Schaap, B.D., 1996, Delineation of flooding within the upper Mississippi River Basin—flood of June 19–July 31, 1993, in Davenport, Iowa, and vicinity

INTRODUCTION

During the spring, summer, and fall of 1993, record flooding disrupted business and transportation and caused widespread property damage and personal hardship in parts of Iowa, Illinois, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin. In an effort to document the 1993 flooding, the U.S. Geological Survey (USGS) is publishing a series of reports collectively known as Circular 1120, *Floods in the upper Mississippi River Basin, 1993.* Also, hydrologic atlases, such as this one, are being published for Davenport, Iowa City, and Des Moines, Iowa, Jefferson City and St. Louis, Missouri, and Kansas City, Kansas, and Kansas City, Missouri.

This hydrologic atlas describes the flooding that occurred from June 19 through July 31, 1993, along the Mississippi River in Davenport, Iowa, and vicinity. The flooding damaged homes and businesses and forced operations in Davenport's main post office to relocate. For a while, the Mississippi River was closed to all boat traffic, stopping barge movement and disrupting passenger service. The 1993 flood elevations and areas inundated by the Mississippi River floodwaters are presented and compared with those estimated by the Federal Emergency Management Agency [(FEMA) 1980b–c, 1981, 1982, 1986a, 1987a, 1988a, 1992a, 1993a] for the 100-year flood.

Davenport is the largest of the Quad Cities, which also include Bettendorf, Iowa, and Moline and Rock Island, Illinois, and it is the most populous city along the Mississippi River between St. Paul, Minnesota, and St. Louis, Missouri (U.S. Bureau of the Census, 1991). The area drained by the Mississippi River upstream from Lock and Dam 15 at Davenport is about 88,550 square miles and includes parts of South Dakota, Iowa, Illinois, Wisconsin, and Minnesota (fig. 1).

CLIMATIC CONDITIONS

In early June 1993, a weather pattern characterized by a strong low-pressure system developed over the Western United States, and a corresponding large high-pressure system developed over the Southeastern United States. The jet stream dipped south over the Western United States and flowed northeasterly across the upper Midwest. The high-pressure system to the southeast blocked the eastward movement of storms, thus creating a convergence zone between the flow of warm, moist air from the Gulf of Mexico and the much cooler, drier air from Canada, which resulted in thunderstorms. As a result, the upper Midwest within this convergence zone was deluged with rain, while the Southeastern and the Eastern United States from Alabama to Vermont, which was under the influence of the high-pressure system, were very hot and dry. Slight movements in the atmospheric pattern determined the timing and location of the excessive rainfall throughout the upper Midwest (Wahl and others, 1993, p. 2–3).

The above-normal precipitation in the upper Mississippi River Basin led to flooding in Davenport, Iowa, for more than 6 weeks of the summer of 1993. The areal distribution of total precipitation as a percentage of normal in the upper Mississippi River Basin from January through July 1993 and the locations of selected precipitation stations within the basin are shown in figure 1. Each of these stations recorded more than 100 percent of normal precipitation for at least 4 of the 7 months, and 2 stations, Guttenberg Lock and Dam 10 and Wisconsin Dells, recorded more than 100 percent of normal precipitation for all 7 months (table 1). From January through July 1993, more than 20 inches (in.) of precipitation fell on most of the drainage basin, with some areas in east-central Iowa receiving over 40 in. (Wahl and others, 1993). During this period, the drainage basin above the Mississippi River at Lock and Dam 15 received from 100 to 250 percent of normal precipitation.

FLOOD DISCHARGE

The rate of discharge of a stream is the volume of flow that passes a specific location in a specified period of time. Floods are described in terms of both discharge and elevation because changes in the river channel can effect the relation between water-surface elevation and discharge. During flooding, the river may widen or deepen its channel so that a subsequent greater discharge might be associated with a lower water-surface elevation.

No discharge data are collected at Mississippi River Lock and Dam 15. However, discharge data is collected at Clinton, Iowa, (05420500) about 29 miles (mi) upstream and at Keokuk, Iowa, about 119 mi downstream. Maximum discharges and stages at these two streamflow-gaging stations (fig. 2) are listed in table 2.

