FLOODS OF JULY 12, 1972, MARCH 19, 1979, AND JUNE 15, 1991, IN THE TURKEY RIVER BASIN, NORTHEAST IOWA

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Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer
ton per acre	2.242	megagram per square hectometer

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

Floods of July 12, 1972, March 19, 1979, and June 15, 1991, in the Turkey River Basin, Northeast Iowa

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ABSTRACT

Water-surface-elevation profiles and peak discharges for the floods of July 12, 1972, March 19, 1979, and June 15, 1991, in the Turkey River Basin, northeast Iowa, are presented in this report. The profiles illustrate the 1979 and 1991 floods along the Turkey River in Fayette and Clayton Counties and along the Volga River in Clayton County; the 1991 flood along Roberts Creek in Clayton County and along Otter Creek in Fayette County; and the 1972 flood along the Turkey River in Winneshiek and Fayette Counties. Water-surface elevations for the flood of March 19, 1979, were collected by the Iowa Natural Resources Council. The June 15, 1991, flood on the Turkey River at Garber (station number 05412500) is the largest known flood-peak discharge at the streamflow-gaging station for the period 1902-95. The peak discharge for June 15, 1991, of 49,900 cubic feet per second was 1.4 times larger than the 100-year recurrence-interval discharge. The report provides information on flood stages and discharges and floodflow frequencies for streamflow-gaging stations in the Turkey River Basin using flood information collected during 1902-95. Information on temporary bench marks and reference points established in the Turkey River Basin during 1981, 1992, and 1996 also is included in the report. A flood history describes rainfall conditions for floods that occurred during 1922, 1947, 1972, 1979, and 1991.

INTRODUCTION

Evaluation of flood hazards and the planning, design, and operation of various structures on flood plains require information about floods. Flood reports supply specific information for selected floods and are used by planners and engineers to evaluate the magnitude and frequency of floods in a river basin.

Purpose and Scope

This report presents water-surface-elevation profiles for the floods of July 12, 1972, March 19, 1979, and June 15, 1991, in the Turkey River Basin in northeast Iowa. Profiles for the flood of March 19, 1979, use flood elevations collected by the Iowa Natural Resources Council (1980, p. 12) and are presented in this report for comparative purposes. The report provides information on flood stages and discharges, and floodflow frequencies for streamflow-gaging stations in the Turkey River Basin using flood information collected during 1902-95. Information on temporary bench marks and reference points established in the Turkey River Basin during 1981, 1992, and 1996 also is included in the report. A flood history briefly describes rainfall conditions for floods that occurred during 1922, 1947, 1972, 1979, and 1991.

Acknowledgments

This report was prepared by the U.S. Geological Survey (USGS) in cooperation with the Iowa Highway Research Board and the Project Development Division of the Iowa Department of Transportation. Various Federal, State, and local agencies cooperated in the collection of streamflow records used in this report, the acknowledgment of which is contained in the annual water-data reports of the USGS (U.S. Geological Survey, 1915-96). The authors express their gratitude to the following: Iowa Department of Natural Resources for the use of the water-surface elevations listed in the report "Turkey/Volga River Flood of March 19, 1979" (Iowa Natural Resources Council, 1980); Doug Schindel, Rust Environment and Infrastructure, for providing correlation profiles from which supplemental surface-water elevations were obtained for the flood of June 15, 1991, and low water December 1, 1994;

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STUDY AREA

The Turkey River Basin is located in northeast Iowa, includes parts of eight counties, and drains as a right-bank tributary to the Mississippi River in Clayton County (fig. 1). The basin is oriented in a general northwest-southeast direction and drains 1,684 mi^2 (Larimer, 1957, p. 102). The Little Turkey River in Fayette County and the Volga River in Clayton County are principal tributaries to the Turkey River, with drainage areas of 355 and 403 mi^2, respectively (Larimer, 1957, p. 146 and 101). Land use in the basin is primarily agricultural with some livestock and timber operations.

The majority of the Turkey River Basin lies within two landform regions of the State, the Iowan Surface and the Paleozoic Plateau (fig. 1) (Prior, 1991, p. 31-34). In the extreme southeast part of the basin, a small part of the basin lies within a third landform region, the Southern Iowa Drift Plain. The topography of the Turkey River Basin developed as a result of repeated continental glacial advances across northeast Iowa, during which the land was scoured and thick deposits of glacial till were deposited. Periods of glaciation were followed by interglacial periods of erosion. The northwestern or upper part of the basin, drains the low-relief plain of the Iowan Surface landform region (Prior, 1991, p. 68-75; Horick and Soenksen, 1989, p. 8-9; Iowa Natural Resources Council, 1958, p. 3-8). Although streams draining the Iowan Surface are well established, stream gradients are low. Soils of the Iowan Surface are characterized as thin, discontinuous loess or loam and clay loam over glacial drift (Prior, 1991, p. 34; Oschwald and others, 1965, p. 41- 45).

In Fayette County, the Turkey River crosses from the Iowan Surface landform region to the Paleozoic Plateau landform region. The bedrock-dominated, erosional topography of the Paleozoic Plateau is characterized by plateau-like uplands, integrated drainage networks with steep gradients, and deeply entrenched valleys (Prior, 1991, p. 34 and 84-97; Horick and Soenksen 1989, p. 6-8; Iowa Natural Resources Council, 1958, p. 3-8). Stream erosion and hillslope development have stripped away glacial deposits from all but limited areas of the Paleozoic Plateau. Karst topography occurs in the Paleozoic Plateau where carbonate rocks occur at depths of less than 50 ft beneath the land surface. Dissolution of these carbonate rocks (limestone and dolomite) by ground water 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 ground-water flow. Soils in the Paleozoic Plateau are characterized as thin loess and glacial drift over bedrock (Prior, 1991, p. 34; Oschwald and others, 1965, p. 35-40 and 66-70).

In parts of the basin, the Turkey River and its tributaries have cut deeply into the bedrock formations. Such entrenched river valleys usually display strong bedrock control of their courses (Prior, 1991, p. 92). Where softer shales form the bedrock, the Turkey River valley may be from 1 to 2 mi wide; and where harder, more-resistant bedrock formations occur, the river valley narrows to gorge-like proportions (Iowa Natural Resources Council, 1958, p. 7-8). The lower river valley is filled with alluvium to a depth of more than 100 ft above its rock-cut channel.

Mean annual precipitation for 1961-90 at rain gages in the Turkey River Basin was 34.15 in. at Cresco (Cresco 1 NE), 33.08 in. at Waucoma, 34.30 in. at Fayette, and 33.23 in. at Elkader (Elkader 5 SSW) (Owenby and Ezell, 1992, p. 23-25). Mean annual runoff for the water years 1913-16, 1920-27, 1930, and 1933-95 in the Turkey River Basin was 8.67 in. as determined at the Turkey River at Garber streamflow-gaging station (station number 05412500) (May and others, 1996, p. 70).

HYDROLOGIC DATA

Gaging-station records are the primary source of data for analyzing and understanding the flood hydrology of a river basin. Flood information is obtained from complete-record streamflow-gaging stations, which provide a continuous chronology of streamflow, and from partial-record, crest-stage streamflow-gaging

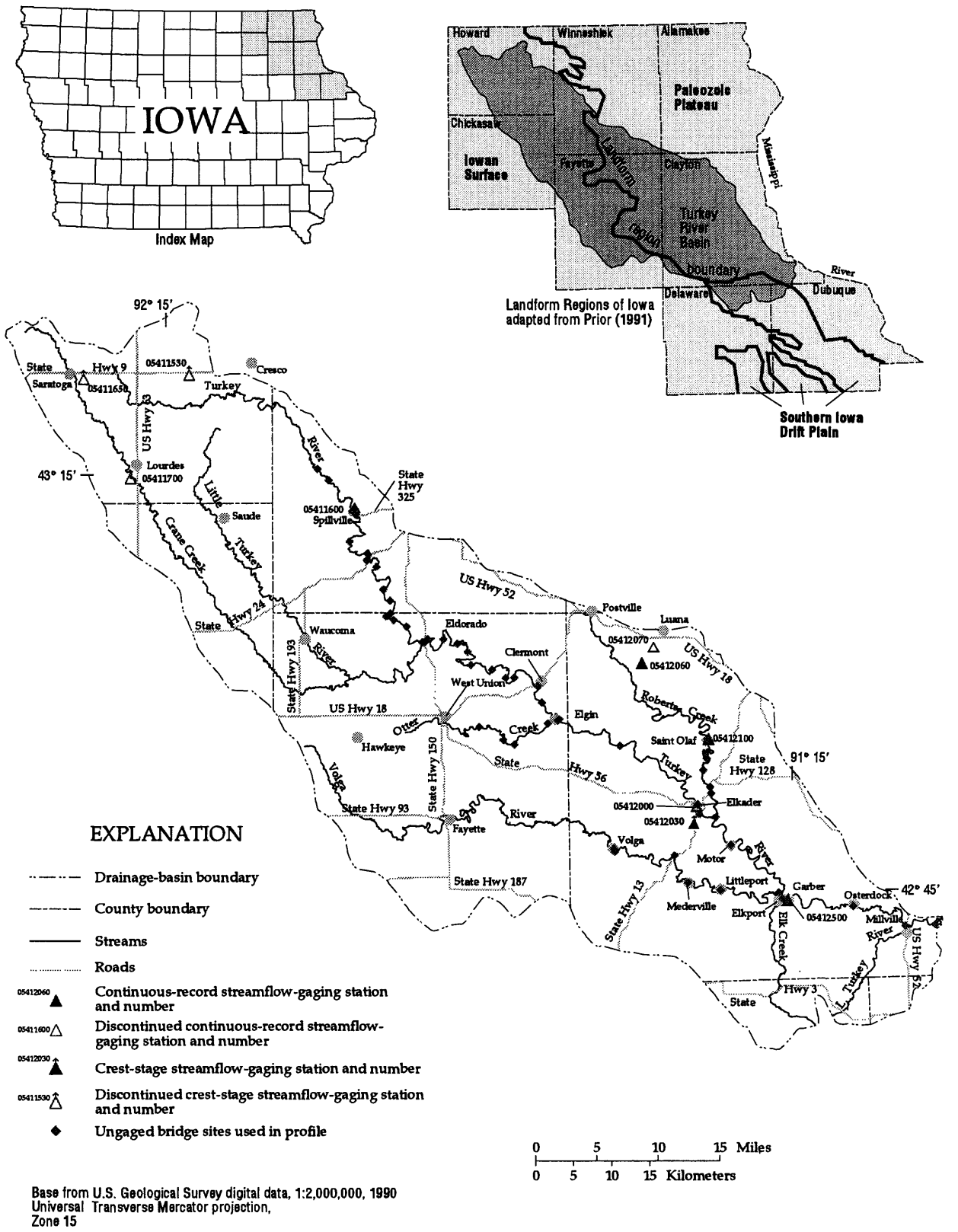

Figure 1. Turkey River Basin showing location of bridge sites used in July 12, 1972, March 19, 1979, and June 15, 1991, flood profiles and U.S. Geological Survey streamflow-gaging stations.

stations, which provide a chronology of annual peak flows. The location of 10 USGS gaging stations in the Turkey River Basin are shown in figure 1; four are active gaging stations (three continuous-record gages and one crest-stage gage) and six are discontinued gaging stations (three continuous-record gages and three crest-stage gages). The specific location, annual peak stages and discharges, and other information pertaining to each gaging station are presented in Appendix A. Discharge records collected during the operation of these gaging stations are published in the annual water-data reports of the USGS (U.S. Geological Survey, 1915-96).

The computation of discharge records at a gaging station is dependent upon the development of a stage-discharge relation, or rating curve, between water-surface elevations (stages) and the corresponding flow rates (discharges). The high-water part of the stage-discharge relation generally remains stable if the channel downstream from the gaging station remains unchanged. Changes in the stage-discharge relation occur from time to time, either gradually or abruptly, due to changes in the stream channel that result from scour, deposition, or the growth of vegetation (Rantz and others, 1982, p. 328-360).

FLOODFLOW FREQUENCIES

The magnitude and frequency of flood discharges, or floodflow frequencies, for a streamflow-gaging station are determined from a flood-frequency curve which relates observed annual-peak discharges to annual exceedance probability or recurrence interval. Annual exceedance probability is expressed as the chance that a specified flood magnitude will be exceeded in any 1 year. Recurrence interval, which is the reciprocal of the annual exceedance probability, is the statistical average number of years between exceedances of a specified flood magnitude. For example, a flood with a magnitude that is expected to be exceeded on average once during any 100-year period (recurrence interval) has a 1-percent chance (annual exceedance probability = 0.01) of being exceeded during any 1 year. This flood, commonly termed the 100-year flood, is the theoretical peak discharge against which actual flood peaks generally are compared. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at shorter intervals or even within the same year.

Floodflow frequencies computed for a gaging station, and recurrence intervals determined for selected flood peaks, are statistics that can change when recalculated as more data become available. Statistics become more reliable as more data are collected and used in the computations. USGS streamflow-gaging stations are the primary source of the streamflow data used in the computations.

A method for determining floodflow frequencies using streamflow-discharge data is outlined in Bulletin 17B of the Interagency Advisory Committee on Water Data (1982, p. 1-28). The Interagency Advisory Committee on Water Data recommends using the Pearson Type-III distribution with log transformation of the data, commonly known as the log-Pearson Type-III distribution, as a base method for determining floodflow frequencies. At least 10 years of gaged annual-peak discharges are required to compute floodflow frequencies using this method. In this report, this method for determining floodflow frequencies is referred to as the "Bulletin 17B" method.

Other methods for determining floodflow frequencies at stream sites in Iowa, including those not gaged, are described by Lara (1987, p. 2-19) and Eash (1993, p. 9-41). Lara (1987) used the physiographic characteristics of Iowa as a guide in defining the boundaries of five hydrologic regions. Regional equations were developed by using the floodflow frequencies for all gaged stations in a hydrologically, homogeneous area, thereby reducing potential errors associated with nonrepresentative, short-term stations. For this reason, a regional analysis might produce improved estimates of the flood characteristics at gaged sites. Two new methods for estimating floodflow frequencies for stream sites in Iowa were developed by Eash (1993). Statewide, drainage-basin equations were developed by relating significant drainage-basin characteristics (quantified using a geographic-information-system procedure) to the floodflow frequencies for 164 streamflow-gaging stations in Iowa. Secondly, statewide and regional channel-geometry equations were developed by relating significant channel-geometry characteristics (measured onsite) to the floodflow frequencies for 157 streamflow-gaging stations in Iowa. Lara (1987) and Eash (1993) both used the Bulletin 17B method as the base method for developing their flood-estimation equations.

The floodflow frequencies computed using the Bulletin 17B method, the regional method of Lara (1987), and the drainage-basin and channel-geometry characteristic methods of Eash (1993) for the gaging stations in the Turkey River Basin are listed in table 1. The flood-frequency discharges listed in table 1 were determined using available historic data and observed annual-peak discharges collected through the following water years: through the 1995 water year for the

Bulletin 17B method, through the 1984 water year for the regional method developed by Lara (1987), and through the 1990 water year for the drainage-basin and channel-geometry methods developed by Eash (1993). It should be noted that different flood-frequency discharges might be computed for these gaging stations by other agencies using the Bulletin 17B method if analyses use different periods of record, different approaches to weighting the skewness (asymmetry) of the frequency distribution of the annual peak discharges, or different approaches to incorporation of historical flood information.

FLOOD HISTORY

Continuous records of streamflow have been collected in the Turkey River Basin in northeast Iowa from as early as August 1913, at the USGS streamflow-gaging station Turkey River at Garber (station number 05412500, fig. 1), with the exception of a few water years during the early period of record (see Appendix A). Selected flood-peak discharges, including maximum known flood-peak discharges, and recurrence intervals for the 10 streamflow-gaging stations in the Turkey River Basin are listed in table 2. The following descriptions of five floods that occurred in the Turkey River Basin include three floods (1972, 1979, and 1991) for which information on water-surface-elevation profiles were available (Appendix B, figs. 2-7) and two floods (1922 and 1947) for which information on water-surface-elevation profiles were not available.

Flood of February 23, 1922

The second largest flood on record in the Turkey River Basin occurred on February 23, 1922 (the largest flood occurred on June 15, 1991). Severe thunderstorms crossed the State during February 21-23, and excessive rainfall occurred over a large area of northeastern Iowa on February 22 (U.S. Department of Agriculture, Weather Bureau, and Iowa Weather and Crop Service, 1922, p. 9). Because the rains fell on frozen ground, most of the rainfall was directed to surface-water runoff, which caused the most severe flooding ever experienced this early in the season to occur in the Turkey River Basin. Flooding was especially severe in Allamakee, Bremer (not shown, located south of Chickasaw County), Clayton, Delaware, Fayette, and Winneshiek Counties. The flooding inundated many miles of roads and railroads. Damage to railroads was especially severe in the flooded area, with many bridges and road-beds washed out. A stretch of the Chicago, Milwaukee, and St. Paul Railroad from West Union to Turkey River Junction was reported to have been the hardest hit by the flooding, with 24 railroad bridges and several miles of track washed out. Rainfall recorded during February 21-22, 1922, at Fayette was 3.20 in. (U.S. Department of Agriculture, Weather Bureau, and Iowa Weather and Crop Service, 1922, p. 11-12).

At the Turkey River at Garber streamflow-gaging station, the peak discharge (32,300 ft^3/s) for the flood of February 23, 1922 (table 2), is the second largest known discharge (1902-95) and the peak stage (28.06 ft) is the second highest since at least 1890. The flood-peak discharge of 32,300 ft^3/s has a recurrence interval of approximately 45 years (table 2).

Flood of June 13, 1947

Severe flooding that affected much of Iowa during June 1947, also involved the Turkey River Basin. Frequent rains during April and early June saturated soils in the basin, and excessive rains over northeastern Iowa during the remainder of June caused one of the most widespread flood periods of record in this area. Most of the flooding was caused by intense, widespread thunderstorms during June 12-13, during which more than 4 in. of rain fell in the middle part of the Turkey River Basin (Iowa Natural Resources Council, 1958, p. 53-54). Rainfall amounts recorded during June 12-13, 1947, were 3.20 in. at Cresco and 3.95 in. at Elkader (U.S. Department of Commerce, Weather Bureau, and Iowa Department of Agriculture, 1947, p. 68). Urban damage was extensive, with most damage occurring on the Volga and Turkey Rivers where parts of the towns of Volga, Littleport, Elkader, and Elkport were inundated; the National Red Cross reported that flooding damaged the homes and property of 50 families in Fayette County and 100 families in Clayton County (Iowa Natural Resources Council, 1958, p. 53). The June 1947 flood in the Turkey River Basin inundated 11,871 acres and total damage was estimated at $936,875; including damage of $438,790 for crops and pasture, $162,055 for rural property, and $336,030 for urban property (Iowa Natural Resources Council, 1958, p. 72).

