The Great Flood of 1993 on the Upper Mississippi River—10 Years Later

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> *"The Mississippi River will always have its own way; no engineering skill can persuade it to do otherwise..."*
> - Mark Twain in Eruption

Background

Ten years ago, the upper Mississippi River Basin in the Midwestern United States experienced the costliest flood in the history of the United States. The flood came to be known as " The Great Flood of 1993."

The Mississippi River drains approximately 40 percent of the continental United States (approximately 1.25 million square miles; fig. 1), and portions of two Canadian provinces, Ontario and Manitoba. During the summer of 1993, the Upper Midwest experienced extremely high amounts of rainfall. An abnormally stationary jet stream was positioned over the central part of the Nation during this time. Moist, unstable air moving north from the Gulf of Mexico converged with unseasonably cool, dry air moving south from Canada.

The magnitude and severity of the resulting flood event was overwhelming. The areal extent, intensity, and long duration of the flooding makes this one of the greatest natural disasters ever in the United States. At least 48 people lost their lives as a result of this extreme flood (Interagency Floodplain Management Task Force, 1994). Over 500 river forecast stations in the Midwest were above flood stage at the same time. Nearly 150 major rivers and tributaries flooded. Banks and channels of many rivers were severely

Grand Tower, Illinois, during the height of the flooding along the Mississippi River. Photo by Kevin Oberg, USGS.

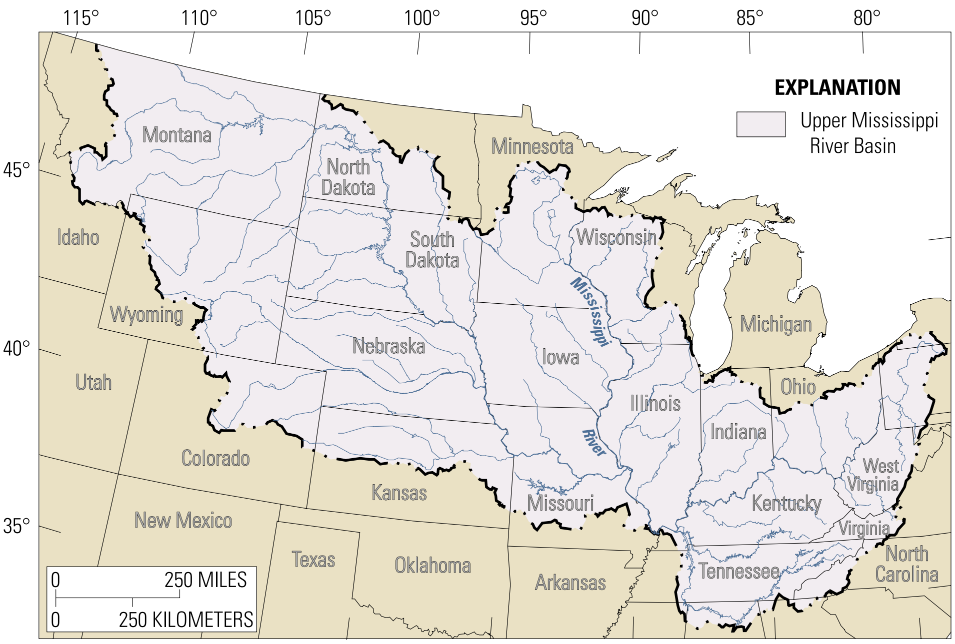


Figure 1. Upper Mississippi River Basin in the United States.

The Mississippi River at downtown St. Louis, looking west, showing lateral variability in the sediment concentration. Lighter areas have a greater suspended-sediment concentration. (Photo from Srenco Photography, St. Louis, Missouri, taken July 30, 1993, and published with permission).

eroded, and sediment was deposited over large areas of the flood plains of the Mississippi, Missouri, and Illinois Rivers. Economic damages approached $20 billion (National Oceanic and Atmospheric Administration, 1994). Levees were broken; farmland, towns, and transportation routes were destroyed; and more than 50,000 homes were damaged or destroyed (Josephson, 1994). Water-quality threats to public health and safety were of paramount concern. These threats included contamination of drinking-water supplies, disruption of wastewater-treatment plant operations, failure of septic systems, and risks associated with the inundation of facilities that handle hazardous materials.