Figure 3 shows a discharge hydrograph for the Mississippi River at Clinton. For most of the time from October 1992–September 1993, the daily mean discharge at this station greatly exceeded the monthly mean discharges from October 1874–September 1993, but it was less than the 100-year flood discharge.

Figure 4 shows a discharge hydrograph for the Mississippi River at Keokuk. The daily mean discharge at Keokuk exceeded the 100-year flood discharge for almost the entire month of July.

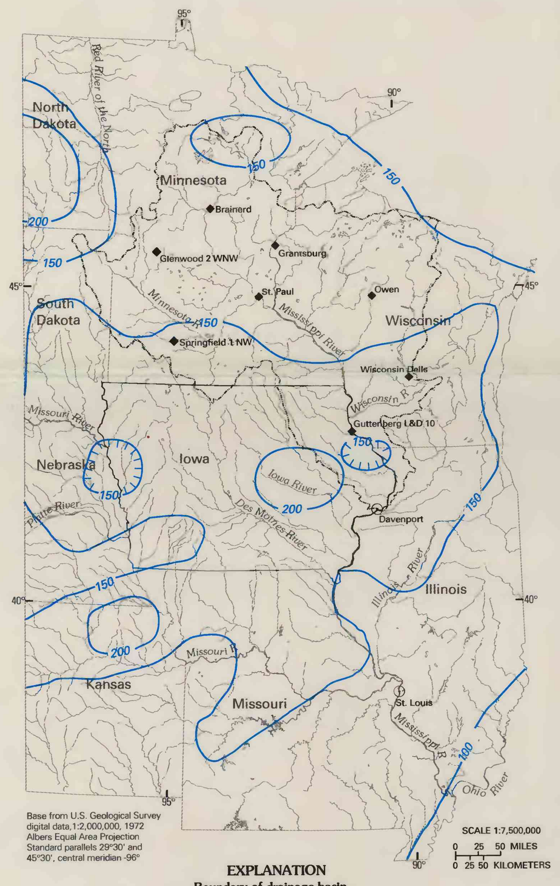

Figure 1. Location of the drainage basin of Mississippi River upstream from Lock and Dam 15 at Davenport and selected National Oceanic and Atmospheric Administration precipitation stations, and the areal distribution of total precipitation as a percentage of normal in the upper Mississippi River Basin, January to July 1993 (modified from Parrett and others, 1993.)