At the Turkey River at Spillville streamflow-gaging station (station number 05411600, fig. 1), the peak discharge (10,000 ft^3/s) and stage (18.4 ft) for the flood in June 1947 (table 2), are the largest recorded at this site during 1947-91. The flood-peak discharge at Spillville of 10,000 ft^3/s has a recurrence interval of

Table 1. *Floodflow frequencies for streamflow-gaging stations in the Turkey River Basin*

[17B, Bulletin 17B (Interagency Advisory Committee on Water Data, 1981); Lara, hydrologic-region flood-frequency equations (Lara, 1987, p. 28); DB, drainage-basin characteristic flood-frequency equations (Eash, 1993, p. 17); CG, channel-geometry characteristic flood-frequency equations (Region I, bankfull; Eash, 1993, p. 25); --, not determined]

Station number (fig. 1)	Station name	Method	Discharge, in cubic feet per second, for indicated recurrence interval, in years					
			2	5	10	25	50	100
05411530	North Branch Turkey River near Cresco	17B	316	1,080	2,000	3,770	5,620	7,970
		Lara[a]	1,000	1,920	2,630	3,650	4,460	5,330
		DB	650	1,350	1,940	2,800	3,530	4,310
		CG	533	1,190	1,770	2,690	3,450	4,380
05411600	Turkey River at Spillville	17B	2,850	5,410	7,290	9,770	11,600	13,500
		Lara[a]	3,690	6,800	9,570	13,000	15,400	18,500
		DB	2,580	4,850	6,640	9,040	11,000	13,000
		CG	2,740	5,300	7,280	10,200	12,400	15,000
05411650	Crane Creek tributary near Saratoga	17B	633	1,180	1,580	2,100	2,500	2,910
		Lara[a]	500	1,010	1,440	2,060	2,540	3,080
		DB	348	780	1,170	1,750	2,260	2,820
		CG	--	--	--	--	--	--
05411700	Crane Creek near Lourdes	17B	2,050	4,530	6,550	9,410	11,700	14,000
		Lara[a]	2,200	4,090	5,710	7,820	9,320	11,200
		DB	1,560	3,060	4,280	5,950	7,320	8,780
		CG	1,760	3,550	4,980	7,120	8,760	10,800
05412000	Turkey River at Elkader	17B	12,000	17,600	21,300	25,700	28,900	31,900
		Lara[b]	12,000	17,600	21,300	25,700	28,900	31,900
		DB	10,000	17,500	23,200	30,400	36,100	42,000
		CG	--	--	--	--	--	--
05412030	French Hollow near Elkader	17B	--	--	--	--	--	--
		Lara[c]	404	808	1,150	1,630	2,000	2,410
		DB	709	1,620	2,430	3,660	4,750	5,950
		CG	--	--	--	--	--	--
05412060	Silver Creek near Luana	17B	--	--	--	--	--	--
		Lara[c]	455	907	1,290	1,830	2,230	2,690
		DB	274	611	910	1,360	1,740	2,160
		CG	--	--	--	--	--	--
05412070	Unnamed Creek near Luana	17B	--	--	--	--	--	--
		Lara[c]	212	434	616	885	1,100	1,320
		DB	94	222	341	527	695	883
		CG	--	--	--	--	--	--
05412100	Roberts Creek above Saint Olaf	17B	--	--	--	--	--	--
		Lara[c]	2,220	4,180	5,930	8,190	9,750	11,800
		DB	2,070	4,080	5,720	7,970	9,820	11,800
		CG	--	--	--	--	--	--
05412500	Turkey River at Garber	17B	15,200	21,100	24,900	29,400	32,700	35,800
		Lara[b]	15,700	21,000	24,100	27,800	30,300	32,700
		DB	--	--	--	--	--	--
		CG	9,170	15,900	20,600	27,200	31,600	37,200

[a] Flood-frequency equations for hydrologic regions 2 and 3 were used based on weighted average, drainage-area ratios.
[b] Flood-frequency discharges were determined from figure 2 (Lara, 1987, p. 8).
[c] Flood-frequency equations for hydrologic region 2 were used.

approximately 25 years (table 2). At the Turkey River at Garber gaging station, the peak discharge (29,000 ft^3/s) for the flood in June 13, 1947 (table 2), is the third largest known discharge (1902-95). The flood-peak discharge at Garber of 29,000 ft^3/s has a recurrence interval of approximately 25 years (table 2).

Flood of July 12, 1972

The flood of July 12, 1972, occurred as a result of two intense localized thunderstorms on July 9 and July 12 in the upper part of the Turkey River Basin. Respective rainfall amounts recorded on July 9 and July 12, 1972, in the Turkey River Basin were as follows: at Cresco, 3.85 and 3.90 in.; at Elkader, 1.10 and 0.04 in.; at Fayette, 1.91 and 1.44 in.; and at Waucoma, 1.10 and 3.54 in. (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and Iowa Department of Agriculture, 1972, p. 97-98). The rain gage at Cresco recorded 13.69 in. during July 1972, which at the time, was the maximum monthly amount of rainfall on record for the rain gage. The flood inundated businesses in Spillville, Waucoma, and Saude; road and bridge damages in southern Howard County were reported at $350,000 (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and Iowa Department of Agriculture, 1972, p. 97).

At the Turkey River at Spillville streamflow-gaging station, the peak discharge (8,600 ft^3/s) for the flood of July 12, 1972 (table 2), is the second largest recorded discharge at this site during 1947-91. The flood-peak discharge of 8,600 ft^3/s has a recurrence interval of approximately 17 years (table 2).

Flood of March 19, 1979

The March 19, 1979, flood is discussed in detail in the report "Turkey/Volga River Flood of March 19, 1979," (Iowa Natural Resources Council, 1980). The flood along the Turkey and Volga Rivers on March 19, 1979, resulted from a rapid snowmelt that occurred over a period of several days prior to the flooding. The Iowa Natural Resources Council (1980, p. 2-3) reported that snow depths in the basin prior to the flooding were approximately 3-4 in. (snow-depth data obtained from the U.S. Army Corps of Engineers), and that the flood of March 19, 1979, was most extensive along the Turkey River from Garber to Osterdock.

At the Turkey River at Garber streamflow-gaging station, the peak discharge (26,000 ft^3/s) for the flood of March 19, 1979 (table 2), is the sixth largest recorded discharge at this site during 1902-95. The flood-peak discharge of 26,000 ft^3/s has a recurrence interval of approximately 13 years (table 2).

Flood of June 15, 1991

The largest flood on record in the Turkey River Basin occurred on June 15, 1991. Significant flooding also occurred during June 1991 elsewhere in Iowa in parts of the Cedar, Skunk, Nishnabotna, Boyer, and Little Sioux River Basins (basins not shown, see O'Connell and others, 1992, p. 7 and 28). Frequent rains from March through May 1991 saturated soils throughout much of Iowa, which at the time, made 1991 the second wettest spring (March to May) of record for the State (Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship, oral and written commun., 1991). Flooding was so widespread in Iowa during March to June 1991, that by the end of June, 94 of Iowa's 99 counties were declared Federal agricultural disaster areas.

During the late afternoon hours of June 14th and into the early morning hours of the 15th, torrential rains, averaging in excess of 6 in. and exceeding 13 in. at two sites, fell in the Turkey River Basin (Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship, oral and written commun., 1991). The Turkey River at Garber streamflow-gaging station recorded an increase in stage of 21 ft in 20 hours during the flood. Postville, in southwestern Allamakee County, recorded 4.30 in. of rainfall, the greatest official rainfall amount recorded during the storm. Other official 24-hour rainfalls recorded in the Turkey River Basin on June 15, 1991 (between 7 and 8 a.m.), were 0.92 in. at Cresco, 3.28 in. at Elkader, 2.16 in. at Fayette, and 3.05 in. at Waucoma; however, unofficial totals of 13 in. were reported at Monona in northern Clayton County and in northern Fayette County (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and Iowa Department of Agriculture and Land Stewardship, 1991, p. 6 and 31). Rainfall amounts recorded at two USGS rain gages during July 14-15 were 13.96 in. at the Unnamed Creek near Luana streamflow-gaging station (station number 05412070, fig. 1) and 9.28 in. at a site located approximately 5 mi south of Postville (Kalkhoff and Kuzniar, 1994, p. 33-34).

Table 2. *Selected flood-peak discharges, recurrence intervals, and unit runoff for streamflow-gaging stations in the Turkey River Basin*

[Water year, October 1-September 30; mi^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, cubic foot per second per square mile; *, maximum flood-peak discharge known for station; --, not determined]

Station number (fig. 1)	Station name and location	Period of flood record (water year)[a]	Drainage area (mi^2)	Date	Gage height (ft)[b]	Discharge (ft^3/s)	Recurrence interval (years)[c]	Unit runoff [$(ft^3/s)/mi^2$]
05411530	North Branch Turkey River near Cresco	1966-93	19.5	06-29-69	92.72	2,400[d]	13	123
				08-25-90	93.88	3,500[d]	20	179
				08-15-93	94.61	*4,500	35	231
05411600	Turkey River at Spillville	1947,	177	06-----47	18.4[e]	*10,000[f]	25	56.5
		1956-73,		07-12-72	16.73	8,600	17	48.6
		1978-91		08-25-90	16.76	8,320	15	47.0
05411650	Crane Creek tributary near Saratoga	1953-78	4.06	08-31-62	6.56	*1,830	16	451
				06-29-69	6.29	1,530	9	377
				06-04-74	6.21	1,500	9	369
05411700	Crane Creek near Lourdes	1953-90	75.8	08-31-62	15.70	*11,900	50	157
				06-29-69	14.10	8,840	20	117
				06-04-74	13.71	7,700	15	102
				08-25-90	13.55	7,400	14	97.6
05412000	Turkey River at Elkader	1916,	891	06-01-16	34.30[e]	*30,000[f]	60	33.7
		1929,		03-16-29	--	25,200[g,h]	25	28.3
		1933-42		04-01-33	--	23,800[g,h]	17	26.7
05412030	French Hollow Creek near Elkader	1991-95	3.56	06-15-91	16.32	*1,900[f]	--	534
05412060	Silver Creek near Luana	1988-95	4.39	06-15-91	14.97	*3,300[i]	--	752
05412070	Unnamed Creek near Luana	1987-92	1.15	06-15-91	16.82	*880[i]	--	765
05412100	Roberts Creek above Saint Olaf	1987-95	70.7	06-15-91	27.88	*19,600[i]	--	277
05412500	Turkey River at Garber	1902,	1,545	02-23-22	28.06[e,j]	32,300	45	20.9
		1914-16,		06-13-47	26.6	29,000	25	18.8
		1919-27,		03-19-79	25.59	26,000	13	16.8
		1929-30,		06-15-91	30.10[e]	*49,900[i]	1.4[k]	32.3
		1933-95						

[a] See Appendix A for list of flood peaks.

[b] See Appendix A for datum of gage above sea level for continuous-record streamflow-gaging stations.

[c] Interpolated from Bulletin 17B flood-frequency analysis (Interagency Advisory Committee on Water Data, 1981) and rounded to the nearest 5 years for 20- to 50-year recurrence intervals and to nearest 10 years above the 50-year recurrence interval.

[d] Discharge revised from previously published value.

[e] Gage height determined from floodmark.

[f] Approximate.

[g] Discharge is a maximum daily average.

[h] From records by Central States Power and Light Corporation.

[i] Discharge computed from indirect measurement.

[j] Maximum gage height known since 1890.

[k] Recurrence interval for discharge larger than the computed 100-year flood discharge is expressed as a ratio of the given flood discharge to the 100-year flood discharge.

In northern Clayton County, an unofficial report of 5 in. of rain in a 2-hour period, received late in the afternoon of June 14th, prompted the National Weather Service to issue a flash flood warning (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, Storm Summary Report, 1991, p. 10-11). Radar showed an east-west line of thunderstorms "training" eastward across northeast Iowa. As the evening of June 14th progressed, flash flooding developed over a large area from Clayton County west to southern Cerro Gordo County (not shown, located in north-central Iowa). Rainfall reports of 2 to 5 in. in 3 hours or less were common across this area as a result of the storm. The most intense rainfall was in Fayette County, where many areas of the county received about 5 in. of rain, and some areas in the county received up to 10 in. The towns of Hawkeye and West Union, in Fayette County, received 9 and 10 in. of rainfall, respectively.

During the flood of June 15th in Elgin, in northeast Fayette County, two 20,000-gallon storage tanks of anhydrous ammonia that were cradled on concrete foundations and an estimated 25 1,000-gallon "nurse tanks" of ammonia were swept away from a local business by the rising waters of Otter Creek (Des Moines Register, June 16, 1991; Fayette County Union, June 19, 1991). When one of the tanks struck a bridge in Elgin at about 10 a.m. and began leaking ammonia, an estimated 400 residents were evacuated. Anhydrous ammonia, a fertilizer and a deadly gas, is stored as a liquid at very cold temperatures or under pressure and vaporizes in the air. The Iowa Department of Natural Resources notified officials in Elkader, located approximately 19 mi downstream of Elgin in Clayton County, that the floating ammonia tanks might possibly be washed down the Turkey River and get caught in the undertow of the Elkader dam and rupture (Clayton County Register, June 19, 1991). As a safety precaution, the downtown area of Elkader was evacuated for a few hours and the Keystone Arch Bridge was closed on June 15th. As it turned out, observation aircraft were unable to spot any tanks floating down the river and the all-clear was given in downtown Elkader at mid-afternoon.

Damage from the flood was severe in Clayton and Fayette Counties. In Clayton County, three bridges were destroyed, 15 other bridges and culverts were severely damaged, and many roads were washed out by the flood; preliminary assessments of damage to roads and bridges in Clayton County were estimated to be from $1 to $1.5 million (Jerry Weber, Clayton County Engineer, Clayton County Register, June 19, 1991). During the flood, most roads into Elkader were inundated, cutting off travel to the town (Des Moines Register, June 16, 1991). In Elkader, city water service was interrupted by the flood when a water main in town was washed out; as were sewer services, when floodwater inundated two of the city's four sewage treatment lift stations (Clayton County Register, June 19, 1991). Ken Lemka, Elkader City Clerk, reported, "To our knowledge this is the worst flood the town's ever had, but we had enough warning from Elgin upstream that this was coming so we could be ready for it. We knew there was no way we could control it, so we just got people out of the way" (Des Moines Register, June 18, 1991). Floodwaters from the Turkey River inundated 35 homes and 38 businesses in Elkader, and floodwaters from tributaries to the Turkey River inundated 20 homes in Garber and 21 homes in Elkport (Owen Pufahl, Director, Clayton County Civil Disaster Services, Telegraph Herald, June 17, 1991). Most of the business district in Garber was severely flooded (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, Storm Summary Report, 1991, p. 12). Preliminary estimates to repair damaged terraces in Clayton County were at least $100,000; an estimated 32,000 acres of corn, soybeans, alfalfa, and oats were destroyed or damaged (Frank Phippen, Clayton County Agriculture Stabilization and Conservation Service, Telegraph Herald, June 18, 1991; Clayton County Register, June 19, 1991). Preliminary estimates of total flood damage in Clayton County were in excess of $3 million (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, Storm Summary Report, 1991, p. 11).

In Fayette County, 15 bridges were washed out and nearly all roads in the county were closed at one time or another during the flood (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, Storm Summary Report, 1991, p. 11). Preliminary estimates of total damage in Fayette County were $2.1 million (does not include agricultural damage), which included damage of $1.3 million to private property and $0.8 million to public property; the damage estimate included damage to 65 homes, businesses, and churches in Elgin estimated at $1 million, and another $100,000 to public properties; West Union's loss was estimated at $350,000, including $250,000 to homes and businesses; damage in Fayette was estimated at $100,000 and in Hawkeye at $12,500; damage to county parks was estimated to be $275,000; and damage to county roads and bridges was estimated to be $250,000 (Fayette County Union, June 19, 1991). Damage to agricultural terraces in Fayette County was estimated to be another $250,000 (U.S. Department of Commerce, National Oceanic and Atmospheric

Administration, and National Weather Service, Storm Summary Report, 1991, p. 11).

Soil erosion was severe as a result of the flood, with top soil losses as high as 200-250 tons per acre (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, Storm Summary Report, 1991, p. 11-12). Reports indicated that a few farms were completely destroyed as intense rain and runoff eroded soils down to bedrock. Crops along river flood plains and creeks in the Turkey River Basin were destroyed. No one was killed or seriously injured by the flooding; however, several hundred head of livestock were swept away and drowned (Des Moines Register, June 18, 1991).

The discharge from the June 15, 1991, flood on the Turkey River at Garber streamflow-gaging station is the largest known peak discharge (49,900 ft^3/s, determined from an indirect measurement) at this site for the period 1902-95 (table 2), and the peak stage (30.10 ft) is the highest since at least 1890. The flood-peak discharge of 49,900 ft^3/s is 1.4 times larger than the Bulletin 17B, 100-year recurrence-interval discharge (table 2). The peak stage at this gage associated with this flood exceeded the flood stage by about 13.1 ft. The flood was limited to the middle and lower parts of the Turkey River Basin, as indicated by the streamflow record at the Turkey River at Spillville gaging station, where the peak discharge on June 15, 1991, was only 462 ft^3/s.

FLOOD PROFILE

Water-surface-elevation profiles for the floods of July 12, 1972, March 19, 1979, and June 15, 1991, in the Turkey River Basin in northeast Iowa, are shown in Appendix B (figs. 2-7). Water-surface elevations for the floods of July 12, 1972, and June 15, 1991, were collected by the USGS; except for two supplemental water-surface elevations of the flood of June 15, 1991, discussed in text below. Water-surface elevations for the flood of March 19, 1979, were collected by the Iowa Natural Resources Council and information on the collection of these flood elevations is described in the report "Turkey/Volga River Flood of March 19, 1979" (Iowa Natural Resource Council, 1980, p. 12). Profiles for the flood of March 19, 1979, are presented in this report for comparative purposes.

Flood elevations collected by the USGS, located both immediately downstream and 1 bridge-length upstream from selected bridges, were identified within a few days of passage of the flood peak and were referenced to a common datum by differential leveling. Low-water profiles measured on July 1-2, 1981, and on September 21-22, 1992, also are shown in figures 2-7 to indicate the approximate low-end of the range of stage that can occur within the profiled reaches.