Precipitation

From June to August 1993, rainfall totals surpassed 12 inches across the eastern Dakotas, southern Minnesota, eastern Nebraska, Wisconsin, Kansas, Iowa, Missouri, Illinois, and Indiana. Specifically, greater than 24 inches of rain fell on central and northeastern Kansas, northern and central Missouri, most of Iowa, southern Minnesota, and southeastern Nebraska, and as much as 38 inches fell in east-central Iowa. These amounts were approximately 200-350 percent greater than normal. From April 1 to August 31, precipitation amounts approached 48 inches in east-central Iowa, easily surpassing the area's normal annual precipitation of 30-36 inches. Record summer rainfalls achieved 75- to 300-year frequencies (Stallings, 1994).

A critical factor affecting the record flooding was the persistent nature of the rainfall. It is notable that the flooding was not the result of one large precipitation event. Throughout July 1993 in many Midwestern States, rain fell 20 days or more, compared to a historical July average of 8-9 days (National Oceanic and Atmospheric Administration, 1994). Measurable rain fell in parts of the upper Mississippi Basin every day between late June and late July. The persistent wet-weather pattern in the Upper Midwest, typical in spring but not summer, sustained the almost daily development of rainfall during much of the summer (fig. 2).

The Great Flood of 1993

The Great Flood of 1993 began in early June with saturated soils and streams filled to capacity across the Upper Midwest. Runoff from the ensuing persistent heavy rains of June, July, and August overflowed the streams and river channels. Flooding began on rivers in Minnesota and Wisconsin and eventually reached the Mississippi

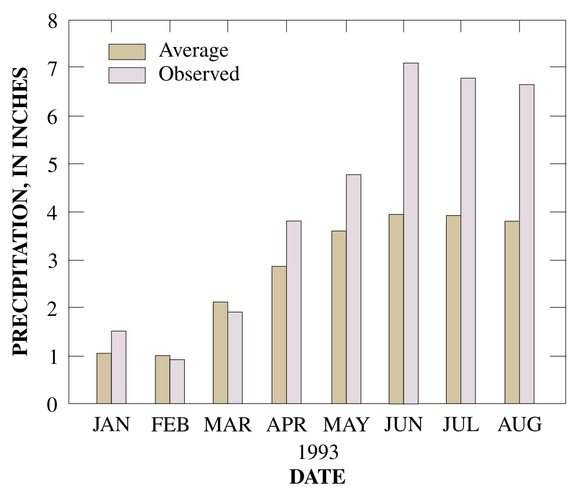


Figure 2. Comparison of average and observed monthly precipitation totals from January 1993 to August 1993 for the upper Mississippi River Basin (from National Oceanic and Atmospheric Administration, 1994).

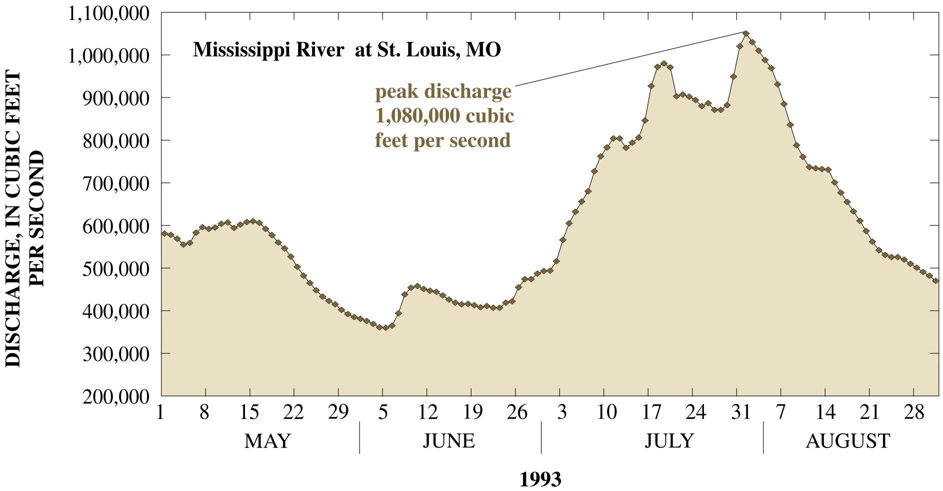


Figure 3. Hydrograph of Mississippi River at St. Louis, Missouri, from May to August 1993.

