one of the major tributaries to the Missouri River in North and South Dakota. The headwaters of the James River are in central North Dakota. The drainage area for the James River Basin is about 20,900 square miles. The James River flows south through South Dakota and empties into the Missouri River in the southeastern part of that State. Since 1993, flooding occurred in many low-lying areas along the James River. On April 19, 1997, the peak stage of the James River at Jamestown, N. Dak. (site 90, fig. 4, table 1), was 12.12 feet, which is 3.70 feet less than the record set on May 13, 1950. On May 5, 1997, the peak discharge at the same site was 1,880 cubic feet per second. The recurrence interval for this peak discharge was between 25 and 50 years. Discharge at the site is regulated by the Jamestown Dam. On April 1, 1997, the peak stage of the James River at LaMoure, N. Dak. (site 91, fig. 4, table 1), was 16.09 feet, which is 0.08 foot less than the record set on April 14, 1969, and the peak discharge was 6,500 cubic feet per second. The recurrence interval for this peak discharge was between 15 and 45 years. On April 6, 1997, the peak stage of the James River at Dakota Lake Dam near Ludden, N. Dak. (site 92, fig. 4, table 1), was 17.86 feet, which is 3.89 feet greater than the record set in 1996, and the peak discharge was 7,500 cubic feet per second. The recurrence interval for this peak discharge was between 25 and 100 years.

On April 6, 1997, the peak stage of the James River at Ashton, S. Dak. (site 97, fig. 4, table 1), was 26.64 feet, which is 4.25 feet greater than the record set on May 18, 1995. On April 23, 1997, the peak discharge at the same site was 9,150 cubic feet per second. The recurrence interval for this peak discharge was between 100 and 200 years. Excessive tributary inflows at the same site on March 31, 1997, caused the discharge to reverse in the channel. A discharge of 8,400 cubic feet per second was measured flowing upstream. On April 6, 1997, the James Valley Christian School near Huron, S. Dak., was evacuated when dikes failed and accumulating downstream inflows inundated the school with 5 to 7 feet of water. On April 6, 1997, the peak stage of the James River at Huron, S. Dak. (site 102, fig. 4, table 1), was 21.28 feet, which is 4.42 feet greater than the record set on May 19, 1995, and the peak discharge was 23,400 cubic feet per second. The recurrence interval for this peak discharge was between 150 and 500 years.

# THE LIFE OF A STREAMFLOW-GAGING STATION

As part of its mission, the U.S. Geological Survey is responsible for the collection and interpretation of water-resources data from many of the Nation's rivers and streams. These data are used by several Federal, State, and local agencies to make decisions regarding the public's welfare during times of flooding. The primary source of these data is the U.S. Geological Survey streamflow-gaging station network. A streamflow-gaging station generally consists of a gage house, which contains instruments for recording continuous river stage. Some stations are equipped with instrumentation to transmit data by satellite for real-time acquisition of the data. The life of one such streamflow-gaging station is described on these pages.

*Since October 1945, water-resources data have been collected continuously by instruments in the James River at Ashton, S. Dak., gage house (site 97, fig. 4, table 1).*

*In March 1997, U.S. Geological Survey personnel dug down through several feet of snow to get to the gage-house door. U.S. Geological Survey personnel monitor gage-house instrumentation routinely and service equipment periodically to ensure the quality of the data collected.*

*On April 8, 1997, the ice-encrusted gage house was flooded as a result of the melting of record-breaking winter snowfall and added precipitation from a blizzard on April 5–6, 1997. On April 6, 1997, the water was nearly a foot higher than the water level in this photograph.*

*In May 1998, the gage house was moved several feet back from the James River and elevated to minimize future flood damage. The concrete pad in the foreground indicates the previous location of the gage house during the 1997 spring flood.*

The Big Sioux River is another tributary that flows into the Missouri River in the southeastern part of South Dakota. The headwaters of the Big Sioux River are in northeastern South Dakota. The drainage area for the Big Sioux River Basin is about 9,000 square miles. Melting of a heavy snowpack in the spring of 1997 caused severe flooding around Watertown, S. Dak. On April 5, 1997, the peak stage of the Big Sioux River near Watertown, S. Dak. (site 119, fig. 4, table 1), was 12.09 feet, which is 0.96 foot greater than the record set on June 21, 1991, and the peak discharge was 7,820 cubic feet per second. The recurrence interval for this peak discharge was between 50 and 100 years. The daily mean stage for March through June 1997 and the previous peak stage for the Big Sioux River near Watertown, S. Dak., are shown in figure 5, and the daily mean discharge for March through June 1997 and the previous peak discharge are shown in figure 6. Lake Kampeska is located on the Big Sioux River near Watertown, S. Dak. Property along the shores of Lake Kampeska was extensively damaged from record-high lake levels caused by inflows from the river. On April 6, 1997, the peak stage of the Big Sioux River at Watertown, S. Dak. (site 121, fig. 4, table 1), was 12.49 feet, which is 1.09 feet greater than the record set on April 8, 1969, and the peak discharge was 5,800 cubic feet per second. The recurrence interval for this peak discharge was between 200 and 500 years. On April 11, 1997, the peak stage of the Big Sioux River near Castlewood, S. Dak. (site 124, fig. 4, table 1), was 12.87 feet, which is 1.14 feet greater than the record set on March 30, 1986, and the peak discharge was 4,300 cubic feet per second. The recurrence interval for this peak discharge was between 50 and 200 years. The peak stage on April 7, 1997, was 13.19 feet, but that stage was affected by backwater.

## Comparison with Previous Floods

Flooding in the northern plains is not uncommon. In any given year, the region is likely to have an area flooded either by spring snowmelt or by intense rainstorms. Within the last 200 years, the region has had several major floods. Before streamflow-gaging stations were installed on rivers and streams, records of high discharge were based on eyewitness accounts. On the basis of those accounts, extensive flooding occurred along the Red River in 1824, 1825, 1826, 1851, 1852, 1853, and 1897; the 1897 flood was one of the most severe for the Red River Valley (Harrison and Bluemle, 1980). Some of the floods that occurred along the Red River in the 1800's apparently exceeded the worst floods of this century by several feet (Harrison and Bluemle, 1980). In this century, major flooding occurred in the Red River and upper Mississippi River Basins in 1979 when conditions were similar to those in 1997. More recently, major flooding occurred in the upper Mississippi River and Missouri River Basins as a result of extensive rainfall in the summer of 1993 (Parrett and others, 1993; Wahl and others, 1993; Southard, 1995). Recent occurrences of major flooding in the three basins are listed in the following table:

| Year of major flooding | Red River of the North Basin | Upper Mississippi River Basin | Missouri River Basin |
|---|---|---|---|
| 1950 | X | -- | X |
| 1952 | -- | -- | X |
| 1957 | -- | -- | X |
| 1960 | -- | -- | X |
| 1962 | -- | -- | X |
| 1965 | X | X | -- |
| 1966 | X | -- | X |
| 1969 | X | X | X |
| 1972 | -- | X | -- |
| 1975 | X | X | -- |
| 1978 | -- | X | -- |
| 1979 | X | X | -- |
| 1983 | -- | X | -- |
| 1984 | -- | -- | X |
| 1989 | X | -- | -- |
| 1993 | -- | X | X |
| 1997 | X | X | X |

In the spring of 1997, record peak stages or discharges occurred at about one-half of the 134 streamflow-gaging stations listed in table 1. Most of the record peaks occurred on the main stems of the Red River, the James River, and the Big Sioux River. The 1997 peak discharges on the lower Red River were about 30 to 60 percent greater than previous record peak discharges. Some of the 1997 peak discharges on the James River were about 60 to 200 percent greater than previous record peak discharges, and some of the 1997 peak discharges on the Big Sioux River were about 10 to 200 percent greater than previous record peak discharges. The 1997 peak discharges and historical peak discharges for the period of record at selected streamflow-gaging stations in the northern plains are shown in figure 7.

## VOLUMES, OCTOBER 1, 1996, THROUGH SEPTEMBER 30, 1997

Most flood volumes in the northern plains are the result of spring snowmelt, precipitation, or both. The highest flows normally occur during March through June. Occasionally, a flood may result from intense rainfall over a basin during another part of the year or, even rarer, from a blockage of normal flow. Regardless of the cause of a flood, the volumes of water that are generated in a basin need to be quantified to design bridges and flood-control structures such as reservoirs, dikes, and levees and to manage flows through regulatory controls such as dams.

Flow volumes for water year 1997 (October 1, 1996, through September 30, 1997) and mean annual volumes for the period of record at selected streamflow-gaging stations are shown in figures 8, 9, and 10. Annual volumes rather than March through June flood volumes were used to illustrate the magnitude of flows occurring in water year 1997 because above-average flows continued in some parts of the basins after June, thus sustaining flood conditions. The direction of flow and the magnitude of volumes for stations on the main stems of the Red River, the Minnesota River, and the James River are shown in the figures along with the volumes for stations on many of the tributaries in each basin. The tributary volumes were determined at active continuous-record stations that were at or near the mouth of the tributaries.

The volume for water year 1997 for the Red River at Emerson, Manitoba, was 9,285,000 acre-feet or 353 percent of the mean annual volume (2,631,000 acre-feet) for the period of record (fig. 8). For stations on the main stem of the Red River, the 1997 volumes were 266 to 412 percent of the mean annual volumes. For stations on selected tributaries to the Red River, the 1997 volumes were 186 to 630 percent of the mean annual volumes. For the Bois de Sioux River near Doran, Minn., the 1997 volume was 516 percent of the mean annual volume, and, for the Wild Rice River near Abercrombie, N. Dak., the 1997 volume was 630 percent of the mean annual volume. The Bois de Sioux and Wild Rice Rivers are located in areas that received some of the highest snowfall totals during the winter of 1996–97 and that were particularly hard hit by the blizzard of April 5–6, 1997.

The volume for water year 1997 for the Minnesota River near Jordan, Minn., was 7,527,000 acre-feet or 238 percent of the mean annual volume (3,161,000 acre-feet) for the period of record (fig. 9). For stations on the main stem of the Minnesota River, the 1997 volumes were 238 to 358 percent of the mean annual volumes. For stations on selected tributaries to the Minnesota River, the 1997 volumes were 260 to 378 percent of the mean annual volumes. Areas located upstream from Mankato, Minn., were particularly hard hit by flooding.

The volume for water year 1997 for the James River near Scotland, S. Dak., was 2,893,000 acre-feet or 712 percent of the mean annual volume (406,500 acre-feet) for the period of record (fig. 10). For stations on the main stem of the James River, the 1997 volumes were 367 to 788 percent of the mean annual volumes. For stations on selected tributaries to the James River, the 1997 volumes were 368 to 501 percent of the mean annual volumes. For the James River at Huron, S. Dak., the 1997 volume was 788 percent of the mean annual volume.

The volumes for water year 1997 as a percentage of the mean annual volumes for the periods of record for the James River are larger than those for the Red River or the Minnesota River. The larger percentages may be attributed to the substantial amounts of snowfall in parts of the James River Basin, but they also may be attributed to the shorter periods of record for many of the streamflow-gaging stations in the James River Basin. Statistics based on shorter periods of record are less reliable than those based on longer periods of record, particularly if the years of record are very wet or very dry. When compared to statistics computed for longer periods of record, statistics, such as the mean, computed for shorter periods of record may be highly influenced by an annual or single event.

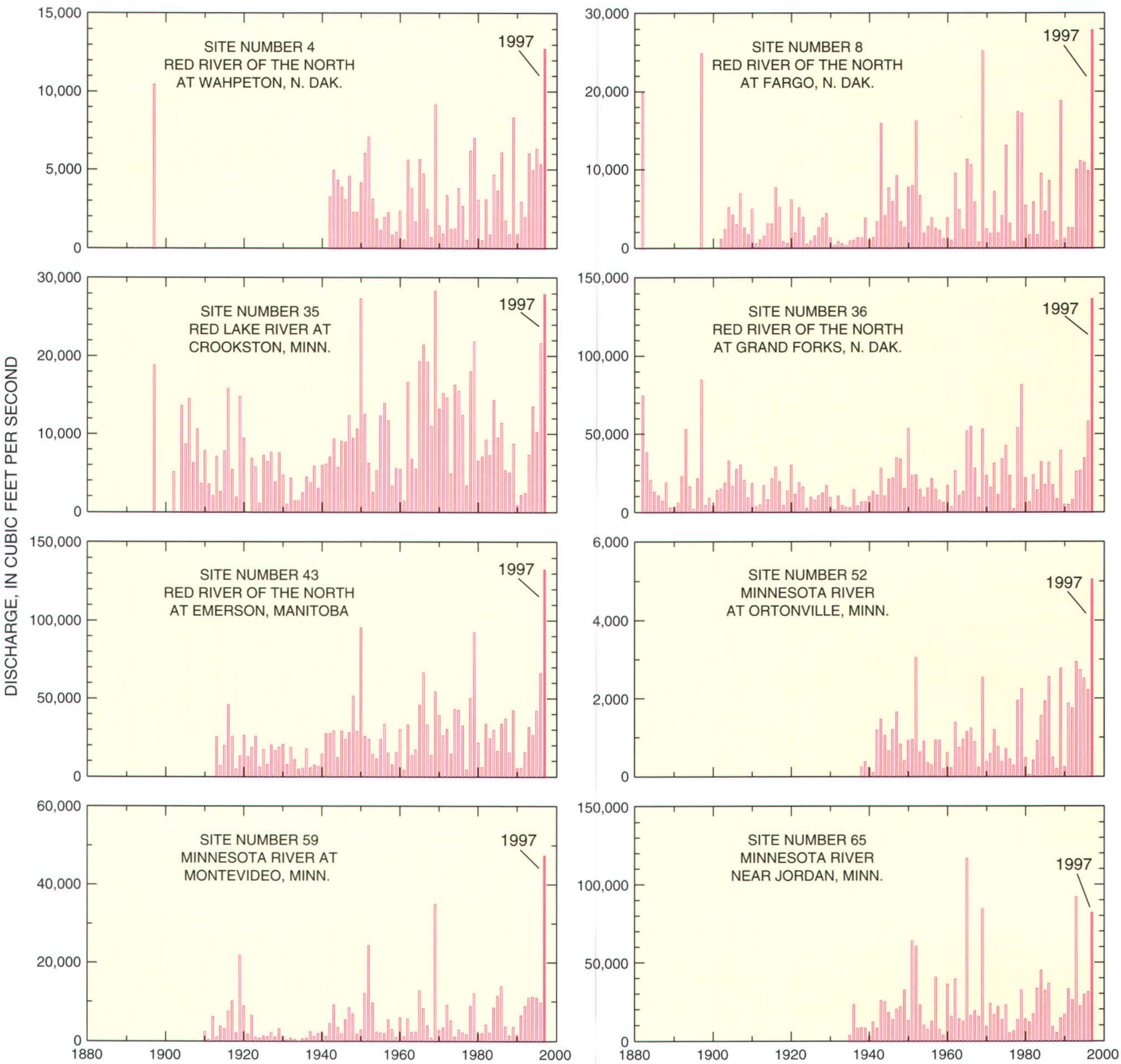



**Figure 7.** The 1997 peak discharges and historical peak discharges at selected streamflow-gaging stations in the northern plains.

## Magnitude and Duration of *n*-Day Flows

The *n*-day maximum mean discharge is the highest mean discharge sustained for *n* consecutive days. The comparisons between the *n*-day discharges for 1997 and the *n*-day discharges for the period of record are made with the assumption that channel and drainage-basin characteristics for each streamflow-gaging station did not change during the periods used for comparison. Data were analyzed for 82 of the 134 streamflow-gaging stations listed in table 1. Of the 82 stations, 34 are in the Red River Basin, 11 are in the upper Mississippi River Basin, and 37 are in the Missouri River Basin.

