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Flood of June 15–17, 1998, Nishnabotna and East Nishnabotna Rivers, Southwest Iowa

by Edward E. Fischer

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

Sea Level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--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.

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ABSTRACT

Record flooding occurred June 15–17, 1998, in the Nishnabotna and East Nishnabotna River basins following severe thunderstorm activity over southwest Iowa. More than 8 inches of rain fell over a large part of Cass County. The rain gage at Atlantic, Iowa recorded a 24-hour total rainfall of 13.18 inches, which established a new official State record for the greatest amount of rainfall in a 24-hour period. The peak discharge was 41,400 cubic feet per second in the East Nishnabotna River near Atlantic, 60,500 cubic feet per second in the East Nishnabotna River at Red Oak, and 65,100 cubic feet per second in the Nishnabotna River above Hamburg. The peak discharge at Atlantic was greater than the theoretical 200-year flood and the peak discharges at Red Oak and Hamburg were greater than the respective theoretical 500-year floods. Information about the basin, the rain storms, the flooding, and a profile of high water marks at selected intervals along the Nishnabotna and East Nishnabotna Rivers are presented in this report.

INTRODUCTION

Severe thunderstorms caused major flooding on the Nishnabotna and East Nishnabotna Rivers in southwest Iowa in June 1998. New maximum peak discharge records were set at three streamflow-gaging stations in the river basin. Flooding occurred in several cities and towns where many homes and businesses were damaged. Many highways were closed and numerous bridges were damaged or destroyed. Nearly all of the highways in Cass County were closed during the height of the flood. The surprising quickness and severity of the flooding received national attention. The storms also caused flooding in other river basins in central Iowa as they moved eastward. Flooding in the Nishnabotna River basin is not unknown to the basin residents, however, as major floods also occurred in 1947, 1972, and 1993.

The total economic damage in the Nishnabotna River basin due to the flooding has not been completely evaluated. As of mid-December 1998, the Federal Emergency Management Agency alone has approved nearly $20 million to assist schools, businesses, private non-profit businesses, and essential utilities recover from the damages (Jerry Ostendorf, Iowa Emergency Management Division, oral commun., December 8, 1998). This figure does not include agricultural losses, losses sustained due to loss of commerce, losses sustained by the transportation infrastructure, or unemployment. In the agricultural sector, many farmers were able to replant flooded areas because the flooding occurred relatively early in the planting season (Bob Muenchrath, Iowa State Farm Services Agency, oral commun., December 8, 1998).

This report provides information about the June 1998 rainstorm and ensuing flood in the Nishnabotna and East Nishnabotna River basins. High water marks at selected points along the Nishnabotna and East Nishnabotna Rivers are presented in a flood profile from Interstate Highway 29 near Hamburg, Iowa to U.S. Highway 71 near Exira, Iowa. Selected profile information about a flood of similar magnitude that occurred in 1972 and a low-flow profile obtained in 1989 are included.

This report was prepared in cooperation with the Iowa Department of Transportation (Iowa DOT) and the Iowa Highway Research Board. A list of other Iowa flood profile reports published by the U.S.

Geological Survey (USGS) can be obtained from the World Wide Web at URL (uniform resource locator) `http://ia.water.usgs.gov/profiles/`. Various Federal, State, and local agencies provide funding for the operation and maintenance of the streamflow-gaging stations operated in the Nishnabotna River Basin. They are acknowledged in the annual water resources data reports of the USGS (May and others, 1998).

RIVER BASIN

The Nishnabotna River is a tributary of the Missouri River (fig. 1). The river basin is located predominantly in southwestern Iowa; the mouth of the river is about 10 miles south of the Iowa-Missouri state line. The drainage area at the state line is 2,810 mi^2. About 4 miles north of Hamburg, the river divides into two major tributaries, the West Nishnabotna River (drainage area 1,649 mi^2) and the East Nishnabotna River (1,148 mi^2).

The topography of the Nishnabotna River basin is characterized by broad, rolling uplands and wide valleys. The soil cover generally consists of loess deposits that range in thickness from almost 100 feet in places near the western edge of the basin to 3–8 feet thick on the ridges in the northeast part of the basin (Iowa Natural Resources Council, 1955, p. 3). Land use in the basin is predominantly agricultural.

Streamflow characteristics in the drainage basin have been affected by extensive channel straightening and levee construction projects that began in the early 1900's. Channelization and levee construction has continued throughout the years for local sections of streams in the basin (U.S. Army Corps of Engineers, 1974, p. 6–7).

STORM DESCRIPTION

The intense rain storms that caused the 1998 flooding in the Nishnabotna River basin covered much of southwest Iowa June 14th and 15th. The heaviest rainfall was concentrated over much of Cass County (fig. 1). The 48-hour rainfall map shown in the figure was developed by the State Climatologist, who said that the demarcation of the area of eight inches or more rainfall was uncertain because of the lack of sufficient data to confidently assess the areal extent of the heaviest rainfall. The State Climatologist also provided a copy of the National Weather Service storm summary, which will be published in *Storm Data* by the National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, North Carolina. The following storm description is adapted from the summary (Harry Hillaker, Iowa Department of Agriculture & Land Stewardship, written commun., 1998).

> A large mesoscale convective weather system developed near the center of an upperlevel low pressure center over southwest Iowa during the early morning hours of June 14th. Extremely heavy rain fell over southwest and central Iowa from this storm. The rain gage at Atlantic received 7 inches in a 4.5-hour period from 08:30 to 13:00 Central Standard Time and had a 24-hour total rainfall of 13.18 inches, which established a new official State record for the greatest amount of rainfall in a 24-hour period. A large area of Cass County was covered by 4- to 8-inch rains (fig. 1). During the morning, a deformation zone formed over the area. Bands of heavy thunderstorms moved up from the south and became stationary in an east to west band from west central into central Iowa. Rainfall of one to two inches in less than 2 hours was common, with many areas receiving three inches or more of additional rainfall.

