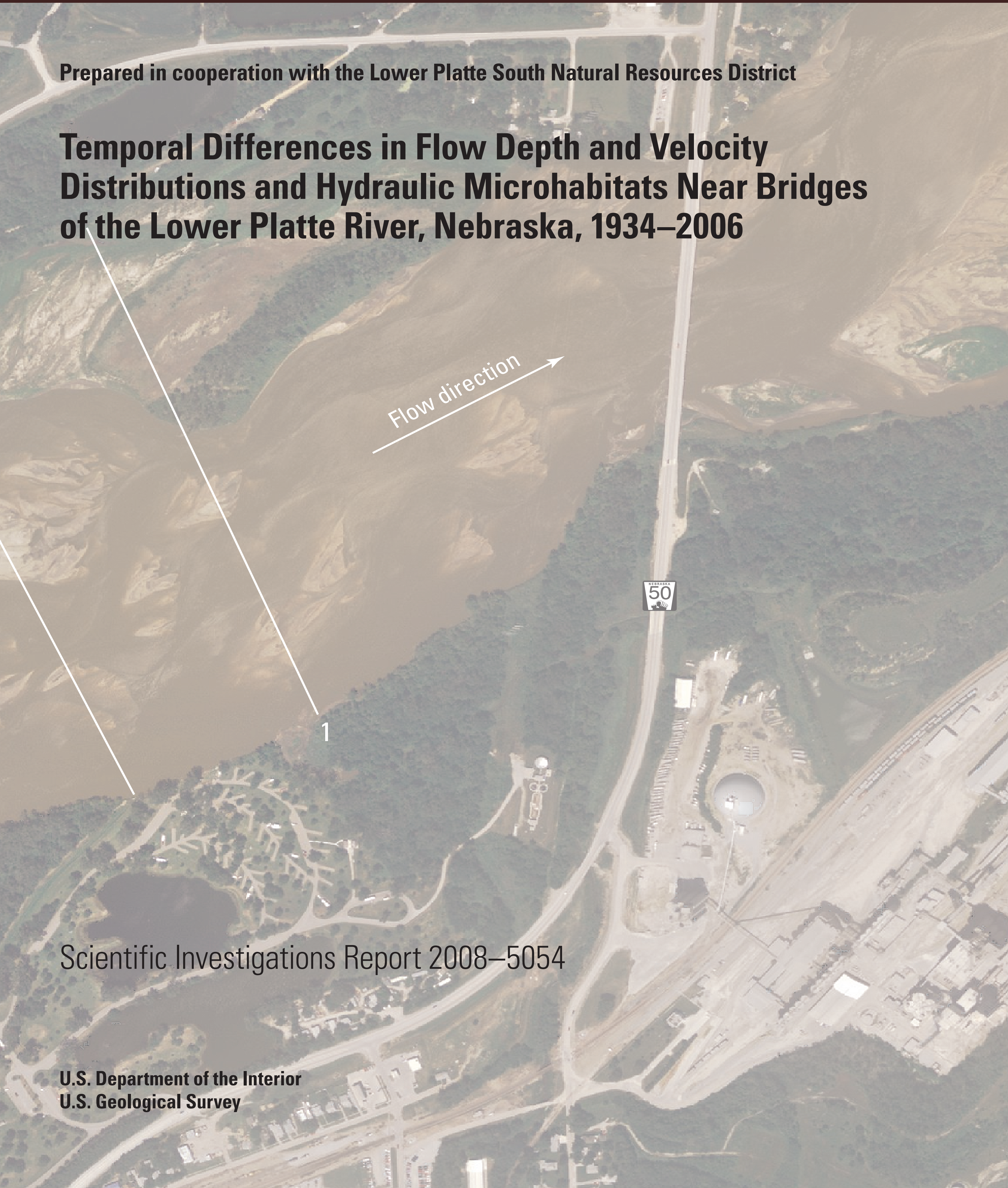
USGS

science for a changing world

Prepared in cooperation with the Lower Platte South Natural Resources District

# Temporal Differences in Flow Depth and Velocity Distributions and Hydraulic Microhabitats Near Bridges of the Lower Platte River, Nebraska, 1934–2006




Scientific Investigations Report 2008–5054

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

**Front cover:** Location of surveyed cross-sectional transects (1985) upstream from bridge on aerial orthophoto of stream channel (2003) of the Platte River at Louisville, Nebraska (Aerial digital orthophoto from the Farm Service Agency, 2003).

# Temporal Differences in Flow Depth and Velocity Distributions and Hydraulic Microhabitats Near Bridges of the Lower Platte River, Nebraska, 1934–2006

By Daniel Ginting and Ronald B. Zelt

Prepared in cooperation with the Lower Platte South Natural Resources District

Scientific Investigations Report 2008–5054

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

**U.S. Department of the Interior**
DIRK KEMPTHORNE, Secretary

**U.S. Geological Survey**
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2008

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS



Suggested citation:
Ginting, Daniel, and Zelt, R.B., 2008, Temporal differences in flow depth and velocity distributions and hydraulic microhabitats near bridges of the lower Platte River, Nebraska, 1934–2006: U.S. Geological Survey Scientific Investigations Report 2008–5054, 98 p.

# Contents



# Figures

# Tables

## Appendixes

# Conversion Factors

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| | Area | |
| square foot ($ft^2$) | 0.09290 | square meter ($m^2$) |
| | Flow rate | |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| | Flow velocity | |
| foot per second (ft/s) | 0.3048 | meter per second (m/s) |
| | Unit discarge | |
| square foot per second ($ft^2/s$) | 0.09290 | square meter per second ($m^2/s$) |

Water year is defined as the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends.

# Temporal Differences in Flow Depth and Velocity Distributions and Hydraulic Microhabitats near Bridges of the Lower Platte River, Nebraska, 1934–2006

By Daniel Ginting and Ronald B. Zelt

## Abstract

As part of a collaborative study of the cumulative impacts on stream and riparian ecology of water and channel management practices in the lower Platte River, Nebraska, this report describes a study by the U.S. Geological Survey in cooperation with the Lower Platte South Natural Resources District that summarizes: (1) temporal differences in distribution of streamflow depth, velocity, and microhabitats among five discrete 11-water-year periods 1934–44, 1951–61, 1966–76, 1985–95, and 1996–2006, and (2) the effects of bridge proximity on distribution of streamflow depth, velocity, and microhabitat of the Platte River when cross sections were measured at a similar discharge. The scope of the study included the four presently (2008) active streamflow-gaging stations located near bridges over the lower Platte River at North Bend, near Leshara, near Ashland, and at Louisville, Nebraska, and the most downstream streamflow-gaging station within the central Platte River segment near Duncan, Nebraska.

Generally, in cases where temporal differences in streamflow depth and velocity were evident, at least one of the water-year periods from 1934 through 1995 had deeper streamflow than the recent water-year period (1996–2006). Temporal differences in distributions of streamflow depth were not strongly associated with differences in either climatic conditions or the maximum peak flow that occurred prior to the latest discharge measurement during each period. The relative cross-sectional area of most hydraulic niches did not differ among the water-year periods. Part of this apparent uniformity likely was an artifact of the broad microhabitat classification used for this study. In cases where temporal differences in relative cross-sectional area of hydraulic niches were evidenced, the differences occurred during high- and low-flow conditions, not during median flow conditions. The temporal differences in relative cross-sectional area were found more frequently for hydraulic niches defined by moderate and fast velocities than for hydraulic niches defined by slow velocities. Generally, any significant increase or decrease in the relative cross-sectional areas of hydraulic niches during the water-year periods from 1934 through 1995 had disappeared during the most recent water-year period, 1996–2006.

Deep-Swift niche was the predominant hydraulic niche for all near-bridge sites on the lower Platte River for high- and median-flow conditions. The Deep-Swift niche also was the predominant niche for the near-bridge sites near Ashland and at Louisville for low-flow conditions; for the near-bridge sites at North Bend and near Leshara, streamflow cross-sectional areas during low-flow conditions were shared among the Shallow-Moderate, Intermediate-Moderate, Intermediate-Swift, and Deep-Swift hydraulic niches. For the near-bridge site near Duncan, the site farthest downstream in the central Platte River system, the Deep-Swift hydraulic niche was predominant only during high-flow conditions; during median- and low-flow conditions the relative cross-sectional area was shared among the Shallow-Slow, Shallow-Moderate, Intermediate-Moderate, and Intermediate-Swift hydraulic niches.

Significant temporal differences in the relative cross-sectional area of the Deep-Swift hydraulic niche were found for sites near the two farthest downstream bridges near Ashland and at Louisville, but only for low-flow conditions. The Deep-Swift microhabitat was of special interest because it is the preferred hydraulic habitat during the adult life of the endangered pallid sturgeon (*Scaphirhynchus albus*). Temporal differences in relative cross-sectional areas of the Glide low-flow geomorphic microhabitat that contained the Deep-Swift hydraulic niche also indicated that relative cross-sectional areas of the Glide during the 1951–61 and 1996–2006 water-year periods were lower than during the 1966–76 period. The temporal differences indicated that any significant temporal change in relative cross-sectional area of the Deep-Swift hydraulic niche, and the Glide and Race microhabitats near the two farthest downstream bridges (near Ashland and at Louisville) since the 1951–61 water-year period had nearly disappeared during the most recent water-year period (1996–2006). It may indicate no evidence of net reduction in the relative cross-sectional area of either the Deep-Swift or the Glide and Race habitats near the two farthest downstream bridges (near Ashland and at Louisville).

The effects of bridge proximity on streamflow depth, velocity, and microhabitats were evaluated for median- and low-flow conditions; high-flow conditions were not evaluated because no cross-sectional measurement was made for

beyond-bridge sites. Streamflows for median-flow conditions were deeper for the near-bridge sites than the beyond-bridge sites at North Bend and near Ashland for the 70th or higher percentiles of the area cumulative frequency distribution. Generally, for low-flow conditions, bridge proximity had no effects on the streamflow depths for sites at North Bend and near Leshara. The effect of bridge proximity on streamflow velocities was either absent or inconclusive. Bridge proximity affected four of the nine hydraulic niches. The relative cross-sectional areas of the Deep-Moderate and Intermediate-Slow hydraulic niches were larger (at Louisville) or similar (at North Bend) for the near-bridge site than for the beyond-bridge site during median-flow conditions. The relative cross-sectional area of the Deep-Moderate hydraulic niche (at North Bend) and the Shallow-Moderate (at Louisville) was larger for the beyond-bridge site than the near-bridge site. The near-bridge and beyond-bridge sites did not differ in relative cross-sectional area of the Deep-Swift hydraulic niche for median-flow conditions. Historical cross-sectional measurements made near near-bridge sites can be used as a primary data set in hydraulic-habitat study, before embarking on a more spatially intensive but costly program of streamflow-depth and -velocity data collection.

# Introduction

The streamflow regime (magnitude, duration, frequency, timing, and rate of change in streamflow time series) and its interaction with other factors results in multiscale habitat complexity. At the basin scale, climate and geology govern the supply, delivery, and quality of runoff and sediment that together largely delimit the potential for channel habitat. At the segment scale, the effects of channel gradient and streamflow are clearly seen (McKenney, 1997; Moir and others, 1998), and micro-scale habitats (microhabitats) are characterized by such streamflow-regime products as bed substrate, hydraulic obstructions, and turbulent vortices (McKenney, 1997; Fitzpatrick and others, 1998). For example, at the local or reach scales, the hydraulic variables exert an important effect on salmonid spawning (Kondolf and Wolman, 1993). Habitat complexity necessitates development of stream habitat classification systems. Classification systems based on morphology and process criteria, such as local gradient or velocity, cross-section morphometry, substrate caliber, and formative structural elements and processes, are broadly applicable for many stream types (McKenney, 1997; Kondolf and others, 2003). For comparability purposes, hydraulic habitat classification systems could be based on hydraulic conditions at similar base flow or other low-flow conditions (Rabeni and Jacobson, 1993; McKenney, 1997).

Understanding how streamflow magnitude (high-, median-, and low-flow conditions) affects stream hydraulics (for example, streamflow depth and velocity) and physical habitat distribution and availability is crucial because even moderate alteration in the streamflow regime (magnitude) can produce large shifts in available habitat (Nebraska Game and Parks Commission, 1993; Stalnaker and others, 1996; McKenney, 1997; Bowen and others, 2003). Streamflow magnitude of the lower Platte River (fig. 1) was greatly dependent on climate and has been altered by storage reservoirs, streamflow regulation, and other water management projects (Ginting and others, 2008). Hydrologic alteration often is regarded as a serious threat to riparian ecological sustainability (Nilsson and Svedmark, 2002; Annear and others, 2004; Bunn and others, 1999; Bunn and Arthington, 2002). Evaluation of streamflow effects on hydraulic habitats on the lower Platte River is particularly important because the lower Platte River provides riverine habitat for resident and migratory fish and wildlife species (Nebraska Game and Parks Commission, 1993), including State and federally listed endangered species.

