

Prepared in cooperation with the Iowa Department of Transportation and Iowa Highway Research Board (Project HR-140)

## Floods of July 23–26, 2010, in the Little Maquoketa River and Maquoketa River Basins, Northeast Iowa



Open-File Report 2011–1301

**Cover.** Map of Iowa showing location of Little Maquoketa River and Maquoketa River Basins.

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By David A. Eash

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

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**U.S. Geological Survey**  
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## Conversion Factors and Datums

Inch/Pound to SI

<b>Multiply</b>	<b>By</b>	<b>To obtain</b>
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi <sup>2</sup> )	2.590	square kilometer (km <sup>2</sup> )
	Flow rate	
cubic foot per second (ft <sup>3</sup> /s)	0.02832	cubic meter per second (m <sup>3</sup> /s)

Elevation or vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). Elevation refers to distance above or below NGVD 29. NGVD 29 can be converted to the North American Vertical Datum of 1988 by using the National Geodetic Survey conversion utility available at <http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html>.

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Map projections are Universal Transverse Mercator, Zone 15

Water year is the 12-month period from October 1 through September 30. The water year is designated by the calendar year in which the water year ends and that includes 9 of the 12 months. Thus, the water year ending September 30, 2010, is called the "2010 water year."



# Floods of July 23–26, 2010, in the Little Maquoketa River and Maquoketa River Basins, Northeast Iowa

By David A. Eash

## Abstract

Minor flooding occurred July 23, 2010, in the Little Maquoketa River Basin and major flooding occurred July 23–26, 2010, in the Maquoketa River Basin in northeast Iowa following severe thunderstorm activity over the region during July 22–24. A breach of the Lake Delhi Dam on July 24 aggravated flooding on the Maquoketa River. Rain gages at Manchester and Strawberry Point, Iowa, recorded 72-hour-rainfall amounts of 7.33 and 12.23 inches, respectively, on July 24. The majority of the rainfall occurred during a 48-hour period. Within the Little Maquoketa River Basin, a peak-discharge estimate of 19,000 cubic feet per second (annual flood-probability estimate of 4 to 10 percent) at the discontinued 05414500 Little Maquoketa River near Durango, Iowa streamgage on July 23 is the sixth largest flood on record. Within the Maquoketa River Basin, peak discharges of 26,600 cubic feet per second (annual flood-probability estimate of 0.2 to 1 percent) at the 05416900 Maquoketa River at Manchester, Iowa streamgage on July 24, and of 25,000 cubic feet per second (annual flood-probability estimate of 1 to 2 percent) at the 05418400 North Fork Maquoketa River near Fulton, Iowa streamgage on July 24 are the largest floods on record for these sites. A peak discharge affected by the Lake Delhi Dam breach on July 24 at the 05418500 Maquoketa River near Maquoketa, Iowa streamgage, located downstream of Lake Delhi, of 46,000 cubic feet per second on July 26 is the third highest on record.

High-water marks were measured at five locations along the Little Maquoketa and North Fork Little Maquoketa Rivers between U.S. Highway 52 near Dubuque and County Road Y21 near Rickardsville, a distance of 19 river miles. High-water marks were measured at 28 locations along the Maquoketa River between U.S. Highway 52 near Green Island and State Highway 187 near Arlington, a distance of 142 river miles. High-water marks were measured at 13 locations along the North Fork Maquoketa River between Rockdale Road near Maquoketa and U.S. Highway 52 near Luxemburg, a distance of 90 river miles. The high-water marks were used to develop flood profiles for the Little Maquoketa, North Fork Little Maquoketa, Maquoketa, and North Fork Maquoketa Rivers.

## Introduction

Severe thunderstorms during July 22–24, 2010, following record statewide precipitation in June, caused minor flooding on the Little Maquoketa River and record flooding on the Maquoketa and North Fork Maquoketa Rivers, in northeast Iowa during July 23–26, 2010. New maximum peak discharges were recorded on July 24, 2010, at streamgages 05416900 Maquoketa River at Manchester, Iowa (fig. 1, site 8) and 05418400 North Fork Maquoketa River near Fulton (fig. 1, site 15). Record flooding on the Maquoketa River in the vicinity of Manchester led to the breach of the Lake Delhi Dam downstream of Manchester on July 24. The July 22–24 storms also caused significant flooding in parts of adjacent watersheds and along reaches of the Turkey, Volga, and Wapsipinicon Rivers (fig. 1).

Because of the flooding in the Little Maquoketa River and Maquoketa River Basins, the counties of Buchanan, Clayton, Delaware, Dubuque, Jackson, and Jones were added to a State disaster proclamation during July 23–26, 2010, which authorized implementation of the State Individual Assistance Grant Program to assist eligible residents of those counties ([http://www.iowahomelandsecurity.org/news\\_room/press\\_releases.html](http://www.iowahomelandsecurity.org/news_room/press_releases.html), accessed July 5, 2011). A Federal disaster declaration (number 1930) was issued on July 29, 2010, to help Iowans recover from losses caused by severe storms, flooding, and tornados for the incident period June 1 to August 31, 2010 (Federal Emergency Management Agency, 2010). The Federal disaster declaration requested individual assistance for 38 counties and public assistance for 59 counties in Iowa. Private property damage claims reported for residential and nonresidential buildings in nine selected counties in northeast Iowa are shown in table 1 (Bonnie Shepard, Federal Emergency Management Agency, National Flood Insurance Program Bureau and Statistical Agent, written commun., May 2011). Approved public assistance costs (assistance to local governments for the repair of disaster-damaged public facilities) for the same nine counties in Iowa are shown in table 2 (Dennis Harper, Iowa Homeland Security and Emergency Management Division, State Hazard Mitigation Officer, written commun., April 2011).

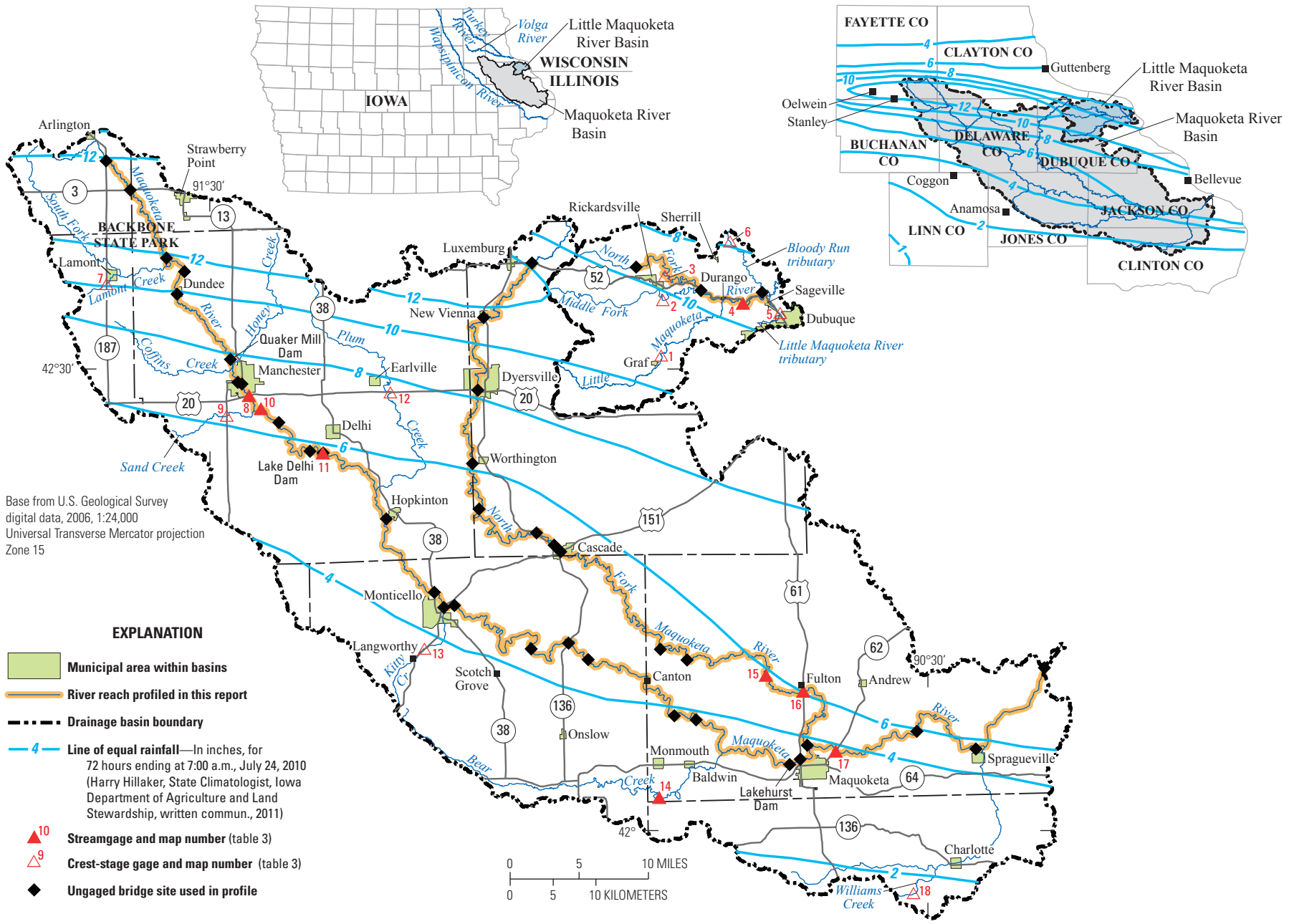


Figure 1. Little Maquoketa River and Maquoketa River Basins and lines of equal rainfall for 72 hours ending at 7:00 a.m. on July 24, 2010.

**Table 1.** National Flood Insurance Program Bureau and Statistical Agent Iowa claims closed with payment for selected counties, July 23–26, 2010, dates of loss, as of February 28, 2011.

[Source: Bonnie Shepard, Federal Emergency Management Agency, National Flood Insurance Program Bureau and Statistical Agent, written commun., May 2011. NC, no claims]

County	Number of claims	Damage payment (dollars)
Buchanan	18	97,125
Clayton	1	35,754
Clinton	NC	NC
Delaware	27	1,425,560
Dubuque	8	178,003
Fayette	7	31,185
Jackson	NC	NC
Jones	12	1,244,501
Linn	4	40,883
<b>Total</b>	<b>77</b>	<b>3,053,011</b>

## Purpose and Scope

This report is part of an on-going program of preparing water-surface profiles of major floods on streams in Iowa. The program is managed by the U.S. Geological Survey (USGS) in cooperation with the Iowa Department of Transportation (Iowa DOT) and the Iowa Highway Research Board (Project HR-140). Flood-peak and water-surface-elevation profile information is needed for the economical and safe location and design of bridges and other structures on or over streams and the adjacent flood plains. Defining the limits of flood inundation and establishing encroachment limits on flood plains are related issues dependent on this information. Data for major floods are needed to compute annual flood-probability discharges and to calibrate water-surface-elevation profile models for sites along streams. A list of other USGS flood-profile reports for Iowa can be obtained by accessing <http://ia.water.usgs.gov/projects/profiles/>.

This report provides information about July 22–24, 2010, rainfall and flooding during July 23–26, 2010, in the Little Maquoketa River and Maquoketa River Basins, and estimated annual flood-probability ranges at eight continuous-record streamgages and ten crest-stage gages (CSG) in the basins. High-water marks (HWMs) at selected sites along the Little Maquoketa and North Fork Little Maquoketa Rivers are presented in a flood profile from U.S. Highway 52 near Dubuque to County Road Y21 (not shown in fig. 1) near Rickardsville, a distance of 19 river miles. HWMs at selected sites along the Maquoketa River are presented in a flood profile from U.S. Highway 52 near Green Island (not shown in fig. 1) to State Highway 187 near Arlington, a distance of 142 river miles. HWMs at selected sites along the North Fork

**Table 2.** Iowa Public Assistance Program project costs for selected counties for disaster number 1930, June–August 2010, as of April 29, 2011.

[Source: Dennis Harper, Iowa Homeland Security and Emergency Management Division, State Hazard Mitigation Officer, written commun., April 29, 2011. NC, no claims]

County	Number of applicants	Debris removal	Emergency protective measures	Roads and bridges	Water control facilities	Buildings and equipment	Utilities	Parks and other	Total
Buchanan	9	26,254	55,037	121,139	NC	3,849	1,370	27,378	235,027
Clayton	6	2,085	14,947	476,510	NC	NC	NC	4,522	498,064
Clinton	0	NC	NC	NC	NC	NC	NC	NC	NC
Delaware	10	64,971	111,463	426,762	14,139	NC	183,060	66,447	866,843
Dubuque	13	121,208	97,095	459,521	29,346	22,572	64,954	97,072	891,768
Fayette	3	3,420	15,729	232,176	28,263	3,400	9,908	7,770	300,667
Jackson	5	17,965	91,999	154,818	NC	NC	4,426	58,955	328,163
Jones	12	46,785	124,761	90,860	0	78,388	251,489	36,716	629,001
Linn	0	NC	NC	NC	NC	NC	NC	NC	NC
<b>Total</b>	<b>58</b>	<b>282,688</b>	<b>511,031</b>	<b>1,961,787</b>	<b>71,749</b>	<b>108,210</b>	<b>515,207</b>	<b>298,860</b>	<b>3,749,532</b>

<sup>1</sup>Cost rounded to whole dollars.

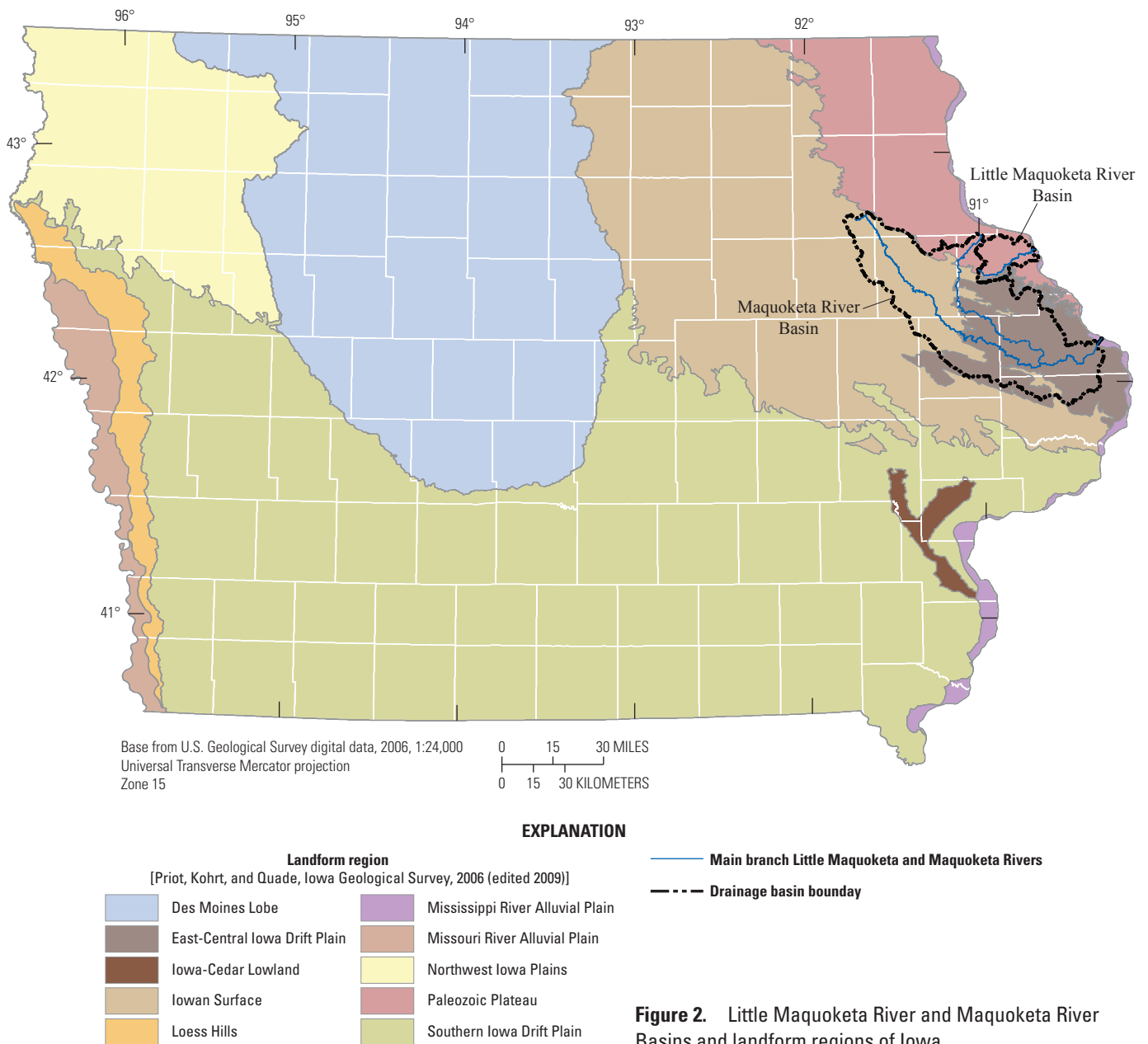
#### 4 Floods of July 23–26, 2010, in the Little Maquoketa River and Maquoketa River Basins, Northeast Iowa

Maquoketa River are presented in a flood profile from Rockdale Road (not shown in fig. 1) near Maquoketa to U.S. Highway 52 near Luxemburg, a distance of 90 river miles.

### Study Area

The Little Maquoketa River and Maquoketa River Basins are adjacent watersheds in northeast Iowa with the Little Maquoketa River Basin draining from west to east and the Maquoketa River Basin draining from northwest to southeast. The two drainage basins, the river reaches profiled, the location of USGS streamgages within these river basins, and the location of bridge sites used in the July 23–26, 2010, flood profiles are shown in figure 1. The Little Maquoketa

River and Maquoketa River Basins lie within three of Iowa's landform regions (fig. 2), the Iowan Surface, the East-Central Iowa Drift Plain, and the Paleozoic Plateau. The Iowan Surface landform region is a low-relief plain with well-established, low-gradient drainage networks. Topography of this region appears slightly inclined to gently rolling with long slopes and open views to the horizon (Prior, 1991). Soils of this region are characterized as thin, discontinuous loess or loam and clay loam over glacial drift (Prior, 1991; Oswald and others, 1965). The East-Central Iowa Drift Plain is similar to the Southern Iowa Drift Plain, and was formerly included as part of the Southern Iowa Drift Plain and the Iowan Surface, but is now considered a separate landform because of its uniqueness (Prior and others, 2009). This region differs from the Southern Iowa Drift Plain with



**Figure 2.** Little Maquoketa River and Maquoketa River Basins and landform regions of Iowa.

bedrock closer to the surface and more bedrock outcropping. Topography of the region consists of steeply rolling hills and valleys. A mantle of loess covers the uplands and upper hill slopes. Soils in this region are characterized as loess over glacial till or limestone bedrock (Oschwald and others, 1965). The Paleozoic Plateau landform region has a bedrock-dominated, erosional topography that is characterized by plateau-like uplands, integrated drainage networks with steep gradients, and deeply entrenched valleys (Prior, 1991; Horick and Soenksen, 1989; Iowa Natural Resources Council, 1958). Stream erosion and hillslope development have stripped away glacial deposits from all but limited areas of this region. Karst topography exists in the Paleozoic Plateau where carbonate rocks are present at depths of less than 50 feet (ft) beneath the land surface. Dissolution of these carbonate rocks (limestone and dolomite) by groundwater enlarges cracks and crevices in the bedrock which can result in surface depressions, sinkholes, caves, caverns, and springs. Where sinkholes have formed in streambeds, streams can abruptly disappear, as surface-water runoff is captured and redirected to groundwater flow or to re-emerge at springs. Soils in this region are characterized as thin loess and glacial drift over bedrock or clay loam till (Prior, 1991; Oschwald and others, 1965). Extensive descriptions of the landform regions are available from Prior (1991) and Prior and others (2009).