The 3-, 7-, and 30-day maximum mean discharges for 1997 and for the periods of record are listed in table 2 in the "Tabular Information" section at the back of this report. In 1997, record 3-day maximum mean discharges occurred at 43 of the 82 stations. Of those 43 stations, 19 are in the Red River Basin, 6 are in the upper Mississippi River Basin

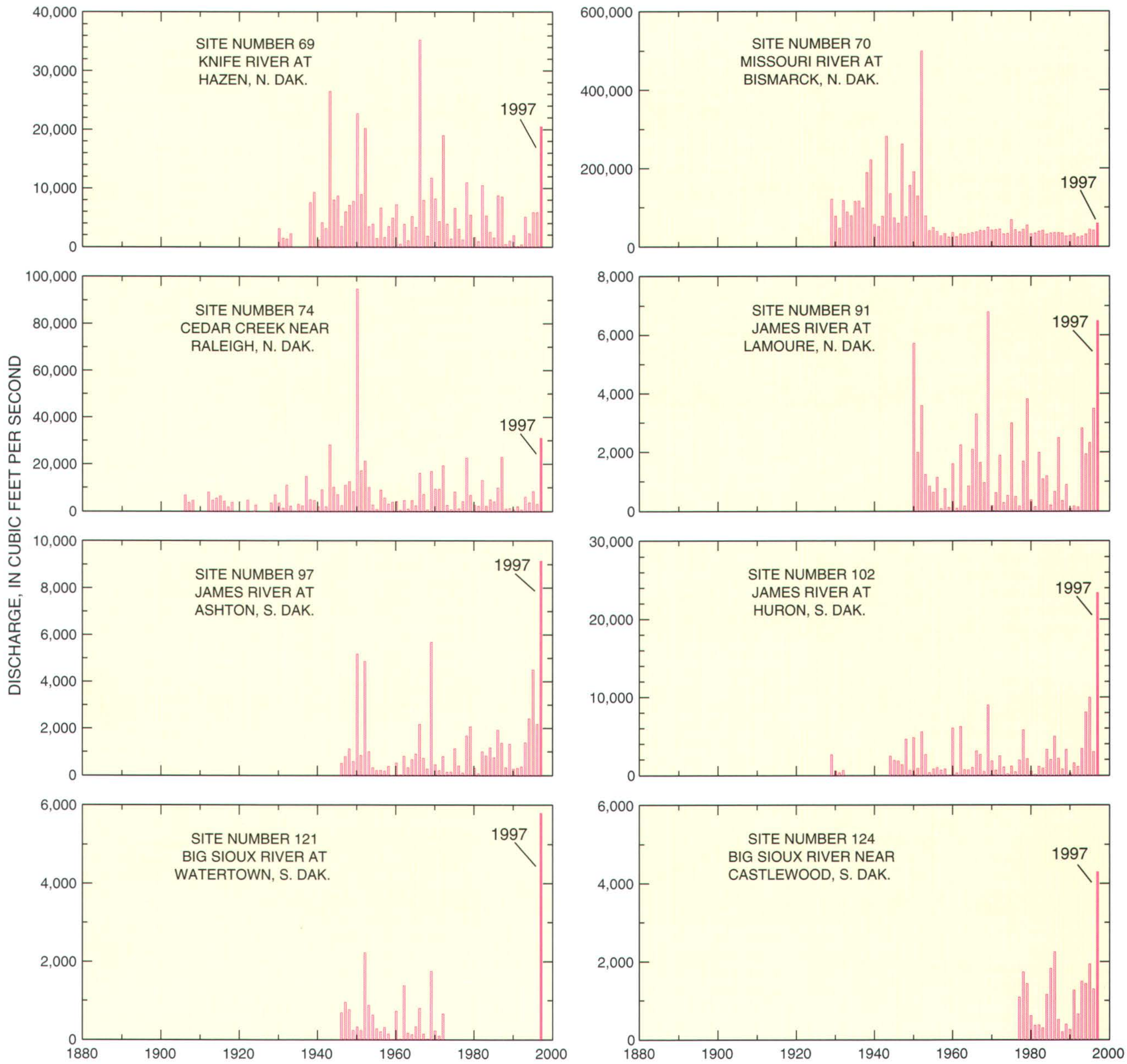



**Figure 7.** The 1997 peak discharges and historical peak discharges at selected streamflow-gaging stations in the northern plains—Continued.

(including the Minnesota River Basin), and 18 are in the Missouri River Basin (including the James River and Big Sioux River Basins). The 60-, 90-, and 120-day maximum mean discharges for 1997 and for the periods of record are listed in table 3 in the "Tabular Information" section at the back of this report. In 1997, record 120-day maximum mean discharges occurred at 44 of the 82 stations. Of those 44 stations, 16 are in the Red River Basin, 8 are in the upper Mississippi River Basin, and 20 are in the Missouri River Basin.

## Recurrence Intervals for *n*-Day Flows

The statistical procedure used to compute recurrence intervals for peak discharges also is applicable to flow analysis for any specific highest daily mean discharge for *n*-day periods. Generally, the longer the *n*-day period and the longer the recurrence intervals for that discharge, the more significant the *n*-day discharge for 1997 when compared to the previous maximums on record. The recurrence interval for the 3-day maximum mean discharge for

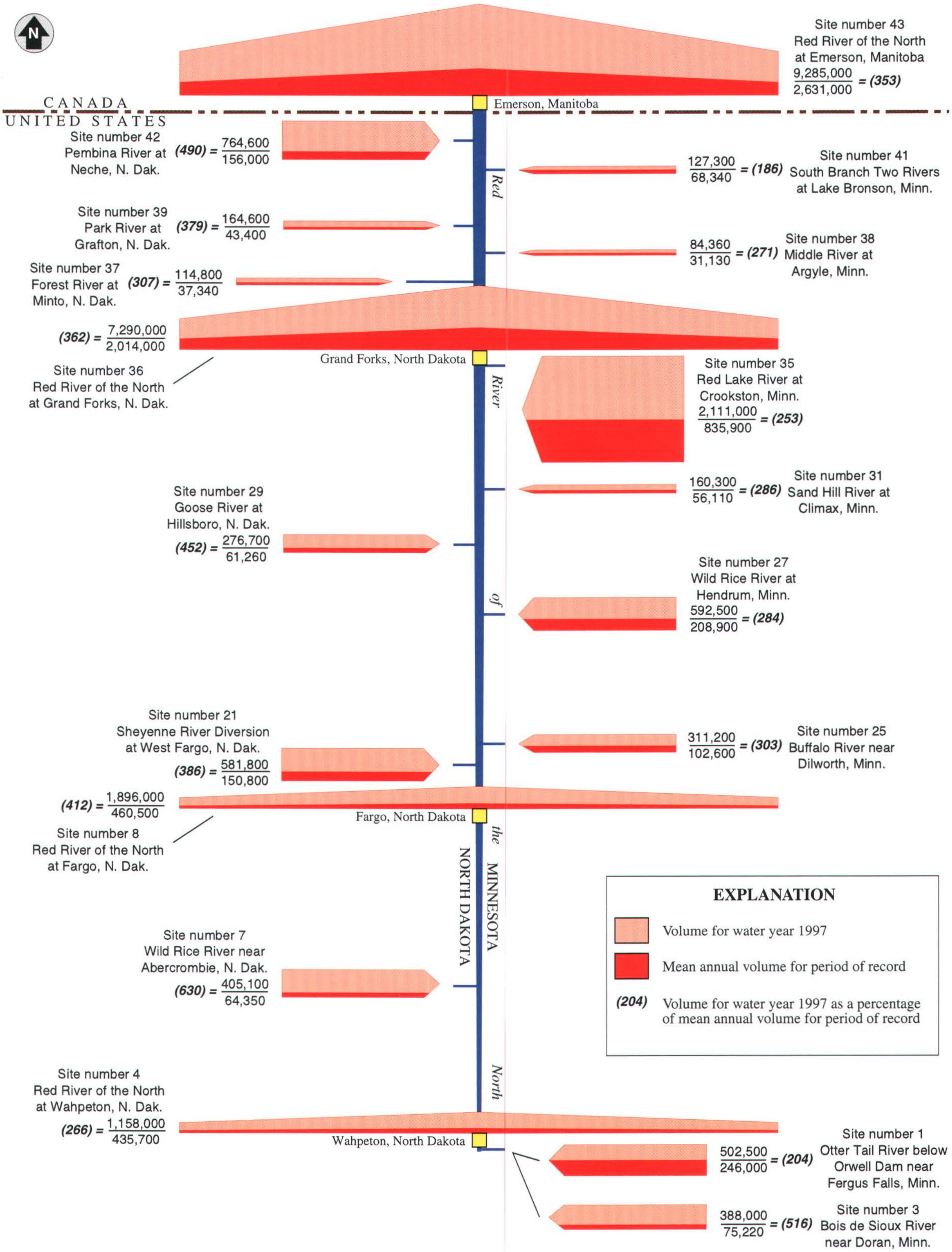



**Figure 8.** Flow volume, in acre-feet, for water year 1997 and mean annual volume, in acre-feet, for period of record at streamflow-gaging stations on the main stem of the Red River of the North and stations on selected tributaries to the Red River of the North.

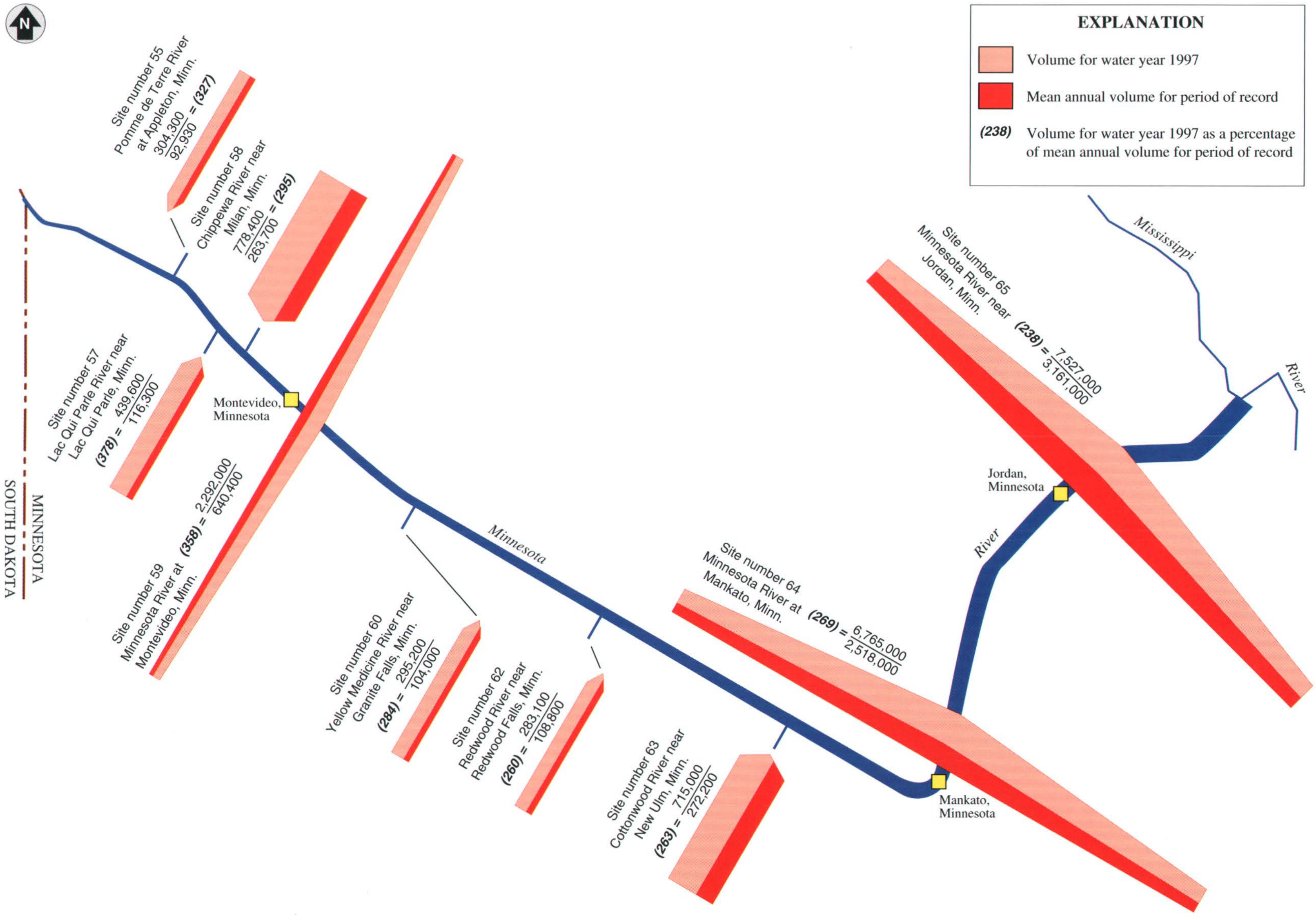



**Figure 9.** Flow volume, in acre-feet, for water year 1997 and mean annual volume, in acre-feet, for period of record at streamflow-gaging stations on the main stem of the Minnesota River and stations on selected tributaries to the Minnesota River.

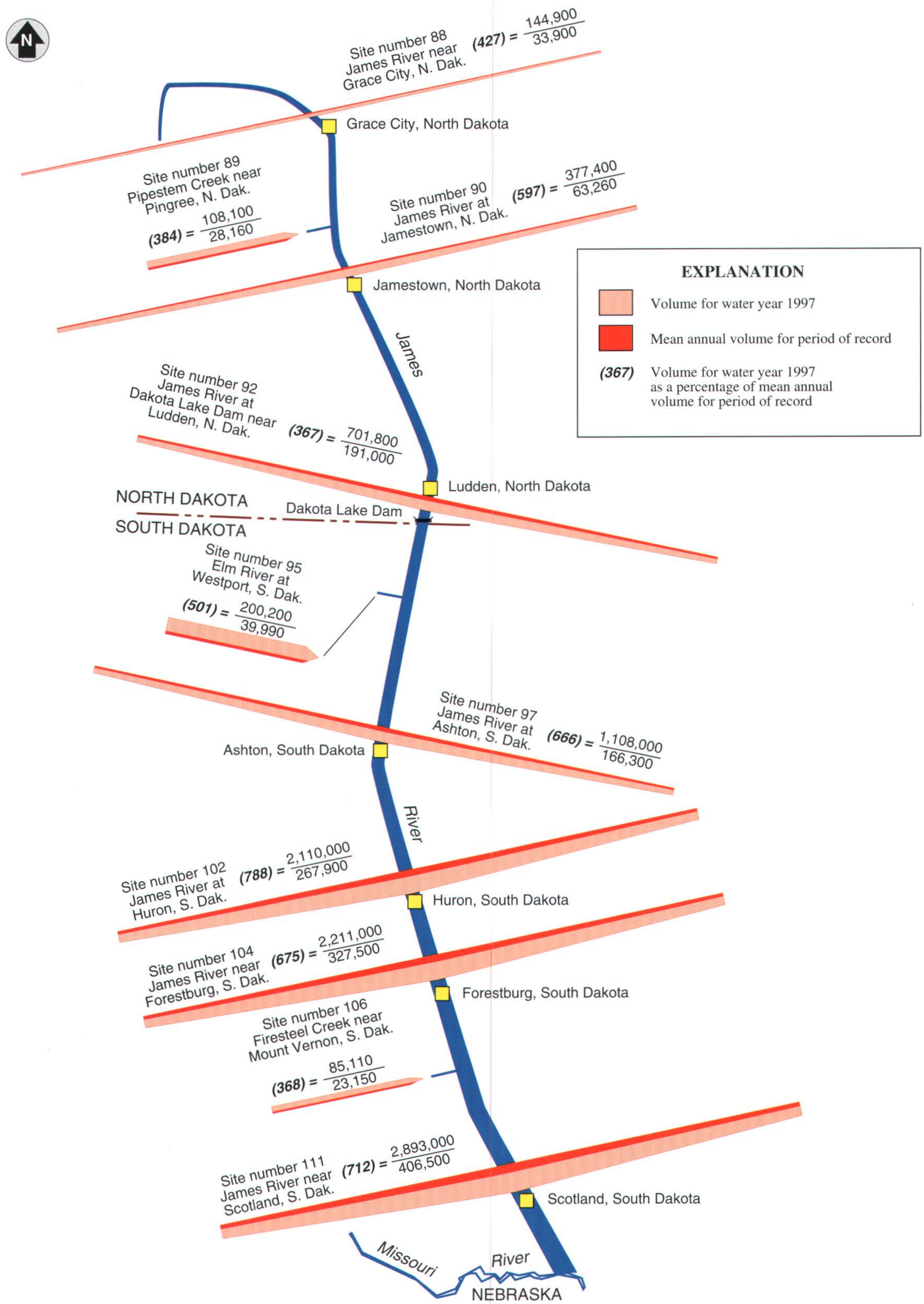



**Figure 10.** Flow volume, in acre-feet, for water year 1997 and mean annual volume, in acre-feet, for period of record at streamflow-gaging stations on the main stem of the James River and stations on selected tributaries to the James River.

1997 was 100 years at 14 of the 82 streamflow-gaging stations and greater than 100 years at 5 of the 82 streamflow-gaging stations (table 2). Of the five stations that had recurrence intervals greater than 100 years, three are in the Red River Basin, one is in the upper Mississippi River Basin, and one is in the Missouri River Basin. The recurrence interval for the 120-day maximum mean discharge for 1997 was 100 years at 8 of the 82 streamflow-gaging stations and greater than 100 years at 6 of the 82 streamflow-gaging stations (table 3). Of the six stations that had recurrence intervals greater than 100 years, two are in the Red River Basin and four are in the Missouri River Basin.