## Lower Platte River Cumulative Impact Study

A cumulative impact study (CIS) for the lower Platte River was begun in 2006. A CIS consortium was formed to include federal (U.S. Geological Survey, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service) and the State institutions (Lower Platte River Corridor Alliance, Nebraska Environmental Trust, Nebraska Game and Parks Commission, Nebraska Department of Natural Resources, Nebraska Department of Roads, the University of Nebraska-Lincoln; and the Lower Platte North, the Lower Platte South, and the Papio-Missouri River Natural Resources Districts). The goal of the consortium was to analyze past, present, and future changes in infrastructure, land use, river management, and hydrology to understand how each of these general factors interrelated to the river, its flood plain, and the bluff-to-bluff corridor. The collaborative CIS was based largely on the analysis of a time series of available aerial photography from 1938, 1954–56, 1973, 1993, and 2002. As part of this consortium, the U.S. Geological Survey (USGS), in cooperation with the Lower Platte South Natural Resources District, compiled available data for analysis of temporal differences in streamflow depth and velocity for various percentiles of the area cumulative frequency distribution (ACFD) and in the extent of microhabitats. The extent of microhabitats was based on cross-sectional information from discharge measurements at long-term USGS streamflow-gaging stations (hereinafter referred to as streamflow-gaging stations) located near bridges on the lower Platte River. Insufficient numbers of discharge measurements were made in any given year to reliably represent or characterize a useful range of flow conditions, so the USGS analysis included data from discharge measurements made within 3 to 4 years of the aerial photography selected by the CIS consortium.

The objectives of the USGS analysis were: (1) to determine whether or not any temporal differences existed in cross-sectional cumulative distributions of water depth, velocity, and microhabitat of near-bridge sites among the five selected water-year periods, (2) to interpret any significant temporal differences in relation to climate conditions or other factors, and (3) to describe spatial differences in cross-sectional cumulative distribution of water depth, velocity, and hydraulic microhabitats between the near-bridge site from the beyond-bridge site when cross sections were measured at a similar discharge. The "near-bridge" sites refer to locations within 100 ft downstream or upstream from a bridge. The "beyond-bridge" sites refer to other locations within the same river segment (that is, a bridge-to-bridge segment). The cross-sectional data of the beyond-bridge sites were critical in evaluating whether or not cross-sectional measurements of the near-bridge sites are biased for or against some habitat types.

## Purpose and Scope

This report summarizes and describes temporal differences in the cross-sectional ACFD of water depth, velocity, and microhabitats (hydraulic niches, and low-flow geomorphic microhabitats) of near-bridge sites on the lower Platte River during high-, median- and low-flow conditions among five selected water-year periods from 1934 through 2006. This report includes data for four presently (2008) active streamflow-gaging stations located near bridges over the lower Platte River main stem at North Bend, near Leshara, near Ashland, and at Louisville, Nebraska, where streamflow records were available for more than 10 years during 1934–2006, as well as the farthest downstream streamflow-gaging station within the central Platte River segment near Duncan, Nebraska, that flows to the confluence with the Loup River (fig. 1).

# Data and Methodology

Daily mean discharge and annual peak discharge for water years from 1934 through 2006 at five streamflow-gaging stations (06774000, Platte River near Duncan; 06796000, Platte River at North Bend; 06796500, Platte River near Leshara; 06801000, Platte River near Ashland; and 06805500, Platte River at Louisville) on the main stem of the Platte River (fig. 1) were acquired from the USGS National Water Information System (NWIS) (U.S. Geological Survey, 2007). Note that periods of record were not identical for all streamflow-gaging stations. Any missing daily streamflow values for each period were estimated using physical model simulation with Diffusion Analogy Flow (DAFLOW) software (Jobson, 1989) and a statistical approach. Details of daily streamflow estimation and quality assurance of estimated data used in this report were described by Ginting and others (2008).

Historical daily discharge, historical cross-sectional discharge measurements, and habitat classification systems were the primary information needed in the analysis of temporal differences in streamflow depth, velocity, and hydraulic microhabitats. Daily-mean discharges and annual peak discharges were used to determine discharge ranges that define high-, median-, and low-flow conditions for each streamflow-gaging station. Discharge ranges for each flow condition were then used to select discharge-measurement field notes. Cross-sectional data recorded on the discharge-measurement field notes were used to calculate the ACFD of streamflow depth and velocity, and the extent of hydraulic microhabitat types. The overall sequence of data analysis is presented in figure 2.

## Discharge Ranges for Streamflow Conditions

Discharge targets for high-, median-, and low-flow conditions were determined using a cumulative probability or frequency curve. The use of a target with uniform probability or frequency of flow occurrence allowed temporal comparison (over time) at a station and spatial comparison (among localities).

### High-Flow Condition

Annual peak discharges for the five streamflow-gaging stations on the Platte River for water years 1934 through 2006 were acquired from the NWIS (U.S. Geological Survey, 2007). The uniquely low annual peak discharge was excluded for the streamflow-gaging station near Duncan from 1941, the year when Kingsley Dam was closed on the North Platte River. Input data sets of the annual series of peak discharge for each of the five stations were prepared for the USGS PeakFQ program (Flynn and others, 2006). The USGS PeakFQ program was used to find a high discharge of common annual probability among all five streamflow-gaging stations for which an adequate number of comparable measurements were available for all five water-year periods. Several iterations led to the selection of the peak discharge that occurs with 99-percent probability per year ($Q_{pk,0.99}$). Discharge ranges for the high-flow condition were determined as the peak discharge, $Q_{pk,\ 0.99}$, minus and plus 10 percent (table 1).

### Low- and Median-Flow Conditions

The daily series of mean discharges for each of the streamflow-gaging stations during the five water-year periods were combined to construct the cumulative frequency distribution for each near-bridge site. Discharges at the 16th and 50th percentiles were selected as the midpoints for the low- and median–flow conditions, respectively. The 16th and 50th percentiles are the discharges that are equaled or exceeded 84 and 50 percent of the time, respectively. The discharge ranges for low- and median-flow conditions were determined as the discharge midpoint minus and plus 10 percent (table 1).

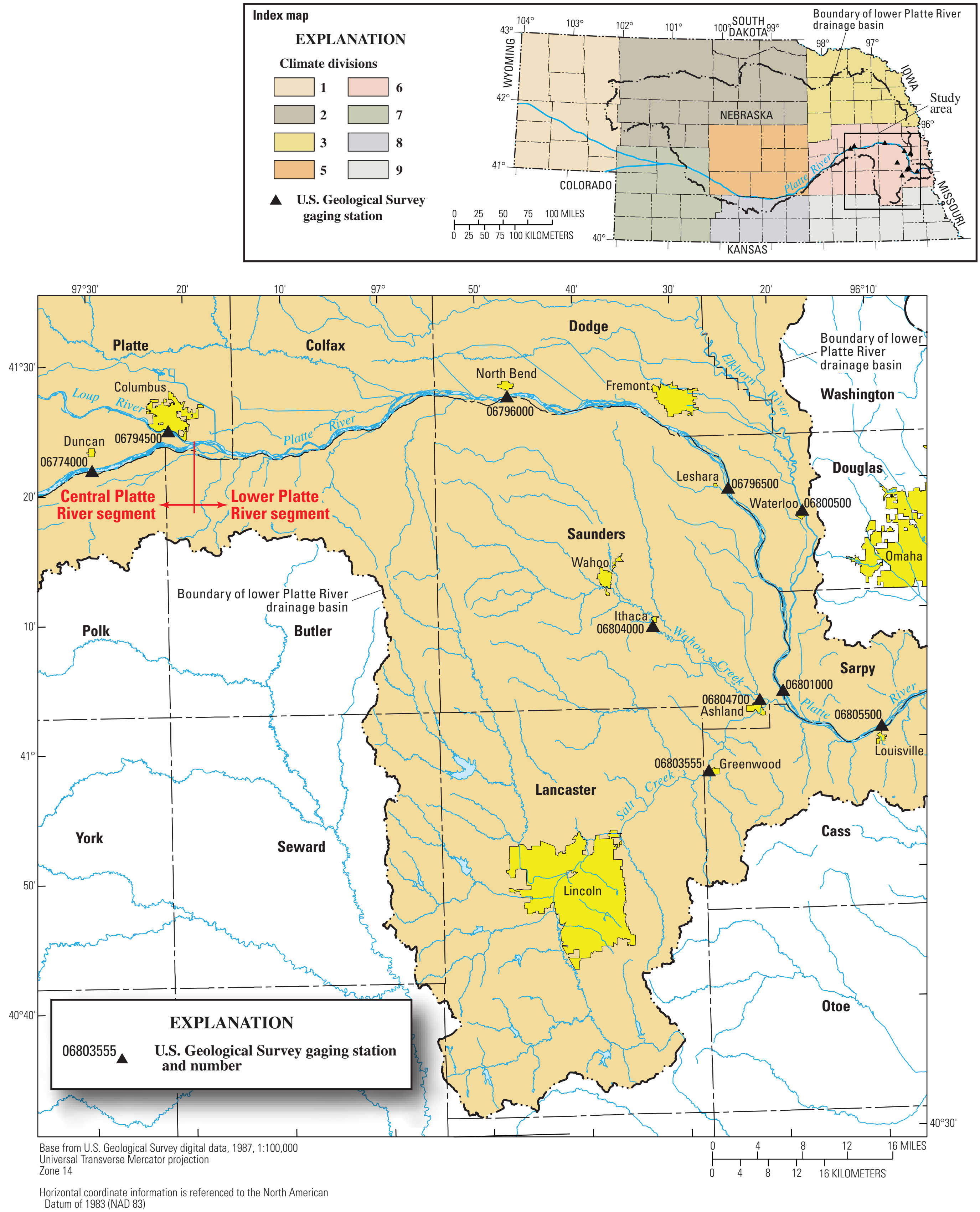



**Figure 1.** Location of study area and gaging stations on the Platte River main stem near Duncan, North Bend, Leshara, Ashland, and Louisville and on the contributing tributaries, Nebraska.

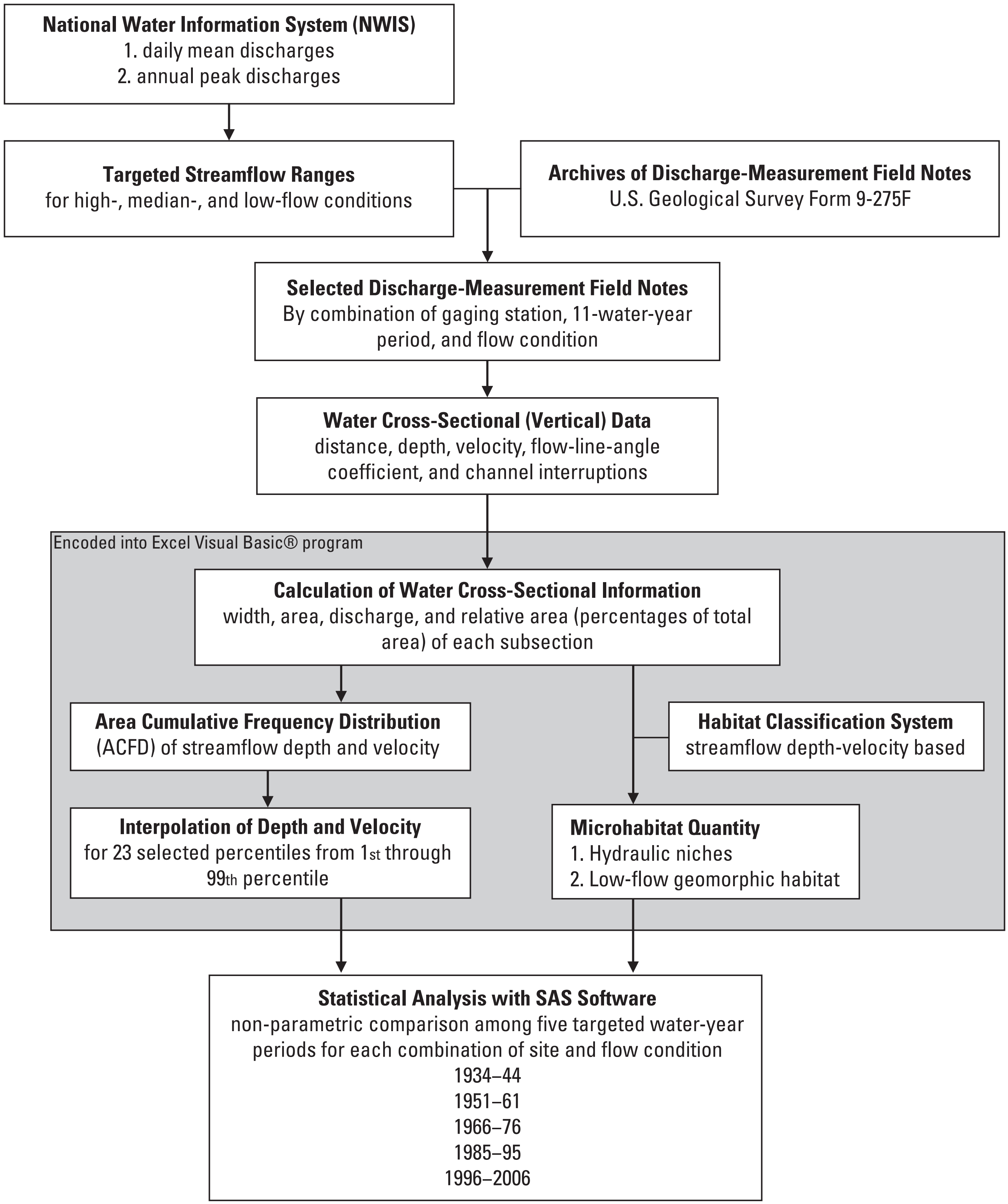



**Figure 2.** Sequence of data analysis for calculation of area cumulative frequency distribution (ACFD) of streamflow depth and velocity, and quantity of hydraulic microhabitats from discharge measurements.

**Table 1.** Discharge ranges for high-, median-, and low-flow conditions at the U.S. Geological Survey streamflow-gaging stations located near bridges over the Platte River.

