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FLOODS OF JULY 19-25, 1999, IN THE WAPSIPINICON AND CEDAR RIVER BASINS, NORTHEAST IOWA

by Jan L. Ballew and David A. Eash

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

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 19-25, 1999, in the Wapsipinicon and Cedar River Basins, Northeast Iowa

by Jan L. Ballew and David A. Eash

ABSTRACT

Severe flooding occurred during July 19-25, 1999, in the Wapsipinicon and Cedar River Basins following two thunderstorms over northeast Iowa. During July 18-19, as much as 6 inches of rainfall was centered over Cerro Gordo, Floyd, Mitchell, and Worth Counties. During July 20-21, a second storm occurred in which an additional rainfall of as much as 8 inches was centered over Chickasaw and Floyd Counties. The cumulative effect of the storms produced floods with new maximum peak discharges at the following streamflow-gaging stations: Wapsipinicon River near Tripoli, 19,400 cubic feet per second; Cedar River at Charles City, 31,200 cubic feet per second (recurrence interval about 90 years); Cedar River at Janesville, 42,200 cubic feet per second (recurrence interval about 80 years); and Flood Creek near Powersville, 19,000 cubic feet per second. Profiles of flood elevations for the July 1999 flood are presented in this report for selected reaches along the Wapsipinicon, Cedar, and Shell Rock Rivers and along Flood Creek. Information about the river basins, rain storms, and flooding are presented along with information on temporary bench marks and reference points in the Wapsipinicon and Cedar River Basins.

INTRODUCTION

Thunderstorms caused severe flooding on the Wapsipinicon, Cedar, and Shell Rock Rivers and along Flood Creek in northeast Iowa in July 1999. New maximum peak stages and discharges were measured

at streamflow-gaging stations on the Wapsipinicon and Cedar Rivers and on Flood Creek.

The flooding caused major damage in Independence and Littleton along the Wapsipinicon River; Charles City, Nashua, Waverly, and Cedar Falls along the Cedar River; Rock Falls, Rockford, and Shell Rock along the Shell Rock River; Rudd along Flood Creek; and Manly, in Worth County from small-stream flooding. More than 1,000 homes in six counties were damaged by the July 1999 floods. The number of homes reported as damaged is listed below (McGlynn and Chatterley, *Des Moines Register*, July 27, 1999); damage to homes in Butler, Cerro Gordo, and Floyd Counties was not reported.

County	Homes destroyed	Homes with major damage	Homes with minor damage
Bremer	0	24	104
Buchanan	10	118	61
Chickasaw	1	9	332
Howard	0	0	40
Mitchell	0	6	4
Worth	2	56	249

The flood forced the evacuation of hundreds of people from their homes and caused many road closures throughout northeast Iowa. Governor Vilsack declared a State disaster emergency for Bremer, Butler, Cerro Gordo, Chickasaw, Floyd, Howard, Mitchell, and Worth Counties. A Federal disaster proclamation followed that included Black Hawk and Jones Counties. As of early June 2000, the total economic damage from flooding in the Wapsipinicon and Cedar River Basins was not completely evaluated. The Federal Emergency Management Agency (FEMA) had approved nearly \$6 million in financial assistance for

schools, businesses, private non-profit businesses, road and bridge repairs, demolition of homes or businesses declared hazardous, and for repair of essential utilities to recover from the flood damage. The FEMA financial assistance did not include agricultural losses, losses sustained due to loss of commerce or unemployment, and several large road and bridge projects not yet completed (Jerry Ostendorf, Iowa Emergency Management Division, written commun., June 2000).

The July 1999 flood resulted in private home buyout assistance totaling about \$4 million for 75 homes in the Cedar River flood plain and for 4 homes in the Shell Rock River flood plain (Dennis Harper, Hazard Mitigation, Iowa Emergency Management Division, written commun., May 2000). Private home buyout assistance was not offered for any homes in the Wapsipinicon River flood plain following the July 1999 flood because 111 homes along the Wapsipinicon River were included in this program following the May 1999 flood at a cost of more than \$6 million (Ballew and Fischer, 2000).

In the agricultural sector, farmers were unable to replant flooded fields because the flooding occurred too late in the growing season. Agricultural losses were a result of yield reductions and damage to farm infrastructure such as waterways and terraces. In Floyd County, for example, crop damage was estimated at \$3.3 million, the result of a 25-percent yield reduction in corn and a 35-percent yield reduction in soybeans (Dennis Sande, District Conservationist, Natural Resources Conservation Service, oral commun., June 2000).

This report provides information about the July 1999 rainstorms and ensuing floods in the Wapsipinicon and Cedar River Basins. Flood elevations at selected sites along the Wapsipinicon, Cedar, and Shell Rock Rivers and along Flood Creek are presented as flood profiles.

This report was prepared in cooperation with the Iowa Department of Transportation and the Iowa Highway Research Board. Various Federal, State, and local agencies provide funding for the operation and maintenance of the streamflow-gaging stations in the Wapsipinicon and Cedar River Basins. They are acknowledged in the annual water resources data reports of the U.S. Geological Survey (USGS) (Nalley and others, 2000). A list of other Iowa flood-profile reports published by the USGS can be obtained from the World Wide Web at the uniform resource locator (URL) <http://ia.water.usgs.gov/projects/profiles/>.

Acknowledgments

The authors express their gratitude to Al Dietz, City of Cedar Falls Land Surveyor's Office; Todd Fonkert and Dennis Haverkamp, Bremer County Engineer's Office; Denny Rops, Butler County Engineer's Office; and Doug Franke, Floyd County Engineer's Office, for providing elevations for temporary bench marks at bridges. The authors also express their gratitude to the following: A.L. Donnelly and R.L. Kuzniar for collecting flood-elevation data and for collecting and processing global-positioning-system data for the establishment of sea-level elevations for temporary bench marks; J.D. Eash, M.S. Linhart, J.C. McVay, M.J. Noon, and M.J. Turco for collecting flood-elevation data, and D.E. Christiansen for preparing the maps for this report.

RIVER BASINS

The Wapsipinicon and Cedar River Basins are parallel river basins draining from the northwest to the southeast across northeast Iowa. The two drainage basins, the river reaches profiled, the location of active and discontinued USGS streamflow-gaging stations in Iowa within these river basins, and the location of bridge sites used in the July 19-25, 1999, flood profiles are shown in figure 1. Station numbers and names, drainage areas, periods of flood records, types of gages, and status of gages for the gaging stations shown in figure 1 are listed in table 1. Archived streamflow data (peak-flow and daily values) can be accessed for these streamflow-gaging stations at the USGS web site URL <http://waterdata.usgs.gov/nwis-w/IA/>.

The Wapsipinicon River originates in southeastern Minnesota and flows about 225 mi to the mouth at the Mississippi River (Iowa Natural Resources Council, 1958, p. 8). The Wapsipinicon River Basin is a long narrow basin with a total drainage area of 2,540 mi², of which all but 13 mi² are in Iowa (Schwob, 1971, p. 3). The topography of the basin changes from relatively flat in the upper part of the basin to gently rolling in the lower part. Land use in the basin is primarily agricultural.

The Cedar River Basin originates in southeastern Minnesota and flows approximately 320 mi to the mouth at the Iowa River. The total drainage area of the Cedar River Basin is 7,819 mi², of which 1,024 mi² are in Minnesota (Schwob, 1963, p. 1). Within Iowa, the

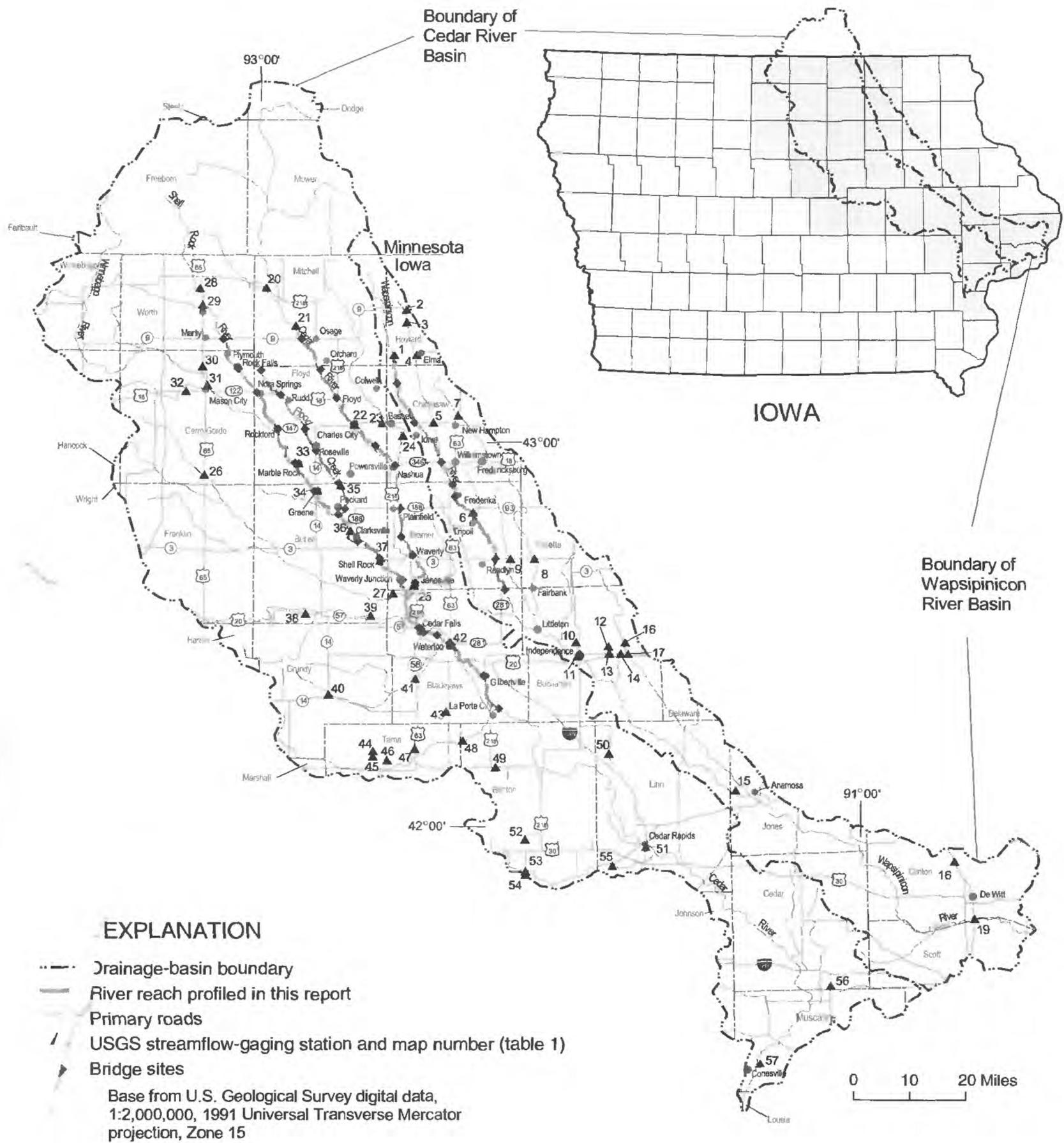


Figure 1. River reaches profiled, location of bridge sites used for the flood profiles of July 19-25, 1999, and U.S. Geological Survey streamflow-gaging stations located in the Wapsipinicon and Cedar River Basins, Iowa.

Table 1. Streamflow-gaging stations in the Wapsipinicon and Cedar River Basins, Iowa
 [no., number; mi², square miles; cont., continuous; csg, crest-stage gage; disc., discontinued]

Map no. (fig. 1)	Station number	Station name	Drainage area (mi ²)	Period of flood record (water years) ^a	Type of gage	Status of gage
1	05420560	Wapsipinicon River near Elma, IA	95.2	1959-92	cont.	disc.
2	05420600	Little Wapsipinicon River tributary near Riceville, IA	1.10	1953-2000	csg	active
3	05420620	Little Wapsipinicon River near Acme, IA	7.76	1953-93	csg	disc.
4	05420640	Little Wapsipinicon River at Elma, IA	37.3	1953-93	csg	disc.
5	05420650	Little Wapsipinicon River near New Hampton, IA	95.0	1966-93	csg	disc.
6	05420680	Wapsipinicon River near Tripoli, IA	343	1969, 1996-99	cont.	active
7	05420690	East Fork Wapsipinicon River near New Hampton, IA	30.3	1966-93	csg	disc.
8	05420850	Little Wapsipinicon River near Oran, IA	94.1	1966-2000	csg	active
9	05420875	Buck Creek near Oran, IA	37.9	1966-2000	csg	active
10	05420960	Harter Creek near Independence, IA	6.17	1952-63	csg	disc.
11	05421000	Wapsipinicon River at Independence, IA	1,048	1934-2000	cont.	active
12	05421100	Pine Creek tributary near Winthrop, IA	0.334	1952-2000	csg	active
13	05421200	Pine Creek near Winthrop, IA	28.3	1950-93	csg	disc.
14	05421300	Wapsipinicon tributary at Winthrop, IA	0.70	1953-2000	csg	active
15	05421500	Wapsipinicon River at Stone City, IA	1,324	1892, 1903-13	cont.	disc.
16	05421550	Buffalo Creek above Winthrop, IA	68.2	1957-90	csg	disc.
17	05421600	Buffalo Creek near Winthrop, IA	71.4	1953-90	csg	disc.
18	05421890	Silver Creek at Welton, IA	9.03	1966-2000	csg	active
19	05422000	Wapsipinicon River near De Witt, IA	2,330	1935-2000	cont.	active
20	05457440	Deer Creek near Carpenter, IA	91.6	1973-2000	csg	active
21	05457500	Cedar River at Mitchell, IA	826	1934-42, 1961-62	cont.	disc.
22	05457700	Cedar River at Charles City, IA	1,054	1946-53, 1961-62, 1965-95, 1999	cont.	active
23	0545776680	Gizzard Creek tributary near Bassett, IA	3.42	1990-2000	csg	active
24	05458000	Little Cedar River near Ionia, IA	306	1954-2000	cont.	active
25	05458500	Cedar River at Janesville, IA	1,661	1905-06, 1915-21, 1923-27, 1933-42, 1945-2000	cont.	active
26	05458560	Beaverdam Creek near Sheffield, IA	123	1966-89	csg	disc.
27	05458900	West Fork Cedar River at Finchford, IA	846	1929, 1946-2000	cont.	active
28	05459000	Shell Rock River near Northwood, IA	300	1946-86	cont.	disc.
29	05459010	Elk Creek at Kensett, IA	58.1	1966-90	csg	disc.
30	05459490	Spring Creek near Mason City, IA	29.3	1966-2000	csg	active
31	05459500	Winnebago River at Mason City, IA	526	1933-2000	cont.	active
32	05460100	Willow Creek near Mason City, IA	78.6	1966-2000	csg	active
33	05460500	Shell Rock River at Marble Rock, IA	1,318	1933-53, 1961-62	cont.	disc.
34	05461000	Shell Rock River at Greene, IA	1,357	1933-42	cont.	disc.
35	05461390	Flood Creek near Powersville, IA	127	1963, 1996-99	cont.	active

Table 1. Streamflow-gaging stations in the Wapsipinicon and Cedar River Basins, Iowa--Continued

Map no. (fig. 1)	Station number	Station name	Drainage area (mi ²)	Period of flood record (water years) ^a	Type of gage	Status of gage
36	05461500	Shell Rock River near Clarksville, IA	1,626	1916-27, 1933-34, 1961-62	cont.	disc.
37	05462000	Shell Rock River at Shell Rock, IA	1,746	1856, 1954-2000	cont.	active
38	05462750	Beaver Creek tributary near Aplington, IA	11.6	1966-91	csg	disc.
39	05463000	Beaver Creek at New Hartford, IA	347	1946-2000	cont.	active
40	05463090	Black Hawk Creek at Grundy Center, IA	56.9	1966-91	csg	disc.
41	05463500	Black Hawk Creek at Hudson, IA	303	1952-95	cont.	disc.
42	05464000	Cedar River at Waterloo, IA	5,146	1929, 1933, 1941-2000	cont.	active
43	05464025	Miller Creek near Eagle Center, IA	9.14	1991-2000	csg	active
44	05464130	Fourmile Creek near Lincoln, IA	13.78	1963-67, 1970-74, 1977-80	cont.	disc.
45	05464133	Half Mile Creek near Gladbrook, IA	1.33	1963-67, 1970-74, 1977-80	cont.	disc.
46	05464137	Fourmile Creek near Traer, IA	19.51	1963-74, 1976-80	cont.	disc.
47	05464145	Twelvemile Creek near Traer, IA	43.8	1966-92	csg	disc.
48	05464220	Wolf Creek near Dysart, IA	299	1996-98	cont.	active
49	05464310	Pratt Creek near Garrison, IA	23.4	1966-94	csg	disc.
50	05464318	East Blue Creek at Center Point, IA	17.6	1966-93	csg	disc.
51	05464500	Cedar River at Cedar Rapids, IA	6,510	1851, 1903-2000	cont.	active
52	05464535	Prairie Creek tributary near Van Horne, IA	0.94	1991-2000	csg	active
53	05464560	Prairie Creek at Blairstown, IA	87	1966-88	csg	disc.
54	05464562	Thunder Creek at Blairstown, IA	0.96	1991-2000	csg	active
55	05464640	Prairie Creek at Fairfax, IA	178	1967-82	cont.	disc.
56	05464880	Otter Creek at Wilton, IA	10.7	1966-93	csg	disc.
57	05465000	Cedar River near Conesville, IA	7,785	1940-2000	cont.	active

^aPeriod of flood record listed through water year 2000.

topography of the basin ranges from flat to rolling and the stream valleys alternate from reaches that are wide and flat to reaches that are narrow and almost gorge-like. A number of low-head dams have been constructed across the main stems of the Cedar and Shell Rock Rivers, but the dams have small pools that do not substantially affect the peak discharge of the rivers during large floods (Schwob, 1963, p. 2). Although land use in the Cedar River Basin is primarily agricultural, several areas within the basin are urban. Tributary streams within the Cedar River Basin that are profiled in this report include the Shell Rock River and Flood Creek.

STORM DESCRIPTION

The July 19-25, 1999, flood in the Wapsipinicon and Cedar River Basins was the result of two storms that occurred during a 72-hour period over northeast Iowa. The first storm occurred during July 18-19 and was followed by a second storm over the same area during July 20-21, resulting in a broader and more intense rainfall pattern. Figures 2 and 3, provided by State Climatologist Harry Hillaker, Iowa Department of Agriculture and Land Stewardship (written commun., July 1999), show areal distribution of rainfall for the 24-hour periods ending July 19 and 21.