FLOOD DESCRIPTION

As a result of the intense storms, the East Nishnabotna River was in flood stage from north of Exira in Audubon County to its confluence with the West Nishnabotna River north of Hamburg in Fremont County. From the confluence, the Nishnabotna River was in flood stage to its mouth at the Missouri River. The effects of the flood on Missouri River streamflow were minimal. Discharge hydrographs for all five Nishnabotna River basin streamflow-gaging stations for the period June 14–20, 1998, are shown in figure 2. Major flooding in Cass County began June 14 and peaked June 15 (fig. 2C). The flood peak also occurred June 15 downstream in Montgomery County (fig. 2D). In Fremont County, the flood peak occurred two days later on June 17 (fig. 2E).

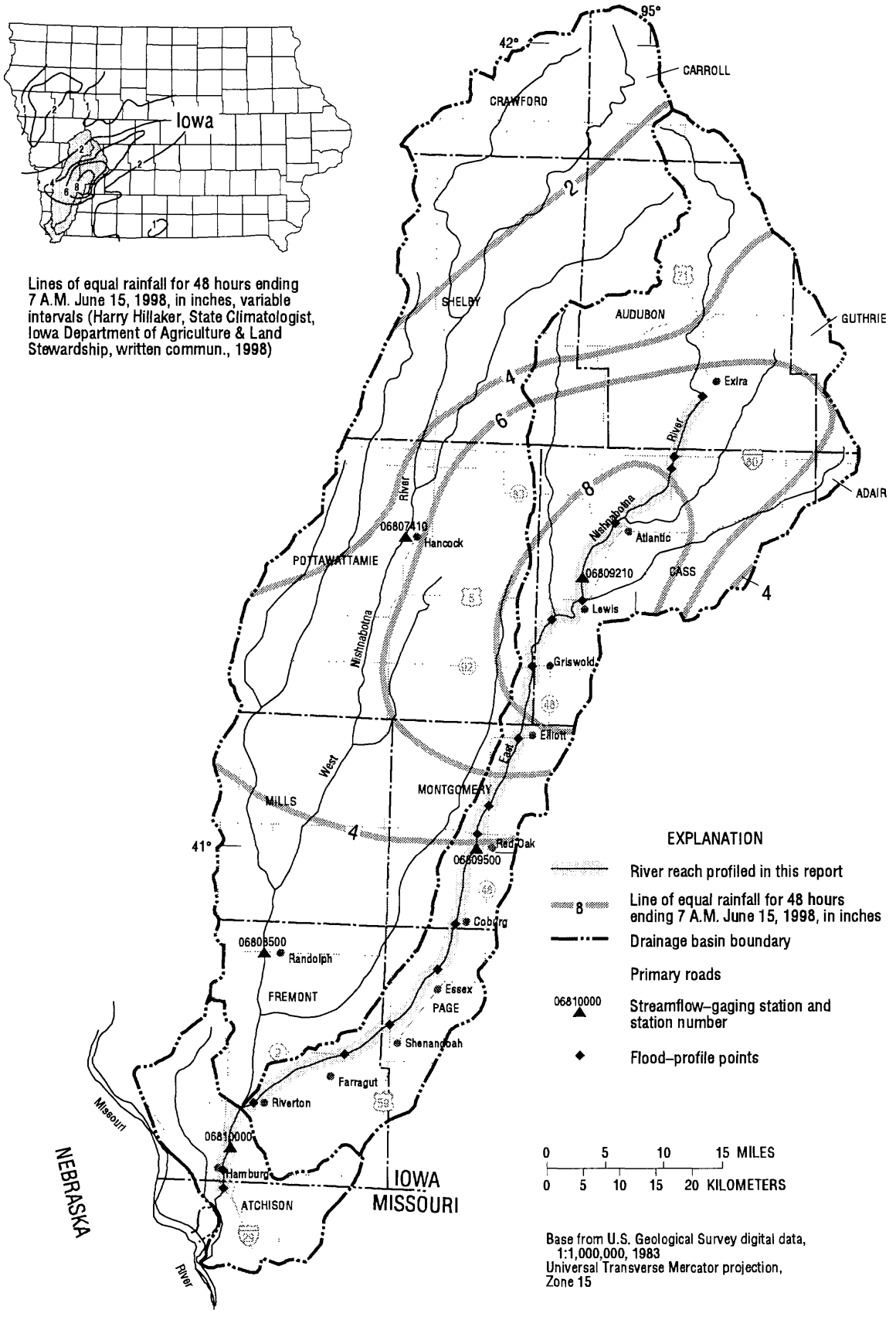

Figure 1. *Nishnabotna River basin and lines of equal rainfall for 48 hours ending 7 A.M. June 15, 1998.*