The profiles were defined using data obtained by the USGS, with the following two exceptions: (1) the profiles of the flood of March 19, 1979, along the Turkey and Volga Rivers (figs. 2-4), were defined using water-surface elevations collected by the Iowa Natural Resources Council (1980, p. 12); and (2) the profiles of the flood of June 15, 1991, and low water September 22, 1992, along the Turkey River in Elkader (figs. 2 and 3C), were supplemented by water-surface elevations obtained from Rust Environment and Infrastructure, Waterloo, Iowa (Doug Schindel, Engineer, Rust Environment and Infrastructure, written commun., August 1996) to better define the water-surface elevations in the vicinity of the two dams in Elkader (one upstream and one downstream of the Keystone Arch bridge in Elkader). The water-surface elevations noted as supplemental on figure 3C were obtained from correlation profiles prepared by Rust Environment and Infrastructure. The supplemental low-water elevations (fig. 3C) were collected on December 1, 1994.

Profiles between the bridges, and between the upstream and downstream sides of individual bridges, are straight-line interpolations which provide only an approximation of the water-surface elevations. While water-surface elevations for the 1972, 1979, and 1991 floods were collected at the majority of the bridges listed along the profiled reaches in figures 2-7, it should be noted that flood elevations were not collected at every bridge, nor were flood elevations necessarily collected at both the upstream and downstream sides of each bridge.

River miles, measured from the most current 1:24,000-scale USGS topographic maps using a geographic-information-system method, are referenced to the mouth of each of the four river reaches profiled (Turkey and Volga Rivers, and Roberts and Otter Creeks). Measurements of river miles using larger- or smaller-scale cartographic data or different measurement methods may yield different values than those contained in this report. Water-surface elevations collected by the Iowa Natural Resources Council (1980, p. 12) for the flood of March 19, 1979 (figs. 2-4), and by Rust Environment and Infrastructure for the flood of June 15, 1991, and low water December 1, 1994 (figs. 2 and 3C), were profiled using river miles measured by the USGS. Bridges are designated by an index number that helps to identify their location. For example, 9102-12 SW refers to a location in Township 91 North, Range 02 West, southwest quarter of section 12.

Differential leveling was performed to reference all the points along the profiles to a common datum, sea level. A bench mark and a reference point were established at the majority of the bridges in the profiled reach. Bench-mark and reference-point descriptions and elevations for bridge sites used in the June 15, 1991, flood profile are listed in Appendix C.

For bridges used in the June 15, 1991, flood profile, bridge-deck and low-bridge-chord elevations are shown in figures 2-7 to indicate the relation between the elevation of important components of the bridges and the elevation of the profiled flood and low-water. For sloping bridges, the profiled bridge-deck and low-bridge-chord elevations represent the lower ends of the bridges.

CONSIDERATIONS

The user of this report is cautioned that the stage-discharge data presented herein are representative of the physical conditions of the basin at the time of the floods described. Changes in the basin can alter the flood magnitude for a specific frequency. Examples of these basin changes include, but are not limited to, extensive urbanization, implementation of agricultural conservation practices, and installation of drainage systems. Changes in the channel conditions immediately downstream from a streamflow-gaging station can substantially affect the stage-discharge relation. Examples of such changes include the construction of dams, bridges, or levees; changes in the flood-plain vegetative cover; straightening of the channel; and natural scour and fill. Temporary changes can be caused by ice and debris jams that produce backwater conditions and can cause the water-surface elevations to plot higher than the normal profile.

SUMMARY

This report provides information on the floods of July 12, 1972, March 19, 1979, and June 15, 1991, in the Turkey River Basin in northeast Iowa. The June 15, 1991, flood on Turkey River at Garber (station number 05412500) is the largest known flood-peak discharge at the streamflow-gaging station for the period 1902-95. The peak discharge for June 15, 1991, of 49,900 cubic feet per second was 1.4 times larger than the 100-year recurrence-interval discharge. The report provides information on flood stages and discharges and flood-flow frequencies for streamflow-gaging stations in the Turkey River Basin using flood information collected during 1902-95. Information on temporary bench marks and reference points established in the Turkey River Basin during 1981, 1992, and 1996 also is included in the report. A flood history describes rainfall conditions for floods that occurred during 1922, 1947, 1972, 1979, and 1991.

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APPENDIX A

PEAK STAGES AND DISCHARGES FOR STREAMFLOW-GAGING STATIONS IN THE TURKEY RIVER BASIN, NORTHEAST IOWA, 1902-1995

The peak-stage and discharge data for streamflow-gaging stations located in the Turkey River Basin were compiled for May 18, 1902, through September 30, 1995. The peak flow data are listed in chronological order. In general, independent peak discharges above a pre-selected base (partial-duration series) are listed for the continuous-record gaging stations. The magnitude of the selected base discharge, given in the "Remarks" section of the headnote, was determined so that it would be equaled or exceeded on the average of about three times per year. Two peak discharges are considered independent if a plot of the recorded stages indicates a well-defined trough between the peaks and if the instantaneous discharge of the trough is 25 percent or more below that of the lower peak (Novak, 1985, p. 93). Only the annual peak discharges are listed for the crest-stage gaging stations.

The peak flow lists for each gaging-station are arranged in downstream order as explained in the annual water-data reports of the USGS (see "References"). The gaging stations are identified by a permanent number that also is used in figure 1 and in tables 1 and 2 of this report. The datum of the gage, when given, is above sea level. Flood stage, as determined by the National Weather Service, is the stage at which overflow of the natural banks of the stream begins to cause damage in the reach in which the elevation is measured.

Footnotes used throughout this appendix are selected so that each letter has the same meaning. For example, each occurrence of footnote "f" in any of the lists means "Affected by ice." Not all footnotes may appear in every list.

05411530 North Branch Turkey River near Cresco, Iowa

(Discontinued September 30, 1993)

Location.--Latitude 43°22'15", longitude 92°12'49", in NW1/4 sec. 25, T.99 N., R.12 W., Howard County, Hydrologic Unit 07060004, at bridge on State Highway 9, 5 mi west of Cresco.

Drainage area.--19.5 mi^2.

Gage.--Crest-stage gage.

Stage-discharge relation.--Defined by current-meter measurements and above 200 ft^3/s by step-backwater computations.

Remarks.--Only annual peaks are shown.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1966	Mar. 4, 1966	89.85	510[a]
1967	--	--[b]	199[c]
1968	--	--[b]	189[c]
1969	June 29, 1969	92.72	2,400[a]
1970	Aug. 8, 1970	88.25	130[a]
1971	Oct. 9, 1970	89.86	510[a]
1972	July 12, 1972	91.47	1,500[a]
1973	Apr. 17, 1973	88.95	200[a]
1974	--	--[b]	25[d]
1975	Apr. 28, 1975	87.73	90[a]
1976	--	--[b]	25[d]
1977	--	--[b]	25[d]
1978	--	--[b]	25[d]
1979	Aug. 22, 1979	90.70	1,100[a]
1980	Sept. 22, 1980	88.04	110[a]
1981	Apr. 4, 1981	88.41	140[a]
1982	Mar. 31, 1982	88.28	130[a]
1983	Nov. 12, 1982	92.19	2,100[a]
1984	June 17, 1984	91.83	1,740[a]
1985	--	87.33	65[a]
1986	Mar. 19, 1986	90.21	700[a]
1987	Oct. 12, 1986	90.06	640[a]
1988	--	--[b]	25[d]
1989	Mar. 12, 1989	88.06	110[a]
1990	Aug. 25, 1990	93.88	3,500[a]
1991	May 18, 1991	90.06	640[a]
1992	Mar. 10, 1992	89.75	450[a]
1993	Aug. 15, 1993	94.61	4,500[a]

[a] Discharge revised from previously published value.
[b] Peak did not reach bottom of gage.
[c] Approximate.
[d] Discharge less than indicated value.

05411600 Turkey River at Spillville, Iowa

(Discontinued September 30,1991)

Location.--Latitude 43°12'28", longitude 91°56'56", in SW1/4 NE1/4 sec. 19, T.97 N., R.9 W., Winneshiek County, Hydrologic Unit 07060004, on right bank 60 ft downstream from bridge on County Road W14 at north edge of Spillville, 150 ft downstream from old mill dam, 0.6 mi upstream from Wonder Creek, and 110.9 mi upstream from mouth.

Drainage area.--177 mi^2.

Gage.--Water-stage recorder. Datum of gage is 1034.92 ft above sea level.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Bankfull stage.--12 ft.

Remarks.--Base for partial-duration series, 1,200 ft^3/s; prior to 1966, peak base was 1,700 ft^3/s.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1947	June 1947	18.4[e]	10,000[c]
	(Systematic operation of gage began in June 1956)		
1956	July 31, 1956	4.13	398
1957	July 16, 1957	6.73	1,230
1958	Feb. 24, 1958	5.17[f]	500[c]
1959	Mar. 29, 1959	11.48[f]	--
	Mar. 30, 1959	9.12	2,100
1960	Mar. 30, 1960	10.70	3,220
	May 7, 1960	9.18	2,360
	June 24, 1960	10.12	2,860
1961	Mar. 27, 1961	14.37	6,420
1962	Mar. 29, 1962	15.32	7,380
	Apr. 6, 1962	7.57	1,740
	Aug. 31, 1962	14.34	5,950
1963	Mar. 17, 1963	8.41	2,000
1964	Apr. 2, 1964	7.25	1,430
1965	Mar. 1, 1965	6.11[f]	3,900[c]
	Apr. 1, 1965	12.58[f]	2,800[c]
	Apr. 5, 1965	11.56	2,740
	Apr. 8, 1965	11.68	2,810
	Sept. 29, 1965	11.68	3,490
1966	Feb. 8, 1966	12.36[f]	--
	Feb. 9, 1966	12.24	3,120
	July 14, 1966	11.88	2,960
1967	Mar. 10, 1967	9.73[f]	--
	Mar. 27, 1967	9.53	1,810
1968	July 24, 1968	9.29	1,720

05411600 Turkey River at Spillville, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1969	Apr. 5, 1969	9.34	1,740
	June 26, 1969	15.59	6,990
	June 29, 1969	14.80	6,220
1970	Aug. 9, 1970	6.78	1,130
1971	Oct. 10, 1970	12.20	4,130
	Apr. 1, 1971	11.66	3,760
1972	Mar. 13, 1972	10.01[f]	1,800[c]
	July 12, 1972	16.73	8,600
	Sept. 25, 1972	15.92	7,470
	Sept. 29, 1972	9.21	1,920
1973	Oct. 24, 1972	8.73	1,780
	Dec. 30, 1972	--	2,300[c]
	Jan. 18, 1973	10.19[f]	1,900[c]
	Feb. 1, 1973	8.53[f]	1,500[c]
	Mar. 11, 1973	8.92	1,780
	Mar. 14, 1973	8.56	1,620
	Apr. 16, 1973	11.92	3,500
	May 2, 1973	12.64	4,070
	May 8, 1973	10.56	2,640
	(Gage discontinued September 30, 1973, reactivated October 1, 1977)		
1978	May 11, 1978	13.77	5,140
	June 18, 1978	8.20	1,250
	July 6, 1978	10.20	2,340
1979	Mar. 19, 1979	11.55	3,540
	Mar. 24, 1979	9.87	2,260
	Mar. 31, 1979	10.92	2,870
	May 19, 1979	8.36	1,300
	Aug. 22, 1979	8.86	1,550
1980	Jan. 16, 1980	10.32[f]	2,200[c]
	Mar. 16, 1980	12.55	3,940
	Sept. 23, 1980	9.82	1,900
1981	Apr. 4, 1981	8.33	1,290
	Aug. 29, 1981	8.30	1,250
	Aug. 30, 1981	8.31	1,260
	Aug. 31, 1981	10.73	2,690
1982	Mar. 16, 1982	9.81[f]	--
	Mar. 24, 1982	7.95	1,210
	May 28, 1982	8.11	1,240
	Aug. 30, 1982	9.14	1,700

05411600 Turkey River at Spillville, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1983	Nov. 12, 1982	11.88	3,720
	Dec. 6, 1982	7.99	1,250
	Dec. 28, 1982	10.26	2,550
	Feb. 21, 1983	8.25	1,350
	Mar. 7, 1983	9.73	2,160
	Apr. 15, 1983	9.69	2,070
	May 8, 1983	8.32	1,330
	May 14, 1983	9.19	1,500
	May 19, 1983	10.00	1,940
	May 22, 1983	10.17	2,040
1984	Feb. 16, 1984	9.77[f]	--
	June 18, 1984	9.02	1,160
1985	Feb. 24, 1985	12.43[f]	3,980
	Mar. 9, 1985	10.21	2,480
1986	Mar. 19, 1986	12.87	4,660
	Sept. 30, 1986	12.24	3,970
1987	Oct. 5, 1986	8.90	1,700
	Oct. 12, 1986	12.24	5,200
1988	Mar. 10, 1988	--[f]	720
1989	Mar. 12, 1989	9.61[f]	800
1990	Mar. 3, 1990	10.42[f]	2,040
	Mar. 11, 1990	9.43	1,920
	Mar. 14, 1990	8.95	1,650
	Aug. 25, 1990	16.76	8,320
1991	Apr. 14, 1991	8.17	1,310
	Apr. 28, 1991	9.01	1,730
	Apr. 29, 1991	10.85	2,830
	May 19, 1991	9.14	1,860

[c]Approximate.
[e]Gage height determined from floodmark.
[f]Affected by ice.

05411650 Crane Creek tributary near Saratoga, Iowa

(Discontinued September 30, 1978)

Location.--Latitude 43°22', longitude 92°23', near SE corner of sec. 21, T.99 N., R.13 W., Howard County, Hydrologic Unit 07060004, at bridge on State Highway 9, 1 mi east of Saratoga.

Drainage area.--4.06 mi^2.

Gage.--Crest-stage gage.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Remarks.--Only annual peaks are shown.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1953	June 13, 1953	5.77	1,050
1954	June 21, 1954	5.41	777
1955	Mar. 15, 1955	3.79	157
1956	Apr. 1, 1956	4.43	316
1957	July 16, 1957	4.44	320
1958	Apr. 7, 1958	2.38	22
1959	Mar. 26, 1959	5.34	734
1960	June 23, 1960	5.97	1,210
1961	June 26, 1961	6.02	700
1962	Aug. 31, 1962	6.56	1,830
1963	May 13, 1963	4.31	270
1964	May 24, 1964	3.84	167
1965	Sept. 30, 1965	5.86	1,120
1966	July 14, 1966	4.79	456
1967	June 9, 1967	5.70	990
1968	May 17, 1968	5.82	1,090
1969	June 29, 1969	6.29	1,530
1970	Aug. 8, 1970	4.34	250
1971	Oct. 9, 1970	5.80	1,030
1972	July 12, 1972	6.01	1,220
1973	May 27, 1973	5.67	560
1974	June 4, 1974	6.21	1,500
1975	Apr. 28, 1975	4.29	238
1976	--	--[b]	--
1977	--	--[b]	--
1978	--	--[b]	--

[b]Peak did not reach bottom of gage.

05411700 Crane Creek near Lourdes, Iowa

(Discontinued September 30, 1990)

Location.--Latitude 43°14'57", longitude 92°18'32", in SE1/4 NW1/4 sec. 6, T.97 N., R.12 W., Howard County, Hydrologic Unit 07060004, at bridge on State Highway 272, 1 mi southwest of Lourdes.

Drainage area.--75.8 mi^2.

Gage.--Crest-stage gage.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Remarks.--Only annual peaks are shown.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1953	June 13, 1953	12.00	3,200
1954	June 21, 1954	10.61	2,620
1955	Mar. 15, 1955	9.35	1,430
1956	Apr. 1, 1956	9.23	1,330
1957	Mar. 24, 1957	7.60	580
1958	Apr. 7, 1958	6.39	336
1959	Mar. 31, 1959	9.28	1,370
1960	June 23, 1960	12.13	5,960
1961	Mar. 26, 1961	11.12	3,890
1962	Aug. 31, 1962	15.70	11,900
1963	May 13, 1963	9.20	1,310
1964	Apr. 3, 1964	8.00	710
1965	Sept. 30, 1965	11.69	4,360
1966	July 14, 1966	9.19	1,300
1967	June 10, 1967	11.38	3,850
1968	July 23, 1968	10.87	3,060
1969	June 29, 1969	14.10	8,840
1970	May 14, 1970	7.32	530
1971	Oct. 9, 1970	11.46	3,700
1972	July 12, 1972	11.36	3,500
1973	Apr. 17, 1973	10.67	2,750
1974	June 4, 1974	13.71	7,700
1975	--	--[b]	210[d]
1976	--	--[b]	210[d]
1977	--	--[b]	210[d]
1978	--	--[b]	210[d]
1979	Mar. 20, 1979	10.33	2,200
1980	Sept. 22, 1980	11.48	3,750

05411700 Crane Creek near Lourdes, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1981	Aug. 31, 1981	10.60	2,600
1982	Aug. 30, 1982	9.29	1,450
1983	Nov. 12, 1982	10.60	2,650
1984	June 17, 1984	11.12	3,020
1985	Sept. 30, 1985	7.49	580
1986	Mar. 19, 1986	11.25	3,400
1987	Oct. 12, 1986	11.97	4,400
1988	--	--[b]	210[d]
1989	--	--[b]	210[d]
1990	Aug. 25, 1990	13.55	7,400

[b]Peak did not reach bottom of gage.
[d]Discharge less than indicated value.

05412000 Turkey River at Elkader, Iowa

(Discontinued September 30, 1942)

Location.--Latitude 42°51'05", longitude 91°24'15", in NW1/4 SE1/4 sec. 23, T.93 N., R.5 W., Clayton County, Hydrologic Unit 07060004, in tailrace of Central States Power and Light Corporation's hydroelectric plant in Elkader, 2.7 mi upstream from Roberts Creek and 39.0 mi from mouth.

Drainage area.--891 mi^2.

Gage.--Nonrecording. Datum of gage is 701.61 ft above sea level.

Stage-discharge relation.--Defined by current-meter measurements.