[Discharge, in cubic feet per second; midpoint (not listed) for high-flow condition equals peak streamflow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively; min, minimum; max, maximum; the minimum and maximum values are plus and minus 10 percent of the midpoint value; C, central Platte River segment; L, lower Platte River segment]

| Station and number | High-flow condition | | Median-flow condition | | Low-flow condition | |
|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max |
| Duncan (C) 06774000 | 1,902 | 2,320 | 1,026 | 1,368 | 225 | 275 |
| North Bend (L) 06796000 | 6,960 | 8,280 | 3,231 | 3,949 | 1,584 | 1,936 |
| Leshara (L) 06796500 | 5,810 | 6,770 | 3,460 | 4,228 | 1,638 | 2,002 |
| Ashland (L) 06801000 | 10,700 | 12,800 | 3,951 | 4,830 | 1,800 | 2,200 |
| Louisville (L) 06805500 | 10,100 | 12,000 | 4,392 | 5,368 | 2,016 | 2,463 |

## Selection of Historical Cross-Sectional Discharge Measurements for Near-Bridge Sites

Water years 1938, 1955, 1971, 1993, and 2003 were selected as targeted water years for the five 11-water-year periods: 1934–44, 1951–61, 1966–76, 1985–95, and 1996–2006, respectively. A five-fold filter was applied to identify discharge measurements as candidates for inclusion as cross-sectional measurements for each 11-water-year period. Acceptable measurements were those:

1. within the discharge-range boundaries (table 1);
2. within 3 years of the target water year;
3. within 100 ft from the bridge (near-bridge site);
4. with measurement-conditions quality rated not less than "fair" and with most of the station-period-streamflow condition subset being rated not less than "good;" and
5. at the same streamflow-gaging station location near the bridge.

Information for criterion "2," "3," and "4" for each discharge measurement is available on the front page of USGS Form 9-275F (fig. 3), hereinafter referred to as discharge-measurement field note. Based on criterion "5," some measurements were excluded while a gaging station was temporarily relocated. For example, measurements for the streamflow-gaging station at Louisville during the 1966–76 period were excluded because at that time the streamflow-gaging station temporarily was relocated upstream; the exclusion, however, still left at least four usable measurements for each of the targeted flow conditions. At times, the temporal criterion "2" was relaxed until at least three candidate measurements were included.

Measurements that passed the five-fold filter were further reviewed for any indication that the criteria were not satisfied; for example, the calculated discharge value may change when recomputed using the present-day method (center of subsection) because the former method (mean of subsection edges) of representing the cross-channel subsections changed between the 1938 and 1955 target water years (Rantz and others, 1982). A change in the discharge value could result in a candidate measurement failing to satisfy criterion "1."

## Area Cumulative Frequency Distribution of Streamflow Depth and Velocity

Stream discharge has been determined by measuring water depth and velocity at many verticals while traversing the wetted-channel cross section (Rantz and others, 1982). The locations of verticals were the distances from a reference point (distance=0), a stationary point on the left side when facing downstream (USGS convention). The discharge-measurement field notes consisted of two primary parts, general information on the front page and details of vertical measurements data on the remaining pages. As an example, information from an actual discharge measurement on June 27, 2003, for the Platte River streamflow-gaging station near Ashland, Nebraska, is presented in figures 3 and 4.

General information on the front page (fig. 3) includes station identification and date of measurement, information about conditions for measurement, and the summary of discharge calculation. Details of the individual subsection (vertical) measurements on the remaining pages of the

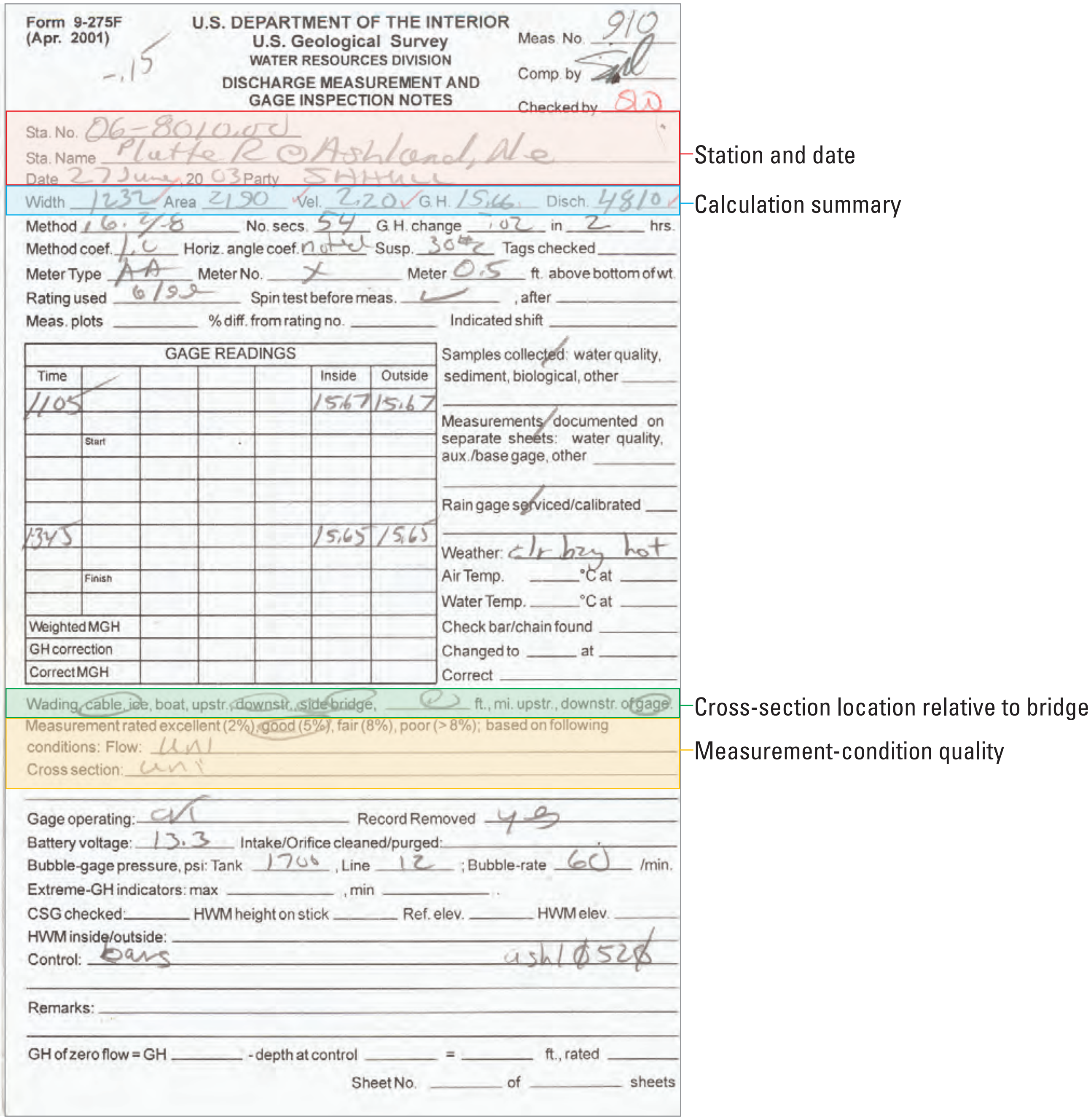



**Figure 3.** General information and summary calculation for discharge measurements near the Platte River bridge near Ashland, Nebraska, on June 27, 2003, recorded on the front page of the U.S. Geological Survey Form 9-275.

discharge-measurement field note are organized in separate columns (fig. 4), including the distance from a reference point, water depth, velocity, horizontal flow-line-angle coefficient, locations of left and right edge of water, and locations of left and right edges of channel interruptions (sandbars, islands, and piers). In addition to the vertical measurements, details of the manual calculations are made on the remaining pages to obtain the summary discharge information for the front page of the discharge-measurement field note.

Depending on streamflow and other complexities in braided channels, such as sandbars, islands, and other flow interruptions, 25 to 70 subsections (verticals) are measured such that discharge at each subsection composes no more than 5 to 10 percent of the total discharge. As examples, data density for one representative discharge measurement for each of high-, median-, and low-flow conditions is presented in figure 5.

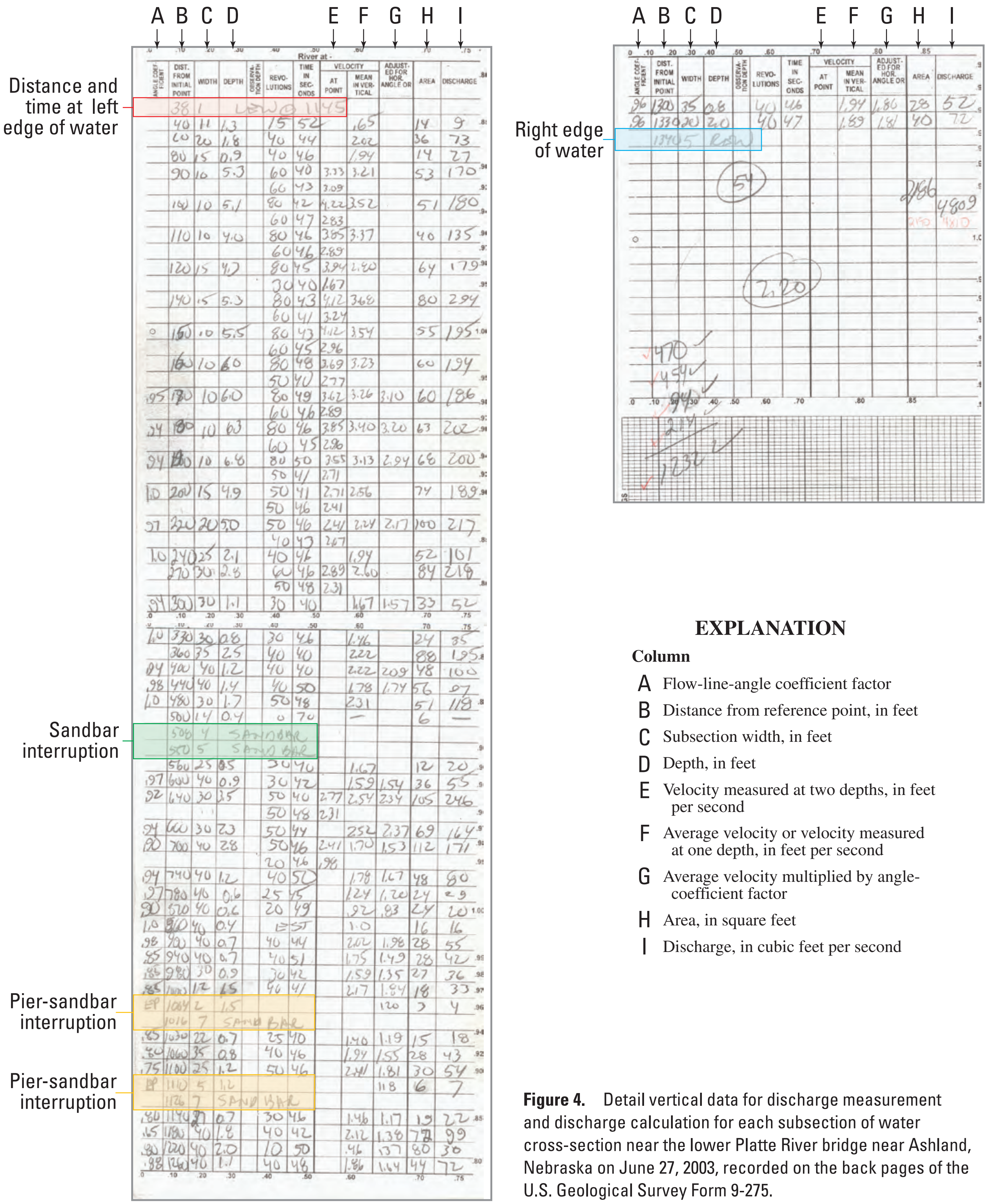



**Figure 4.** Detail vertical data for discharge measurement and discharge calculation for each subsection of water cross-section near the lower Platte River bridge near Ashland, Nebraska on June 27, 2003, recorded on the back pages of the U.S. Geological Survey Form 9-275.