## ELEVATIONS AND CONTENTS OF SELECTED RESERVOIRS AND LAKES

Flood control is a function of many reservoirs in the northern plains. The elevations and contents of selected reservoirs and lakes in the region (fig. 4) are listed in table 4 in the "Tabular Information" section at the back of this report. The largest dams in the region are on the Missouri River. Of the six major dams on the Missouri River, one (Garrison) is in North Dakota, four (Oahe, Big Bend, Fort Randall, and Gavins Point) are in South Dakota, and one (not included in this report) is in Montana. In 1997, snowmelt in North Dakota and South Dakota in April and snowmelt in the Rocky Mountains of Montana and Wyoming in June produced the largest discharges in the Missouri River Basin in a century of record keeping. The six major reservoirs on the Missouri River have a capacity of 73.4 million acre-feet. In 1997, the reservoirs held 71.6 million acre-feet of water, the largest volume since July 1975 when the reservoirs held 72.1 million acre-feet of water. By capturing the runoff from snowmelt and timing the releases at all dams, the U.S. Army Corps of Engineers was able to prevent major flooding along the main stem of the Missouri River downstream from the dams. The peak stage of the Missouri River at Bismarck, N. Dak., in April 1997 was about 13.7 feet; flood stage is about 16.0 feet. Without Garrison Dam, the peak stage for April 1997 probably would have been about 17.5 feet, and the peak stage for June 1997 probably would have been about 20.5 feet (Paul Johnston, U.S. Army Corps of Engineers, written commun., 1997). The peak stage of the Missouri River at Pierre, S. Dak., in April 1997 was about 12.6 feet; flood stage is about 15.0 feet. Without the dams, the peak stage for April 1997 probably would have been about 21.0 feet, and the peak stage for June 1997 probably would have been about 19.0 feet (Paul Johnston, written commun., 1997).

Peak discharges on the James River and the Minnesota River and on tributaries to the Red River also were affected by dams. During the 1997 spring floods, many of the smaller reservoirs were at or near storage capacity. The amount of discharge into a reservoir, the volume of water currently being stored in the reservoir, the volume of water that can be stored before a critical stage exists, and the types of hydrologic conditions that exist downstream from the reservoir determine the discharge that can be released from the reservoir without causing a detrimental effect downstream. Discharges into and out of six selected reservoirs in the northern plains during March through June 1997 are shown in figure 11. During that time, the discharges into and out of Homme Lake near Park River, N. Dak., were nearly identical. Reservoir elevations for April through June 1997 indicated the reservoir storage was near capacity during those months (G. Heitzman, U.S. Army Corps of Engineers, written commun., 1997). Lower Red Lake near Red Lake, Minn., is part of a naturally occurring lake system (the Upper and Lower Red Lakes). The reservoir has a storage capacity of about 4 million acre-feet (Ruddy and Hitt, 1990). During March and April 1997, storage in the reservoir increased 333,300 acre-feet because of snowmelt in the area. Because of the storage capacity, discharge out of the reservoir during those months remained fairly constant. During April 1997, discharges into Orwell Lake near Fergus Falls, Minn., and Lake Traverse near Wheaton, Minn., were larger than discharges out of those reservoirs. The difference in discharges probably was caused by the melting of heavy snowpacks in the area, additional moisture in the area from the blizzard on April 5–6, 1997, and attempts to mitigate downstream flooding during April by controlling discharge from the reservoirs. High flows have an unusual effect on Lake Traverse, located about 6 miles upstream from Mud Lake on the Bois de Sioux River in Minnesota. When the water level in

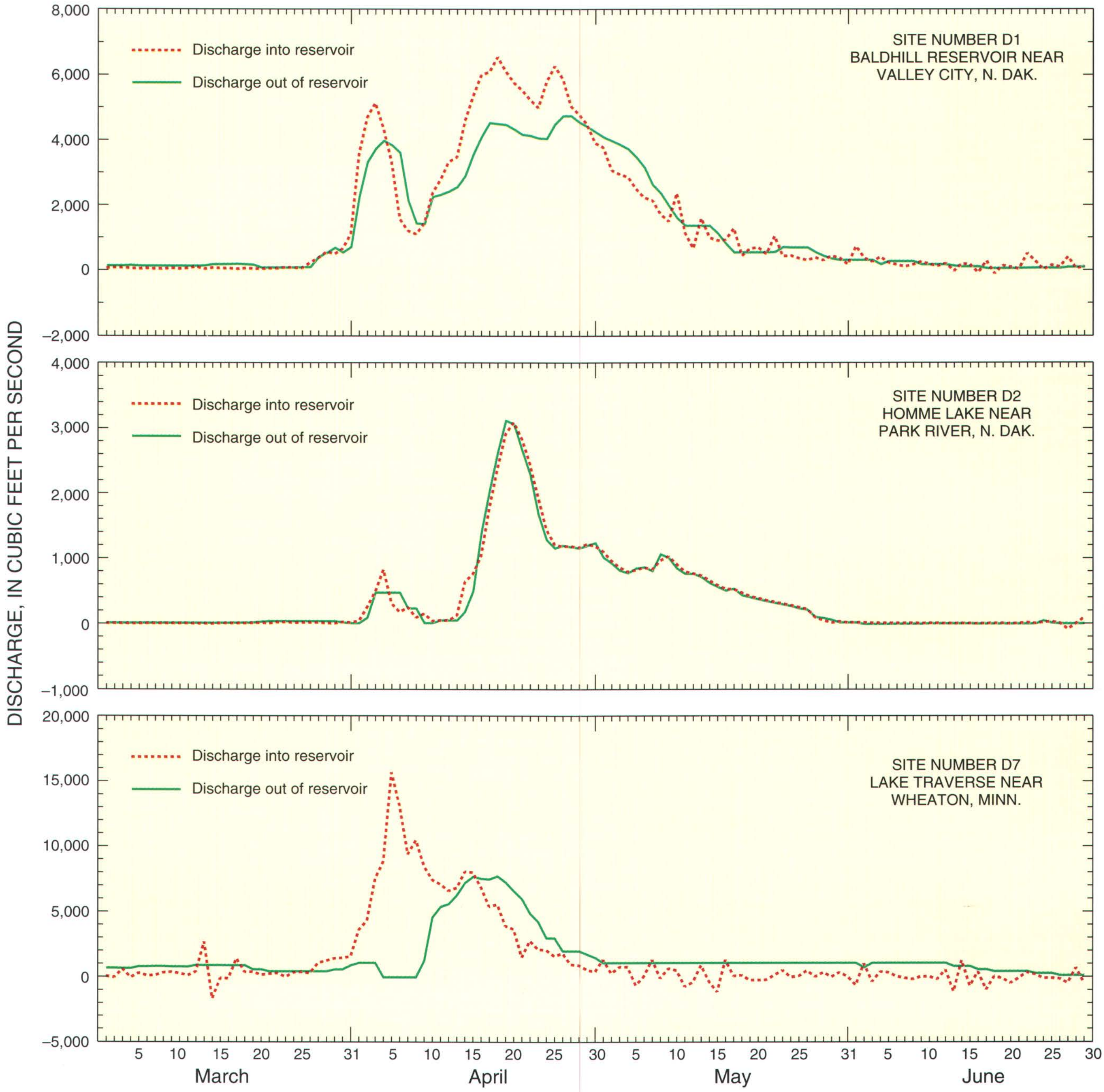



**Figure 11.** Discharge into and out of selected reservoirs in the northern plains, March through June 1997. (Data from the U.S. Army Corps of Engineers, St. Paul District. All reservoir data were retrieved during July 1998. Lower Red Lake data were updated during February 1999. Negative discharge into reservoirs can be caused by evaporation from the pool, wind effect on the pool elevation, or other similar conditions.)

Lake Traverse reaches about 977 feet above sea level, water spills into Mud Lake and begins filling that lake. When the water level in Mud Lake reaches about 977 feet above sea level, both lakes combine and form a much larger Lake Traverse. The water level in the larger Lake Traverse can rise to about 982 feet above sea level before water needs to be released downstream from White Rock Dam on Mud Lake. This situation occurred with Lake Traverse and Mud Lake during the 1997 spring floods. A similar situation exists with Lac Qui Parle Reservoir and Marsh Lake in the Minnesota River Basin.

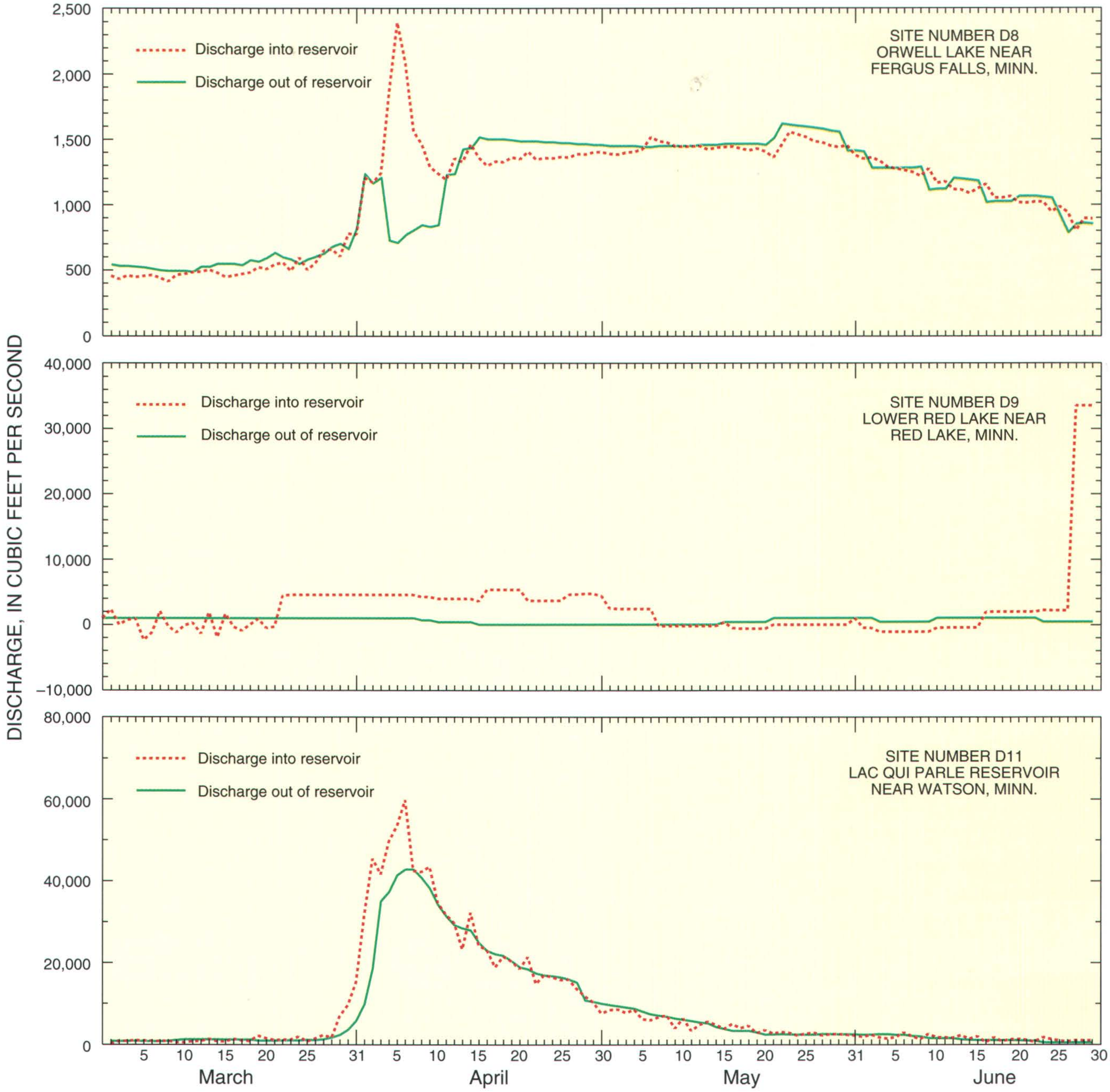



**Figure 11.** Discharge into and out of selected reservoirs in the northern plains, March through June 1997—Continued.

## EFFECTS OF WINTER STORMS AND SPRING FLOODS ON PEOPLE IN THE NORTHERN PLAINS

For thousands of years, major snowstorms or floods have occurred somewhere in the northern plains in any given year. However, the winter and spring of 1996–97 was the first time in recent history when severe weather and widespread flooding combined to devastate so many people in the northern plains. With any natural disaster, the effect on humans cannot be determined until long after the disaster has occurred. The snowstorms and floods that occurred during 1996–97 are no exception. The effects of major snowstorms and floods on people in the northern plains during the winter and spring of 1996–97 are described in publications by the North Dakota Water Education Foundation (1997) and *The Forum* (1997).

*Floodwater moved this house off its foundation and on top of a car in Grand Forks, North Dakota, in the spring of 1997. (Photograph from North Dakota Geological Survey.)*

The winter of 1996–97 in the northern plains was one of the most severe on record. A series of storms produced recordbreaking snowfall in many parts of the northern plains and periodically caused the closing of schools and businesses. Cities, towns, counties, and townships exhausted budgets, manpower, and machines trying to keep roads clear and traffic moving. Little-used secondary roads became increasingly difficult to keep open; eventually, some of those roads were closed until after the snow melted and the floodwaters receded. The closed roads affected many people. For example, dairy farmers were forced to empty milk-storage tanks on their property time and again when tanker trucks carrying milk could not make it to and from markets. Livestock losses across the region also were high (table 5 in the "Tabular Information" section at the back of this report). In North Dakota, unofficial reports indicate more than 137,000 cattle either froze during blizzards or drowned during flooding. In South Dakota, total livestock losses were estimated to be more than 296,000 (Teller and Burr, 1998). Many of the livestock losses in both North Dakota and South Dakota occurred during the blizzard on April 5–6, 1997. Heavy snows and high winds caused farms and communities throughout the region to be without electrical power several times during the winter. During the spring blizzard, ice and wind toppled transmission towers and power poles. In central and eastern North Dakota, 5,729 power poles were lost to ice damage, causing about 36,150 consumers to be without power for many days or, in some cases, even longer (North Dakota Association of Rural Electric Cooperatives, 1997).

As winter ended, snowmelt began. At first, floodwaters covered low-lying areas and affected mostly rural and agricultural lands, but, as the snow continued to melt, the floodwaters began pouring into towns and cities along many rivers in the region; many people lost their homes, businesses, or other property. President Clinton issued Presidential Disaster Declarations for all of the counties in North Dakota and South Dakota and for 59 of the 87 counties in Minnesota (table 5), resulting in Federal assistance of more than $2 billion. The Federal Emergency Management Agency, along with the Division of Emergency Management offices in each State, rendered aid, in the form of emergency shelter, food, and clothing, to the flood-ravaged region. Many residents began applying for Federal disaster assistance, disaster housing assistance, small business loans, and unemployment claims (table 5). Organizations such as the American Red Cross and the Salvation Army supplied temporary housing, clothing, meals, and basic staples and necessities. Additional supplies and aid came from other organizations and from countless individuals. The National Guard supplied temporary drinking-water-supply units, built dikes, and rescued people and animals stranded by the floodwaters. Most of the floodwaters receded in a few months, but cleaning, repairing, and rebuilding many of the communities affected by the floods is taking much longer.

*Debris from flood-ravaged homes lined many streets in Grand Forks, North Dakota, in the spring of 1997. (Photograph from North Dakota Geological Survey.)*

## CHRONOLOGICAL OVERVIEW

Flooding in the northern plains usually is caused by spring snowmelt. Conditions that contribute to flooding include above-normal precipitation in the fall, high soil-moisture levels at freezeup, above-normal snowfall in the winter, a late spring thaw, above-normal precipitation during the spring thaw, and ice jams on rivers and streams. Many of these conditions were present in the northern plains before and during the 1997 spring floods.

During September through October 1996, precipitation in the flood-affected region generally was between 4 and 8 inches; however, precipitation in east-central South Dakota was more than 10 inches. Most of the region received between 100 and 300 percent of normal precipitation, and single-day totals at some weather stations nearly equaled or exceeded the monthly normal.

During November 1996 through March 1997, a series of winter storms caused above-normal precipitation (125 to 200 percent of normal) across the region. Snowfall totals exceeded 100 inches in the southern part of the Red River Basin, the central part of the Missouri River Basin, and the central part of the Big Sioux River Basin. Temperatures in most of the region were below normal and few mild days occurred during the winter. The colder temperatures slowed the dissipation of accumulated snowfall so that substantial snowpacks remained in many areas. Generally, the areas that received the most snowfall had the highest river stages and peak discharges in the spring.