River, cresting at St. Louis on July 12 at about 43 feet, approaching the previous stage of record. The Missouri River crested at 48.87 feet at Kansas City on July 27. This crest moved down the Missouri River setting new records at Boonville, Jefferson City, Hermann, St. Charles, and other locations. This record flow combined with the flood stage of the Mississippi River just north of St. Louis resulted in another record crest of the Mississippi River at St. Louis on August 1 of 49.58 feet, and record flow of greater than 1 million cubic feet per second (fig. 3). A new record crest (over 4 feet higher than the previous record) was measured on the Illinois River at Hardin on August 3. Every streamflow-gaging station on the Mississippi River from Rock Island, Illinois to Thebes, Illinois experienced a new flood of record. Selected locations where new record stages were set during the Great Flood of 1993 are shown in table 1 (Parrett and others, 1993).

Thousands of acres were inundated as a result of the record flooding. The first levee was overtopped on June 7, but levee failures soon became common. Over 1,000 Federal and non-Federal levees were topped or failed (table 2) during the flood (Larson, 1996). Levee failures resulted in large amounts of sediments deposited in some inundated areas, and large quantities of sediments were scoured from other inundated areas (Schalk and Jacobson, 1997; Schalk, Holmes, and Johnson, 1998; and Jacobson and Oberg, 1997).

Table 1. Some locations with new record stages in the upper Mississippi River Basin (from Parrett and others, 1993). [ft, feet; mm/dd/yy, month, day, and year]

		Old record		New record	
	Flood stage (ft)	**Stage (ft)**	**Date (mm/dd/yy)**	**Stage (ft)**	**Date (mm/dd/yy)**
		Mississippi River			
Rock Island, IL	15	22.5	04/28/65	22.6	07/09/93
Keithsburg, IL	13	20.4	04/27/65	24.2	07/09/93
Quincy, IL	17	28.9	04/23/73	32.2	07/13/93
Hannibal, MO	16	28.6	04/25/73	31.8	07/16/93
Clarksville, MO	25	36.8	04/24/73	37.7	07/29/93
Winfield, MO	26	36.9	04/27/73	39.6	08/01/93
Grafton, IL	18	33.2	04/28/73	38.17	08/01/93
Alton, IL	21	36.7	04/28/73	42.72	08/01/93
St Louis, MO	30	43.23	04/28/73	49.58	08/01/93
Chester, IL	27	43.32	04/30/73	49.74	08/07/93
		Missouri River			
St. Joseph, MO	17	26.82	04/23/52	32.07	07/26/93
Kansas City, MO	32	36.20	07/14/51	48.87	07/27/93
Boonville, MO	21	32.82	07/17/51	37.10	07/29/93
Jefferson City, MO	23	34.2	07/18/51	38.6	07/30/93
Hermann, MO	21	35.79	10/05/86	36.97	07/31/93
St. Charles, MO	25	37.50	10/07/86	40.04	08/02/93
		Illinois River			
Hardin, IL	25	38.2	04/29/73	42.36	08/03/93