The Little Maquoketa River Basin lies entirely within Dubuque County just northwest of the city of Dubuque, Iowa and drains 157 square miles (mi<sup>2</sup>) (Larimer, 1957). The Little Maquoketa River flows about 30 miles (mi) from drainage divide to its mouth at the Mississippi River in northeast Dubuque County; major tributaries include the Middle Fork Little Maquoketa River with a drainage area of 33.2 mi<sup>2</sup> and the North Fork Little Maquoketa River with a drainage area of 70.0 mi<sup>2</sup> that includes the entire Middle Fork Little Maquoketa River Basin (Larimer, 1957). Basin topography is rugged, with many small valleys bounded by steep hills. The lowlands are predominately agricultural and the hillslopes are in forest and pasture. The region is sometimes referred to as the “Little Switzerland of Iowa” (Heinitz, 1973). No dams have been constructed across the Little Maquoketa River or its tributaries (Iowa Conservation Commission, 1979).

The Maquoketa River Basin originates in Fayette County and flows about 150 mi through the cities of Manchester, Monticello, and Maquoketa to its mouth at the Mississippi River in eastern Jackson County (fig. 1). The Maquoketa River Basin includes parts of nine counties and drains 1,879 mi<sup>2</sup> (Larimer, 1957). The North Fork Maquoketa River, a major tributary to the Maquoketa River with a drainage area of 592 mi<sup>2</sup> (Larimer, 1957), originates in Dubuque County and flows about 97 mi through the cities of New Vienna, Dyersville, and Cascade to its mouth in Jackson County. In northwest Delaware County, the Maquoketa River valley changes for a few miles from a gently sloped valley to a rugged gorge in Backbone State Park. Farther downstream in central Delaware County, a few miles southeast of Manchester, the Maquoketa River enters a canyon-like valley that

persists throughout much of the remaining length of the river (Iowa Natural Resources Council, 1958). Land use in the basin is predominately agricultural and includes some wooded areas. Eight low-head dams have been constructed across the Maquoketa River (Iowa Conservation Commission, 1979); no dams have been constructed across the North Fork Maquoketa River. Six of the dams on the Maquoketa River were originally built for hydroelectric power (Iowa Natural Resources Council, 1958); only the Lakehurst Dam upstream from the city of Maquoketa in Jackson County (fig. 1) is currently operating as a hydroelectric dam. Prior to its breach on July 24, 2010, the Lake Delhi Dam was the largest dam on the Maquoketa River, at a height of 38 ft (Iowa Conservation Commission, 1979). Lake Delhi (federally recognized as Hartwick Lake) was approximately 8 mi in length and 450 acres in area prior to the breach of the dam. The local name “Lake Delhi” was adopted by area residents in recognition of the nearby town of Delhi in Delaware County (fig. 1).

## Flood History

Floods on the Little Maquoketa River have been well documented during the operation of the streamgage 05414500 Little Maquoketa River near Durango (fig. 1, site 4) during water years 1935–2000. The only other flood data recorded in the Little Maquoketa River Basin prior to streamgage operation were for the 1925 flood that was documented by the U.S. Army Corps of Engineers (Heinitz, 1973). Heinitz (1973) briefly describes six major storm events (1876, 1918, 1919, 1925, 1937, and 1947) that occurred in the Dubuque area; descriptions for three of these storms are noteworthy for reprinting in this report.

*Storm of 1876.*—One of the largest storms recorded in the area occurred on July 4, 1876, when 40 people were drowned at Rockdale (not shown in fig. 1) on the outskirts of Dubuque. Rainfall of 4.55 inches in 2 hours and 5 minutes was recorded at Dubuque.

*Storm of 1919.*—A storm on July 9, 1919, caused the deaths of seven people. Flooding was the result of 3.81 inches of rain in 4 hours. Great damage occurred to streets in all portions of the city (Dubuque) lying below the bluffs. The USGS made a computation of discharge on the Little Maquoketa River tributary at Dubuque. This is the same stream on which the streamgage 05414600 was located (fig. 1, site 5); however, the discharge computation of 3,000 cubic feet per second (ft<sup>3</sup>/s) was made for a site 0.25 mi upstream from the streamgage with a drainage area of 1.07 mi<sup>2</sup> and this discharge is not entered into the flood record for the streamgage.

*Storm of 1925.*—Rainfall for the month of June at Dubuque was 10.80 inches with most of this resulting from four heavy rainstorms between June 11 and 24. The greatest of these storms occurred on the night of June 14–15 when 3.15 inches of rain fell between 10 p.m. and 4 a.m. A discharge of 29,000 ft<sup>3</sup>/s for the Little Maquoketa River near

Durango was computed by the U.S. Army Corps of Engineers by an indirect measurement. On the Sageville road, this flood was reported to be 0.4 ft higher than the previous record of July 1919.

The flood of August 2, 1972, is the largest known flood in the Little Maquoketa River Basin. A peak discharge of 40,000 ft<sup>3</sup>/s (annual flood-probability estimate of less than 0.2 percent) was recorded at the discontinued streamgage 05414500 Little Maquoketa River near Durango (fig. 1, site 4). The 1972 flood is also the greatest flood on record at streamgage 05414400 Middle Fork Little Maquoketa River (fig. 1, site 2) with a discharge of 23,000 ft<sup>3</sup>/s (annual flood-probability estimate of 0.2 to 1 percent). As much as 9 inches of rain fell in the headwater of the Middle Fork Little Maquoketa River with 6 to 7 inches occurring over most of the Little Maquoketa River Basin (Heinitz, 1973). Flood damages were extensive to crops, roads, and bridges. Many of the homes in Durango, Daytonville (not shown in fig. 1), and Sageville were inundated to some extent and were evacuated. Flood damages were estimated to be greater than 1 million dollars (Heinitz, 1973).

Continuous records of streamflow have been collected in the Maquoketa River Basin since September 1913 at streamgage 05418500 Maquoketa River near Maquoketa (fig. 1, site 17). Descriptions of historic floods in the Maquoketa River Basin are limited; available information is summarized for floods that occurred in the Maquoketa River Basin in 1925, 1944, 1947, and 2002 in the report *Flood of June 4–5, 2002, in the Maquoketa River Basin, East-Central Iowa* (Eash, 2005), and is summarized for the flood that occurred in 2004 in the report *Flood of May 23, 2004, in the Turkey and Maquoketa River Basins, Northeast Iowa* (Eash, 2006).

Peak stages and discharges, and the corresponding annual flood-probability ranges for the largest known floods, including the July 2010 flood, are listed in table 3 for streamgages in the Little Maquoketa River and Maquoketa River Basins. The streamgages listed in table 3 also are listed in the USGS National Water Information System (NWIS) database, and users may obtain surface-water data for Iowa streamgages, including information on types of data available and years of data collection, at <http://waterdata.usgs.gov/ia/nwis/sw>.

## Floods of July 23–26, 2010

The floods of July 23–26, 2010, are some of the largest floods on record in the Maquoketa River Basin (table 3). The 2010 flood is the largest flood on record at streamgages 05416900 Maquoketa River at Manchester (fig. 1, site 8) and 05418400 North Fork Maquoketa River near Fulton (fig. 1, site 15). At streamgage 05418500 Maquoketa River near Maquoketa (fig. 1, site 17), the 2010 flood is the third largest flood on record; the peak discharge of the 2010 flood at this site was affected by the Lake Delhi Dam breach on July 24. Within the Little Maquoketa River Basin, the flood at the

discontinued streamgage 05414500 Little Maquoketa River near Durango (fig. 1, site 4) is the sixth largest flood on record.

## Annual Flood Probability

Annual flood probability, also referred to as annual exceedance probability, is an estimate of the likelihood of a flood of a specific magnitude occurring in any 1 year, and an annual flood-probability range expresses the uncertainty of estimating precise annual flood probabilities. The reporting ranges are as follows: greater than 10 percent, 4 to 10 percent, 2 to 4 percent, 1 to 2 percent, 0.2 to 1 percent, and less than 0.2 percent. The range is determined from the estimated annual flood-probability discharges that bracket the observed flood-peak discharge. If the observed peak discharge is the same value as an estimated annual flood-probability discharge, the lower annual flood-probability range is used. In the “Flood Description” section, flood discharges and their respective annual flood-probability ranges are discussed and are listed in table 3. Unless noted otherwise, annual flood-probability estimates listed in table 3 were computed using the Weighting of Independent Estimates (WIE) program (Charles Berenbrock and Tim Cohn, U.S. Geological Survey, written commun., 2008) following guidelines in appendix 8 of Bulletin 17B (Interagency Advisory Committee on Water Data, 1982). The WIE program uses the variance and estimate of the Bulletin 17B annual streamgage-probability analysis and the variance and estimate of the regional-regression annual probability calculation (Eash, 2001) to compute a weighted estimate and variance at a streamgage. As noted in table 3, the WIE program was not used to estimate annual flood probabilities for streamgages with basin characteristic values outside of the applicable range of characteristic values used to develop the regional-regression annual probability calculations, in which case only Bulletin 17B annual streamgage-probability analyses were used.

Annual flood probabilities change as streamflow records get longer. Bulletin 17B annual probability analyses are computed for streamgages using annual peak-discharge data. As additional annual peak discharges are measured at streamgages, Bulletin 17B annual probability estimates are updated and become more statistically reliable. A minimum of 10 years of record is required to compute Bulletin 17B annual streamgage-probability estimates.

Annual flood probabilities formerly were reported as flood recurrence intervals expressed in years. For example, a 1-percent annual flood-probability discharge is the same as the 100-year recurrence-interval flood discharge. But, because of widespread confusion caused in recent years by two or more “100-year floods” occurring in a period of much less than 100 years, the scientific and engineering community has begun expressing the annual likelihood of occurrence of flood discharges as a probability. Percent probability is the inverse of the recurrence interval multiplied by 100. Selected annual flood probabilities and equivalent flood recurrence intervals

**Table 3.** Maximum stages and discharges for 2010 and selected largest-flood years, and the corresponding annual flood-probability ranges, at streamgages in the Little Maquoketa River and Maquoketa River Basins, Iowa.[mi<sup>2</sup>, square miles; ft, feet; ft<sup>3</sup>/s, cubic feet per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic feet per second per square mile; >, greater than; <, less than; --, not determined]

Map number (fig. 1)	Streamgage number and name	Peak-flow record (water years)	Drainage area (mi <sup>2</sup> )	Date of peak	Peak stage (ft)	Peak discharge (ft <sup>3</sup> /s)	Annual flood probability range <sup>1</sup> (percent)	Unit runoff [(ft <sup>3</sup> /s)/mi <sup>2</sup> ]
Little Maquoketa River Basin								
1	05414350 Little Maquoketa River near Graf, Iowa	1951–2010	39.6	6/4/2002 6/8/2008 <b>7/23/2010</b>	15.93 16.47 <b>13.15</b>	7,700 8,370 <b>4,830</b>	2–4 2–4 <b>&gt;10</b>	194.4 211.4 <b>122.0</b>
2	05414400 Middle Fork Little Maquoketa River near Rickardsville, Iowa	1951–2010	30.2	8/2/1972 4/13/1991 <b>7/23/2010</b>	27.70 21.81 <b>19.86</b>	23,000 13,400 <b>8,690</b>	0.2–1 1–2 <b>4–10</b>	761.6 443.7 <b>287.7</b>
3	05414450 North Fork Little Maquoketa River near Rickardsville, Iowa	1951–2010	21.6	8/2/1972 6/8/2008 <b>7/23/2010</b>	14.02 12.58 <b>10.54</b>	7,180 8,040 <b>4,200</b>	1–2 0.2–1 <b>4–10</b>	332.4 372.2 <b>194.4</b>
4	05414500 Little Maquoketa River near Durango, Iowa (discontinued)	1925, 1935–2000, 2010	130	8/2/1972 6/15/1925 <b>7/23/2010</b>	23.13 22.10 <b>20.76</b>	40,000 <sup>2</sup> 29,000 <b><sup>2</sup>19,000</b>	<0.2 0.2–1 <b>4–10</b>	307.7 223.1 <b>146.2</b>
5	05414600 Little Maquoketa River tributary at Dubuque, Iowa	1951–2002	1.54	7/31/1957	7.98	<sup>2</sup> 1,650	2–4	1,071.4
6	05414605 Bloody Run Tributary near Sherrill, Iowa	1991–2010	0.59	6/8/2008 <b>7/23/2010</b>	22.71 <b>13.06</b>	1,110 <b>144</b>	<sup>3</sup> 2–4 <b><sup>3</sup>&gt;10</b>	1,881.4 <b>244.1</b>
Maquoketa River Basin								
7	05416200 Lamont Creek tributary near Lamont, Iowa	1991–2010	1.78	4/25/2008 <b>7/23/2010</b>	23.18 <b>20.22</b>	1,190 <b>647</b>	4–10 <b>&gt;10</b>	668.5 <b>363.5</b>
8	05416900 Maquoketa River at Manchester, Iowa	2001–10	275	5/23/2004 5/26/2008 <b>7/24/2010</b>	21.66 20.80 <b>24.48</b>	26,000 22,100 <b>26,600</b>	<sup>4</sup> 0.2–1 <sup>4</sup> 1–2 <b><sup>4</sup>0.2–1</b>	94.5 80.4 <b>96.7</b>
9	05416972 Sand Creek near Manchester, Iowa	1991–10	11.0	6/4/2002 10/8/2007 <b>7/23/2010</b>	19.31 20.95 <b>15.48</b>	<sup>2</sup> 4,290 5,090 <b>2,390</b>	2–4 1–2 <b>&gt;10</b>	390.0 462.7 <b>217.3</b>
10	05417000 Maquoketa River near Manchester, Iowa (discontinued)	1925, 1928–30, 1933–73, 1976–83	305	6/15/1925 6/13/1947 7/9/1951	-- 21.36 19.65	<sup>5</sup> 25,400 20,000 16,800	<sup>6</sup> 1–2 <sup>6</sup> 2–4 <sup>6</sup> 4–10	83.3 65.6 55.1
11	05417500 Maquoketa River near Delhi (discontinued)	1929, 1933–40	347	3/14/1929	89.82	7,360	<sup>7</sup> --	21.2
12	05417530 Plum Creek at Earlville, Iowa (discontinued)	1966–91	41.1	9/13/1972 6/21/1974 9/26/1981	88.34 88.75 88.22	<sup>2</sup> 4,800 <sup>2</sup> 6,200 <sup>2</sup> 4,500	4–10 2–4 4–10	116.8 150.9 109.5
13	05417590 Kitty Creek near Langworthy, Iowa (discontinued)	1966–92	14.4	7/19/1969 7/8/1986	90.24 88.68	<sup>8</sup> 3,700 2,100	2–4 4–10	256.9 145.8
14	05417700 Bear Creek near Monmouth, Iowa (discontinued)	1944, 1958–76	61.3	6/--/1944 9/21/1965	<sup>9</sup> 21.50 13.76	-- 7,340	-- 2–4	-- 119.7

## 8 Floods of July 23–26, 2010, in the Little Maquoketa River and Maquoketa River Basins, Northeast Iowa

**Table 3.** Maximum stages and discharges for 2010 and selected largest-flood years, and the corresponding annual flood-probability ranges, at streamgages in the Little Maquoketa River and Maquoketa River Basins, Iowa.—Continued

[mi<sup>2</sup>, square miles; ft, feet; ft<sup>3</sup>/s, cubic feet per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic feet per second per square mile; >, greater than; <, less than; --, not determined]

Map number (fig. 1)	Streamgage number and name	Peak-flow record (water years)	Drainage area (mi <sup>2</sup> )	Date of peak	Peak stage (ft)	Peak discharge (ft <sup>3</sup> /s)	Annual flood probability range <sup>1</sup> (percent)	Unit runoff [(ft <sup>3</sup> /s)/mi <sup>2</sup> ]
Maquoketa River Basin—Continued								
15	05418400 North Fork Maquoketa River near Fulton, Iowa	1999–2010	505	6/5/2002	19.87	22,600	<sup>10</sup> 2–4	44.8
				6/13/2008	18.67	20,700	<sup>10</sup> 2–4	41.0
				<b>7/24/2010</b>	<b>22.44</b>	<b>25,000</b>	<sup>10</sup> <b>1–2</b>	<b>49.5</b>
16	05418450 North Fork Maquoketa River at Fulton, Iowa (discontinued)	1974, 1977–91, 2002	516	6/5/2002	21.21	<sup>2</sup> 22,600	2–4	43.8
17	05418500 Maquoketa River near Maquoketa, Iowa	1903, 1914–2010	1,553	--/--/1903	<sup>11</sup> 23.50	43,200	2–4	27.8
				6/27/1944	<sup>11</sup> 24.70	48,000	1–2	30.9
				6/5/2002	34.09	47,900	1–2	30.8
				<b>7/26/2010</b>	<b>35.26</b>	<sup>12</sup> <b>46,000</b>	<sup>13</sup> --	<sup>12</sup> <b>29.6</b>
18	5418645 Williams Creek near Charlotte, Iowa	1989–2010	1.77	5/29/1996	13.02	<sup>2</sup> 990	4–10	559.3
				<b>7/24/2010</b>	<b>11.76</b>	<b>598</b>	<b>&gt;10</b>	<b>337.9</b>

<sup>1</sup>Annual flood-probability ranges reflect the uncertainty of estimating annual flood-probability discharges. The annual flood probability is calculated using established techniques but then reported in one of the following ranges: greater than 10 percent, 4 to 10 percent, 2 to 4 percent, 1 to 2 percent, 0.2 to 1 percent, and less than 0.2 percent. Unless noted otherwise, annual flood-probability ranges are based on a weighted average of two independent probability estimates. The WIE (weighting of independent estimates) program was used to estimate annual flood probabilities following guidelines in Appendix 8 of Bulletin 17B (Interagency Advisory Committee on Water Data, 1982; Charles Berenbrock and Tim Cohn, U.S. Geological Survey, written commun., 2008). The WIE program uses the variance and estimate of the Bulletin 17B annual streamgage-probability analysis and the variance and estimate of the regional-regression annual probability calculation (Eash, 2001) to compute a weighted probability estimate and variance at a streamgage.

<sup>2</sup>Estimate.

<sup>3</sup>Computed using Bulletin 17B annual streamgage-probability analysis (Interagency Advisory Committee on Water Data, 1982) because regional-regression equations are not applicable.

<sup>4</sup>Annual flood-probability estimates are based on inclusion of additional annual-peak discharges from discontinued downstream streamgage (05417000).

<sup>5</sup>Discharge computed by Prof. F.A. Nagler, University of Iowa (U.S. Geological Survey, 1964).

<sup>6</sup>Flood-probability estimates are based on inclusion of additional annual-peak discharges from active upstream streamgage (05416900).

<sup>7</sup>Annual flood probability not determined because all peak discharges are regulated by upstream dam.

<sup>8</sup>Discharge computed from indirect measurement.

<sup>9</sup>Stage affected by backwater.

<sup>10</sup>Annual flood-probability estimates are based on inclusion of additional annual-peak discharges from discontinued downstream streamgage (05418450).

<sup>11</sup>Prior to Sept. 30, 1972, streamgage at different site and datum.

<sup>12</sup>Peak discharge affected by Lake Delhi Dam failure on July 24.

<sup>13</sup>Annual flood probability not determined because peak discharge affected by Lake Delhi Dam failure. Magnitude of peak discharge is equivalent to that of a natural flood with an annual flood-probability range of 1 to 2 percent.



are listed in table 4. Although the annual probability is an estimate of the likelihood of a flood discharge of a specific magnitude occurring in any one year, more than one flood discharge with a specific magnitude and annual probability could occur in the same year.

**Table 4.** Annual flood probability and equivalent flood recurrence interval for selected probabilities.

Annual flood probability (percent)	Recurrence interval (years)
20	5
10	10
4	25
2	50
1	100
.5	200
.2	500

## Storm Description

The floods of July 23–26, 2010, were the result of a series of thunderstorms that crossed northeast Iowa during July 22–24. The storms were part of an exceptionally wet period for Iowa from June through September 2010 that followed a wetter than normal first half of the year. A new statewide rainfall record of 10.34 inches was set for the month of June; the old record of 10.33 inches occurred in 1947. Overall, 2010, with an average statewide rainfall of 44.81 inches, was the second wettest year in Iowa in 138 years of record (Hillaker, Iowa Preliminary Annual Weather Summary–2010, <http://www.iowaagriculture.gov/climatology/weatherSummaries/2010/pas2010.pdf>; accessed June 28, 2010). Although rainfall during July 2010 was not as great as in June, it was more intense for shorter periods of time, which resulted in greater flooding; the greatest rain event in July occurred on the night of the 22nd when the Oelwein rain gage officially recorded 9.93 inches. An additional 3 to 4 inches of rain fell over the same areas of northeast Iowa the next night. An exceptional rainfall total of 20.33 inches for the month of July at Oelwein far exceeded the old monthly record of 13.30 inches for June 1925 (Hillaker, 2010).