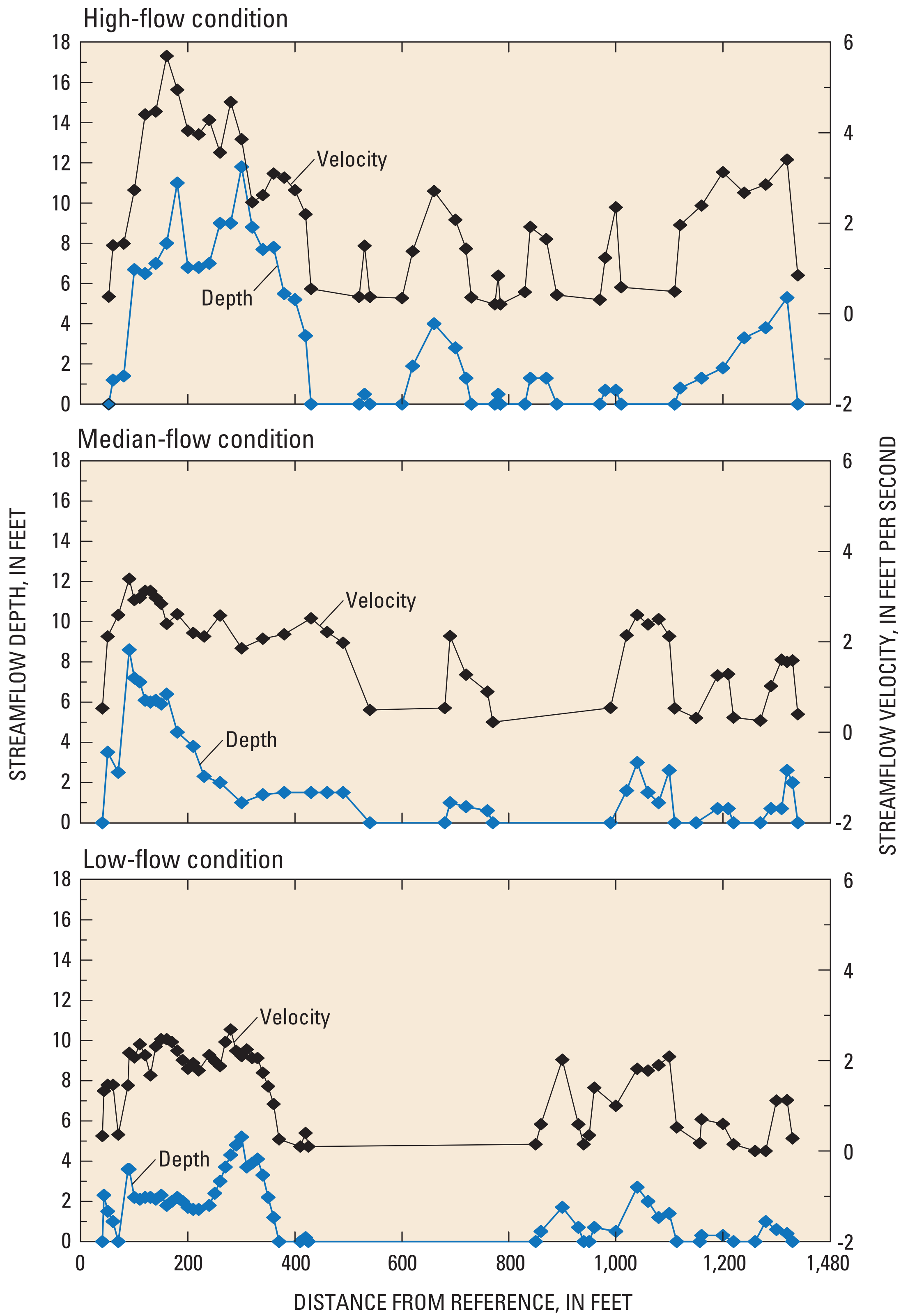



**Figure 5.** Examples of streamflow depth and velocity data density for water cross section during high-, median-, and low-flow conditions in 2003 near the lower Platte River bridge near Ashland, Nebraska.

## Calculation of Width, Area, and Discharge of Cross-Sectional Subsections

Discharge measurements use a series of individual measurements (verticals) to divide the water cross section into many subsections. A simplified diagram of water verticals and subsections within a cross section is presented in figure 6. The midpoint distances between a vertical and its two (left and right) neighboring verticals determine the width of a subsection (fig. 6; column C of fig. 4). The width of the subsection multiplied by the depth of the vertical (fig. 6; column D of fig. 4) results in a rectangle representing the area of each subsection (fig. 6, column H of fig. 4). The subsection area multiplied by the adjusted average velocity (column G of fig. 4) for each subsection equals the subsection discharge (column I of fig. 4). Depending on water depth of a subsection, one or two velocity measurements were made. If one velocity measurement was made, velocity measured at six-tenths of depth is used as the average velocity (column F of fig. 4). If two velocity measurements were made, the arithmetic average of velocity measurements at two-tenths and eight-tenths of depth (column E of fig. 4) is used as the average velocity for the subsection (column F of fig. 4). The adjusted average velocity (column G of fig. 4) is the average velocity multiplied by an adjustment factor (column A of fig. 4) to correct for horizontal flow-line direction being non-orthogonal to the cross section. Total water width, area, and discharge were derived as the sum of width, area, and discharge of all subsections.

Discharge calculation (fig. 4) ignores discharges from edge-water subsections because discharges from edge-water subsections (fig. 6) are much smaller than non-edge-water subsections and very small relative to the total discharge. Edge-water areas, in terms of hydraulic habitat, could not be ignored because the edge water was an important component of shallow pools represented by low velocity and shallow depth, especially when many sandbars and islands were located in the channel. In such cases, the mean depth and velocity of each edge-water subsection was estimated to be 0.25 times the depth and velocity of its adjacent vertical.

## Construction of Area Cumulative Frequency Distribution of Streamflow Depth and Velocity

The ACFD was calculated from the subsection measurement data. The percentage of total area (hereafter referred to as areal fraction) of each water subsection was first calculated. Subsections were then sorted by depth in ascending order and ranked from the shallowest to the deepest; for the velocity distribution, subsections were sorted by velocity in ascending order from the slowest to the fastest.

Cumulative-area percentage for each sorted subsection was derived as:

$$CA_i = \sum_{1}^{n} A_i \tag{1}$$

where $i$ is the depth (or velocity) ranking of a subsection [$i$=1 for the shallowest (or slowest) and $i$=$n$ for the deepest (or fastest)], $n$ is the total number of subsections, and $CA_i$ is the cumulative-area percentage for the $i$-ranked subsection. The value of $CA_n$ equals 100. As an example, the ACFD of streamflow depth for a discharge measurement on June 27, 2003 (fig. 4) near Ashland, Nebraska, is presented in figure 7.

Temporal comparison of depth (or velocity) cumulative distribution among the 11-water-year periods was based on interpolated depths (or velocities) for pre-selected percentiles common to all water-year periods, that is, for the 1st, 2nd, 98th, 99th, and every fifth percentile from the 5th through the 95th percentiles. Estimated depth (or velocity) for each selected percentile was derived by linear interpolation between two neighboring depths, which enclosed the percentile. An example of streamflow depths interpolated from the original ACFD of streamflow depth in figure 4 is presented in figure 7, which demonstrates that the interpolated ACFD accurately represents the original ACFD.

Plotting positions of values of a response variable (such as depth and velocity) and their corresponding cumulative-area percentages generates a curve similar to a cumulative frequency distribution. Throughout this report, the distribution is appropriately called ACFD (area cumulative frequency distribution) because the frequency is based on areal percentage. All calculation processes and construction of ACFDs of streamflow depth and velocity for each discharge-measurement field note were automated using the Cross-Sectional Hydraulic Habitat Distribution Calculator (CSHHAD_CAL), an Excel Visual Basic® program developed by the authors (fig. 2, Appendixes 17 and 18). The program required, as inputs, the cross-section distance, depth, velocity, horizontal flow-angle coefficients, and channel interruptions (left edge of water, right edge of water, left and right edges of sandbars, islands, and piers, if any). The program also calculated the quantity of microhabitats, which include hydraulic niches and low-flow geomorphic microhabitats, based on the habitat classification systems described in the next section of this report.

# Classification of Fishery Habitats Using Hydraulic Niches

The hydraulic-niche approach to fishery-habitat classification segregates the physical dimensions of a river reach or cross section into discrete depth and velocity combinations. Following Peters and Holland (1992), streamflow depths were divided into three classes: shallow (less than 1 ft), intermediate (1–2 ft), and deep (greater than 2 ft). Streamflow velocities also were divided into three classes: slow (less than 1 ft/s), moderate (1–2 ft/s), and swift (greater than 2 ft/s). The combinations of depth and velocity classes comprise nine

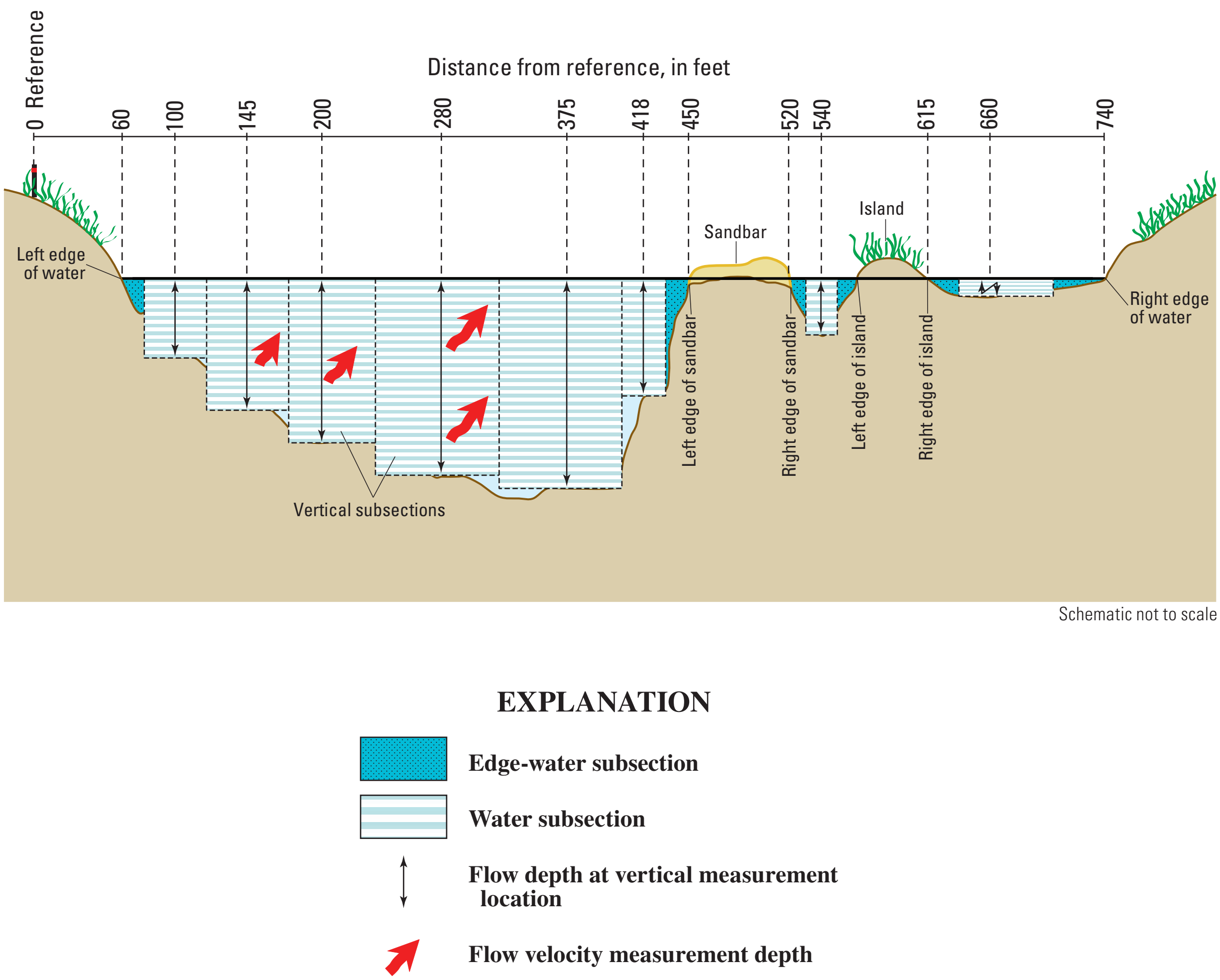



**Figure 6.** Simplified water cross section showing verticals, subsections, and channel interruptions facing downstream.

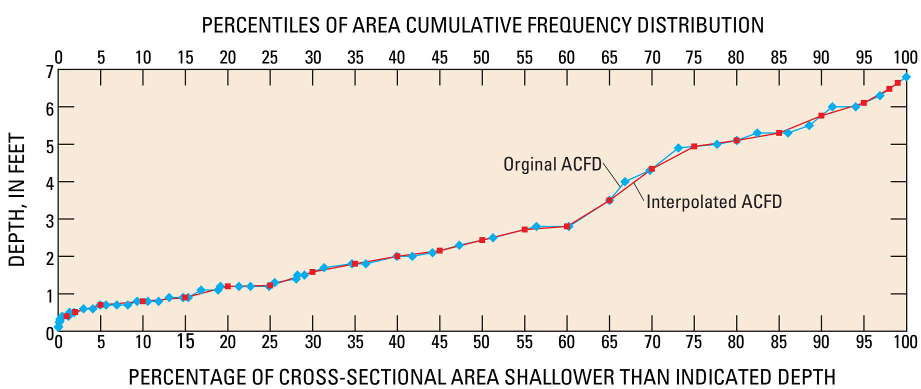



**Figure 7.** Original and interpolated area cumulative frequency distribution (ACFD) of streamflow depth derived from discharge measurement field notes for the lower Platte River bridge near Ashland, Nebraska, on June 27, 2003.

hydraulic-niche categories. The hydraulic niches preferred by selected fish species from the lower Platte River, Nebraska, are listed in table 2. To aid the reader, descriptive names were applied to the hydraulic niches as two-word labels; the first word indicates depth class and the second word indicates velocity class. For example, the hydraulic niche with streamflow between 1–2 ft deep and velocity slower than 1 ft/s was labeled “Intermediate-Slow.”

## Classification of Low-Flow Geomorphic Habitats

To improve the consistency of feature classification by different observers and for greater comparability among streams and water years, six geomorphic habitat classes have been defined using low-flow conditions. In this study, the geomorphic habitat classifications of Rabeni and Jacobson (1993) and McKenney (1997) were modified to be solely based on the discrete depth and velocity combinations as presented in figure 8. Except for the “Pool” habitat category, the depth and velocity ranges for each class were fixed. For the “Pool” habitat, the range of depths varied with channel width; the flow depth boundary was computed as one percent of the total wetted width.