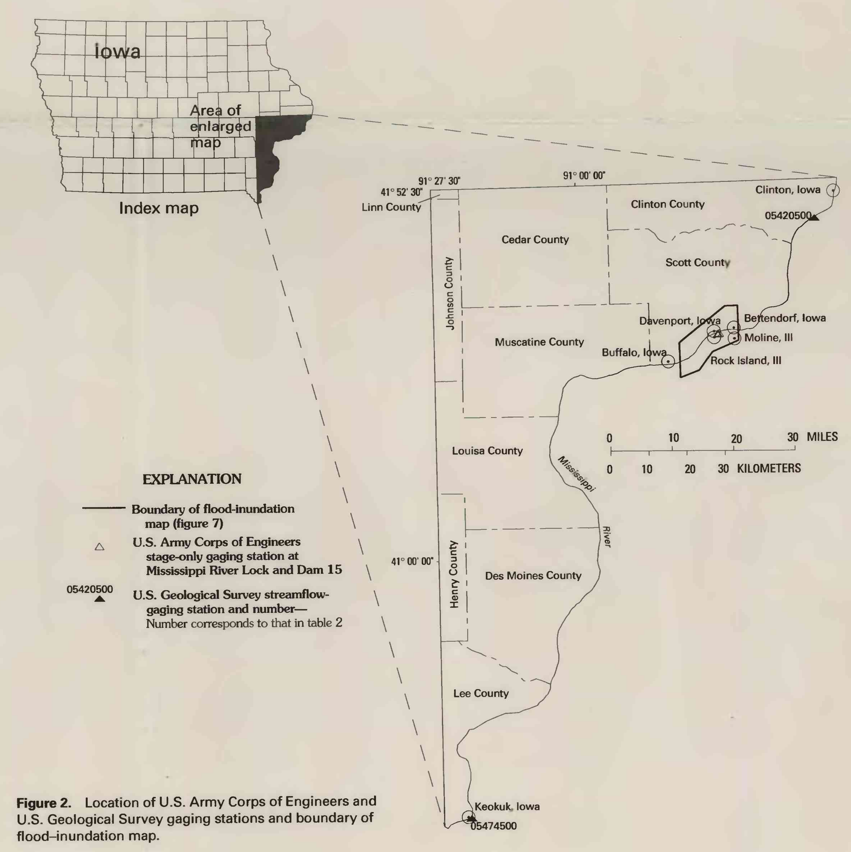

Figure 2. Location of U.S. Army Corps of Engineers and U.S. Geological Survey gaging stations and boundary of flood-inundation map.

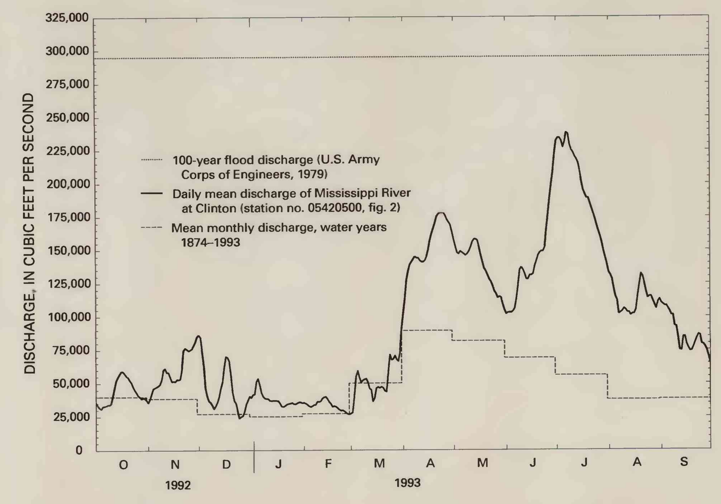

Figure 3. The 100-year flood discharge, daily mean discharge for October 1992–September 1993, and mean monthly discharge for the U.S. Geological Survey streamflow-gaging station at Clinton, Iowa.

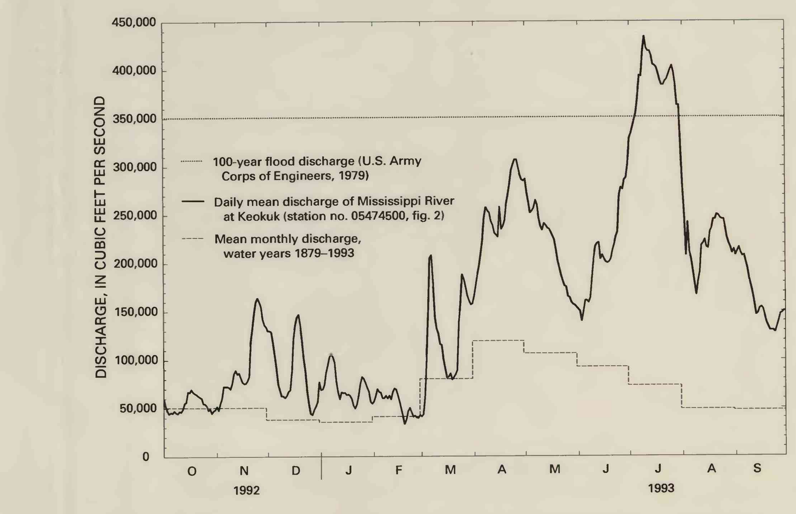

Figure 4. The 100-year flood discharge, daily mean discharge for October 1992–September 1993, and mean monthly discharge for the U.S. Geological Survey streamflow-gaging station at Keokuk, Iowa.