Remarks.--Only annual peaks are shown.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1916	June 1, 1916	34.30[e]	30,000[c]
1929	Mar. 16, 1929	--	25,200[g,h]
1933	Apr. 1, 1933	--	23,800[g,h]
	(Systematic operation of gage began in July 1933)		
1934	Jan. 22, 1934	12.8	6,860
1935	Mar. 6, 1935	14.0	11,400
1936	Mar. 11, 1936	26.4	9,000
1937	Mar. 7, 1937	27.5	12,300
1938	Feb. 5, 1938	14.50	13,000
1939	Mar. 14, 1939	11.50	4,970
1940	July 27, 1940	29.1	19,000
1941	May 31, 1941	29.1	19,300
1942	June 30, 1942	13.0	9,200

[c]Approximate.
[e]Gage height determined from floodmark.
[g]Discharge is a maximum daily average.
[h]From records by Central States Power and Light Corporation.

05412030 French Hollow Creek near Elkader, Iowa

Location.--Latitude 42°50'19", longitude 91°24'25", in SW1/4, sec. 26, T.93 N., R.5 W., Clayton County, Hydrologic Unit 07060004, at culvert on State Highway 13, 1.1 mi south of Elkader.

Drainage area.--3.56 mi^2.

Gage.--Crest-stage gage.

Stage-discharge relation.--Defined by theoretical culvert rating.

Remarks.--Only annual peaks are shown.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1990	Aug. 25, 1990	12.97	1,050[c]
1991	June 15, 1991	*16.32	1,900[c]
1992	Dec. 13, 1991	9.46	150[c]
1993	July 11, 1993	11.92	650[c]
1994	July 20, 1994	10.13	250[c]
1995	Apr. 19, 1995	9.48	150[c]

[c]Approximate.

*Gage height at gage 55 ft upstream of culvert entrance, all other gage heights at gage 30 ft upstream of culvert entrance.

05412060 Silver Creek near Luana, Iowa

Location.--Latitude 43°01'19", longitude 91°29'21", in NE1/4 sec. 25, T.95 N., R.6 W., Clayton County, Hydrologic Unit 07060004, on right upstream bank at bridge on County Road W70, 2.3 mi south of Highway 52 and 18, and 3.2 mi south of Luana.

Drainage area.--4.39 mi^2.

Gage.--Water-stage recorder.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Remarks.--Base for partial-duration series, 50 ft^3/s.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1988	Mar. 1, 1988	6.45	63.0
1989	Mar. 11, 1989	8.78[f]	181
1990	Mar. 8, 1990	8.21	299
1991	Apr. 12, 1991	6.77	53.0
	Apr. 14, 1991	6.87	64.0
	June 14, 1991	13.64	1,860
	June 15, 1991	14.97	3,300[i]
	Sept. 12, 1991	9.30	468
1992	Nov. 1, 1991	7.23	182
	Nov. 18, 1991	6.65	111
	Jan. 22, 1992	6.44	62.0
	Feb. 3, 1992	6.82	140
	Dec. 12, 1991	6.60	101
	Feb. 20, 1992	6.52	79.0
	Apr. 20, 1992	7.68	233
	Sept. 6, 1992	6.76	134
	Sept. 9, 1992	6.53	81.0
	Sept. 14, 1992	6.91	149
1993	Mar. 16, 1993	7.20	141
	Mar. 30, 1993	8.89	340
	Mar. 31, 1993	8.34	268
	June 17, 1993	9.97	533
	June 29, 1993	11.58	960
	July 9, 1993	7.00	107
	July 11, 1993	10.78	731
	Aug. 15, 1993	7.90	215
	Aug. 18, 1993	6.35	53.0
	Aug. 23, 1993	6.50	58.0
1994	Feb. 19, 1994	7.92[f]	--
	Mar. 5, 1994	7.77	200
	July 20, 1994	6.60	52.0
1995	Feb. 20, 1995	6.33	57
	Mar. 11, 1995	6.67	115

[f]Affected by ice.
[i]Discharge computed from indirect measurement.

05412070 Unnamed Creek near Luana, Iowa

(Discontinued September 30,1992)

Location.--Latitude 43°02'24", longitude 91°28'07", in SE1/4 sec. 18, T.95 N., R.5. W., Clayton County, Hydrologic Unit 07060004, on right upstream bank at culvert on the north-south gravel road between County Road W70 and County Road X16, 0.8 mi south of State Highway 52 and 18 and approximately 1.6 mi south of Luana.

Drainage area.--1.15 mi^2.

Gage.--Water-stage recorder.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Remarks.--Base for partial-duration series, 25 ft^3/s.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1987	Aug. 13, 1987	11.81	96.0
1988	Mar. 1, 1988	11.84[f]	65.0
1989	Mar. 11, 1989	11.46[f]	--
	Mar. 14, 1989	11.45	43.0
1990	Aug. 25, 1990	11.99	110
1991	May 29, 1991	11.13	45.0
	May 30, 1991	10.93	35.0
	June 14, 1991	15.24	365
	June 15, 1991	16.82	880[i]
	Sept. 12, 1991	12.85	169
1992	Apr. 20, 1992	11.12	37.0
	Sept. 9, 1992	11.31	45.0
	Sept. 14, 1992	11.20	40.0

[f]Affected by ice.
[i]Discharge computed from indirect measurement.

05412100 Roberts Creek above Saint Olaf, Iowa

Location.--Latitude 42°55'49", longitude 91°23'03", in SW1/4 NW1/4 sec. 25, T.94 N., R.5 W., Clayton County, Hydrologic Unit 07060004, on left downstream bank at bridge on road X28, 0.1 mi north of county road B65, on north edge of Saint Olaf.

Drainage area.--70.7 mi^2.

Gage.--Water-stage recorder. Datum of gage is 826.73 ft above sea level.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Remarks.--Base for partial-duration series, 500 ft^3/s.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
	(Operated as a low-flow station only, September 1957 to July 1977)		
1987	Sept. 17, 1987	13.02	513
1988	Mar. 2, 1988	12.68[f]	270
1989	Mar. 11, 1989	15.77[f]	1,020
1990	Aug. 25, 1990	14.88	758
1991	Apr. 12, 1991	14.45	625
	June 15, 1991	27.88	19,600[i]
1992	Nov. 1, 1991	17.46	2,120
	Apr. 21, 1992	14.96	628
1993	Mar. 31, 1993	16.72	2,120
	June 18, 1993	14.48	726
	June 30, 1993	15.86	1,530
	July 9, 1993	14.41	714
	July 11, 1993	16.08	1,740
	July 17, 1993	14.92	935
	Aug. 15, 1993	13.77	517
	Aug. 23, 1993	13.95	572
1994	Mar. 5, 1994	15.78[f]	1,280
1995	Mar. 10, 1995	13.56[e,f]	--

[e]Gage height determined from floodmark.
[f]Affected by ice.
[i]Discharge computed from indirect measurement.

05412500 Turkey River at Garber, Iowa

Location.--Latitude 42°44'24", longitude 91°15'42", in SE1/4 NW1/4 sec. 36, T.92 N., R.4 W., Clayton County, Hydrologic Unit 07060004, on right bank 10 ft upstream from bridge on County Road C43, 800 ft upstream from Wayman Creek, 1,000 ft southeast of Garber, 2,000 ft downstream from Elk Creek, 1 mi downstream from Volga River, and 21.2 mi upstream from mouth.

Drainage area.--1,545 mi^2.

Gage.--Water-stage encoder. Datum of gage is 634.46 ft above sea level. Prior to Feb. 7, 1935, nonrecording gage at same site and datum.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Flood stage.--17 ft.

Remarks.--Base for partial-duration series, 8,000 ft^3/s; prior to 1974, peak base was 10,000 ft^3/s.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1902	May 18, 1902	23.70	25,000[c]
	(Systematic operation of gage began in August 1913)		
1914	June 15, 1914	13.2	8,960
1915	Aug. 4, 1915	14.7	10,900
1916	Mar. 25, 1916	20.60	18,000
	June 2, 1916	22.0	20,300
	Sept. 30, 1916	17.79	11,900
	(Gage discontinued November 1916, reactivated May 14, 1919)		
1919	June 4, 1919	16.8	13,100
1920	Mar. 12, 1920	15.1	11,000
1921	May 31, 1921	14.5	10,400
1922	Feb. 23, 1922	28.06[e,j]	32,300
	July 22, 1922	23.00	23,000
1923	Mar. 4, 1923	17.2	13,800
	Apr. 3, 1923	24.2	25,200
1924	Mar. 4, 1924	15.0	11,000
	July 21, 1924	17.4	14,600
	Aug. 19, 1924	15.5	11,700
1925	June 15, 1925	24.7	26,200
	June 17, 1925	15.5	11,700
	June 24, 1925	15.5	11,700
1926	Aug. 20, 1926	12.0	7,130
1927	Oct. 3, 1926	16.80	13,700
	May 28, 1927	14.6	10,300
	(Gage discontinued September 1927, reactivated April 1929)		
1929	July 13, 1929	--	7,630
1930	June 13, 1930	--	14,500[c]

05412500 Turkey River at Garber, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
	(Gage discontinued September 1930, reactivated October 1932)		
1933	Dec. 24, 1932	14.9	10,700
	Mar. 30, 1933	22.5	20,600
	Apr. 1, 1933	20.9	18,500
	Apr. 10, 1933	14.4	10,200
	May 20, 1933	14.7	10,600
	July 2, 1933	22.4	20,400
1934	Jan. 22, 1934	11.5	6,230
1935	Mar. 4, 1935	19.9	17,100
1936	Mar. 11, 1936	20.7[f]	15,000[c]
1937	Mar. 6, 1937	20.8	18,900
	June 13, 1937	17.1	13,500
1938	Sept. 13, 1938	21.1	19,600
1939	Mar. 14, 1939	19.13[f]	9,200[c]
1940	July 27, 1940	25.3	26,100
	Aug. 27, 1940	16.4	10,400
1941	Mar. 21, 1941	17.6	12,300
	May 28, 1941	20.0	16,200
	May 31, 1941	20.0	16,200
	June 12, 1941	23.3	22,100
1942	June 30, 1942	17.5	12,000
1943	Mar. 16, 1943	21.0	17,600
	Aug. 13, 1943	20.0	15,900
1944	May 23, 1944	16.6	10,800
	June 16, 1944	20.6	16,900
1945	Mar. 18, 1945	17.2	11,600
	June 2, 1945	18.2	13,000
	June 28, 1945	17.3	11,700
	Aug. 14, 1945	17.0	11,300
1946	Jan. 5, 1946	24.3	24,100
	Mar. 6, 1946	22.1	19,600
	Mar. 13, 1946	17.9	12,600
1947	Mar. 13, 1947	17.2	11,600
	Apr. 10, 1947	17.3	11,700
	June 13, 1947	26.6	29,000
	June 29, 1947	22.9	21,200
1948	Feb. 28, 1948	23.62[f]	18,000[c]
	Mar. 15, 1948	17.1	11,400
	Mar. 17, 1948	19.8	15,600
	Mar. 19, 1948	21.7	19,000
	May 10, 1948	17.3	11,700
1949	Mar. 4, 1949	20.5	16,800

05412500 Turkey River at Garber, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1950	Mar. 7, 1950	23.7	23,700
	Mar. 27, 1950	23.3	22,900
	June 13, 1950	16.9	11,900
	June 25, 1950	17.0	12,000
	July 16, 1950	17.2	12,300
	Aug. 1, 1950	17.3	12,400
	Sept. 22, 1950	17.9	13,200
1951	Feb. 26, 1951	18.72	14,600
	Mar. 28, 1951	22.79	21,900
	Apr. 7, 1951	20.90	18,300
	Apr. 26, 1951	15.94	10,500
	Apr. 30, 1951	20.44	17,400
	June 27, 1951	16.71	11,600
	July 8, 1951	21.44	19,200
1952	Apr. 1, 1952	15.88	9,840
1953	July 27, 1953	20.62	16,900
	Aug. 4, 1953	19.71	15,300
	Aug. 6, 1953	19.85	15,700
1954	June 21, 1954	19.94	16,400
1955	June 3, 1955	15.32	9,840
1956	Mar. 28, 1956	17.00	12,300
1957	June 18, 1957	14.20	7,320
1958	May 31, 1958	17.61	12,100
1959	Mar. 26, 1959	21.06	17,000
	Apr. 1, 1959	19.93	15,000
	June 26, 1959	17.35	11,400
1960	Jan. 12, 1960	20.02	15,200
	Mar. 30, 1960	22.96	20,000
	May 6, 1960	21.07	17,000
1961	Feb. 23, 1961	17.31	11,200
	Mar. 6, 1961	16.48	10,100
	Mar. 26, 1961	22.84	19,700
	Aug. 1, 1961	17.55	11,600
	Sept. 30, 1961	17.79	11,900
1962	Nov. 2, 1962	16.80	10,500
	Mar. 29, 1962	24.70	24,500
	May 6, 1962	17.47	11,500
1963	Mar. 17, 1963	20.69	16,300
	Mar. 19, 1963	16.79	10,500
1964	Apr. 3, 1964	17.00	10,800
1965	Mar. 1, 1965	22.10[f]	13,000[c]
	Apr. 1, 1965	19.15	13,800
1966	Feb. 9, 1966	24.80	24,800
	July 14, 1966	20.98	16,100

05412500 Turkey River at Garber, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1967	Jan. 24, 1967	22.18	18,900
1968	July 17, 1968	16.83	10,300
	Aug. 8, 1968	17.02	10,500
	Sept. 22, 1968	16.91	10,400
1969	June 29, 1969	22.50	19,600
1970	Aug. 8, 1970	17.32	11,200
1971	Mar. 15, 1971	19.02	13,600
	Apr. 1, 1971	18.39	12,700
	June 20, 1971	20.81	16,500
	July 13, 1971	19.05	13,700
1972	Sept. 11, 1972	17.64	10,300
	Sept. 13, 1972	17.42	10,000
	Sept. 28, 1972	21.41	16,300
1973	Jan. 18, 1973	21.90[f]	15,000[c]
	Feb. 2, 1973	19.00	12,300
	Apr. 16, 1973	22.88	19,600
	May 8, 1973	19.17	12,500
1974	Mar. 3, 1974	16.40	8,680
	June 10, 1974	16.80	9,160
	June 21, 1974	21.08	15,700
1975	Mar. 22, 1975	21.72	16,500
	Mar. 24, 1975	20.93	16,700
	Apr. 29, 1975	16.45	9,740
1976	Mar. 12, 1976	22.18	18,300
	Apr. 22, 1976	15.68	8,220
1977	Aug. 16, 1977	15.52	8,320
1978	Apr. 6, 1978	15.43	8,220
	May 13, 1978	15.46	8,250
1979	Mar. 19, 1979	25.59	26,000
	Mar. 24, 1979	17.00	10,300
	Mar. 30, 1979	20.70	16,300
	May 3, 1979	15.40	8,180
	Aug. 18, 1979	21.17	17,100
	Aug. 24, 1979	15.99	8,890
1980	Jan. 16, 1980	17.77[f]	11,000[c]
	Mar. 16, 1980	18.79[f]	10,800[c]
	Aug. 21, 1980	15.86	8,730
1981	Aug. 2, 1981	23.29	20,500
	Sept. 1, 1981	20.28	14,400
1982	Mar. 14, 1982	16.25	8,800
	Mar. 16, 1982	20.65	15,500
	Mar. 20, 1982	17.15	9,920

05412500 Turkey River at Garber, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1983	Nov. 12, 1982	19.37	13,300
	Dec. 6, 1982	15.88	8,190
	Dec. 29, 1982	16.37	8,600
	Feb. 22, 1983	18.33	11,300
	Apr. 15, 1983	16.72	9,290
	May 20, 1983	16.06	8,430
	May 23, 1983	16.63	9,140
	July 2, 1983	17.25	10,100
1984	Feb. 19, 1984	17.62	10,100
	Apr. 30, 1984	18.50	11,400
1985	Feb. 24, 1985	19.11	12,300
	Mar. 9, 1985	17.13	9,390
1986	Mar. 19, 1986	22.47	19,400
	June 22, 1986	16.13	8,290
	Sept. 21, 1986	16.50	8,900
1987	Oct. 14, 1986	15.37	7,390
1988	Mar. 9, 1988	12.83[f]	3,400
1989	Mar. 12, 1989	17.82[f]	9,900
1990	Aug. 27, 1990	24.63	23,000
1991	Apr. 13, 1991	20.63	15,700
	Apr. 30, 1991	17.46	9,940
	June 15, 1991	30.10[e]	49,900[i]
1992	Apr. 21, 1992	18.17	11,400
1993	Mar. 27, 1993	18.62	11,800
	Mar. 31, 1993	22.94	19,400
	Apr. 21, 1993	18.24	10,800
	May 2, 1993	18.16	10,700
	June 21, 1993	19.58	13,000
	June 30, 1993	16.46	8,470
	July 9, 1993	19.35	12,600
	July 11, 1993	22.04	17,700
	July 19, 1993	18.05	10,500
	Aug. 18, 1993	22.71	19,100
	Aug. 20, 1993	18.46	11,100
	Aug. 24, 1993	17.61	9,920
1994	Feb. 20, 1994	18.48[f]	--
	June 23, 1994	16.98	9,700
1995	Apr. 13, 1995	13.35	5,230

[c]Approximate.
[e]Gage height determined from floodmark.
[f]Affected by ice.
[i]Discharge computed from indirect measurement.
[j]Maximum gage height known since 1890.