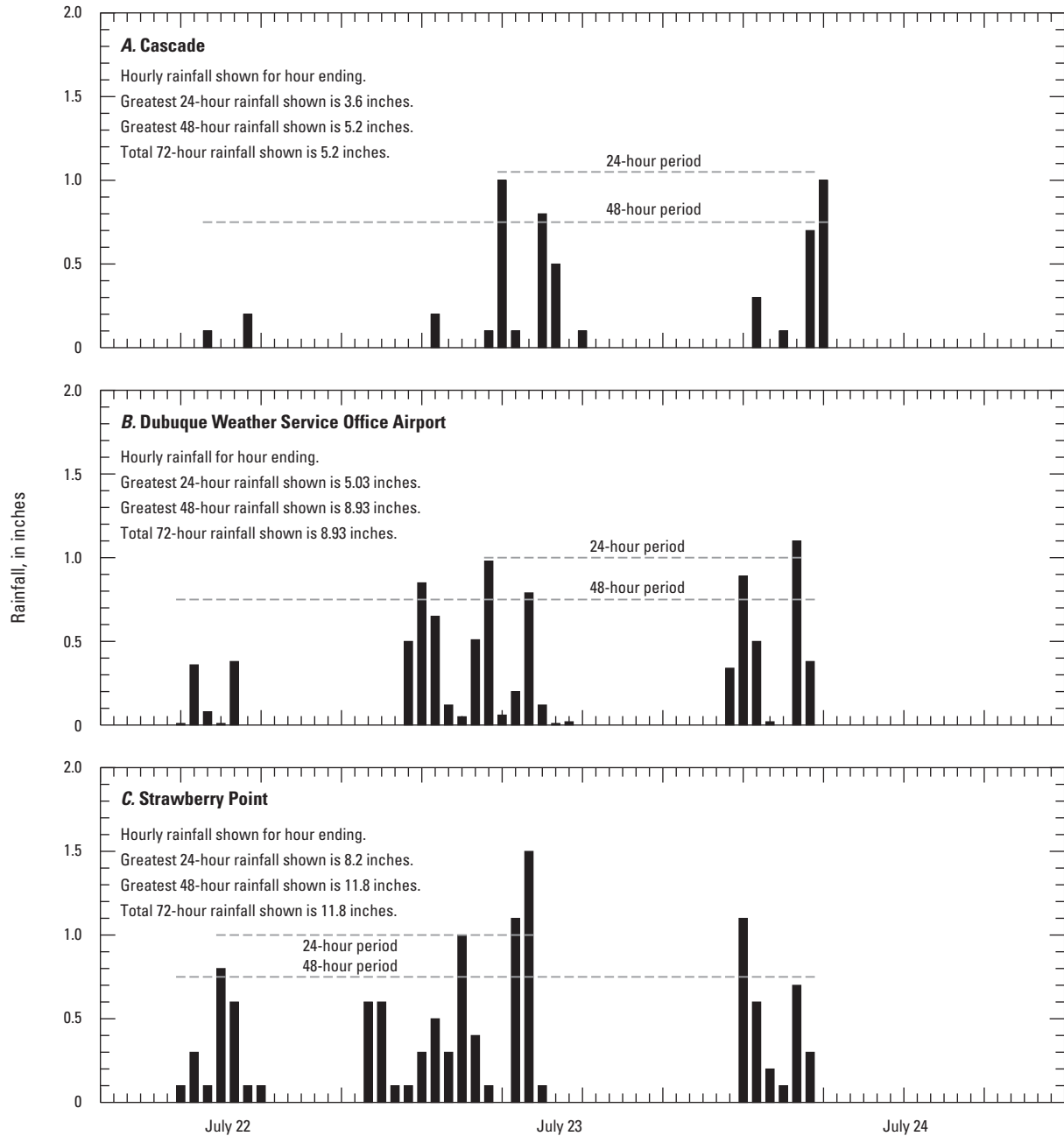
The following rainfall and flood information is from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center (2010a) <http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~storms> (search terms *Iowa*, *7/22/2010 to 7/24/2010*, and *flood* were entered to obtain a list of 61 flood events; the following quotes were obtained from event numbers (22) Oelwein, (24) Lamont, (38) Backbone State Park, and (46) Arlington).

*“Several rounds of thunderstorms [beginning on July 22] developed along a slow moving cold front. These thunderstorms stretched across much of*

*southern Wisconsin into north central and central Iowa. The thunderstorms tracked repeatedly over the same areas dropping several inches of rain across Fayette and Clayton Counties which resulted in flooding problems on July 22nd into the 23rd. Thunderstorms with extremely heavy rain developed [overnight on July 22] along a stationary front and moved from northeast Iowa into northwest Illinois. Some locations measured 5 to 7 inches of rainfall, causing localized flash flooding and pushing numerous creeks out of their banks. The North Fork Maquoketa River through Dubuque County was particularly hard-hit. This round of rainfall further set the stage for the extreme flooding that developed with the next round of storms later that night [July 23]. After about 10 inches of rain fell in the upper Maquoketa River basin, the river surged to record stage levels. Thunderstorms developed along a cold front and swept across northeast Iowa for a second [consecutive] night [July 23]. These storms brought additional heavy rains producing more flood problems on July 23 and 24th.”*

Hourly rainfall amounts for July 22–24, 2010, for rain gages at Cascade, Dubuque, and Strawberry Point are shown in figure 3 (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2010b). The graphs provide a general indication of the timing and intensity of the rainfall in the Little Maquoketa River Basin and the upper and central parts of the Maquoketa River Basin. The greatest 1-hour rainfall intensity of 1.5 inches occurred at Strawberry Point ending at 8 a.m. on July 23 (fig. 3C). Data from the three rain gages (fig. 3) indicate that much of the rainfall occurred during a 48-hour period from 6 a.m. on July 22 to 6 a.m. on July 24, and also indicate that Strawberry Point recorded the greatest 24-hour and 48-hour rainfall of 8.2 inches and 11.8 inches, respectively.

An isohyetal map of the areal distribution of rainfall for the 72-hour period beginning at 7:00 a.m. on July 21 and ending at 7:00 a.m., on June 24, 2010, is shown in figure 1; data were provided by Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship (written commun., June 2011). The isohyetal map shows a band of over 12 inches of rainfall in the headwaters of the Maquoketa River Basin upstream of Backbone State Park. Each 24-hour rainfall amount from July 22 to July 24, 2010, for 12 selected rain gages in northeast and east-central Iowa is listed in table 5 (Hillaker, 2010). The 72-hour rainfall total listed in table 5 from July 22–24 is the time period for which the most significant rainfall could be considered directly contributing to the flooding of July 23–26; although, essentially all rainfall within the Little Maquoketa River and Maquoketa River Basins fell within a 48-hour period (Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship, written commun., June 2011). Seventy-two hour rainfall totals ending on July 24 of 7.33 and 12.23 inches were recorded at Manchester and Strawberry Point, respectively.



**Figure 3.** Hourly rainfall for July 22–24, 2010, at three rain gages in the Maquoketa River Basin and vicinity. (Central Daylight Time; U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center, 2010b).

**Table 5.** Twenty-four-hour rainfall amounts at selected rain gages in northeast and east-central Iowa during July 22–24, 2010.

[T, Trace]

Rain gage	Observation time	24-hour rainfall, in inches <sup>1</sup>			Greatest 48-hour rainfall total, in inches	72-hour rainfall total, in inches
		July 22, 2010	July 23, 2010	July 24, 2010		
Anamosa 1 WNW	8 a.m.	0	0.95	1.50	2.45	2.45
Bellevue Lock and Dam 12	7 a.m.	0	3.85	2.45	6.30	6.30
Cascade	8 a.m.	.13	2.50	2.86	5.36	5.49
Coggon	7 a.m.	.15	.25	3.08	3.33	3.48
Dubuque Lock and Dam 11	7 a.m.	.15	7.18	2.10	9.28	9.43
Dubuque Airport	1 a.m.	<sup>2</sup> 2.84	<sup>3</sup> 4.59	<sup>4</sup> 1.5	7.43	8.93
Guttenberg Lock and Dam 10	7 a.m.	.05	3.94	2.70	6.64	6.69
Manchester-2	8 a.m.	.52	3.89	2.92	6.81	7.33
Maquoketa 4 W	8 a.m.	T	.43	2.50	2.93	2.93
Oelwein 1 E	8 a.m.	.22	9.93	3.16	13.09	13.31
Stanley 4 W	7 a.m.	.39	6.84	3.22	10.06	10.45
Strawberry Point	8 a.m.	.53	8.51	3.19	11.70	12.23

<sup>1</sup> Iowa Climate Review (Hillaker, 2010).<sup>2</sup> July 23, 2010.<sup>3</sup> July 24, 2010.<sup>4</sup> July 25, 2010

The *Rainfall Frequency Atlas of the Midwest* (Huff and Angel, 1992) provides a table of the mean distribution of theoretical rainfall amounts for climatological divisions in Iowa for selected rain periods and annual probabilities (recurrence intervals). The magnitude and annual probability of theoretical rainfall amounts for selected rain periods (durations) from the table in Huff and Angel (1992) for 2 of the 9 climatological divisions in Iowa are listed in table 6. Eight of the 12 rain gages listed in table 5 are in the Northeast Iowa Climatological Division and four are located in the East-Central Climatological Division (Hillaker, 2010). A map showing the location of climatological divisions in Iowa is available on page 4 of Huff and Angel (1992) at <http://www.isws.illinois.edu/pubdoc/B/ISWSB-71.pdf>, accessed July 6, 2011. The greatest 48-hour rainfalls listed in table 5 exceeded 6.34 inches at seven rain gages all located in the Northeast Climatological Division (Dubuque Lock and Dam 11, Dubuque Airport, Guttenberg Lock and Dam 10, Manchester, Oelwein, Stanley, and Strawberry Point). Annual rainfall probabilities for greatest 48-hour rainfalls for two of these rain gages (Guttenberg and Manchester) are estimated to be 1 to 2 percent, and for the other five of these seven rain gages, annual rainfall probabilities are estimated to be less than 1 percent (table 6).

**Table 6.** Magnitude and annual probability of theoretical rainfall amounts for selected storm periods in the East-Central and Northeast Iowa Climatological Divisions.

[Rainfall amounts from Huff and Angel, (1992)]

Duration (hours)	East-Central			
	Rainfall (inches) for indicated annual probabilities			
	10 (percent)	4 (percent)	2 (percent)	1 (percent)
24	4.44	5.42	6.25	7.13
48	5.05	6.02	6.87	7.83
72	5.31	6.42	7.35	8.42
120	5.61	6.70	7.75	9.00
240	7.12	8.25	9.27	10.35
Duration (hours)	Northeast			
	Rainfall (inches) for indicated annual probabilities			
	10 (percent)	4 (percent)	2 (percent)	1 (percent)
24	4.31	5.11	5.73	6.36
48	4.69	5.62	6.34	7.09
72	5.14	6.19	7.00	7.84
120	5.64	6.84	7.75	8.77
240	7.07	8.29	9.20	10.19

Annual probabilities for two different components of a hydrologic event—rainfall and runoff, respectively—and for various locations in the Little Maquoketa River and Maquoketa River Basins are listed in tables 3 and 6. Similar to the concept of annual flood probability, annual rainfall probability is an estimate of the likelihood of a rainfall of a specific magnitude occurring in any one year, more than one rainfall with a specific magnitude and annual probability could occur in the same year.

## Flood Description

Minor flooding occurred July 23, 2010, in the Little Maquoketa River Basin and major flooding occurred July 23–26, 2010, in the Maquoketa River Basin as a result of the intense rain that fell during July 22–24. The 2010 peak discharges for 11 streamgages in the Little Maquoketa River and Maquoketa River Basins are listed in table 3. Also listed in the table are selected historical peak discharges for the largest-flood years.

Hydrographs of instantaneous discharges measured at continuous-record streamgages on the Maquoketa River and the North Fork Maquoketa River are presented in figure 4. The period shown is July 22 to July 29, 2010. The streamgages record instantaneous values at 15-minute time intervals. Also shown on the hydrographs are lines denoting discharge estimates for selected annual flood probabilities. The annual flood-probability range listed in table 3 for the sites is the range between the annual flood-probability discharges that bracket the flood peak discharge. For example, the 2010 peak discharge at streamgage 05416900 Maquoketa River at Manchester, Iowa (fig. 1, site 8) falls between the 1-percent and 0.2-percent annual flood-probability estimates (table 3; fig. 4).

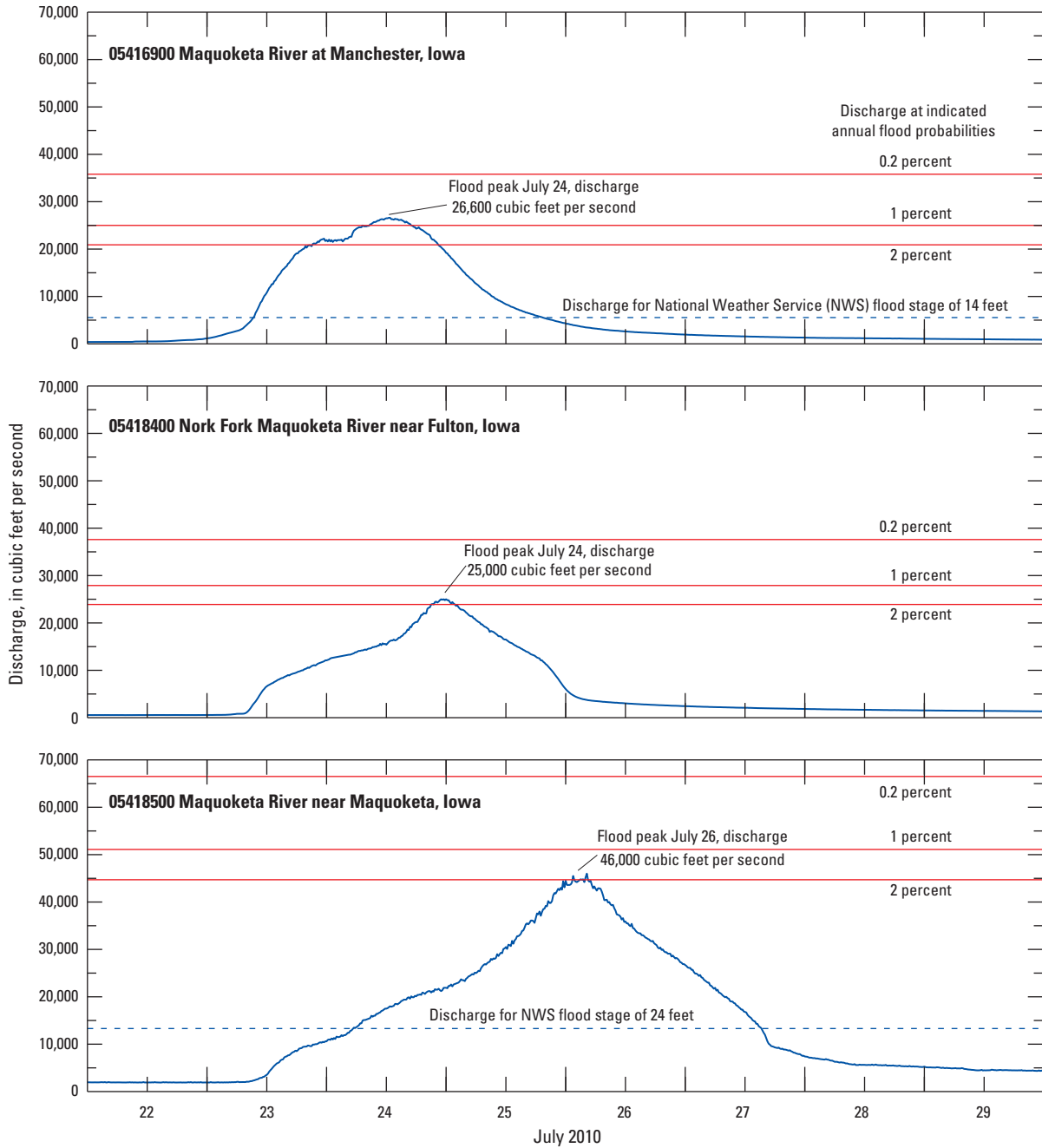
## Little Maquoketa River Basin

The 2010 flood caused minor flooding (annual flood probability greater than 4 percent) in the Little Maquoketa River Basin on July 23, 2010, at four active streamgages located on small drainage-area tributaries (fig. 1, sites 1–3 and 6) and at a discontinued mainstem streamgage located in the lower reach of the basin (fig. 1 site 4). Of the four tributaries, the streamgage 05414450 Middle Fork Little Maquoketa River near Rickardsville recorded the greatest peak discharge of 8,690 ft<sup>3</sup>/s (table 3). The 2010 flood at this site is estimated to have an annual probability of 4 to 10 percent. At the discontinued streamgage 05414500 Little Maquoketa River near Durango, a peak discharge of 19,000 ft<sup>3</sup>/s was estimated on the basis of the stage-discharge rating curve that was in effect during the 2000 water year. The 2010 flood at this site is the sixth largest known flood in the basin since at least 1925, and the annual probability of this peak discharge is estimated to be 4 to 10 percent (table 3).

## Maquoketa River Basin

Flooding began on July 23 at streamgages 05416900 Maquoketa River at Manchester (fig. 1, site 8) and 05418400 North Fork Maquoketa River near Fulton (fig. 1, site 15). The peak discharge at both of these streamgages occurred on July 24 (fig. 4); the flood peaked at the Manchester streamgage at 12:30 p.m. with a discharge of 26,600 ft<sup>3</sup>/s and at the Fulton streamgage at 11:00 p.m. with a discharge of 25,000 ft<sup>3</sup>/s. The 2010 flood is the largest known flood at both the Manchester and Fulton streamgages. The annual flood-probability range of the 2010 flood at the Manchester streamgage is estimated to be 0.2 to 1 percent and at the Fulton streamgage is estimated to be 1 to 2 percent (table 3). The peak discharge at streamgage 05418500 Maquoketa River at Maquoketa (fig. 1, site 17) on July 26 at 4:15 a.m. (fig. 4) occurred after the breach of the Lake Delhi Dam on July 24. The dam is located approximately 74 river miles upstream from the Maquoketa streamgage. Because the peak discharge of 46,000 ft<sup>3</sup>/s at the Maquoketa streamgage was affected by the dam breach, an annual flood probability was not determined for the 2010 flood at this site (table 3). The magnitude of the 2010 peak discharge at the Maquoketa streamgage is equivalent to that of a natural flood with an annual flood-probability range of 1 to 2 percent. Peak discharges at the three streamgages shown in figure 4 were determined from rating curves that were verified by discharge measurements made near the time of occurrence of the respective peaks.

For informational purposes, also shown on two of the hydrographs, are the discharges corresponding to the National Weather Service (NWS) designated flood stage (fig. 4). The flood stages represent “an established gage height for a given location at which a rise in water surface level begins to impact lives, property, or commerce” (<http://www.weather.gov/directives/sym/pd01009050curr.pdf>, accessed September 13, 2011). The discharges corresponding to the NWS flood stages were determined from the respective USGS stage-discharge rating curves in use at the time of the flood. At streamgage 05416900 Maquoketa River at Manchester, the NWS flood stage is 14.0 ft (discharge 5,550 ft<sup>3</sup>/s), which is the stage that water affects West Main Street and residences on the south side of town (at <http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=mchi4&view=1,1,1,1,1,1,1>”, accessed September 13, 2011). The streamgage Maquoketa River at Manchester was above flood stage during July 23–25, and the peak stage of 24.48 ft (table 3) exceeded the flood stage by 10.48 ft. At streamgage 05418500 Maquoketa River near Maquoketa, the NWS flood stage is 24.0 ft (discharge 13,300 ft<sup>3</sup>/s), which is the stage that water affects agricultural land in the Maquoketa area and several storm sewers in town (at <http://water.weather.gov/ahps2/hydrograph.php?wfo=dvn&gage=maqi4&view=1,1,1,1,1,1,1>”, accessed September 13, 2011). The streamgage Maquoketa River near Maquoketa was above flood stage during July 24–27, and the peak stage of 35.26 ft (table 3) exceeded the flood stage by 11.26 ft.