Table 1. Precipitation recorded during January through July 1993 within the drainage basin of Mississippi River Lock and Dam 15 at Davenport, Iowa

[in., inches. Data from National Oceanic and Atmospheric Administration (1993a, 1993b, 1993c). Percent of normal is percentage of the 30-year precipitation normal for 1961–1990]

Period of precipitation	National Oceanic and Atmospheric Administration precipitation station (fig. 1)															
	Brainerd		Glenwood 2 WNW		Grantsburg		Guttenberg L&D 10		Owen		St. Paul		Springfield 1 NW		Wisconsin Dells	
	Precipitation (in.)	Percent of normal	Precipitation (in.)	Percent of normal	Precipitation (in.)	Percent of normal	Precipitation (in.)	Percent of normal	Precipitation (in.)	Percent of normal	Precipitation (in.)	Percent of normal	Precipitation (in.)	Percent of normal	Precipitation (in.)	Percent of normal
January	1.19	**170**	0.54	**86**	1.39	**125**	1.25	**142**	1.44	**160**	1.37	**151**	0.55	**92**	1.46	**157**
February	.11	**19**	.18	**32**	.23	**27**	1.08	**103**	.08	**10**	.41	**48**	.77	**105**	1.40	**157**
March	1.38	**101**	1.69	**132**	.77	**46**	2.84	**147**	.93	**51**	1.64	**86**	1.92	**105**	2.48	**110**
April	1.85	**84**	2.04	**107**	2.47	**114**	4.41	**146**	3.46	**141**	2.17	**82**	3.29	**126**	6.07	**204**
May	6.68	**222**	5.00	**157**	5.12	**145**	5.98	**172**	6.43	**175**	4.34	**121**	6.73	**221**	5.68	**167**
June	4.67	**116**	4.45	**121**	5.44	**121**	6.38	**162**	9.53	**217**	5.98	**127**	8.51	**240**	6.47	**166**
July	4.15	**105**	5.19	**176**	7.72	**197**	8.98	**213**	2.77	**65**	7.30	**185**	5.82	**164**	6.18	**164**

Table 2. Summary of maximum stages and discharges at two streamflow-gaging stations in the Davenport, Iowa, vicinity

[mi^2, square miles; ft, feet above gage datum; ft^3/s, cubic feet per second; >, greater than. Data from Southard and others (1994)]

Station number (fig. 2)	Station name	River miles upstream from confluence with Ohio River	Drainage area (mi^2)	Gage datum (feet above sea level)	Flood data						
					Flood of June 19–July 31, 1993				Prior to 1993 flood		
					Date (month/day)	Maximum stage (ft)	Maximum discharge (ft^3/s)	[1]Recurrence interval (years)	Date (month/year)	Maximum stage (ft)	Maximum discharge (ft^3/s)
05420500	Mississippi River at Clinton	511.8	85,600	562.68	[2]7/07	22.87	239,000	25	4/1965	24.65	307,000
05474500	Mississippi River at Keokuk	364.2	119,000	477.41	7/10	27.58	[3]446,000	>100 [4](1.3)	6/1851	21.0	360,000

[1] Based on information from U.S. Army Corps of Engineers (1979).
[2] Date of maximum discharge. Maximum stage was 22.98 on July 8, 1993.
[3] Maximum discharge for 1993 exceeds the previous maximum known discharge.
[4] Ratio of flood discharge to that of the 100-year flood.

FLOOD ELEVATIONS

At Mississippi River Lock and Dam 15 (fig. 2), operated by the U.S. Army Corps of Engineers (USACE), the Mississippi River reached its maximum elevation on July 9, 1993, with a tail-water elevation of 564.62 feet (ft). Prior to 1993, the highest recorded tailwater elevation was 564.47 ft, which occurred on April 28, 1965 (U.S. Army Corps of Engineers, 1994). From June 19 to July 31, 1993, the elevation of the Lock and Dam 15 tailwater equaled or exceeded the flood elevation of 556.99 ft, as defined by the USACE (U.S. Army Corps of Engineers, 1994). Figure 5 shows that during this time, the tailwater elevation at Lock and Dam 15 did not exceed 564.8 ft, the 100-year flood tailwater elevation as defined by the USACE (U.S. Army Corps of Engineers, 1979).

The USACE determined the maximum elevation of the Mississippi River at several other points in the Davenport vicinity. A profile of the maximum water-surface elevations along the Iowa side of the Mississippi River within the study area is shown in figure 6.