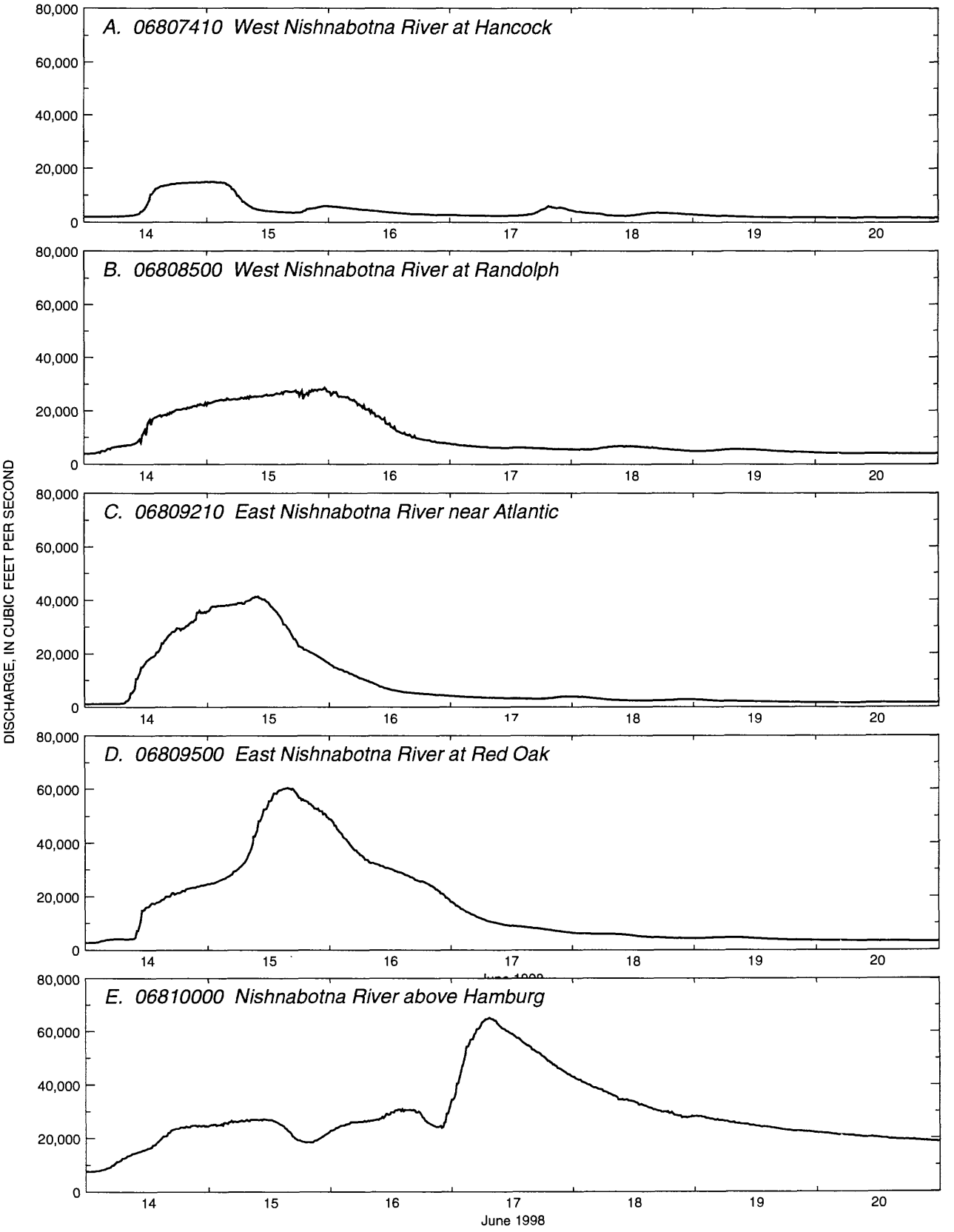

Figure 2. *Discharge hydrographs at Nishnabotna River basin streamflow-gaging stations, June 14–20, 1998*

With respect to flood streamflow characteristics, the smallest increase in discharge occurred at the West Nishnabotna River at Hancock streamflow-gaging station (fig. 2A), which is consistent with the total rainfall amounts depicted in figure 1. The fastest increase in discharge occurred at the East Nishnabotna River at Red Oak streamflow-gaging station (fig. 2D). The maximum discharge occurred at the Hamburg streamflow-gaging station (fig. 2E), which measures the combined discharge of the East and West Nishnabotna Rivers (fig. 1). The maximum flood discharge that occurred at each streamflow-gaging station is listed in table 1

Many levees in the lower reaches of the river basins failed during the flooding. The unsteady rise of the Hamburg hydrograph (fig.2E) June 15 and 16 most likely reflects the effects on discharge of major levee failures as they occurred in the vicinity of the streamflow-gaging station. Also, the recession limb of the hydrograph shows a large, sustained flow that continued beyond June 20. The discharge dropped slowly, falling below 10,000 ft^3/s five days later on June 25. The sustained large discharge was the result of return flows from the flood plains. The levee failures and floodplain storage effects attenuated the maximum discharge that otherwise would have been measured at the gaging station. A hydraulic analysis would be needed to determine how much the peak discharge was attenuated.

At the request of the U.S. Army Corps of Engineers, the USGS measured the discharge along County Road J46 (not shown in fig. 1) west of Riverton during the evening of June 16. The road is about 2.5 miles upstream from the confluence of the East and West Nishnabotna Rivers. The measurement section was along the road crown and included both rivers. About 1.5 miles of the roadway was submerged. The measured discharge was 92,600 ft^3/s, which was 42 percent greater than the maximum discharge that subsequently occurred at the Hamburg streamflow-gaging station. The station is about 4 miles downstream from the road. It is surmised that the measurement was made at a time just after one or more near-downstream levees failed, causing a surge in the discharge at the road.

The recurrence intervals of the flood peaks at the five Nishnabotna River basin streamflow-gaging stations also are listed in table 1. Included for each station is information from two previous floods in the peak flow record (three for Hamburg). The recurrence intervals were determined from standard flood frequency analyses that included the 1998 flood peaks. The peak discharge at Atlantic was greater than the theoretical 200-year flood and the peak discharges at Red Oak and Hamburg were greater than the theoretical 500-year floods calculated from the respective peak flow records. The next largest peak discharge at the Hamburg streamflow-gaging station, which occurred in 1947, also was greater than the theoretical 500-year flood.

Road overflow occurred at numerous places in the Nishnabotna and East Nishnabotna River basins, forcing closure of many roads. Interstate Highway 29 south of Hamburg was closed for nearly two days June 17 and 18 as the flood peak passed through to the Missouri River. Many bridges were damaged throughout the East Nishnabotna River basin. The streambed at the State Highway 92 bridge west of Griswold (fig. 1) scoured below the pier footings. The Iowa DOT subsequently determined that the bridge had to be replaced.

FLOOD PROFILE

To develop a flood profile, the USGS measured the elevations of high water marks (HWMs) at selected points along the Nishnabotna and East Nishnabotna Rivers after flood waters receded. Most of the marks were measured at Federal and State Highway bridges and at USGS streamflow-gaging stations; HWMs at several county-road bridges also were measured so there would not be more than 10 miles between marks. HWMs were measured at the upstream and downstream side of each bridge. The HWMs are listed in table 2. They are profiled in figure 3 and in expanded form in figures 4–7 (following References). The line connecting the marks is a linear interpolation and therefore only approximates the maximum flood stage between the marks; it does not depict the effects on the profile caused by intermediate bridges or geomorpholcgic (channel) features. The HWM elevations used in the profiles are listed in table 2 following the profiles and the bench marks used to establish the HWM elevations are listed in the appendix.