**Figure 4.** Discharge hydrographs for streamgages on the Maquoketa River and the North Fork Maquoketa River, July 22–29, 2010.

The NWS has not determined a flood stage at streamgage 05418400 North Fork Maquoketa River near Fulton.

## Chronology of Flood Impacts

The following flood description information was obtained from newspaper articles posted online by the *Des Moines Register* (Finney, July 24, 2010), the *Gazette* (David DeWitte, July 26, 2010a, July 26, 2010b), the *Associated Press* (July 25, 2010), and the *Telegraph Herald* (Andy Piper and Michael Schmidt, July 24, 2010; Eileen Mozinski Schmidt, July 26, 2010); and from on-line sources obtained from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Climatic Data Center (2010a) and from *KCRG-TV* (Dave DeWitte, July 26, 2010c).

In New Vienna, near the headwaters of the North Fork Maquoketa River, Fire Chief Henry Westhoff, reported the river crested at 5:30 a.m. on July 23, 2010, about 2 ft higher than ever before, and that the river returned to within its banks at about 11 a.m. Further downstream in Dyersville, Candy Cane and West Side parks were inundated with several feet of water where the North Fork Maquoketa River, Bear Creek, and Hewitt Creek converge on the southwest side of the city. Tim Pins, Dyersville Fire Chief, reported the flood water rose very quickly, noting that the North Fork Maquoketa River topped its banks at about 3 a.m. and crested at 14 ft at 9:20 a.m. on July 23. Residents on the west side of Third Avenue in Dyersville suffered flooded basements. Also on the morning of July 23, in the upper part of the Maquoketa River Basin, flash flooding occurred in Lamont where city crews had to sandbag the lift pump station due to rising flood waters. In Manchester, the Maquoketa River was reported to have been rising at about 1-foot per hour; the Delaware County Emergency Management and the City of Manchester decided to close West Main Street between Franklin Avenue and Legions Street around 11:30 a.m. Jack Klaus, Delaware County Emergency Management noted the closing of West Main Street usually occurs when the river stage reaches 17 ft. Several Manchester streets and county roads were closed due to dangerous conditions. Numerous homes in Manchester and several buildings in the downtown area were flooded, and utilities were shut off to parts of the city that were considered to be at risk of flooding. Four to five ft of water filled some homes and businesses; many basements filled with water and several basement walls were reported to have collapsed. A man in town escaped a life-threatening situation when a sinkhole developed in a parking lot and the skidloader he was driving collapsed into the raging Maquoketa River beneath the parking lot. Downstream of Manchester, some campers and residents on Lake Delhi had to be rescued by boat overnight on July 23. Numerous properties were damaged along the Maquoketa River, including about 500 homes and the marina bordering Lake Delhi. Also, overnight on July 23, the main street in Arlington, in southeastern Fayette County, was reported impassable due to rising waters.

On July 24, water from the Maquoketa River began flowing over the Delhi Dam at 10:30 a.m.; by 1:00 p.m., a 30-ft section of road, rock, and earthen embankment broke loose and a torrent of river water raged through, destroying at least five homes and threatening the town of Hopkinton downstream. Boats, propane tanks, and a construction barge crashed through the breach and tumbled downstream. Downstream of the dam, County Road D47 was closed as water from the dam submerged the bridge near Hopkinton. Craig Wilson, Hopkinton Fire Chief, ordered half the town to evacuate; he began allowing residents to return to their homes in the afternoon of July 24. Aircraft from the Iowa State Patrol monitored the surge of water from the dam breach and reported that the surge slowed upstream of Hopkinton where the flood plain attenuated the flood waters. On the southeast side of Hopkinton, about five homes were flooded. Police Chief Britt Smith reported that downstream along the Maquoketa River in Monticello about 50 homes, including two mobile home parks, were evacuated. U.S. Business Highway 151/Main Street in Monticello was one of about a dozen roads closed by the weekend flooding of the Maquoketa and Wapsipinicon Rivers in Jones County, reported Mike McClain, Jones County Engineer, the road closures also included County Road E17 and State Highway 136 north of Onslow. Minor damage was reported for a stretch of State Highway 38. Downstream of Monticello near Scotch Grove, the Maquoketa River flood washed away the privately owned Corbett's Mill Bridge, a historic bowstring (or tied-arch bridge) built in 1871. Further downstream along the Maquoketa River in the city of Maquoketa, emergency workers and area residents teamed up on July 25 to build a wall of sandbags at the intersection of North Main Street and Pershing Road to prevent flooding of the city's wastewater plant, electric plant, and water treatment facility, reported Al Muhlhausen, Assistant Fire Chief for the City of Maquoketa. The dam breach at Lake Delhi flooded agricultural land downstream of the dam. On July 26, 2010, Keith Krause, Delaware County District Conservationist, Natural Resources Conservation Service (NRCS), estimated that 2,000 acres of crop land and 2,000 acres of pasture were inundated along the Maquoketa River; Virgil Schmitt, extension field agronomist for Iowa State University, said it was too late in the year for farmers to replant lost crops.

## Breach of Lake Delhi Dam

Lake Delhi Dam was built between 1922 and 1929 by the Interstate Power Company for hydroelectric power generation. In 1974, the Lake Delhi Recreation Association bought the dam and has owned it since then. Jon Garton, Iowa Department of Natural Resources dam safety engineer, reported that Lake Delhi Dam was used to maintain water levels in the upper and lower parts of the lake for recreational purposes and it was not used for flood control downstream of Lake Delhi (Lynch, *The Gazette*, July 26, 2010). Detailed information on the breach of Lake Delhi Dam is available from the *Report on*

*Breach of Delhi Dam* (Independent Panel of Engineers, 2010). The crest of Lake Delhi Dam is at elevation 904.8 ft and the spillway crest is at 879.8 ft NGVD 29 (the peak-flood elevation at the dam determined by the USGS was 905.55 ft). The cause of the dam breach was internal erosion in the embankment coupled with overtopping flow which resulted in an estimated peak breach outflow of about 69,000 ft<sup>3</sup>/s (Independent Panel of Engineers, 2010).

## Flood Profile

To develop profiles of the 2010 floods for the Little Maquoketa, North Fork Little Maquoketa, Maquoketa, and North Fork Maquoketa Rivers, the USGS measured high-water marks (HWMs) at 46 locations. The HWMs that were used in the profiles were measured at all Federal and State Highway bridges, at USGS streamgages, at selected county and local bridges, and at selected dams. The HWMs at bridges were located immediately downstream from a bridge and one bridge-length upstream from the bridge. The distances between most of the profile points are less than about 12 mi (fig. 1). The distance between Ebys Mill Road and U.S. Highway 151 on the Maquoketa River is about 13.8 mi, and between 21st Avenue and 1st Avenue on the North Fork Maquoketa River is about 18.3 mi. River miles were determined using a geographic information system (GIS) to measure the distance along each river reach from its mouth using USGS 1:24,000-scale topographic-map data.

The HWMs were surveyed to bench marks (see appendix) at bridges, dams, and intermediate sites within one week of the flood peak, and were later referenced to the NGVD 29 by differential leveling or differential positioning using a global positioning system (GPS). In addition, bridge-deck, low-bridge-chord, and reference-point elevations were measured with respect to the bench marks. The elevations for the bridge deck and low-bridge chord were generally measured on the lowest end of the bridge. The reference points were established so that low-flow water-surface elevations could be measured by using a weight suspended on a measuring tape. Low-flow water-surface elevations were obtained during November 2010 to indicate the range in stage along the river and to define the low-water slope.

The HWMs are profiled in figures 5–18 and listed in tables 7–9. The profile lines connecting the HWMs in the figures approximate the flood elevation between marks. The lines do not account for any intermediate features that could affect flood elevation such as channel morphology or bridges and dams where HWMs were not measured. Primary highways referenced in the report are shown in figure 1; secondary roads are not shown in the figure.

The July 23, 2010, flood along the Little Maquoketa and North Fork Little Maquoketa Rivers is profiled from U.S. Highway 52 near Dubuque upstream to County Road Y21 near Rickardsville (fig. 1). The 19-mi river reach is

shown in figure 1, and the five stream sites where HWMs were measured are listed in table 7.

**Table 7.** Locations and elevations of high-water marks used in the Little Maquoketa River and North Fork Little Maquoketa River flood profiles of July 23, 2010.

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; USGS, U.S. Geological Survey]

Distance from mouth (river miles)	Location	Downstream HWM (feet above NGVD 29)	Upstream HWM (feet above NGVD 29)
4.13	U.S. Highway 52, south of Sageville	621.82	621.98
6.48	Clay Hill Road, east of Durango, discontinued USGS streamgage 05414500	632.79	635.63
10.62	U.S. Highway 52, west of Durango	662.42	663.43
16.40	South Mound Road, east of Rickardsville, USGS streamgage 05414450	755.81	757.57
23.03	County Road Y21/James Road, northwest of Rickardsville	849.26	850.54

The July 23–26, 2010, flood along the Maquoketa River is profiled from U.S. Highway 52 near Green Island upstream to State Highway 187 near Arlington (fig. 1). The 142-mi river reach is shown in figure 1, and the 28 stream sites where HWMs were measured are listed in table 8. A flood profile measured in June 2002 and a low-water profile measured in December 2002 (Eash, 2005) are shown in figures 8–12 for the Maquoketa River from U.S. Highway 52 near Green Island upstream to U.S. Highway 20 south of Manchester. A flood profile measured in May 2004 and a low-water profile measured in November 2004 (Eash, 2006) also are shown in figures 8, and 12–13, for the Maquoketa River from County Road D47 near Hopkinton upstream to State Highway 187 near Arlington.

The July 23–24, 2010, flood along the North Fork Maquoketa River is profiled from Rockdale Road near Maquoketa upstream to U.S. Highway 52 near Luxemburg (fig. 1). The 90-mi river reach is shown in figure 1, and the 13 stream sites where HWMs were measured are listed in table 9. A flood profile measured in June 2002 and a low-water profile measured in December 2002 (Eash, 2005) are shown in figures 14–18 for the North Fork Maquoketa River along the entire North Maquoketa River reach profiled for the 2010 flood with the exception of the reach between State Highway 136 at New Vienna and U.S. Highway 52 near Luxemburg.

**16 Floods of July 23–26, 2010, in the Little Maquoketa River and Maquoketa River Basins, Northeast Iowa**

**Table 8.** Locations and elevations of high-water marks used in the Maquoketa River flood profile of July 23–26, 2010.

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; USGS, U.S. Geological Survey; ND, not determined]

<b>Distance from mouth (river miles)</b>	<b>Location</b>	<b>Downstream HWM (feet above NGVD 29)</b>	<b>Upstream HWM (feet above NGVD 29)</b>
2.20	U.S. Highway 52 , northwest of Green Island	601.44	604.86
11.22	County Road Z20/387th Avenue, north of Spragueville	623.55	625.14
19.51	County Road E23Y/Iron Bridge Road, southeast of Andrew	641.13	641.55
27.60	USGS streamgage 05418500, State Highway 62, northeast of Maquoketa	661.22	ND
31.72	U.S. Highway 61, Maquoketa	669.10	669.31
32.61	Lakehurst Dam, west of Maquoketa	671.31	677.87
44.30	County Road Y34/50th Avenue, north of Baldwin	707.96	708.64
47.06	30th Avenue, north of Monmouth	716.79	716.86
59.02	Temple Hill Road, northwest of Canton	743.47	743.68
61.86	State Highway 136, northeast of Scotch Grove	749.19	749.41
66.84	Ebys Mill Road, northeast of Scotch Grove	764.45	765.08
80.61	U.S. Highway 151, east of Monticello	805.97	806.46
81.50	Main Street, Monticello	807.62	808.79
83.00	State Highway 38, Monticello	811.66	813.07
92.17	County Road D47/Marion Street, southwest of Hopkinton	846.36	846.51
101.58	County Road X31/230th Avenue crossing Lake Delhi Dam, southwest of Delhi	889.17	905.55
103.58	County Road X29/220th Avenue, southwest of Delhi	906.08	906.32
109.40	County Road X21/240th Street, southeast of Manchester	911.23	911.45
113.25	USGS streamgage 05416900, U.S. Highway 20, south of Manchester	924.89	925.46
114.42	Marion Street, Manchester	931.99	932.78
114.76	State Highway 13/West Main Street, Manchester	933.26	933.56
116.98	195th Street, northwest of Manchester	938.61	938.67
117.03	Quaker Mill Pond dam, northwest of Manchester	938.67	948.01
125.52	County Road C64/Richland Street, Dundee	982.13	982.21
127.82	Backbone State Park Dam	996.30	1,003.57
131.32	Backbone State Park Road, near road leading to County Road C57/120th Street	1,016.68	1,016.68
139.73	State Highway 3, west of Strawberry Point	1,077.65	1,078.32
143.71	State Highway 187, southeast of Arlington	1,104.08	1,105.08

**Table 9.** Locations and elevations of high-water marks used in the North Fork Maquoketa River flood profile of July 23–24, 2010.

[HWM, high-water mark; NGVD 29, National Geodetic Vertical Datum of 1929; ND, not determined; USGS, U.S. Geological Survey; NA, not applicable]

<b>Distance from mouth (river miles)</b>	<b>Location</b>	<b>Downstream HWM (feet above NGVD 29)</b>	<b>Upstream HWM (feet above NGVD 29)</b>
0.27	Rockdale Road, north of Maquoketa	666.44	666.49
8.24	U.S. Highway 61, south of Fulton, discontinued USGS streamgage 05418450	686.88	ND
12.37	USGS streamgage 05418400, County Road E17/150th Street, northwest of Fulton	701.44	702.04
22.12	60th Avenue, northeast of Canton	733.34	733.47
26.24	21st Avenue, northeast of Canton	747.30	748.50
44.58	1st Avenue West, Cascade	814.82	818.87
45.29	U.S. Highway 151, north of Cascade	820.97	822.03
47.50	State Highway 136, northwest of Cascade	830.70	830.82
57.74	Along 305th Street, south of Worthington	874.20	NA
63.90	County Road D35/272nd Street, west of Worthington	897.61	897.94
71.52	U.S. Highway 20, Dyersville	944.06	944.13
80.67	State Highway 136/Columbus Street, New Vienna	993.05	993.84
90.07	U.S. Highway 52, east of Luxemburg	1,058.76	1,060.06



## Summary

Information on flood peaks and water-surface-elevation profiles is needed for the planning and safe design of bridges and other structures along rivers and streams and also for effective management of flood plains. Data for major floods are needed to compute flood-peak discharges and calibrate water-surface-elevation models. This report was prepared in cooperation with the Iowa Department of Transportation and the Iowa Highway Research Board.

As a result of intense periods of rainfall July 22–24, 2010, minor flooding occurred in the Little Maquoketa River Basin and major flooding occurred in the Maquoketa River Basin during July 23–26. Seventy-two-hour rainfall amounts recorded at Manchester and Strawberry Point on July 24 were 7.33 and 12.23 inches, respectively. The majority of the rainfall occurred during a 48-hour period. Within the Little Maquoketa River Basin, a peak-discharge estimate of 19,000 ft<sup>3</sup>/s (annual flood-probability estimate of 4 to 10 percent) at the discontinued streamgage 05414500 Little Maquoketa River near Durango, Iowa on July 23 is the sixth largest flood on record. Within the Maquoketa River Basin, peak discharges of 26,600 ft<sup>3</sup>/s (annual flood-probability estimate of 0.2 to 1 percent) at the 05416900 Maquoketa River at Manchester, Iowa streamgage on July 24, and of 25,000 ft<sup>3</sup>/s (annual flood-probability estimate of 1 to 2 percent) at the 05418400 North Fork Maquoketa River near Fulton, Iowa streamgage also on July 24 are the largest floods on record for these sites. A peak discharge of 46,000 ft<sup>3</sup>/s on July 26 at the 05418500 Maquoketa River near Maquoketa, Iowa streamgage is the third highest on record. The July 24 breach of Lake Delhi Dam, located 74 river miles upstream of the Maquoketa River near Maquoketa streamgage, affected the flood peak at the Maquoketa streamgage.

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## Figures 5–18

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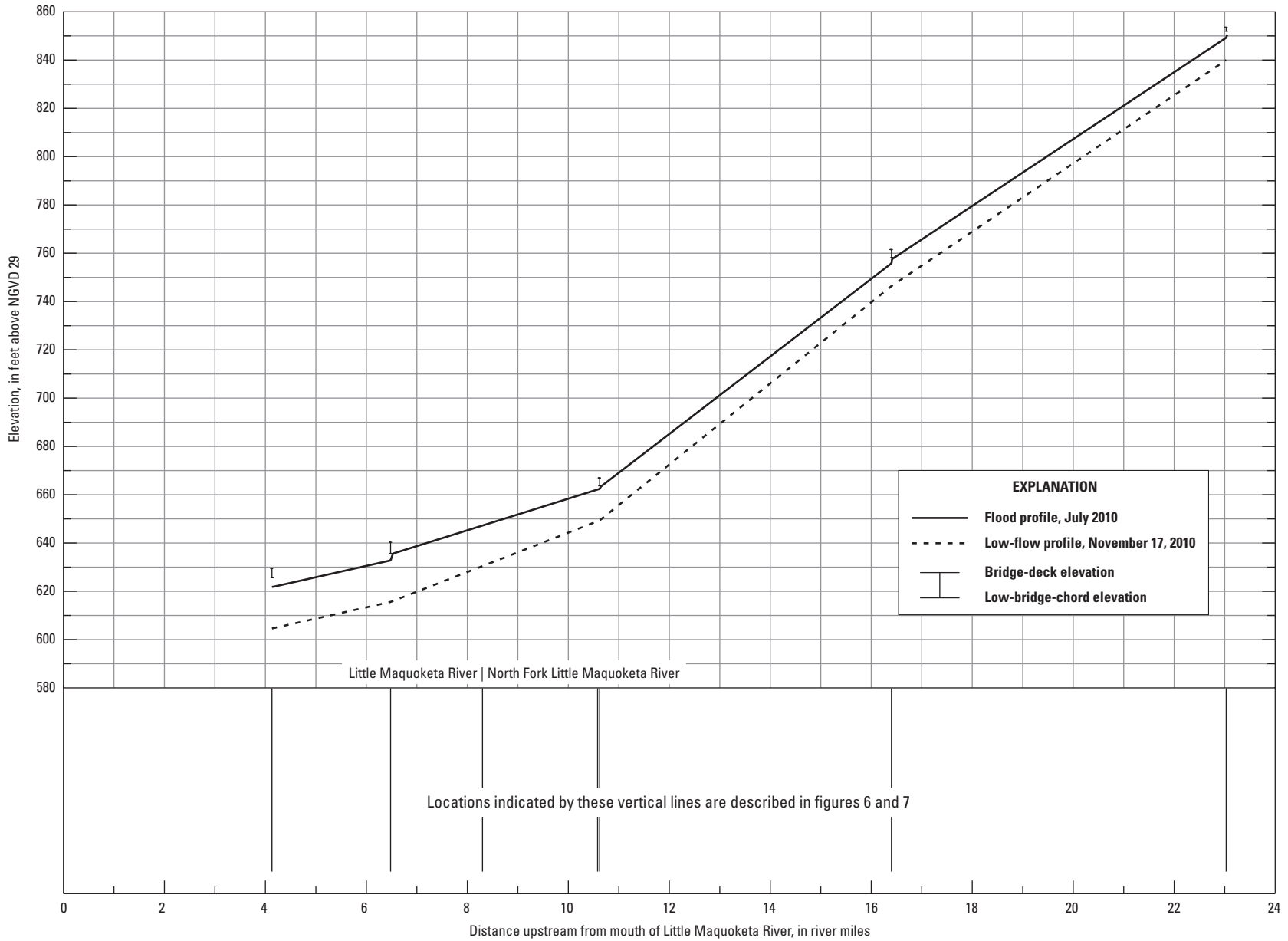
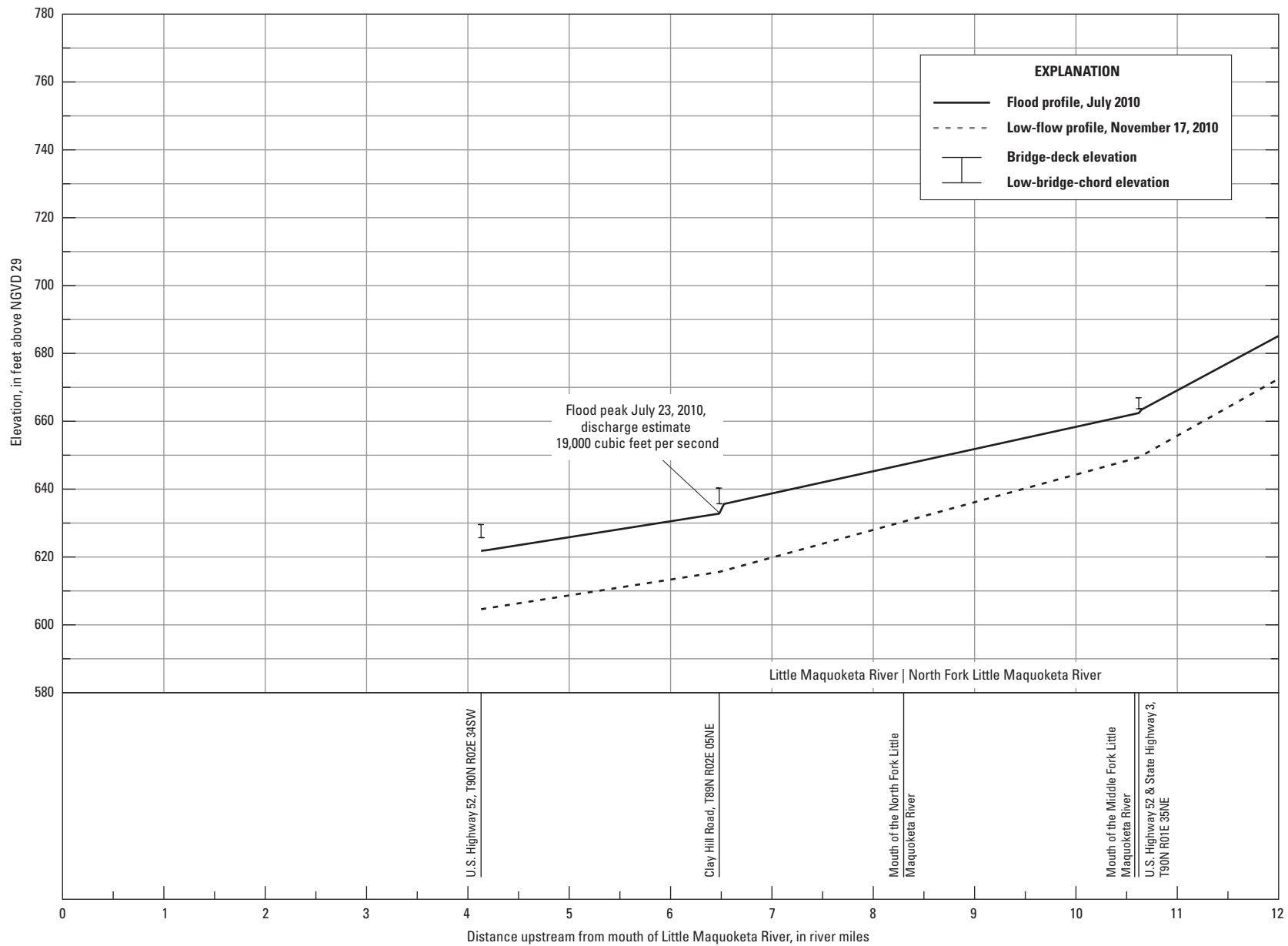