Spring flooding began in west-central and southeastern North Dakota, southwestern Minnesota, and north-central South Dakota by mid-March. However, colder temperatures at the end of March and a blizzard on April 5–6 slowed the snowmelt. The blizzard brought a severe drop in temperatures, windspeeds as much as 70 miles per hour, and as much as 2 feet of snow, with drifts many feet higher in several areas. The drifting caused many roads in the region to be blocked. Schools and businesses were closed for several days. In southeastern North Dakota, southwestern Minnesota, and eastern South Dakota, the blizzard was preceded by wind-driven rain and sleet. The wind and ice toppled transmission towers and power poles, leaving thousands of people without power for days. Livestock losses were high because the intensity and timing of the blizzard prevented many farmers and ranchers from reacting in time to save their livestock. The blizzard also hampered flood and rescue operations in areas where flooding already was occurring. The additional moisture brought by the blizzard added to the flows in many basins and caused ice jams on many rivers and streams in the region.

Peak stages and discharges occurred on many rivers and streams in the northern plains. In the Red River Basin, heavy snowpacks and a northerly flow combined to cause some of the worst flooding in this century. Record peak stages or discharges occurred at 28 of 45 streamflow-gaging stations. Grand Forks, N. Dak., and East Grand Forks, Minn., which are located on the main stem of the Red River, were evacuated when floodwaters inundated both cities. The flow volumes for water year 1997 at selected streamflow-gaging stations were 186 to 630 percent of the mean annual volumes for the period of record. Most of the reservoirs in the Red River Basin were at or near storage capacity.

In the upper Mississippi River Basin (including the Minnesota River Basin), record peak stages or discharges occurred at 10 of 22 streamflow-gaging stations. Some streams such as the Yellow Medicine River and the Redwood River crested at the end of March during the first major warmup. Areas located upstream from Mankato, Minn., were particularly hard hit by flooding. The flow volumes for water year 1997 at selected streamflow-gaging stations were 260 to 378 percent of the mean annual volumes for the period of record. Some reservoirs in the upper Mississippi River Basin were at or near storage capacity.

*The flag of the United States of America flies over floodwater in Grand Forks, North Dakota, in April 1997. (Photograph from North Dakota Water Education Foundation and North Dakota National Guard.)*

In the Missouri River Basin (including the James River and Big Sioux River Basins), record peak stages or discharges occurred at 34 of 67 streamflow-gaging stations. Discharges on the main stem of the Missouri River are controlled by a series of large dams. Without such control, peak stages probably would have been about 4 to 8 feet higher in many areas. Flooding did occur on some of the tributaries to the Missouri River. The flow volumes for water year 1997 at selected streamflow-gaging stations on one of the tributaries, the James River, were 367 to 788 percent of the mean annual volumes for the period of record. Several low-lying areas were inundated by the high discharges, and when dikes failed near Huron, S. Dak., the James Valley Christian School was inundated with 5 to 7 feet of water.

In 1997, record 3-day maximum mean discharges occurred at 43 of 82 streamflow-gaging stations, and record 120-day maximum mean discharges occurred at 44 of 82 streamflow-gaging stations. Of the 82 stations analyzed, 34 are in the Red River Basin, 11 are in the upper Mississippi River Basin, and 37 are in the Missouri River Basin.

The floodwaters and severe weather forced thousands of people to flee their homes, some permanently, and caused more than $2 billion in damages to the region. All of the counties in North Dakota and South Dakota and 59 of the 87 counties in Minnesota were declared Federal disaster areas.