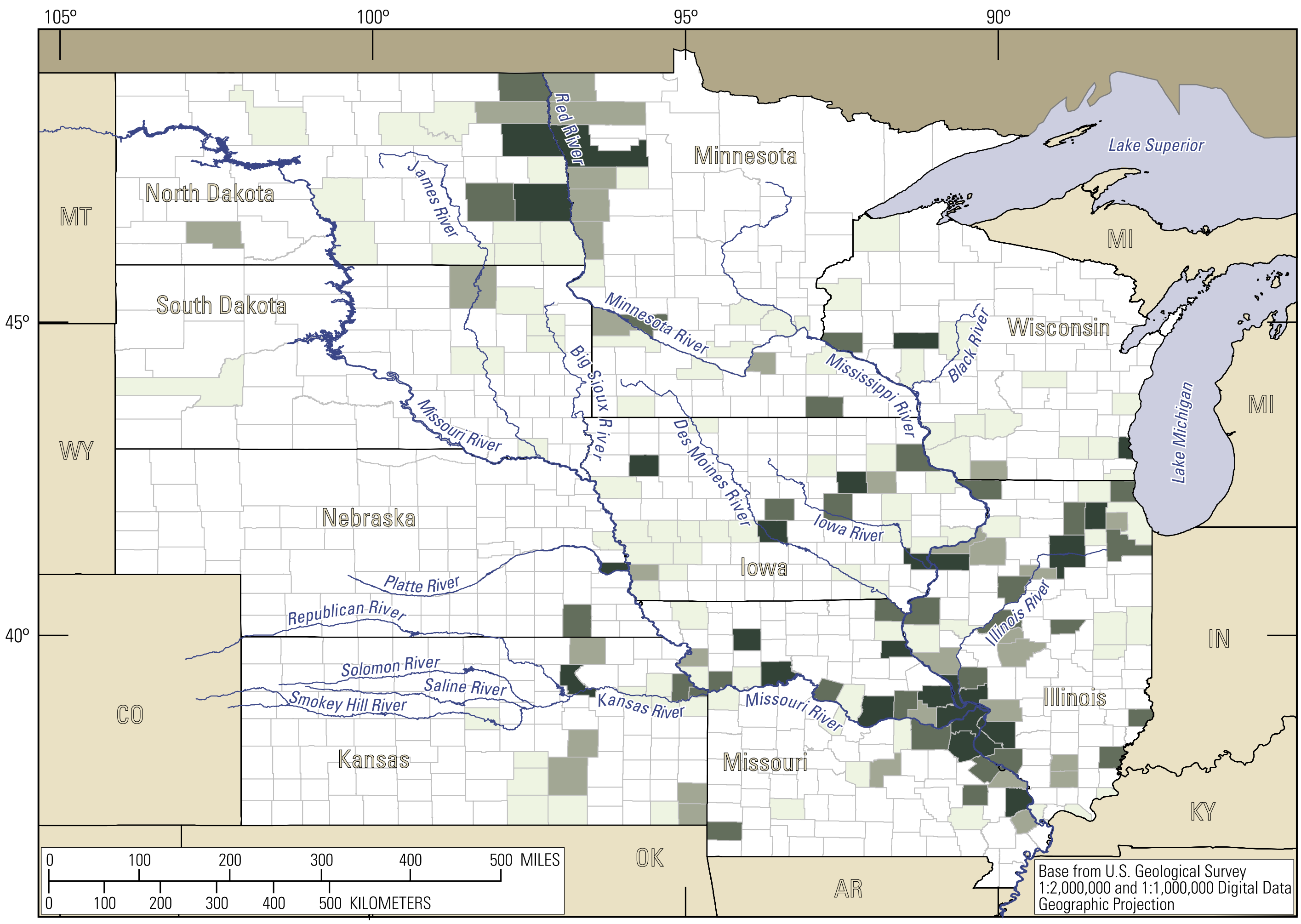
Table 2. Levee failures during the Great Flood of 1993 (from Larson, 1996).

Corps of Engineers District	**Number of failed or overtopped levees**	
	Federal	**Non-Federal**
St. Paul, MN	1 of 32	2 of 93
Rock Island, IL	12 of 73	19 of 185
St. Louis, MO	12 of 42	39 of 47
Kansas City, MO	6 of 48	810 of 810
Omaha, NE	9 of 31	173 of 210
Totals	40 of 226	1,043 of 1,345

Federal Response in the 10 Years Since the Flood

In addition to the response of the Federal Government during the Great Flood of 1993, including extensive data collection, forecasting, flood-control efforts, and rescue and evacuation efforts, the Federal Government has continued to respond to the effects of the flood.