The maximum pool and tailwater elevations are reported on the flood-inundation map (fig. 7) to the nearest hundredth of a foot. The other maximum water-surface elevations are reported to the nearest tenth of a foot.

INUNDATED AREA

The areas inundated by the flooding in 1993 are shown in figure 7. Flood extent was determined by combining several sources of information. Aerial photographs taken July 12, 1993, for the USACE were used to draw flood-extent boundaries. These boundaries were adjusted where the differences between the July 12 elevations and the known 1993 maximum water-surface elevations determined by the USACE were significant and in areas where the edge of the floodwaters was obscured on the photographs by buildings or vegetation. These adjustments were based on comparisons of the known 1993 water-surface elevations to the topographic elevations on the 1:24,000 base maps and on discussions with local authorities. In some places, the flood-inundation line is shown to cross back and forth across topographic contour lines of different elevations because the topography has changed since the base maps were published (fig. 7).

FLOOD-RECURRENCE INTERVAL

The recurrence interval is the long-run average number of years between occurrences of annual-maximum flood peaks that exceed a given magnitude. The magnitude may be expressed in terms of peak discharge or peak stage (water-surface elevation). The recurrence interval also is the reciprocal of the annual probability of occurrence of a flood exceeding the given magnitude. For example, a flood magnitude having a recurrence interval of 100 years (the 100-year flood) has a 1-percent chance (0.01 probability) of being exceeded in any given year. Recurrence intervals do not imply regularity of occurrence: the 100-year flood might be exceeded in consecutive years or might not occur at all for over 100 years.

Recurrence intervals for selected maximum elevations and discharges are statistics that can change and that tend to become more reliable as more data are collected and used in the computations. Long-term climatic changes and physical changes in the basin can alter the recurrence interval for a specified discharge. Examples of such basin changes include, but are not limited to, extensive urbanization, implementation of agricultural conservation practices, installation of drainage systems, and construction of reservoirs.

A comparison of the flood-inundation boundaries to the FEMA 100-year flood boundaries (fig. 7) and of the profile of maximum water-surface elevations to the FEMA 100-year flood profile (fig. 6) also indicates that the 1993 flood was less than a 100-year flood for the Mississippi River at Davenport and vicinity.

FEDERAL EMERGENCY MANAGEMENT AGENCY 100-YEAR FLOOD INFORMATION

The 100-year flood boundary, as determined by FEMA (1980b–c, 1981, 1982, 1986a, 1987a, 1988a, 1992a, 1993a), is shown on the flood-inundation map (fig. 7). The 100-year flood boundary outlines those areas expected to be inundated during a 100-year flood. The outlined areas do not include those areas protected by flood-prevention measures, such as dikes, levees, or other structures which may fail or be overtopped during larger floods. The FEMA 100-year flood boundary is of interest to many people because it is the basis for flood-insurance rates. It also may affect local zoning ordinances and qualification for home and business loans.

The FEMA 100-year flood boundaries for Rock Island County, Bettendorf, Davenport, and Scott County are based on a Mississippi River discharge of 303,000 cubic feet per second (ft^3/s) just upstream from the confluence with the Rock River at about river mile 479.2 (Federal Emergency Management Agency, 1986b, 1988b, 1992b, 1993b). The FEMA 100-year flood boundaries for Moline and Rock Island are based on a discharge of 296,000 ft^3/s at the same location (Federal Emergency Management Agency, 1979, 1987b). For Buffalo, Iowa (fig. 2) the FEMA 100-year flood boundaries are based a Mississippi River discharge of 333,000 ft^3/s downstream from the confluence with the Rock River (Federal Emergency Management Agency, 1980a), as are the boundaries for Rock Island County, Davenport, and Scott County (Federal Emergency Management Agency, 1986b, 1992b, 1993b).

The FEMA flood-boundary information is published in map form for individual cities and counties within the study area. The FEMA maps were prepared by different contractors at different times on a variety of base maps and were published at several different scales. For this hydrologic atlas, the 100-year flood-boundary information was created by combining information from the appropriate city and county maps. FEMA maps may be revised as physical changes in the basins occur. These changes can affect the flow of floodwaters and be reflected in future FEMA maps. For official FEMA information, one should consult individual FEMA maps, including any that may have been published since this hydrologic atlas was published.

