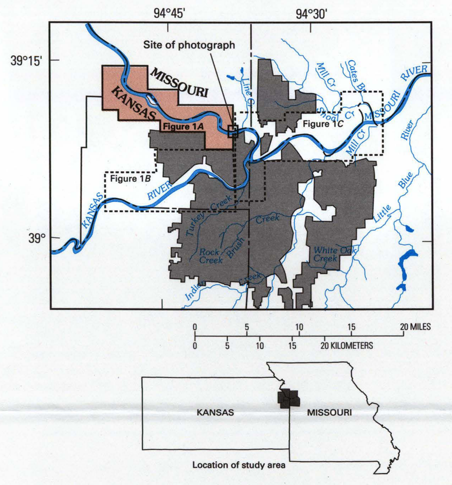
Perry, Charles A., Clement, Ralph W., and Studley, Seth E., 1997, Delineation of Flooding within the Upper Mississippi River Basin—Floods of July 10 and 27, 1993, in Kansas City, Missouri, and Kansas City, Kansas, and vicinity



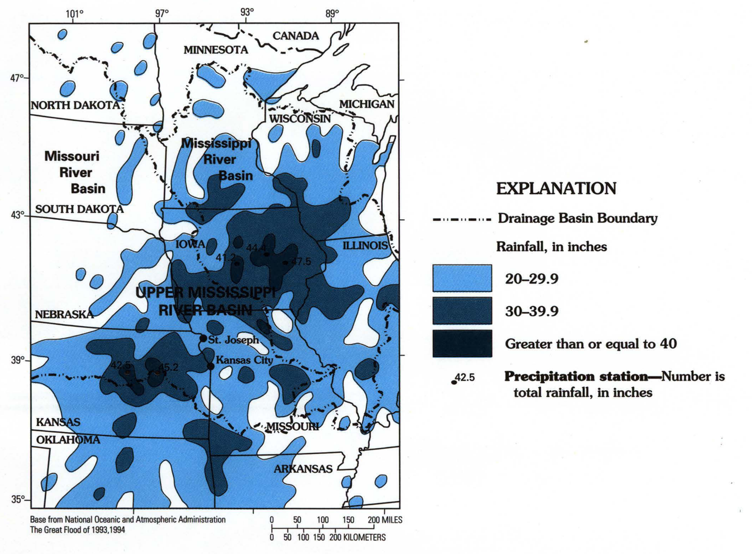


Figure 2. Rainfall for the Midwestern States from April 1 through August 31, 1993 and boundary of the Upper Mississippi River Basin (modified from National Oceanic and Atmospheric Administration, 1994).

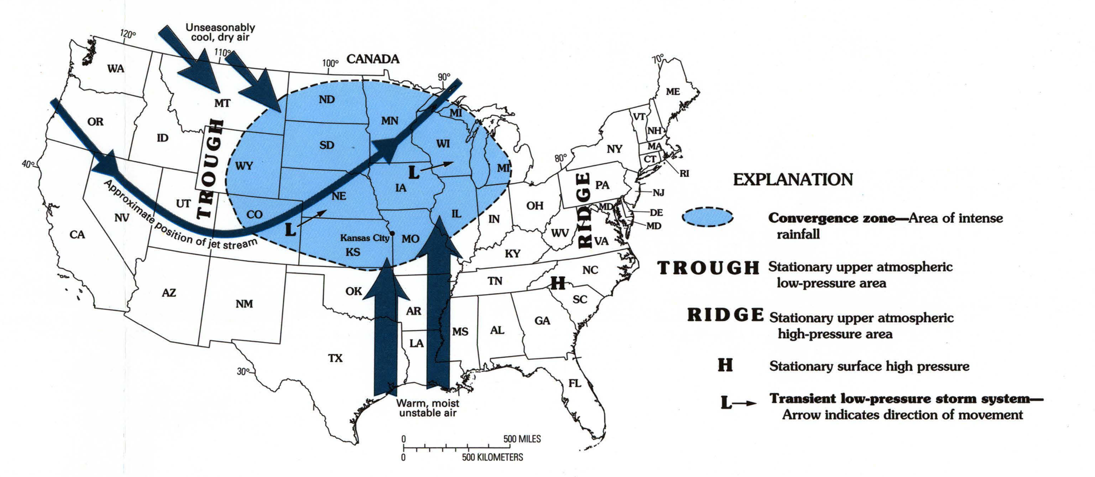


Figure 3. Persistent weather patterns responsible for the floods of 1993 (modified from Wahl and others, 1993).