The Federal Government response and recovery costs for the Great Flood of 1993 exceeded \$4.2 billion. The expenditures of the Federal Emergency Management Agency (FEMA), now part of the U.S. Department of Homeland Security, totaled \$1.14 billion. Much of this cost went to hazard mitigation projects. Over 12,000 properties have been hazard-mitigated by FEMA since the flood (fig. 4), either by Federal acquisitions, property relocations, property elevating, or by flood proofing of properties (Federal Emergency Management Agency, 2003). In addition, the Great Flood of 1993 provided the impetus for the U.S. Fish and Wildlife Service to create the Big Muddy National Fish and Wildlife Refuge. To create this refuge, Congress enacted Public Law 103-211 and authorized expendi-



EXPLANATION

TOTAL MITIGATED PROPERTIES PER COUNTY

- Greater than 100
- 50 to 100
- 25 to 49
- Less than 25
- FLOODING SOURCE

TOTAL HAZARD-MITIGATION PROJECTS BY TYPE

Properties acquired	11,888
Properties relocated	356
Properties flood proofed	110
Properties elevated	31
TOTAL	12,385

Figure 4. Hazard-mitigation projects from June 1993 through April 2003 per county for the Great Flood of 1993 region (modified from Federal Emergency Management Agency, 2003).

Levee breaches were a common occurrence during the Great Flood of 1993. More than 1,000 Federal and non-Federal levees were topped or failed during the flood. Photo by Perry Draper, USGS.

ture of funds to purchase land from willing landowners in the Missouri River bottoms (U.S. Fish and Wildlife Service, 2003). As of November 2003, over 8,000 acres of flood plain have been purchased with hopes of acquisition of 60,000 total acres (John Connors, U.S. Fish and Wildlife Service, oral communication, 2003).

Streamflow-Gaging Stations—An Essential Resource

Was the Great Flood of 1993 an anomalous, unique event? Was it caused by levees? Was it exacerbated by other actions of man? We'll never know without reliable data from long-term streamflow-gaging stations.

Streamflow monitoring on the main stem of the Mississippi River began in January 1861 when the first station began operation at St. Louis, Missouri. Currently (2003), the USGS maintains more than 7,000 streamflow-gaging stations nationwide in cooperation with various local, State, and Federal agencies. Real-time streamflow data from the USGS are used by the National Weather Service River Forecast Centers to determine flood stages for various streams, and to help forecast when and where streams will crest during floods (for more information visit *http://www.riverwatch.noaa.gov/*). The U.S. Army Corps of Engineers uses real-time streamflow data to schedule reservoir releases that are designed to lessen the amount of potential damage from overflowing streams and to prevent water from backing up into smaller tributaries when the main stem already is bankfull. USGS streamflow data also are used to design bridges, highways, and culverts that will convey sufficient streamflow so that transportation infrastructure will remain above water during flooding. FEMA uses USGS streamflow data to address emergency response needs before, during, and after the flooding, and to develop flood-insurance rate maps.

Deaths and damage from floods can be mitigated by collecting real-time streamflow data and disseminating reliable forecasts. Information on the quantity and timing of the streamflow in the Nation's rivers is a vital asset that can be used to safeguard lives and property and to help ensure adequate water resources for a healthy environment and economy. The USGS streamgaging network is

Homes surrounded by flood waters near Miller City, Illinois; 12,385 properties were hazard-mitigated by FEMA following the flood. Photo by Kevin Oberg, USGS.

"Hydrologic data is vitally important to water resource planning, design, construction and operation. Such data are critical to properly conduct risk assessment and economic analysis, and to accurately evaluate the impact of water projects on public health, welfare, safety and the environment. Many U.S. agencies, in particular the National Weather Service and the U.S. Geological Survey, provide the foundation of the basic data collection program for water in the United States. Inadequate hydrologic data collection, resulting from budget shortages, has long-term adverse effects on the efficiency and certainty of planning, design, construction and operation of water and other projects." [From American Society of Civil Engineers Policy Statement 447 on Hydrologic Data Collection, April 27, 2001].

operated as a partnership between the USGS and over 800 Federal, State, Tribal, and local agencies. This partnership has great value, but the number of streamgages has declined in recent years. Users of USGS streamflow data agree that a plan is needed to reverse the loss of streamgages and to provide for a stable and modern streamflow-monitoring network for the future.

The USGS continues to be committed to the collection and dissemination of high-quality streamflow data as a crucial part of the USGS mission to provide earth science information for the wise management of the Nation's natural resources (Wahl and others, 1995).

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For more information about the water resources in Illinois, visit the USGS Web site:

http://il.water.usgs.gov/

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