Figure 5. Profile of the July 23, 2010, flood for the Little Maquoketa River and the North Fork Little Maquoketa River, river miles 4 to 23.



**Figure 6.** Profile of the July 23, 2010, flood for the Little Maquoketa River and the North Fork Little Maquoketa River, river miles 4 to 12.

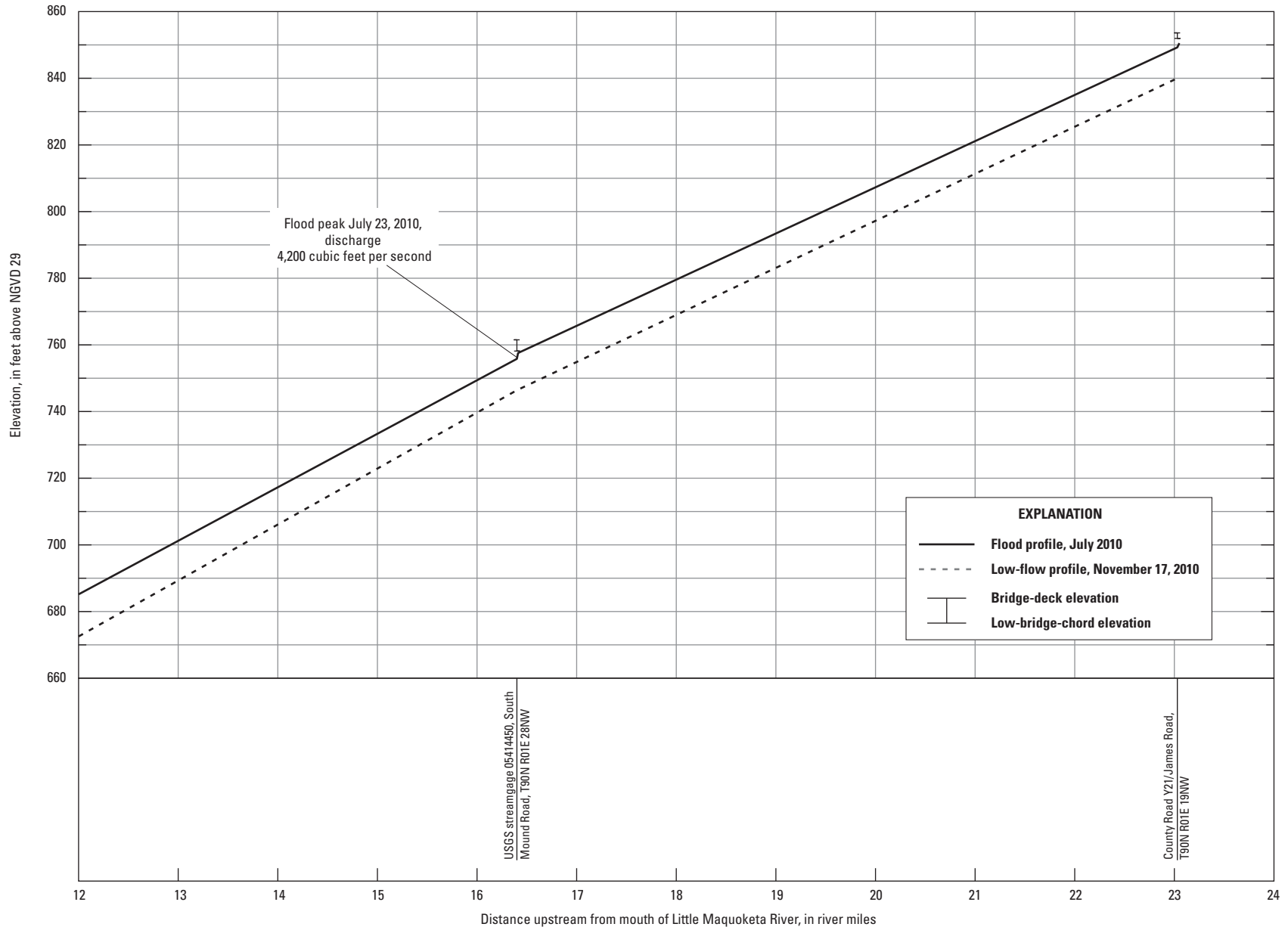
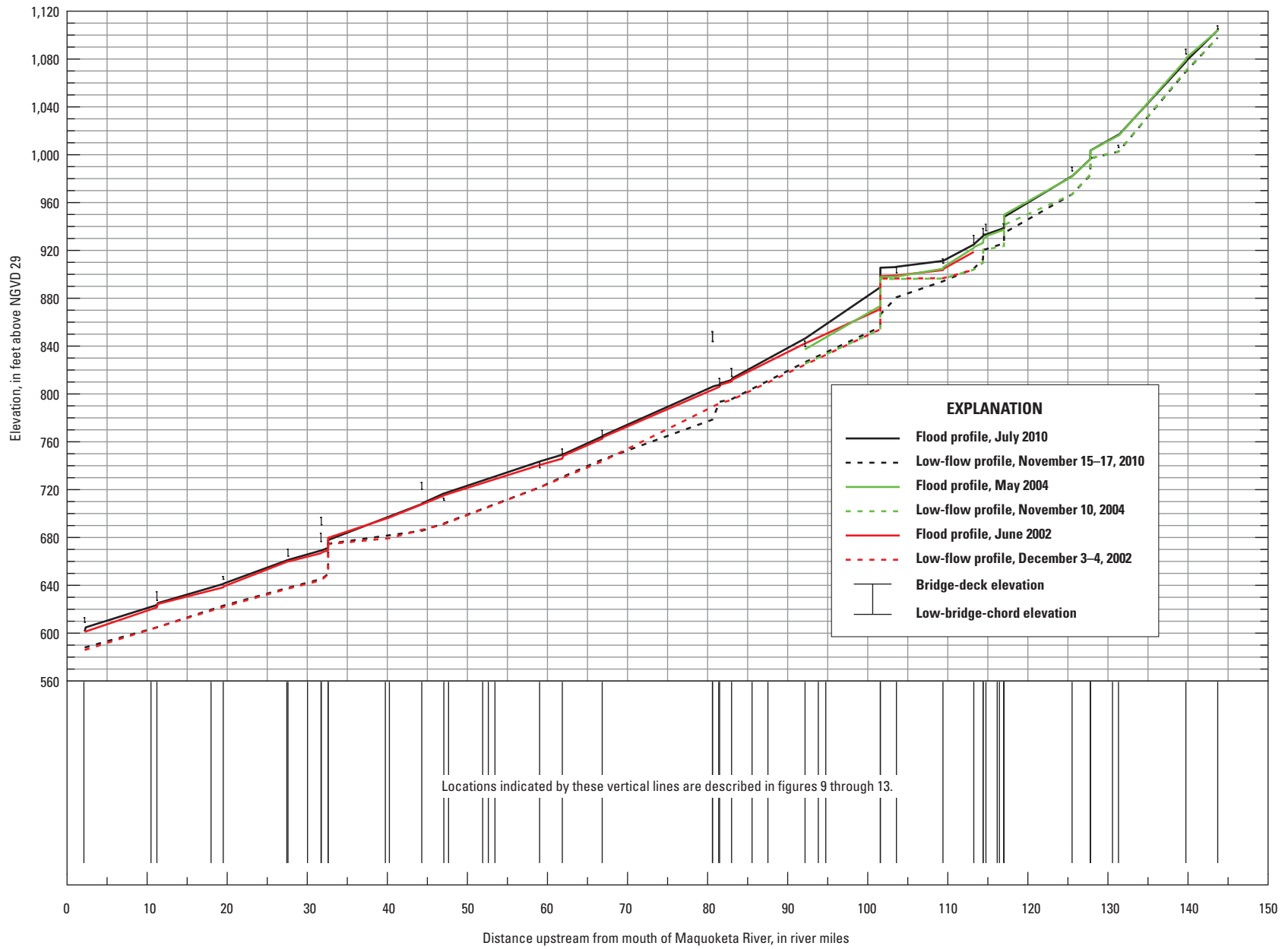


Figure 7. Profile of the July 23, 2010, flood for the North Fork Little Maquoketa River, river miles 12 to 23.



**Figure 8.** Profile of the July 23–26, 2010, flood for the Maquoketa River, river miles 2 to 144.

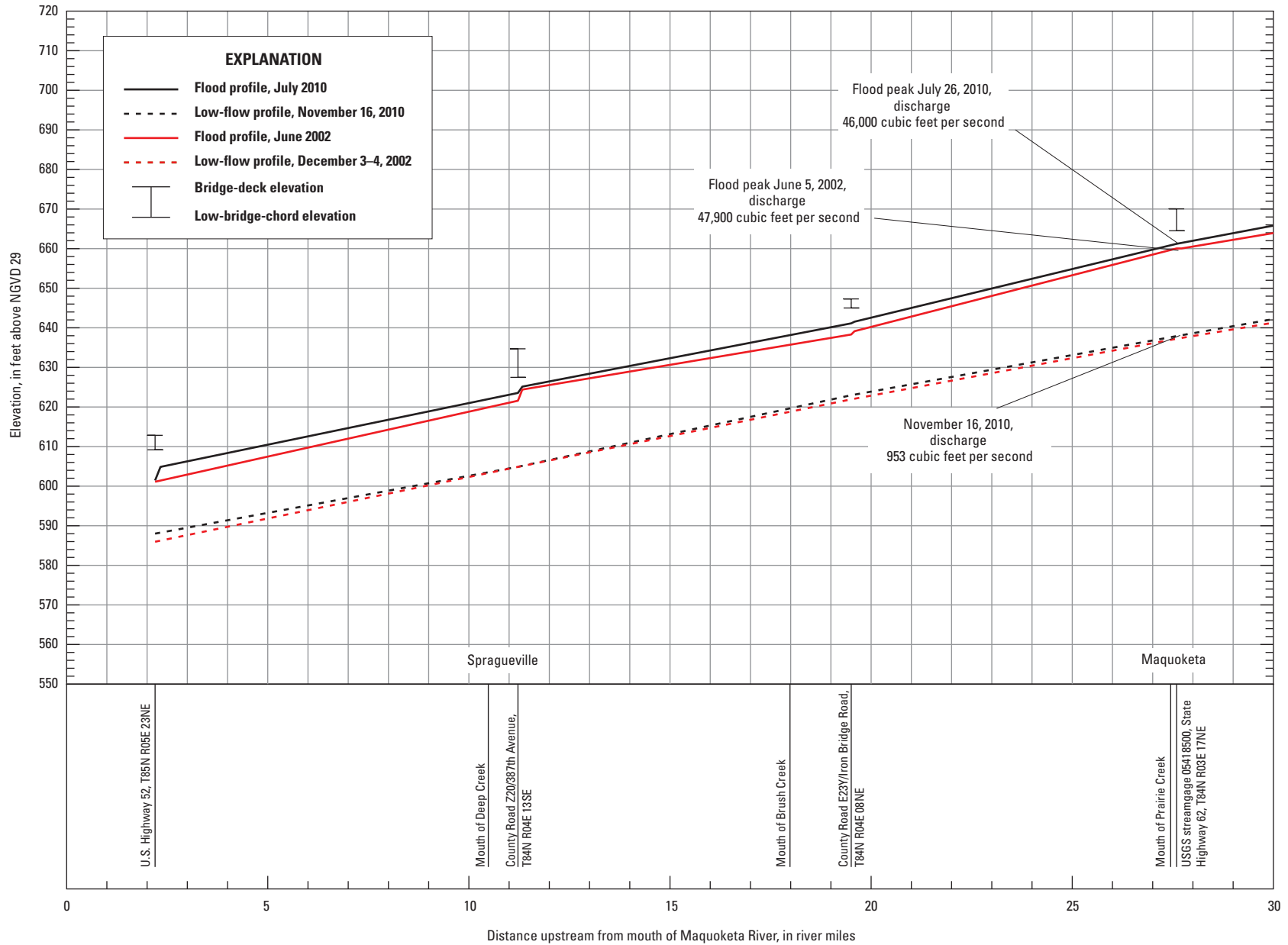
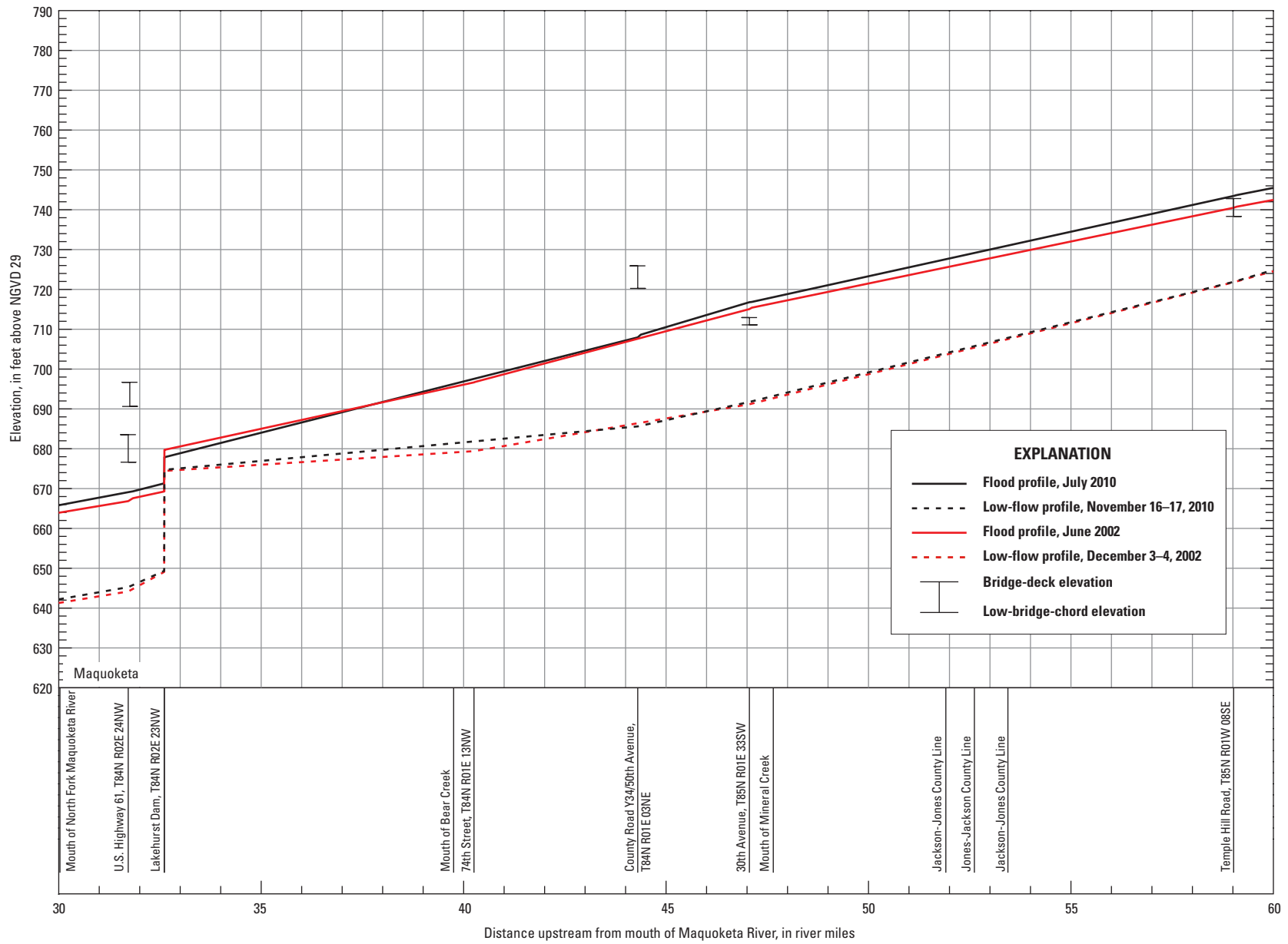


Figure 9. Profile of the July 23–26, 2010, flood for the Maquoketa River, river miles 2 to 30.