## Quality Assurance of Data Entry

Discharge-measurement field notes had to be manually entered into a spreadsheet format for analysis. Quality assurance of data entry from discharge-measurement field notes into a computer spreadsheet format was done with a dual approach. The CSHHAD_CAL program tool provided the first screening of certain typographical errors; for example, numerical values for measured distance, depth, or velocity that were outside expected ranges. The second screening of data entry was performed by comparing the summary discharge information on the discharge-measurement field note (fig. 3) and the corresponding summary information output by the program. When there was a discrepancy between these values, a detailed manual examination of the spreadsheet data against each field note was pursued.

## Channel Cross-Sectional Measurements for Beyond-Bridge Sites

There was a concern that hydraulic interaction of the bridge piers and the locations of discharge-measurement transects may have resulted in biases for or against some habitat categories. Discharge measurements for near-bridge sites described previously were made within 100 ft downstream or upstream from a bridge. Aerial orthophotographs of stream channels near bridges and photographs of bridge piers near Duncan, North Bend, Leshara, Ashland, and Louisville, are presented in figures 9, 10, 11, 12, and 13, respectively. These aerial orthophotographs provide readers the opportunity to form an opinion on the importance of pier effects.

In addition to the channel cross-sectional data obtained from discharge measurements for the near-bridge sites, cross-sectional data for the beyond-bridge sites were obtained for some segments of the lower Platte River. These channel cross-sectional data were provided by the Nebraska Game and Parks Commission (NGPC) and originally were collected for either the Platte River Instream Flow project (Nebraska Game and Parks Commission, 1993) or the analysis of levee conservation measures for a river segment of the Platte River (Nebraska Game and Parks Commission, 2002).

### Downstream from Bridge at North Bend

Cross-sectional transects for a river segment, located downstream from the bridge over the Platte River at North Bend (fig. 14) were surveyed for bed elevations, water-surface elevations, and streamflow velocities. Five transects were surveyed from August 12 through 14, 1985, and seven transects were surveyed from July 29 through 30, 1987. Water depth for each survey point in the wetted channel was computed as the difference between bed elevation and water-surface elevation. Discharges calculated from the transects measured in 1985 ranged from 2,460 to 2,800 $ft^3/s$, which were between 400 and 800 $ft^3/s$ less than the lower boundary of discharge for the median-flow condition defined at the streamflow-gaging station at North Bend (table 1). The discharges in 1987 also varied among transects, ranging from 1,180 (at the farthest upstream transect) to 1,380 $ft^3/s$ (at the farthest downstream transect), which were between 200 to 400 $ft^3/s$ less than the lower boundary of discharge for the low-flow condition defined at the streamflow-gaging station at North Bend (table 1).

### Downstream from Bridge near Leshara and Upstream from Bridge near Ashland

On the main stem of the Platte River in 2001, 13 cross-sectional transects were surveyed downstream from the bridge near Leshara, within 2.8 miles (mi) upstream from the Platte River-Elkhorn River confluence (fig. 15*A*), and 16 cross-sectional transects were surveyed upstream from the Ashland bridge, within 5.7 mi downstream from the Platte River-Elkhorn River confluence (figs. 15*B* and 15*C*). These transects were surveyed for channel-bed elevations and water-surface elevations during July 26 through August 1, 2001; flow velocities were not measured. Water depth for each survey point in the wetted channel was computed as the difference between bed elevation and water-surface elevation. Discharge measured at streamflow-gaging station near Ashland during the 2001 survey ranged from 4,850 to 5,460 $ft^3/s$, which were between 20 and 630 $ft^3/s$ higher than the upper boundary of the targeted discharge range for median-flow condition defined at the streamflow-gaging station (table 1). Streamflow measured at the streamflow-gaging station near Leshara during the 2001 survey ranged from 1,690 to 2,890 $ft^3/s$, which were 52 and

**Table 2.** Hydraulic niches preferred by selected fish species from the lower Platte River, Nebraska (From Peters and Holland, 1992).

[ft, foot; ft/s, foot per second]

| Streamflow depth | Streamflow velocity | | |
|---|---|---|---|
| | **Slow (slower than 1 ft/s)** | **Moderate (1–2 ft/s)** | **Swift ( faster than 2 ft/s)** |
| Shallow<br>(shallower than 1 ft) | *Notropis blennius*<br>(River shiner)<br>*Cyprinella lutrensis*<br>(Red shiner)<br>*Notropis stramineus*<br>(Sand shiner)<br>*Hybognathus placitus*<br>(Plains minnow)<br>*Hybognathus argyritus*<br>(Silvery minnow)<br>*Platygobio gracilis*<br>(Flathead chub)<br>*Carpiodes cyprinus*<br>(River carpsucker)<br>*Carpiodes carpio*<br>(Quillback) | *Hybognathus placitus*<br>(Plains minnow)<br>*Hybognathus argyritus*<br>(Silvery minnow)<br>*Platygobio gracilis*<br>(Flathead chub)<br>*Ictalurus punctatus*<br>(Channel catfish) | *Aplodinotus grunniens*<br>(Freshwater drum) |
| Intermediate<br>(1–2 ft) | *Cyprinella lutrensis*<br>(Red shiner)<br>*Ictalurus punctatus*<br>(Channel catfish)<br>*Aplodinotus grunniens*<br>(Freshwater drum) | *Ictalurus punctatus*<br>(Channel catfish)<br>*Aplodinotus grunniens*<br>(Freshwater drum) | |
| Deep<br>(deeper than 2 ft) | *Cyprinella lutrensis*<br>(Red shiner)<br>*Ictalurus punctatus*<br>(Channel catfish) | *lctalurus punctatus*<br>(Channel catfish)<br>*Aplodinotus grunniens*<br>(Freshwater drum) | *Ictalurus punctatus*<br>(Channel catfish)<br>*Aplodinotus grunniens*<br>(Freshwater drum)<br>*Scaphirhynchus sp.*[1]<br>(Sturgeon) |

[1] Based on studies by Bramblett and White, 2001, and Wildhaber and others, 2007; the Deep-Swift niche is the preferred habitat requirements by pallid sturgeon (Scaphirhynchus albus) and shovelnose sturgeon (Scaphirhynchus platorynchus) during their adult life.

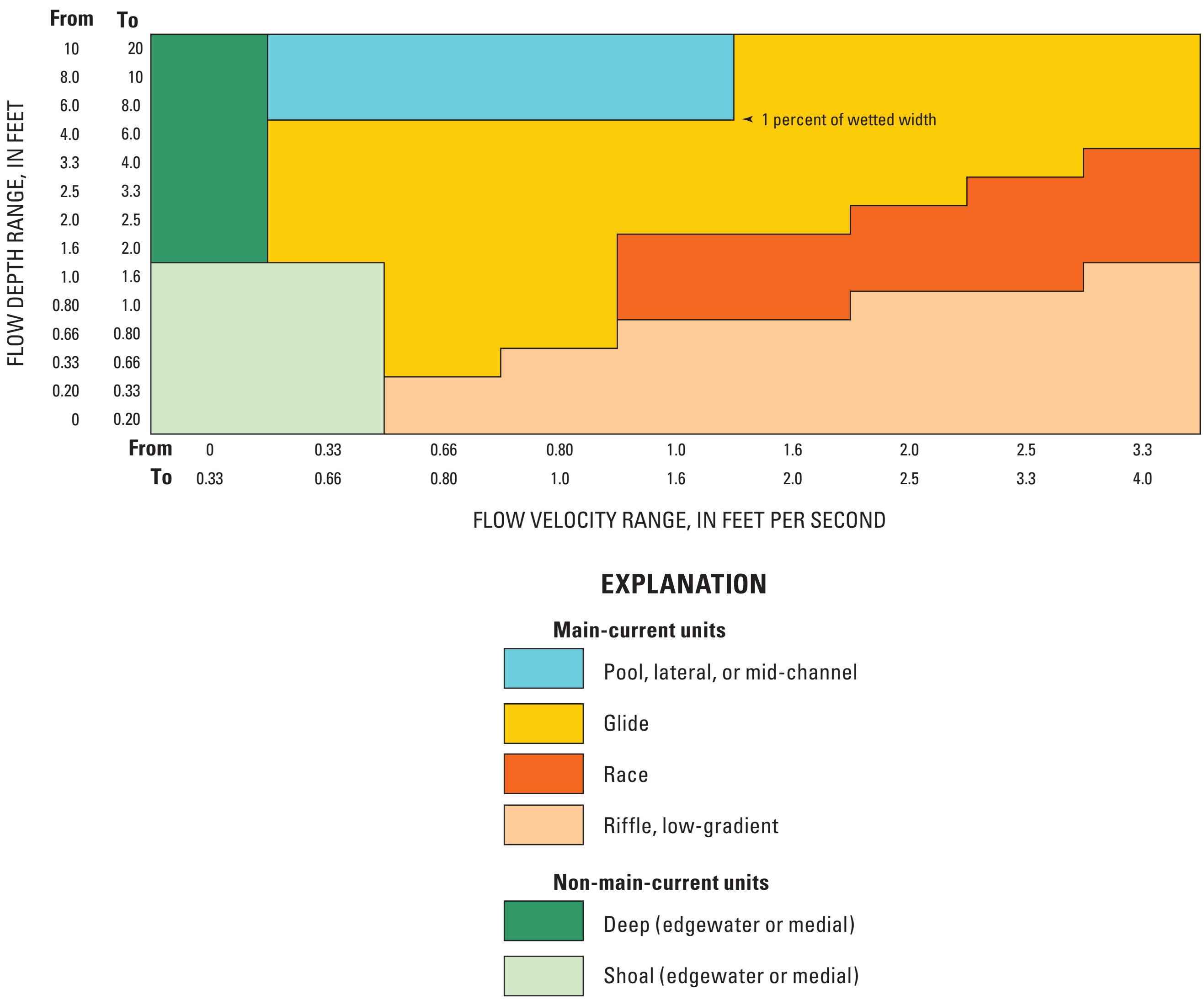



**Figure 8.** Low-flow geomorphic habitat units for the Platte River, Nebraska.

888 ft$^3$/s greater than the targeted minimum and maximum discharges, respectively, for low-flow conditions defined at the station (table 1).

The cross-sectional transects upstream from the confluence of the Platte and Elkhorn Rivers are assumed to be representative of the river segment between the bridge near Leshara and the Platte-Elkhorn confluence; therefore, comparisons of cross-sectional distributions of streamflow depth were made between the cross sections measured near the bridge near Leshara and those measured downstream from the bridge near Leshara to the Platte-Elkhorn River confluence. The surveyed transects downstream from the Platte-Elkhorn River confluence were assumed to be representative of the river segment between the Platte-Elkhorn River confluence and the bridge near Ashland; therefore, comparisons were made for cross-sectional distributions of streamflow depth between the sections measured near the bridge near Ashland and those measured upstream from the bridge near Ashland to the Platte-Elkhorn confluence.

## Upstream from Bridge at Louisville

Data for four transects in a 0.5-mi river segment located 0.4 mi upstream from the bridge at Louisville (fig. 16) were available. Water-surface elevations, depths, and velocities were surveyed in 1985 and in 1988 (Nebraska Game and Parks Commission, 1993). The discharge calculated from the transect measurements in 1985 varied among the transects, the lowest being 4,932 ft$^3$/s at the upstream-most transect and 6,767 ft$^3$/s at the downstream-most transect, which were 540 and 1,400 ft$^3$/s greater than the target minimum and maximum discharges, respectively, for median-flow condition defined at the streamflow-gaging station at Louisville (table 1). The streamflow calculated from transects measured in 1988 varied from 1,513 ft$^3$/s at the farthest upstream transect to 1,898 ft$^3$/s at the farthest downstream transect,