Table 1. *Maximum stages and discharges for 1998 and selected additional years and corresponding flood frequencies at streamflow-gaging stations in the Nishnabotna River basin, Iowa*

[**boldfaced type**, flood profile included in this report; >, greater than]

Streamflow-gaging station	Drainage area (mi^2)	Date	Peak stage[a] (ft)	Peak discharge (ft^3/s)	Recurrence interval (years)
06807410 West Nishnabotna River at Hancock	609	9/13/1972	22.12	26,400	25
		7/10/1993	23.52	30,100	50
		6/15/1998	17.53	15,000	4
06808500 West Nishnabotna River at Randolph	1,326	6/21/1967	22.60	35,500	20
		5/26/1987	24.50	40,800	50
		6/15/1998	23.92	28,700	9
06809210 East Nishnabotna River near Atlantic	436	7/2/1958	22.49[b]	34,200[b]	80
		9/12/1972	**22.81**	**26,700**	**25**
		6/15/1998	**22.36**	**41,400**	**250**
06809500 East Nishnabotna River at Red Oak	894	6/13/1947	28.23	36,200	70
		9/13/1972	**27.43**	**38,000**	**90**
		6/15/1998	**29.39**	**60,500**	**>500**
06810000 Nishnabotna River above Hamburg	2,806	6/24/1947	26.03	55,500	>500
		9/15/1972	**27.42**	**25,200**	**6**
		7/25/1993	30.56	37,700	25
		6/17/1998	**33.18**	**65,100**	**>500**

[a]All values at current datums except as noted.
[b]Discharge measured at site 2 miles upstream at different datum.

Profiles for both the 1972 flood and the 1989 low-flows (Eash and Heinitz, 1991) also are shown in the figures. Only the HWMs and low-flow stages measured in the same localities as the 1998 HWMs are shown. Like the 1998 profile, the lines connecting the 1972 HWMs and the 1989 low-flow marks only approximate the river stage between measurement locales.

The profiles for both floods are similar. When comparing the floods, however, it is instructive to note that the floods occurred at different times of the year. The 1998 flood occurred in June, which is relatively early in the growing season, while the 1972 flood occurred in September, when crops were mature. Mature crops tend to increase the overall roughness, causing the stage of a given discharge to be higher. Conversely, channel degradation (down-cutting) between 1972 and 1998 might also result in lower stages for the 1998 flood as compared to that of 1972. A detailed hydraulic analysis would be needed to provide answers to these possibilities.

SUMMARY

Record flooding occurred June 14 to 18, 1998, in the Nishnabotna and East Nishnabotna River basins following severe thunderstorm activity over southwest Iowa. More than 8 inches of rain fell over a large part of Cass County. The rain gage at Atlantic had a 24-hour total rainfall of 13.18 inches, which established a new official State record for the greatest amount of rainfall in a 24-hour period. The peak discharge was 41,400 ft^3/s at the East Nishnabotna River near Atlantic streamflow-gaging station; 60,500 ft^3/s at the East Nishnabotna River at Red Oak streamflow-gaging station; and 65,100 ft^3/s at the Nishnabotna River above Hamburg streamflow-gaging station. The peak discharge at Atlantic was greater than the theoretical 200-year flood and the peak discharges at Red Oak and Hamburg were greater than theoretical 500-year floods calculated from the respective peak flow records. At the Hamburg streamflow-gaging station, the previous maximum peak discharge of record, 55,500 ft^3/s which occurred in 1947, also was greater than the theoretical 500-year flood.

REFERENCES

Eash, D.A., and Heinitz, A.J., 1991, Floods in the Nishnabotna River basin, Iowa: U.S. Geological Survey Open-File Report 91-171, 118 p.

Iowa Natural Resources Council, 1955, An inventory of water resources and water problems, Nishnabotna River basin, Iowa: Des Moines, Iowa, Iowa Natural Resources Council Bulletin no. 2, 61 p.

May, J.E., Gorman, J.G., Goodrich, R.D., and Miller, V.E., 1998, Water resources data Iowa, water year 1997: U.S. Geological Survey Water-Data Report IA-97-1, 2 vols, 668 p.

U.S. Army Corps of Engineers, 1974, Nishnabotna River basin, Iowa, report on flood of September 1972: Omaha, Nebraska, 79 p.