ADDITIONAL INFORMATION

Additional information pertaining to the 1993 floods in the Midwest can be found in USGS Circular 1120–K, *Floods in the upper Mississippi River Basin, 1993.* That report is published as individual chapters (1120–A, 1120–B, 1120–C, etc.) that provide data and findings on the magnitude and frequency of maximum discharges, precipitation, water-quality characteristics, effects of reservoir storage on flood maximums, effects of inundation on ground-water quality, flood-discharge volumes, transport of sediment, assessment of sediment deposited on flood plains, stream-channel scour at selected bridges, and documentation of geomorphologic changes.

Additional information also is available from the U.S. Army Corps of Engineers, Rock Island District; the Engineering Departments of Davenport, Moline, and Rock Island; and the Bi-State Regional Commission. Also, the areas in Davenport and vicinity inundated in 1993 may be compared with areas inundated in 1965, which are shown by Anderson and Burmeister (1970).

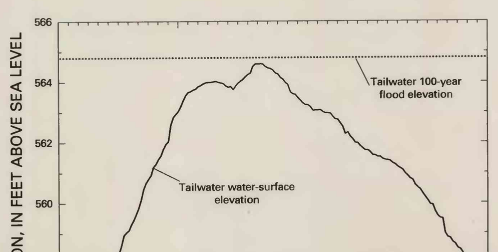

Figure 5. Tailwater elevation for the Mississippi River at Lock and Dam 15, June 19–July 31, 1993. (Data from U.S. Army Corps of Engineers.)

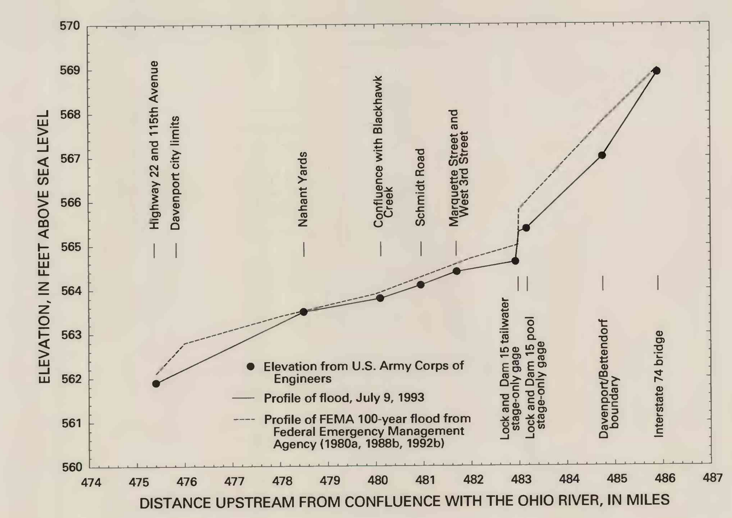

Figure 6. Profile of maximum water-surface elevations along the Mississippi River, July 9, 1993, and Federal Emergency Management Agency (FEMA) 100-year flood profile for the Iowa side of the Mississippi River.