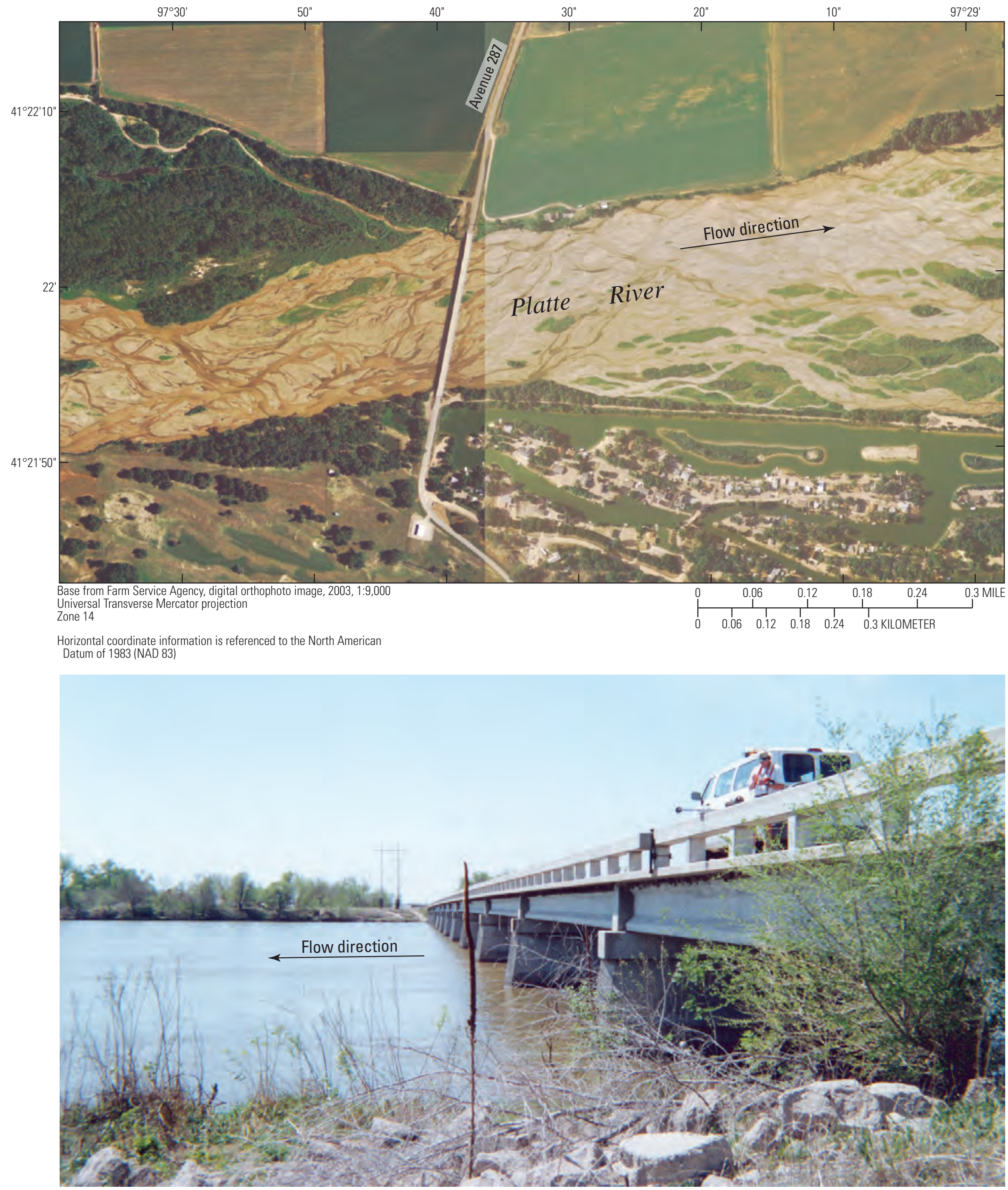



**Figure 9.** Stream channel (2003) near bridge and photograph of bridge piers (April 20, 2001) over the Platte River near Duncan, Nebraska. (Aerial digital orthophoto from the Farm Service Agency, 2003; bridge photograph courtesy of S.H. Hull, U.S. Geological Survey.)


**Figure 10.** Stream channel (2003) near bridge and photograph of bridge piers (October 2, 2001) over the Platte River at North Bend, Nebraska. (Aerial digital orthophoto from the Farm Service Agency, 2003; bridge photograph courtesy of S.H. Hull, U.S. Geological Survey.)


**Figure 11.** Stream channel (2003) near bridge over the Platte River near Leshara, Nebraska. (Aerial digital orthophoto from the Farm Service Agency, 2003.)

which were between 500 and 120 $ft^3/s$ less than the targeted minimum discharge for low-flow condition defined at the streamflow-gaging station at Louisville (table 1).

## Statistical Analysis

Temporal comparison (among water-year periods) and spatial comparison (between near-bridge sites and beyond-bridge sites) of the centers of distribution (median) were made using a non-parametric rank-based method, the analysis of variance (ANOVA) approximation of the Kruskal-Wallis test (Helsel and Hirsch, 1992). All statistical analyses and tests were computed using SAS software (SAS Institute, 1990). Response variables are the interpolated depth and velocity for each of the 23 selected percentiles, the relative cross-sectional area of each of the nine hydraulic niches, and the relative cross-sectional area of each of the six low-flow geomorphic habitats. The ranks of values for each response variable by each combination of streamflow-gaging station and flow condition were obtained using the RANK procedure, and the one-way ANOVA of the ranks was calculated using the general linear model, GLM procedure of SAS (SAS Institute, 1990). Significant differences for comparisons were declared at a 95-percent confidence level (alpha=0.05). Significant differences among the water-year periods, or between near-bridge and beyond-bridge sites, were declared if *p*-value was less than 0.05. If *p*-value was less than 0.05, then Duncan's multiple-range test (Duncan, 1955) was used for pairwise comparison between the water-year periods. In tables, median values of each response variable that were significantly different among the water-year periods were indexed with a different letter. The median-, and lower- and upper-quartile values of response variables, where applicable, were calculated using the UNIVARIATE procedure (SAS Institute, 1990). The 95-percent confidence interval for the mean of each response variable by streamflow-gaging station, water-year period, and flow condition, where applicable, also were calculated and are reported in the appendix, at the end of this report.

# Temporal Differences in Streamflow Depth, Velocity, and Hydraulic Microhabitats for Near-Bridge Sites

Temporal differences in streamflow depth and velocity existed for some selected percentiles of their respective ACFD for all near-bridge sites, except for the near-bridge site near Leshara. Only the 20th percentile for the ACFD for the high-flow condition had a temporal difference in streamflow depth for the near-bridge site near Leshara. Absence of temporal differences in streamflow depth and velocity for the near-bridge sites near Leshara was inconclusive because of a weak statistical test; in addition to the small number of analyzed discharge-measurement field notes in each period (n=3 to 6) (Appendix 1), only two water-year periods (1985–95 and 1996–2006) were available for statistical analysis, resulting in a lack of statistical power to detect any temporal differences. The same water-year periods (1985–95 and 1996–2006) for the other near-bridge sites differed in streamflow depth and velocity (for some percentiles of their respective ACFD) because a larger number of water-year periods (five for Duncan, and four each


Base from Farm Service Agency, digital orthophoto image, 2003, 1:8,000
Universal Transverse Mercator projection
Zone 14

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


**Figure 12.** Stream channel (2003) near bridge and photograph of bridge piers over the Platte River near Ashland, Nebraska. (Aerial digital orthophoto from the Farm Service Agency, 2003; bridge photograph courtesy of S.H. Hull, U.S. Geological Survey.)

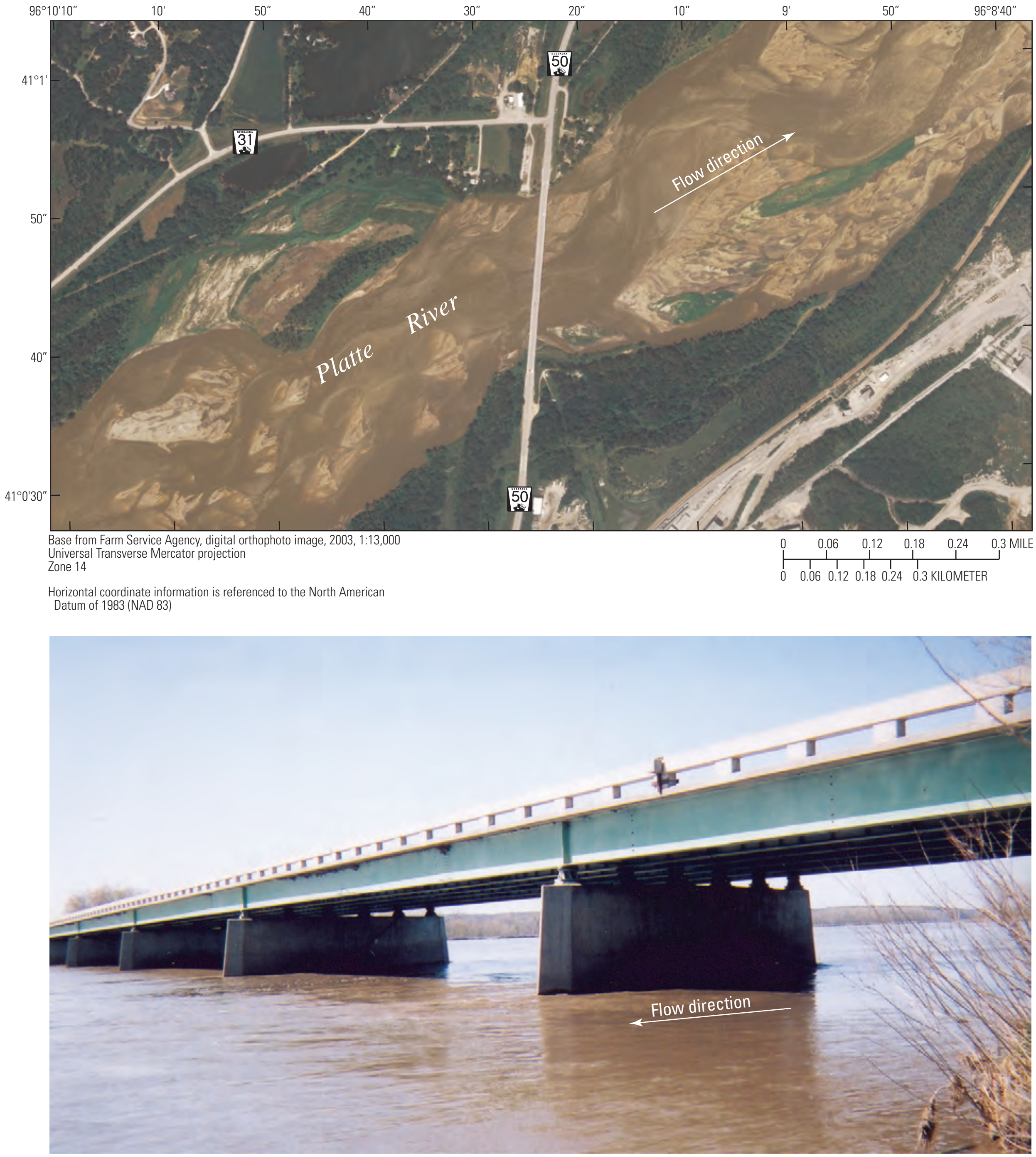



**Figure 13.** Stream channel (2003) near bridge and photograph of bridge piers over the lower Platte River at Louisville, Nebraska. (Aerial digital orthophoto from the Farm Service Agency, 2003; bridge photograph courtesy of S.H. Hull, U.S. Geological Survey.)

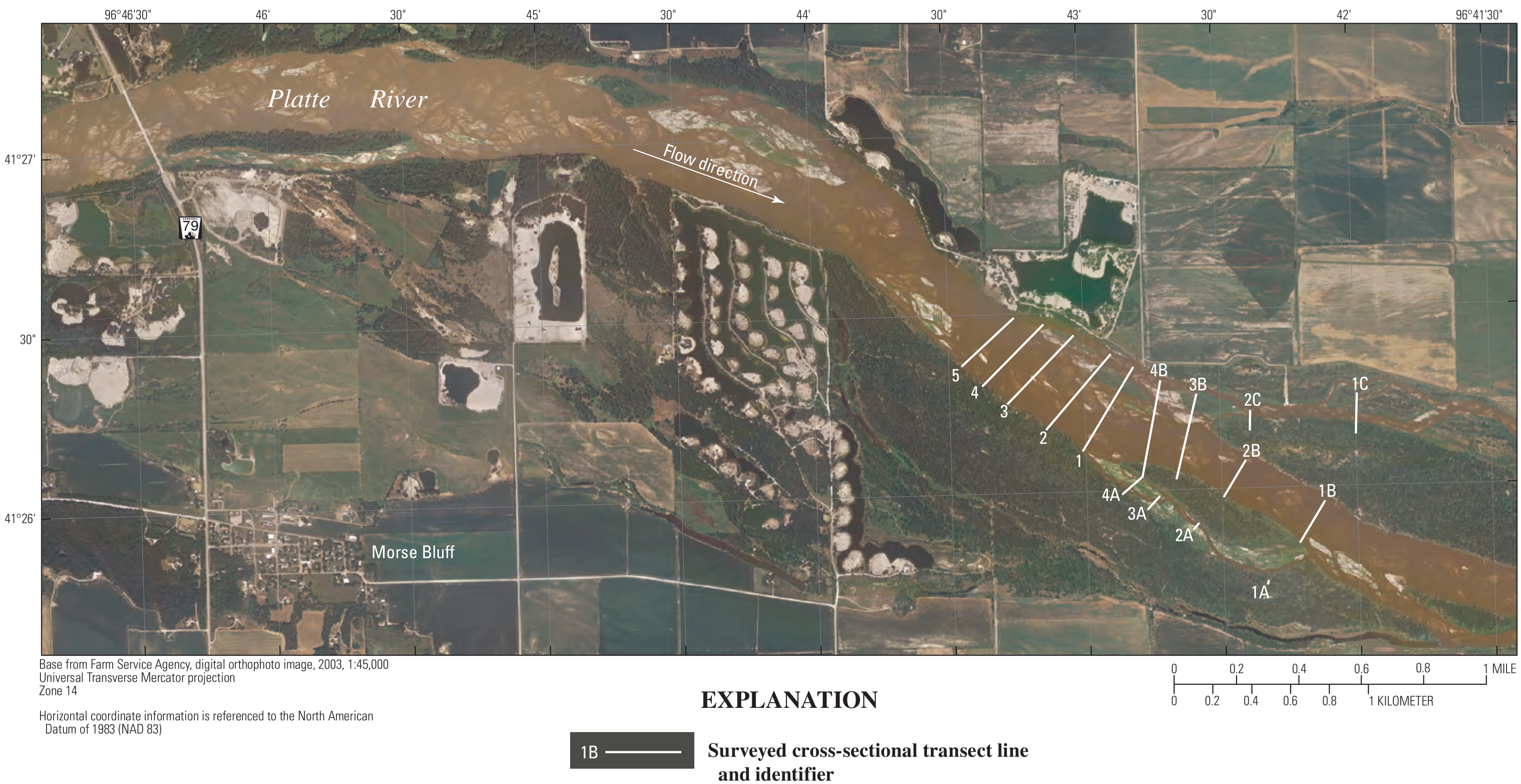



**Figure 14.** Location of surveyed cross-sectional transects downstream from bridge (August 1985 and July 1987) on aerial orthophoto of stream channel of the Platte River at North Bend, Nebraska. (Aerial digital orthophoto from the Farm Service Agency, 2003.)