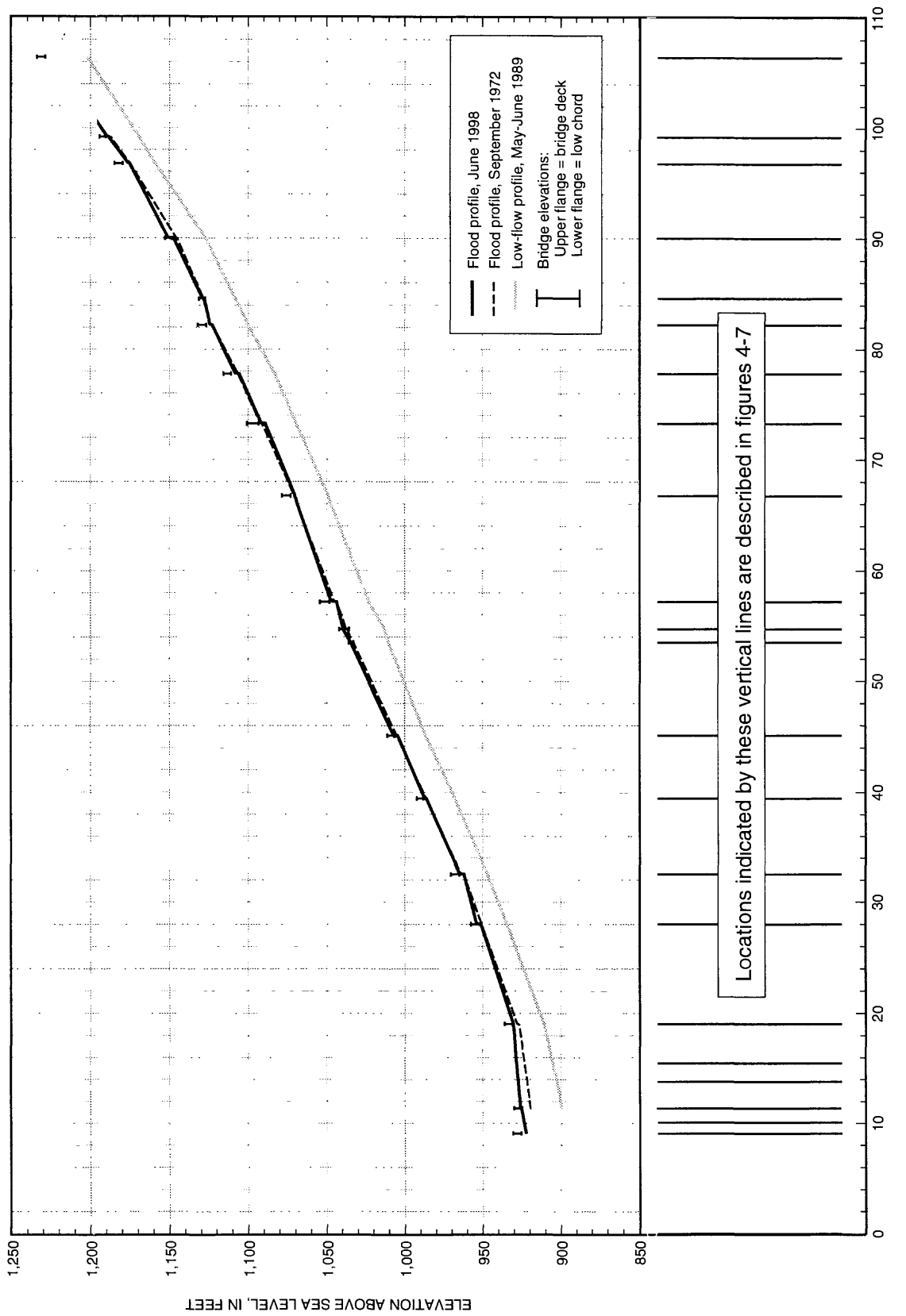

Figure 3. *Profile of the June 1998 flood in the Nishnabotna and East Nishnabotna Rivers, river miles 9 to 106*

(1972 and 1989 profiles from Eash and Heinitz, 1991).

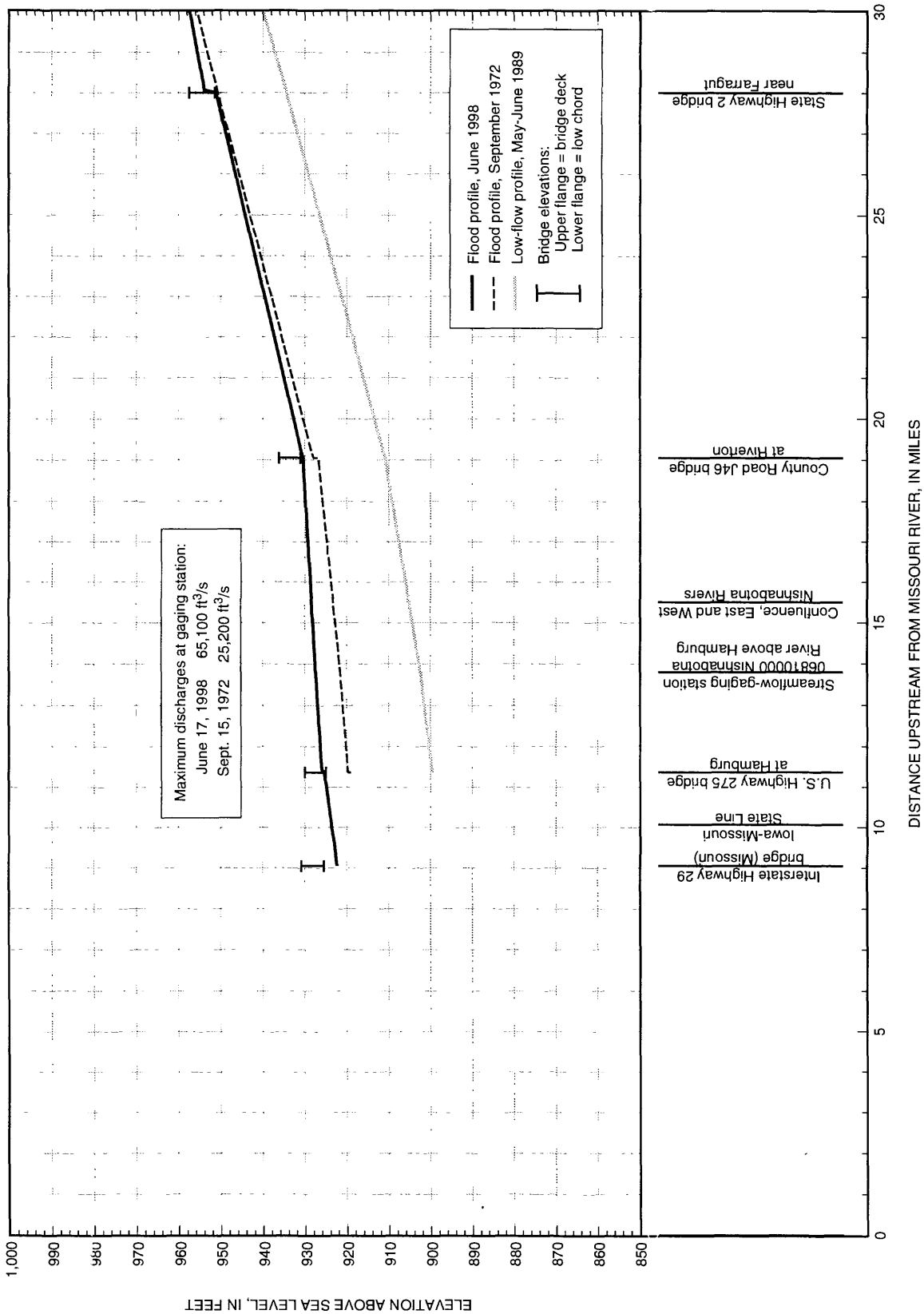

Figure 4. *Profile of the June 1998 flood in the Nishnabotna and East Nishnabotna Rivers, river miles 9 to 30*

(1972 and 1989 profiles from Eash and Heimitz, 1991).