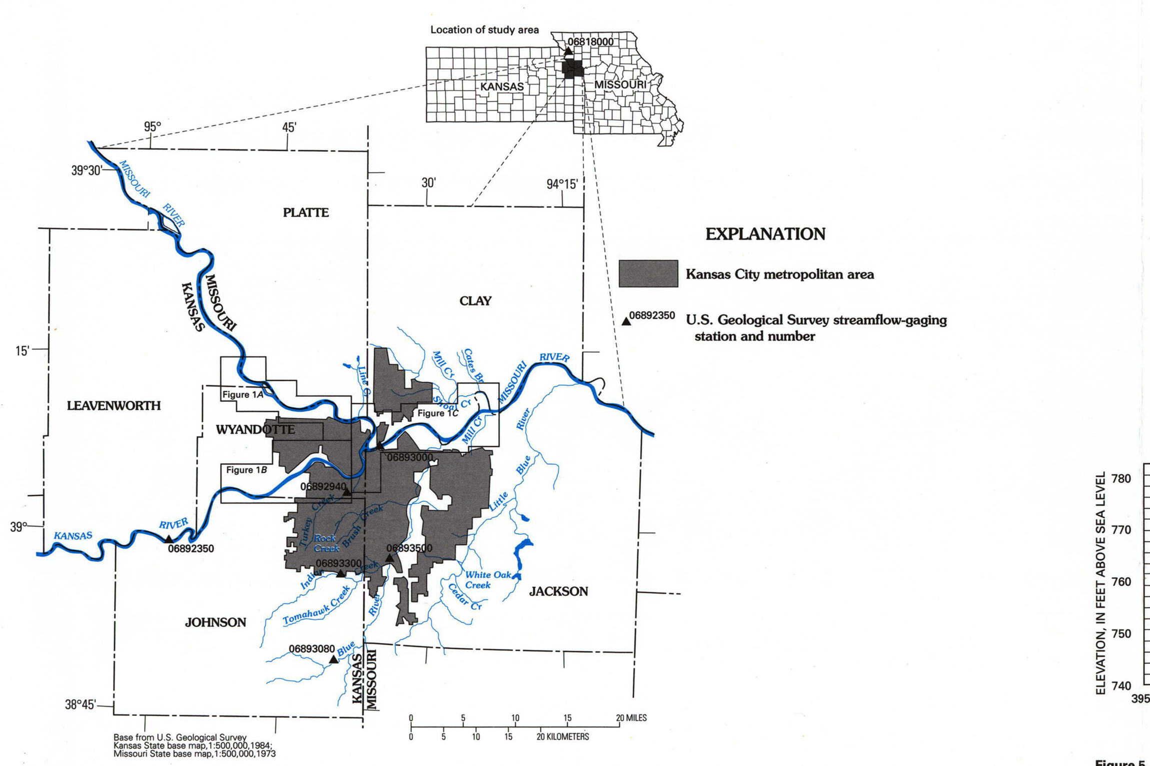


Figure 4. Location of streamflow-gaging stations in the Kansas City metropolitan area.

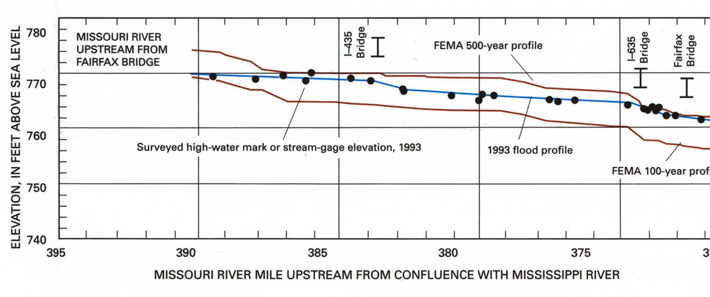


Figure 5. Water-surface profiles for the Federal Emergency Management Agency (FEMA) 100- and 500-year discharges and for the July 27, 1993, peak discharge along the Missouri River upstream from the Fairfax Bridge, Kansas City, Missouri.

INTRODUCTION

During spring and summer 1993, record flooding inundated many of the stream and river valleys in the upper Mississippi and the Missouri River Basins. The flooding was the result of widespread and numerous intense thunderstorms that, together with saturated soils, produced large volumes of runoff. The magnitude of flooding exceeded the 100-year discharge values (1-percent chance of exceedance in any given year) at many streamflow-gaging stations in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin. The flooding was unusual because of its long duration and widespread severe damage. The Mississippi and the Missouri Rivers were above flood stage for more than 1 month at several locations along their lengths. Millions of acres of agricultural and urban lands were inundated for weeks, and unofficial damage estimates exceeded $10 billion in the flooded States (Parrett and others, 1993).