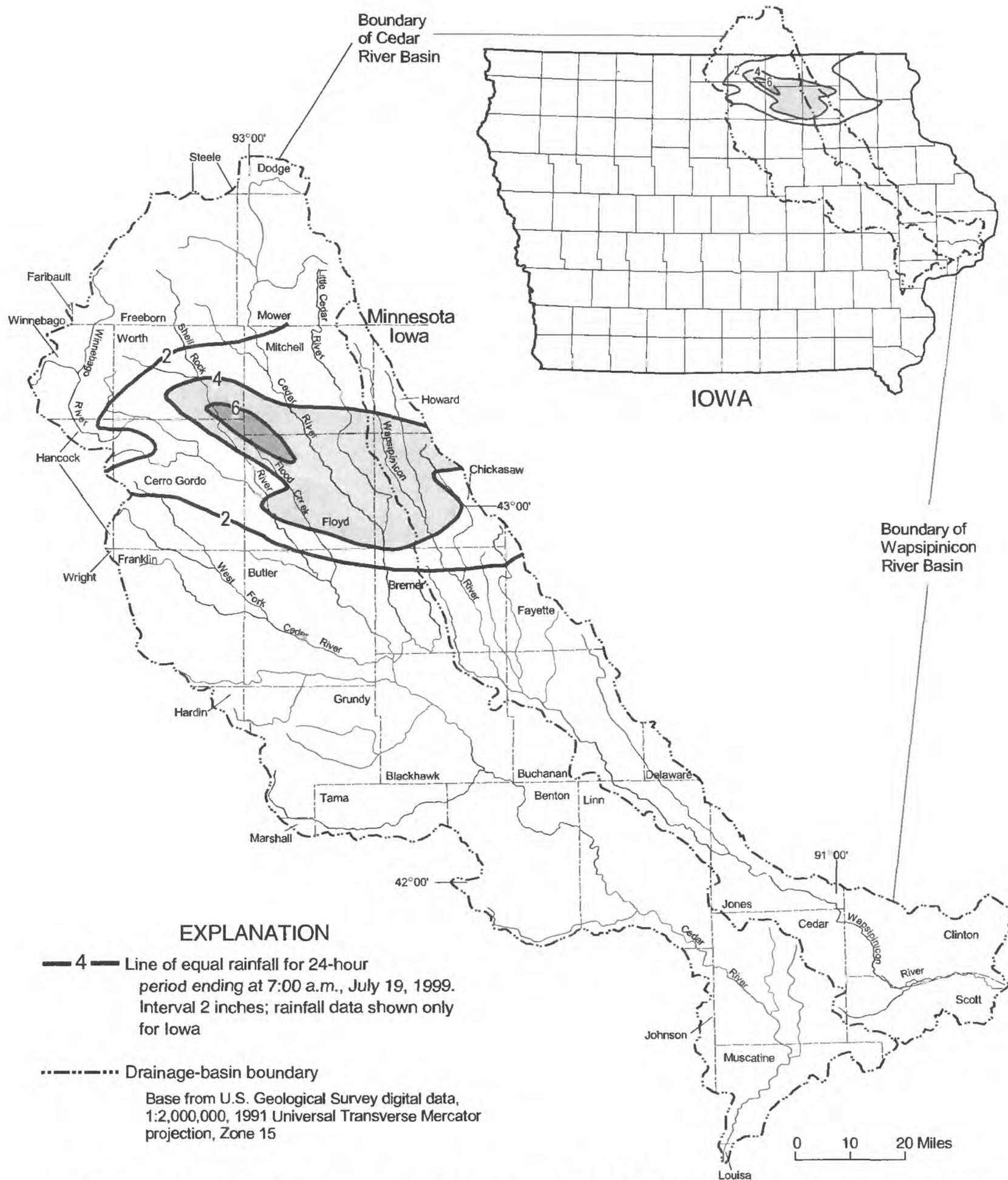


Figure 2. Areal distribution of rainfall for the July 18-19, 1999, storm in the Wapsipinicon and Cedar River Basins, Iowa (lines of equal rainfall, in inches, provided by Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship, written commun., July 1999).

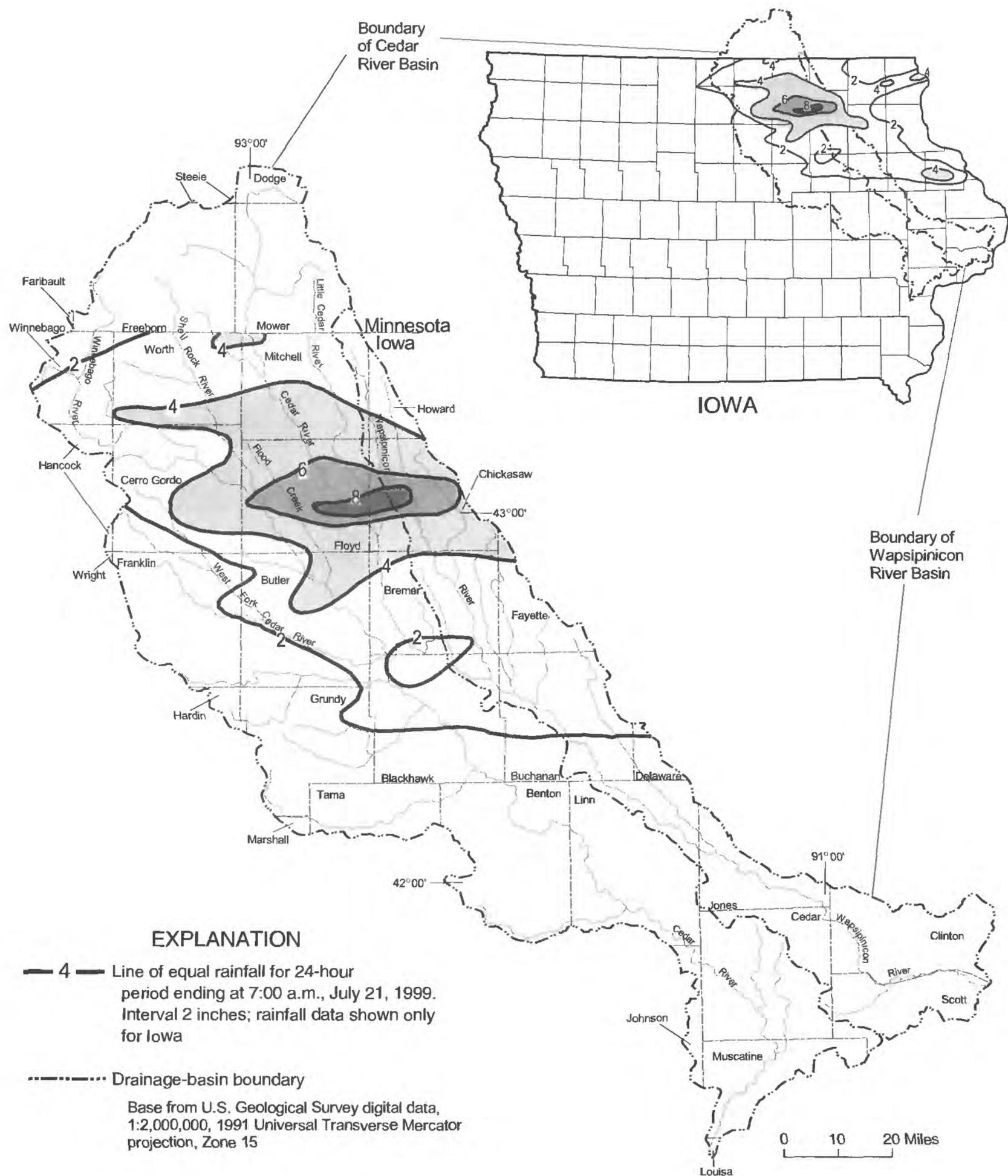


Figure 3. Areal distribution of rainfall for the July 20-21, 1999, storm in the Wapsipinicon and Cedar River Basins, Iowa (lines of equal rainfall, in inches, provided by Harry Hillaker, State Climatologist, Iowa Department of Agriculture and Land Stewardship, written commun., July 1999).

Excerpts from records of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service (URL <http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~storms>) describe the sequence of storm events as follows:

(7/18—7/19/99) A nearly stationary frontal boundary was draped across Iowa during the afternoon of the 18th into the night. Thunderstorms erupted in the vicinity of the front as dew point temperatures in the mid-70s to around 80 pooled just south of the front. Most of the storms produced heavy rain and gusty winds with very few producing severe weather. The main problem was flash flooding over north central Iowa. Near Manly in Worth County, 5.75 inches of rain was recorded in a four-hour period just after midnight. Heavy rains also fell over northeast Cerro Gordo County, overtopping many roads with 1 to 2 feet of water. The heaviest rainfall occurred over Worth County. A bucket survey indicated spot 9- to 12-inch rainfall amounts northeast of Manly, with the highest unofficial measurement at 13.5 inches, though there was one report of an incredible 20 inches of rain.

(7/20—7/21/99) Another flash flood watch was issued early on the 20th for roughly the north half of Iowa. Factors cited in discussions about the potential for heavy rainfall included the presence of a very slow moving cold front, combined with 30- to 45-MPH low level winds feeding abundant moisture into the boundary. The forecasts for extreme rainfall were verified by tremendous rains which began late on the afternoon of the 20th. A flash flood warning was already issued by the early evening hours for southern Worth County with radar-estimated rainfall at 2 inches per hour. Storms continued to develop over the same areas during the evening hours, causing additional flash flood warnings in both Bremer and Butler Counties. Rainfall was heaviest in the Cedar and Shell Rock River Basins, as the band of intense rainfall sank slowly southward with the frontal boundary. Unofficial reports of 7 to 8 inches of rain were reported near Clarksville, located along the Cedar River in Butler County. River flood warnings were issued before midnight, late on the 20th, for the Cedar River from the Bremer County line and into the Waterloo area. As additional rainfall reports were received early on Wednesday the 21st, the extent and degree of possible river flooding became evident. Radar-estimated rainfall indicated a large area of greater than 6 inches of rainfall centered over Floyd County with a center of 8 to 11 inches stretching from just south of Charles City

westward to Rockford. The highest 24-hour gage report within the Cedar Basin was at Charles City with 6.65 inches. According to the Rainfall Frequency Atlas of the Midwest (Midwest Climate Center, 1992), the 100-year, 24-hour rainfall in this part of Iowa is around 6 inches, meaning that 2 out of 3 nights the rain gage in Charles City had rains at or in excess of the 100-year frequency for 24 hours.

Excerpts from the records of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service (1999) indicate that:

Very heavy rains fell in the Cedar River Basin from Mower County in Minnesota to Floyd County in Iowa on July 18th, and across Mitchell, Floyd, and Chickasaw Counties in Iowa on July 20th. Totals of 10 to 12 inches were reported for Osage, Charles City, and New Hampton during this three-day period. Though no readings were available, a record or near-record flood crest likely occurred on the upper reaches of the Wapsipinicon River through Chickasaw County.

The Rainfall Frequency Atlas of the Midwest (Huff and Angel, 1992, p. 101) shows the 100-year, 72-hour rainfall for northeast Iowa to be about 8 inches. Rainfall amounts for six communities in northeast Iowa, as reported by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Environmental Satellite, Data, and Information Service (1999), are listed in table 2.

FLOOD DESCRIPTION

As a result of the intense storms, severe flooding occurred in the upper and middle parts of the Wapsipinicon and Cedar River Basins and in the middle and lower parts of the Shell Rock River Basin. New maximum peak stages and discharges were measured at streamflow-gaging stations on the Wapsipinicon River near Tripoli, on the Cedar River at Charles City and Janesville, and on Flood Creek near Powersville. In Cedar Falls, the Cedar River unofficially reached a new record-high stage on July 23, 1999. After consulting with the U.S. Army Corps of Engineers, Ron Arends, City of Cedar Falls Engineer, indicated that this record stage was about 0.5 ft higher than the stage of 96.3 ft estimated for the 1961 flood at the city's river gage (Ericson and Jamison, *Waterloo-Cedar Falls Courier*, July 23, 1999). Maximum stages and discharges, recurrence intervals, and unit runoff for the floods of July 1999 and selected additional years at

Table 2. Rainfall amounts at selected communities in northeast Iowa during July 19-21, 1999
[Blank entries indicate zero. T, trace]

Community	24-hour rainfall, in inches ^a			72-hour rainfall total, in inches
	July 19, 1999	July 20, 1999	July 21, 1999	
Osage	5.75	0.05	5.00	10.80
Mason City	3.04	0.15	3.88	7.07
Charles City	5.16		6.65	11.81
New Hampton	4.75		7.10	11.85
Tripoli	0.77	T	3.06	3.83
Independence	0.86	0.37	3.77	5.00

^a*Climatological Data, Iowa, July 1999* (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Environmental Satellite, Data, and Information Service).

selected gaging stations in the Wapsipinicon and Cedar River Basins are listed in table 3.

The flooding inundated many roads throughout northeast Iowa; on July 21 authorities closed all roads into Floyd County and travel was not recommended within Bremer, Chickasaw, and Floyd Counties because of secondary roads being inundated and some gravel roads being washed out. In Bremer County, road closures during the flood included U.S. Highway 218 at Plainfield, U.S. Highway 63 at the Bremer/Chickasaw County line, and State Highway 3 in Waverly. In Waverly, the Cedar River inundated 65 city blocks on July 22 and forced 1,500 people from their homes; between 600 and 650 homes and a dozen downtown businesses were affected by the flooding (*Waterloo-Cedar Falls Courier*, July 23, 1999).

In Chickasaw County, road closures during the flood included State Highway 346 at the Wapsipinicon River bridge. U.S. Highway 18 at several places west of Fredericksburg and around New Hampton, County Road B76 east of Ionia, and County Road T76 south of Bassett. At Nashua, the Cedar River topped the dam at Cedar Lake and flooded nearby homes. In addition, flood water crossing State Highway 346 backed up along the railroad bridge, causing water to rise into downtown Nashua (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, July 19-22, 1999, URL <http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~storms>).

In Floyd County, U.S. Highway 218 at the Mitchell/Floyd County line and south of Charles City, State Highway 14 at Charles City, and U.S. Highway 18 between the towns of Floyd and Rudd were closed during the flood. According to Ken Mahler, Emergency Management Coordinator, Rockford was the hardest hit area in Floyd County following the first storm during July 18-19 (Lee and McGlynn, *Des Moines Register*, July 20, 1999). Jim Zirbel, Charles City Police Chief, estimated that between 500 and 1,000 homes in Charles City sustained flood-related damage (Lynch, *Cedar Rapids Gazette*, July 22, 1999). Because of the flooding in Charles City, many businesses were closed, as were all bridges crossing the Cedar River, with the exception of the Main Street Bridge (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, July 19-22, 1999, URL <http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~storms>). A fatality occurred on a county road crossing Flood Creek south of Rudd when flood water washed a car downstream after the motorist entered the flooded roadway (Wilde, *Waterloo-Cedar Falls Courier*, July 20, 1999). In the town of Nora Springs, a small earthen dambreak on the Shell Rock River may have increased flow downstream. Because flood water had already substantially overtopped the dam at the time of the failure, the exact impact on flow downstream was difficult to determine (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, July 19-26, 1999, URL

Table 3. Maximum stages and discharges, recurrence intervals, and unit runoff for the floods of July 1999 and selected additional years at selected streamflow-gaging stations in the Wapsipinicon and Cedar River Basins, Iowa

[mi², square miles; ft³/s, cubic feet per second; [(ft³/s)/mi²], cubic feet per second per square mile; **boldfaced type**, flood profile included in this report; --, not determined]

Streamflow-gaging station	Drainage area (mi ²)	Date	Peak stage ^a (feet)	Peak discharge (ft ³ /s)	Recurrence interval ^b (years)	Unit runoff [(ft ³ /s)/mi ²]
Wapsipinicon River Basin						
05420560 Wapsipinicon River near Elma	95.2	6/29/1969	14.53	5,500	6	57.8
		6/04/1974	14.94	10,100	25	106
		6/17/1984	14.81	6,580	9	69.1
		7/21/1999	14.15	3,800^c	4	39.9
05420680 Wapsipinicon River near Tripoli	343	7/01/1969	17.26	18,900^c	--	55.1
		5/17/1999	14.39	3,900	--	11.4
		7/21/1999	18.50	19,400	--	56.6
05421000 Wapsipinicon River at Independence	1,048	7/18/1968	21.11	26,800	50	25.6
		5/18/1999	22.35	31,100	90	29.7
		7/24/1999	18.80	20,900	20	19.9
Cedar River Basin						
05457700 Cedar River at Charles City	1,054	3/27/1961	21.53	29,200	60	27.7
		8/16/1993	21.44	26,400	35	25.0
		7/21/1999	22.81	31,200	90	29.6
05458000 Little Cedar River near Ionia	306	3/27/1961	15.58	10,800	19	35.3
		8/16/1993	18.99	14,000	40	45.8
		7/21/1999	17.52	12,200	25	39.9
05458500 Cedar River at Janesville	1,661	3/28/1961	16.33	37,000	45	22.3
		8/18/1993	15.74	35,000	35	21.1
		7/22/1999	17.15	42,200	80	25.4
05460500 Shell Rock River at Marble Rock	1,318	3/27/1933	107.6 ^d	36,400	180	27.6
		3/28/1961	11.97	32,000^c	90	24.3
		7/21/1999	9.77	--	--	--
05461390 Flood Creek near Powersville	127	5/10/1963	8.00	6,500^c	--	51.2
		7/21/1999	12.57	19,000^c	--	150
05462000 Shell Rock River at Shell Rock	1,746	--/--/1856	17.7	45,000 ^c	180	25.8
		3/28/1961	16.26	33,500	45	19.2
		7/22/1999	16.73	27,500	20	15.8
05464000 Cedar River at Waterloo	5,146	3/29/1961	21.86	76,700	35	14.9
		4/08/1965	21.67	69,500	25	13.5
		7/23/1999	20.78	69,300	25	13.5
05464500 Cedar River at Cedar Rapids	6,510	3/18/1929	20.00	64,000	20	9.83
		3/31/1961	19.66	73,000	40	11.2
		4/04/1993	19.27	71,000	35	10.9
		7/25/1999	18.31	62,300	20	9.57

^aAll values at current datums.

^bInterpolated from Bulletin 17B flood-frequency analysis (Interagency Advisory Committee on Water Data, 1982) and rounded to nearest 5 years for 20- to 50-year recurrence intervals, to nearest 10 years for 50- to 100-year recurrence intervals, and to nearest 20 years for 100- to 200-year recurrence intervals.

^cEstimated.

^dAt different site and datum, in tailrace of power plant at Greene located 5.7 miles downstream.

<http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~storms>). In Nora Springs and Rockford, sewage backups and resulting water contamination problems left many residents without water service for several days (*Waterloo-Cedar Falls Courier*, July 21, 1999).

In Black Hawk County, about 100 people were evacuated from the Cedar Falls neighborhood known as Cedar City. In Buchanan County, Bob Hummel, Emergency Management Director, reported that about 100 families were evacuated from their homes (Lynch and Gosch, *Cedar Rapids Gazette*, July 24, 1999). In Butler County, State Highway 188 south of Clarksville was closed during the flood.

In Cerro Gordo County, road closures during the flood included U.S. Highway 65 (4.5 mi west of Plymouth) and County Road B20. Flooding on the Winnebago River in Mason City threatened a levee, causing the evacuation of vulnerable neighborhoods and roads in town were inundated in more than 50 locations. Jim Witt, Cerro Gordo County Engineer, reported extensive damage to five bridges, and road repairs were estimated to exceed \$500,000. At the Camp in the Woods campground near Rock Falls, five people were rescued from the tops of trailers and campers by firefighters using boats on July 19th (Zeleny, *Des Moines Register*, July 22, 1999).

In Mitchell County, State Highway 9 was closed west of Osage during the flood. In Worth County, State Highway 9 was closed east of Manly and about one-half of the 550 buildings in Manly were flooded (Zeleny, *Des Moines Register*, July 22, 1999).

During the July 1999 flood, some reaches of the Wapsipinicon River were reported to be nearly 1 mi wide. The July flood produced a new maximum peak stage and discharge at the Wapsipinicon River near Tripoli gaging station (station number 05420680); the peak stage of 18.50 ft on July 21, 1999, is about 4.1 ft higher than the peak stage measured during the May 1999 flood and about 1.2 ft higher than the previous maximum peak stage measured during the 1969 flood; the new record peak discharge is 19,400 ft³/s. At the Wapsipinicon River at Independence gaging station (station number 05421000), the river was at or higher than the flood stage of 12 ft from 8:00 a.m. on July 23 to 10:00 a.m. on July 26; a peak stage of 18.80 ft was recorded on July 24 at 4:00 a.m., which is about 3.5 ft lower than the maximum peak stage recorded on May 18, 1999. The peak discharge of 20,900 ft³/s represents about a 20-year recurrence interval flood compared to the May 18 peak discharge, which represents

approximately a 90-year recurrence interval flood (table 3).