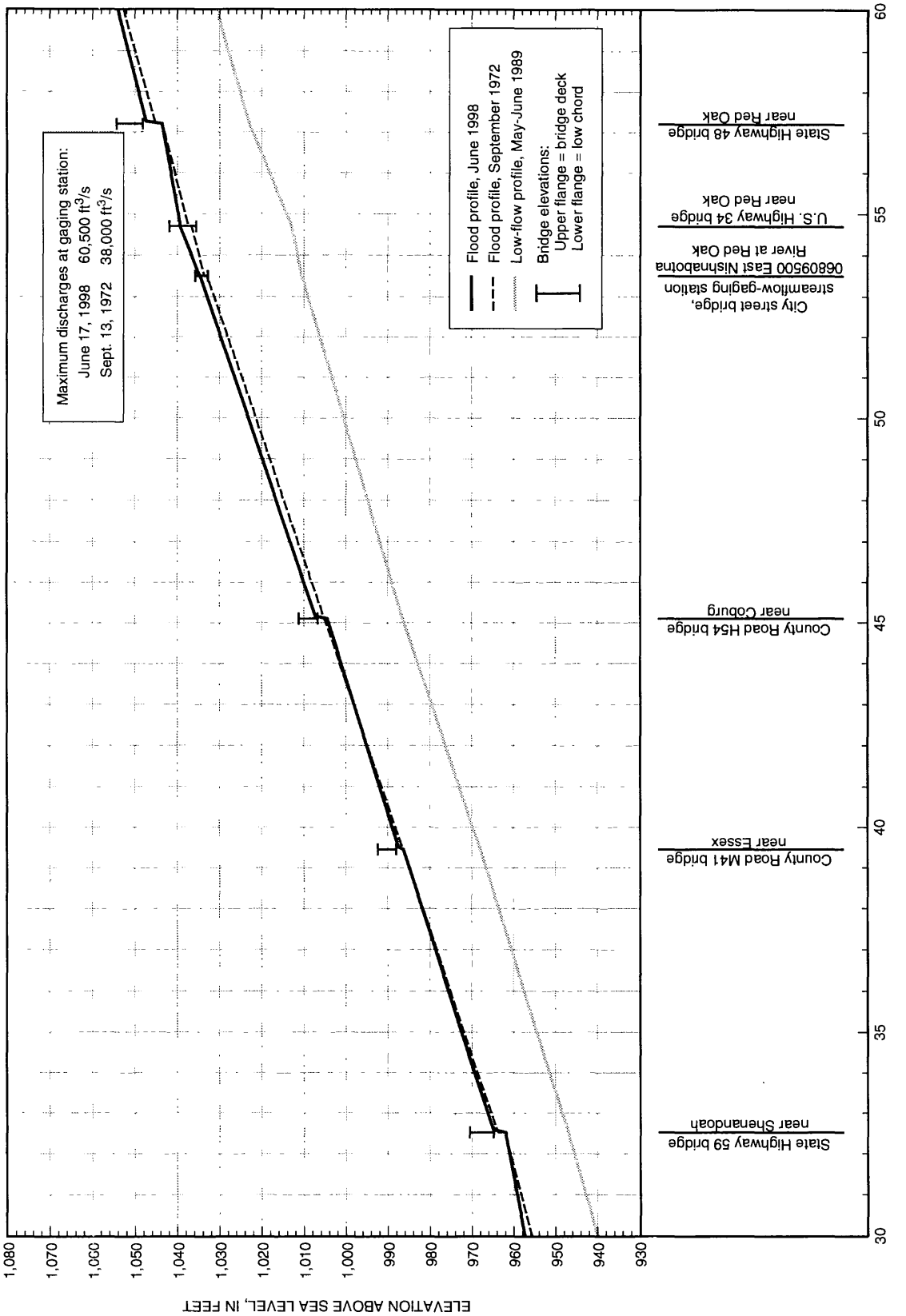

Figure 5. *Profile of the June 1998 flood in the Nishnabotna and East Nishnabotna Rivers, river miles 30 to 60*

(1972 and 1989 profiles from Eash and Heinitz, 1991).