During summer 1993, large parts of Kansas City, Missouri, and Kansas City, Kansas, and vicinity were flooded from overflows of the Missouri and the Kansas Rivers and numerous smaller tributaries. This report provides flood-peak elevation data and delineates the areal extent of the 1993 floods in the Kansas City metropolitan area for July 10 and 27, 1993 (fig. 1*A*, sheet 1; *B*, sheet 2; *C*, sheet 3). The 1993 flood elevations and extent of flooding are compared with flood-plain boundaries defined by Flood Insurance Studies conducted by the Federal Emergency Management Agency (FEMA) for cities and counties in the area (U.S. Department of Housing and Urban Development, 1975–95).

This report is one of a series of U.S. Geological Survey (USGS) investigations that document the effects of the 1993 flooding of the upper Mississippi and the Missouri River Basins and that improve the technical base from which flood-plain management decisions can be made by other agencies.

CLIMATIC CONDITIONS

Stream, ground-water, and lake levels in many Midwestern States were near normal at the beginning of 1993. Precipitation during the winter, spring, and summer months (January–August 1993) in the nine-State area that includes the upper Mississippi and the Missouri River Basins generally was more than 100 to 200 percent of normal (January–August 1961–90) (National Weather Service, 1993). Some precipitation stations recorded single-month (July) rainfall accumulations of more than 600 percent of normal (July 1961–90) (Wahl and others, 1993). From April 1 through August 31, 1993, excessive rainfall was centered in eastern Kansas, northern Missouri, southeastern Nebraska, and most of Iowa (fig. 2). In 1993, persistent wet soil conditions and many intense rainstorms throughout this large area led to widespread flooding within the upper Mississippi and the Missouri River Basins (fig. 2).

In the upper Midwest, the above-average precipitation was created by a storm-steering jet stream that anchored itself to an upper-atmospheric, low-pressure trough over the Northwestern States and a strong high-pressure ridge over the Eastern States (fig. 3). West of the trough, the jet stream directed cool air from the Gulf of Alaska and western Canada southeastward, while east of the trough, the jet stream pulled warm, moist air northward from the Gulf of Mexico. Under the high-pressure ridge in the Eastern States, severe drought conditions developed by midsummer.

As a result of the persistent position of the jet stream, cool conditions prevailed in the Northwestern States through the spring and summer months, while the Southeastern States were warm. Weather on the eastern side of the trough was active as the contrasting air masses clashed within the convergence zone. Thunderstorms that extended to heights of 60,000 ft above land surface released torrential rains somewhere in the North-Central States nearly every day during the spring and summer. Individual storm rainfall totals, which often exceeded 5 in., fell on already saturated soils. This produced many local flash floods in small streams and persistent riverine floods in each State of the nine-State region.

1993 FLOOD PEAKS

Rivers and streams in the Kansas City metropolitan area had several periods of flooding from April through August 1993, but flooding was most severe during July. Most of the smaller streams in the area (fig. 4) flooded at various times during July. On July 10, the small-stream flooding was most damaging along Turkey Creek in eastern Kansas City, Kansas, and western Kansas City, Missouri. Other streams in the area, which include Indian and Brush Creeks, and the Blue River, also flooded during the first 2 weeks of July. However, the extent of the flooding was greatest when the Missouri and the Kansas Rivers peaked simultaneously on July 27. During this time, most of the Missouri River Valley and parts of the Kansas River Valley were inundated. On July 27, the largest flood elevations on both rivers were recorded at streamflow-gaging stations in the Kansas City metropolitan area. However, discharges on the Missouri and the Kansas Rivers have been higher in the past (table 1); the extensive system of flood-control reservoirs throughout the Missouri and Kansas River Basins reduced the flood peaks on many streams in 1993 (Perry, 1994).

Two methods are used for measuring the severity of floods. One method measures the peak stage, or greatest height, of the floodwaters above a datum at a specific reference point. The deeper the floodwater at the reference point, the higher the stage. The zero, or datum, of a stage gage usually is referenced to sea level to enable water-surface elevations between locations along the stream or on tributary streams be related to the topography. Elevations throughout this report are referenced to sea level. The other method measures the flow rate, or volume of water per unit time, that moves past a reference point along the stream (Kennedy, 1983).