APPENDIX B

WATER-SURFACE-ELEVATION PROFILES FOR THE TURKEY RIVER BASIN, NORTHEAST IOWA

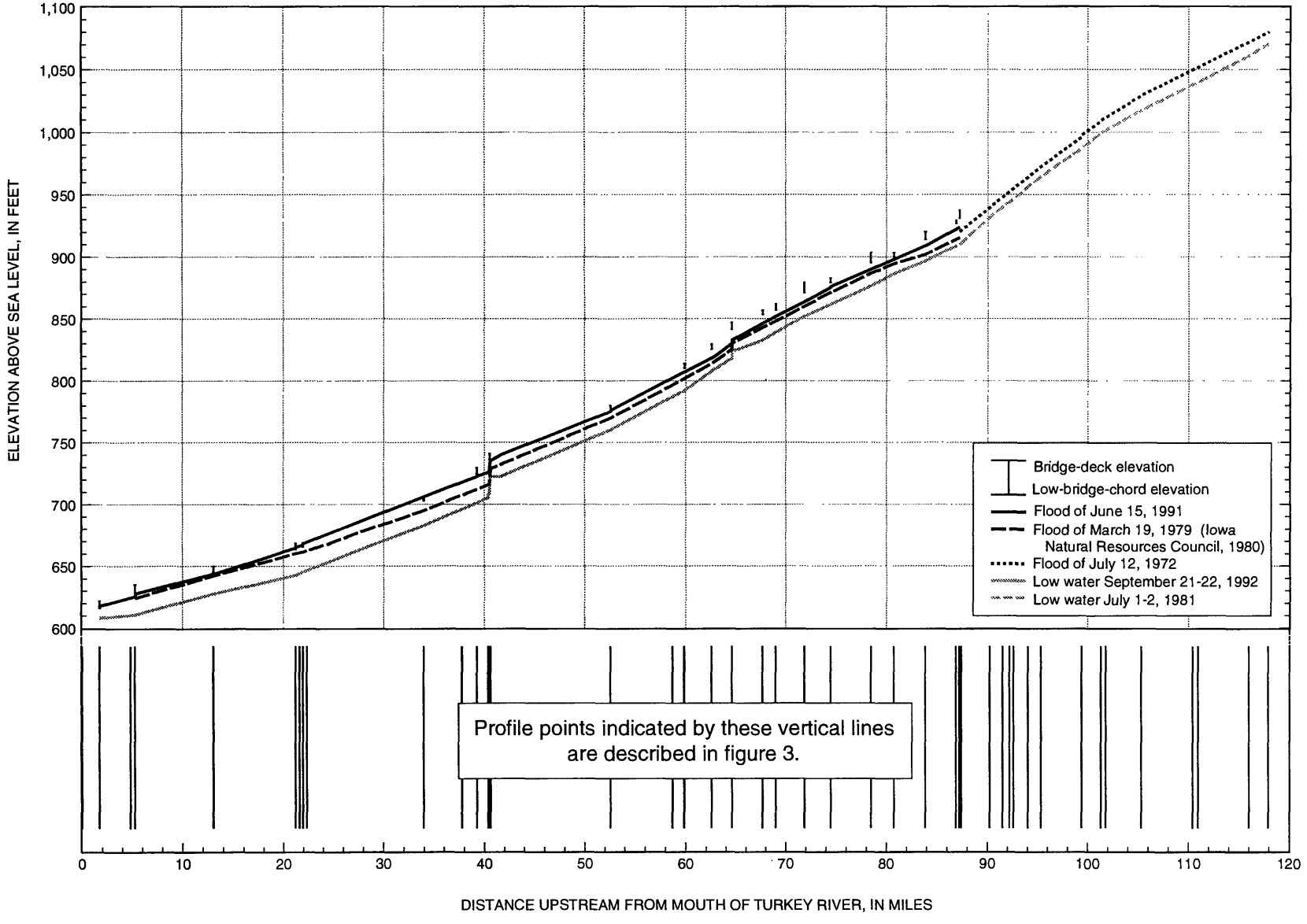

Figure 2. Water-surface-elevation profiles for the Turkey River, river miles 1.71-117.94.

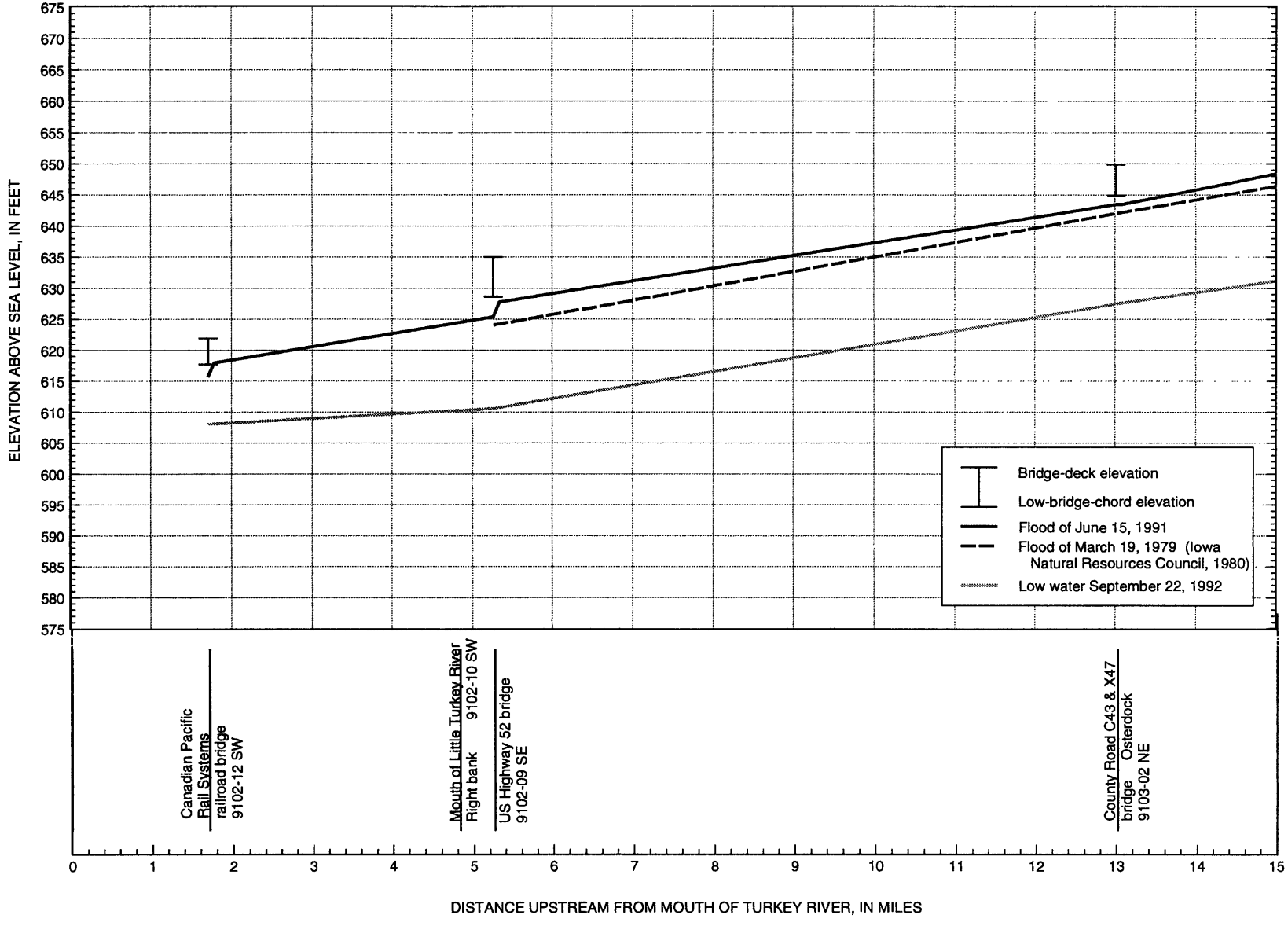

Figure 3A. Water-surface-elevation profiles for the Turkey River, river miles 1.71-15.

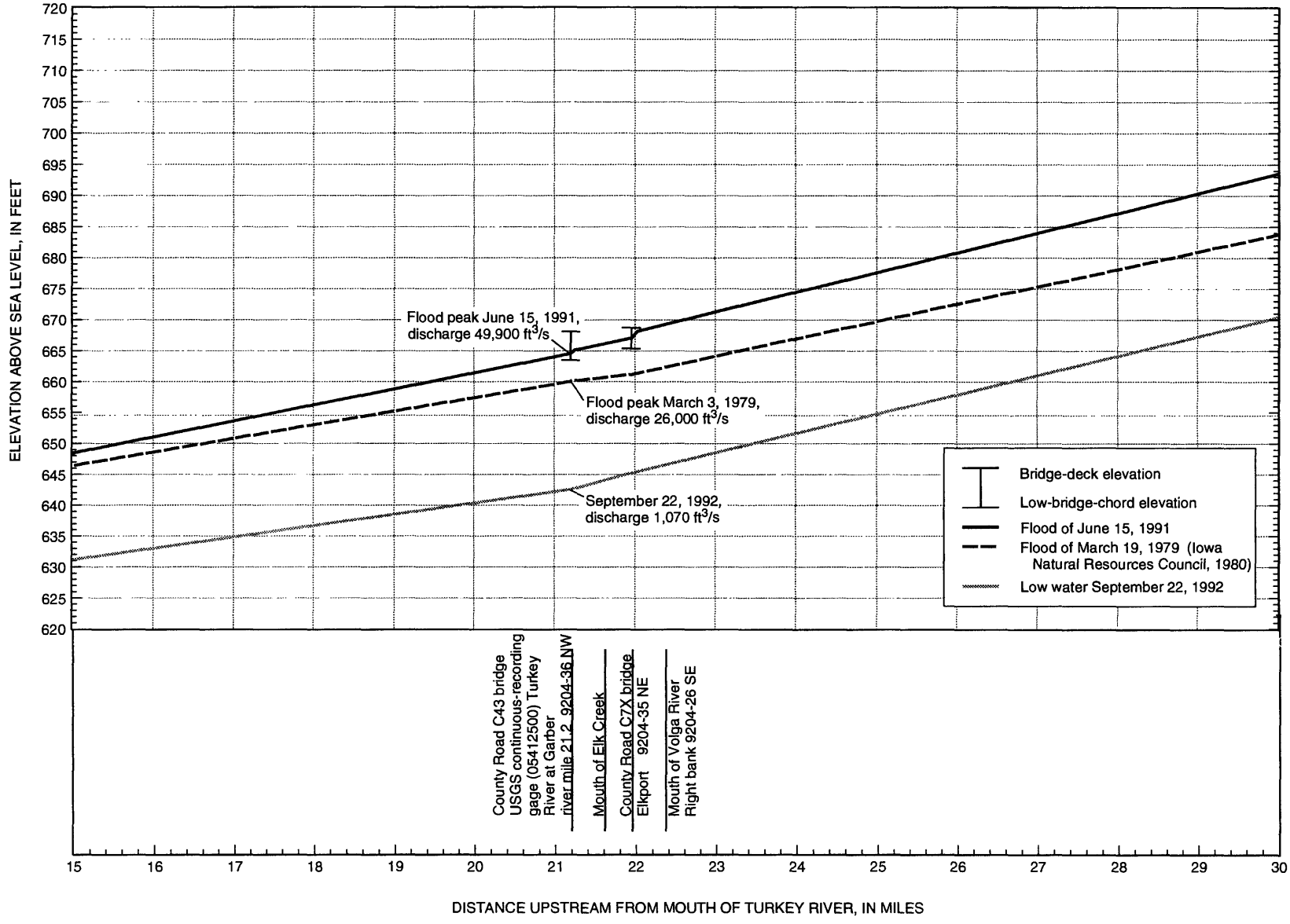

Figure 3B. Water-surface-elevation profiles for the Turkey River, river miles 15-30.

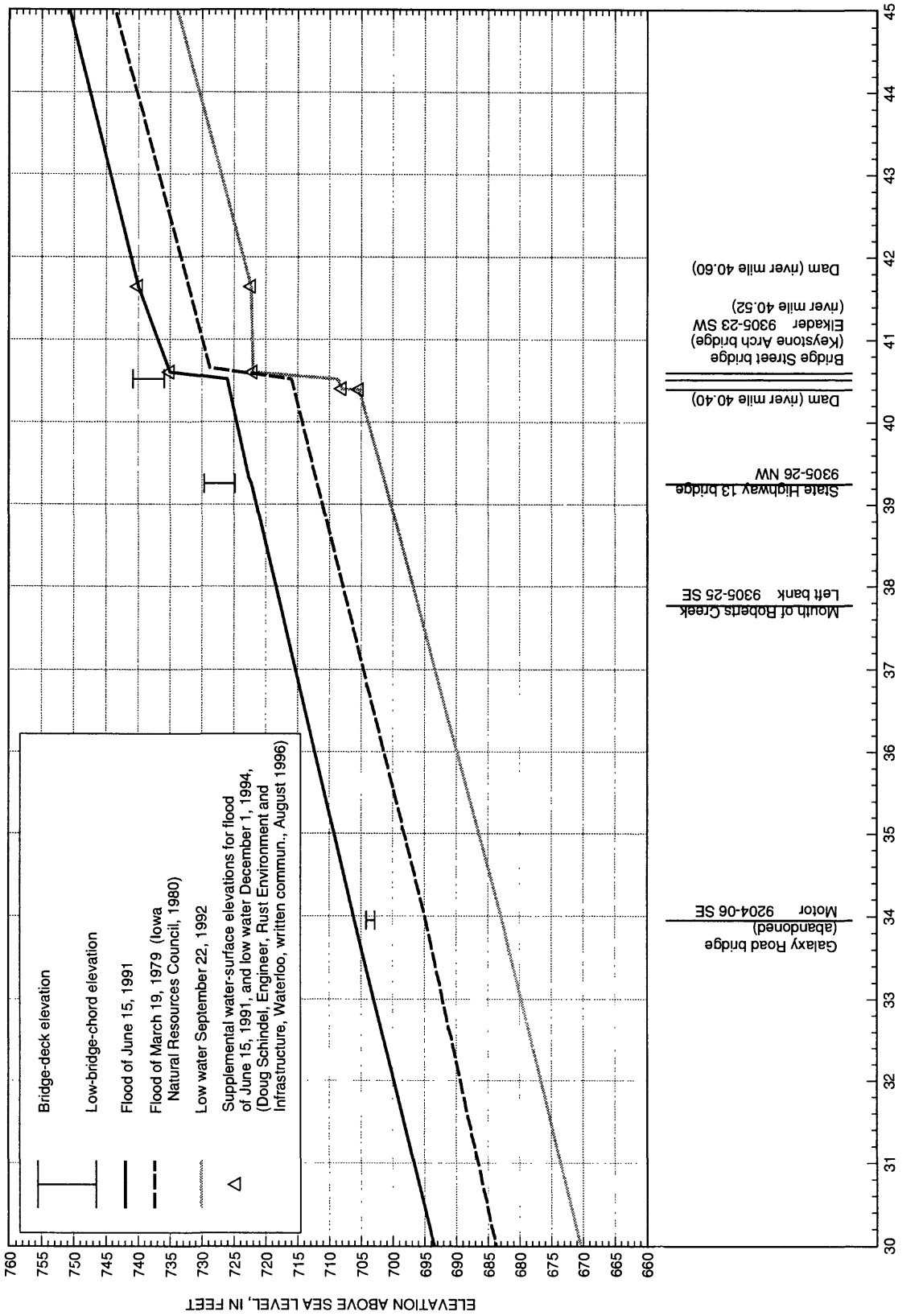

Figure 3C. Water-surface-elevation profiles for the Turkey River, river miles 30-45.

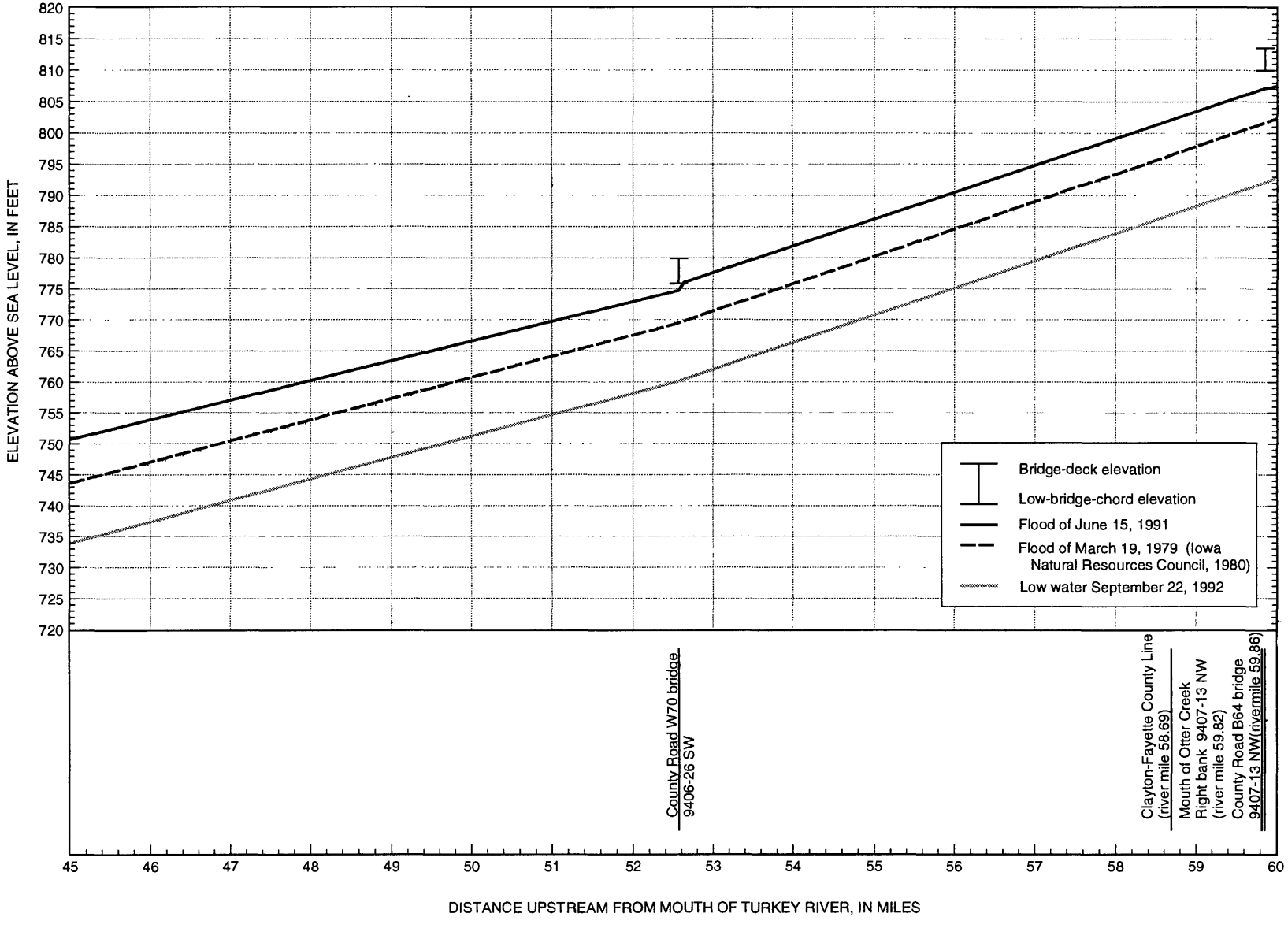

Figure 3D. Water-surface-elevation profiles for the Turkey River, river miles 45-60.