The Cedar River, at the gaging station in Charles City (station number 05457700), was at or higher than the flood stage of 12 ft from 11:15 a.m. on July 19 to 8:45 a.m. on July 23; an initial peak stage of 18.24 ft was recorded at 1:45 a.m. on July 20, which was followed by a second peak stage of 22.81 ft recorded at noon on July 21 (fig. 4). The second peak stage exceeds the maximum stage measured in 1961 by about 1.3 ft. The peak discharge of 31,200 ft³/s represents about a 90-year recurrence interval flood compared to the 60-year recurrence interval for the 1961 flood (table 3). The Cedar River, at the gaging station in Janesville (station number 05458500), was at or higher than the flood stage of 11 ft from 4:45 a.m. on July 21 to 10:30 p.m. on July 24; a peak stage of 17.15 ft was measured at 6:00 p.m. on July 22, which exceeds the maximum stage recorded in 1961 by about 0.8 ft. The peak discharge of 42,200 ft³/s represents about an 80-year recurrence interval flood compared to the 45-year recurrence interval for the 1961 flood. The Cedar River, at the gaging station in Waterloo (station number 05464000), was at or higher than the flood stage of 12 ft from 2:30 p.m. on July 21 to 2:30 a.m. on July 26; the July 1999 flood produced the third highest peak stage and discharge on record; a peak stage of 20.78 ft was recorded at 5:00 p.m. on July 23, which is about 1.1 ft lower than the maximum stage recorded in 1961. The peak discharge of 69,300 ft³/s represents about a 25-year recurrence interval flood compared to the 35-year recurrence interval for the 1961 flood. The Cedar River, at the gaging station in Cedar Rapids (station number 05464500), was at or higher than the flood stage of 13 ft from 8:00 a.m. on July 24 to 6:30 p.m. on July 27; a peak stage of 18.31 ft was recorded at 11:30 p.m. on July 25, which is about 1.7 ft lower than the record peak stage of the 1929 flood. The peak discharge of 62,300 ft³/s represents about a 20-year recurrence interval flood.

On the Shell Rock River, the second highest peak stage on record was measured at Marble Rock and Shell Rock. The Shell Rock River at Marble Rock was at or higher than the flood stage of 4 ft from July 19 to July 25, and crested on July 21 (Brad Small, National Weather Service, written commun., June 2000). The Shell Rock River at the gaging station at Shell Rock (station number 05462000) was at or higher than the flood stage of 12 ft from 9:30 a.m. on July 20 to 11:30 a.m. on July 29; the peak stage of 16.73 ft at 1:45 p.m. on July 22 is about 0.5 ft higher than that for the flood of 1961. The peak discharge of 27,500 ft³/s represents

about a 20-year recurrence interval flood compared to the 45-year recurrence interval for the 1961 flood. The flood of 1856 reached a stage of 17.7 ft at a bridge 400 ft downstream from the gaging station (Nalley and others, 2000, p. 174).

At the Flood Creek near Powersville gaging station (station number 05461390), a record peak stage of 12.57 ft on July 21 is about 4.6 ft higher than that for the flood of 1963. The peak discharge estimate of 19,000 ft³/s is almost three times greater than that for the 1963 flood.

PROFILES FOR THE FLOODS OF JULY 19-25, 1999, IN THE WAPSIPINICON AND CEDAR RIVER BASINS

To develop flood profiles, the USGS measured the elevation of high-water marks (HWM's) at selected bridge sites along the Wapsipinicon, Cedar, and Shell Rock Rivers and along Flood Creek. Most of the marks were measured at Federal and State Highway bridges and at USGS streamflow-gaging stations. Additional HWM's were measured at several county road bridges to keep the maximum distance between points at about

10 river mi. The flood profiles were determined from HWM's generally located immediately downstream and 1 bridge length upstream from selected bridges. The HWM's were surveyed to temporary bench marks at bridges within a few days after the flood peak and were later referenced to sea level by differential leveling or differential positioning using a global positioning system (GPS). In figures 5-24, the line connecting the marks on the profiles is a linear interpolation and, therefore, only approximates the flood elevation between marks; the line does not depict the effects on the profile caused by intermediate bridges or flood-plain and channel features. The HWM's used to profile the July 19-25, 1999, floods in the Wapsipinicon and Cedar River Basins are listed in tables 4-7 and are plotted by river mile in figures 5-24 (following references); each table of HWM's follows the river profiled. Primary highways referred to in the report are shown in figure 1; secondary roads and streets are not shown.

For comparison purposes, profiles of previous floods are included with the July 1999 profiles where they are available. The Wapsipinicon River profile includes a profile of the 1969 flood (Schwob, 1971) and

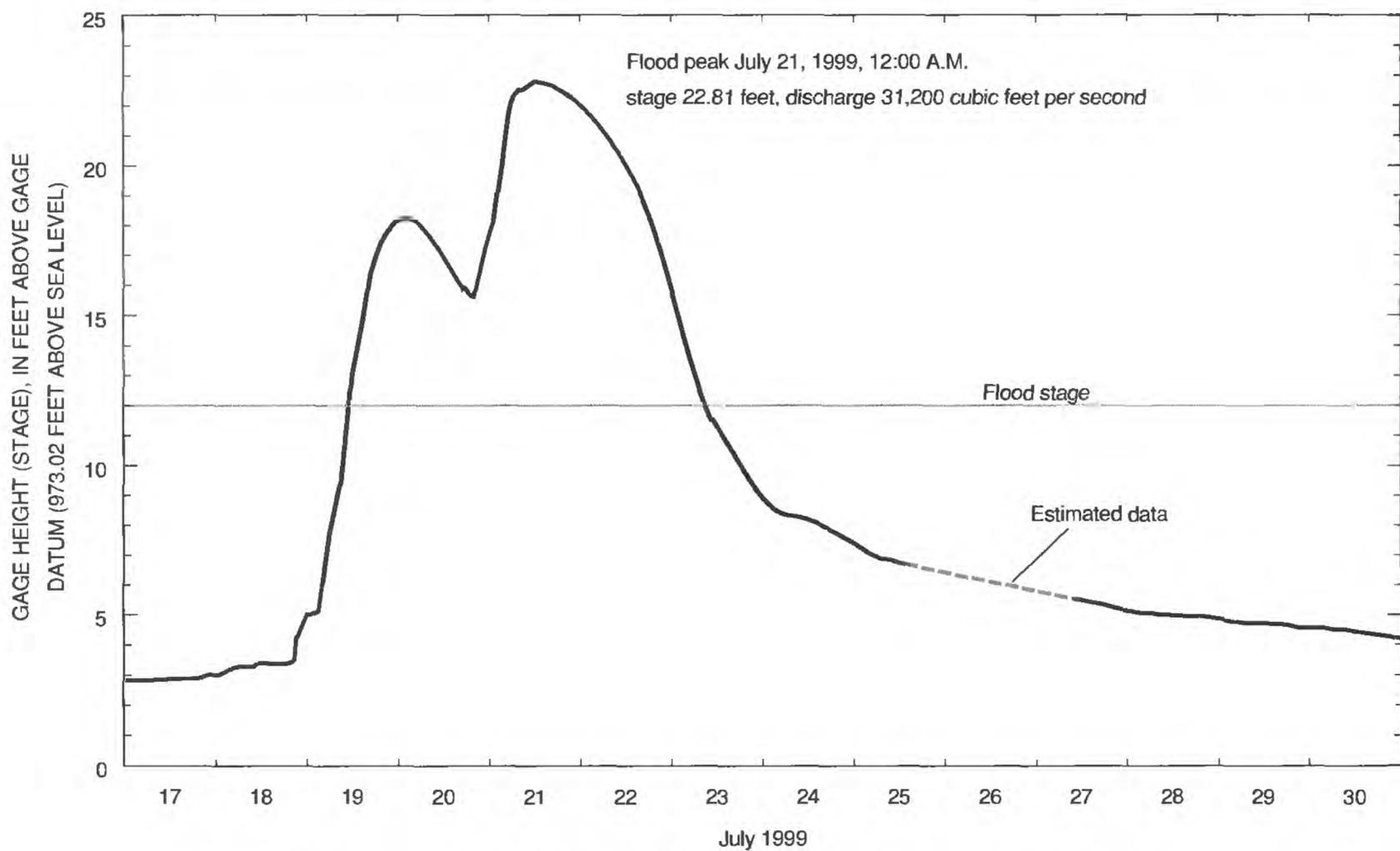


Figure 4. Stage hydrograph of the Cedar River at Charles City, Iowa, streamflow-gaging station (station number 05457700), July 17-30, 1999.

the May 1999 flood (Ballew and Fischer, 2000). The Cedar and Shell Rock River profiles include a profile of the 1961 flood (Schwob, 1963). The Flood Creek profile includes a profile of the 1963 flood (Schwob, 1963). Low-flow profiles also are shown for each river reach profiled. The HWM's from previous floods were not always measured at the same locations used for the July 1999 profiles. For locations where water-surface elevations were not measured for all years profiled, a note in the figure indicates which years were included in the profile.

The July 1999 flood on the Wapsipinicon River is profiled from State Highway 281 near Fairbank upstream to County Road B17 near Elma. The 53-mi river reach that was profiled is shown in figure 1 and figures 5-8; the locations of the nine stream sites where HWM's were measured are shown in figure 1 and their descriptions are listed in table 4 following the Wapsipinicon River profile. The three most downstream bridges crossing the Wapsipinicon River that were used to profile the July 1999 flood (figs. 6 and 7) were also the three most upstream bridge sites used to profile the May 1999 flood (Ballew and Fischer, 2000). In general, the July 1999 flood elevations exceeded both the June 1969 and May 1999 flood elevations throughout most of the profiled reach (figs. 6-8). For instance, the flood elevation measured for the July 1999 flood at the U.S. Highway 18 bridge crossing the Wapsipinicon River west of New Hampton is about 2.2 ft higher than the elevation measured at the same location for the 1969 flood (fig. 8) (Schwob, 1971).

The July 1999 flood on the Cedar River is profiled from Brandon Road near La Porte City upstream to State Highway 9 near Osage. The 110-mi river reach that was profiled is shown in figure 1 and figures 9-15; the locations of the 21 stream sites where HWM's were measured are shown in figure 1 and their descriptions are listed in table 5 following the Cedar River profile. In general, the Cedar River profile indicates that the July 1999 flood produced a new flood-elevation record and exceeded the elevation of the March 1961 flood by 0.8 to 3.2 ft from about Janesville upstream to about U.S. Highway 218 north of Floyd (figs. 12-14). For instance, in Waverly at the State Highway 3 bridge crossing the Cedar River, the elevation for the 1999 flood is about 1.9 ft higher than the elevation of the 1961 flood (fig. 12) (Schwob, 1963). Downstream from Cedar Falls (figs. 10 and 11) and upstream from Floyd (figs. 14 and 15), the profiled river reach elevations for the 1961 flood are still the highest on record. From the most downstream bridge

profiled on the Cedar River (Brandon Road at La Porte City), to Mullan Avenue in Waterloo, the July 1999 flood elevations are generally lower than the 1961 flood elevations by 0.4 to 2.7 ft (Schwob, 1963).

The July 1999 flood on the Shell Rock River is profiled from 265th Street near Waverly Junction upstream to State Highway 9 near Plymouth. The 72-mi river reach that was profiled is shown in figure 1 and figures 16-20; the locations of the 11 stream sites where HWM's were measured are shown in figure 1 and their descriptions are listed in table 6 following the Shell Rock River profile. The July 1999 flood profile for the Shell Rock River can be compared to the March 1961 flood profile from Waverly Junction to Nora Springs (figs. 17-20) (Schwob, 1963). In general, at the two most downstream sites included in the Shell Rock River profile, flood elevations for the 1999 flood exceeded those measured for the 1961 flood by 0.1 to 0.5 ft (fig. 17) (Schwob, 1963). However, upstream from Shell Rock from approximately Clarksville to Rockford, elevations measured for the 1961 flood are generally higher than those measured for the 1999 flood by 1.1 to 3.6 ft, with the exception of the County Road T47 bridge crossing the Shell Rock River south of Packard, where the 1999 flood elevation exceeded the 1961 flood elevation by about 1.5 ft (figs. 17-19). At Nora Springs, the elevation for the 1999 flood is approximately 3.5 ft higher than the elevation measured for the 1961 flood (fig. 20) (Schwob, 1963).

The July 1999 flood on Flood Creek is profiled from County Road C23 (140th Street) near Packard upstream to County Road S70 near Nora Springs. The 39-mi reach that was profiled is shown in figure 1 and figures 21-24; the locations of the six stream sites where HWM's were measured are shown in figure 1 and their descriptions are listed in table 7 following the Flood Creek profile. The July 1999 flood profile for Flood Creek can be compared to the May 1963 flood profile from southeast of Packard to east of Rockford (figs. 22 and 23) (Schwob, 1963). In general, elevations measured for the 1999 flood were higher than those measured for the 1963 flood throughout the river reach by 4.6 to 6.7 ft. For instance, the flood elevation measured for the July 1999 flood at the County Road C23 bridge crossing Flood Creek southeast of Packard is about 6.1 ft higher than the elevation measured for the 1963 flood (fig. 22).

SUMMARY

Severe flooding occurred during July 19-25, 1999, in the Wapsipinicon and Cedar River Basins following two intense thunderstorms over northeast Iowa. As much as 6 inches of rainfall was centered over Cerro Gordo, Floyd, Mitchell, and Worth Counties during July 18-19. This storm was followed by rainfall up to 8 inches that was centered over Chickasaw and Floyd Counties during July 20-21. The cumulative effect of the two storms produced floods with new maximum peak stages and discharges on the Wapsipinicon River near Tripoli, the Cedar River at Charles City and Janesville, and Flood Creek near Powersville. Peak discharges of 31,200 ft³/s on the Cedar River at Charles City and 42,200 ft³/s on the Cedar River at Janesville represent recurrence intervals of about 90 and 80 years, respectively. The peak discharge on the Wapsipinicon River near Tripoli is 19,400 ft³/s and on Flood Creek near Powersville is estimated to be 19,000 ft³/s.

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APPENDIX: TEMPORARY BENCH MARKS AND REFERENCE POINTS IN THE WAPSIPINICON AND CEDAR RIVER BASINS

To facilitate measuring and referencing the HWM's used in the flood profiles to a common datum, temporary bench marks (TBM's) and reference points (RP's) were established by the USGS at many of the bridges along the profiled river reaches. All TBM and RP elevations listed in this tabulation are referenced to sea level. TBM's and RP's are listed only for those bridges used in the July 19-25, 1999, flood profiles. The TBM's and RP's were established in the Wapsipinicon and Cedar River Basins during 1958-67 and 1999-2000, with the exception of reference marks (RM's) and RP's established at USGS streamflow-gaging stations, which are identified in this tabulation with an RM or RP number. TBM and RP elevations were determined from differential leveling, with the exception of 17 bridges, where elevations were

determined from post-processed differential positioning using the global positioning system (GPS). Elevations determined using GPS are noted in the TBM and RP descriptions. Level lines or GPS networks used to establish the third-order accuracy of the TBM's and RP's shown herein were surveyed or configured from bench marks established and adjusted by the National Mapping Division of the USGS and National Geodetic Survey. GPS networks were also supplemented with GPS-control sites established by Black Hawk and Butler Counties. Errors of closure in the USGS level work were adjusted along level lines to balance TBM and RP elevations. Specific GPS-network and satellite-constellation configurations, equivalent hours of data collection with multiple GPS receivers, and post-processing quality controls were used to control the effects of error in GPS-derived elevations. TBM's and RP's established by other agencies are noted in the descriptions where they occur.

The TBM's and RP's are designated by an index number or legal description derived from their respective locations using Public Land Survey System coordinates (township, range, section). Within the section, the quarter section in which the TBM or RP is located is designated by NW, NE, SW, or SE. For example, 9011-04 SE refers to a location in Township 90 North, Range 11 West, southeast quarter of section 4. A number in parentheses following the quarter-section designation indicates the number of the TBM or RP in that particular quarter section. The index number describes the legal description of the mark without further reference in the body of the description. The physical location of the bench mark on a bridge dictates the appropriate legal description. REFERENCE POINTS are listed with the related bench marks and are identified by the same legal description, though at times they are in a different section, range, or township as determined by upstream or downstream location.

Standard marks, such as squares, crosses, marks, or arrows, were chiseled or filed on concrete or metal, or existing bolts on bridges were used as TBM's or RP's. Existing TBM's or RP's were used whenever available, and the agency responsible for the mark, when known, is indicated in the description. RP's are distinguished from TBM's by the notation "(REFERENCE POINT)" following the legal description. RPs were established to permit water-surface elevations to be determined by use of a tape and weight. The terms "right" and "left" in the descriptions

are determined as viewed while facing in the downstream direction.

The TBM's and RP's are listed in the downstream to upstream order with respect to their correspondence to bridges over the Wapsipinicon, Cedar, and Shell Rock Rivers and Flood Creek. The user of this information is cautioned that TBM's and RP's listed herein might have been disturbed, destroyed, or moved since elevations were established. It is the responsibility of the user to determine the condition and suitability of the TBM or RP.

Wapsipinicon River

9011-04 SE (1) - Approximately 5 mi west of Fairbank, on State Highway 281 bridge over Wapsipinicon River, on left downstream wingwall curb; chiseled square. Elevation determined using GPS.

Elevation 958.09 ft

9011-04 SE (2) - (REFERENCE POINT) Approximately 5 mi west of Fairbank, on State Highway 281 bridge over Wapsipinicon River, on top of left downstream concrete guardrail and 15 ft right of the third drain; chiseled arrow. Elevation determined using GPS.

Elevation 961.28 ft

9111-08 NW (1) - Approximately 3 mi northeast of Readlyn, on State Highway 3 bridge over Wapsipinicon River, on left downstream wingwall; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 978.22 ft

9111-08 NW (2) - (REFERENCE POINT) Approximately 3 mi northeast of Readlyn, on State Highway 3 bridge over Wapsipinicon River, on top of 30th guardrail post from left downstream end of bridge; three filed marks. Elevation determined using GPS.

Elevation 978.98 ft

9312-27 SW (1) - Approximately 2 mi north of Tripoli, on State Highway 93 bridge over Wapsipinicon River, on left downstream corner of abutment; Iowa Department of Transportation bench mark. Elevation determined using GPS. (RM 2)

Elevation 1,016.23 ft

9312-27 SW (2) - Approximately 2 mi north of Tripoli, on State Highway 93 bridge over Wapsipinicon River, on left upstream abutment; chiseled square. Elevation determined using GPS. (RM 4)

Elevation 1,018.62 ft

9312-18 NW (1) - At Frederika, on County Road C16 bridge over Wapsipinicon River, on left downstream wingwall; chiseled square.

Elevation 1,026.89 ft

9312-18 NW (2) - (REFERENCE POINT) At Frederika, on County Road C16 bridge over Wapsipinicon River, on top of 18th handrail post (streetside) from right downstream end of bridge; chiseled square.

Elevation 1,027.45 ft

9312-07 SW (1) - At Frederika, at dam in city park, on left abutment 9 ft upstream from sloping wingwall on streamward edge of abutment; chiseled square.

Elevation 1,019.87 ft

9413-36 SW (1) - Approximately 2 mi northwest of Frederika, on U.S. Highway 63 bridge over Wapsipinicon River, on left upstream concrete wall; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 1,037.01 ft

9413-36 SW (2) - (REFERENCE POINT) Approximately 2 mi northwest of Frederika, on U.S. Highway 63 bridge over Wapsipinicon River, on top of concrete guardrail and between fifth and sixth drain from right downstream end of bridge; two chiseled marks. Elevation determined using GPS.

Elevation 1,038.04 ft

9413-10 SE (1) - Approximately 2 mi west of Williamstown, on State Highway 346 bridge over Wapsipinicon River, on left upstream bridge abutment; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 1,053.39 ft

9413-10 SE (2) - (REFERENCE POINT) Approximately 2 mi west of Williamstown, on State Highway 346 bridge over Wapsipinicon River, on top of concrete bridge rail and between third and fourth drain from right downstream end of bridge; two chiseled marks. Elevation determined using GPS.

Elevation 1,054.36 ft

9514-01 SW (1) Approximately 7 mi west of New Hampton, on U.S. Highway 18 bridge over Wapsipinicon River, on right upstream concrete wall; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 1,093.80 ft

9514-01 SW (2) - (REFERENCE POINT) Approximately 7 mi west of New Hampton, on U.S. Highway 18 bridge over Wapsipinicon River, on top of concrete guardrail and right of fourth drain from right downstream end of

bridge; two chiseled marks. Elevation determined using GPS.

Elevation 1,094.62 ft

9614-09 NW (1) - Approximately 4.5 mi east of Colwell, on County Road B28 bridge over Wapsipinicon River, on right downstream bridge abutment; chiseled square. Elevation determined using GPS.

Elevation 1,125.46 ft

9614-09 NW (2) - (REFERENCE POINT) Approximately 4.5 mi east of Colwell, on County Road B28 bridge over Wapsipinicon River, on top of concrete guardrail at 10th post from right downstream end of bridge; two chiseled marks. Elevation determined using GPS.