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# TABULAR INFORMATION

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | | | | **Red River of the North Basin** | | | | | | | | |
| 1 | Otter Tail River below Orwell Dam near Fergus Falls, Minn. (05046000) | 1,740 | 1931–97 | 06–17–1953 | [a]5.60 | 06–17–1953 | 1,710 | 05–22–1997 | 4.63 | 05–22–1997 | 1,500 | [b]10–25 |
| 2 | Bois de Sioux River near White Rock, S. Dak. (05050000) | 1,160 | 1942–97 | 04–19–1969 | [c]15.07 | 04–19–1969 | 3,770 | 04–20–1997 | 16.90 | 04–20–1997 | 8,750 | [b]100–200 |
| 3 | Bois de Sioux River near Doran, Minn. (05051300) | 1,880 | 1989–97 | 03–16–1995 | 22.33 | 03–16–1995 | 4,290 | 04–16–1997 | 24.42 | 04–16–1997 | 12,300 | -- |
| 4 | Red River of the North at Wahpeton, N. Dak. (05051500) | 4,010 | 1897<br>1942–97 | 1897<br>04–05–1989 | [d]17.00<br>17.95 | 1897<br>04–10–1969 | [d]10,500<br>9,200 | 04–06–1997<br>04–15–1997 | [a c]19.42<br>19.25 | --<br>04–15–1997 | --<br>12,800<br>[e]2,200 | --<br>50–150 |
| 5 | Red River of the North at Hickson, N. Dak. (05051522) | 4,300 | 1976–97 | 04–07–1989 | 35.81 | 04–07–1989 | 12,900 | 04–14–1997<br>04–16–1997 | 36.85<br>37.60 | 04–14–1997<br>04–16–1997 | 13,300<br>12,800 | 50–150<br>-- |
| 6 | La Belle Creek near Veblen, S. Dak. (05051650) | 8.74 | 1988–97 | 03–26–1989 | [a]8.58 | 05–18–1996 | 664 | 04–01–1997<br>04–04–1997 | [a]12.57<br>[a]10.60 | --<br>04–04–1997 | --<br>[a]100 | --<br><10 |
| 7 | Wild Rice River near Abercrombie, N. Dak. (05053000) | 2,080 | 1897<br>1933–97 | 1897<br>04–11–1969 | 27.50<br>24.58 | --<br>04–11–1969 | --<br>9,540 | 04–06–1997<br>04–16–1997 | [a]26.59<br>25.40 | --<br>04–16–1997 | --<br>9,470 | --<br>[b]25–70 |
| 8 | Red River of the North at Fargo, N. Dak. (05054000) | 6,800 | 1882<br>1897<br>1902–97 | 04–11–1882<br>04–07–1897<br>04–15–1969 | [d]36.10<br>[d]39.10<br>37.34 | 04–11–1882<br>04–07–1897<br>04–15–1969 | [d]20,000<br>[d]25,000<br>25,300 | 04–17–1997<br>04–18–1997 | 39.57<br>39.72 | 04–17–1997<br>04–18–1997 | 28,000<br>27,700 | 50–100<br>-- |
| 9 | Sheyenne River near Warwick, N. Dak. (05056000) | 2,070 | 1950–97 | 04–18–1956 | [a]7.83 | 04–14–1969 | 4,660 | 04–21–1997 | 8.08 | 04–21–1997 | 3,990 | 10–25 |
| 10 | Mauvais Coulee near Cando, N. Dak. (05056100) | 387 | 1954–97 | 04–25–1979 | 11.18 | 04–25–1979 | 2,660 | 04–21–1997 | 11.68 | 04–21–1997 | 3,000 | 10–50 |
| 11 | Edmore Coulee near Edmore, N. Dak. (05056200) | 382 | 1956–97 | 07–30–1993 | 87.76 | 07–30–1993 | 1,180 | 04–24–1997 | 87.95 | 04–24–1997 | 1,830 | 10–50 |
| 12 | Starkweather Coulee near Webster, N. Dak. (05056239) | 310 | 1980–97 | 04–06–1989 | 10.05 | 08–11–1987 | 570 | 04–04–1997<br>04–27–1997 | 8.79<br>7.75 | --<br>04–27–1997 | --<br>782 | --<br>25–100 |
| 13 | Big Coulee near Churchs Ferry, N. Dak. (05056400) | [g]2,510 | 1950–97 | 04–23–1995 | 7.62 | 04–23–1995 | 1,450 | 09–12–1997<br>-- | [f]10.74<br>-- | --<br>05–04–1997 | --<br>2,280 | --<br>[g]25–100 |
| 14 | Channel A near Penn, N. Dak. (05056410) | 930 | 1984–97 | 08–15–1993 | 43.67 | 08–15–1993 | 1,560 | 04–30–1997<br>05–05–1997 | 45.55<br>[h]45.74 | 04–30–1997<br>05–05–1997 | 2,050<br>[a]2,010 | --<br>-- |
| 15 | Sheyenne River near Cooperstown, N. Dak. (05057000) | 6,470 | 1945–97 | 04–18–1996 | 19.13 | 04–17–1950 | 7,830 | 04–24–1997 | 18.52 | 04–24–1997 | 5,280 | 10–25 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | | | | **Red River of the North Basin—Continued** | | | | | | | | |
| 16 | Sheyenne River at Valley City, N. Dak. (05058500) | 7,810 | 1882<br>1897<br>1919<br>1938–97 | 04–1882<br>04–21–1996 | 20.00<br>18.78 | --<br>04–21–1996 | --<br>5,250 | 04–19–1997 | 18.01 | 04–19–1997 | 4,810 | [b]15–40 |
| 17 | Sheyenne River at Lisbon, N. Dak. (05058700) | 8,190 | 1950<br>1957–97 | 04–13–1996 | [a]19.20 | 07–01–1975 | 5,270 | 04–05–1997<br>04–23–1997 | [a]19.29<br>18.24 | 04–05–1997<br>04–23–1997 | [a]6,100<br>5,670 | 25–50<br>-- |
| 18 | Sheyenne River near Kindred, N. Dak. (05059000) | 8,800 | 1947<br>1950–97 | 1947<br>07–06–1975 | 22.10<br>21.66 | 04–30–1996 | 5,100 | 04–08–1997<br>04–27–1997 | [a]22.33<br>21.38 | 04–08–1997<br>04–27–1997 | [a]5,800<br>5,970 | --<br>[b]25–50 |
| 19 | Sheyenne River above Sheyenne River Diversion near Horace, N. Dak. (05059300)[i] | 8,840 | 1992–97 | 05–02–1996 | 24.67 | 05–02–1996 | 4,430 | 04–17–1997<br>05–08–1997 | [a]25.44<br>25.27 | --<br>05–08–1997 | --<br>5,210 | --<br>-- |
| 20 | Sheyenne River Diversion near Horace, N. Dak. (05059310)[j] | -- | 1992–97 | 05–02–1996 | 24.67 | 04–22–1996 | [m]2,300 | 04–17–1997<br>04–28–1997 | [a]25.44<br>25.38 | --<br>04–28–1997 | --<br>2,590 | --<br>-- |
| 21 | Sheyenne River Diversion at West Fargo, N. Dak. (05059480) | -- | 1992–97 | 04–18–1996 | [a]28.77 | 05–02–1996 | 4,280 | 04–09–1997<br>04–19–1997 | [a]22.90<br>22.68 | --<br>04–19–1997 | --<br>[k]4,810 | --<br>-- |
| 22 | Sheyenne River at West Fargo, N. Dak. (05059500)[l] | 8,870 | 1902<br>1903–05<br>1919<br>1929–97 | 07–05–1975 | 22.25 | 05–02–1996 | [m]4,240 | 04–09–1997<br>04–19–1997 | [n]22.90<br>22.68 | --<br>04–19–1997 | --<br>4,810 | --<br>-- |
| 23 | Buffalo River near Hawley, Minn. (05061000) | 322 | 1945–97 | 1921 | 11.30 | 1921 | 3,000 | 04–06–1997 | [a]10.77 | 04–06–1997 | [a o]2,360 | 10–25 |
| 24 | South Branch Buffalo River near Sabin, Minn. (05061500) | 522 | 1945–97 | 07–02–1975 | 19.90 | 07–02–1975 | 8,500 | --<br>04–06–1997 | --<br>[a]19.11 | 04–05–1997<br>-- | [a o]5,850<br>-- | 10–25<br>-- |
| 25 | Buffalo River near Dilworth, Minn. (05062000) | 1,040 | 1931–97 | 07–02–1975 | 27.10 | 07–02–1975 | 13,600 | 04–06–1997 | [a]27.02 | 04–06–1997 | [o]8,370 | 10–25 |
| 26 | Wild Rice River at Twin Valley, Minn. (05062500) | 929 | 1909–17<br>1931–97 | 07–22–1909 | 20.00 | 07–22–1909 | 9,200 | 04–06–1997 | 15.91 | 04–06–1997 | 10,000 | 100–200 |
| 27 | Wild Rice River at Hendrum, Minn. (05064000)[p] | 1,600 | 1944–97 | 04–21–1979 | 32.30 | 04–10–1978 | 9,350 | 04–18–1997 | [q]33.85 | 04–18–1997 | 10,600 | [b]20–50 |
| 28 | Red River of the North at Halstad, Minn. (05064500) | 21,800 | 1936–37<br>1942–97 | 04–22–1979 | 39.00 | 04–22–1979 | 42,000 | 04–19–1997 | 40.74 | 04–19–1997 | 71,500 | 100–200 |
| 29 | Goose River at Hillsboro, N. Dak. (05066500) | 1,203 | 1931–97 | 04–21–1979 | 16.76 | 04–21–1979 | 14,800 | 04–06–1997 | 15.62 | 04–06–1997 | 8,520 | 15–40 |
| 30 | Marsh River near Shelly, Minn. (05067500) | 151 | 1944–97 | 04–19–1979 | [c]23.36 | 04–19–1979 | 4,880 | 04–18–1997 | [c]25.45 | 04–18–1997 | [q]4,300 | 50–100 |
| 31 | Sand Hill River at Climax, Minn. (05069000) | 426 | 1943–97 | 04–23–1979 | [c q]32.79 | 04–14–1965 | 4,560 | 04–20–1997 | [q]39.40 | 04–20–1997 | [o q]4,360 | 25–50 |
| 32 | Red Lake River at High Landing near Goodridge, Minn. (05075000)[p] | 2,300 | 1929–97 | 07–03–1975<br>07–07–1975 | 13.44<br>13.39 | --<br>07–07–1975 | --<br>4,060 | 04–10–1997<br>-- | [a]12.36<br>-- | --<br>04–15–1997 | --<br>2,260 | --<br><10 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | | | | **Red River of the North Basin—Continued** | | | | | | | | |
| 33 | Thief River near Thief River Falls, Minn. (05076000) | 959 | 1909–17<br>1920–21<br>1922–24<br>1928–81<br>1982–97 | 05–13–1950 | 17.38 | 05–13–1950 | 5,610 | 04–18–1997<br>04–22–1997 | [a]16.33<br>15.20 | --<br>04–22–1997 | --<br>4,120 | --<br>10–25 |
| 34 | Clearwater River at Red Lake Falls, Minn. (05078500) | 1,370 | 1909–17<br>1934–81<br>1982–97 | 04–25–1979<br>03–06–1983 | 12.38<br>[a]15.85 | 04–25–1979<br>-- | 10,300<br>-- | 04–05–1997<br>04–15–1997 | [a]11.15<br>11.10 | --<br>04–15–1997 | --<br>7,860 | --<br>10–25 |
| 35 | Red Lake River at Crookston, Minn. (05079000) | 5,270 | 1897<br>1902<br>1904–20<br>1922–97 | 04–12–1969 | 27.33 | 04–12–1969 | 28,400 | 04–17–1997 | [a]28.40 | 04–17–1997 | [w]28,000 | 30–100 |
| 36 | Red River of the North at Grand Forks, N. Dak. (05082500) | 30,100 | 1882–1997 | 04–10–1897 | 50.20 | 04–10–1897 | 85,000 | 04–18–1997<br>04–22–1997 | 52.04<br>[c]54.35 | 04–18–1997<br>04–22–1997 | [r]137,000<br>114,000 | --<br>100–200 |
| 37 | Forest River at Minto, N. Dak. (05085000) | 740 | 1944–97 | 04–19–1948<br>04–18–1950 | 11.80<br>11.80 | --<br>04–18–1950 | --<br>16,600 | 04–04–1997<br>04–20–1997 | [a]9.11<br>5.93 | --<br>04–20–1997 | --<br>2,140 | --<br><10 |
| 38 | Middle River at Argyle, Minn. (05087500) | 265 | 1945<br>1950–81<br>1982–97 | 05–19–1996 | [c]18.27 | 05–19–1996 | 5,020 | 04–19–1997 | 17.96 | 04–19–1997 | 4,330 | 25–50 |
| 39 | Park River at Grafton, N. Dak. (05090000) | 695 | 1932–97 | 04–19–1950 | 20.13 | 04–19–1950 | 12,600 | 04–21–1997 | 15.40 | 04–21–1997 | 5,250 | [b]<10 |
| 40 | Red River of the North at Drayton, N. Dak. (05092000) | 34,800 | 1936–37<br>1941–97 | 04–28–1979 | 43.66 | 04–28–1979 | 92,900 | 04–24–1997 | 45.55 | 04–24–1997 | 124,000 | 100–200 |
| 41 | South Branch Two Rivers at Lake Bronson, Minn. (05094000) | 444 | 1929–37<br>1941–47<br>1954–97 | 04–05–1966 | 18.23 | 04–05–1966 | 5,410 | 04–20–1997 | 14.58 | 04–20–1997 | 4,260 | 10–25 |
| 42 | Pembina River at Neche, N. Dak. (05100000) | 3,410 | 1904–08<br>1910–15<br>1919–97 | 04–20–1979 | [a]23.64 | 04–20–1950 | 10,700 | 04–21–1997<br>04–27–1997 | [a]24.51<br>24.20 | 04–21–1997<br>04–27–1997 | [a]12,800<br>15,100 | --<br>50–100 |
| 43 | Red River of the North at Emerson, Manitoba (05102500) | 40,200 | 1902<br>1912–29<br>1929–97 | 05–01–1979 | 791.19 | 05–13–1950 | 95,500 | 04–26–1997 | 792.41 | 04–26–1997 | 133,000 | 100–200 |
| 44 | Roseau River at Ross, Minn. (05107500) | 1,220 | 1928–91<br>1995–97 | 05–12–1950 | 18.25 | 05–12–1950 | 6,560 | 04–26–1997 | 17.30 | 04–26–1997 | 4,670 | [b]10–25 |
| 45 | Roseau River below State Ditch 51 near Caribou, Minn. (05112000) | 1,560 | 1917<br>1920–97 | 05–19–1950 | 11.81 | 05–19–1950 | 4,080 | 04–19–1997<br>05–08–1997 | [a]11.13<br>10.74 | 04–19–1997<br>-- | 3,320<br>-- | 25–50<br>-- |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | **Upper Mississippi River Basin** | | | | | | | | | | | |
| 46 | Sauk River near St. Cloud, Minn. (05270500) | 925 | 1909–12<br>1913<br>1929<br>1930–31<br>1932–33<br>1934–81<br>1990–97 | 04–13–1965 | 10.68 | 04–13–1965 | 9,100 | 04–06–1997 | 8.72 | 04–06–1997 | 5,150 | 10–25 |
| 47 | Crow River at Rockford, Minn. (05280000) | 2,520 | 1906<br>1909–17<br>1929<br>1930–31<br>1932<br>1933<br>1934–97 | 04–16–1965 | [c]19.27 | 04–16–1965 | 22,400 | 04–08–1997 | 14.42 | 04–08–1997 | 11,800 | 10–25 |
| 48 | Mississippi River near Anoka, Minn. (05288500) | 19,100 | 1963–67<br>1975–97 | 04–17–1965 | 19.53 | 04–17–1965 | 91,000 | 04–09–1997 | 16.44 | 04–09–1997 | 69,800 | 25–50 |
| | **Minnesota River Basin** | | | | | | | | | | | |
| 49 | Big Coulee Creek near Peever, S. Dak. (05289985) | 12.1 | 1988–97 | 06–21–1991<br>03–11–1995 | 8.21<br>[a]9.08 | 06–21–1991<br>-- | 456<br>-- | 03–27–1997<br>04–05–1997 | [a]9.43<br>7.73 | --<br>04–05–1997 | --<br>358 | --<br>-- |
| 50 | Little Minnesota River near Peever, S. Dak. (05290000) | 447 | 1939–81<br>1989–97 | 07–25–1993 | 13.58 | 04–25–1993 | 8,900 | 03–27–1997<br>-- | [a]14.40<br>-- | --<br>03–28–1997 | --<br>3,590 | 10–25<br>-- |
| 51 | Whetstone River near Big Stone City, S. Dak. (05291000)[s] | 389 | 1910–12<br>1931–97 | 04–08–1969 | [c]14.32 | 04–08–1969 | 6,870 | 04–06–1997 | 14.21 | 04–06–1997 | 7,930 | 25–50 |
| 52 | Minnesota River at Ortonville, Minn. (05292000) | 1,160 | 1938–97 | 04–13–1952 | 12.92 | 04–13–1952 | 3,060 | 04–10–1997 | 12.85 | 04–10–1997 | 5,070 | [b]50–150 |
| 53 | North Fork Yellow Bank River near Odessa, Minn. (05292704) | 208 | 1992–97 | 07–08–1994 | 14.62 | 07–08–1994 | 2,580 | 03–29–1997<br>03–31–1997 | [a]18.02<br>15.94 | --<br>03–31–1997 | --<br>4,670 | --<br>-- |
| 54 | Yellow Bank River near Odessa, Minn. (05293000) | 398 | 1939–97 | 04–09–1969 | [c]19.07 | 04–09–1969 | 6,970 | 04–02–1997 | [c]17.94 | 04–02–1997 | 6,770 | 25–50 |
| 55 | Pomme de Terre River at Appleton, Minn. (05294000) | 905 | 1931–35<br>1935–97 | 04–09–1969 | [a]14.58 | 04–11–1969 | 5,520 | 04–07–1997 | [c,t]18.13 | 04–07–1997 | [t]8,890 | -- |
| 56 | Cobb Creek near Gary, S. Dak. (05299700) | 70.3 | 1993–97 | 06–17–1992 | 12.09 | 06–17–1992 | 860 | 03–31–1997 | [a]13.99 | 03–31–1997 | [a]2,100 | -- |
| 57 | Lac Qui Parle River near Lac Qui Parle, Minn. (05300000) | 983 | 1910–14<br>1931–97 | 04–09–1965 | [a,c]19.37 | 04–10–1969 | 17,100 | 04–07–1997 | 17.68 | 04–07–1997 | 13,100 | 50–100 |
| 58 | Chippewa River near Milan, Minn. (05304500) | 1,870 | 1937–97 | 04–09–1969 | 15.45 | 04–09–1969 | 11,400 | 04–06–1997 | [c]18.03 | 04–06–1997 | 14,400 | 50–100 |
| 59 | Minnesota River at Montevideo, Minn. (05311000) | 6,180 | 1909–17<br>1917–29<br>1929–97 | 04–12–1969 | [c]21.68 | 04–12–1969 | 35,100 | 04–06–1997 | 23.90 | 04–06–1997 | 47,500 | [b]100–300 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | **Minnesota River Basin—Continued** | | | | | | | | | | | |
| 60 | Yellow Medicine River near Granite Falls, Minn. (05313500) | 653 | 1931–35<br>1935–38<br>1939–97 | 04–10–1969 | 14.90 | 04–10–1969 | 17,200 | 03–31–1997 | 11.80 | 03–31–1997 | 9,020 | 10–25 |
| 61 | Redwood River near Marshall, Minn. (05315000) | 259 | 1940–97 | 05–09–1993 | 17.00 | 05–09–1993 | 6,380 | 03–30–1997 | 15.82 | 03–30–1997 | 3,310 | 10–25 |
| 62 | Redwood River near Redwood Falls, Minn. (05316500) | 629 | 1909–14<br>1930–35<br>1935–97 | 06–18–1957 | [c]15.92 | 06–18–1957 | 19,700 | 03–29–1997<br>-- | [a]18.01<br>-- | --<br>03–30–1997 | --<br>[a][o]7,200 | --<br>10–25 |
| 63 | Cottonwood River near New Ulm, Minn. (05317000) | 1,280 | 1909–13<br>1931–38<br>1938–97 | 04–08–1965 | 20.86 | 04–10–1969 | 28,700 | 03–30–1997 | 16.03 | 03–30–1997 | 13,800 | 10–25 |
| 64 | Minnesota River at Mankato, Minn. (05325000) | 14,900 | 1967–81<br>1982–97 | 06–21–1993 | 30.11 | 04–10–1965 | 94,100 | 04–10–1997 | 27.61 | 04–10–1997 | 79,800 | 50–100 |
| 65 | Minnesota River near Jordan, Minn. (05330000) | 16,200 | 1934–97 | 04–12–1965 | 35.07 | 04–11–1965 | 117,000 | 04–12–1997 | 32.24 | 04–12–1997 | 82,300 | 25–50 |
| | **Upper Mississippi River Basin—Continued** | | | | | | | | | | | |
| 66 | Mississippi River at St. Paul, Minn. (05331000) | 36,800 | 1892–1997 | 04–16–1965 | 26.01 | 04–16–1965 | 171,000 | 04–13–1997 | 22.37 | 04–13–1997 | 134,000 | 50–100 |
| 67 | Mississippi River at Prescott, Wis. (05344500) | 44,800 | 1928–97 | 04–18–1965 | 43.11 | 04–18–1965 | 228,000 | 04–12–1997 | 40.09 | 04–12–1997 | 161,000 | 25–50 |
| | **Missouri River Basin** | | | | | | | | | | | |
| 68 | Spring Creek at Zap, N. Dak. (06340000) | 549 | 1924<br>1945–97 | 03–15–1972 | 20.70 | 04–07–1952 | 6,130 | 03–22–1997 | 12.87 | 03–22–1997 | 3,500 | <10 |
| 69 | Knife River at Hazen, N. Dak. (06340500) | 2,240 | 1930–33<br>1938–97 | 06–24–1966 | 27.01 | 06–24–1966 | 35,300 | 03–23–1997 | [c]26.92 | 03–23–1997 | [u]20,500 | 25–50 |
| 70 | Missouri River at Bismarck, N. Dak. (06342500) | 186,400 | 1928–97 | 03–31–1881<br>04–06–1952<br>12–18–1979 | 31.60<br>27.90<br>[a]14.24 | --<br>04–06–1952<br>07–13–1975 | --<br>500,000<br>68,900 | 07–13–1997 | [v]14.00 | 07–25–1997 | 59,500 | 50–100 |
| 71 | Green River near New Hradec, N. Dak. (06344600) | 152 | 1964–97 | 03–22–1978 | [a]17.60 | 05–09–1970 | 4,120 | 03–21–1997 | [a]19.58 | 03–21–1997 | 1,400 | <10 |
| 72 | Heart River near Richardton, N. Dak. (06345500) | 1,240 | 1905–21<br>1938<br>1943–97 | 03–30–1912<br>04–16–1950 | 41.95<br>28.05 | --<br>04–16–1950 | --<br>23,400 | 03–20–1997 | [a]24.22 | 03–23–1997 | [w]13,000 | 25–50 |
| 73 | Heart River near Mandan, N. Dak. (06349000) | 3,310 | 1924<br>1928–33<br>1937–97 | 04–04–1952 | [a]25.75 | 04–19–1950 | 30,500 | 03–23–1997 | [a]24.21 | 03–23–1997 | [w]22,000 | [b]10–25 |
| 74 | Cedar Creek near Raleigh, N. Dak. (06353000) | 1,750 | 1939<br>1962–97 | 03–28–1978 | 13.70 | 03–28–1978 | 13,400 | 03–24–1997 | [a]17.05 | 03–24–1997 | 14,600 | 50–100 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | Recurrence interval (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | |
| | **Missouri River Basin—Continued** | | | | | | | | | | | |
| 75 | Cannonball River at Breien, N. Dak. (06354000) | 4,100 | 1935–97 | 04–19–1950 | [c]22.30 | 04–19–1950 | [dd]94,800 | 03–25–1997 | 20.82 | 03–25–1997 | 31,100 | 10–25 |
| 76 | Spring Creek near Herreid, S. Dak. (06354860) | 440 | 1881<br>1963–[x]87<br>1989–97 | 03–22–1987 | 13.38 | 03–22–1987 | 4,540 | 03–31–1997 | [c]12.64 | 03–31–1997 | 2,680 | 10–20 |
| 77 | Oak Creek near Wakpala, S. Dak. (06354882) | 356 | 1985–97 | 03–04–1986<br>03–14–1995 | 17.73<br>[a]18.62 | 03–04–1986<br>-- | 3,780<br>-- | 03–27–1997 | [a]19.83 | 03–27–1997 | [a]7,500 | 10–50 |
| 78 | Grand River at Little Eagle, S. Dak. (06357800) | 5,370 | [b]1959–97 | 03–18–1966<br>03–23–1987 | [a c]21.76<br>19.16 | --<br>03–23–1987 | --<br>31,000 | 03–24–1997<br>03–27–1997 | [a]19.58<br>19.58 | --<br>03–27–1997 | --<br>20,900 | --<br>15–40 |
| 79 | Moreau River near Whitehorse, S. Dak. (06360500) | 4,880 | 1955–97 | 03–14–1972<br>05–24–1982 | [a]26.20<br>26.00 | --<br>05–24–1982 | --<br>27,700 | 03–21–1997 | [a]27.68 | 03–23–1997 | 29,700 | 15–45 |
| 80 | Bad River near Fort Pierre, S. Dak. (06441500) | 3,107 | [x]1905<br>1927<br>1929–97 | 06–18–1967 | 29.55 | 06–18–1967 | 43,800 | 02–21–1997<br>05–02–1997 | [a]25.28<br>21.74 | --<br>05–02–1997 | --<br>14,700 | --<br><10 |
| 81 | Medicine Knoll near Blunt, S. Dak. (06442000) | 317 | 1950–97 | 06–05–1991 | 12.98 | 06–05–1991 | [o]5,000 | 03–28–1997 | [a]13.15 | 03–28–1997 | [a]4,000 | 15–40 |
| 82 | Campbell Creek near Lee's Corner, S. Dak. (06442718) | 54.1 | 1988–97 | 07–24–1993 | 15.01 | 07–24–1993 | 3,260 | 06–03–1997 | 14.60 | 06–03–1997 | 3,060 | <10 |
| 83 | Elm Creek near Gann Valley, S. Dak. (06442900) | 381 | 1987–97 | 07–25–1993 | 17.24 | -- | -- | 03–22–1997<br>03–28–1997 | [a]17.00<br>15.58 | --<br>03–28–1997 | --<br>3,440 | --<br>([b]) |
| 84 | White River near Oacoma, S. Dak. (06452000) | 10,200 | 1929–97 | 03–30–1952<br>03–04–1994 | [y]15.40<br>[a]24.70 | 03–30–1952<br>-- | 51,900<br>-- | 02–20–1997<br>06–05–1997 | [a]23.84<br>18.58 | --<br>06–05–1997 | --<br>33,700 | --<br>10–20 |
| 85 | Platte Creek near Platte, S. Dak. (06452320) | 741 | 1989–97 | 05–11–1995 | 11.29 | 05–11–1995 | 2,600 | 02–20–1997<br>05–08–1997 | [a]9.13<br>[a]12.67 | 02–20–1997<br>-- | 1,400<br>-- | ([b])<br>-- |
| 86 | Choteau Creek near Avon, S. Dak. (06453255) | 602 | 1983–97 | 06–12–1984 | 13.93 | 06–12–1984 | 7,280 | 03–13–1997 | 7.13 | 03–13–1997 | 1,320 | <10 |
| 87 | Snatch Creek near Tabor, S. Dak. (06466715) | 44.0 | 1993–97 | 05–30–1995 | 10.58 | 05–30–1995 | 1,660 | 03–10–1997 | 6.65 | 03–10–1997 | 500 | ([b]) |
| | **James River Basin** | | | | | | | | | | | |
| 88 | James River near Grace City, N. Dak. (06468170) | 1,060 | 1969–97 | 03–21–1996 | [a]16.18 | 07–28–1993 | 3,520 | 04–03–1997 | [a]14.77 | 04–03–1997 | 4,000 | 10–20 |
| 89 | Pipestem Creek near Pingree, N. Dak. (06469400) | 700 | 1974–97 | 03–17–1995 | 11.70 | 03–17–1995 | 3,180 | 04–19–1997 | 11.37 | 04–19–1997 | 3,400 | 10–25 |
| 90 | James River at Jamestown, N. Dak. (06470000) | 2,820 | 1928,1933<br>1938–39<br>1943–97 | 05–13–1950 | 15.82 | 05–13–1950 | 6,390 | 04–19–1997<br>-- | 12.12<br>-- | --<br>05–05–1997 | --<br>1,880 | --<br>[b]25–50 |
| 91 | James River at LaMoure, N. Dak. (06470500) | 4,390 | 1950–97 | 04–14–1969 | 16.17 | 04–14–1969 | 6,800 | 04–01–1997 | [a]16.09 | 04–01–1997 | [w]6,500 | [b]15–45 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | | | | **James River Basin—Continued** | | | | | | | | |
| 92 | James River at Dakota Lake Dam near Ludden, N. Dak. (06470875) | 5,480 | 1982–97 | 04–19–1996 | 13.97 | 04–19–1996 | 2,850 | 04–06–1997 | [a]17.86 | 04–06–1997 | 7,500 | 25–100 |
| 93 | James River at Columbia, S. Dak. (06471000) | 5,857 | [b]1974–97 | 05–13–1995 | [a]18.50 | 05–03–1979 | 2,340 | 04–19–1997<br>04–30–1997 | [a]19.08<br>[a]18.63 | --<br>04–30–1997 | --<br>[a]4,130 | --<br>15–40 |
| 94 | Maple River at North Dakota-South Dakota State line (06471200) | 716 | 1881<br>1957–97<br>([x]1969) | 04–11–1969 | [a]16.05 | 04–11–1969 | [a]5,930 | 03–29–1997 | [a]16.19 | 03–29–1997 | [a]5,300 | 20–45 |
| 95 | Elm River at Westport, S. Dak. (06471500) | 1,493 | 1881<br>1947–97<br>([x]1969) | 04–10–1969 | 22.11 | 04–10–1969 | 12,600 | 03–30–1997 | [a]21.56 | 03–30–1997 | [a]9,380 | 15–30 |
| 96 | James River near Stratford, S. Dak. (06472000) | 8,865 | 1881<br>1950–72<br>1977,1995<br>[x]1997 | 05–18–1995 | 19.86 | 05–14–1950 | 5,580 | 04–06–1997 | [c]19.48 | 04–06–1997 | 8,400 | 50–100 |
| 97 | James River at Ashton, S. Dak. (06473000) | 9,742 | 1881<br>1946–[x]97 | 04–24–1969<br>05–18–1995 | 20.63<br>[a]22.39 | 04–24–1969<br>-- | [a]5,680<br>-- | 04–06–1997<br>04–23–1997 | [a c]26.64<br>[a]25.03 | --<br>04–23–1997 | --<br>[a]9,150 | --<br>100–200 |
| 98 | Snake Creek near Ashton, S. Dak. (06473700) | 2,657 | 1881<br>1956–72<br>1977–79<br>1985–89<br>[x]1997 | 04–10–1969 | [y]17.21 | 04–10–1969 | 6,980 | 04–01–1997 | 20.74 | 04–01–1997 | 15,000 | 50–200 |
| 99 | Turtle Creek near Tulare, S. Dak. (06474000) | 1,124 | 1881<br>1954–56<br>1966–81<br>1985–[x]97 | 04–05–1969 | [a]18.51 | 04–05–1969 | [a]6,000 | 03–26–1997<br>03–28–1997 | [a]19.32<br>18.80 | --<br>03–28–1997 | --<br>13,500 | --<br>25–100 |
| 100 | Turtle Creek at Redfield, S. Dak. (06474500) | 1,481 | 1881<br>1946–72<br>[x]1997 | 04–07–1969 | 15.94 | 04–07–1969 | 7,660 | 03–29–1997 | [c]18.32 | 03–29–1997 | 13,500 | 25–75 |
| 101 | James River near Redfield, S. Dak. (06475000) | 13,911 | 1881<br>1950–[x]97 | 05–15–1995 | 26.26 | 05–15–1995 | 9,800 | 04–03–1997<br>04–06–1997 | 29.92<br>[a c]31.10 | 04–03–1997<br>-- | 17,000<br>-- | 100–400<br>-- |
| 102 | James River at Huron, S. Dak. (06476000) | 15,869 | 1881<br>1929–32<br>1944–[x]97 | 05–19–1995 | 16.86 | 05–19–1995 | 10,000 | 04–06–1997 | [a c]21.28 | 04–06–1997 | [a]23,400 | 150–500 |
| 103 | Sand Creek near Alpena, S. Dak. (06476500) | 261 | 1950–97 | 03–28–1950<br>03–28–1960 | [a]14.10<br>13.35 | --<br>03–28–1960 | --<br>2,240 | 03–23–1997 | [a]13.45 | 03–23–1997 | [a]2,000 | 10–20 |
| 104 | James River near Forestburg, S. Dak. (06477000) | 17,590 | 1881<br>1950–[x]97 | 04–22–1995<br>05–18–1995 | [a]17.26<br>17.08 | --<br>05–18–1995 | --<br>13,000 | 04–06–1997 | 20.61 | 04–06–1997 | 25,600 | 100–200 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | **James River Basin—Continued** | | | | | | | | | | | |
| 105 | Rock Creek near Fulton, S. Dak. (06477150) | 240 | 1967–79<br>1989–97 | 04–07–1969<br>04–18–1995 | [y]10.21<br>11.75 | 04–07–1969<br>-- | 2,040<br>-- | 03–29–1997 | 13.74 | 03–29–1997 | 3,120 | 10–20 |
| 106 | Firesteel Creek near Mount Vernon, S. Dak. (06477500) | 521 | 1956–97 | 04–03–1969<br>04–04–1969 | [a]17.12<br>15.34 | --<br>04–04–1969 | --<br>6,610 | 03–20–1997 | 12.37 | 03–20–1997 | 2,690 | <10 |
| 107 | James River near Mitchell, S. Dak. (06478000) | 19,064 | 1881<br>1954–58<br>1966–72<br>1995,[x]1997 | 04–23–1995 | [z]20.43 | 04–23–1995 | 16,200 | 04–07–1997 | [z]23.14 | 04–07–1997 | 28,000 | -- |
| 108 | Enemy Creek near Mitchell, S. Dak. (06478052) | 163 | 1976–87<br>1989–97 | 06–22–1984 | 15.15 | 06–22–1984 | 4,280 | 03–10–1997 | [a]13.23 | 03–10–1997 | 1,000 | <10 |
| 109 | Dry Creek near Parkston, S. Dak. (06478300) | 97.2 | 1956–80<br>1989–97 | 03–27–1960 | [c y]12.70 | 03–27–1960 | 4,210 | 03–10–1997 | [a]9.48 | 03–10–1997 | 1,100 | <10 |
| 110 | Wolf Creek near Clayton, S. Dak. (06478390) | 396 | 1976–97 | 06–21–1984 | 18.01 | 06–21–1984 | 6,520 | 04–05–1997 | 13.64 | 04–05–1997 | 2,530 | <10 |
| 111 | James River near Scotland, S. Dak. (06478500) | 20,653 | 1881<br>1929–[x]97 | 06–23–1984 | 20.45 | 06–23–1984 | 29,400 | 04–09–1997 | 19.87 | 04–09–1997 | 28,000 | 50–100 |
| 112 | James River near Yankton, S. Dak. (06478513) | 20,942 | 1881<br>1982–[x]97 | 06–23–1984 | 24.34 | 06–23–1984 | 26,400 | 04–09–1997 | 22.94 | 04–09–1997 | 28,800 | 50–100 |
| 113 | East Fork Vermillion River near Ramona, S. Dak. (06478535) | 508 | 1987–89<br>1996–97 | 11–04–1995<br>02–12–1996 | [a]7.87<br>[a]8.39 | 11–04–1995<br>-- | [a]350<br>-- | 04–30–1997 | 8.50 | 04–30–1997 | 1,600 | ([b]) |
| 114 | Little Vermillion River near Salem, S. Dak. (06478540) | 78.6 | 1881<br>1967–97<br>([x]1993) | 07–04–1993 | [c]11.95 | 07–04–1993 | [o]3,300 | 03–28–1997 | 10.01 | 03–28–1997 | 1,560 | 10–25 |
| 115 | East Fork Vermillion River near Parker, S. Dak. (06478600) | 973 | 1996–97 | 06–03–1996 | 8.13 | 06–03–1996 | 1,060 | 03–22–1997<br>03–29–1997 | [a]12.75<br>12.73 | --<br>03–29–1997 | --<br>4,210 | --<br>([b]) |
| 116 | West Fork Vermillion River near Parker, S. Dak. (06478690) | 377 | 1962–97 | 05–08–1993 | 13.14 | 05–08–1993 | 6,300 | 03–27–1997 | 11.63 | 03–27–1997 | 3,360 | 10–25 |
| | **Big Sioux River Basin** | | | | | | | | | | | |
| 117 | Big Sioux River near Florence, S. Dak. (06479215) | 638 | 1985–97 | 03–29–1986<br>07–25–1993 | 9.08<br>9.18 | 03–29–1986<br>-- | 1,810<br>-- | 04–02–1997<br>04–04–1997 | [a]9.52<br>9.32 | --<br>04–04–1997 | --<br>2,000 | --<br>10–50 |
| 118 | Still Lake Outflow near Florence, S. Dak. (06479430) | 224 | 1996–97 | 06–02–1996 | 4.80 | 06–02–1996 | 64 | 04–07–1997 | 7.43 | 04–19–1997 | [m]408 | ([b]) |
| 119 | Big Sioux River near Watertown, S. Dak. (06479438) | 1,007 | 1881<br>1973–[x]97 | 03–30–1986<br>06–21–1991 | 11.08<br>[a]11.13 | 03–30–1986<br>-- | 4,970<br>-- | 04–05–1997 | 12.09 | 04–05–1997 | 7,820 | 50–100 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | | | | **Big Sioux River Basin—Continued** | | | | | | | | |
| 120 | Lake Kampeska inlet/outlet near Watertown, S. Dak. (06479450) | 28.8 | 1881<br>1994–97 | 03–23–1994 | 22.32 | 03–14–1996<br>04–30–1995 | [m]3,030 into lake<br>[m]402 out of lake | 04–06–1997 | [aa]25.78 | 04–06–97 into lake<br>04–10–97 out of lake | 5,890<br>[m]1,410 | ([b]) |
| 121 | Big Sioux River at Watertown, S. Dak. (06479500) | 1,129 | 1881<br>1946–72<br>[x]1997 | 04–08–1969 | [a]11.40 | 04–09–1952 | 2,220 | 04–06–1997 | [c]12.49 | 04–06–1997 | 5,800 | 200–500 |
| 122 | Willow Creek near Watertown, S. Dak. (06479515) | 110 | 1972–86<br>1997 | 03–15–1972<br>03–30–1986 | [a]9.86<br>8.96 | --<br>03–30–1986 | --<br>[bb]2,300 | 04–02–1997<br>04–05–1997 | [a c]11.21<br>[c]10.93 | --<br>04–05–1997 | --<br>3,650 | --<br>[bb]25–50 |
| 123 | Big Sioux River below Watertown, S. Dak. (06479520) | 1,902 | 1995–97 | 03–12–1995<br>03–13–1996 | 11.74<br>[a]11.78 | 03–12–1995<br>-- | [a]1,600<br>-- | 04–02–1997<br>04–11–1997 | [a]13.13<br>12.99 | --<br>04–11–1997 | --<br>6,700 | --<br>([b]) |
| 124 | Big Sioux River near Castlewood, S. Dak. (06479525) | 1,997 | 1881<br>1977–[x]97 | 03–30–1986 | 11.73 | 03–30–1986 | 2,250 | 04–07–1997<br>04–11–1997 | [a]13.19<br>[a]12.87 | --<br>04–11–1997 | --<br>[a]4,300 | --<br>50–200 |
| 125 | Hidewood Creek near Estelline, S. Dak. (06479640) | 164 | 1881<br>1969–84<br>1990–97<br>([x]1992) | 06–16–1992 | [c]13.10 | 06–16–1992 | [cc]17,300 | 03–29–1997<br>04–02–1997 | [c]11.75<br>[a c]10.71 | --<br>04–02–1997 | --<br>[a]3,000 | --<br>10–25 |
| 126 | Battle Creek near Nunda, S. Dak. (06479928) | 163 | 1988–97 | 07–04–1993 | [a]12.99 | 07–04–1993 | [o]3,400 | 03–28–1997<br>03–30–1997 | [a]11.33<br>10.95 | --<br>03–30–1997 | --<br>2,570 | --<br>10–25 |
| 127 | Medary Creek near Brookings, S. Dak. (06479980) | 200 | 1981–97 | 07–04–1993 | 11.78 | 07–04–1993 | 3,710 | 03–28–1997 | [a]13.02 | 03–28–1997 | [a]3,500 | 10–25 |
| 128 | Big Sioux River near Brookings, S. Dak. (06480000) | 3,898 | 1881<br>1954–97<br>([x]1969) | 04–09–1969 | 14.77 | 04–09–1969 | 33,900 | 04–02–1997<br>04–08–1997 | 13.02<br>[a c]13.29 | 04–02–1997<br>-- | 11,000<br>-- | 10–20<br>-- |
| 129 | Flandreau Creek above Flandreau, S. Dak. (06480650) | 100 | 1982–97 | 06–20–1984 | 11.02 | 06–20–1984 | 2,650 | 03–28–1997 | [a]11.40 | 03–28–1997 | [a]1,800 | <10 |
| 130 | Big Sioux River near Dell Rapids, S. Dak. (06481000) | 4,483 | 1881<br>1949–97<br>([x]1969) | 04–09–1969 | 16.47 | 04–09–1969 | 41,300 | 04–07–1997 | 15.54 | 04–07–1997 | 16,500 | 10–25 |
| 131 | Skunk Creek at Sioux Falls, S. Dak. (06481500) | 622 | 1881<br>1949–97<br>([x]1957) | 06–17–1957 | [y]17.78 | 06–17–1957 | [cc]29,400 | 03–28–1997 | 6.10 | 03–28–1997 | 3,240 | <10 |
| 132 | Big Sioux River at North Cliff Avenue, at Sioux Falls, S. Dak. (06482020) | 5,216 | [dd]1944–97<br>([x]1969) | 04–10–1969 | 27.45 | 04–10–1969 | 40,700 | 04–07–1997 | 23.11 | 04–07–1997 | 17,700 | [dd]10–25 |