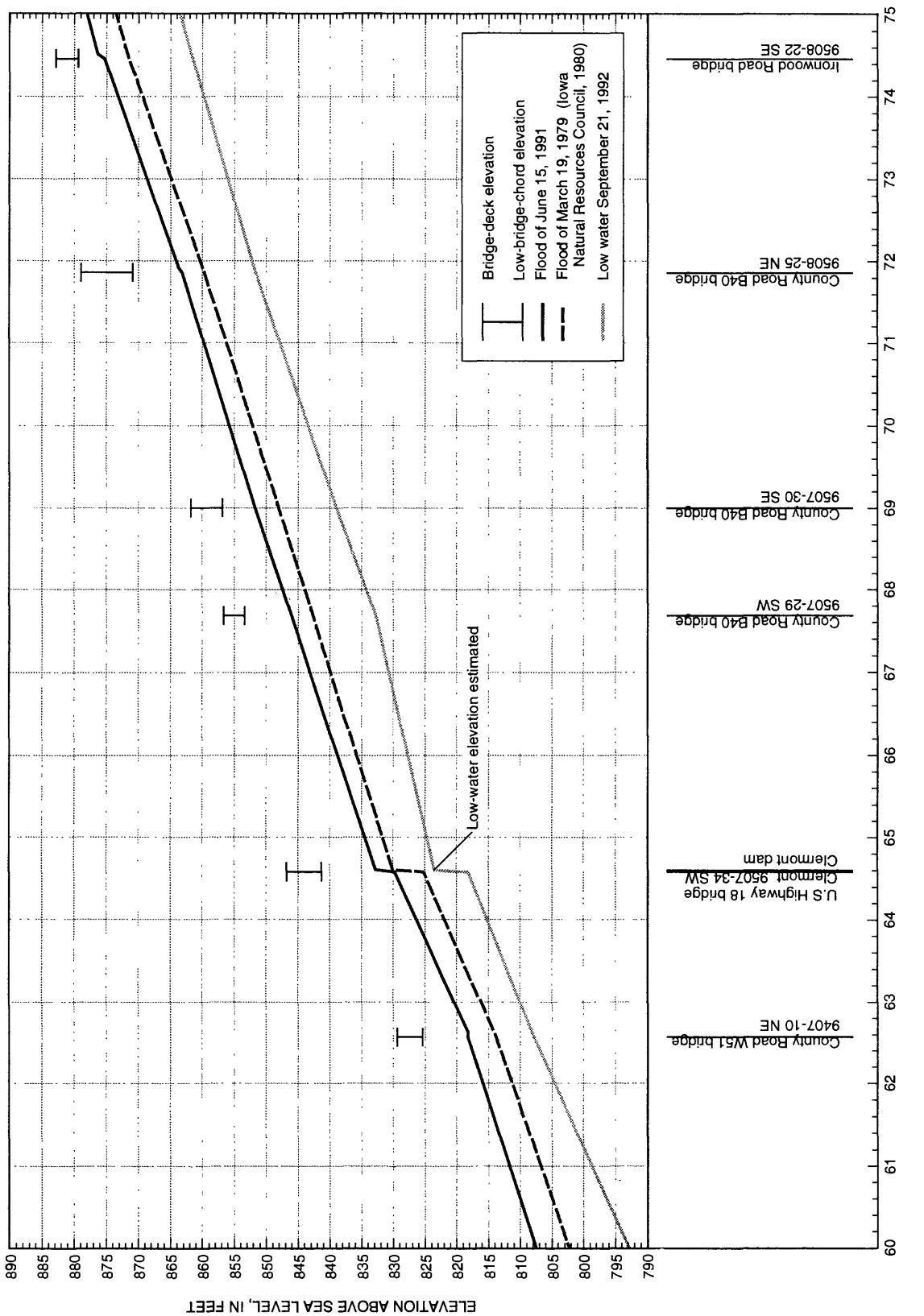

Figure 3E. Water-surface-elevation profiles for the Turkey River, river miles 60-75.

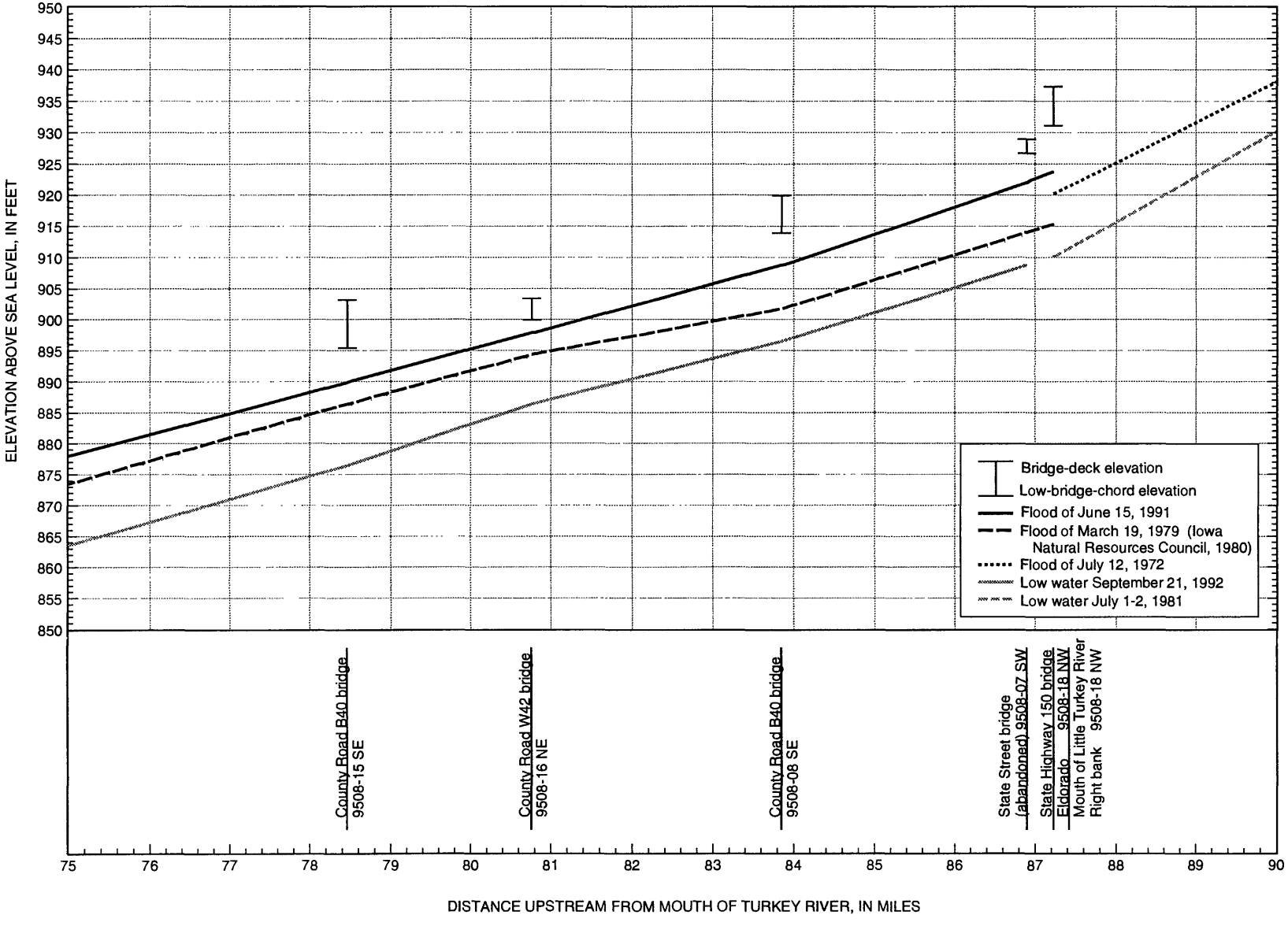

Figure 3F. Water-surface-elevation profiles for the Turkey River, river miles 75-90.

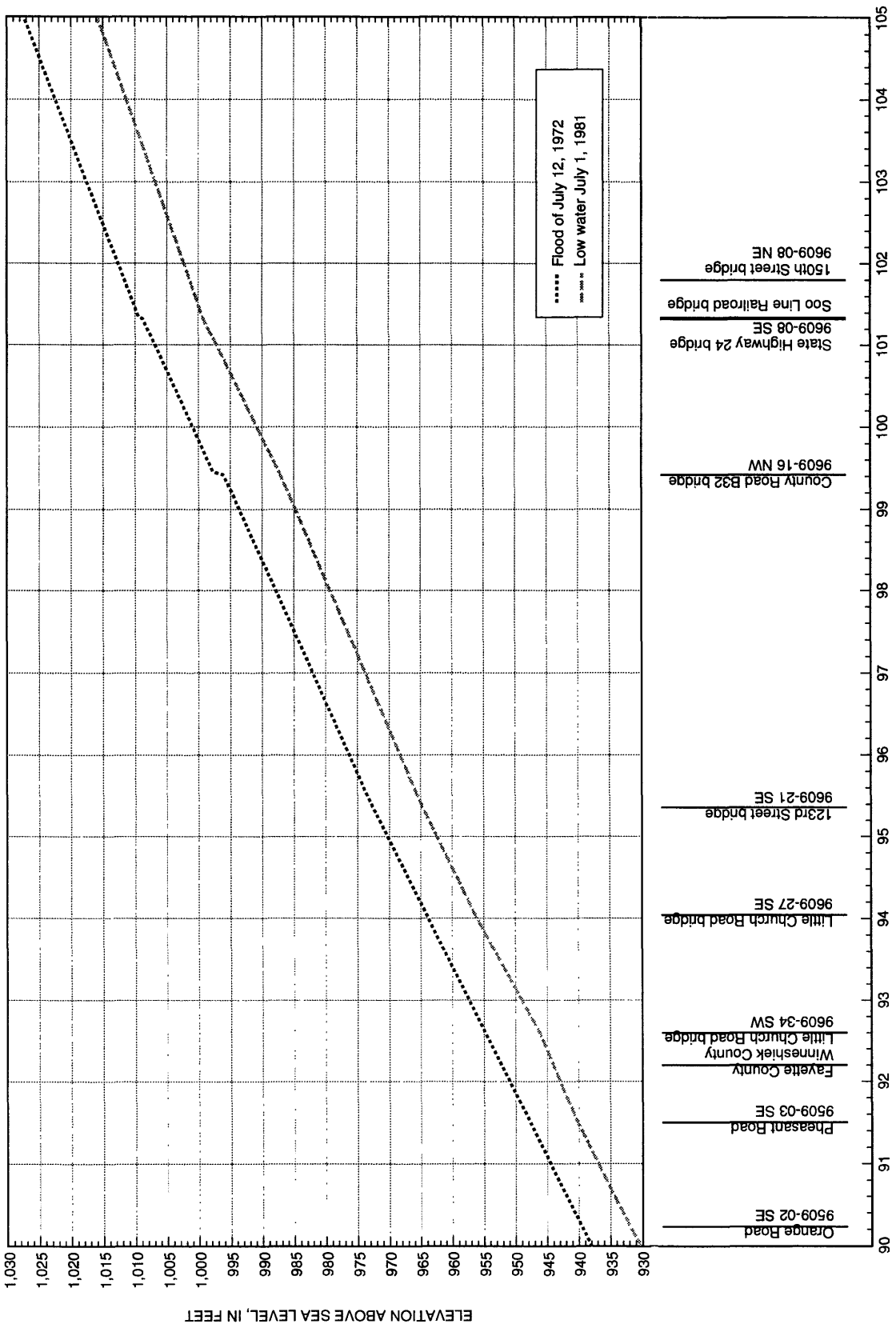

Figure 3G. Water-surface-elevation profiles for the Turkey River, river miles 90-105.

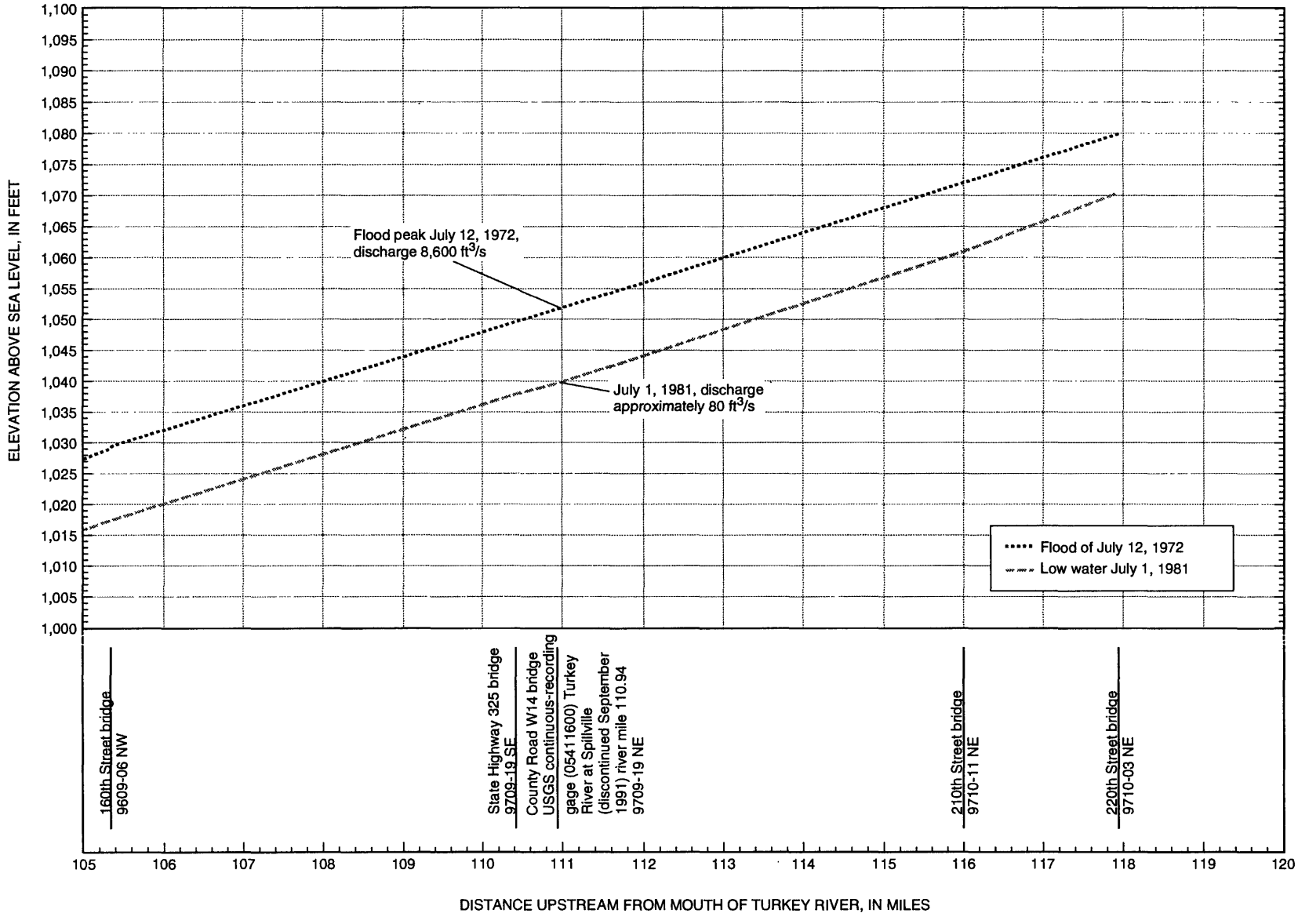

Figure 3H. Water-surface-elevation profiles for the Turkey River, river miles 105-117.94.

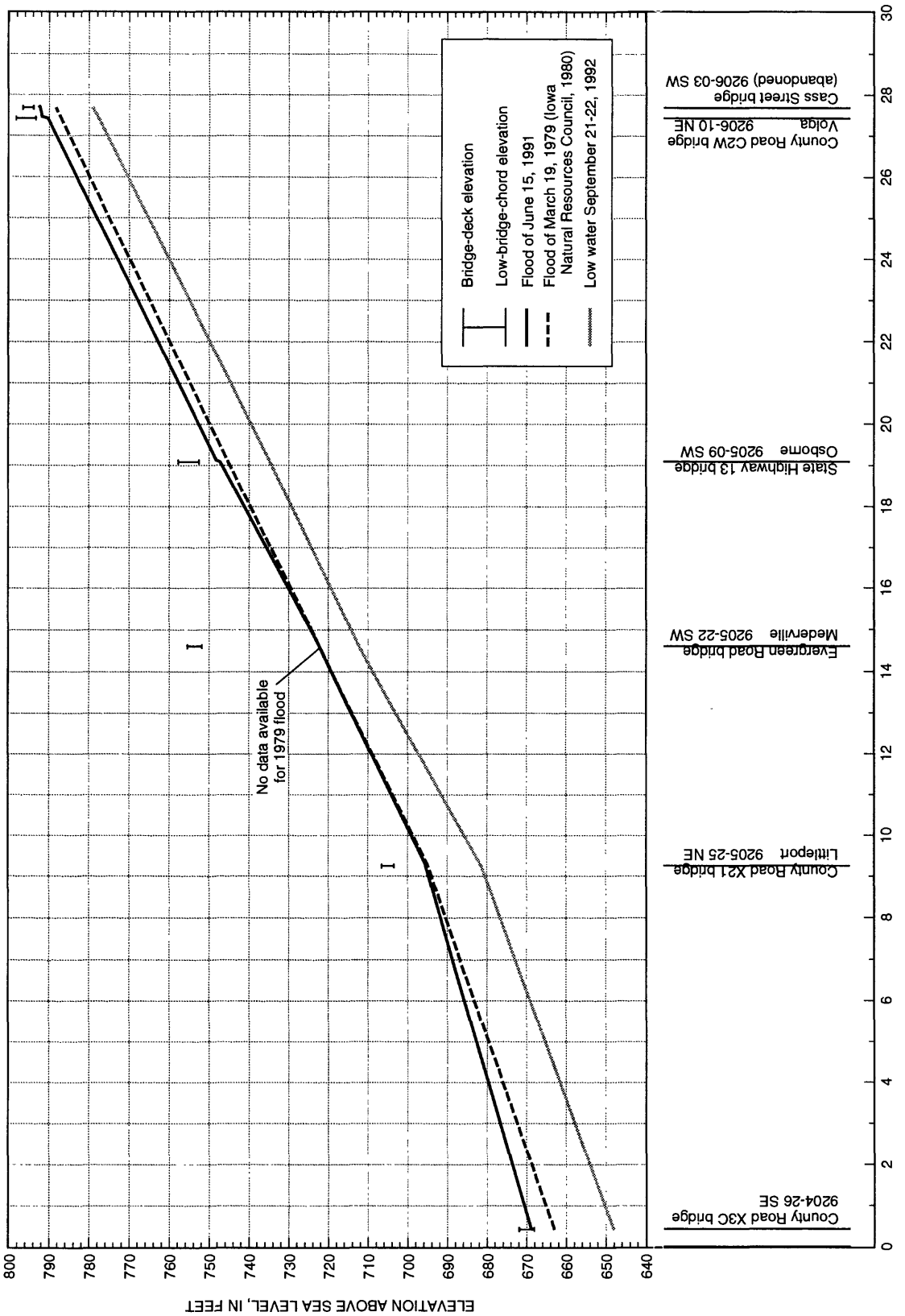

Figure 4. Water-surface-elevation profiles for the Volga River, river miles 0.42-27.68.