Elevation 1,125.29 ft

9714-08 NW (1) - Approximately 5 mi west of Elma, on County Road B17 bridge over Wapsipinicon River, on right downstream end of guardrail post; top of bolt next to lettering "RM" painted red.

Elevation 1,152.90 ft

9714-08 NW (2) - (REFERENCE POINT) Approximately 5 mi west of Elma, on County Road B17 bridge over Wapsipinicon River, on top of metal railing and between fourth and fifth drain from right downstream end of bridge; filed arrow.

Elevation 1,154.27 ft

Cedar River

8711-19 NE (1) - Approximately 1.5 mi northeast of La Porte City, on Brandon Road bridge over Cedar River, on left downstream curb; National Geodetic Survey (U.S. Coast and Geodetic Survey) brass cap.

Elevation 816.05 ft

8711-19 NE (2) - (REFERENCE POINT) Approximately 1.5 mi northeast of La Porte City, on Brandon Road bridge over Cedar River, on guardrail and right of 10th guardrail post from left downstream end of bridge; filed arrow.

Elevation 818.10 ft

8812-23 SW (1) - At Gilbertville, on County Road D38 bridge over Cedar River, on left upstream curb; USGS brass cap.

Elevation 841.42 ft

8812-23 SW (2) - (REFERENCE POINT) At Gilbertville, on County Road D38 bridge over Cedar River, on top of handrail at 20th handrail post from left downstream end of bridge; three filed marks. (RM 1)

Elevation 841.32 ft

8913-25 NW (1) - At Waterloo, on left bank of Cedar River near East Seventh Street bridge and about 30 ft upstream from gage house, on upstream landward corner of concrete foundation for pumping; USGS bronze bench mark. (RM 1)

Elevation 846.96 ft

8913-26 NE (1) - At Waterloo, on Park Avenue bridge over Cedar River, on curb at left upstream end of bridge, top of most upstream and landward bolt; chiseled cross. Elevation determined using GPS.

Elevation 853.02 ft

8913-26 NE (2) - (REFERENCE POINT) At Waterloo, on Park Avenue bridge over Cedar River, on top of guardrail and right of fifth guardrail post from left downstream end of bridge; filed arrow. Elevation determined using GPS.

Elevation 857.09 ft

8913-23 SE (1) - At Waterloo, on Mullan Avenue bridge over Cedar River, on right downstream wingwall abutment behind concrete guardrail; chiseled cross. Elevation surveyed from City of Waterloo bench mark.

Elevation 856.80 ft

8913-23 SE (2) - (REFERENCE POINT) At Waterloo, on Mullan Avenue bridge over Cedar River, on ledge behind concrete guardrail and between 15th and 16th metal guardrail posts from right downstream end of bridge; two chiseled marks.

Elevation 861.33 ft

8913-16 SE (1) - At Waterloo, on U.S. Highway 218 bridge over Cedar River, on top of right downstream end of concrete barrier wall; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 868.73 ft

8913-16 SE (2) - (REFERENCE POINT) At Waterloo, on U.S. Highway 218 bridge over Cedar River, on concrete guardrail and above fifth drain from right downstream end of bridge; two chiseled marks. Elevation determined using GPS.

Elevation 869.00 ft

8913-18 NW (1) - At Cedar Falls, on State Highway 58 bridge over Cedar River, on left downstream concrete abutment wall; Iowa Department of Transportation bench mark. Elevation supplied by City of Cedar Falls, Land Survey Office.

Elevation 879.50 ft

8913-18 NW (2) - At Cedar Falls, on State Highway 58 bridge over Cedar River, on left upstream concrete abutment; chiseled cross.

Elevation 873.44 ft

8913-18 NW (3) - (REFERENCE POINT) At Cedar Falls, on State Highway 58 bridge over Cedar River, on top of concrete guardrail and at center of bridge at 41st drain from right downstream end of bridge; two chiseled marks.

Elevation 887.48 ft

8914-12 NE (1) - At Cedar Falls, on State Highway 57 bridge over Cedar River, on right downstream wingwall abutment; Iowa Department of Transportation bench mark. Elevation supplied by City of Cedar Falls, Land Survey Office.

Elevation 866.92 ft

8914-12 NE (2) - At Cedar Falls, on State Highway 57 bridge over Cedar River, on left downstream wingwall abutment; chiseled square.

Elevation 870.77 ft

8914-12 NE (3) - (REFERENCE POINT) At Cedar Falls, on State Highway 57 bridge over Cedar River, on guardrail at 45th guardrail post from right downstream end of bridge; three filed marks.

Elevation 872.87 ft

8914-12 NW (1) - At Cedar Falls, on Center Street bridge over Cedar River, on right downstream end of sidewalk concrete barrier wall; Iowa Department of Transportation bench mark. Elevation supplied by City of Cedar Falls, Land Survey Office.

Elevation 873.69 ft

8914-12 NW (2) At Cedar Falls, on Center Street bridge over Cedar River, on left downstream end of sidewalk concrete barrier wall; Iowa Department of Transportation bench mark. Elevation supplied by City of Cedar Falls, Land Survey Office.

Elevation 874.47 ft

8914-12 NW (3) - (REFERENCE POINT) At Cedar Falls, on Center Street bridge over Cedar River, on concrete guardrail and below 43d metal post from left downstream end of bridge; two chiseled marks.

Elevation 876.93 ft

9114-35 SW (1) - At Janesville, on left bank of Cedar River and 300 ft downstream from County Road C50 (275th Street) bridge, set in concrete just above ground surface and 3 ft northeast of gage house; USGS bench mark. (RM 16)

Elevation 877.95 ft

9114-35 NW (1) - Approximately 0.50 mi north of Janesville, on northbound lane of U.S. Highway 218 bridge over Cedar River (upstream bridge), on right downstream end of concrete barrier wall; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.
Elevation 904.700 ft

9114-35 NW (2) - Approximately 0.50 mi north of Janesville, on southbound lane of U.S. Highway 218 bridge over Cedar River (downstream bridge), on left upstream end of concrete barrier wall; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.
Elevation 911.140 ft

9114-35 NW (3) - (REFERENCE POINT) Approximately 0.50 mi north of Janesville, on southbound lane of U.S. Highway 218 bridge over Cedar River (downstream bridge), on top of concrete guardrail and about 85 ft from right downstream end of bridge; two chiseled marks.
Elevation 907.31 ft

9114-02 NW (1) - At Waverly, on State Highway 3 bridge over Cedar River, on right downstream handrail and north of lamp post; chiseled cross.
Elevation 920.27 ft

9114-02 NW (2) - At Waverly, on State Highway 3 bridge over Cedar River, about 30 ft upstream from right upstream end of bridge, on top of streamward corner of concrete retaining wall; chiseled square.
Elevation 914.69 ft

9114-02 NW (3) - (REFERENCE POINT) At Waverly, on State Highway 3 bridge over Cedar River, on top of handrail and left of 15th post from left downstream end of bridge; filed arrow.
Elevation 921.19 ft

9214-21 NW (1) - Approximately 3.5 mi north of Waverly, on County Road C33 bridge over Cedar River, on right downstream curb near wingwall; chiseled square enclosing Iowa Department of Transportation bench mark. Elevation obtained from Bremer County Flood Insurance Study (Federal Emergency Management Agency, 1990).
Elevation 931.77 ft

9214-21 NW (2) - (REFERENCE POINT) Approximately 3.5 mi north of Waverly, on County Road C33 bridge over Cedar River, on top of guardrail post at second drain from right downstream end of bridge; three filed marks.
Elevation 934.50 ft

9314-29 NE (1) - Approximately 0.5 mi east of Plainfield, on State Highway 188 bridge over Cedar River, on left upstream wingwall; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.
Elevation 946.59 ft

9314-29 NE (2) - Approximately 0.5 mi east of Plainfield, on State Highway 188 bridge over Cedar River, on right upstream wingwall; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.
Elevation 947.22 ft

9314-29 NE (3) - (REFERENCE POINT) Approximately 0.5 mi east of Plainfield, on State Highway 188 bridge over Cedar River, on concrete curb at third drain from right downstream end of bridge; two chiseled marks.
Elevation 945.63 ft

9414-18 SE (1) - At Nashua, on State Highway 346 bridge over Cedar River, on right upstream wingwall; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.
Elevation 973.28 ft

9414-18 SE (2) - (REFERENCE POINT) At Nashua, on State Highway 346 bridge over Cedar River, on top of concrete guardrail at third drain from right upstream end of bridge; two chiseled marks.
Elevation 975.48 ft

9515-34 NE (1) - Approximately 4 mi northwest of Nashua, on County Road B59 (240th Street) bridge over Cedar River, on left downstream concrete guardrail; Iowa Department of Transportation bench mark. Elevation supplied by Floyd County Engineer's Office.
Elevation 985.48 ft

9515-34 NE (2) - (REFERENCE POINT) Approximately 4 mi northwest of Nashua, on County Road B59 (240th Street) bridge over Cedar River, on top of concrete guardrail at fourth drain from left downstream end of bridge; two chiseled marks.
Elevation 986.40 ft

9516-12 NE (1) - At Charles City, on right bank of Cedar River and 800 ft downstream from U.S. Highway 18 bridge, 25 ft landward of gage house, and on landward downstream corner of concrete pedestal to walkway; USGS bronze bench mark. (RM 5)
Elevation 993.28 ft

9516-12 NE (2) - At Charles City, near Main Street bridge over Cedar River, on top of bolt head on streamward and upstream side of fire hydrant located on southeast corner of Main and Court Streets; chiseled cross. Elevation determined using GPS.

Elevation 1,003.52 ft

9516-12 NE (3) - (REFERENCE POINT) At Charles City, on Main Street bridge over Cedar River, on concrete sidewalk and below seventh handrail post from right downstream end of bridge; two chiseled marks. Elevation determined using GPS.

Elevation 1,002.32 ft

9616-16 SE (1) - Approximately 0.25 mi north of Floyd, on U.S. Highway 218 bridge over Cedar River, on right upstream wingwall guardrail; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 1,031.74 ft

9616-16 SE (2) - (REFERENCE POINT) Approximately 0.25 mi north of Floyd, on U.S. Highway 218 bridge over Cedar River, on top of concrete guardrail at second drain from right downstream end of bridge; two chiseled marks. Elevation determined using GPS.

Elevation 1,030.65 ft

9717-24 NE (1) - Approximately 1.5 mi southwest of Orchard, on 105th Street bridge over Cedar River, on top of right downstream concrete guardrail; chiseled square.

Elevation 1,047.99 ft

9717-24 NE (2) - (REFERENCE POINT) Approximately 1.5 mi southwest of Orchard, on 105th Street bridge over Cedar River, on handrail post above left concrete pier and between second and third drains from left downstream end of bridge; chiseled square.

Elevation 1,045.63 ft

9817-28 NE (1) - Approximately 1.5 mi west of Osage, on State Highway 9 bridge over Cedar River, on right downstream end of concrete guardrail; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.

Elevation 1,092.20 ft

9817-28 NE (2) - Approximately 1.5 mi west of Osage, on State Highway 9 bridge over Cedar River, on left downstream end of concrete guardrail; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.

Elevation 1,097.15 ft

9817-28 NE (3) - (REFERENCE POINT) Approximately 1.5 mi west of Osage, on State Highway 9 bridge over Cedar River, on top of guardrail and above third drain from right downstream end of bridge; two chiseled marks.

Elevation 1,095.12 ft

Shell Rock River

9114-28 NW (1) - Approximately 0.25 mi east of Waverly Junction, on 265th Street bridge over Shell Rock River, on right upstream concrete wingwall; top of bolt. Elevation obtained from Bremer County Engineer's Office.

Elevation 896.67 ft

9114-28 NW (2) - (REFERENCE POINT) Approximately 0.25 mi east of Waverly Junction, on 265th Street bridge over Shell Rock River, on top of concrete guardrail and between 20th and 21st guardrail supports from left upstream end of bridge; chiseled square.

Elevation 900.36 ft

9115-11 NE (1) - At Shell Rock, on right bank of Shell Rock River and 400 ft upstream from County Road C45 bridge, on downstream end of concrete footing for walkway of gage house; USGS bronze bench mark. (RM 2)

Elevation 902.54 ft

9215-19 SW (1) - Approximately 0.50 mi south of Clarksville, on State Highway 188 bridge over Shell Rock River, on right upstream end of abutment; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.

Elevation 934.74 ft

9215-19 SW (2) - Approximately 0.50 mi south of Clarksville, on State Highway 188 bridge over Shell Rock River, on left upstream end of abutment; Iowa Department of Transportation bench mark. Elevation supplied by Iowa Department of Transportation.

Elevation 935.86 ft

9215-19 SW (3) - (REFERENCE POINT) Approximately 0.50 mi south of Clarksville, on State Highway 188 bridge over Shell Rock River, on top of concrete guardrail at first drain from right upstream end of bridge; chiseled square.

Elevation 935.69 ft

9317-01 SW (1) - At Greene, on Traer Street bridge over Shell Rock River, on left downstream abutment; chiseled square. Elevation supplied by Butler County Engineer's Office.

Elevation 962.33 ft

9317-01 SW (2) - (REFERENCE POINT) At Greene, on Traer Street bridge over Shell Rock River, on handrail bolt at 22d post from left downstream end of bridge; three filed marks.

Elevation 962.80 ft

9417-08 SE (1) - At Marble Rock, 200 ft upstream from left upstream end of County Road B60 bridge over Shell Rock River, on upstream side of abandoned power plant, in foundation and 3 inches from north side of building; USGS bronze bench mark.

Elevation 970.91 ft

9518-11 SW (1) - At Rockford, on Main Avenue bridge over Shell Rock River, on right upstream end post of handrail; chiseled square. Elevation determined using GPS.

Elevation 1,004.79 ft

9618-07 SE (1) - At Nora Springs, on First Street bridge over Shell Rock River, on handrail near right downstream end of bridge; chiseled cross.

Elevation 1,054.47 ft

9618-07 SE (2) - (REFERENCE POINT) At Nora Springs, on First Street bridge over Shell Rock River, on handrail and approximately 30 ft right of second light structure from left downstream end of bridge; chiseled square.

Elevation 1,055.66 ft

9719-21 NE (1) - At Rock Falls, on County Road B20 bridge over Shell Rock River, on left upstream wingwall; USGS bronze bench mark.

Elevation 1,102.541 ft

9819-30 NE (1) - Approximately 2.5 mi north of Plymouth, on State Highway 9 bridge over Shell Rock River, on right downstream wingwall; chiseled cross. Elevation determined using GPS.

Elevation 1,137.30 ft

9819-30 NE (2) - (REFERENCE POINT) 2 mi north of Plymouth, on State Highway 9 bridge over Shell Rock River, on guardrail and left of seventh post from right downstream end of bridge; chiseled square. Elevation determined using GPS.

Elevation 1,134.99 ft

Flood Creek

9416-34 SE (1) - Approximately 4 mi east of Greene, on left bank of Flood Creek and 20 ft downstream from Floyd Line Road bridge, near northwest corner of gage house; USGS brass bench mark. Elevation determined using GPS. (RM 1)

Elevation 964.63 ft

9416-34 SE (2) - Approximately 4 mi east of Greene, on Floyd Line Road bridge over Flood Creek, on left downstream wingwall; chiseled square. Elevation determined using GPS. (RM 2)

Elevation 968.09 ft

9416-34 SE (3) - (REFERENCE POINT) Approximately 4 mi east of Greene, on Floyd Line Road bridge over Flood Creek, on guardrail and between seventh and eighth supports from left downstream end of bridge; two chiseled marks. Elevation determined using GPS. (RP 1)

Elevation 970.31 ft

9517-36 SW (1) - Approximately 3.5 mi northeast of Marble Rock, on State Highway 14 bridge over Flood Creek, on right downstream concrete abutment; chiseled square.

Elevation 1,023.29 ft

9517-36 SW (2) - (REFERENCE POINT) Approximately 3.5 mi northeast of Marble Rock, on State Highway 14 bridge over Flood Creek, on top of metal guardrail at sixth post from left downstream end of bridge; chiseled arrow.

Elevation 1,024.68 ft

9517-15 NW (1) - Approximately 5 mi east of Rockford, on State Highway 147 bridge over Flood Creek, on right downstream wingwall; chiseled square. Elevation determined using GPS.

Elevation 1,053.78 ft

9517-15 NW (2) - (REFERENCE POINT) Approximately 5 mi east of Rockford, on State Highway 147 bridge over Flood Creek, on guardrail at the fifth post from left downstream end of bridge; filed arrow. Elevation determined using GPS.

Elevation 1,053.61 ft

9618-14 NW (1) - Approximately 2 mi northwest of Rudd, on State Highway 122 (old U.S. Highway 18) bridge over Flood Creek, on left downstream wingwall; Iowa Department of Transportation bench mark. Elevation determined using GPS.

Elevation 1,105.48 ft

9618-14 NW (2) - (REFERENCE POINT) Approximately 2 mi northwest of Rudd, on State Highway 122 (old U.S. Highway 18) bridge over Flood Creek, on concrete guardrail at 11th post from left downstream end of bridge; two chiseled marks. Elevation determined using GPS.

Elevation 1,105.20 ft

9718-29 NW (1) - Approximately 3 mi north of Nora Springs, on County Road S70 bridge over Flood Creek, on right downstream abutment; chiseled square. Elevation determined using GPS.

Elevation 1,147.68 ft

9718-29 NW (2) - (REFERENCE POINT) Approximately 3 mi north of Nora Springs, on County Road S70 bridge over Flood Creek, on concrete guardrail and between the third and fourth posts from left downstream end of bridge; chiseled square. Elevation determined using GPS.

Elevation 1,147.36 ft

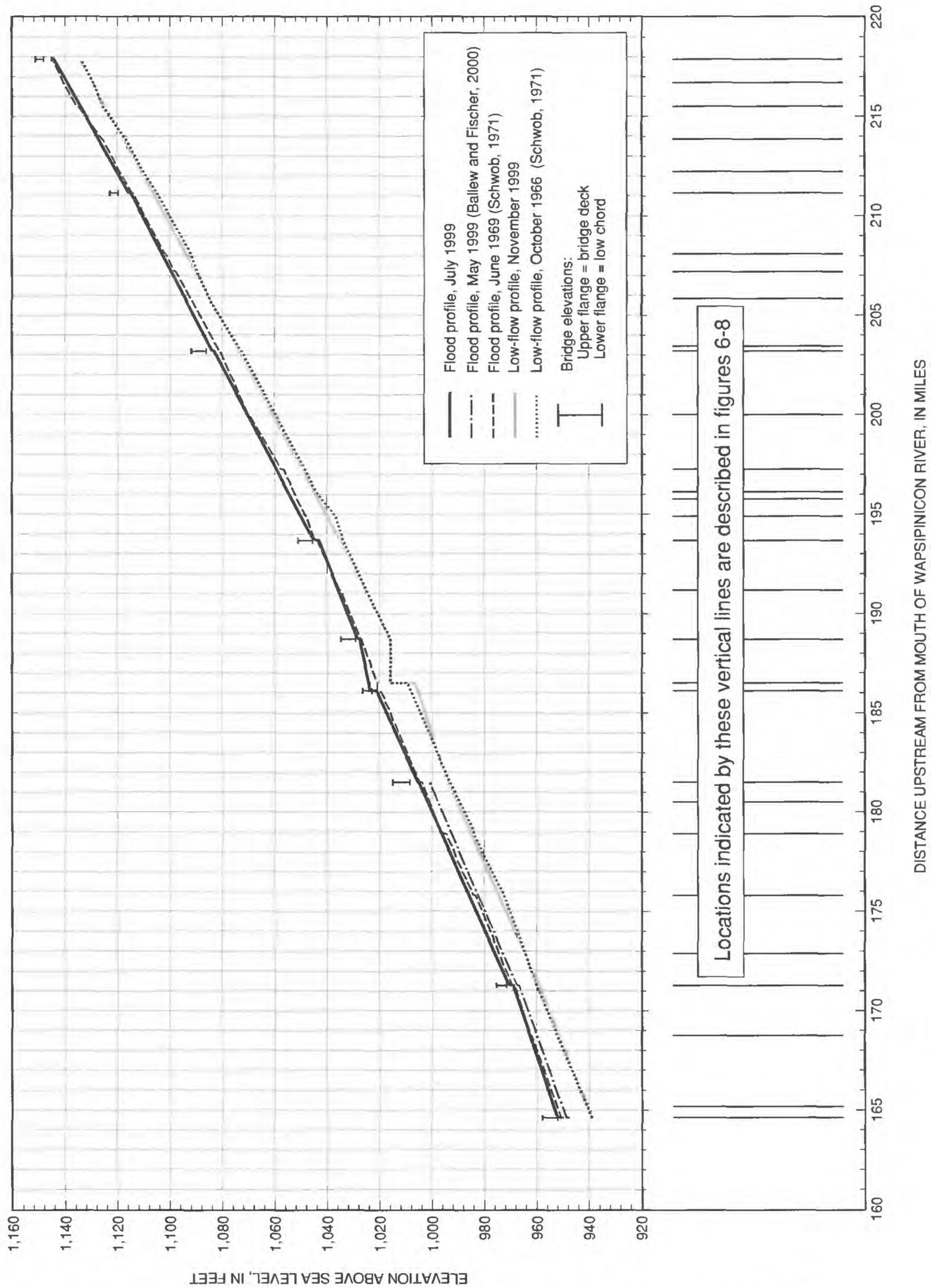


Figure 5. Profile of the July 1999 flood for the Wapsipinicon River, Iowa; river miles 164 to 218.