Seven streamflow-gaging stations are on rivers and streams in the Kansas City metropolitan area. At some stations, only stage is recorded, and at others stage/discharge relations have been established. Included in this group is the Missouri River at St. Joseph, Missouri, which is 82 river mi upstream from the Missouri River at Kansas City, Missouri (fig. 4). A list of these gaging stations with 1993 and previous maximums is provided in table 1.

Flood-Stage Measurements

The stage of a stream for a specific flow rate is dependent upon several factors. These factors include the cross-sectional area of the stream (average depth multiplied by the width), slope of the water surface moving downstream, and the roughness of the inundated surface (amount of trees, brush, weeds, rocks, or bare ground within the cross-sectional area). For example, if a stream is constricted by a road embankment and a bridge, the water depth upstream may be greater than without the constriction. To convey the same flow rate with a reduced width, the depth of the stream must increase. However, for a given cross-sectional area, a deep and narrow stream will convey more water than a shallow and wide stream.

Stream stage was measured continuously at each of the gaging stations in the Kansas City metropolitan area during the floods. Other locations along the stream valleys had intermittent manual gage measurements, whereas maximum river stages at many locations were measured by surveying high-water marks after the floodwaters had receded.

Flood-Discharge Measurements

Although stage of a stream is useful information, most users of streamflow data need to know the discharge of the stream. Discharge is defined as the volume of flow passing a specified point in a given interval of time and includes the volume of the water and any sediment or other solids that may be dissolved or mixed with the water. Discharge is derived from the stage data through the use of a relation between stage and discharge. The stage/discharge relation for a specific stream location is defined from periodic discharge measurements made at known stages (Wahl and others, 1995). If the maximum discharge exceeds the range of the current-meter measurements, then short extensions may be made to the graph of the stage/discharge relation at a gaging station by logarithmic extrapolation, velocity-area studies, or the use of other measurable hydraulic factors (Kennedy, 1983). Flood discharges are not affected as much by manmade changes in the stream and are more likely to be comparable over periods of time.

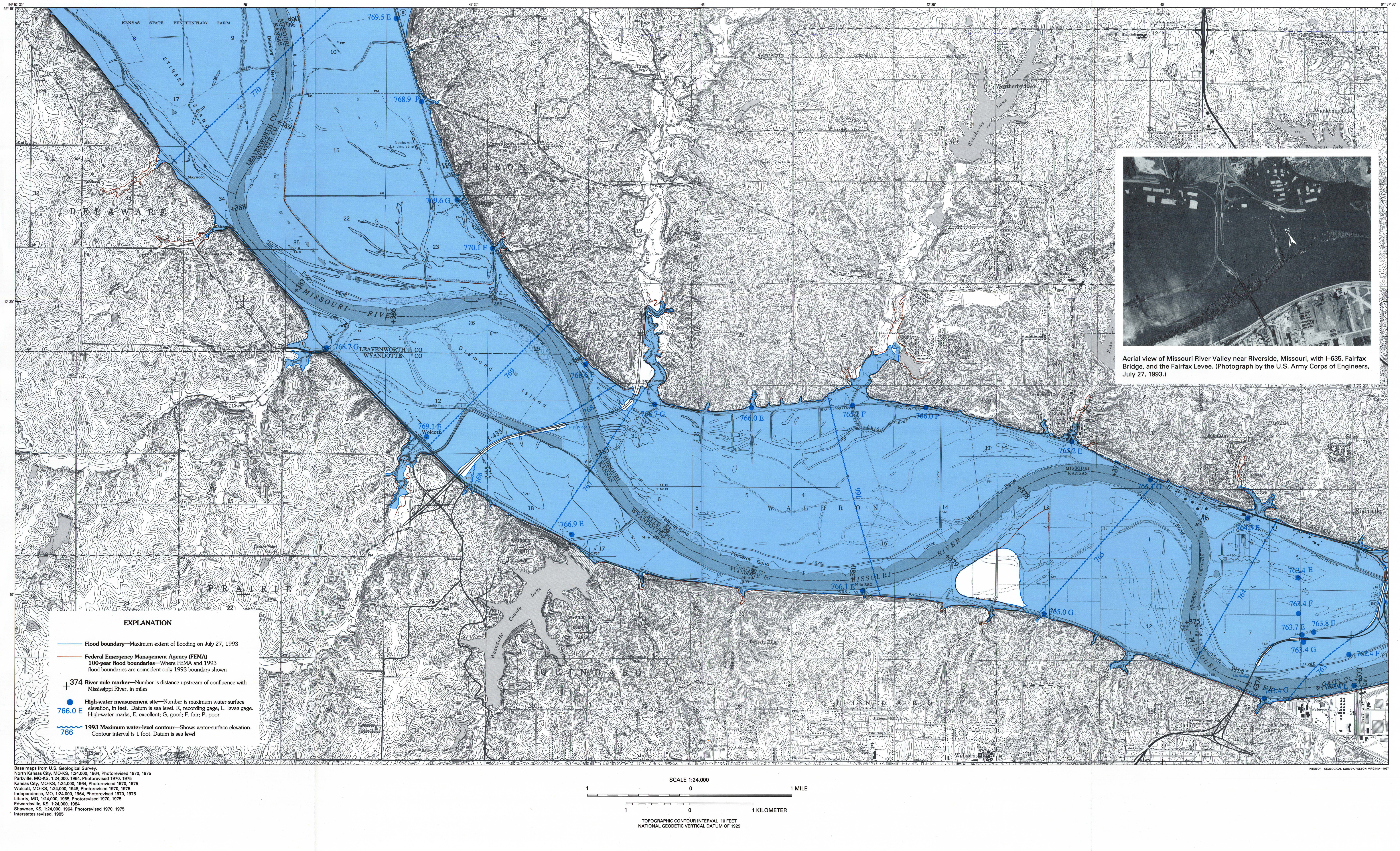
Flood-discharge measurements were made at the streamflow-gaging stations in the Kansas City metropolitan area during various times of the flood to confirm or revise stage/discharge relations at the streamflow-gaging stations. Maximum discharges at the streamflow-gaging stations are listed in table 1.