**Figure 10.** Profile of the July 23–26, 2010, flood for the Maquoketa River, river miles 30 to 60.

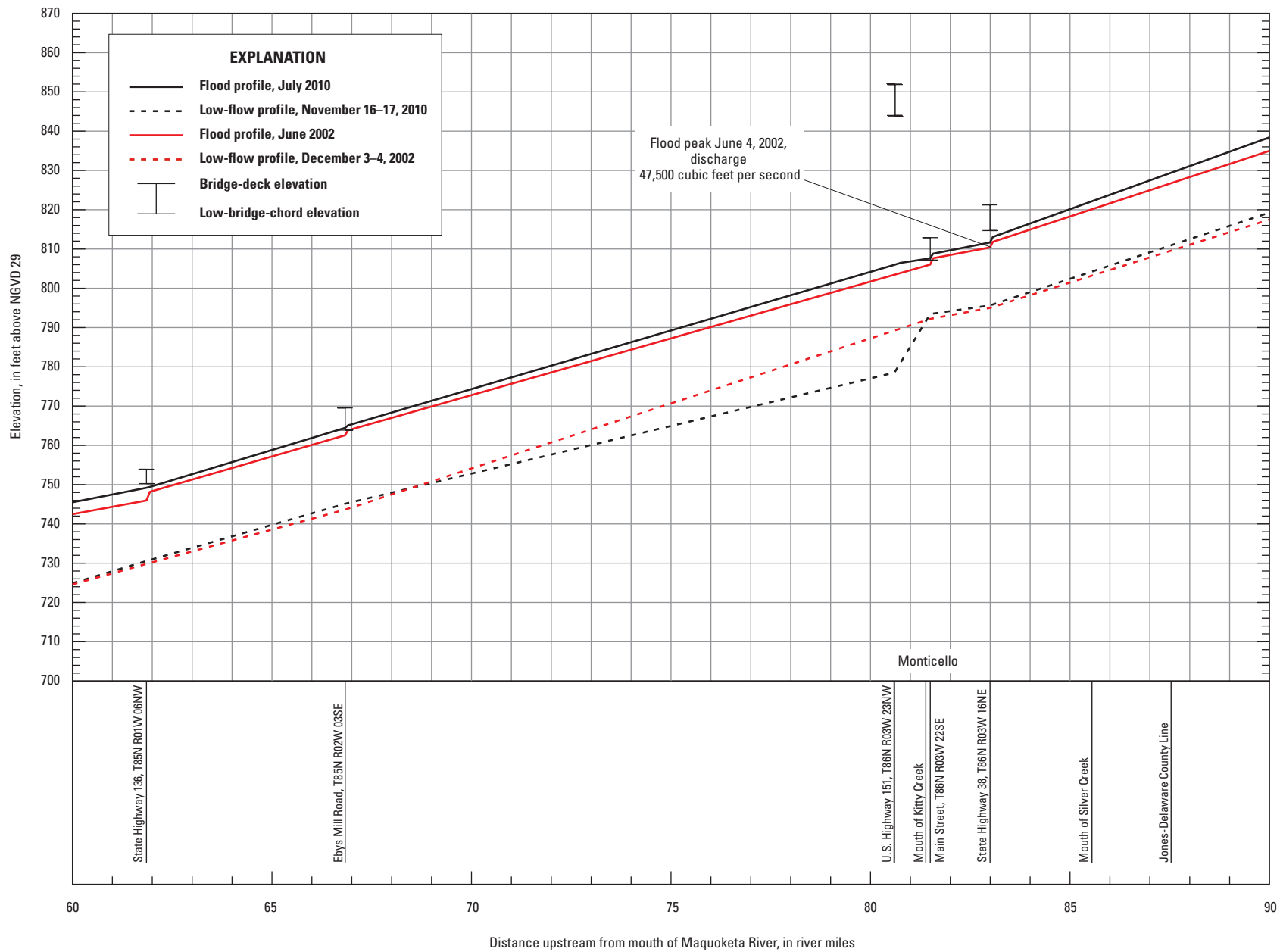


Figure 11. Profile of the July 23–26, 2010, flood for the Maquoketa River, river miles 60 to 90.

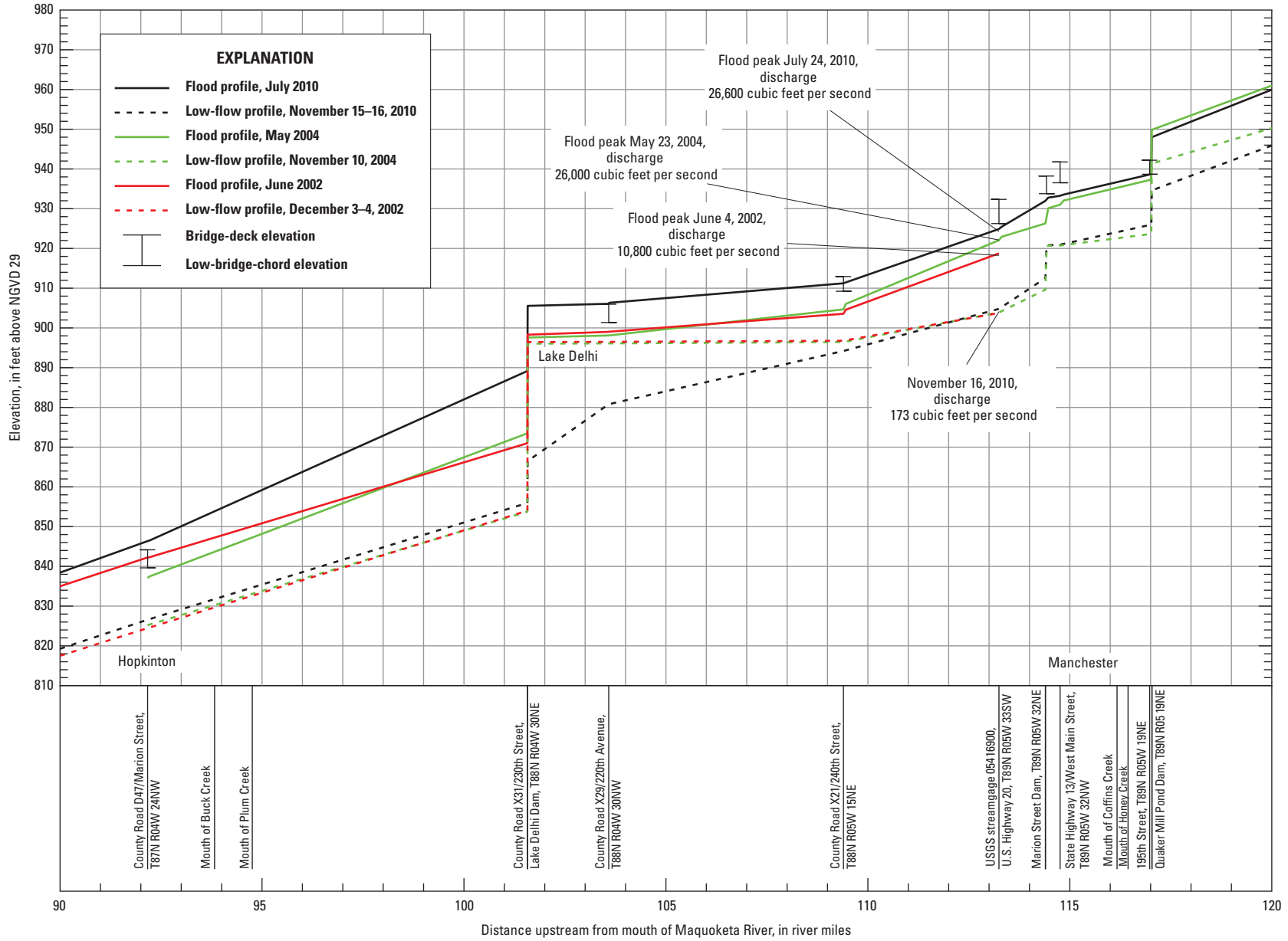


Figure 12. Profile of the July 23–26, 2010, flood for the Maquoketa River, river miles 90 to 120.

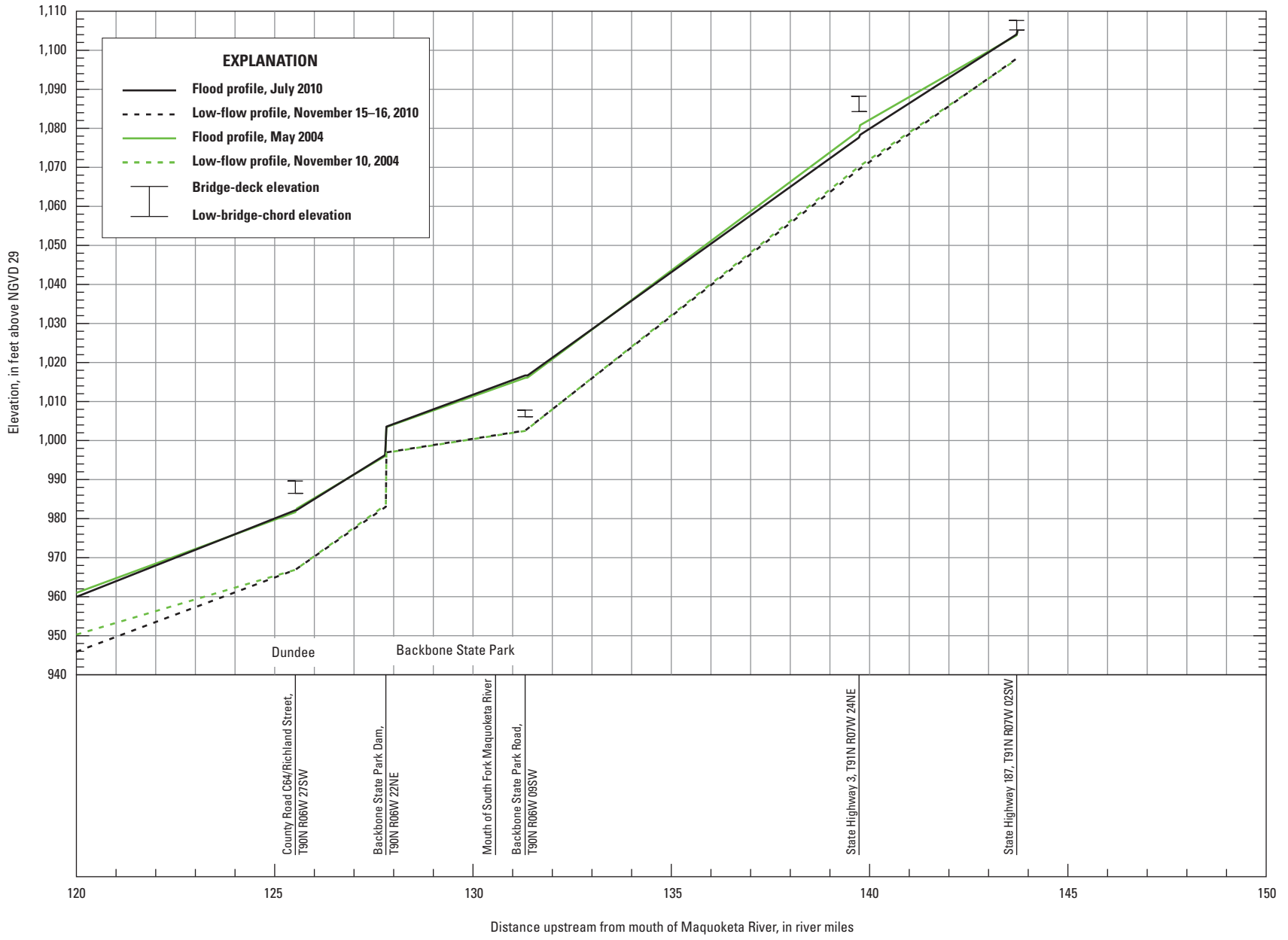
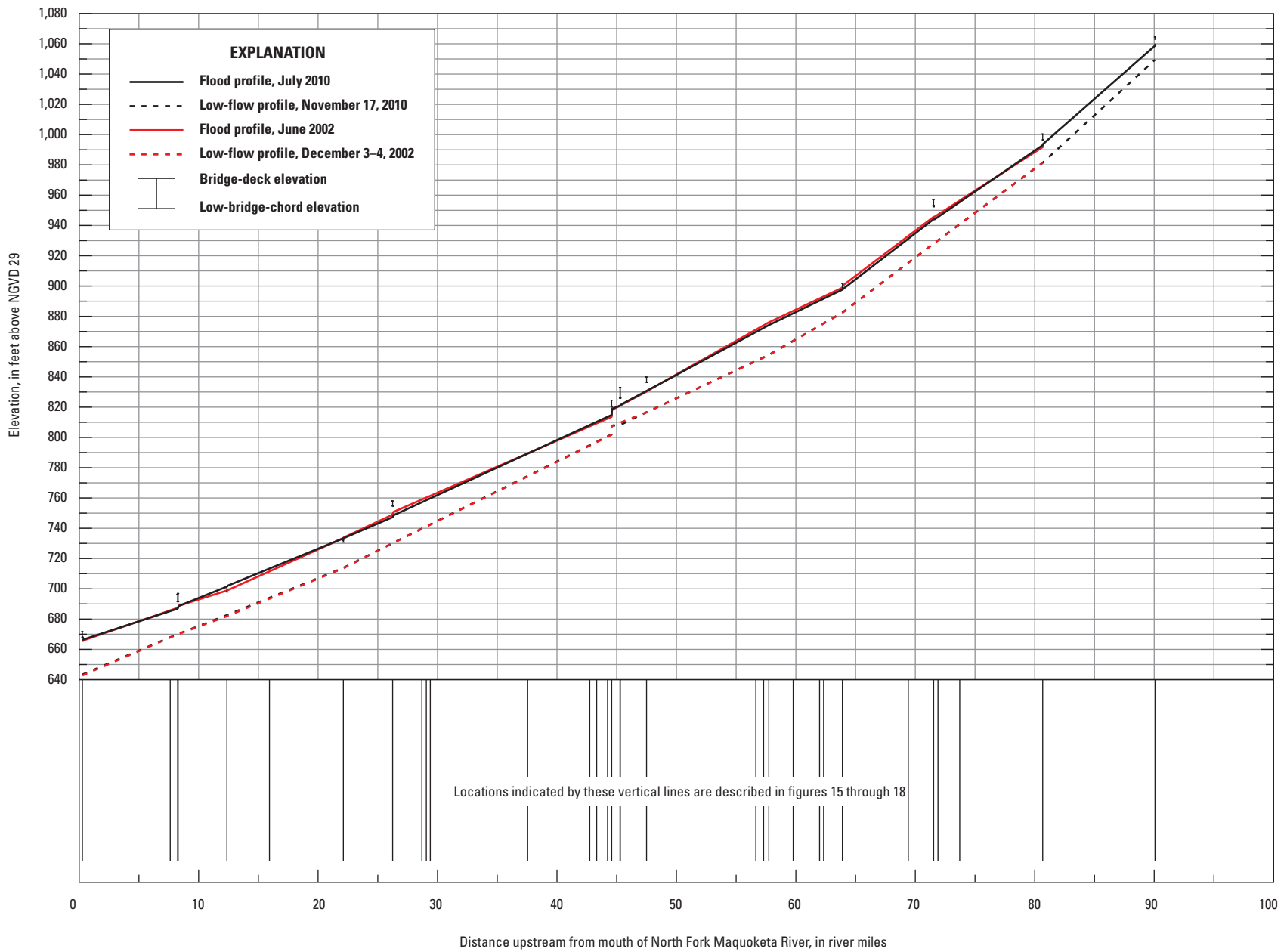


Figure 13. Profile of the July 23–26, 2010, flood for the Maquoketa River, river miles 120 to 144.



**Figure 14.** Profile of the July 23–24, 2010, flood for the North Fork Maquoketa River, river miles 0 to 90.

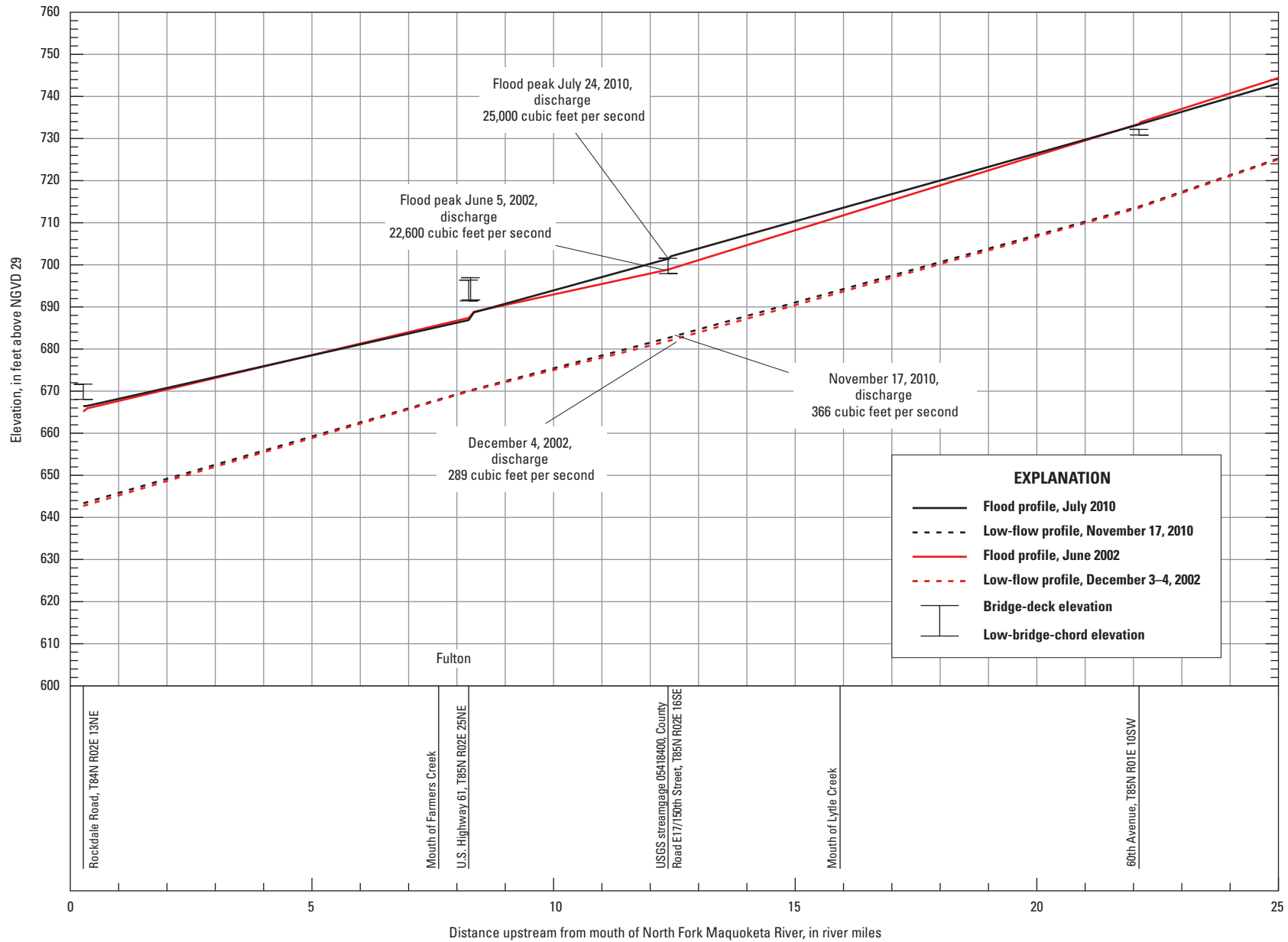
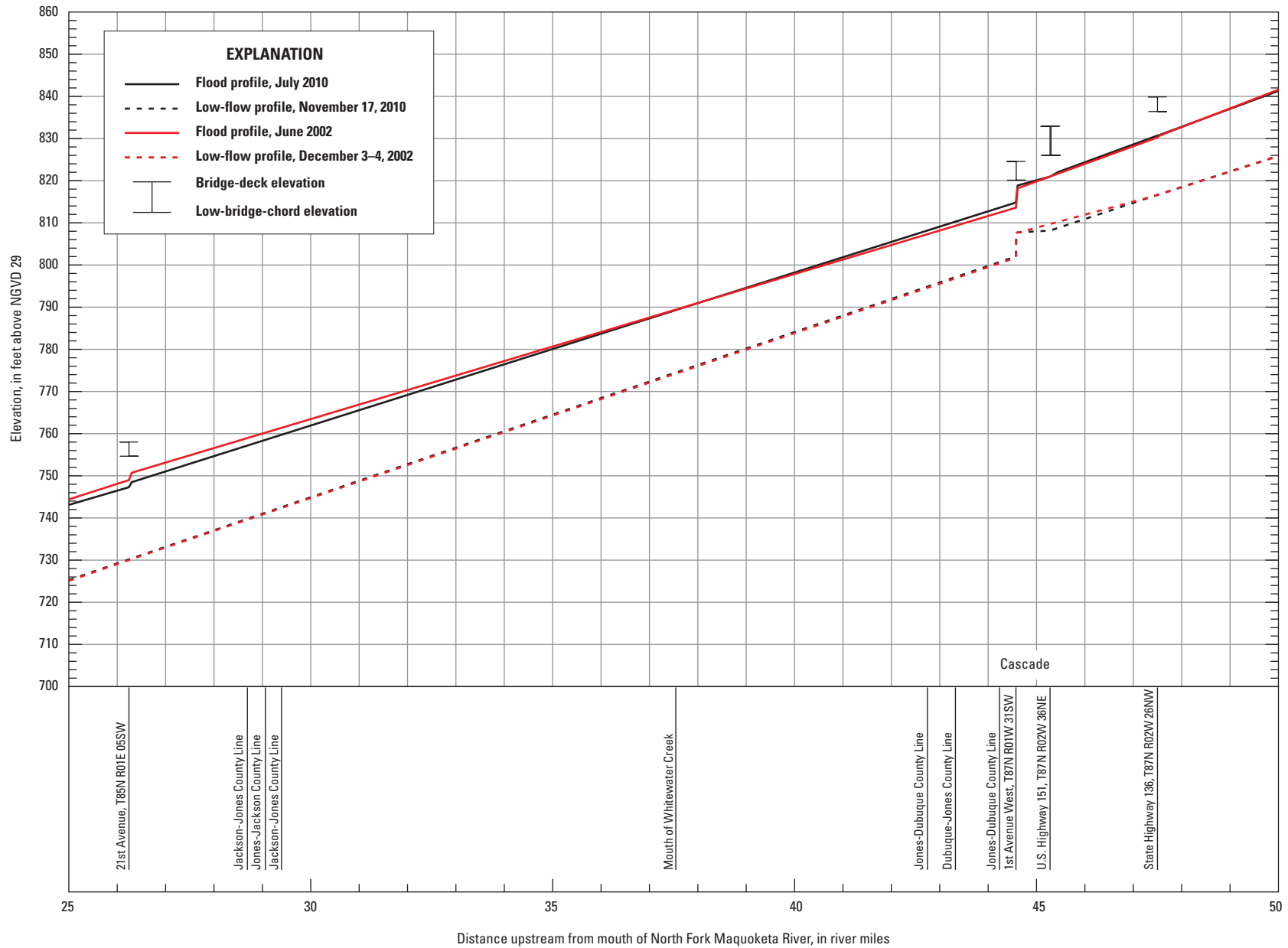


Figure 15. Profile of the July 23–24, 2010, flood for the North Fork Maquoketa River, river miles 0 to 25.