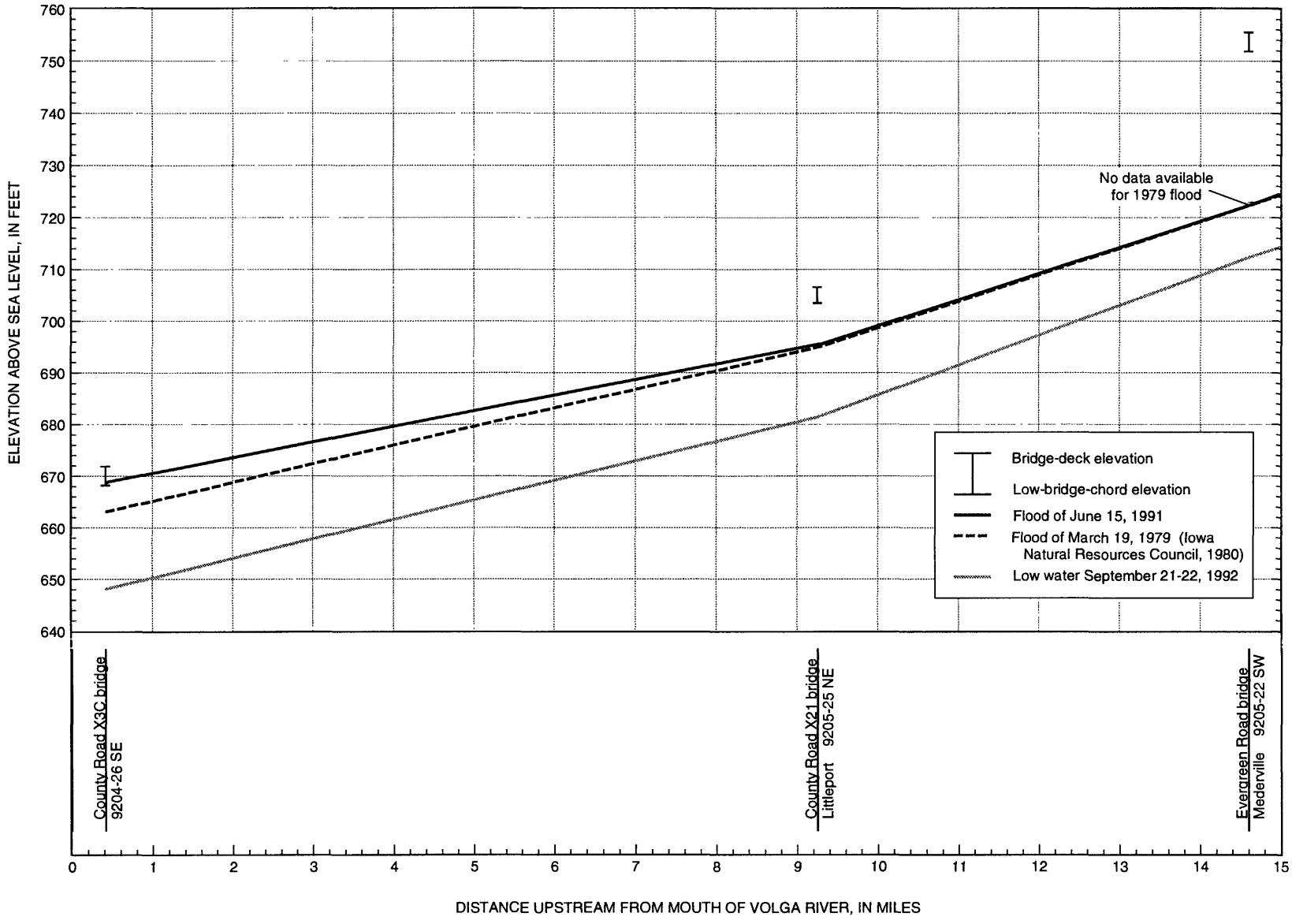

Figure 5A. Water-surface-elevation profiles for the Volga River, river miles 0.42-15.

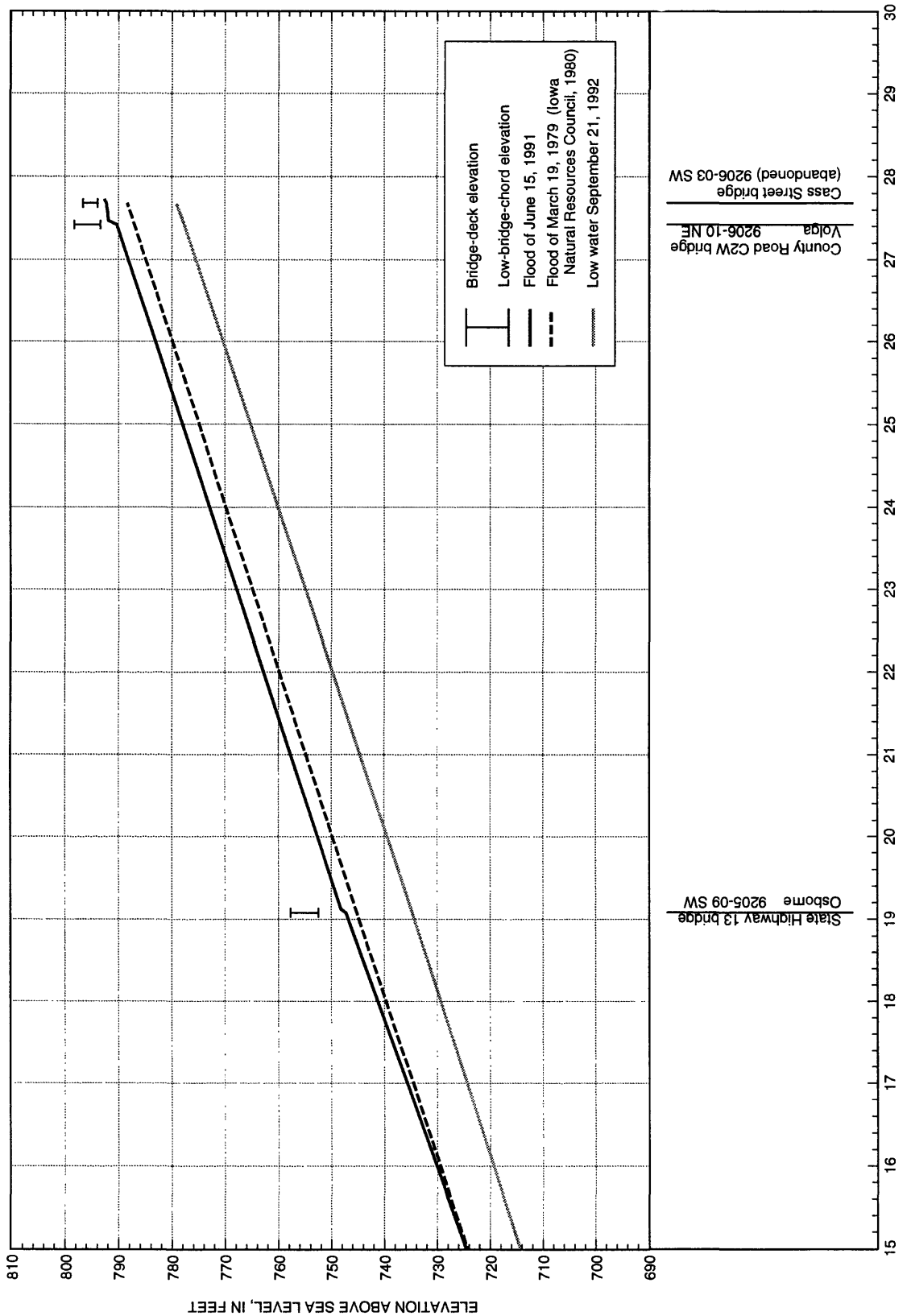

Figure 5B. Water-surface-elevation profiles for the Volga River, river miles 15-27.68.

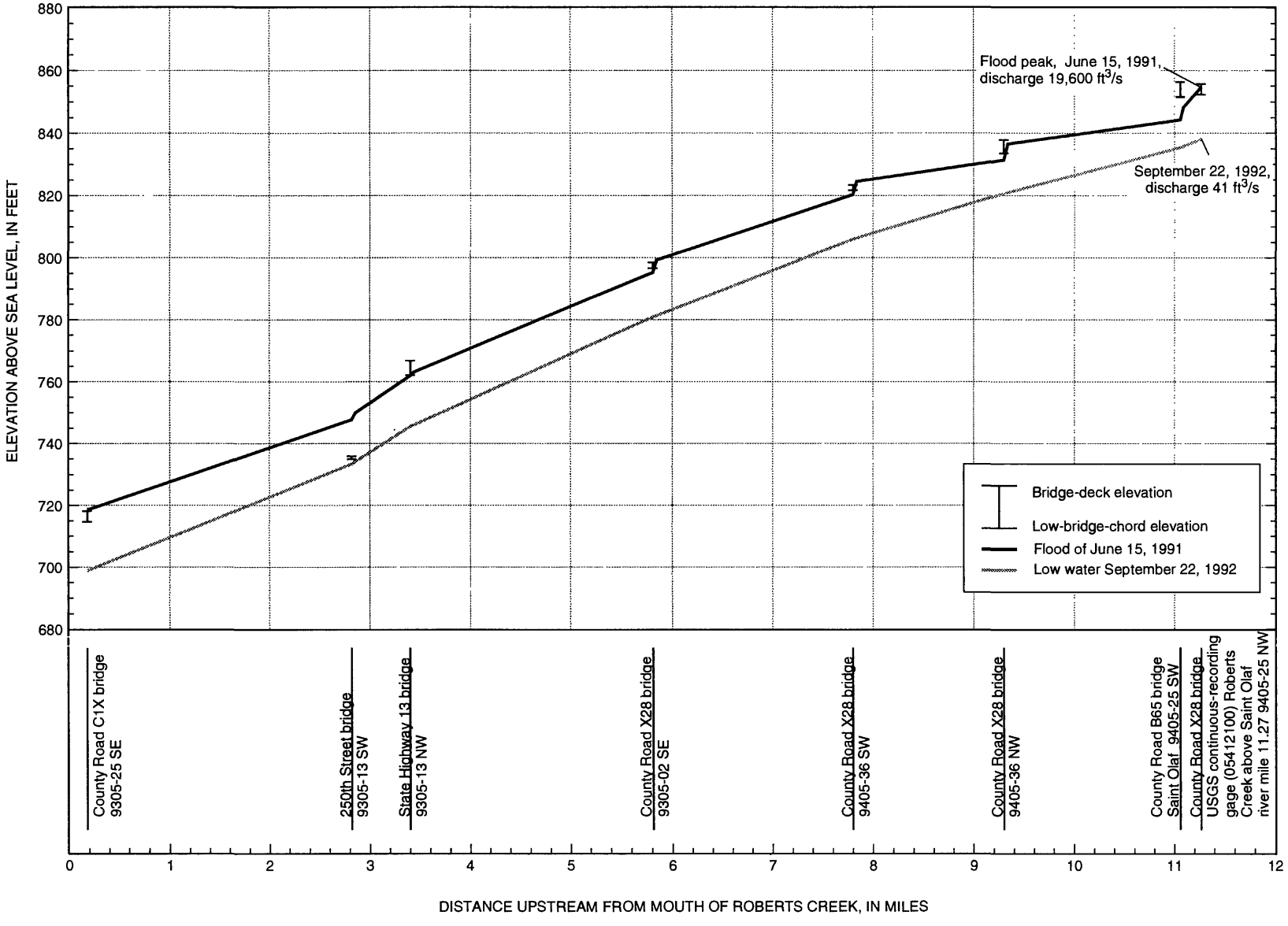

Figure 6. Water-surface-elevation profiles for Roberts Creek, river miles 0.18-11.27.

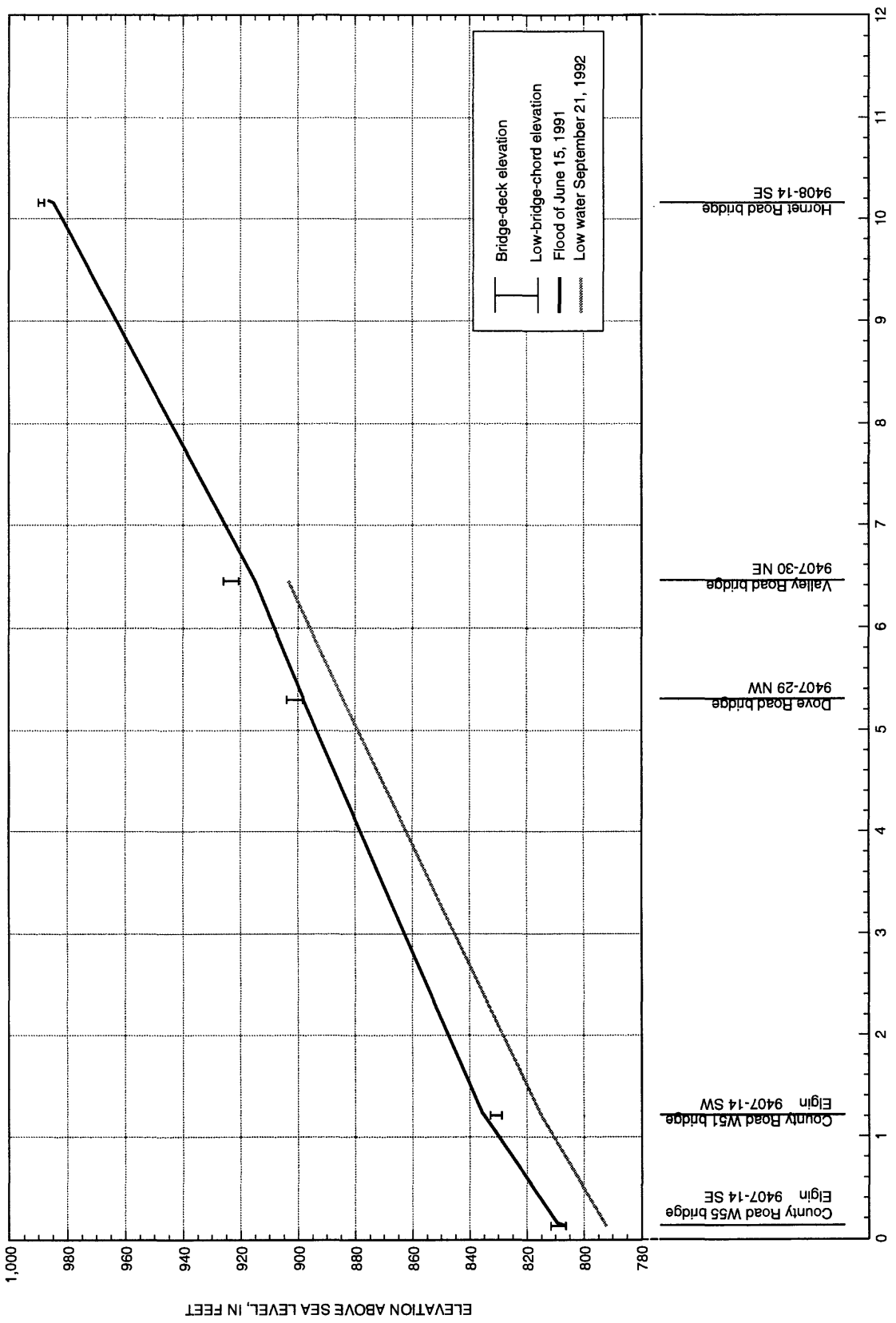

Figure 7. Water-surface-elevation profiles for Otter Creek, river miles 0.13-10.16.

APPENDIX C

TEMPORARY BENCH MARKS AND REFERENCE POINTS IN THE TURKEY RIVER BASIN, NORTHEAST IOWA

The temporary bench marks (BM) and reference points (RP) listed in this tabulation were established during 1981, 1992, and 1996 by the U.S. Geological Survey (USGS) except those for which credit is given in the descriptions. The work was done as a part of a stream-profile study jointly funded by the Iowa Highway Research Board and the Project Development Division of the Iowa Department of Transportation, and the USGS.

BM and RP elevations listed in this tabulation were determined from differential leveling that was performed along the following four river reaches that were profiled for the flood of June 15, 1991: Turkey River from the Canadian Pacific Rail Systems railroad bridge, located approximately 2.4 mi east of Millville in Clayton County, to the State Highway 150 bridge in Eldorado in Fayette County (figs. 1-3); Volga River in Clayton County from the County Road X21 bridge in Littleport to the County Road C2W bridge in Volga (figs. 1 and 4-5); Roberts Creek in Clayton County from the County Road C1X bridge, located approximately 1.6 mi southeast of Elkader to the County Road X28 bridge in Saint Olaf (figs. 1 and 6); and Otter Creek in Fayette County from the County Road W55 bridge in Elgin to the Valley Road bridge, located approximately 0.5 mi west of Brainard (figs. 1 and 7). BMs and RPs were set at the majority of bridges crossing the four profiled river reaches in the Turkey River Basin. Level lines to establish the third-order accuracy of the BMs and RPs shown herein were surveyed from bench marks established and adjusted by the National Mapping Division of the USGS, the National Geodetic Survey, or Clayton County. Errors of closure in the USGS level work were adjusted along the level lines to balance the BM and RP elevations. All elevations are referenced to sea level.

The BMs and RPs are identified by an index number, which is composed of the township, range, and section number, and the quarter section in which the BM or RP is located. The township and range numbers are combined into a four-digit number, such as 9102 for Township 91 North and Range 02 West. The township and range number is followed by a dash and the section number in which the BM or RP is located. Within the section, the quarter in which the BM or RP is located is designated by NE, SE, SW, and NW. A number in parentheses following this letter designation indicates the number of the BM or RP in that particular quarter section. The index number serves to describe the landline location of the BM or RP without further reference in the body of the description.

Standard BMs and RPs such as chiseled squares, arrows, or crosses on concrete; filed arrows or marks on steel; or existing bolts on bridges were used. Existing marks were used wherever available, and the agency responsible for the mark, when known, is indicated in the description. RPs are distinguished from BMs in this tabulation by the notation "(REFERENCE POINT)" following the index number. 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 direction of the flow of the stream.