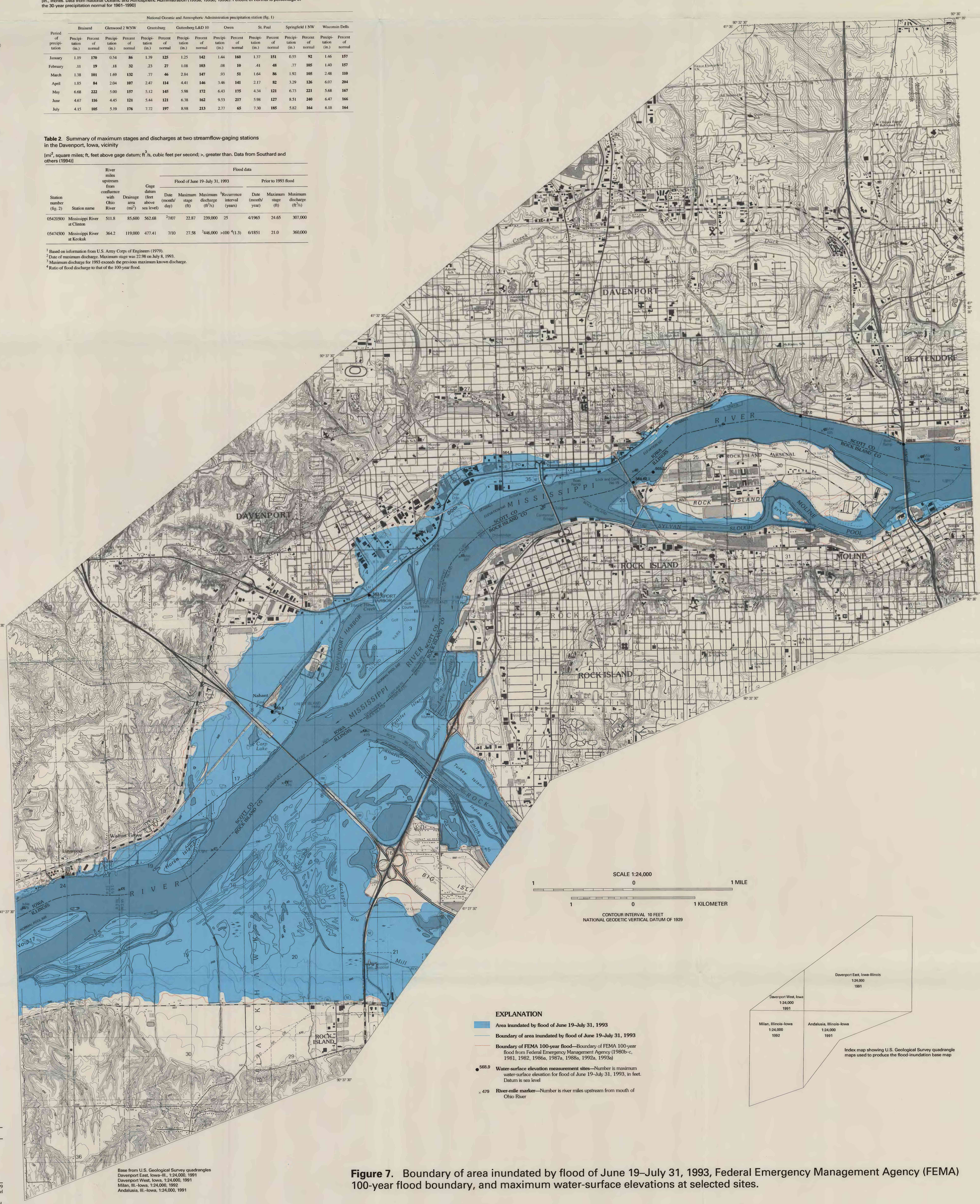

Figure 7. Boundary of area inundated by flood of June 19–July 31, 1993, Federal Emergency Management Agency (FEMA) 100-year flood boundary, and maximum water-surface elevations at selected sites.

REFERENCES

Anderson, D.B. and Burmeister, I.L., 1970, Floods of March–May 1965 in the Upper Mississippi River Basin: U.S. Geological Survey Water-Supply Paper 1850–A, 448 p.

Eash, D.A., in press, Effects of the 1993 flood on the determination of flood magnitude and frequency in Iowa, *in* Floods in the upper Mississippi River Basin, 1993: U.S. Geological Survey Circular 1120–K.

Federal Emergency Management Agency (FEMA), 1979, Flood insurance study for Moline, Illinois: Baltimore, Md., community 170591, 18 p., pt. 7.

_____1980a, Flood insurance study for Buffalo, Iowa: Baltimore, Md., community 190241, 16 p., pt 4.

_____1980b, Flood insurance rate map for Buffalo, Iowa: Baltimore, Md., community 190241, panel 0004 B, scale 1:4,800.

_____1980c, Flood boundary and floodway map for Moline, Illinois: Baltimore, Md., community 170591, panel 0005 B, scale 1:12,000.