**Figure 16.** Profile of the July 23–24, 2010, flood for the North Fork Maquoketa River, river miles 25 to 50.

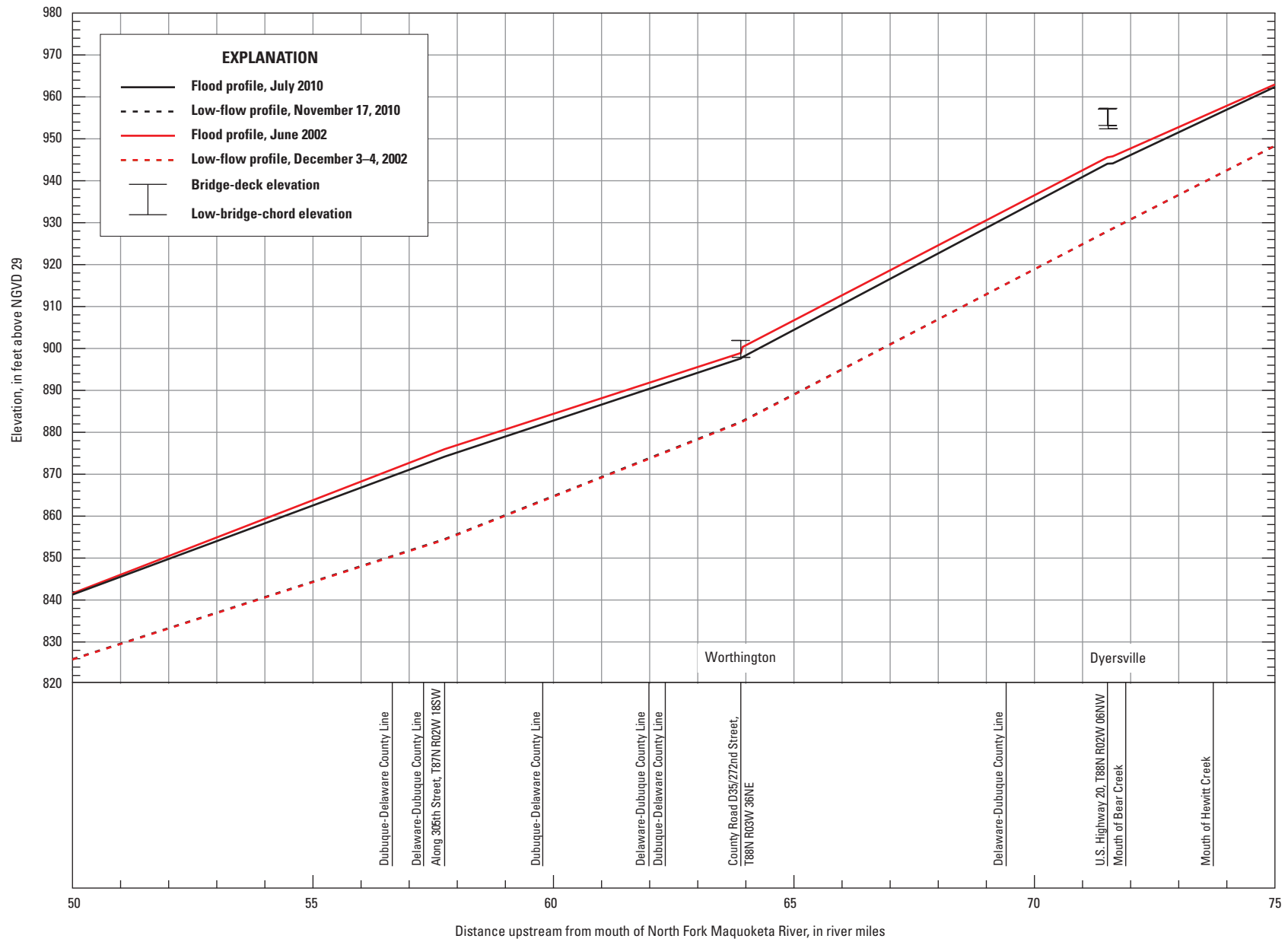
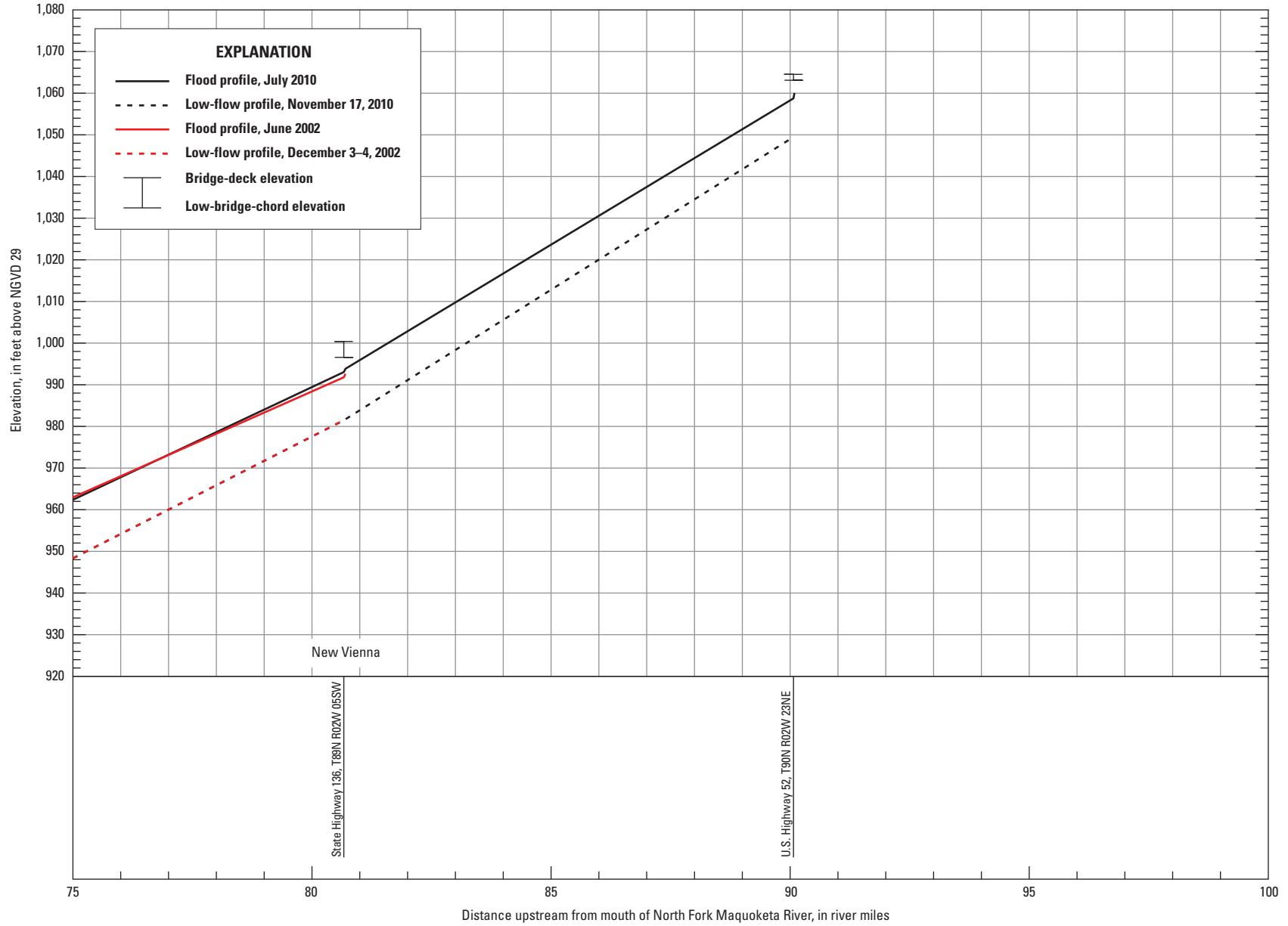


Figure 17. Profile of the July 23–24, 2010, flood for the North Fork Maquoketa River, river miles 50 to 75.





**Figure 18.** Profile of the July 23–24, 2010, flood for the North Fork Maquoketa River, river miles 75 to 100.



# Appendix

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## List of Bench Marks and Reference Points

To facilitate measuring and referencing the high-water marks (HWMs) used in the flood profiles to a common datum, bench marks (BMs), temporary bench marks (TBMs), and reference points (RPs) were found or established by the U.S. Geological Survey (USGS) at selected bridges along the profiled river reaches. All BM, TBM, and RP elevations listed in appendix table 1 are referenced to the National Geodetic Vertical Datum of 1929. The list of 46 sites where the USGS measured HWMs for the July 2010 floods is shown in tables 7–9. Of these 46 sites, BMs or TBMs are listed for 44 of the sites and RPs are listed for 39 of the sites in appendix table 1. For 8 of the 46 sites listed in this appendix, elevations for BMs and TBMs were established by other agencies and these agencies are listed in appendix table 1. At USGS streamgages, BMs or TBMs are identified as reference marks (RMs) that are listed in appendix table 1 with an RM number. BM, TBM, and RP elevations established by the USGS were determined from a combination of global positioning system (GPS) technology and differential leveling. For 31 of the 46 sites listed in this appendix, elevations were established by the USGS using GPS and are noted in the BM, TBM, and RP descriptions. GPS data were collected by the USGS using two different methods. Static surveys of GPS data were submitted for processing to the Online Positioning User Service (OPUS), an Internet service provided by the National Geodetic Survey (<http://www.ngs.noaa.gov/OPUS/>). The quality of the OPUS GPS data is based on the guidelines of “What to look for in a quality solution” (<http://www.ngs.noaa.gov/OPUS/about.html>, accessed May 27, 2011). Real Time Kinematic (RTK) surveys of GPS data were processed using the IARTN SmartNet, a Global Navigation Satellite System (GNSS) reference station network service provided by Iowa DOT and Leica Geosystems (<http://spiderweb.iartn.com/spiderweb/fmIndex.aspx>). The quality of the RTK GPS data is based on an average of multiple sets of GPS data collected using satellite configurations spaced at least 30 minutes apart, and on comparisons of elevations between RTK GPS surveys of GPS BMs and published elevations.

In general, BMs are points that were specifically designed to mark an elevation, such as USGS elevation disks and Iowa DOT BMs (round-top rods embedded in concrete at one or more corners of a bridge). Marks—such as squares and crosses that were chiseled or filed on concrete or metal, or existing bolts on bridges—were used as TBMs or RPs. RPs were established to permit water-surface elevations to be determined by use of a tape and weight. The terms “right” and “left” in the descriptions are determined as viewed while facing in the downstream direction.

The BMs, TBMs, and RPs are designated by an index number or legal description derived from their respective locations using Public Land Survey System coordinates (township, range, section). Within the section, the quarter section in which the BM, TBM, or RP is located is designated by NE, SE, NW, and SW. For example, T90N R02E 34 SW refers to a location in Township 90 North, Range 2 East, southwest quarter of section 34. A number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section. The index number serves to describe the legal description of the mark without further reference in the body of the description. The physical location of the BM or TBM on a bridge dictates the appropriate legal description. The RPs, and any additional BMs or TBMs, are listed with the related BMs or TBMs and are identified by the same legal description though, at times, they are in a different section, range, or township as determined by upstream or downstream location.

The BMs, TBMs, and RPs are listed in appendix table 1 in upstream order for the Little Maquoketa, North Fork Little Maquoketa, Maquoketa, and North Fork Maquoketa Rivers. The user of this information is cautioned that BMs, TBMs, and RPs listed herein might have been disturbed, destroyed, or moved since elevations were established. It is the responsibility of the user to determine the condition and the suitability of the BM, TBM, or RP.

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
Little Maquoketa River					
T90N R02E 34 SW (1)	BM	About 0.25 mile south of Sageville, on U.S. Highway 52 bridge over Little Maquoketa River, on left downstream wingwall.	Iowa Department of Transportation bench mark	634.25	GPS
T90N R02E 34 SW (2)	RP	About 0.25 mile south of Sageville, on U.S. Highway 52 bridge over Little Maquoketa River, at 2nd drain from right downstream end of bridge.	Chiseled arrow	633.52	GPS
T89N R02E 05 NE (1)	BM	About 1.5 miles east of Durango, site of discontinued streamgage 05414500 Little Maquoketa River near Durango, on Clay Hill Road bridge over Little Maquoketa River, on left upstream wingwall.	USGS bench mark	643.40	GPS
T89N R02E 05 NE (2)	RP	About 1.5 miles east of Durango, site of discontinued streamgage 05414500 Little Maquoketa River near Durango, on Clay Hill Road bridge over Little Maquoketa River, between 18th and 19th vertical concrete pillars from end of bridge.	Chiseled arrow	643.08	GPS
North Fork Little Maquoketa River					
T90N R01E 35 NE (1)	BM	About 1.5 miles northwest of Durango, on U.S. Highway 52 bridge over North Fork Little Maquoketa River, on concrete rail at left downstream end of bridge.	National Geodetic Survey U.S. Coast & Geodetic Survey bench mark stamped "R177 reset 1995"	669.85	GPS
T90N R01E 35 NE (2)	RP	About 1.5 miles northwest of Durango, on U.S. Highway 52 bridge over North Fork Little Maquoketa River, on downstream concrete lip between 1st and 2nd drains.	Chiseled arrow	668.06	GPS
T90N R01E 28 NW (1)	TBM	About 1.3 miles east of Rickardsville, site of streamgage 05414450 North Fork Little Maquoketa River near Rickardsville, on South Mound Road bridge over North Fork Little Maquoketa River, on bolt head 1 foot below curb at left upstream end of bridge.	Chiseled cross.	760.71	GPS
T90N R01E 28 NW (2)	RP	About 1.3 miles east of Rickardsville, site of streamgage 05414450 North Fork Little Maquoketa River near Rickardsville, on South Mound Road bridge over North Fork Little Maquoketa River, on largest metal rail about 30 feet from left downstream end of bridge.	Three filed marks	766.14	GPS
T90N R01E 19 NW (1)	TBM	About 0.75 mile northwest of Rickardsville, on James Road bridge over North Fork Little Maquoketa River, on right downstream wingwall.	Chiseled square.	857.85	GPS
T90N R01E 19 NW (2)	RP	About 0.75 mile northwest of Rickardsville, on James Road bridge over North Fork Little Maquoketa River, on downstream concrete rail at middle of bridge.	Chiseled arrow	856.79	GPS

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
Maquoketa River					
T85N R05E 23 NE (1)	BM	About 1 mile northwest of Green Island, on U.S. Highway 52 bridge over Maquoketa River, on right downstream wingwall.	Iowa Department of Transportation bench mark	615.70	GPS
T85N R05E 23 NE (2)	BM	About 1 mile northwest of Green Island, on U.S. Highway 52 bridge over Maquoketa River, on left upstream wingwall.	Iowa Department of Transportation bench mark.	615.69	GPS
T85N R05E 23 NE (3)	BM	About 1 mile northwest of Green Island, on U.S. Highway 52 bridge over Maquoketa River, on concrete platform at curb level at left upstream end of bridge.	Iowa Department of Transportation bench mark.	613.57	GPS
T85N R05E 23 NE (4)	RP	About 1 mile northwest of Green Island, on U.S. Highway 52 bridge over Maquoketa River, on concrete platform behind 7th drain from left downstream end of bridge.	Chiseled square.	614.29	GPS
T84N R04E 13 SE (1)	TBM	About 0.75 mile north of Spragueville, on County Road Z20/387th Avenue bridge over Maquoketa River, on outer wingwall about 1.5 ft from guardrail at left downstream end of bridge.	Chiseled square.	635.01	GPS
T84N R04E 13 SE (2)	RP	About 0.75 mile north of Spragueville, on County Road Z20/387th Avenue bridge over Maquoketa River, behind 18th guardrail post from right downstream end of bridge.	Three filed marks	638.93	GPS
T84N R04E 08 NE (1)	TBM	About 5 miles southeast of Andrew, on County Road E23Y/Iron Bridge Road over Maquoketa River, on corner of lower wingwall at left upstream end of bridge.	Chiseled square	647.40	GPS
T84N R04E 08 NE (2)	RP	About 5 miles southeast of Andrew, on County Road E23Y/Iron Bridge Road over Maquoketa River, on guardrail about 8 feet left of 2nd vertical truss member from right downstream end of bridge.	Three filed marks	661.14	GPS
T84N R03E 17 NE (1)	TBM	About 1.5 miles northeast of Maquoketa, site of streamgage 05418500 Maquoketa River near Maquoketa, on State Highway 62 bridge over Maquoketa River, on right downstream abutment.	Chiseled square (RM 19)	670.77	Streamgage elevation data
T84N R03E 17 NE (2)	TBM	About 1.5 miles northeast of Maquoketa, site of streamgage 05418500 Maquoketa River near Maquoketa, on State Highway 62 bridge over Maquoketa River, on right upstream abutment.	Chiseled square (RM 20)	670.78	Streamgage elevation data
T84N R02E 24 NW (1)	BM	At Maquoketa, on northbound lane of U.S. Highway 61 bridge over Maquoketa River (downstream bridge), on right upstream wingwall.	Iowa Department of Transportation bench mark	683.94	Elevation supplied by Iowa Department of Transportation