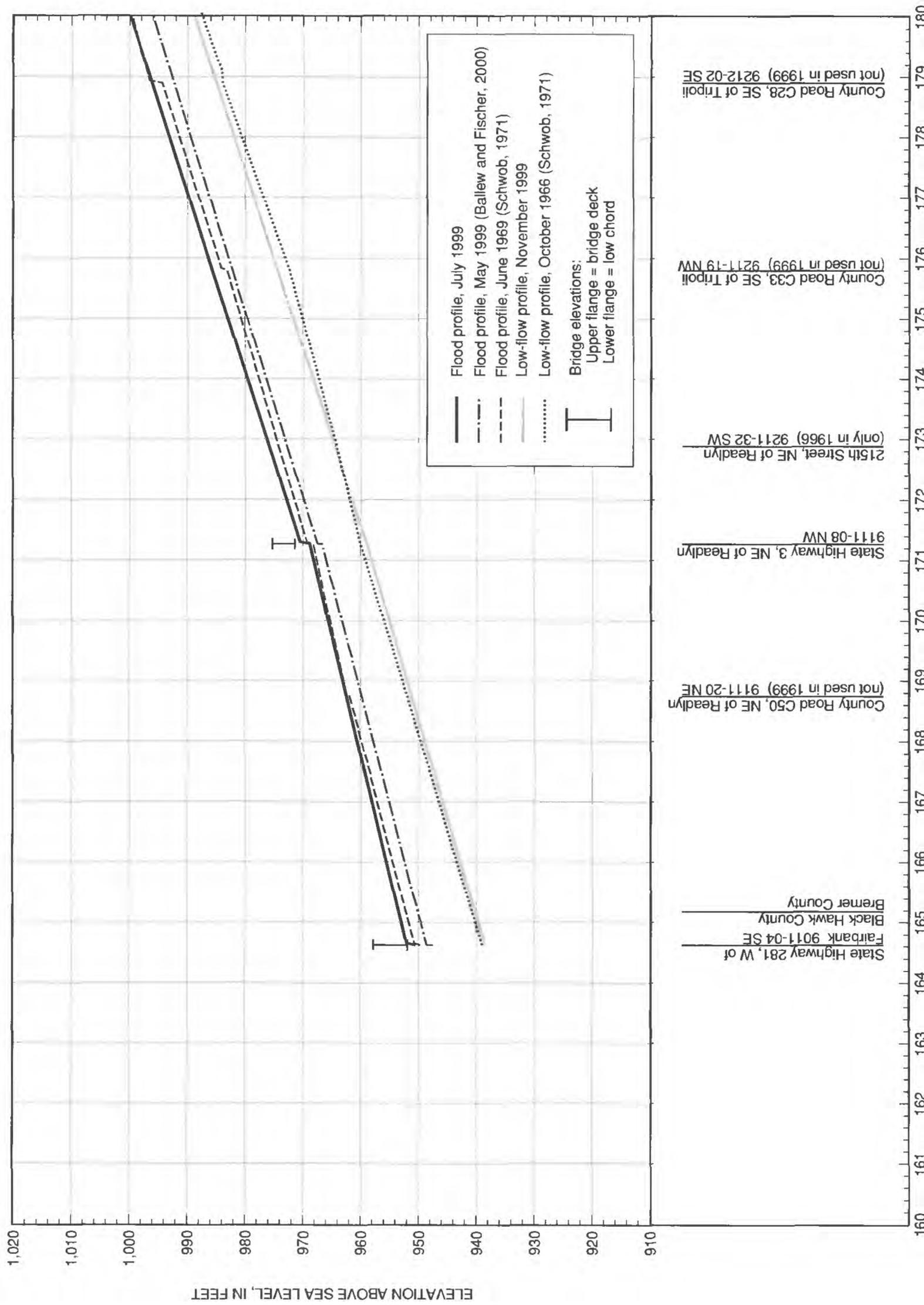
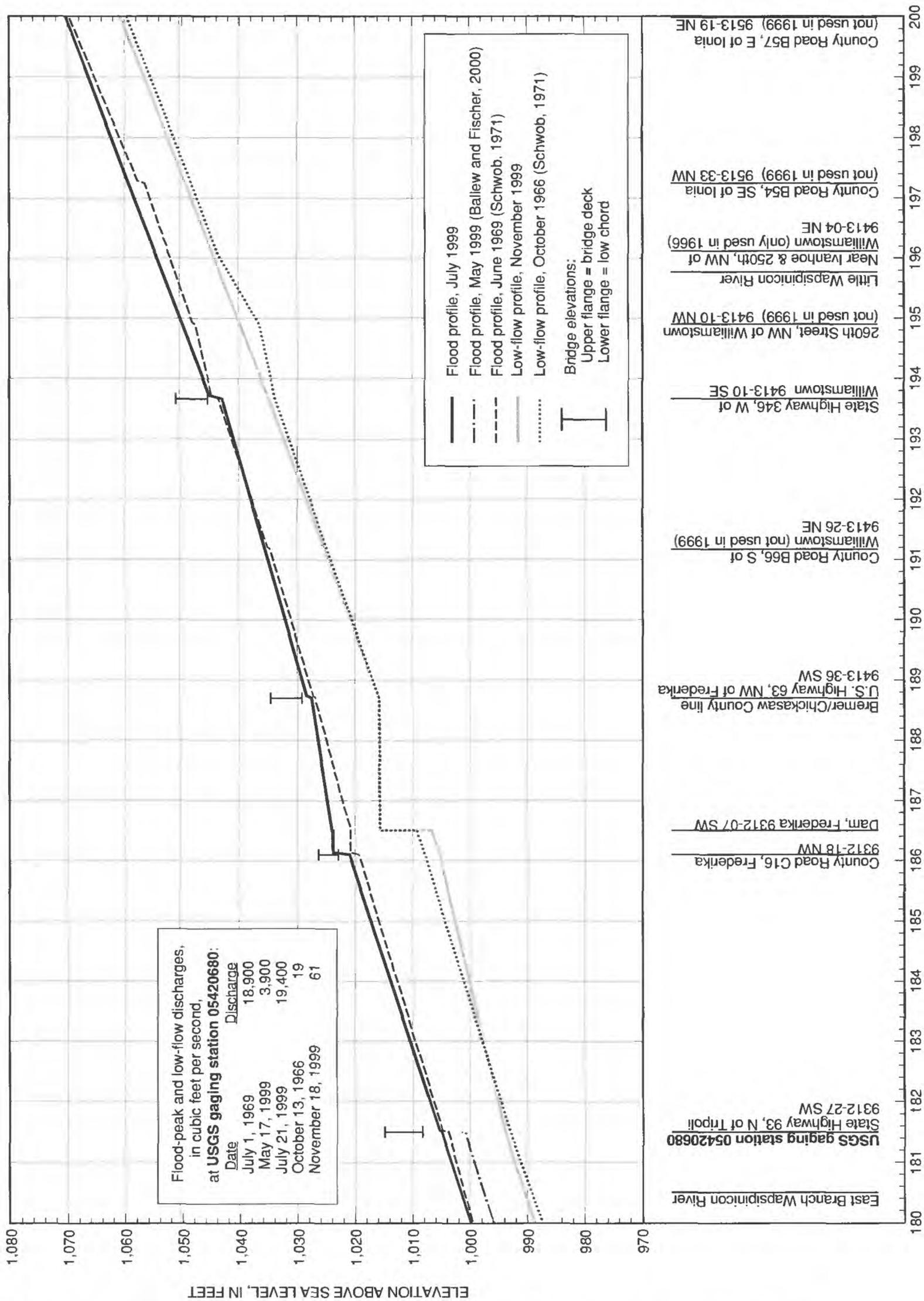


Figure 6. Profile of the July 1999 flood for the Wapsipicon River, lowa; river miles 164 to 180.



DISTANCE UPSTREAM FROM MOUTH OF WAPSIPINICON RIVER, IN MILES

Figure 7. Profile of the July 1999 flood for the Wapsipinicon River, Iowa; river miles 180 to 200.

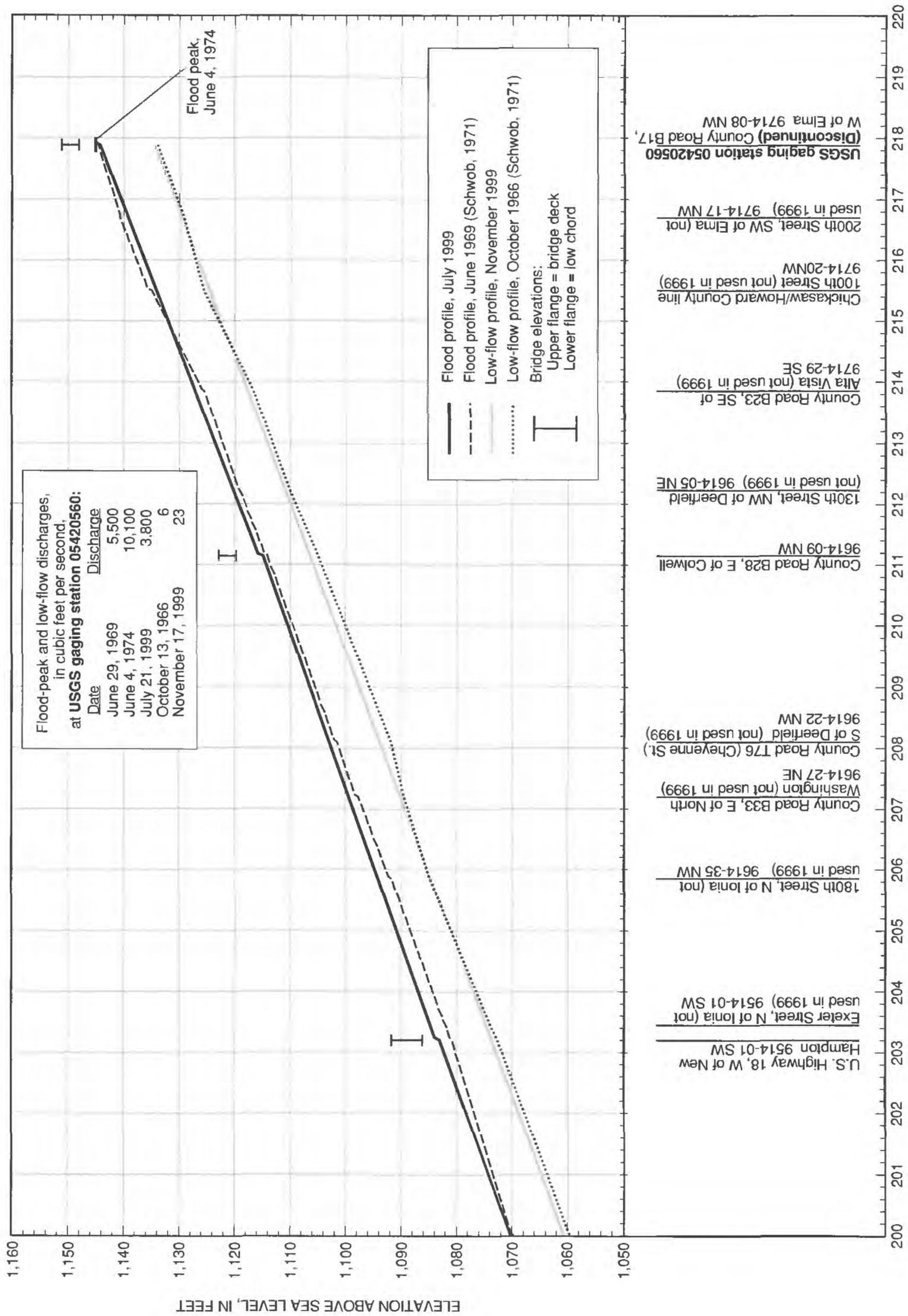


Figure 8. Profile of the July 1999 flood for the Wapsipicon River, Iowa; river miles 200 to 218.

Table 4. Elevations of high-water marks used in the flood profile of July 1999 for the Wapsipinicon River, Iowa
 [HWM, high-water mark; USGS, U.S. Geological Survey]

Distance upstream from mouth of Wapsipinicon River (river miles)	Bridge-site and streamflow-gaging station description	Downstream HWM (feet above sea level)	Upstream HWM (feet above sea level)
164.62	State Highway 281, W of Fairbank	950.54	952.09
171.27	State Highway 3, NE of Readlyn	968.84	970.50
181.50	USGS gaging station 05420680, State Highway 93, N of Tripoli	1,004.92	1,005.40
186.10	County Road C16, Frederika	1,020.97	1,023.83
188.70	U.S. Highway 63, NW of Frederika	1,027.55	1,028.40
193.67	State Highway 346, W of Williamstown	1,043.06	1,045.31
203.2	U.S. Highway 18, W of New Hampton	1,083.01	1,083.95
211.15	County Road B28, E of Colwell	1,114.90	1,115.80
217.88	Discontinued USGS gaging station 05420560, County Road B17, W of Elma	1,144.20	1,145.02

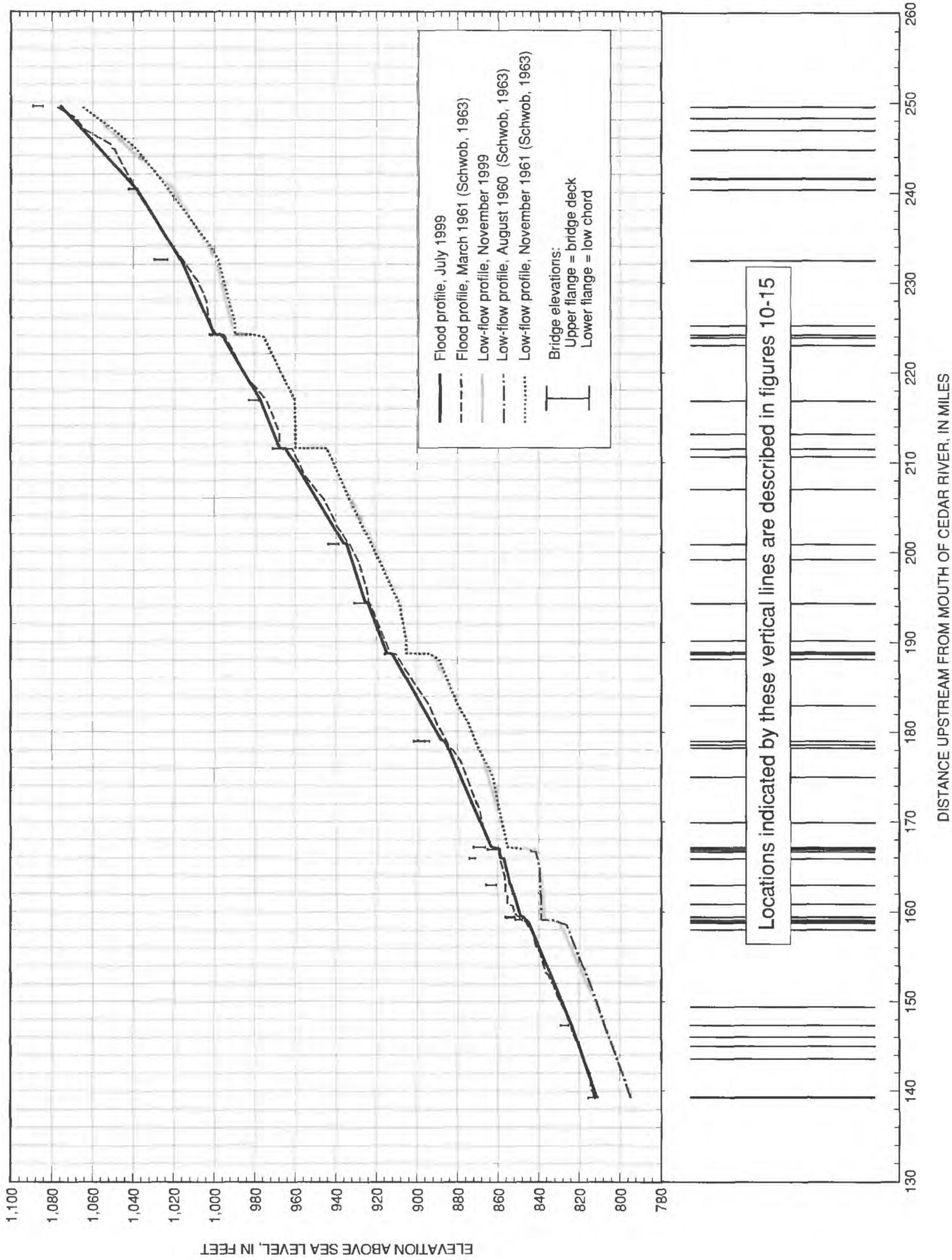


Figure 9. Profile of the July 1999 flood for the Cedar River, lowa; river miles 139 to 250.

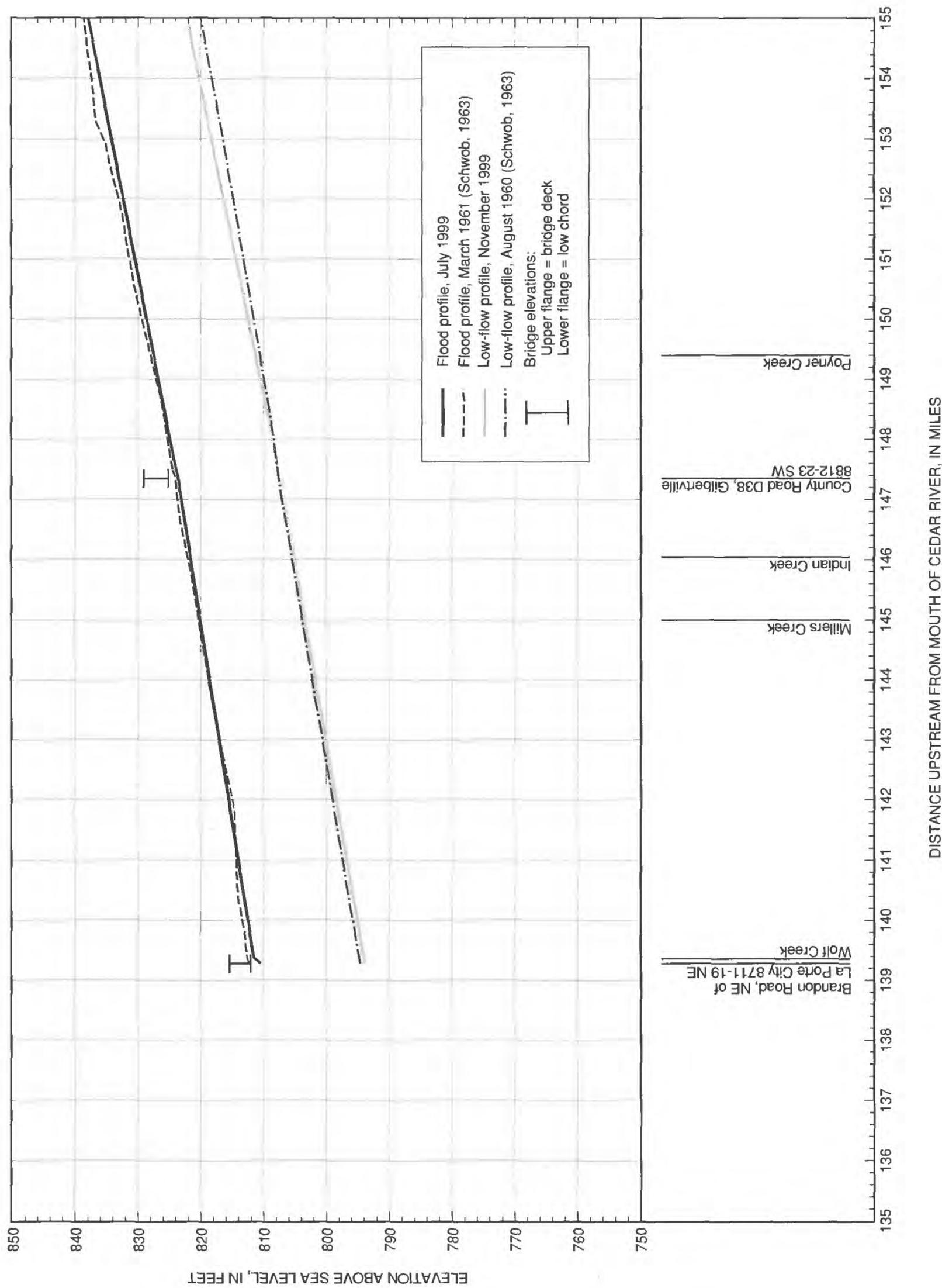


Figure 10. Profile of the July 1999 flood for the Cedar River, Iowa; river miles 139 to 155.