_____1981, Flood insurance rate map for Rock Island, Illinois: Baltimore, Md., community 175171, panel 0005 C, scale 1:9,600.

_____1982, Flood insurance rate map for Rock Island County, Illinois: Baltimore, Md., community 170582, panel 0175 B, scale 1:24,000.

_____1986a, Flood insurance rate map for Rock Island County, Illinois: Baltimore, Md., community 170582, panels 0075 C, 0010 C, 0200 C, scale 1:24,000.

_____1986b, Flood insurance study for Rock Island County, Illinois: Baltimore, Md., community 170582, 30 p., pt 26.

_____1987a, Flood insurance rate map for Rock Island, Illinois: Baltimore, Md., community 175171, panel 0010 D, scale 1:9,600.

_____1987b, Flood insurance study for Rock Island, Illinois: Baltimore, Md., community 175171, 24 p., pt 7.

_____1988a, Flood boundary and floodway map for Bettendorf, Iowa: Baltimore, Md., community 190240, panel 0005, scale 1:6,000.

_____1988b, Flood insurance study for Bettendorf, Iowa: Baltimore, Md., community 190240, 31 p., pt 13.

_____1992a, Flood insurance rate map for Davenport, Iowa: Baltimore, Md., community 190242, panels 0004 B, 0005 B, 0006 B, scale 1:9,600.

_____1992b, Flood insurance study for Davenport, Iowa: Baltimore, Md., community 190242, 30 p., pt. 17.

_____ 1993a, Flood insurance rate map for Scott County, Iowa: Baltimore, Md., community 190239, panel 0235 B, scale 1:12,000.

_____1993b, Flood insurance study for Scott County, Iowa: Baltimore, Md., community 190239, 29 p., pt 8.

National Oceanic and Atmospheric Administration, 1993a, Climatologic data, Iowa: Asheville, N.C., monthly summaries, v. 104, no. 1–7.

_____1993b, Climatologic data, Minnesota: Asheville, N.C., monthly summaries, v. 99, no. 1–7.

_____ 1993c, Climatologic data, Wisconsin: Asheville, N.C., monthly summaries, v. 98, no. 1–7.

Parrett, Charles, Melcher, N.B., and James, R.W., Jr., 1993, Flood discharges in the upper Mississippi River Basin, January 1 through July 31, 1993, *in* Floods in the upper Mississippi River Basin, 1993: U.S. Geological Survey Circular 1120–A, 14 p.

Southard, R.E., Sneck-Fahrer, D., Anderson, C.J., Goodrich, R.D., and Gorman, J.G., 1994, Water resources data, Iowa, water year 1993: U.S. Geological Survey, Water-Data Report IA–93–1, 388 p.

U.S. Army Corps of Engineers, 1979, Upper Mississippi River water surface profiles, river mile 0.0 to river mile 847.5: Prepared for the technical flood plain management task force of the Upper Mississippi River Basin Commission by the U.S. Army Corps of Engineers, Rock Island District, in cooperation with St. Paul District, north-central division, and St. Louis Division, Lower Mississippi Valley division, pt. 17.

_____ 1994, The great flood of 1993 post-flood report, upper Mississippi River Basin, appendix B: U.S. Army Corps of Engineers, Rock Island District, 95 p., 104 pls.

U.S. Bureau of the Census, 1991, Census of the population and housing—Summary tape file 1A.

Wahl, K.L., Vining, K.C., and Wiche, G.J., 1993, Precipitation in the upper Mississippi River Basin, January 1 through July 31, 1993, *in* Floods in the upper Mississippi River Basin, 1993: U.S. Geological Survey Circular 1120–B, 13 p.

CONVERSION FACTORS AND VERTICAL DATUM

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

Sea Level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Water Year: In U.S. Geological Survey reports, the water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year ending September 30, 1993, is called the "1993 water year."

DELINEATION OF FLOODING WITHIN THE UPPER MISSISSIPPI RIVER BASIN—FLOOD OF JUNE 19–JULY 31, 1993, IN DAVENPORT, IOWA, AND VICINITY

By
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1996