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
Maquoketa River—Continued					
T84N R02E 24 NW (2)	BM	At Maquoketa, on southbound lane of U.S. Highway 61 bridge over Maquoketa River (upstream bridge), on right downstream wingwall.	Iowa Department of Transportation bench mark	699.76	Elevation surveyed from Iowa Department of Transportation bench mark
T84N R02E 24 NW (3)	RP	At Maquoketa, on northbound lane of U.S. Highway 61 bridge over Maquoketa River (downstream bridge), on concrete platform behind 7th drain from either end of bridge.	Chiseled square	683.08	Elevation surveyed from Iowa Department of Transportation bench mark
T84N R01E 03 NE (1)	TBM	About 3.2 miles northeast of Baldwin, on County Road Y34/50th Avenue bridge over Maquoketa River, on left downstream concrete rail.	Chiseled square	728.72	GPS
T84N R01E 03 NE (2)	RP	About 3.2 miles northeast of Baldwin, on County Road Y34/50th Avenue bridge over Maquoketa River, on meatal rail at 4th drain from left downstream end of bridge.	Three filed marks	725.82	GPS
T85N R01E 33 SW (1)	TBM	About 3.5 miles north of Monmouth, on 30th Avenue bridge over Maquoketa River, on threaded bolt on outer downstream end of left downstream pier.	Filed cross	713.56	GPS
T85N R01E 33 SW (2)	RP	About 3.5 miles north of Monmouth, on 30th Avenue bridge over Maquoketa River, on guardrail about 0.5 foot left of guardrail post between 2nd and 3rd vertical truss members from left downstream end of bridge.	Three file marks	719.18	GPS
T85N R01W 08 SE (1)	TBM	About 4.25 miles northwest of Canton, on Temple Hill Road bridge over Maquoketa River, on right downstream wingwall.	Chiseled cross	749.79	GPS
T85N R01W 08 SE (2)	RP	About 4.25 miles northwest of Canton, on Temple Hill Road bridge over Maquoketa River, on concrete barrier wall at 20th concrete post from left downstream end of bridge.	Chiseled square	746.61	GPS
T85N R01W 06 NW (1)	BM	About 5.75 miles northeast of Scotch Grove, on State Highway 136 bridge over Maquoketa River, on left upstream wingwall.	Iowa Department of Transportation bench mark	756.74	GPS
T85N R01W 06 NW (2)	RP	About 5.75 miles northeast of Scotch Grove, on State Highway 136 bridge over Maquoketa River, on concrete platform behind 4th drain from left downstream end of bridge.	Chiseled square	757.03	GPS
T85N R02W 03 SE (1)	BM	About 3 miles northeast of Scotch Grove, on Ebys Mill Road bridge over Maquoketa River, on right downstream concrete rail.	Brass tablet	774.43	GPS
T85N R02W 03 SE (2)	RP	About 3 miles northeast of Scotch Grove, on Ebys Mill Road bridge over Maquoketa River, on downstream concrete rail at 27th vertical rail from right end of bridge.	Chiseled arrow	772.74	GPS

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
Maquoketa River—Continued					
T86N R03W 23 NW (1)	BM	About 1 mile northeast of Monticello, on northbound lane of U.S. Highway 151 bridge over Maquoketa River (downstream bridge), on right downstream concrete rail.	Iowa Department of Transportation bench mark.	854.86	GPS
T86N R03W 23 NW (2)	RP	About 1 mile northeast of Monticello, on northbound lane of U.S. Highway 151 bridge over Maquoketa River (downstream bridge), on downstream concrete rail at 4th drain from right end of bridge.	Chiseled arrow	860.12	GPS
T86N R03W 22 SE (1)	BM	At Monticello, on Main Street bridge over Maquoketa River, on outside curb behind guardwall at left upstream end of bridge.	Iowa Department of Transportation bench mark	813.68	Elevation surveyed from National Geodetic Survey U.S. Coast & Geodetic Survey bench mark
T86N R03W 22 SE (2)	RP	At Monticello, on Main Street bridge over Maquoketa River, on concrete platform behind 7th drain from left downstream end of bridge.	Chiseled square	814.16	Elevation surveyed from National Geodetic Survey U.S. Coast & Geodetic Survey bench mark
T86N R03W 16 NE (1)	BM	At Monticello, on State Highway 38 bridge over Maquoketa River, on left upstream wingwall.	Iowa Department of Transportation bench mark	823.96	Elevation supplied by Iowa Department of Transportation
T86N R03W 16 NE (2)	RP	At Monticello, on State Highway 38 bridge over Maquoketa River, on concrete platform right of 21st metal bracket from right downstream end of bridge and across from center of 3rd and 4th drains from right upstream end of bridge.	Chiseled square	824.68	Elevation surveyed from Iowa Department of Transportation bench mark
T87N R04W 24 NW (1)	BM	About 0.5 mile southwest of Hopkinton, on County Road D47/Marion Street bridge over southern channel of Maquoketa River, on left downstream end of sidewalk concrete barrier wall.	Delaware County bench mark	846.90	Elevation surveyed from Delaware County bench mark southwest of bridge
T87N R04W 24 NW (2)	RP	About 0.5 mile southwest of Hopkinton, on County Road D47/Marion Street bridge over southern channel of Maquoketa River, on downstream side of cyclone fence at 12th fence post from right downstream end of bridge.	Edge of concrete sidewalk	844.83	Elevation surveyed from Delaware County bench mark southwest of bridge
T88N R04W 30 NE (1)	TBM	About 1.5 miles southwest of Delhi, on County Road X31/230th Avenue crossing Lake Delhi dam on Maquoketa River, on end of right downstream wingwall.	Chiseled cross	907.37	GPS
T88N R04W 30 NW (1)	BM	About 2 miles southwest of Delhi, on County Road X29/220th Avenue bridge over Lake Delhi, on concrete rail at left upstream end of bridge.	Delaware County bench mark	909.60	GPS



**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
Maquoketa River—Continued					
T88N R04W 30 NW (2)	RP	About 2 miles southwest of Delhi, on County Road X29/220th Avenue bridge over Lake Delhi, on 22nd vertical concrete post from left downstream end of bridge.	Chiseled arrow	913.54	GPS
T88N R05W 15 NE (1)	TBM	About 4 miles southeast of Manchester, on County Road X21/240th Street bridge over Maquoketa River, on corner of wingwall near guardrail at right upstream end of bridge.	Chiseled square	915.58	GPS
T88N R05W 15 NE (2)	RP	About 4 miles southeast of Manchester, on County Road X21/240th Street bridge over Maquoketa River, on metal guardrail behind 3rd drain from right downstream end of bridge.	Three filed marks	917.32	GPS
T89N R05W 33 SW(1)	BM	About 0.5 mile south of Manchester, on eastbound lane of U.S. Highway 20 bridge over Maquoketa River (downstream bridge), on left upstream abutment.	Iowa Department of Transportation bench mark (RM 1)	938.14	GPS
T89N R05W 33 SW(2)	TBM	About 0.5 mile south of Manchester, on eastbound lane of U.S. Highway 20 bridge over Maquoketa River (downstream bridge), on left downstream abutment.	Chiseled square (RM 2)	938.34	GPS
T89N R05W 32 NE (1)	TBM	At Manchester, on Marion Street bridge over Maquoketa River, at left downstream end of bridge underneath Marion Street bridge sign.	Chiseled cross	939.00	Elevation surveyed from USGS bench mark at Post Office
T89N R05W 32 NE (2)	TBM	At Manchester, on Marion Street bridge over Maquoketa River, on retaining wall at left upstream abutment.	Chiseled cross	938.93	Elevation surveyed from USGS bench mark at Post Office
T89N R05W 32 NE (3)	RP	At Manchester, on Marion Street bridge over Maquoketa River, beneath metal box attached to downstream guardrail.	Edge of concrete sidewalk	940.72	Elevation surveyed from USGS bench mark at Post Office
T89N R05W 32 NW (1)	BM	At Manchester, on State Highway 13/West Main Street bridge over Maquoketa River, on left downstream end of sidewalk concrete barrier wall at end of metal rail.	Iowa Department of Transportation bench mark	944.30	Elevation supplied by Iowa Department of Transportation
T89N R05W 32 NW (2)	RP	At Manchester, on State Highway 13/West Main Street bridge over Maquoketa River, on downstream side of cyclone fence at 10th fence post from left downstream end of bridge.	Edge of concrete sidewalk	945.08	Elevation surveyed from Iowa Department of Transportation bench mark
T89N R05W 19 NE (1)	TBM	About 0.5 mile northwest of Manchester, on 195th Street bridge over Maquoketa River, on right upstream end of lower wingwall.	Chiseled square	943.11	GPS

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
Maquoketa River—Continued					
T89N R05W 19 NE (2)	RP	About 0.5 mile northwest of Manchester, on 195th Street bridge over Maquoketa River, on downstream metal rail between 3rd and 4th drains from left end of bridge.	Three filed marks	945.78	GPS
T90N R06W 27 SW (1)	TBM	At west edge of Dundee, on County Road C64/Richland Street bridge over Maquoketa River, on right upstream end of concrete rail.	Chiseled square	991.96	GPS
T90N R06W 27 SW (2)	BM	At west edge of Dundee, on County Road C64/Richland Street bridge over Maquoketa River, on left downstream concrete rail.	Delaware County bench mark	996.20	GPS
T90N R06W 27 SW (3)	RP	At west edge of Dundee, on County Road C64/Richland Street bridge over Maquoketa River, on downstream concrete rail near middle of channel.	Chiseled arrow	994.59	GPS
T90N R06W 22 NE (1)	TBM	At Backbone State Park, on southeast dam of two dams across Maquoketa River, below cyclone fence on downstream end of upper horizontal concrete structure on left end of dam.	Chiseled square	1007.34	GPS
T90N R06W 22 NE (2)	RP	At Backbone State Park, on southeast dam of two dams across Maquoketa River, below cyclone fence on upstream end of upper horizontal concrete structure on left end of dam.	Most upstream edge of upper horizontal concrete surface	1007.48	GPS
T90N R06W 22 NE (3)	RP	At Backbone State Park, on southeast dam of two dams across Maquoketa River, behind cyclone fence post on upstream end of lower horizontal concrete structure on left end of dam.	Most upstream edge of lower horizontal concrete surface	996.08	GPS
T90N R06W 09 SW (1)	BM	At Backbone State Park, on County Road C57/ 120th Street bridge over Maquoketa River, on right downstream wingwall.	Iowa Department of Transportation bench mark	1,010.28	GPS
T90N R06W 09 SW (2)	RP	At Backbone State Park, on County Road C57/ 120th Street bridge over Maquoketa River, on downstream concrete barrier wall about 1 foot right of center of concrete sections.	Chiseled square	1,010.27	GPS
T91N R07W 24 NE (1)	BM	About 3.5 miles west of Strawberry Point, on State Highway 3 bridge over Maquoketa River, on left downstream lower wingwall.	Iowa Department of Transportation bench mark	1,088.42	Elevation supplied by Iowa Department of Transportation
T91N R07W 24 NE (2)	RP	About 3.5 miles west of Strawberry Point, on State Highway 3 bridge over Maquoketa River, on outer concrete platform behind 8th guardrail post from left downstream end of bridge.	Chiseled square	1,089.44	Elevation surveyed from Iowa Department of Transportation bench mark
T91N R07W 02 SW (1)	BM	About 2.25 miles southeast of Arlington, on State Highway 187 bridge over Maquoketa River, on left downstream wingwall.	Iowa Department of Transportation bench mark	1,109.99	GPS
T91N R07W 02 SW (2)	RP	About 2.25 miles southeast of Arlington, on State Highway 187 bridge over Maquoketa River, on outer concrete platform behind 3rd drain from right downstream end of bridge.	Chiseled square	1,108.37	GPS

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
<b>North Fork Maquoketa River</b>					
T84N R02E 13 NE (1)	BM	About 1 mile north of Maquoketa, on Rockdale Road bridge over North Fork Maquoketa River, on right downstream wingwall.	Iowa Department of Transportation bench mark	674.39	GPS
T84N R02E 13 NE (2)	RP	About 1 mile north of Maquoketa, on Rockdale Road bridge over North Fork Maquoketa River, on guardrail about 3 inches right of 28th guardrail post from left downstream end of bridge.	Three filed marks	675.24	GPS
T85N R02E 25 NE (1)	BM	About 0.5 mile south of Fulton, site of discontinued streamgage 05418450 North Fork Maquoketa River at Fulton, on southbound lane of U.S. Highway 61 bridge over North Fork Maquoketa River (upstream bridge), on left downstream wingwall.	Iowa Department of Transportation bench mark	699.52	Elevation supplied by Iowa Department of Transportation
T85N R02E 25 NE (2)	BM	About 0.5 mile south of Fulton, site of discontinued streamgage 05418450 North Fork Maquoketa River at Fulton, on northbound lane of U.S. Highway 61 bridge over North Fork Maquoketa River (downstream bridge), on right downstream wingwall.	Iowa Department of Transportation bench mark	700.05	Elevation surveyed from Iowa Department of Transportation bench mark
T85N R02E 25 NE (3)	RP	About 0.5 mile south of Fulton, site of discontinued streamgage 05418450 North Fork Maquoketa River at Fulton, on northbound lane of U.S. Highway 61 bridge over North Fork Maquoketa River (downstream bridge), on concrete platform behind 4th drain from right downstream end of bridge.	Chiseled square	697.68	Elevation surveyed from Iowa Department of Transportation bench mark
T85N R02E 16 SE (1)	TBM	About 2.75 miles northwest of Fulton, site of streamgage 05418400 North Fork Maquoketa River near Fulton, on County Road E17/150th Street bridge over North Fork Maquoketa River, on left downstream wingwall.	Chiseled square (RM 1)	711.21	Streamgage elevation data
T85N R02E 16 SE (2)	TBM	About 2.75 miles northwest of Fulton, site of streamgage 05418400 North Fork Maquoketa River near Fulton, on County Road E17/150th Street bridge over North Fork Maquoketa River, on right upstream wingwall.	Chiseled square (RM 3)	711.16	Streamgage elevation data
T85N R01E 10 SW (1)	TBM	About 3.25 miles northeast of Canton, on 60th Avenue bridge over North Fork Maquoketa River, on right upstream bolt on right upstream pier.	Filed cross	732.21	GPS
T85N R01E 10 SW (2)	RP	About 3.25 miles northeast of Canton, on 60th Avenue bridge over North Fork Maquoketa River, on guardrail about 10 feet left of 2nd vertical truss member from right downstream end of bridge.	Three filed marks	736.15	GPS
T85N R01E 05 SW (1)	TBM	About 2.5 miles northeast of Canton, on 21st Avenue bridge over North Fork Maquoketa River, on roadside end of concrete curb next to metal bracket at left downstream end of bridge.	Chiseled square	758.63	GPS
T85N R01E 05 SW (2)	RP	About 2.5 miles northeast of Canton, on 21st Avenue bridge over North Fork Maquoketa River, on metal guardrail at 4th drain from right downstream end of bridge.	Three filed marks	767.33	GPS

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
North Fork Maquoketa River—Continued					
T87N R01W 31 SW (1)	BM	At Cascade, on 1st Avenue West bridge over North Fork Maquoketa River, on corner of right downstream wingwall.	Iowa Department of Transportation bench mark	828.54	Elevation supplied by Iowa Department of Transportation
T87N R01W 31 SW (2)	RP	At Cascade, on 1st Avenue West bridge over North Fork Maquoketa River, on downstream side of cyclone fence centered between 8th and 9th fence posts from right downstream end of bridge.	Edge of concrete sidewalk	825.52	Elevation surveyed from Iowa Department of Transportation bench mark
T87N R01W 31 SW (3)	RP	At Cascade, on 1st Avenue West bridge over North Fork Maquoketa River, on upstream side of cyclone fence centered between 8th and 9th fence posts from right upstream end of bridge.	Edge of concrete sidewalk	825.53	Elevation surveyed from Iowa Department of Transportation bench mark
T87N R02W 36 NE (1)	BM	About 0.4 mile north of Cascade, on east bound lane of U.S. Highway 151 bridge over North Fork Maquoketa River (downstream bridge), on concrete rail at left downstream end of bridge.	Iowa Department of Transportation bench mark	835.61	GPS
T87N R02W 36 NE (2)	TBM	About 0.4 mile north of Cascade, on east bound lane of U.S. Highway 151 bridge over North Fork Maquoketa River (downstream bridge), on concrete rail at right downstream end of bridge.	Chiseled square	850.31	GPS
T87N R02W 36 NE (3)	RP	About 0.4 mile north of Cascade, on east bound lane of U.S. Highway 151 bridge over North Fork Maquoketa River (downstream bridge), on downstream concrete rail between 8th and 9th drains from right end of bridge.	Chiseled arrow	843.28	GPS
T87N R02W 26 NW (1)	BM	About 2 miles northwest of Cascade, on State Highway 136 bridge over North Fork Maquoketa River, on left downstream wingwall.	Iowa Department of Transportation bench mark	843.72	GPS
T87N R02W 26 NW (2)	BM	About 2 miles northwest of Cascade, on State Highway 136 bridge over North Fork Maquoketa River, on right downstream wingwall.	Iowa Department of Transportation bench mark	843.64	GPS
T87N R02W 26 NW (3)	RP	About 2 miles northwest of Cascade, on State Highway 136 bridge over North Fork Maquoketa River, on concrete platform behind downstream concrete barrier wall across from 4th drain from either upstream end of bridge.	Chiseled square	841.75	GPS
T87N R02W 18 SW (1)	TBM	About 3.5 miles south of Worthington, on 305th Street bridge over unnamed tributary to North Fork Maquoketa River, in post near right downstream wingwall of small wooden bridge.	Top of horizontal lag bolt	864.43	GPS
T88N R03W 36 NE (1)	BM	About 0.5 mile west of Worthington, on County Road D35/272nd Street bridge over North Fork Maquoketa River, on left upstream wingwall.	Delaware County bench mark	904.62	GPS

**Table 1.** Bench marks and reference points used in the July 23–26, 2010, Little Maquoketa River, North Fork Little Maquoketa River, Maquoketa River, and North Fork Maquoketa River flood profiles.—Continued

[Bench marks and reference points are listed in upstream order. BM, bench mark; TBM, temporary bench mark; RP, reference point; GPS, Global Positioning System; USGS, U.S. Geological Survey; T, township; R, range; N, north; W, west; S, south; E, east; RM, reference mark; a number in parentheses following the quarter-section designation indicates the sequence number of the BM, TBM, or RP in that particular quarter section]

Public Land Survey System (township, range, section, quarter section)	Mark classification	Location	Mark	Elevation, in feet (NGVD 1929)	Elevation determination method
North Fork Maquoketa River—Continued					
T88N R03W 36 NE (2)	RP	About 0.5 mile west of Worthington, on County Road D35/272nd Street bridge over North Fork Maquoketa River, on concrete barrier wall between 13th and 14th concrete posts from left downstream end of bridge.	Chiseled square	904.32	GPS
T88N R02W 06 NW (1)	BM	At Dyersville, on eastbound lane of U.S. Highway 20 bridge over North Fork Maquoketa River (downstream bridge), on left upstream end of concrete barrier wall.	Iowa Department of Transportation bench mark	959.79	Elevation supplied by Iowa Department of Transportation
T88N R02W 06 NW (2)	TBM	At Dyersville, on eastbound lane of U.S. Highway 20 bridge over North Fork Maquoketa River (downstream bridge), on right upstream end of concrete barrier wall.	Chiseled cross	961.81	Elevation supplied by Iowa Department of Transportation
T88N R02W 06 NW (3)	RP	At Dyersville, on eastbound lane of U.S. Highway 20 bridge over North Fork Maquoketa River (downstream bridge), on concrete barrier wall at 9th drain from left downstream end of bridge.	Chiseled square	960.67	Elevation surveyed from Iowa Department of Transportation bench mark
T89N R02W 05 SW (1)	BM	At New Vienna, on State Highway 136/Columbus Street bridge over North Fork Maquoketa River, on left upstream end of concrete barrier wall.	Iowa Department of Transportation bench mark	1,005.28	Elevation supplied by Iowa Department of Transportation
T89N R02W 05 SW (2)	BM	At New Vienna, on State Highway 136/Columbus Street bridge over North Fork Maquoketa River, on right downstream end of concrete barrier wall.	Iowa Department of Transportation bench mark	1,003.01	Elevation surveyed from Iowa Department of Transportation bench mark
T89N R02W 05 SW (3)	RP	At New Vienna, on State Highway 136/Columbus Street bridge over North Fork Maquoketa River, on concrete barrier wall between 2nd and 3rd drains from either downstream end of bridge.	Chiseled square	1,004.25	Elevation surveyed from Iowa Department of Transportation bench mark
T90N R02W 23 NE (1)	BM	About 1.5 miles east of Luxemburg, on U.S. Highway 52 bridge over North Fork Maquoketa River, on right downstream concrete rail.	Iowa Department of Transportation bench mark	1,067.30	GPS
T90N R02W 23 NE (2)	RP	About 1.5 miles east of Luxemburg, on U.S. Highway 52 bridge over North Fork Maquoketa River, on downstream concrete lip at middle of bridge.	Chiseled arrow	1,065.24	GPS

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