**Figure 15.** Locations of surveyed cross-sectional transects (July–August 2001) on aerial orthophoto of the reaches *(A)* upstream from Elkhorn–Platte River confluence and *(B* and *C)* downstream from Elkhorn–Platte River confluence to downstream from bridge over the Platte River near Ashland, Nebraska. (Aerial digital orthophoto from the Farm Service Agency, 2003.)

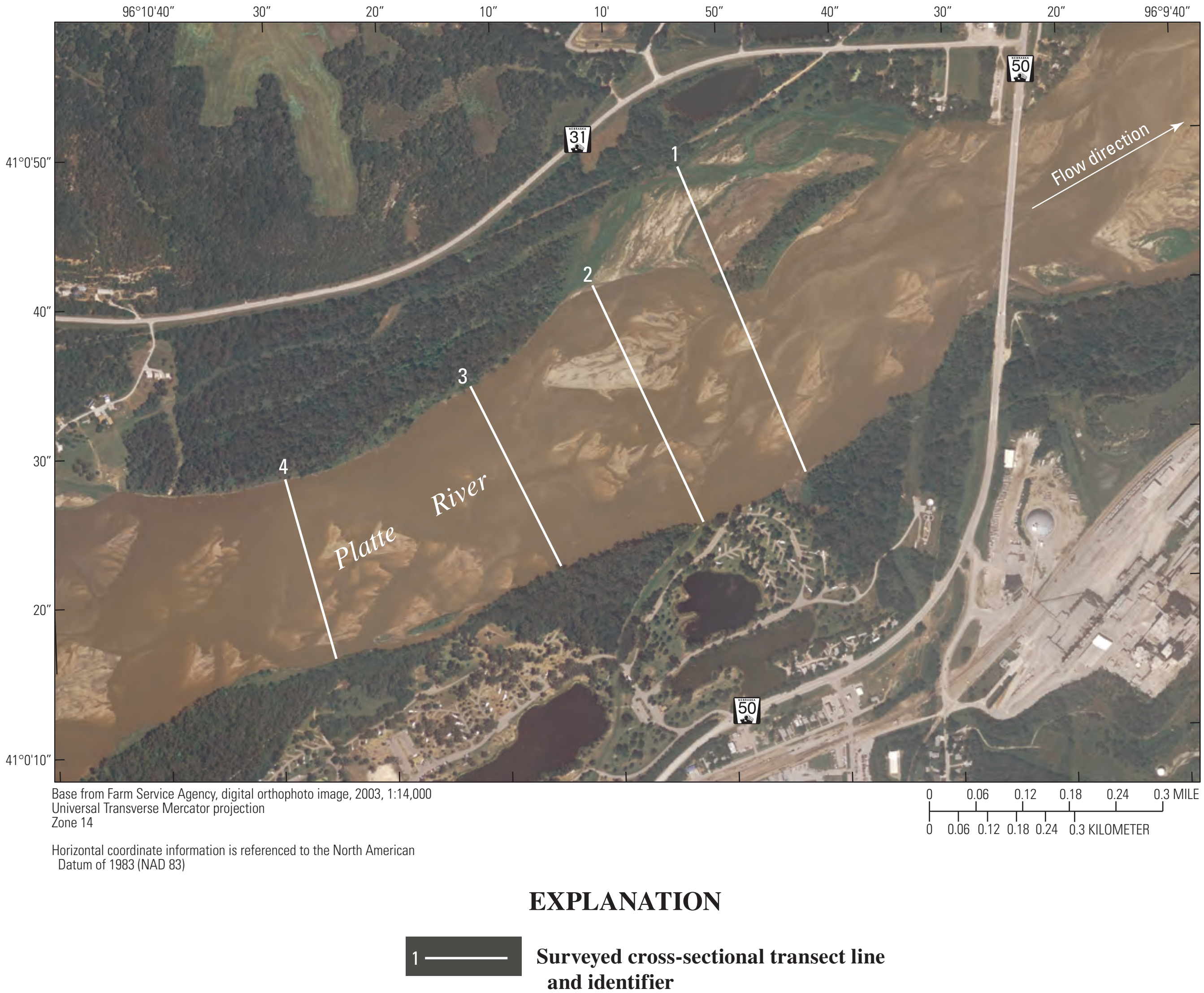



**Figure 16.** Location of surveyed cross-sectional transects (1985) upstream from bridge on aerial orthophoto of stream channel (2003) of the Platte River at Louisville, Nebraska (Aerial digital orthophoto from the Farm Service Agency, 2003).

for North Bend, Ashland, and Louisville) had data available, enhancing statistical power despite the small number of observations (n=3 to 7) in each of the water-year periods.

## Streamflow Depth

Temporal differences for all 23 selected percentiles of the ACFD of streamflow depth for the near-bridge sites near Duncan, North Bend, Leshara, Ashland, and Louisville are presented in tables 3, 4, 5, 6, and 7 (at the back of this report), respectively. Except for the near-bridge site near Duncan, 65 to 85 percent of cross-sectional area ($A_{xs}$) for high-flow conditions, and 50 to 70 percent of $A_{xs}$ for median-flow conditions was deeper than 2 ft during all water-year periods; the relative cross-sectional area deeper than 2 ft increased with increasing distance downstream. Only 30 percent of $A_{xs}$ for the high-flow condition and 15 percent for the median-flow condition was deeper than 2 ft for the near-bridge site near Duncan; the entire wetted cross section was shallower than 2 ft for the low-flow condition. More than 50 percent of $A_{xs}$ for low-flow conditions was shallower than 2 ft for all other near-bridge sites. Generally, in cases where temporal differences in streamflow depth were evident, at least one of the water periods from 1934 to 1995 had deeper/shallower streamflow than the recent water-year period (1996–2006). Some temporal changes indicated that any significant change (increase or decrease) in the ACFD of streamflow depths among the water-year periods from 1934 to 1995 had nearly disappeared during the most recent water-year period (1996–2006).

The percentiles, where temporal differences in streamflow depth were found, varied among flow conditions and near-bridge sites. Temporal differences in streamflow depth for some selected percentiles (those greater than the 35th percentile) for high- and median-flow conditions always involved streamflow deeper than 2 ft in at least one of the water-year periods. Temporal differences in streamflow depth for the near-bridge site near Duncan for the 30th or lower percentiles generally involved streamflow shallower than 1 ft for high- and median-flow conditions; for low-flow conditions, only the central part of the ACFD (30th to 70th percentiles, which generally is shallower than 1 ft) indicated significant temporal differences for the near-bridge site near Duncan (table 3). For all near-bridge sites on the lower Platte River, except at Louisville, temporal differences in streamflow depths for the low-flow condition was less obvious than those for the median- and high-flow conditions. No temporal difference in streamflow depths for the low-flow condition was evidenced for the near-bridge site at North Bend (table 4). For the near-bridge site near Ashland, temporal differences in streamflow depths for the low-flow condition were evidenced only for the 35th to 45th percentiles of the ACFD (table 6); wide and overlapped interquartile ranges of the ACFD indicated lack of temporal differences for 55th and higher percentiles (fig. 17*A*). For the near-bridge site at Louisville, temporal differences in streamflow depths for the low-flow condition were evidenced for all percentiles of the ACFD (table 7); the interquartile ranges (fig. 18*A*) indicate that streamflow was deepest in the 1966–76 period, but the significant increase in the ACFD of streamflow depths among the water-year periods from 1934 to 1995 had nearly disappeared during the most recent water-year period (1996–2006).

Temporal differences in streamflow depth did not coincide with temporal differences in climate (drought or wetness), or with temporal differences in maximum peak flow. The Platte River Basin experienced severe drought during the 1934–44 period; the moderately wet period (1985–95) was the wettest among the five water-year periods (Ginting and others, 2008). However, generally streamflow depth during similar flow conditions was similar or deeper during 1934–44 than it was during the 1985–95 period for the near-bridge sites near Duncan and Ashland (tables 3 and 6), where cross-sectional data from 1934–44 period were available. Streamflow depths during high- and median-flow conditions during the 1966–76 mildly wet period also were similar or deeper than those for similar flow conditions during the 1985–95 wettest period for near-bridge sites at North Bend and Louisville (tables 4 and 7).

The instantaneous peak discharge and the corresponding daily mean discharge (on the same day of instantaneous peak discharge) that occurred prior to the latest selected discharge-measurements during each water-year period were not strongly associated with the temporal difference in streamflow depths for the near-bridge sites. For the near-bridge site near Ashland, however, a much higher maximum peak flow on March 10, 1993, compared to June 14, 1943 (Appendix 2), did not result in a deeper streamflow distribution during the 1985–95 period than what was measured during the 1934–44 period. For the near-bridge sites at North Bend and Louisville, large differences in maximum instantaneous peak flow that occurred before the latest cross-sectional measurements were made during the 1985–95 and 1934–1944 periods, did not result in temporal differences in flow depths. Perhaps other factors beyond the scope of this report, related to the concept of geomorphic effectiveness (Wolman and Gerson, 1978) such as the duration of the high-flow, channel-scouring flow, or length of episodes of aggradation or degradation of the sand bed of the Platte River, may have stronger effects on the cross-sectional dynamics. Streamflows with 1.54-year return period often have been linked to channel morphology over the long term (Simon and others, 2004).

## Velocity

Except for the near-bridge site near Duncan, 75 to 80 percent of $A_{xs}$ for high-flow conditions and 55 to 70 percent of $A_{xs}$ for median-flow conditions were faster than 2 ft/s during all periods (tables 4, 5, 6, and 7). Only 45 percent of $A_{xs}$ for the high-flow condition, and 25 percent for the median-flow condition for the near-bridge site near Duncan were faster than 2 ft/s (table 3). More than 30 percent of $A_{xs}$ for low-flow conditions was slower than 2 ft/s for all near-bridge sites and periods; 85 percent of $A_{xs}$ was slower than 2 ft/s for the low-flow condition for the near-bridge site near Duncan.

No temporal difference in streamflow velocity was evidenced for the near-bridge site near Leshara (table 5). For the near-bridge site near Duncan, temporal differences in ACFD, for some percentiles less than or equal to 30 percent, of streamflow velocity for the low-flow condition were evidenced for streamflow slower than 1 ft/s for all water-year periods (table 3). Temporal differences in ACFD, for some percentiles greater than 35 percent, of streamflow velocity for high- and median-flow conditions for all near-bridge sites involved streamflow faster than 2 ft/s for at least one of the water-year periods (tables 3, 4, 5, 6, and 7). Within the central part of the ACFD of streamflow velocity for the near-bridge site at North Bend, the 1966–76 period typically had the fastest velocities during high- and low-flow conditions, whereas during median-flow conditions, the 1951–61 period had the fastest velocities (table 4). Generally for the near-bridge site near Ashland, the ACFD, for some percentiles greater than 50 percent, of streamflow velocities were fastest during the 1951–61 for high- and low-flow conditions (table 6). The interquartile ranges of streamflow velocity of the low-flow condition for the near-bridge site near Ashland (fig. 17*B*) indicate that streamflows were fastest in the 1951–61 period, but the significant increase in the ACFD of streamflow velocity among the water-year periods from 1934 to 1995 had nearly disappeared during the most recent water-year period (1996–2006); for the median-flow condition, the velocities were fastest during the 1985–95 period (table 6). The streamflows for the near-bridge site at Louisville for high-, median- and low-flow conditions had the fastest velocities in the 1966–76 period (table 7). The interquartile ranges of streamflow velocities for the low-flow condition (fig. 18*B*) indicate that the significant increase in streamflow velocities in the 1966–76 period had nearly disappeared during the 1985–95 period and the most recent water-year period (1996–2006).