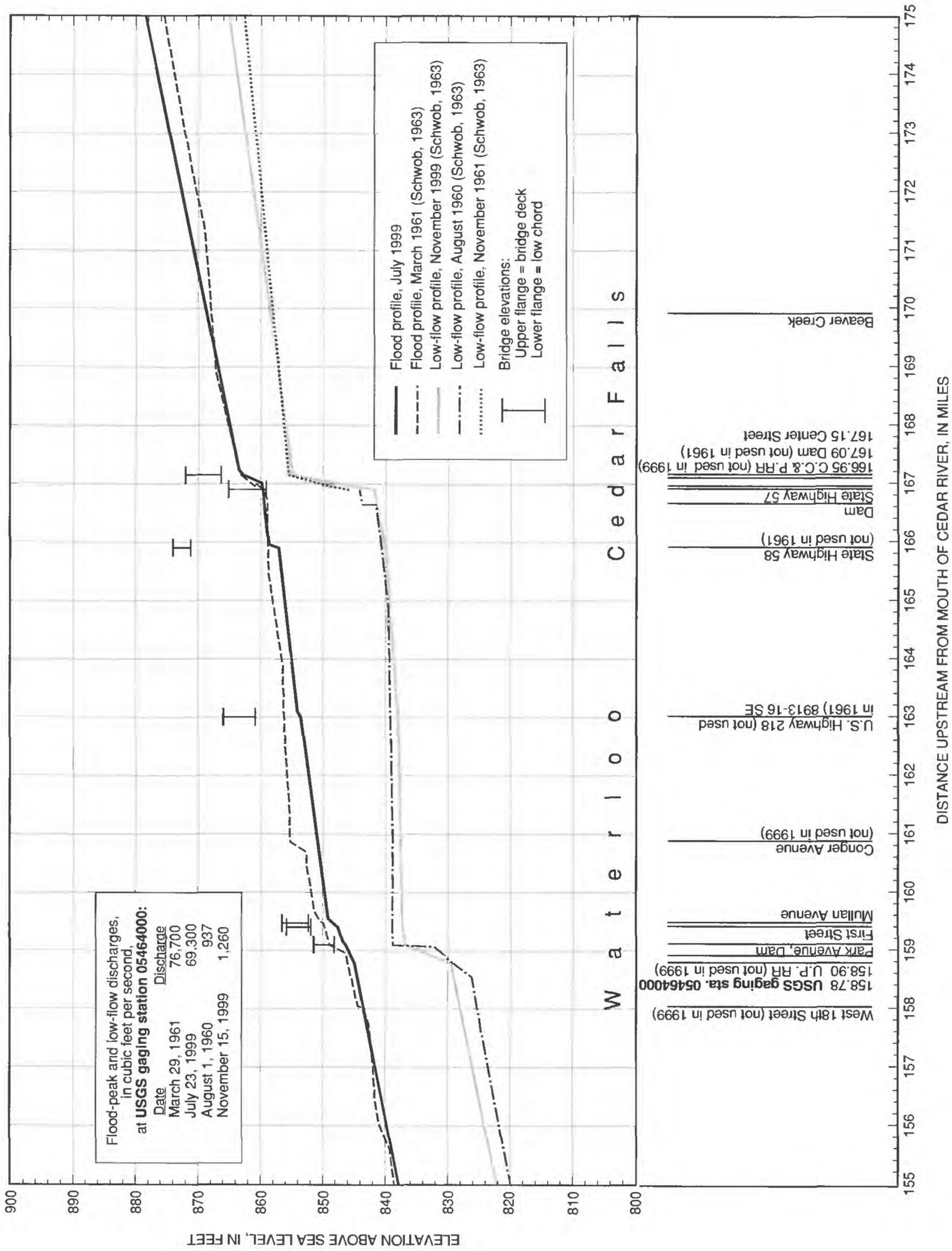


Figure 11. Profile of the July 1999 flood for the Cedar River, Iowa; river miles 155 to 175.

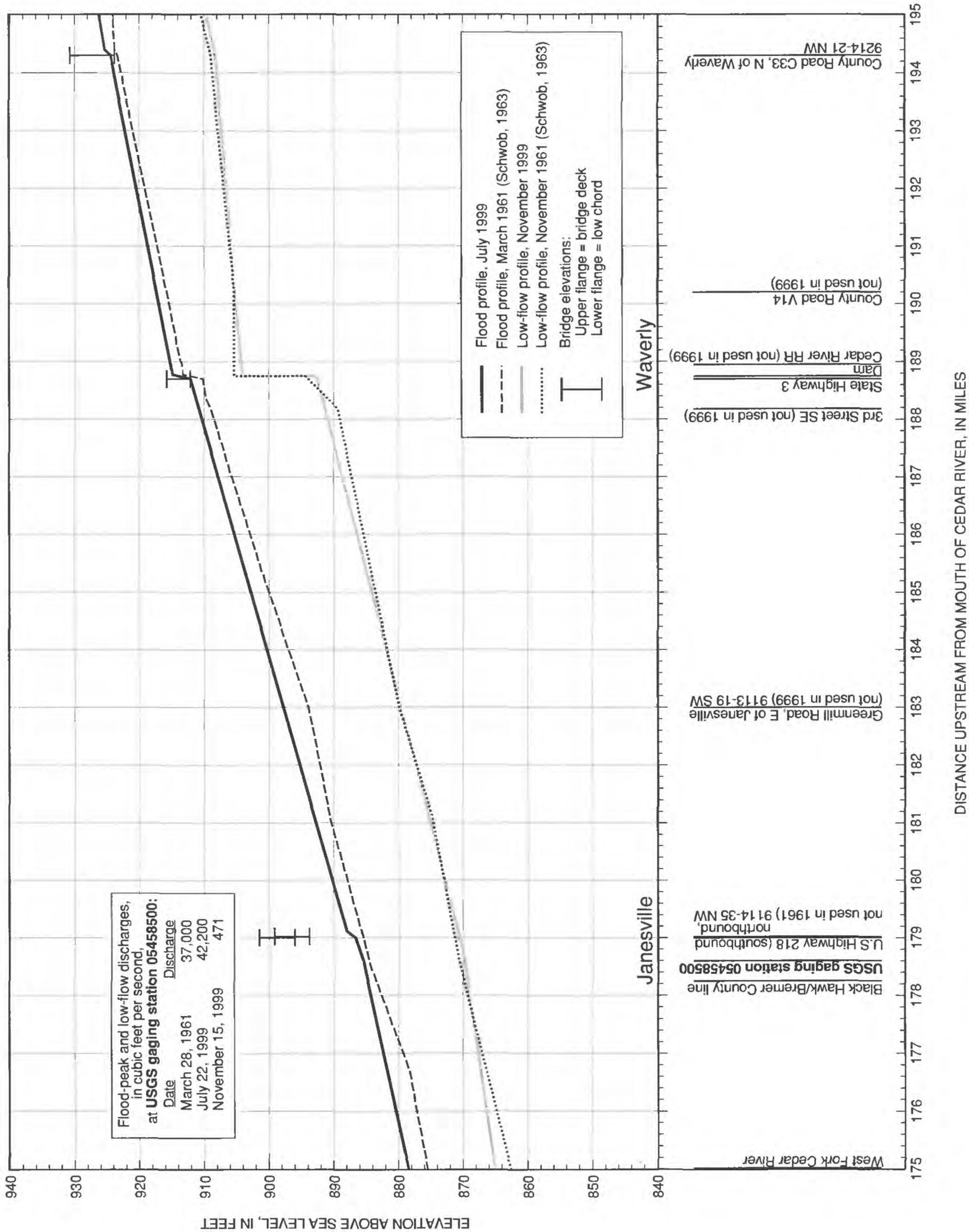
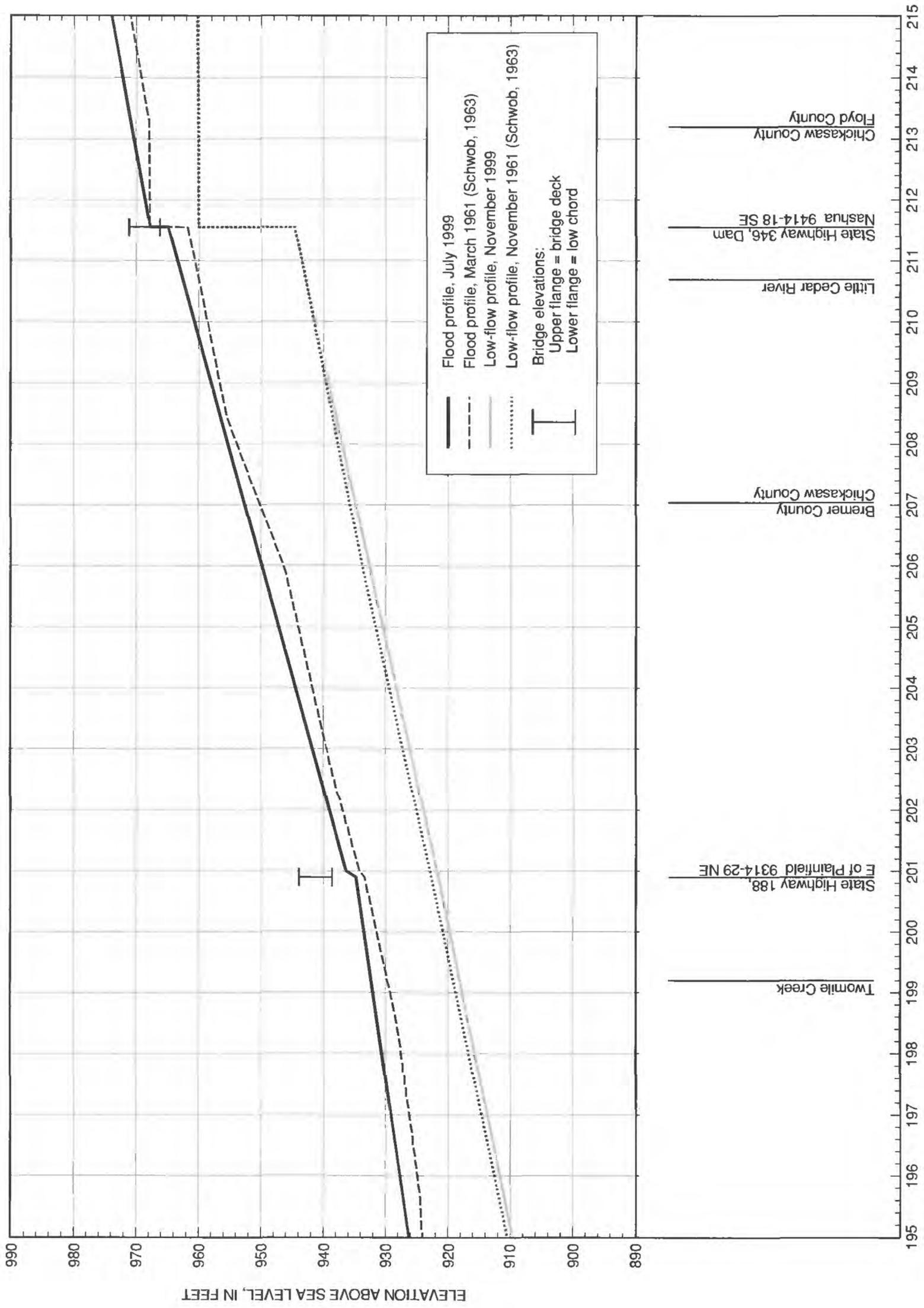
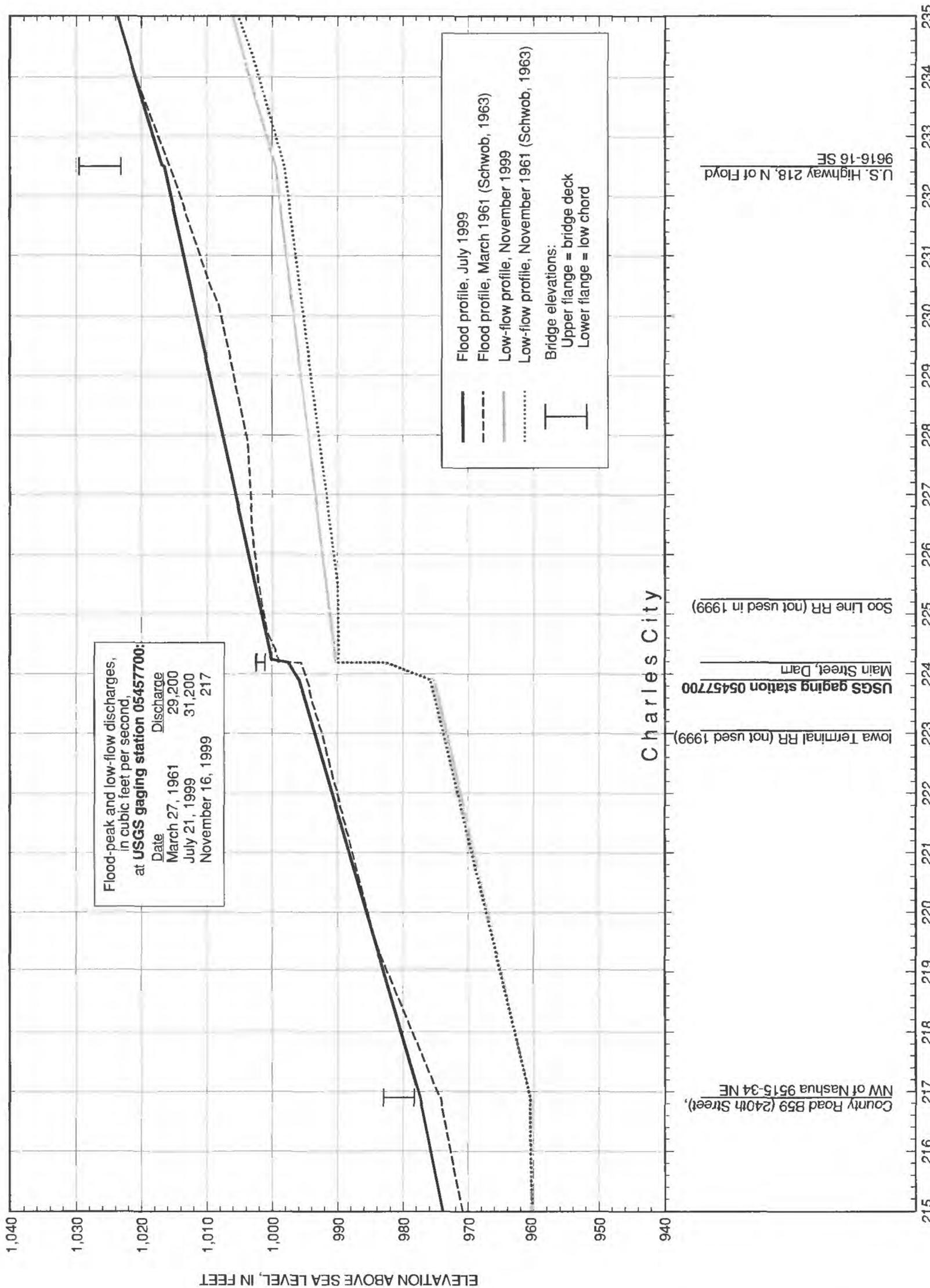


Figure 12. Profile of the July 1999 flood for the Cedar River, Iowa; river miles 175 to 195.



DISTANCE UPSTREAM FROM MOUTH OF CEDAR RIVER, IN MILES

Figure 13. Profile of the July 1999 flood for the Cedar River, lowa; river miles 195 to 215.



DISTANCE UPSTREAM FROM MOUTH OF CEDAR RIVER, IN MILES

Figure 14. Profile of the July 1999 flood for the Cedar River, Iowa; river miles 215 to 235.

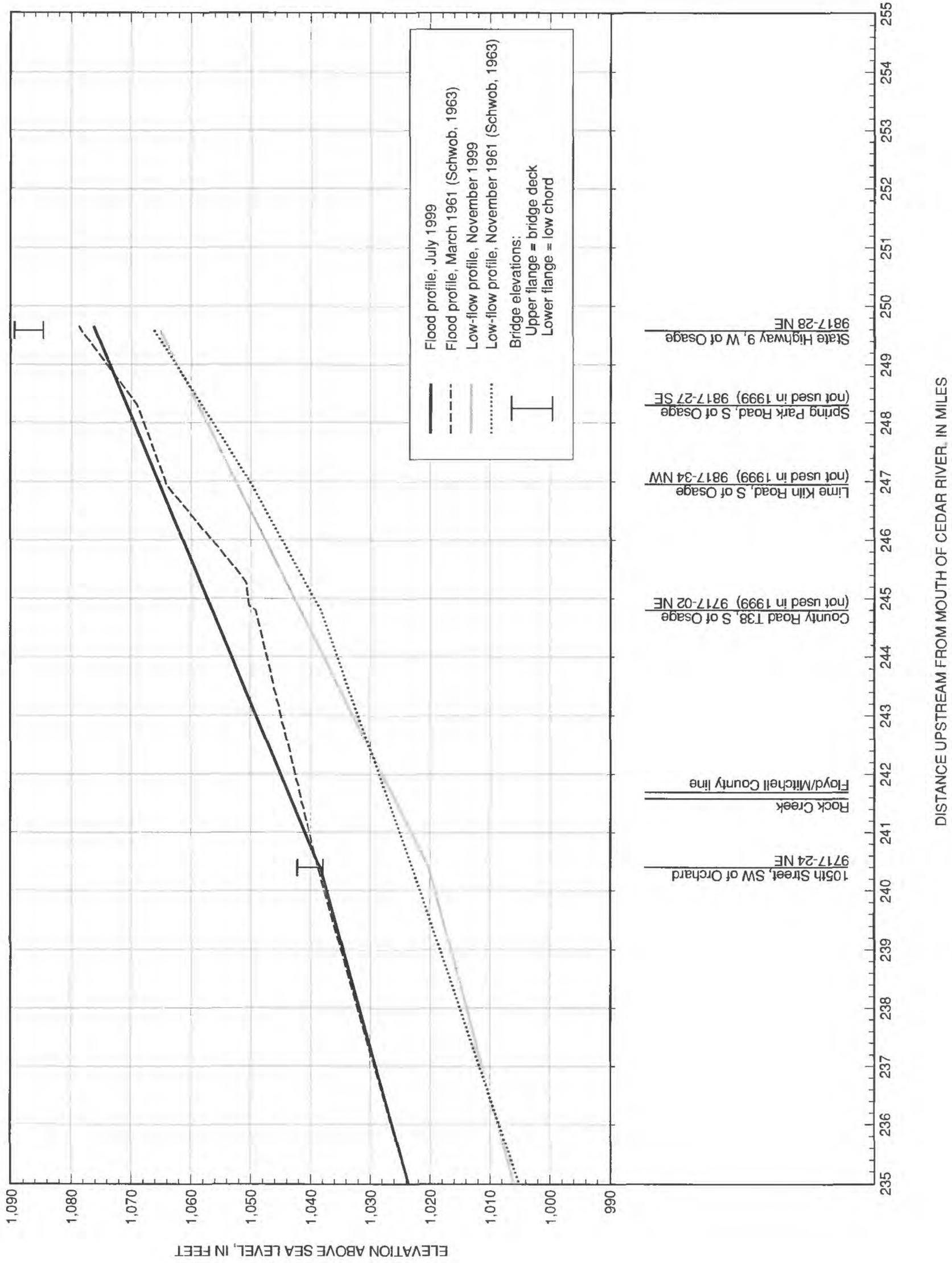


Figure 15. Profile of the July 1999 flood for the Cedar River, Iowa; river miles 235 to 250.