**Table 1.** Historical peak stages and peak discharges and 1997 peak stages, peak discharges, and recurrence intervals at selected streamflow-gaging stations in the Red River of the North, upper Mississippi River, and Missouri River Basins, North Dakota, Minnesota, and South Dakota—Continued

[$ft^3/s$, cubic feet per second; --, not available; <, less than]

| Site number (fig. 4) | Station name and number | Drainage area (square miles) | Period of known peaks | Maximum peaks previously known from period of record | | | | Maximum peaks during February through September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Date | Stage (feet) | Date | Discharge ($ft^3/s$) | Recurrence interval (years) |
| | | | | **Big Sioux River Basin—Continued** | | | | | | | | |
| 133 | Split Rock Creek at Corson, S. Dak. (06482610) | 464 | 1881<br>1966–97<br>([x]1993) | 05–08–1993 | [c]17.58 | 05–08–1993 | 18,900 | 03–28–1997 | [c]12.80 | 03–28–1997 | 8,290 | <10 |
| 134 | Rock River at Luverne, Minn. (06483000) | 425 | 1911–14<br>1972–95<br>1995–97 | 05–08–93 | 14.23 | 05–08–1993 | 35,400 | 03–28–1997 | 11.69 | 03–28–1997 | 13,600 | 10–25 |

[a]Backwater from aquatic vegetation, ice, debris, or other water source.
[b]Affected by regulation period.
[c]From floodmark/high watermark.
[d]Extreme outside period of record.
[e]Overland flow to the Wild Rice River Basin about 7 miles upstream from the gage.
[f]Stage affected by Devils Lake.
[g]Calculation based on reduction in drainage area from 2,510 to 1,690 square miles upon completion of Channel A in 1979.
[h]Backwater from Devils Lake.
[i]Total Sheyenne River flow immediately upstream from Horace flood diversion.
[j]When flows are greater than 1,000 $ft^3/s$ at Sheyenne River above Sheyenne River Diversion near Horace, diversions are made to this channel in order to control flood discharge downstream.
[k]Unknown amount of flow entered diversion through flapper gates and overtopping of diversion levee during April and May.
[l]Includes flow of diversion.
[m]Maximum daily discharge.
[n]Maximum gage height in diversion channel; backwater from ice.
[o]Estimated.
[p]Most peaks affected by diversion.
[q]Backwater from Red River of the North.
[r]Maximum observed flow affected by breakout flow from Red River about 20 river miles upstream of gage. The breakout flow reentered the Red Lake River about 2 miles upstream from the gage.
[s]1919 peak not used in frequency analysis.
[t]Caused in part by dam failure.
[u]Based on measurement made at peak.
[v]Affected by backwater from Lake Oahe.
[w]Approximate value.
[x]Historical frequency analysis used.
[y]Site and datum used different from current site and datum.
[z]Gage height from bridge 0.6 mile upstream.
[aa]Highest stage since 1881 based on local records.
[bb]Previous peaks were revised based on 1997 data.
[cc]Based on indirect measurement.
[dd]Period of analysis includes 1944–60 data from station 06482000, Big Sioux River at Sioux Falls, and 1960–72 data from station 06482100, Big Sioux River near Brandon, combined with data from this station.