Table 1. Stage and peak-discharge values for period of streamflow record and for 1993 floods with recurrence interval and peak-discharge values for Federal Emergency Management Agency (FEMA) 100-year and 500-year modeled profiles for streamflow-gaging stations in the Kansas City metropolitan area

[mi^2, square miles; ft, feet; ft^3/s, cubic feet per second; <, less than; >, greater than. FEMA, Federal Emergency Management Agency]

Station number (fig. 4)	Station name	Drainage area (mi^2)	Period of record	Maximum prior to July 1993: Year	Maximum prior to July 1993: Stage (ft)	Maximum prior to July 1993: Discharge (ft^3/s)	1993 maximum: Date (month/day)	1993 maximum: Stage (ft)	1993 maximum: Discharge (ft^3/s)	1993 maximum: Recurrence interval (years)	FEMA flood study[1]: Discharge for 100-year recurrence interval (ft^3/s)	FEMA flood study[1]: Discharge for 500-year recurrence interval (ft^3/s)
06818000	Missouri River at St. Joseph, Mo.	420,300	1929–94	1952	26.82	397,000	7/26	32.07	335,000	>100	350,000	460,000
06893000	Missouri River at Kansas City, Mo.	485,200	1929–94	1951	46.20	573,000	7/27	48.87	541,000	>100	425,000	540,000
06893500	Blue River at Kansas City, Mo.	188	1939–94	1961	44.46	41,000	7/10	33.91	17,900	<10	53,000	84,000
06892350	Kansas River at Desoto, Kans.	59,800	1917–94	1951	37.30	510,000	7/27	26.91	170,000	10–50	232,000	390,000
06893080	Blue River near Stanley, Kans.	46	1974–94	1990	20.51	20,200	7/10	20.10	18,600	50–100	21,000	35,000
06893300	Indian Creek at Overland Park, Kans.	27	1963–94	1984	17.78	12,800	7/10	15.82	9,070	10–25	15,600	21,300
06892940	Turkey Creek at Kansas City, Kans.	22	1974–89	1977	25.20	11,700	7/10	24.70	11,000	10–25	14,800	25,200

[1] From U.S. Department of Housing and Urban Development (1975–95).



Aerial view of Missouri River Valley near Riverside, Missouri, with I-635, Fairfax Bridge, and the Fairfax Levee. (Photograph by the U.S. Army Corps of Engineers, July 27, 1993.)

Figure 1*A*. Flood boundaries, water-elevation measurements, and water-level contours for 1993 and Federal Emergency Management Agency 100-year flood boundaries for the Kansas City metropolitan area from about Missouri River miles 390 to 373.

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DELINEATION OF FLOODING WITHIN THE UPPER MISSISSIPPI RIVER BASIN—FLOOD OF JULY 10 AND 27, 1993, IN KANSAS CITY, MISSOURI, AND KANSAS CITY, KANSAS, AND VICINITY

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1997