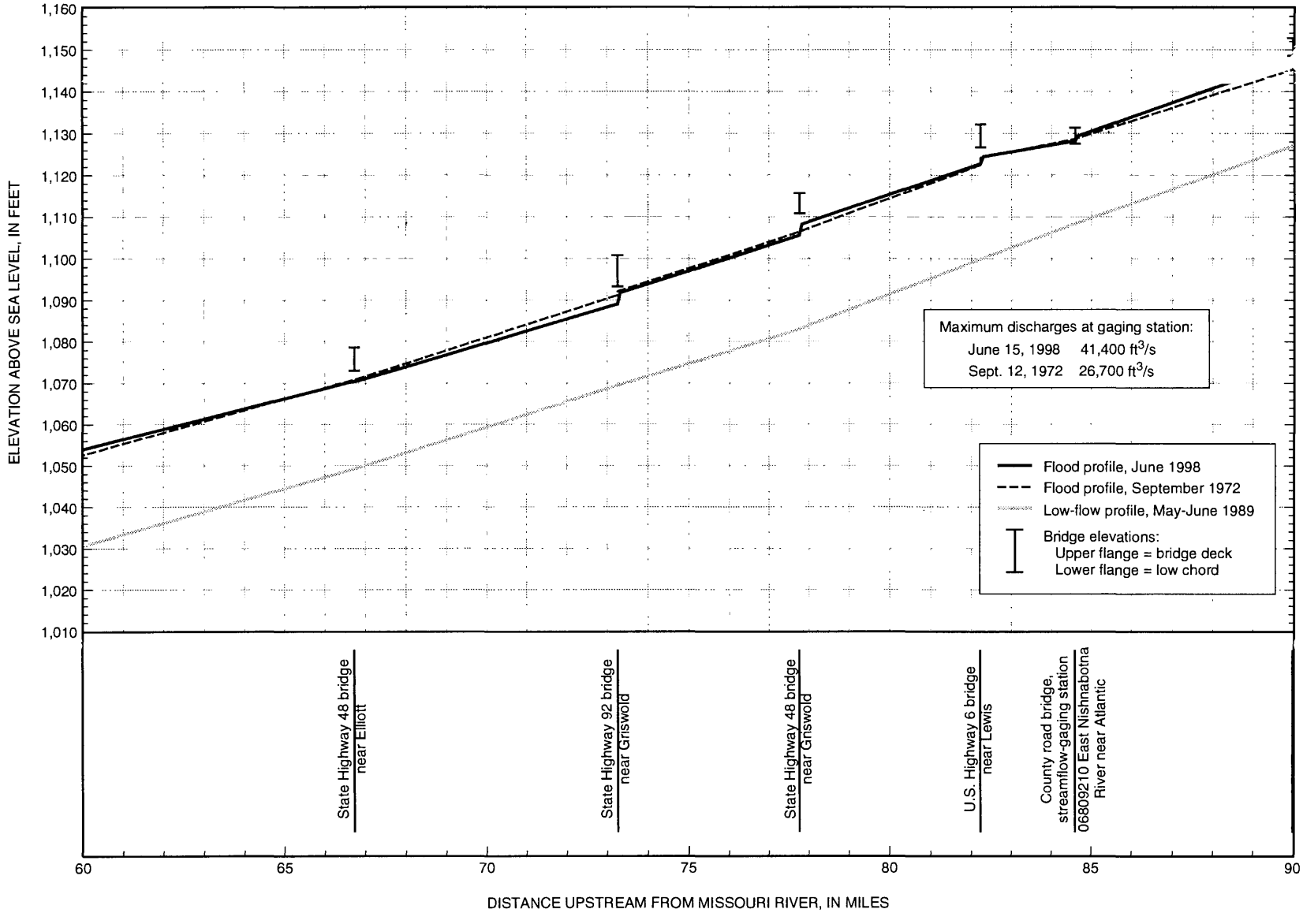

Figure 6. *Profile of the June 1998 flood in the Nishnabotna and East Nishnabotna Rivers, river miles 60 to 90*

(1972 and 1989 profiles from Eash and Heinitz, 1991).

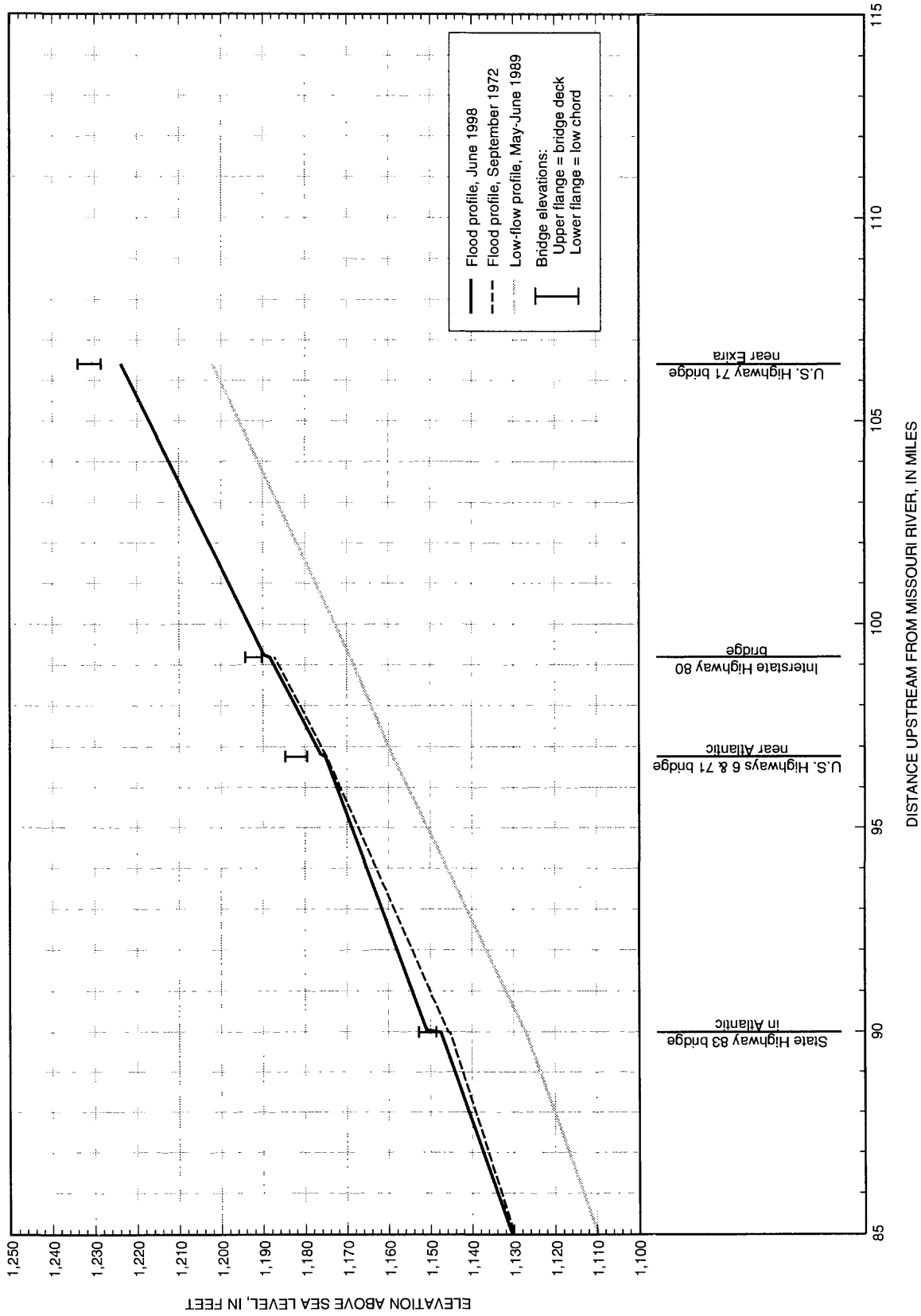

Figure 7. *Profile of the June 1998 flood in the Nishnabotna and East Nishnabotna Rivers, river miles 85 to 106*

(1972 and 1989 profiles from Eash and Heinitz, 1991).