**Table 2.** Maximum mean discharges and recurrence intervals for 3, 7, and 30 consecutive days at selected streamflow-gaging stations in the northern plains

[$ft^3/s$, cubic feet per second; recurrence interval, rounded to nearest 5 years for 20- to 50-year recurrence intervals and to nearest 10 years for 55- to 100-year recurrence intervals; >, greater than; <, less than]

| Site number (fig. 4) | Station name and number | 3-day | | | 7-day | | | 30-day | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) |
| | **Red River of the North Basin** | | | | | | | | | |
| 1 | Otter Tail River below Orwell Dam near Fergus Falls, Minn. (05046000) | 1,500 | 25 | 1,660 | 1,490 | 25 | 1,650 | 1,410 | 25 | 1,540 |
| 2 | Bois de Sioux River near White Rock, S. Dak. (05050000) | 7,620 | >200 | 3,370 | 7,340 | 200 | 3,250 | 4,210 | 50 | 1,970 |
| 4 | Red River of the North at Wahpeton, N. Dak. (05051500) | 12,500 | 100 | 8,810 | 12,100 | 100 | 7,910 | 9,060 | >200 | 4,990 |
| 5 | Red River of the North at Hickson, N. Dak. (05051522) | 12,900 | 25 | 10,700 | 12,600 | 25 | 8,650 | 10,400 | 50 | 4,510 |
| 6 | La Belle Creek near Veblen, S. Dak. (05051650) | 48.3 | <5 | 130 | 32.1 | <5 | 72.9 | 21.5 | 5 | 26.5 |
| 7 | Wild Rice River near Abercrombie, N. Dak. (05053000) | 9,250 | 25 | 9,020 | 8,510 | 25 | 7,660 | 5,640 | 50 | 3,220 |
| 8 | Red River of the North at Fargo, N. Dak. (05054000) | 27,000 | 100 | 23,500 | 26,100 | 100 | 21,000 | 19,100 | 200 | 11,200 |
| 9 | Sheyenne River near Warwick, N. Dak. (05056000) | 3,650 | 25 | 3,730 | 3,220 | 25 | 3,010 | 1,810 | 50 | 1,490 |
| 13 | Big Coulee near Churchs Ferry, N. Dak. (05056400) | 2,280 | 25 | 1,430 | 2,280 | 25 | 1,410 | 2,120 | 25 | 1,270 |
| 15 | Sheyenne River near Cooperstown, N. Dak. (05057000) | 4,630 | 25 | 6,540 | 4,140 | 25 | 5,480 | 2,740 | 25 | 3,110 |
| 17 | Sheyenne River at Lisbon, N. Dak. (05058700) | 5,600 | 25 | 4,960 | 5,390 | 25 | 4,660 | 4,520 | 25 | 3,510 |
| 18 | Sheyenne River near Kindred, N. Dak. (05059000) | 5,580 | 25 | 4,920 | 5,480 | 25 | 4,650 | 4,760 | 25 | 3,680 |
| 23 | Buffalo River near Hawley, Minn. (05061000) | 1,950 | 25 | 1,900 | 1,650 | 25 | 1,660 | 1,050 | 50 | 1,040 |
| 24 | South Branch Buffalo River near Sabin, Minn. (05061500) | 4,550 | 25 | 7,570 | 3,490 | 25 | 5,300 | 1,690 | 50 | 1,640 |
| 25 | Buffalo River near Dilworth, Minn. (05062000) | 7,390 | 25 | 12,700 | 6,070 | 25 | 9,630 | 3,440 | 50 | 3,540 |
| 26 | Wild Rice River at Twin Valley, Minn. (05062500) | 5,900 | 100 | 4,910 | 4,360 | 50 | 3,780 | 2,510 | 50 | 2,310 |
| 27 | Wild Rice River at Hendrum, Minn. (05064000) | 9,870 | 25 | 9,010 | 9,130 | 25 | 7,750 | 5,250 | 50 | 3,740 |
| 28 | Red River of the North at Halstad, Minn. (05064500) | 68,700 | 100 | 40,300 | 63,300 | 50 | 38,300 | 42,800 | 100 | 23,300 |
| 29 | Goose River at Hillsboro, N. Dak. (05066500) | 7,500 | 25 | 11,800 | 5,860 | 25 | 8,990 | 3,410 | 50 | 3,520 |
| 31 | Sand Hill River at Climax, Minn. (05069000) | 4,200 | 25 | 4,030 | 3,710 | 25 | 3,410 | 1,590 | 25 | 1,660 |
| 32 | Red Lake River at High Landing near Goodridge, Minn. (05075000) | 2,070 | 5 | 4,010 | 1,950 | 5 | 3,890 | 1,590 | 5 | 3,350 |
| 33 | Thief River near Thief River Falls, Minn. (05076000) | 4,050 | 50 | 5,540 | 3,840 | 50 | 5,440 | 2,720 | 25 | 4,340 |
| 34 | Clearwater River at Red Lake Falls, Minn. (05078500) | 7,160 | 10 | 8,530 | 6,640 | 25 | 8,160 | 3,580 | 10 | 5,920 |
| 35 | Red Lake River at Crookston, Minn. (05079000) | 26,200 | 100 | 24,100 | 22,900 | 100 | 22,400 | 12,300 | 50 | 16,500 |

**Table 2.** Maximum mean discharges and recurrence intervals for 3, 7, and 30 consecutive days at selected streamflow-gaging stations in the northern plains—Continued

[$ft^3/s$, cubic feet per second; recurrence interval, rounded to nearest 5 years for 20- to 50-year recurrence intervals and to nearest 10 years for 55- to 100-year recurrence intervals; >, greater than; <, less than]

| Site number (fig. 4) | Station name and number | 3-day | | | 7-day | | | 30-day | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) |
| | **Red River of the North Basin—Continued** | | | | | | | | | |
| 36 | Red River of the North at Grand Forks, N. Dak. (05082500) | 116,000 | 200 | 80,400 | 110,000 | 200 | 78,600 | 64,000 | 100 | 44,000 |
| 37 | Forest River at Minto, N. Dak. (05085000) | 1,930 | 5 | 9,520 | 1,770 | 5 | 6,140 | 1,100 | 10 | 2,990 |
| 38 | Middle River at Argyle, Minn. (05087500) | 3,390 | 50 | 4,270 | 2,710 | 50 | 3,030 | 985 | 25 | 1,060 |
| 39 | Park River at Grafton, N. Dak. (05090000) | 5,010 | 10 | 9,660 | 4,600 | 10 | 7,610 | 1,990 | 10 | 3,970 |
| 40 | Red River of the North at Drayton, N. Dak. (05092000) | 123,000 | 100 | 90,000 | 115,000 | 100 | 85,500 | 69,400 | 50 | 66,400 |
| 41 | South Branch Two Rivers at Lake Bronson, Minn. (05094000) | 4,010 | 25 | 4,790 | 3,560 | 25 | 3,850 | 1,520 | 10 | 2,090 |
| 42 | Pembina River at Neche, N. Dak. (05100000) | 13,600 | 100 | 8,840 | 12,100 | 100 | 7,550 | 8,130 | 100 | 5,620 |
| 43 | Red River of the North at Emerson, Manitoba (05102500) | 132,000 | 200 | 93,300 | 126,000 | 200 | 91,500 | 82,400 | 100 | 76,200 |
| 44 | Roseau River at Ross, Minn. (05107500) | 4,590 | 25 | 6,430 | 4,450 | 25 | 6,260 | 3,400 | 25 | 4,670 |
| 45 | Roseau River below State Ditch 51 near Caribou, Minn. (05112000) | 3,280 | 50 | 3,260 | 3,270 | 50 | 3,140 | 3,040 | 25 | 3,010 |
| | **Upper Mississippi River Basin** | | | | | | | | | |
| 46 | Sauk River near St. Cloud, Minn. (05270500) | 5,040 | 25 | 7,630 | 4,710 | 25 | 6,510 | 3,000 | 50 | 3,060 |
| 47 | Crow River at Rockford, Minn. (05280000) | 11,600 | 25 | 21,600 | 10,900 | 25 | 19,400 | 7,220 | 10 | 10,500 |
| 48 | Mississippi River near Anoka, Minn. (05288500) | 68,500 | 50 | 88,600 | 65,900 | 50 | 82,000 | 43,800 | 25 | 50,100 |
| | **Minnesota River Basin** | | | | | | | | | |
| 50 | Little Minnesota River near Peever, S. Dak. (05290000) | 3,190 | 25 | 4,140 | 2,620 | 25 | 2,500 | 1,600 | 100 | 1,320 |
| 51 | Whetstone River near Big Stone City, S. Dak. (05291000) | 5,310 | 50 | 5,120 | 4,700 | 200 | 3,440 | 2,220 | >200 | 1,390 |
| 52 | Minnesota River at Ortonville, Minn. (05292000) | 4,940 | 200 | 3,020 | 4,830 | 200 | 3,020 | 4,110 | >200 | 2,380 |
| 54 | Yellow Bank River near Odessa, Minn. (05293000) | 6,090 | 100 | 5,760 | 5,170 | 200 | 3,790 | 2,040 | 200 | 1,420 |
| 55 | Pomme de Terre River at Appleton, Minn. (05294000) | 6,420 | 100 | 4,660 | 5,490 | 100 | 3,800 | 3,090 | 100 | 1,770 |
| 57 | Lac Qui Parle River near Lac Qui Parle, Minn. (05300000) | 11,300 | 50 | 14,000 | 10,800 | 100 | 10,700 | 5,620 | 200 | 3,710 |
| 58 | Chippewa River near Milan, Minn. (05304500) | 12,900 | 100 | 9,780 | 11,300 | 100 | 8,360 | 6,610 | 100 | 3,970 |
| 59 | Minnesota River at Montevideo, Minn. (05311000) | 45,300 | 100 | 33,000 | 40,800 | 100 | 27,900 | 22,400 | 100 | 14,000 |
| | **Missouri River Basin** | | | | | | | | | |
| 68 | Spring Creek at Zap, N. Dak. (06340000) | 2,670 | 10 | 5,040 | 1,850 | 10 | 3,660 | 645 | 10 | 1,040 |
| 69 | Knife River at Hazen, N. Dak. (06340500) | 16,300 | 25 | 19,800 | 10,700 | 25 | 13,800 | 3,270 | 25 | 4,300 |

**Table 2.** Maximum mean discharges and recurrence intervals for 3, 7, and 30 consecutive days at selected streamflow-gaging stations in the northern plains—Continued

[$ft^3/s$, cubic feet per second; recurrence interval, rounded to nearest 5 years for 20- to 50-year recurrence intervals and to nearest 10 years for 55- to 100-year recurrence intervals; >, greater than; <, less than]

| Site number (fig. 4) | Station name and number | 3-day: Maximum mean discharge for 1997 ($ft^3/s$) | 3-day: Recurrence interval for 1997 (years) | 3-day: Previous maximum mean discharge for period of record used ($ft^3/s$) | 7-day: Maximum mean discharge for 1997 ($ft^3/s$) | 7-day: Recurrence interval for 1997 (years) | 7-day: Previous maximum mean discharge for period of record used ($ft^3/s$) | 30-day: Maximum mean discharge for 1997 ($ft^3/s$) | 30-day: Recurrence interval for 1997 (years) | 30-day: Previous maximum mean discharge for period of record used ($ft^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Missouri River Basin—Continued** | | | | | | | | | |
| 70 | Missouri River at Bismarck, N. Dak. (06342500) | 59,200 | 50 | 68,700 | 59,000 | 50 | 68,600 | 57,100 | 50 | 67,500 |
| 71 | Green River near New Hradec, N. Dak. (06344600) | 900 | 5 | 2,360 | 499 | 5 | 1,370 | 147 | 5 | 347 |
| 72 | Heart River near Richardton, N. Dak. (06345500) | 10,800 | 25 | 9,500 | 6,180 | 10 | 7,000 | 1,750 | 10 | 2,420 |
| 73 | Heart River near Mandan, N. Dak. (06349000) | 16,700 | 10 | 25,800 | 14,400 | 25 | 17,700 | 6,060 | 25 | 6,600 |
| 74 | Cedar Creek near Raleigh, N. Dak. (06353000) | 11,600 | 25 | 9,130 | 9,030 | 25 | 8,060 | 3,060 | 25 | 2,640 |
| 75 | Cannonball River at Breien, N. Dak. (06354000) | 27,000 | 25 | 43,900 | 21,600 | 25 | 30,500 | 7,190 | 25 | 10,100 |
| 77 | Oak Creek near Wakpala, S. Dak. (06354882) | 5,710 | 25 | 2,570 | 3,550 | 25 | 2,000 | 1,260 | 25 | 586 |
| 78 | Grand River at Little Eagle, S. Dak. (06357800) | 17,300 | 25 | 20,200 | 14,700 | 50 | 12,500 | 6,880 | 50 | 6,250 |
| 79 | Moreau River near Whitehorse, S. Dak. (06360500) | 26,600 | 25 | 22,700 | 20,700 | 50 | 17,600 | 8,550 | 50 | 6,260 |
| 80 | Bad River near Fort Pierre, S. Dak. (06441500) | 11,800 | 10 | 23,800 | 8,560 | 10 | 21,900 | 4,900 | 25 | 7,820 |
| 82 | Campbell Creek near Lee's Corner, S. Dak. (06442718) | 652 | 5–10 | 548 | 389 | 10 | 326 | 139 | 10 | 144 |
| 83 | Elm Creek near Gann Valley, S. Dak. (06442900) | 2,690 | 25 | 1,210 | 2,250 | 25 | 644 | 953 | 25 | 284 |
| 84 | White River near Oacoma, S. Dak. (06452000) | 26,600 | 25 | 38,000 | 16,500 | 25 | 25,000 | 6,040 | 10 | 14,400 |
| 86 | Choteau Creek near Avon, S. Dak. (06453255) | 1,110 | <5 | 4,150 | 904 | <5 | 2,780 | 614 | <5 | 1,210 |
| | **James River Basin** | | | | | | | | | |
| 88 | James River near Grace City, N. Dak. (06468170) | 3,100 | 10 | 2,900 | 2,700 | 10 | 2,400 | 1,900 | 25 | 1,100 |
| 89 | Pipestem Creek near Pingree, N. Dak. (06469400) | 2,480 | 50 | 2,050 | 2,070 | 50 | 1,560 | 1,360 | >200 | 751 |
| 90 | James River at Jamestown, N. Dak. (06470000) | 1,840 | 50 | 1,350 | 1,840 | 25 | 1,340 | 1,750 | 25 | 1,280 |
| 91 | James River at LaMoure, N. Dak. (06470500) | 5,870 | 25 | 3,520 | 4,870 | 25 | 2,950 | 3,350 | 50 | 1,720 |
| 92 | James River at Dakota Lake Dam near Ludden, N. Dak. (06470875) | 6,930 | 50 | 2,840 | 5,960 | 50 | 2,740 | 4,740 | 50 | 2,030 |
| 93 | James River at Columbia, S. Dak. (06471000) | 4,090 | 50 | 2,290 | 4,070 | 50–100 | 2,180 | 3,670 | 200 | 1,830 |
| 94 | Maple River at North Dakota-South Dakota State line (06471200) | 3,800 | 25 | 4,550 | 2,500 | 25 | 2,760 | 1,200 | 25 | 802 |
| 95 | Elm River at Westport, S. Dak. (06471500) | 8,600 | 25 | 11,000 | 6,410 | 25 | 8,170 | 2,880 | 25 | 2,420 |

**Table 2.** Maximum mean discharges and recurrence intervals for 3, 7, and 30 consecutive days at selected streamflow-gaging stations in the northern plains—Continued

[$ft^3/s$, cubic feet per second; recurrence interval, rounded to nearest 5 years for 20- to 50-year recurrence intervals and to nearest 10 years for 55- to 100-year recurrence intervals; >, greater than; <, less than]

| Site number (fig. 4) | Station name and number | 3-day | | | 7-day | | | 30-day | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) |
| | **James River Basin—Continued** | | | | | | | | | |
| 97 | James River at Ashton, S. Dak. (06473000) | 8,970 | 100 | 5,650 | 8,670 | 100 | 5,580 | 7,700 | 200 | 4,140 |
| 102 | James River at Huron, S. Dak. (06476000) | 22,500 | >200 | 9,880 | 21,100 | >200 | 9,540 | 16,600 | >200 | 7,480 |
| 104 | James River near Forestburg, S. Dak. (06477000) | 24,500 | 100 | 12,800 | 23,200 | 100 | 12,100 | 17,600 | 200 | 9,470 |
| 106 | Firesteel Creek near Mount Vernon, S. Dak. (06477500) | 2,140 | 5 | 4,140 | 1,770 | 5–10 | 2,730 | 840 | 10 | 1,320 |
| 111 | James River near Scotland, S. Dak. (06478500) | 27,500 | 100 | 25,600 | 26,500 | 100 | 19,800 | 21,200 | 100 | 13,700 |
| 114 | Little Vermillion River near Salem, S. Dak. (06478540) | 1,070 | 25 | 1,680 | 734 | 25 | 1,040 | 317 | 25 | 535 |
| 116 | West Fork Vermillion River near Parker, S. Dak. (06478690) | 2,890 | 25 | 3,200 | 2,490 | 25–50 | 2,870 | 1,220 | 200 | 1,360 |
| | **Big Sioux River Basin** | | | | | | | | | |
| 117 | Big Sioux River near Florence, S. Dak. (06479215) | 1,300 | 25 | 917 | 756 | 25 | 549 | 297 | 25 | 216 |
| 124 | Big Sioux River near Castlewood, S. Dak. (06479525) | 3,960 | 50 | 1,930 | 3,540 | 50 | 1,760 | 2,540 | 25 | 1,400 |
| 128 | Big Sioux River near Brookings, S. Dak. (06480000) | 10,100 | 10–25 | 24,000 | 9,190 | 25 | 14,500 | 6,060 | 25–50 | 5,010 |
| 130 | Big Sioux River near Dell Rapids, S. Dak. (06481000) | 14,700 | 25 | 30,900 | 13,900 | 25 | 20,600 | 8,840 | 50 | 7,080 |
| 131 | Skunk Creek at Sioux Falls, S. Dak. (06481500) | 2,770 | 5–10 | 6,220 | 2,350 | 10 | 4,870 | 1,620 | 10–25 | 3,040 |
| 132 | Big Sioux River at North Cliff Avenue, at Sioux Falls, S. Dak. (06482020) | 16,200 | 25 | 18,600 | 15,300 | 25 | 15,300 | 10,400 | 25 | 10,000 |