Table 5. Elevations of high-water marks used in the flood profile of July 1999 for the Cedar River, Iowa
 [HWM, high-water mark; USGS, U.S. Geological Survey; --, not measured]

Distance upstream from mouth of Cedar River (river miles)	Bridge-site and streamflow-gaging station description	Downstream HWM (feet above sea level)	Upstream HWM (feet above sea level)
139.28	Brandon Road, NE of La Porte City	810.46	811.52
147.35	County Road D38, Gilbertville	823.60	823.90
158.78	USGS gaging station 05464000, Waterloo	844.92	--
159.1	Park Avenue, Waterloo	846.36	846.80
159.47	Mullan Avenue, Waterloo	847.52	849.14
163.0	U.S. Highway 218, Waterloo	853.55	854.09
165.9	State Highway 58, Cedar Falls	857.14	858.72
166.9	State Highway 57, Cedar Falls	859.66	859.86
167.15	Center Street, Cedar Falls	862.80	863.45
178.6	USGS gaging station 05458500, Janesville	885.41	--
179.0	U.S. Highway 218, N of Janesville	886.64	887.97
188.70	State Highway 3, Waverly	912.10	914.84
194.3	County Road C33, N of Waverly	924.43	925.38
200.9	State Highway 188, E of Plainfield	934.73	936.33
211.55	State Highway 346, Nashua	964.86	967.71
216.9	County Road B59 (240th Street), NW of Nashua	977.39	--
223.9	USGS gaging station 05457700, Charles City	995.83	--
224.19	Main Street, Charles City	997.54	1,000.07
232.5	U.S. Highway 218, N of Floyd	1,016.48	1,016.88
240.4	105th Street, SW of Orchard	1,038.37	1,038.80
249.58	State Highway 9, W of Osage	1,075.92	1,076.20

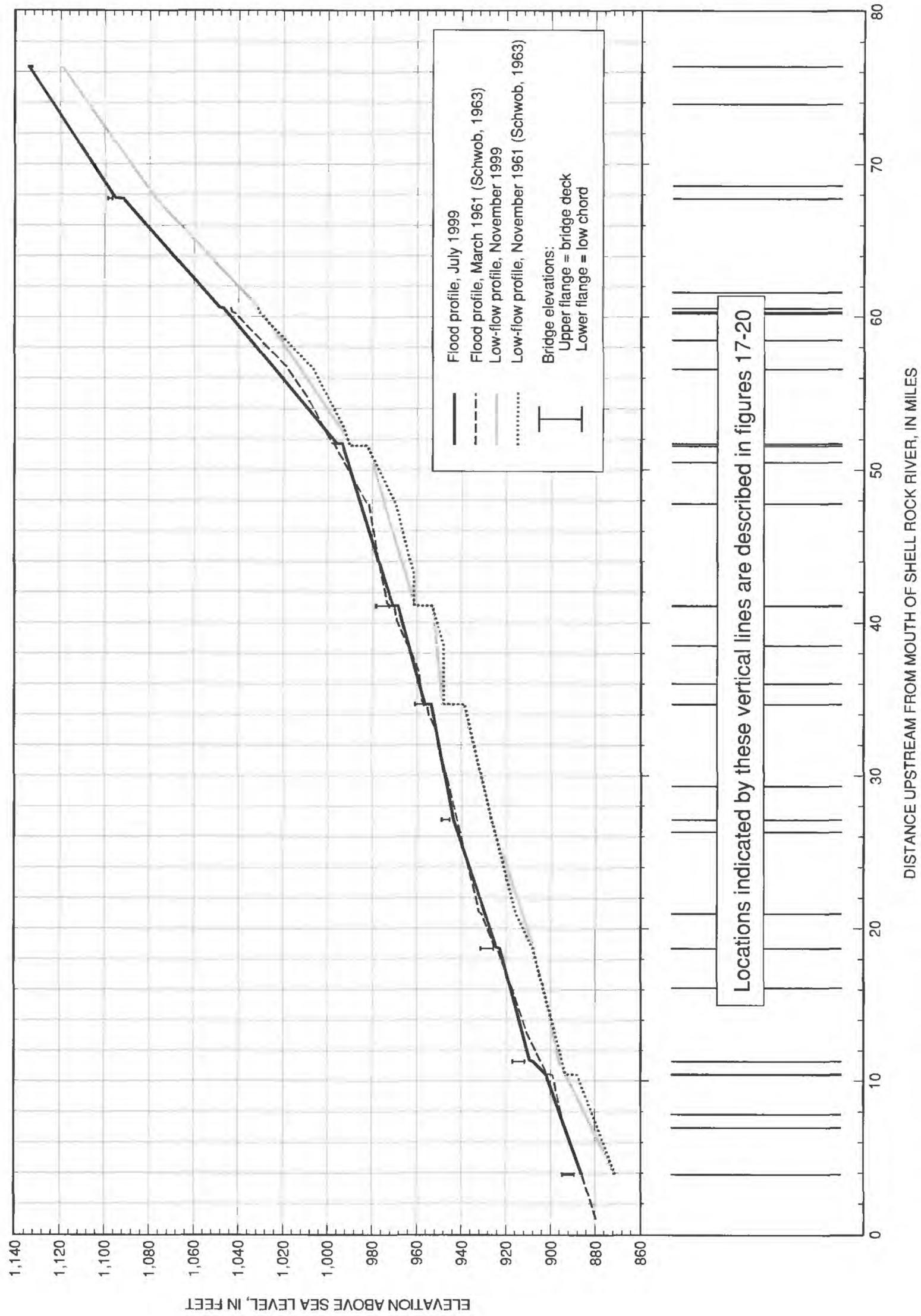
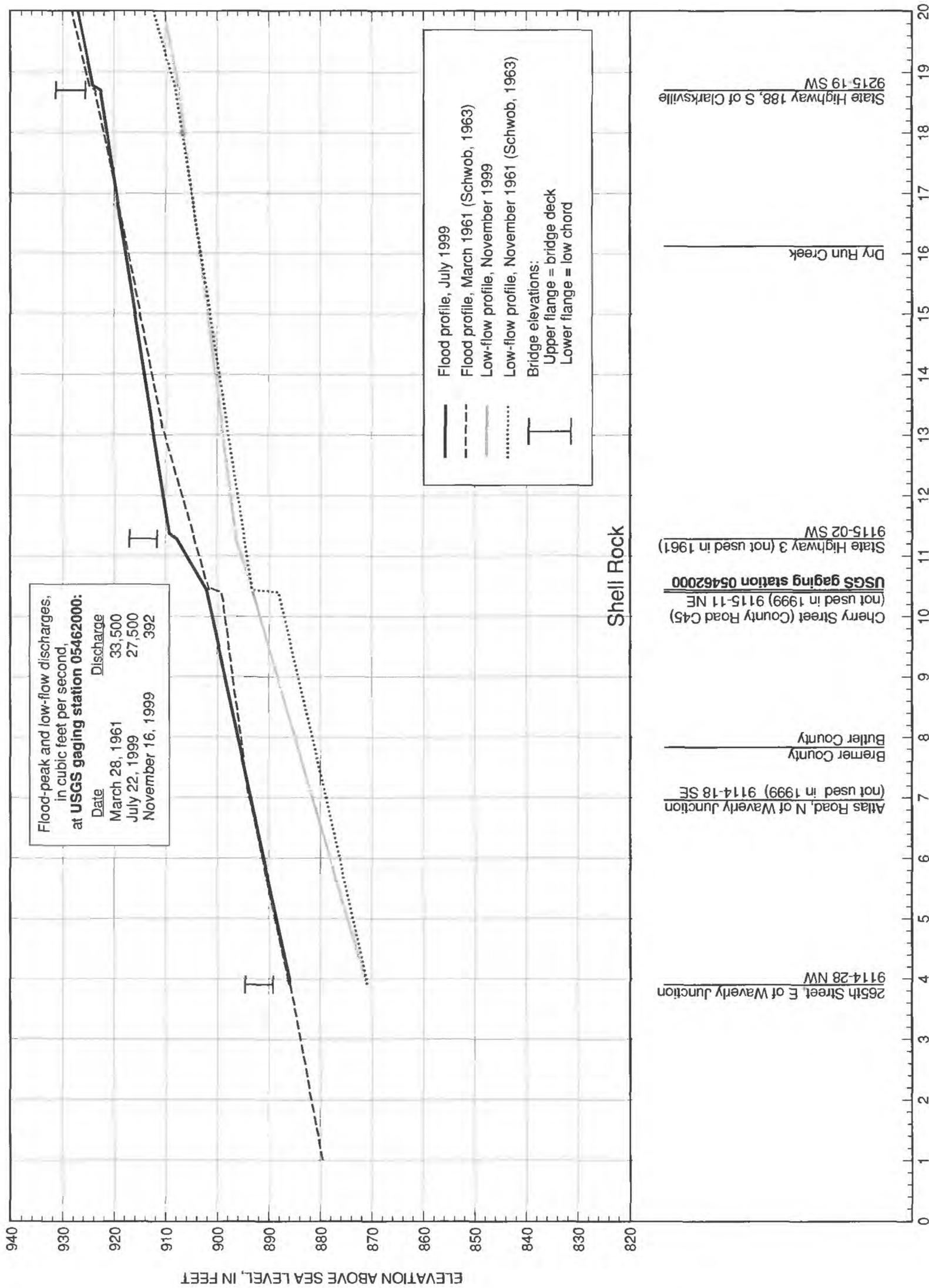


Figure 16. Profile of the July 1999 flood for the Shell Rock River, Iowa; river miles 1 to 76.



DISTANCE UPSTREAM FROM MOUTH OF SHELL ROCK RIVER, IN MILES

Figure 17. Profile of the July 1999 flood for the Shell Rock River, Iowa; river miles 1 to 20.

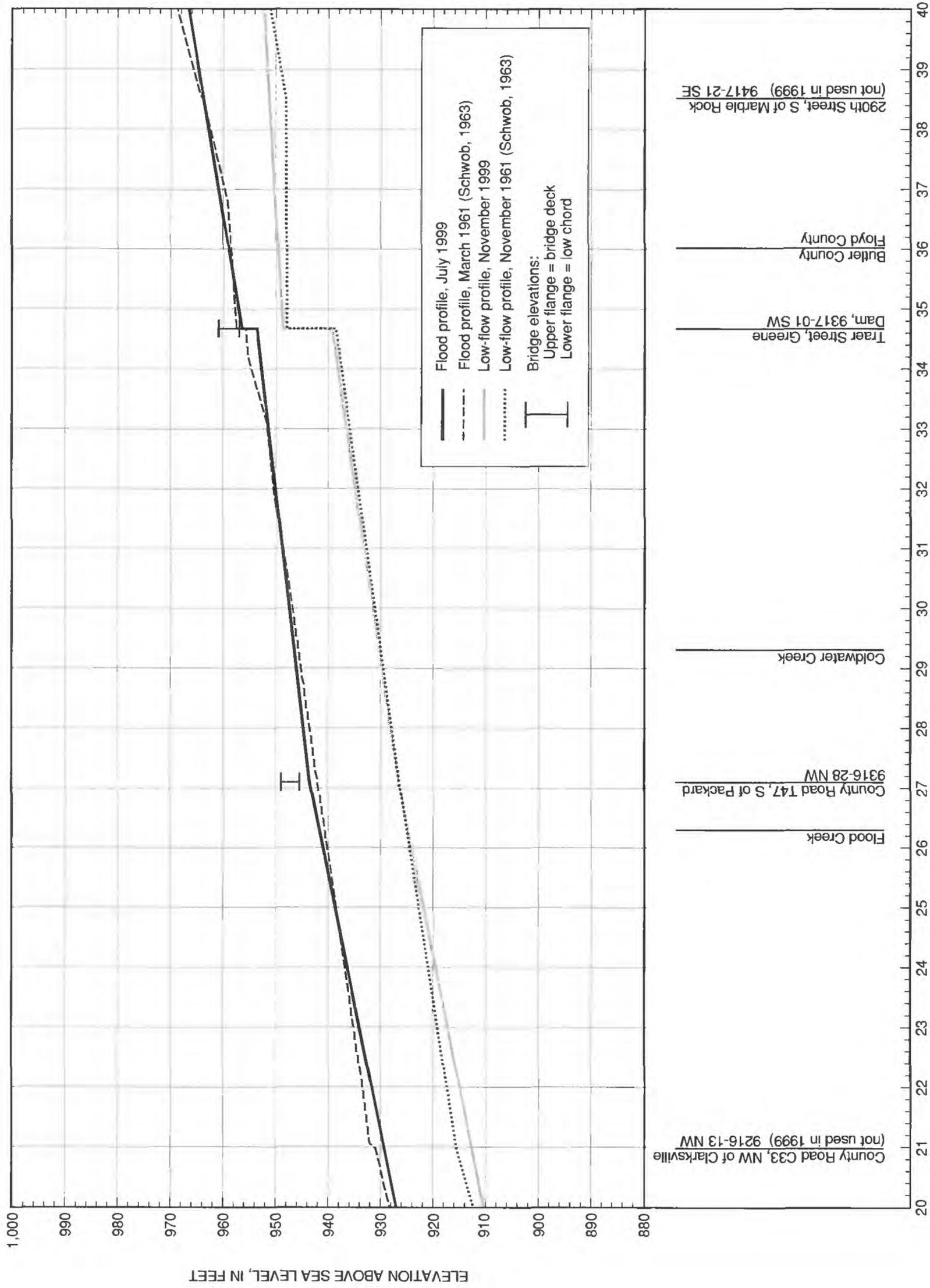
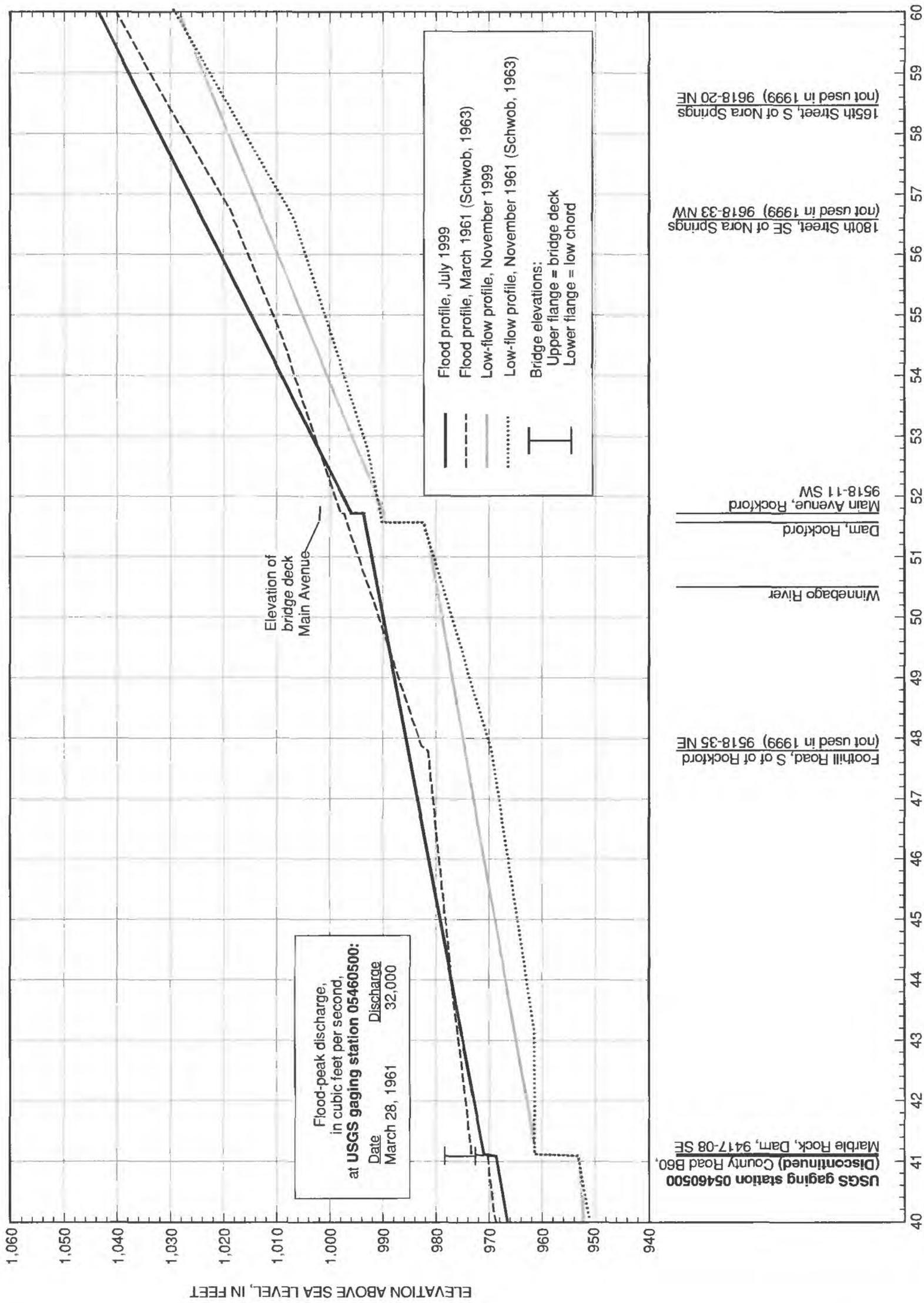
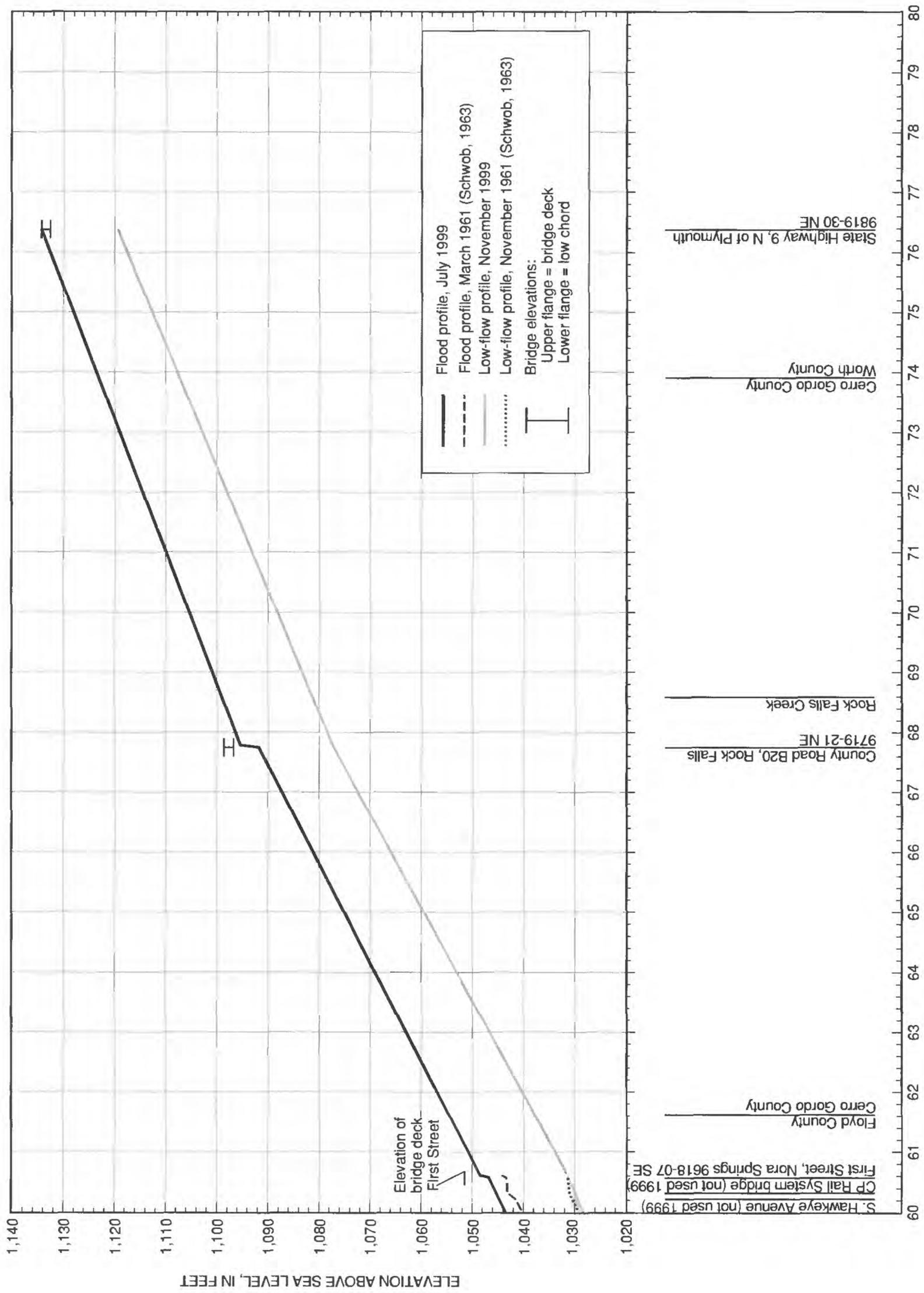


Figure 18. Profile of the July 1999 flood for the Shell Rock River, Iowa; river miles 20 to 40.