Table 2. *Elevations of high water marks used in the Nishnabotna and East Nishnabotna Rivers flood profile, flood of June 15–17, 1998.*

[HWM, high water mark; --, not measured]

Distance upstream from Missouri River (river miles)	Description	Downstream HWM (ft above sea level)	Upstream HWM (ft above sea level)
9.05	Interstate Highway 29 bridge	922.29	--
11.37	U.S. Highway 275 bridge at Hamburg	925.38	925.99
13.80	Streamflow-gaging station 06810000 Nishnabotna River above Hamburg	927.45	--
19.05	County Road J46 bridge at Riverton	930.53	930.53
28.00	State Highway 2 bridge near Farragut	951.07	953.95
32.52	State Highway 59 bridge near Shenandoah	961.93	964.92
39.45	County Road M41 bridge near Essex	986.30	987.50
45.10	County Road H54 bridge near Coburg	1004.46	1007.28
53.50	Coolbaugh Street bridge, streamflow-gaging station 06809500 East Nishnabotna River at Red Oak	1034.57	1035.00
54.70	U.S. Highway 34 bridge near Red Oak	1039.41	1039.42
57.20	State Highway 48 bridge near Red Oak	1043.60	1047.34
66.73	State Highway 48 bridge near Elliott	1070.42	1070.42
73.26	State Highway 92 bridge near Griswold	1089.03	1091.77
77.76	State Highway 48 bridge near Griswold	1105.57	1108.29
82.23	U.S. Highway 6 bridge near Lewis	1122.8	1124.45
84.60	County road bridge, streamflow-gaging station 06809210 East Nishnabotna River near Atlantic	1128.17	1129.36
89.99	State Highway 83 bridge in Atlantic	1147.48	1150.91
96.76	U.S. Highways 6 & 71 bridge near Atlantic	1175.18	1176.30
99.19	Interstate Highway 80 bridge	1188.35	1189.77
106.41	State Highway 71 bridge near Exira	1223.78	--

APPENDIX: LIST OF BENCH MARKS

Bench marks (BM) that were established for previous flood profile studies were used in this study to reference the profiles to the sea level datum. Only the BMs used to establish the 1998 flood elevations are listed. Many of the BMs were established in the 1970's (Eash and Heinitz, 1991, p. 88). Since the 1970's, BMs at several bridges were destroyed by bridge renovation or bridge replacement; new BMs were established at these sites. The elevations reflect third-order accuracy conventions of running level lines from bench marks established and adjusted by the National Mapping Division of the USGS and the National Geodetic Survey.

The BMs are identified by an index number that comprises the Public Land Survey System township, range, section number and quarter-section in which they are located. For example, 6642–3 NE is composed from township 66 north, range 42 west, section 3, northeast quadrant. Where more than one BM is located in the same quarter section, the indices are followed by an order number in parentheses.

The BMs are listed in downstream to upstream order with respect to their correspondence to bridges over the Nishnabotna and East Nishnabotna Rivers. Users are cautioned that the BMs in this list might be altered or destroyed since being used to establish elevations presented in this report.

6642-3 NE – About 1.5 miles south of Hamburg in Missouri, on downstream Interstate Highway 29 bridge over Nishnabotna River, on top of curb at left downstream corner, a chiseled square. Elevation provided by Missouri Department of Transportation.

Elevation 931.67 ft

6742-22 SE – At Hamburg, on U.S. Highway 275 bridge over Nishnabotna River, on top of right downstream guardrail, a chiseled cross.

Elevation 931.35 ft

6841-29 NW – At Riverton, on County Road J46 bridge over East Nishnabotna River, on left downstream abutment, standard disk stamped "J 9 Reset 1975."

Elevation 936.51 ft

6940-28 SE – About 2.5 miles northeast of Farragut, on State Highway 2 bridge over East Nishnabotna River, on right upstream abutment curb, an Iowa Highway Commission bench mark. Elevation provided by Iowa DOT.

Elevation 957.61 ft

6940-13 NE – About 1.5 miles north of Shenandoah, on U.S. Highway 59 bridge over East Nishnabotna River, on curb at left downstream end of bridge, an Iowa Highway Commission bench mark.

Elevation 970.68 ft

7039-23 NW – About 1 mile northwest of Essex, on County Road M41 bridge over East Nishnabotna River, on curb behind left upstream wingwall, a bolt head.

Elevation 992.45 ft

7139-36 NE – About 0.5 miles west of Coburg, on County Road H54 bridge over East Nishnabotna River, on left downstream abutment, a chiseled square.

Elevation 1,009.58 ft

7238-20 NW – About 1 mile northwest of Red Oak, on U.S. Highway 34 bridge over East Nishnabotna River, on left downstream abutment, an Iowa Highway Commission bench mark.

Elevation 1,041.91 ft

7238-9 SW – About 1.5 miles north of Red Oak, on State Highway 48 bridge over East Nishnabotna River, on left upstream wingwall, an Iowa DOT bench mark.

Elevation 1,056.86 ft

7338-11 NE – About 0.5 miles west of Elliott, on State Highway 48 bridge over East Nishnabotna River, on downstream curb near center of bridge, a chiseled square.

Elevation 1,079.21 ft

7438-1 SE – About 1 mile west of Griswold, on State Highway 92 bridge over East Nishnabotna River, on left downstream wingwall, a chiseled cross. Elevation provided by Iowa DOT. (BM destroyed when bridge replacement commenced in fall 1998.)

Elevation 1,100.37 ft

7537-18 SE – About 3.5 miles north of Griswold, on State Highway 48 bridge over East Nishnabotna River, on top of right downstream abutment, a chiseled square.

Elevation 1,116.39 ft

7537-3 SE – About 0.5 miles north of Lewis, on U.S. Highway 6 bridge over East Nishnabotna River, on right upstream wingwall, an Iowa Highway Commission bench mark.

Elevation 1,132.95 ft

7636-6 SE (1) – At Atlantic, on State Highway 83 bridge over East Nishnabotna River, on right downstream wingwall, an Iowa DOT bench mark.

Elevation 1,155.26 ft

7636-6 SE (2) – At Atlantic, on State Highway 83 bridge over East Nishnabotna River, on right upstream wingwall, an Iowa DOT bench mark.

Elevation 1,155.30 ft

7736-14 SE – About 2.3 miles south of Interstate Highway 80, on U.S. Highways 6 and 71 bridge over East Nishnabotna River, on downstream curb at 19th guardrail post from right end of bridge, a chiseled arrow.

Elevation 1,185.08 ft

7736-1 SE – About 0.8 miles east of U.S. Highway 71 intersection, on downstream Interstate Highway 80 bridge over East Nishnabotna River, on right downstream abutment, an Iowa Highway Commission bench mark.

Elevation 1,194.95 ft

7835-4 SW – At Exira, on U.S. Highway 71 bridge over East Nishnabotna River, on left downstream wingwall curb, a standard National Geodetic Survey brass tablet. Elevation provided by Iowa DOT.

Elevation 1,233.51 ft

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