**Table 3.** Maximum mean discharges and recurrence intervals for 60, 90, and 120 consecutive days at selected streamflow-gaging stations in the northern plains

[$ft^3/s$, cubic feet per second; recurrence interval, rounded to nearest 5 years for 20- to 50-year recurrence intervals and to nearest 10 years for 55- to 100-year recurrence intervals; <, less than; >, greater than]

| Site number (fig. 4) | Station name and number | 60-day | | | 90-day | | | 120-day | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used ($ft^3/s$) | Maximum mean discharge for 1997 ($ft^3/s$) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for periodof record used ($ft^3/s$) |
| | **Red River of the North Basin** | | | | | | | | | |
| 1 | Otter Tail River below Orwell Dam near Fergus Falls, Minn. (05046000) | 1,370 | 200 | 1,430 | 1,230 | 200 | 1,310 | 1,130 | 200 | 1,210 |
| 2 | Bois de Sioux River near White Rock, S. Dak. (05050000) | 2,710 | 25 | 1,470 | 1,980 | 25 | 1,100 | 1,570 | 25 | 926 |
| 4 | Red River of the North at Wahpeton, N. Dak. (05051500) | 6,070 | 200 | 3,690 | 4,640 | 200 | 2,990 | 3,760 | 100 | 2,730 |
| 5 | Red River of the North at Hickson, N. Dak. (05051522) | 6,940 | 50 | 3,750 | 5,230 | 50 | 3,350 | 4,190 | 25 | 3,030 |
| 6 | La Belle Creek near Veblen, S. Dak. (05051650) | 12.9 | <5 | 18.5 | 8.84 | <5 | 14.8 | 6.74 | <5 | 11.9 |
| 7 | Wild Rice River near Abercrombie, N. Dak. (05053000) | 3,140 | 50 | 1,730 | 2,160 | 50 | 1,240 | 1,660 | 25 | 1,060 |
| 8 | Red River of the North at Fargo, N. Dak. (05054000) | 11,700 | 200 | 6,990 | 8,600 | 200 | 5,190 | 6,820 | 200 | 4,400 |
| 9 | Sheyenne River near Warwick, N. Dak. (05056000) | 1,110 | 50 | 1,160 | 768 | 50 | 801 | 600 | 50 | 610 |
| 13 | Big Coulee near Churchs Ferry, N. Dak. (05056400) | 1,660 | 25 | 1,080 | 1,340 | 25 | 911 | 1,130 | 25 | 761 |
| 15 | Sheyenne River near Cooperstown, N. Dak. (05057000) | 1,790 | 25 | 2,180 | 1,260 | 25 | 1,530 | 998 | 25 | 1,170 |
| 17 | Sheyenne River at Lisbon, N. Dak. (05058700) | 3,330 | 50 | 2,200 | 2,380 | 25 | 1,730 | 1,890 | 25 | 1,400 |
| 18 | Sheyenne River near Kindred, N. Dak. (05059000) | 3,480 | 50 | 2,830 | 2,490 | 25 | 2,220 | 1,980 | 25 | 1,780 |
| 23 | Buffalo River near Hawley, Minn. (05061000) | 657 | 25 | 642 | 499 | 25 | 504 | 434 | 50 | 421 |
| 24 | South Branch Buffalo River near Sabin, Minn. (05061500) | 893 | 25 | 918 | 621 | 25 | 693 | 506 | 25 | 573 |
| 25 | Buffalo River near Dilworth, Minn. (05062000) | 1,940 | 50 | 1,860 | 1,400 | 50 | 1,590 | 1,170 | 50 | 1,280 |
| 26 | Wild Rice River at Twin Valley, Minn. (05062500) | 1,570 | 25 | 1,900 | 1,180 | 25 | 1,630 | 1,100 | 25 | 1,350 |
| 27 | Wild Rice River at Hendrum, Minn. (05064000) | 3,160 | 25 | 2,660 | 2,360 | 25 | 2,270 | 2,150 | 50 | 1,880 |
| 28 | Red River of the North at Halstad, Minn. (05064500) | 27,300 | 100 | 13,800 | 19,800 | 100 | 12,500 | 16,100 | 100 | 10,800 |
| 29 | Goose River at Hillsboro, N. Dak. (05066500) | 1,900 | 25 | 2,260 | 1,310 | 25 | 1,560 | 1,110 | 50 | 1,190 |
| 31 | Sand Hill River at Climax, Minn. (05069000) | 874 | 25 | 1,010 | 691 | 25 | 732 | 606 | 50 | 578 |
| 32 | Red Lake River at High Landing near Goodridge, Minn. (05075000) | 1,310 | 5 | 2,860 | 1,230 | 5 | 2,600 | 1,220 | 5 | 2,320 |
| 33 | Thief River near Thief River Falls, Minn. (05076000) | 2,050 | 25 | 3,020 | 1,670 | 25 | 2,280 | 1,420 | 25 | 1,780 |
| 34 | Clearwater River at Red Lake Falls, Minn. (05078500) | 2,120 | 10 | 4,040 | 1,930 | 10–25 | 3,000 | 1,940 | 25 | 2,380 |
| 35 | Red Lake River at Crookston, Minn. (05079000) | 7,990 | 25 | 11,900 | 6,670 | 25 | 9,250 | 6,160 | 50 | 7,580 |

**Table 3.** Maximum mean discharges and recurrence intervals for 60, 90, and 120 consecutive days at selected streamflow-gaging stations in the northern plains—Continued

| Site number (fig. 4) | Station name and number | 60-day: Maximum mean discharge for 1997 (ft³/s) | 60-day: Recurrence interval for 1997 (years) | 60-day: Previous maximum mean discharge for period of record used (ft³/s) | 90-day: Maximum mean discharge for 1997 (ft³/s) | 90-day: Recurrence interval for 1997 (years) | 90-day: Previous maximum mean discharge for period of record used (ft³/s) | 120-day: Maximum mean discharge for 1997 (ft³/s) | 120-day: Recurrence interval for 1997 (years) | 120-day: Previous maximum mean discharge for periodof record used (ft³/s) |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Red River of the North Basin—Continued** | | | | | | | | | |
| 36 | Red River of the North at Grand Forks, N. Dak. (05082500) | 41,100 | 100 | 31,500 | 30,400 | 100 | 24,500 | 26,100 | 100 | 20,200 |
| 37 | Forest River at Minto, N. Dak. (05085000) | 687 | 10 | 1,580 | 480 | 10 | 1,070 | 447 | 25 | 806 |
| 38 | Middle River at Argyle, Minn. (05087500) | 560 | 25 | 753 | 402 | 25 | 505 | 346 | 25 | 382 |
| 39 | Park River at Grafton, N. Dak. (05090000) | 1,100 | 10 | 2,120 | 822 | 10 | 1,420 | 676 | 25 | 1,070 |
| 40 | Red River of the North at Drayton, N. Dak. (05092000) | 47,200 | 50 | 48,400 | 34,500 | 50 | 36,200 | 29,400 | 50 | 29,000 |
| 41 | South Branch Two Rivers at Lake Bronson, Minn. (05094000) | 919 | 10 | 1,550 | 650 | 5 | 1,180 | 524 | 10 | 902 |
| 42 | Pembina River at Neche, N. Dak. (05100000) | 4,960 | 50 | 4,480 | 3,690 | 50 | 3,300 | 3,020 | 100 | 2,620 |
| 43 | Red River of the North at Emerson, Manitoba (05102500) | 54,000 | 50 | 56,300 | 40,100 | 50 | 42,100 | 34,000 | 100 | 33,700 |
| 44 | Roseau River at Ross, Minn. (05107500) | 2,450 | 10 | 3,220 | 1,790 | 10 | 2,550 | 1,440 | 10 | 2,010 |
| 45 | Roseau River below State Ditch 51 near Caribou, Minn. (05112000) | 2,580 | 25 | 2,740 | 1,980 | 25 | 2,140 | 1,640 | 25 | 1,800 |
| | **Upper Mississippi River Basin** | | | | | | | | | |
| 46 | Sauk River near St. Cloud, Minn. (05270500) | 1,920 | 25 | 2,100 | 1,390 | 10 | 1,670 | 1,160 | 10 | 1,330 |
| 47 | Crow River at Rockford, Minn. (05280000) | 4,720 | 10 | 6,880 | 3,390 | 5 | 5,350 | 3,510 | 10 | 4,860 |
| 48 | Mississippi River near Anoka, Minn. (05288500) | 30,200 | 10 | 39,500 | 23,000 | 5 | 33,000 | 21,400 | 10 | 28,300 |
| | **Minnesota River Basin** | | | | | | | | | |
| 50 | Little Minnesota River near Peever, S. Dak. (05290000) | 967 | 100 | 699 | 669 | 50 | 471 | 506 | 50 | 440 |
| 51 | Whetstone River near Big Stone City, S. Dak. (05291000) | 1,230 | 200 | 815 | 842 | 100 | 618 | 642 | 50 | 493 |
| 52 | Minnesota River at Ortonville, Minn. (05292000) | 2,610 | 200 | 1,720 | 1,850 | 100 | 1,220 | 1,440 | 50 | 980 |
| 54 | Yellow Bank River near Odessa, Minn. (05293000) | 1,120 | 100 | 1,030 | 766 | 50 | 737 | 592 | 50 | 572 |
| 55 | Pomme de Terre River at Appleton, Minn. (05294000) | 1,880 | 100 | 1,270 | 1,340 | 50 | 938 | 1,070 | 50 | 779 |
| 57 | Lac Qui Parle River near Lac Qui Parle, Minn. (05300000) | 3,100 | 100 | 1,980 | 2,120 | 50 | 1,420 | 1,630 | 50 | 1,520 |
| 58 | Chippewa River near Milan, Minn. (05304500) | 4,140 | 50 | 3,110 | 2,980 | 50 | 2,600 | 2,630 | 50 | 2,360 |
| 59 | Minnesota River at Montevideo, Minn. (05311000) | 14,100 | 100 | 9,790 | 10,100 | 50 | 7,610 | 8,160 | 50 | 6,240 |
| | **Missouri River Basin** | | | | | | | | | |
| 68 | Spring Creek at Zap, N. Dak. (06340000) | 371 | 10 | 535 | 254 | 10 | 367 | 211 | 10 | 280 |
| 69 | Knife River at Hazen, N. Dak. (06340500) | 1,930 | 25 | 2,220 | 1,320 | 10 | 1,510 | 1,060 | 10 | 1,230 |
| 70 | Missouri River at Bismarck, N. Dak. (06342500) | 52,700 | 50 | 63,400 | 50,300 | 50 | 56,000 | 48,300 | 50 | 51,600 |

**Table 3.** Maximum mean discharges and recurrence intervals for 60, 90, and 120 consecutive days at selected streamflow-gaging stations in the northern plains—Continued

| Site number (fig. 4) | Station name and number | 60-day | | | 90-day | | | 120-day | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Maximum mean discharge for 1997 (ft³/s) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used (ft³/s) | Maximum mean discharge for 1997 (ft³/s) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for period of record used (ft³/s) | Maximum mean discharge for 1997 (ft³/s) | Recurrence interval for 1997 (years) | Previous maximum mean discharge for periodof record used (ft³/s) |
| | **Missouri River Basin—Continued** | | | | | | | | | |
| 71 | Green River near New Hradec, N. Dak. (06344600) | 88 | 5 | 189 | 59.3 | 5 | 133 | 53.8 | 5 | 102 |
| 72 | Heart River near Richardton, N. Dak. (06345500) | 1,100 | 10 | 1,350 | 753 | 10 | 953 | 594 | 10 | 912 |
| 73 | Heart River near Mandan, N. Dak. (06349000) | 3,950 | 25 | 4,130 | 2,700 | 25 | 3,020 | 2,080 | 10 | 2,610 |
| 74 | Cedar Creek near Raleigh, N. Dak. (06353000) | 2,090 | 50 | 1,500 | 1,430 | 25 | 1,060 | 1,090 | 25 | 899 |
| 75 | Cannonball River at Breien, N. Dak. (06354000) | 4,730 | 50 | 5,630 | 3,230 | 50 | 3,860 | 2,480 | 25 | 2,940 |
| 77 | Oak Creek near Wakpala, S. Dak. (06354882) | 703 | 10 | 355 | 476 | 10 | 282 | 365 | 10 | 213 |
| 78 | Grand River at Little Eagle, S. Dak. (06357800) | 4,990 | 50 | 3,820 | 3,470 | 50 | 2,700 | 2,780 | 50 | 2,130 |
| 79 | Moreau River near Whitehorse, S. Dak. (06360500) | 6,710 | 50–100 | 3,810 | 4,970 | 50 | 2,650 | 4,000 | 50 | 2,080 |
| 80 | Bad River near Fort Pierre, S. Dak. (06441500) | 3,940 | 50 | 4,410 | 3,400 | 50–100 | 3,130 | 2,880 | 100 | 2,380 |
| 82 | Campbell Creek near Lee's Corner, S. Dak. (06442718) | 96.0 | 10 | 85.6 | 88.4 | 10 | 58.2 | 68.6 | 10 | 48.8 |
| 83 | Elm Creek near Gann Valley, S. Dak. (06442900) | 602 | 25 | 181 | 452 | 25 | 127 | 347 | 25 | 111 |
| 84 | White River near Oacoma, S. Dak. (06452000) | 4,540 | 25 | 8,890 | 3,460 | 25 | 6,330 | 3,650 | 25 | 4,860 |
| 86 | Choteau Creek near Avon, S. Dak. (06453255) | 434 | 5 | 677 | 331 | <5 | 585 | 295 | 5 | 496 |
| | **James River Basin** | | | | | | | | | |
| 88 | James River near Grace City, N. Dak. (06468170) | 1,200 | 25 | 740 | 800 | 25 | 570 | 600 | 25 | 440 |
| 89 | Pipestem Creek near Pingree, N. Dak. (06469400) | 826 | >200 | 526 | 564 | >200 | 403 | 428 | >200 | 327 |
| 90 | James River at Jamestown, N. Dak. (06470000) | 1,663 | 25 | 1,180 | 1,470 | 25 | 1,060 | 1,220 | 25 | 1,020 |
| 91 | James River at LaMoure, N. Dak. (06470500) | 2,640 | 25 | 1,480 | 2,260 | 25 | 1,280 | 1,910 | 25 | 1,230 |
| 92 | James River at Dakota Lake Dam near Ludden, N. Dak. (06470875) | 3,480 | 25 | 1,770 | 2,810 | 25 | 1,590 | 2,370 | 25 | 1,360 |
| 93 | James River at Columbia, S. Dak. (06471000) | 2,930 | 200 | 1,670 | 2,460 | 200 | 1,470 | 2,140 | 200 | 1,300 |
| 94 | Maple River at North Dakota-South Dakota State line (06471200) | 683 | 25 | 415 | 463 | 25 | 283 | 349 | 25 | 214 |
| 95 | Elm River at Westport, S. Dak. (06471500) | 1,630 | 25 | 1,250 | 1,100 | 25 | 859 | 831 | 25 | 660 |
| 97 | James River at Ashton, S. Dak. (06473000) | 5,770 | 200 | 2,830 | 4,550 | 200 | 2,330 | 3,850 | 100–200 | 2,090 |
| 102 | James River at Huron, S. Dak. (06476000) | 12,200 | >200 | 6,620 | 9,090 | >200 | 5,740 | 7,400 | >200 | 4,940 |

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