DISTANCE UPSTREAM FROM MOUTH OF SHELL ROCK RIVER, IN MILES

Figure 19. Profile of the July 1999 flood for the Shell Rock River, Iowa; river miles 40 to 60.



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DISTANCE UPSTREAM FROM MOUTH OF SHELL ROCK RIVER, IN MILES

Figure 20. Profile of the July 1999 flood for the Shell Rock River, Iowa; river miles 60 to 76.

Table 6. Elevations of high-water marks used in the flood profile of July 1999 for the Shell Rock River, Iowa
 [HWM, high-water mark; USGS, U.S. Geological Survey; --, not measured]

Distance upstream from mouth of Shell Rock River (river miles)	Bridge-site and streamflow-gaging station description	Downstream HWM (feet above sea level)	Upstream HWM (feet above sea level)
3.9	265th Street, E of Waverly Junction	885.91	885.91
10.44	USGS gaging station 05462000, Shell Rock	902.07	--
11.27	State Highway 3, Shell Rock	907.79	909.34
18.7	State Highway 188, S of Clarksville	922.63	924.19
27.1	County Road T47, S of Packard	943.49	--
34.67	Traer Street, Greene	953.54	956.37
41.09	Discontinued USGS gaging station 05460500, County Road B60, Marble Rock	968.63	970.94
51.72	Main Avenue, Rockford	993.60	995.94
60.57	First Street, Nora Springs	1,046.78	1,048.46
67.75	County Road B20, Rock Falls	1,091.81	1,095.37
76.38	State Highway 9, N of Plymouth	1,134.31	--

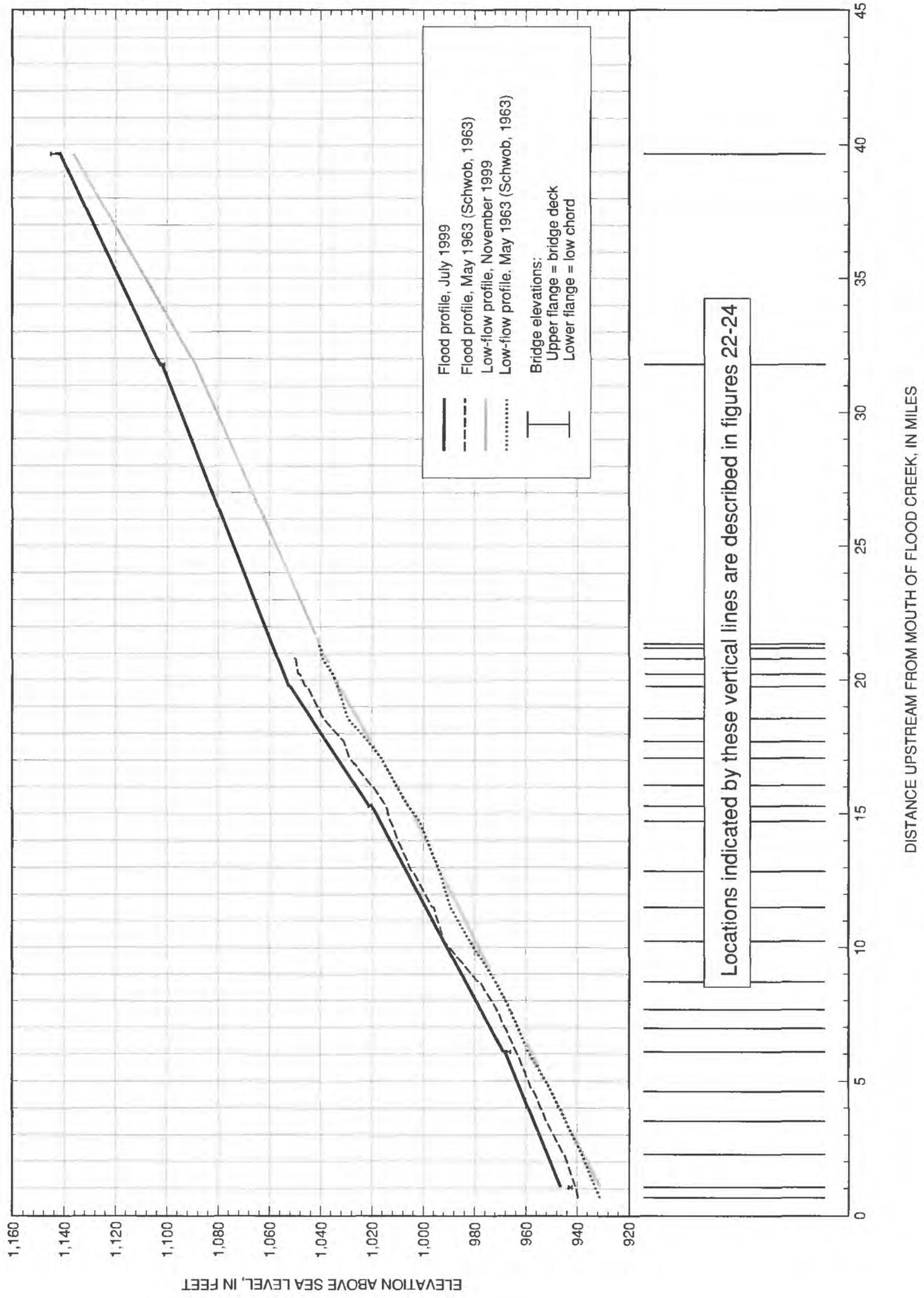


Figure 21. Profile of the July 1999 flood for Flood Creek, Iowa; river miles 1 to 40.

DISTANCE UPSTREAM FROM MOUTH OF FLOOD CREEK, IN MILES

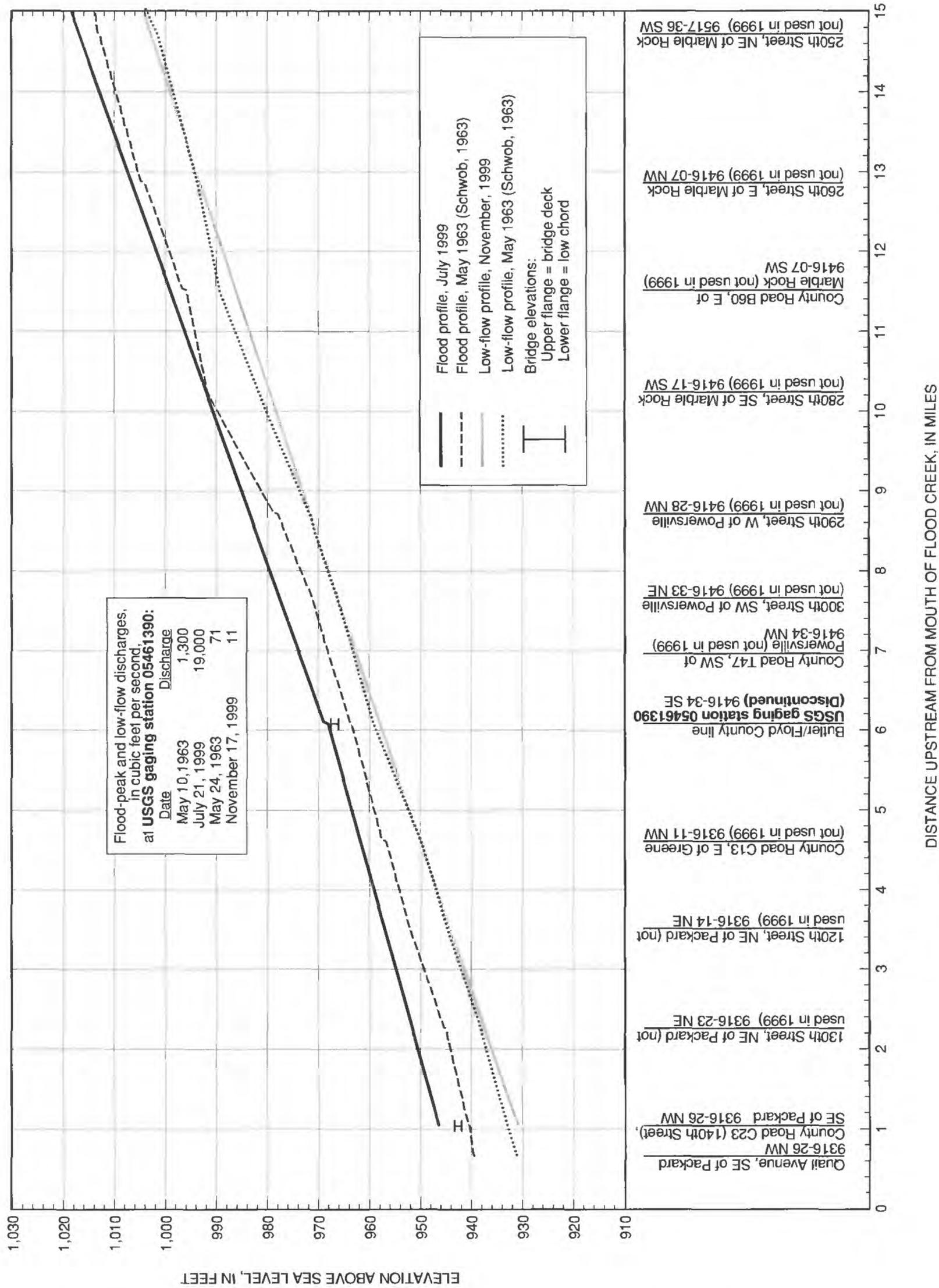


Figure 22. Profile of the July 1999 flood for Flood Creek, Iowa; river miles 1 to 15.

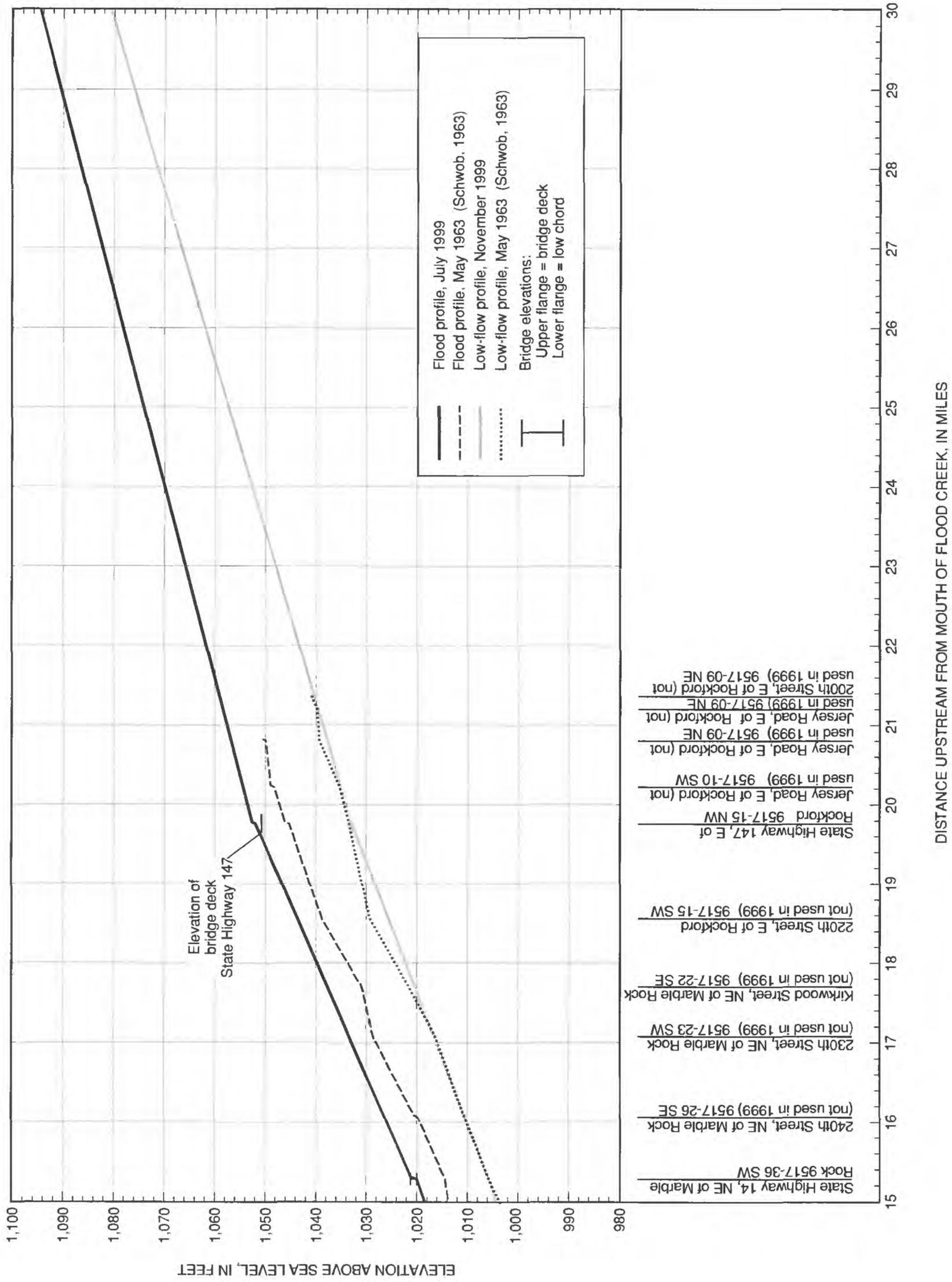


Figure 23. Profile of the July 1999 flood for Flood Creek, lowa; river miles 15 to 30.

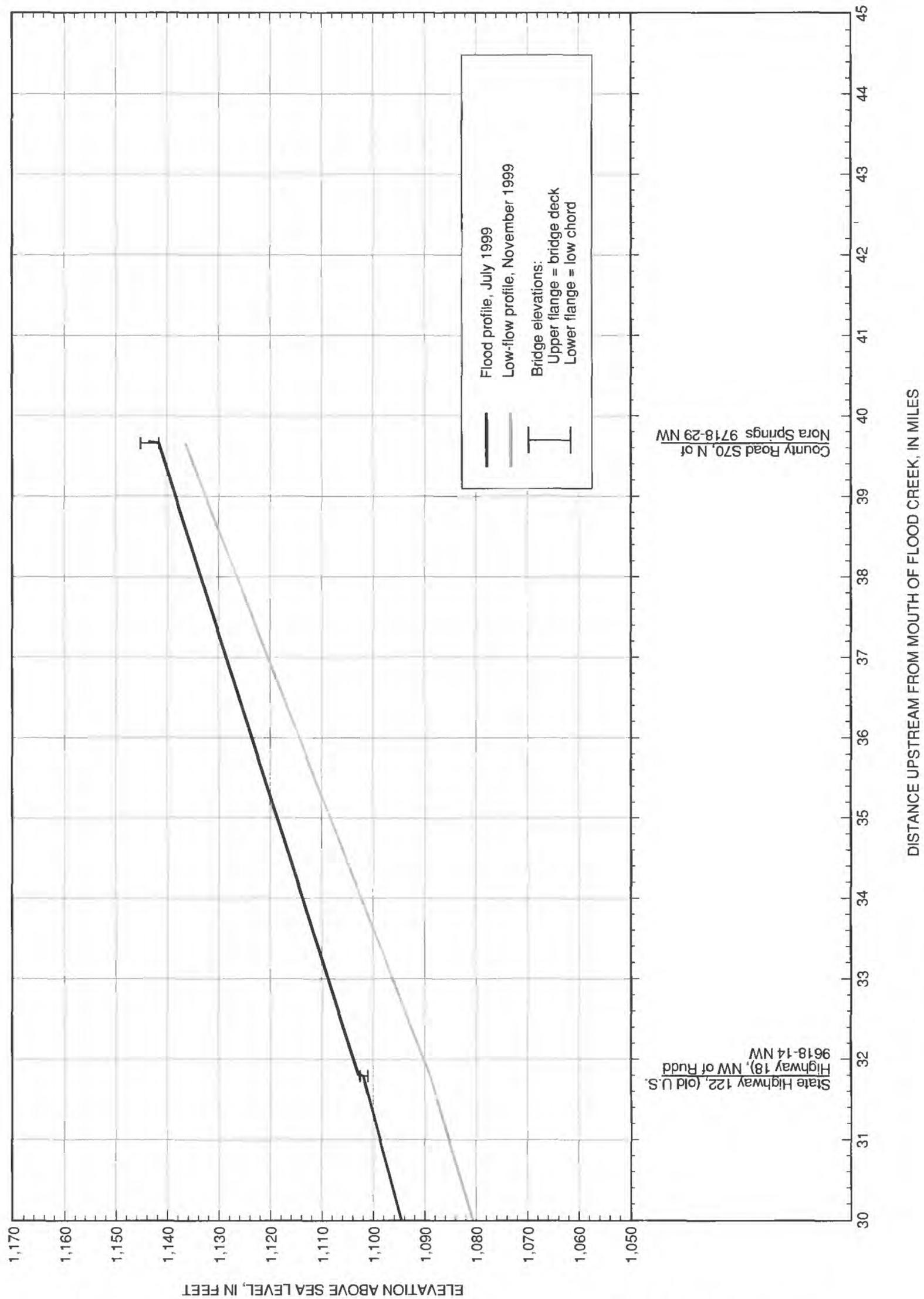


Figure 24. Profile of the July 1999 flood for Flood Creek, Iowa; river miles 30 to 40.

Table 7. Elevations of high-water marks used in the flood profile of July 1999 for Flood Creek, Iowa
 [HWM, high-water mark; USGS, U.S. Geological Survey]

Distance upstream from mouth of Flood Creek (river miles)	Bridge-site and streamflow-gaging station description	Downstream HWM (feet above sea level)	Upstream HWM (feet above sea level)
1.04	County Road C23 (140th Street), SE of Packard	946.46	946.47
6.08	Discontinued USGS gaging station 05461390, Floyd Line Road, E of Greene	968.06	968.96
15.28	State Highway 14, NE of Marble Rock	1,020.00	1,021.18
19.76	State Highway 147, E of Rockford	1,051.94	1,052.56
31.79	State Highway 122 (old U.S. Highway 18), NW of Rudd	1,101.95	1,102.87
39.66	County Road S70, N of Nora Springs	1,141.64	1,143.69