The user of this information is cautioned that the BMs and RPs listed herein might have been disturbed, destroyed, or moved since surveys used in this report were made. Many of the BMs and RPs are located on bridges that might have been repaired, replaced, or destroyed since the original level lines were surveyed. It is the responsibility of the user to determine the condition and the suitability of the BM or RP.

Additional information can be obtained by writing to the following address: U.S. Geological Survey, Water Resources Division, Room 269, Federal Building, 400 South Clinton Street, Iowa City, IA 52244.

TEMPORARY BENCH MARKS AND REFERERNCE POINTS IN THE TURKEY RIVER BASIN, NORTHEAST IOWA

9102-09 SE (1)--At north of Millville, on U.S. Highway 52 bridge over Turkey River, on right upstream wingwall; National Geodetic Survey (U.S. Coast & Geodetic Survey) bench mark disk stamped "B179-1970." Elevation obtained from National Geodetic Survey.

Elevation 634.822 ft.

9102-09 SE (2)--(REFERENCE POINT) At north of Millville, on U.S. Highway 52 bridge over Turkey River, on downstream curb between 13th and 14th guardrail posts from right end of bridge; chiseled square.

Elevation 634.78 ft.

9102-12 SW (1)--Approximately 2.4 mi east of Millville at Canadian Pacific Rail Systems railroad bridge over Turkey River, on right upstream bridge footing, 5.1 ft lower than wood plank, most streamward and downstream bolt; top of bolt.

Elevation 616.89 ft.

9102-12 SW (2)--(REFERENCE POINT) Approximately 2.4 mi east of Millville at Canadian Pacific Rail Systems railroad bridge over Turkey River, on third truss member from right upstream bridge abutment, 6 in. lower than wood deck; chiseled arrow.

Elevation 621.43 ft.

9103-02 NE (1)--At Osterdock, on County Roads C43 and X47 bridge over Turkey River, on right upstream concrete curb; brass tablet stamped "1957." Elevation obtained from Clayton County Engineer.

Elevation 649.53 ft.

9103-02 NE (2)--(REFERENCE POINT) At Osterdock, on County Roads C43 and X47 bridge over Turkey River, on downstream curb between 31st and 32nd guardrail posts from left end of bridge; chiseled arrow.

Elevation 650.47 ft.

9204-35 NE (1)--Between Elkport and Garber, on County Road C7X bridge over Turkey River, on left upstream curb near bridge abutment and 1 ft above bridge deck; chiseled square.

Elevation 670.29 ft.

9204-35 NE (2)--(REFERENCE POINT) Between Elkport and Garber, on County Road C7X bridge over Turkey River, on downstream curb between 20th and 21st guardrail posts from right end of bridge; chiseled arrow.

Elevation 670.40 ft.

9204-36 NW (1)--At Garber, on County Road C43 bridge over Turkey River, on center of left upstream guardrail; Iowa Highway Commission bench mark.

Elevation 672.10 ft.

9205-09 SW (1)--At Osborne, on State Highway 13 bridge over Volga River, on top of concrete guardrail at right downstream end of bridge; Iowa Highway Commission bench mark.

Elevation 758.80 ft.

9205-17 SE (1)--Approximately 1.2 mi southwest of Osborne, on County Road C5X bridge over Cox Creek, on left downstream abutment curb and 2 in. above level of bridge deck; chiseled square.

Elevation 779.58 ft.

9205-22 SW (1)--At Mederville, on Evergreen Road bridge over Volga River, on top of retaining wall at right upstream end of bridge; chiseled square.

Elevation 755.86 ft.

9205-22 SW (2)--At Mederville, on Evergreen Road bridge over Volga River, on third guardrail stone post from right downstream end of bridge, on streamward side of post; chiseled square.

Elevation 759.26 ft.

9205-25 NE (1)--At Littleport, on County Road X21 bridge over Volga River, on left upstream wingwall curb; U.S. Geological Survey brass tablet stamped "15 JRE 1964 708."

Elevation 708.254 ft.

9205-25 NE (2)--(REFERENCE POINT) At Littleport, on County Road X21 bridge over Volga River, on top of upstream guardrail and left of 15th guardrail post from right end of bridge; three filed marks.

Elevation 709.64 ft.

9206-10 NE (1)--At Volga, on County Road C2W bridge over Volga River, on top of right upstream wingpost; chiseled square.

Elevation 800.52 ft.

9206-10 NE (2)--(REFERENCE POINT) At Volga, on County Road C2W bridge over Volga River, on top of upstream guardrail and right of 22nd guardrail post from right end of bridge; two filed marks.

Elevation 800.59 ft.

9305-02 SE (1)--Approximately 2.3 mi south of Saint Olaf, on County Road X28 bridge over Roberts Creek, on right upstream end of bridge; Iowa Highway Commission bench mark.

Elevation 800.67 ft.

9305-02 SE (2)--(REFERENCE POINT) Approximately 2.3 mi south of Saint Olaf, on County Road X28 bridge over Roberts Creek, on downstream guardrail and 80 ft from right end of bridge; chiseled arrow.

Elevation 800.98 ft.

9305-13 SW (1)--Approximately 1.2 mi northeast of Elkader, on 250th Street bridge over Roberts Creek, on bridge deck at left downstream end of bridge; chiseled square.

Elevation 735.88 ft.

9305-13 SW (2)--(REFERENCE POINT) Approximately 1.2 mi northeast of Elkader, on 250th Street bridge over Roberts Creek, on downstream lip of bridge deck and 8.5 ft from left end of bridge; chiseled arrow.

Elevation 735.87 ft.

9305-13 NW (1)--Approximately 1.5 mi northeast of Elkader, on State Highway 13 bridge over Roberts Creek, on left upstream wingwall; U.S. Geological Survey brass tablet stamped "18 WEK 1964 reset 1979."

Elevation 770.212 ft.

9305-13 NW (2)--(REFERENCE POINT) Approximately 1.5 mi northeast of Elkader, on State Highway 13 bridge over Roberts Creek, on downstream guardrail and 90 feet from left end of bridge; chiseled arrow.

Elevation 769.35 ft.

9305-23 SW(1)--At Elkader, on Bridge Street bridge (Keystone Arch bridge) over Turkey River, on top of concrete guardrail at left upstream end of bridge; U.S. Geological Survey brass tablet stamped "17 WEK 1964".

Elevation 745.060 ft.

9305-23 SW(2)--(REFERENCE POINT) At Elkader, on Bridge Street bridge (Keystone Arch bridge) over Turkey River, on edge of upstream concrete walkway between 8th and 9th guardrail posts from left end of bridge; chiseled arrow.

Elevation 740.59 ft.

9305-25 SE (1)--Approximately 1.6 mi southeast of Elkader, on County Road C1X bridge over Roberts Creek, on left upstream wingwall; U.S. Geological Survey brass tablet stamped "33 WEK 1964".

Elevation 718.748 ft.

9305-25 SE (2)--(REFERENCE POINT) Approximately 1.6 mi southeast of Elkader, on County Road C1X bridge over Roberts Creek, on downstream guardrail at 7th guardrail post from right end of bridge; two filed marks.

Elevation 720.93 ft.

9305-26 NW (1)--Approximately 0.8 mi south of Elkader, on State Highway 13 bridge over Turkey River, on top of concrete guardrail at right upstream end of bridge; Iowa Department of Transportation bench mark.

Elevation 732.88 ft.

9305-26 NW (2)--Approximately 0.8 mi south of Elkader, on State Highway 13 bridge over Turkey River, on top of concrete guardrail at left upstream end of bridge; Iowa Department of Transportation bench mark.

Elevation 731.50 ft.

9305-26 NW (3)--(REFERENCE POINT) Approximately 0.8 mi south of Elkader, on State Highway 13 bridge over Turkey River, on top of concrete guardrail at center of downstream side of bridge and 1 ft right of wire weight; chiseled arrow.

Elevation 732.11 ft.

9405-25 SW (1)--At Saint Olaf, on County Road B65 bridge over Roberts Creek, on right downstream end of bridge; chiseled square.

Elevation 858.68 ft.

9405-25 SW (2)--(REFERENCE POINT) At Saint Olaf, on County Road B65 bridge over Roberts Creek, on downstream guardrail and 90 ft from right end of bridge; chiseled arrow.

Elevation 859.90 ft.

9405-25 NW (1)--At Saint Olaf, on County Road X28 bridge over Roberts Creek, on left upstream end of bridge, on upstream rivet head; chiseled cross.

Elevation 854.88 ft.

9405-25 NW (2)--At Saint Olaf, on County Road X28 bridge over Roberts Creek, on right downstream wingwall; chiseled square.

Elevation 859.43 ft.

9405-36 SW (1)--Approximately 1.3 mi south of Saint Olaf, on County Road X28 bridge over Roberts Creek, on downstream guardrail at left end of bridge; Iowa Highway Commission bench mark.

Elevation 827.53 ft.

9405-36 SW (2)--(REFERENCE POINT) Approximately 1.3 mi south of Saint Olaf, on County Road X28 bridge over Roberts Creek, on downstream guardrail and 120 ft from left end of bridge; chiseled arrow.

Elevation 827.93 ft.

9405-36 NW (1)--Approximately 0.8 mi south of Saint Olaf, on County Road X28 bridge over Roberts Creek, on upstream guardrail at right end of bridge; Iowa Highway Commission bench mark.

Elevation 840.33 ft.

9405-36 NW (2)--(REFERENCE POINT) Approximately 0.8 mi south of Saint Olaf, on County Road X28 bridge over Roberts Creek, on downstream guardrail and 83 ft from right end of bridge; chiseled arrow.

Elevation 842.79 ft.

9406-26 SW(1)--Approximately 5.5 mi southeast of Elgin, on County Road W70 bridge over Turkey River, on upstream curb at left end of bridge; U.S. Geological Survey brass tablet stamped "45 WEK 1964".

Elevation 779.991 ft.

9406-26 SW(2)--Approximately 5.5 mi southeast of Elgin, on County Road W70 bridge over Turkey River, on downstream curb at right end of bridge; chiseled square.

Elevation 779.94 ft.

9406-26 SW(3)--(REFERENCE POINT) Approximately 5.5 mi southeast of Elgin, on County Road W70 bridge over Turkey River, on top of downstream guardrail between 10th and 11th guardrail posts from right end of bridge; chiseled arrow.

Elevation 782.59 ft.

9407-10 NE (1)--Approximately 1.5 mi south of Clermont, on County Road W51 bridge over Turkey River, on top of old wingwall support at right downstream end of bridge; chiseled square.

Elevation 829.36 ft.

9407-10 NE (2)--Approximately 1.5 mi south of Clermont, on County Road W51 bridge over Turkey River, on left downstream abutment curb and 0.5 ft left of steel plate; chiseled square.

Elevation 829.78 ft.

9407-10 NE (3)--(REFERENCE POINT) Approximately 1.5 mi south of Clermont, on County Road W51 bridge over Turkey River, on downstream curb between 10th and 11th guardrail posts from left end of bridge; chiseled arrow.

Elevation 829.99 ft.

9407-13 NW (1)--At Elgin, on County Road B64 bridge over Turkey River, on top of left downstream wingpost; chiseled square.

Elevation 815.56 ft.

9407-13 NW (2)--At Elgin, on County Road B64 bridge over Turkey River, on downstream curb at right end of bridge; chiseled square.

Elevation 813.66 ft.

9407-13 NW (3)--(REFERENCE POINT) At Elgin, on County Road B64 bridge over Turkey River, on downstream curb between 20th and 21st cement guardrail posts from right end of bridge; chiseled arrow.

Elevation 814.29 ft.

9407-14 SE (1)--At Elgin, on County Road W55 bridge over Otter Creek, on upstream curb at left end of bridge; chiseled cross.

Elevation 809.62 ft.

9407-14 SE (2)--At Elgin, on County Road W55 bridge over Otter Creek, on left downstream end of bridge; chiseled square.

Elevation 809.77 ft.

9407-14 SE (3)--(REFERENCE POINT) At Elgin, on County Road W55 bridge over Otter Creek, on top of 10th guardrail post from left downstream end of bridge; three filed marks.

Elevation 816.07 ft.

9407-14 SW (1)--At Elgin, on County Road W51 bridge over Otter Creek, on top of right downstream wingpost; chiseled square.

Elevation 835.54 ft.

9407-14 SW (2)--(REFERENCE POINT) At Elgin, on County Road W51 bridge over Otter Creek, on top of downstream guardrail and right of 6th guardrail post from left end of bridge; chiseled arrow.

Elevation 835.44 ft.

9407-29 NW (1)--Approximately 0.4 mi east of Brainard, on Dove Road bridge over Otter Creek, on left upstream wingwall; chiseled square.

Elevation 904.82 ft.

9407-29 NW (2)--(REFERENCE POINT) Approximately 0.4 mi east of Brainard, on Dove Road bridge over Otter Creek, top of downstream truss at center vertical support; chiseled arrow.

Elevation 908.71 ft.

9407-30 NE (1)--Approximately 0.5 mi west of Brainard, on Valley Road bridge over Otter Creek, on top of left downstream wingpost; chiseled square.

Elevation 925.71 ft.

9407-30 NE (2)--(REFERENCE POINT) Approximately 0.5 mi west of Brainard, on Valley Road bridge over Otter Creek, on downstream guardrail between 4th and 5th guardrail posts from left end of bridge; three chiseled marks.

Elevation 928.11 ft.

9507-29 SW(1)--Approximately 2.1 mi northwest of Clermont, on County Road B40 bridge over Turkey River, on left downstream wingwall, chiseled cross.

Elevation 857.27 ft.

9507-29 SW(2)--(REFERENCE POINT) Approximately 2.1 mi northwest of Clermont, on County Road B40 bridge over Turkey River, on downstream curb between 14th and 15th guardrail posts from right end of bridge; chiseled square.

Elevation 859.98 ft.

9507-30 SE (1)--Approximately 2.7 mi northwest of Clermont, on County Road B40 bridge over Turkey River, on center of downstream curb; chiseled square.

Elevation 862.68 ft.

9507-30 SE (2)--Approximately 2.7 mi northwest of Clermont, on County Road B40 bridge over Turkey River, on corner of left upstream wingpost; chiseled square.

Elevation 865.02 ft.

9507-30 SE (3)--(REFERENCE POINT) Approximately 2.7 mi northwest of Clermont, on County Road B40 bridge over Turkey River, on downstream guardrail between 15th and 16th guardrail posts from right end of bridge; chiseled arrow.

Elevation 864.06 ft.

9507-34 SW (1)--At Clermont, on U.S. Highway 18 bridge over Turkey River, on right downstream end of bridge and approximately 5 ft off of bridge on sidewalk, on ridge of manhole cover; chiseled cross.

Elevation 846.73 ft.

9507-34 SW (2)--(REFERENCE POINT) At Clermont, on U.S. Highway 18 bridge over Turkey River, on downstream concrete guardrail, on right side of wire weight and approximately 10 ft streamward of center pier; chiseled arrow.

Elevation 849.59 ft.

9508-08 SE (1)--Approximately 1.4 mi east of Eldorado, on County Road B40 bridge over Turkey River, on top of right downstream wingwall; chiseled square.

Elevation 920.20 ft.

9508-08 SE (2)--Approximately 1.4 mi east of Eldorado, on County Road B40 bridge over Turkey River, on top of right downstream wingwall; chiseled cross.

Elevation 922.99 ft.

9508-08 SE (3)--(REFERENCE POINT) Approximately 1.4 mi east of Eldorado, on County Road B40 bridge over Turkey River, seven concrete guardrail sections from left downstream end of bridge; chiseled cross.

Elevation 922.46 ft.

9508-15 SE (1)--Approximately 3.5 mi southeast of Eldorado on County Road B40 bridge over Turkey River, on top of concrete guardrail on left downstream end of bridge; chiseled square.

Elevation 902.81 ft.

9508-15 SE (2)--(REFERENCE POINT) Approximately 3.5 mi southeast of Eldorado on County Road B40 bridge over Turkey River, left of 10th concrete section from right downstream wingwall; chiseled square.

Elevation 907.31 ft.

9508-16 NE (1)--Approximately 2.5 mi east of Eldorado, on County Road W42 bridge over Turkey River, on left downstream wingwall at curb height; chiseled square.

Elevation 903.65 ft.

9508-16 NE (2)--Approximately 2.5 mi east of Eldorado, on County Road W42 bridge over Turkey River, on top of left upstream wingpost; chiseled square.

Elevation 906.07 ft.

9508-16 NE (3)--(REFERENCE POINT) Approximately 2.5 mi east of Eldorado, on County Road W42 bridge over Turkey River, on downstream curb between 12th and 13th guardrail posts from left end of bridge; chiseled arrow.

Elevation 903.92 ft.

9508-18 NW(1)--At Eldorado, on State Highway 150 bridge over Turkey River, on right upstream wingwall curb; Iowa Highway Commission bench mark.

Elevation 946.66 ft.

9508-18 NW(2)--At Eldorado, on State Highway 150 bridge over Turkey River, on left downstream abutment and 10 ft right of wingwall curb; chiseled square.

Elevation 938.16 ft.

9508-18 NW(3)--(REFERENCE POINT) At Eldorado, on State Highway 150 bridge over Turkey River, on 19th metal plate of old guardrail from right downstream end of bridge; three filed marks.

Elevation 940.93 ft.

9508-22 SE (1)--Approximately 4.0 mi southeast of Eldorado, on Ironwood Road bridge over Turkey River, on left upstream curb of triple pony truss bridge; chiseled square.

Elevation 882.22 ft.

9508-22 SE (2)--Approximately 4.0 mi southeast of Eldorado, on Ironwood Road bridge over Turkey River, on top of left upstream wingpost of triple pony truss bridge; chiseled square.

Elevation 884.09 ft.

9508-22 SE (3)--(REFERENCE POINT) Approximately 4.0 mi southeast of Eldorado, on Ironwood Road bridge over Turkey River, on curb in center of middle pony truss of triple pony truss bridge; chiseled arrow.

Elevation 883.99 ft.

9508-25 NE (1)--Approximately 3.9 mi northwest of Clermont, on County Road B40 bridge over Turkey River, on left upstream wingpost; chiseled square.

Elevation 878.68 ft.

9508-25 NE (2)--(REFERENCE POINT) Approximately 3.9 mi northwest of Clermont on County Road B40 bridge over Turkey River, on top of downstream guardrail and 125 feet from left end of bridge; chiseled arrow.

Elevation 881.35 ft.