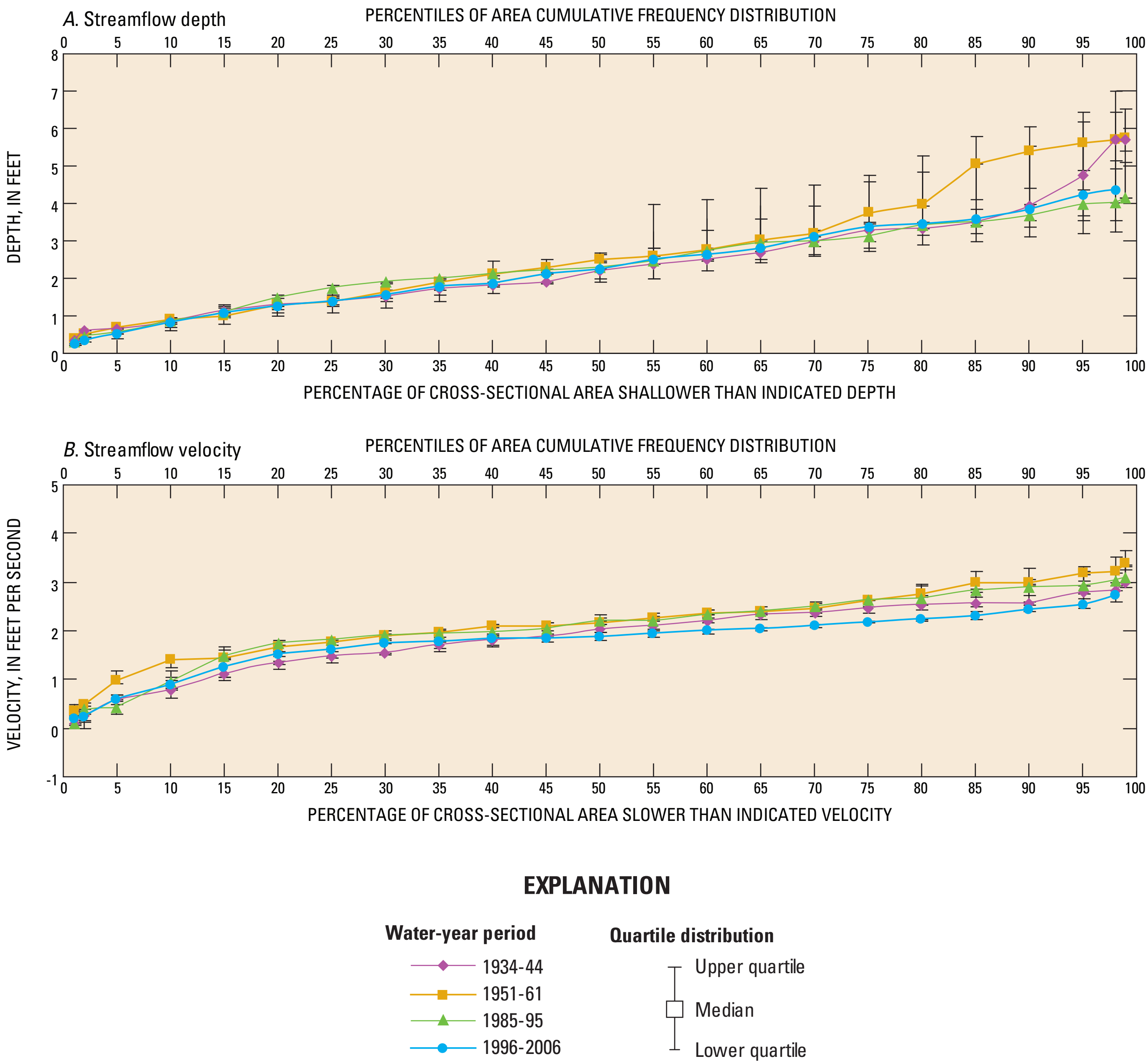



**Figure 17.** Temporal differences in area cumulative frequency distribution of streamflow *(A)* depth and *(B)* velocity for low-flow condition near the Platte River bridge near Ashland, Nebraska, 1934–2006. (No calculation of relative cross-sectional areas was made during the 1966–76 water-year period because streamflow-gaging station was inactive during the period.)

## Hydraulic Microhabitat of Near-Bridge Sites

The relative cross-sectional area of most hydraulic niches did not differ among the water-year periods. Part of this apparent uniformity likely was an artifact of the broad microhabitat classification system. Temporal differences in the distribution of water depth or velocity for high- and median-flow conditions were found generally for streamflows deeper than 2 ft and faster than 2 ft/s, which were classified into the same hydraulic niches (table 2) or low-flow geomorphic habitats (fig. 8). Temporal differences in relative cross-sectional area of hydraulic niches occurred only for high- and low-flow conditions, not for median-flow conditions (tables 8, 9, 10, 11, and 12). The temporal differences were not niche specific, but the differences were more frequent for hydraulic niches of moderate and swift velocity than niches of slow velocity. Generally, any significant increase or decrease in relative cross-sectional areas of hydraulic niches during the period from 1934 through 1995 had disappeared during the most recent period (1996–2006) (tables 8, 9, 10, 11, and 12). Note that the medians of relative cross-sectional area of hydraulic niche for some near-bridge sites were zero for all water-year periods and

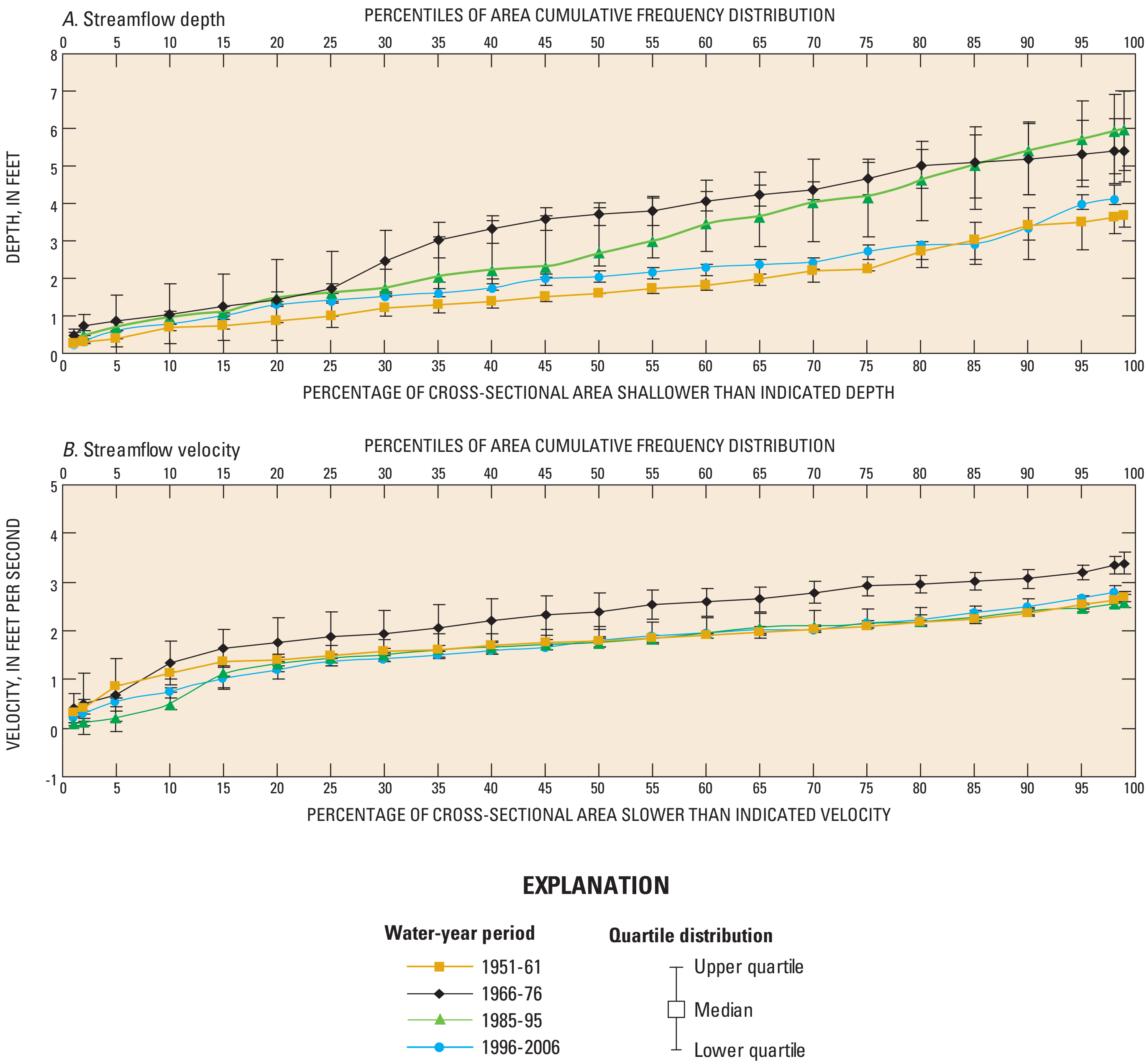



**Figure 18.** Temporal differences in area cumulative frequency distribution of streamflow *(A)* depth and *(B)* velocity for low-flow condition near the Platte River bridge at Louisville, Nebraska, 1934–2006. (No calculation of relative cross-sectional areas was made during the 1934–44 water-year period because discharge measurements were not made during the period.)

all flow conditions, yet the *p* values were different among flow conditions, because the *p*-values are for ranking comparison and not directly for median comparison.

Temporal differences in relative cross-sectional area of the Shallow-Moderate, Shallow-Swift, and Intermediate-Moderate hydraulic niches were evidenced for the near-bridge site near Duncan; any significant increase in relative cross-sectional areas of these three niches during the period from 1934 through 1995 had disappeared during the most recent period (1996–2006) (table 8). Temporal differences in relative cross-sectional area of the Shallow-Swift and Intermediate-Moderate niches were evidenced for the near-bridge site at North Bend; relative cross-sectional areas of the two niches during the 1966–76 period were the lowest among the periods (table 9). Temporal differences in relative cross-sectional area of the Intermediate-Swift and Deep-Swift niches were evidenced for the near-bridge site near Leshara; relative cross-sectional area of the Deep-Swift (only for the high-flow condition) was larger during the 1985–95 water-year period than the 1996–2006 water-year period (table 10). The Intermediate-Swift niche was larger during the 1985–95 water-year period than the 1996–2006 water-year period

**Table 8.** Median value and rank comparison among water-year periods in relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge near Duncan, Nebraska, 1934–2006.

[Tabled values for each time period are the median percentages of streamflow cross-sectional area; the 95-percent confidence intervals about the mean percentage of streamflow cross-sectional area are presented in Appendix 8; letter(s) following each median indicates results of rank-comparison tests among time periods within each combination of hydraulic niche and flow condition: medians within each combination of hydraulic niche and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of hydraulic niche and flow condition are equal; midpoint for the high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively; NC, not computed because all raw data have values equal to zero]

| Water-year period | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Intermediate-Slow | Intermediate-Moderate | Intermediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1934–44 | 4.9 a | 12.7 a | 5.4 ba | 2.5 a | 9.2 b | 21.8 a | 0 a | 1.9 a | 36.9 a |
| 1951–61 | 1.5 a | 18.4 a | 8.4 a | .9 a | 9.7 b | 17.9 a | 0 a | 5.7 a | 34.5 a |
| 1966–76 | 1.6 a | 15.2 a | 4.9 ba | 0 a | 17.1 ba | 25.0 a | 0 a | 4.5 a | 30.8 a |
| 1985–95 | 2.1 a | 10.7 a | 2.6 b | .8 a | 19.5 a | 22.6 a | 0 a | 9.3 a | 27.1 a |
| 1996–2006 | 3.2 a | 15.1 a | 3.8 b | 1.1 a | 10.7 b | 27.1 a | 0 a | 3.3 a | 33.1 a |
| *p*-value | .2556 | .1433 | **.0212** | .3309 | **.0283** | .6845 | .4432 | .3390 | .4126 |
| Median-flow condition | | | | | | | | | |
| 1934–44 | 7.8 a | 18.2 a | .7 a | 0 a | 16.4 a | 18.4 a | 0 a | 3.2 a | 25.6 a |
| 1951–61 | 6.3 a | 28.1 a | 4.8 a | 0 a | 20.6 a | 17.8 a | 0 a | 2.8 a | 19.4 a |
| 1966–76 | 2.4 a | 29.4 a | 3.2 a | 4.4 a | 24.6 a | 9.4 a | 0 a | 4.6 a | 16.3 a |
| 1985–95 | 3.3 a | 28.6 a | 2.6 a | .8 a | 28.1 a | 16.9 a | 0 a | 10.7 a | 6.2 a |
| 1996–2006 | 6.1 a | 27.7 a | 5.2 a | 0 a | 24.6 a | 8.0 a | 0 a | 6.8 a | 12.8 a |
| *p*-value | .1271 | .1088 | .9522 | .5381 | .4700 | .3516 | .3271 | .6448 | .1606 |
| Low-flow condition | | | | | | | | | |
| 1934–44 | 17.2 a | 32.5 c | 0 a | 6.0 a | 20.6 a | 14.5 a | 0 a | 0 a | 0 a |
| 1951–61 | 16.7 a | 36.5 c | 2.6 a | 1.6 a | 24.9 a | 7.6 a | 0 a | 0 a | 0 a |
| 1966–76 | 18.4 a | 58.8 a | 0 a | 0 a | 10.6 a | 0 a | 0 a | 0 a | 0 a |
| 1985–95 | 17.3 a | 51.8 ba | .9 a | 3.8 a | 19.2 a | 1.1 a | 0 a | 0 a | 0 a |
| 1996–2006 | 28.5 a | 39.3 bc | 3.1 a | 0 a | 14.1 a | 1.4 a | 0 a | 0 a | 3.3 a |
| *p*-value | .1955 | **.0122** | .9197 | .2854 | .0999 | .1595 | NC | .8398 | .0535 |

for the low-flow condition, but the opposite was evidenced for the high-flow condition (table 10). Temporal differences in relative cross-sectional area of the Deep-Moderate and Deep-Swift niches were evidenced for the near-bridge site near Ashland for the low-flow condition (table 11). Any significant increase in relative cross-sectional areas of the Deep-Swift niche during the period from 1934 through1995 had disappeared during the most recent period (1996–2006); conversely, relative cross-sectional area of the Deep-Moderate niche was the largest during the most recent period (table 11). Temporal differences in the Shallow-Slow, Shallow-Moderate, Intermediate-Moderate, Intermediate-Swift, Deep-Moderate, and Deep-Swift hydraulic niches were evidenced for the near-bridge site at Louisville (table 12); any significant increase or decrease in relative cross-sectional areas of these niches during the periods from 1934 through 1995 had disappeared during the most recent period (1996–2006).

The Deep-Swift hydraulic niche was predominant only during high-flow conditions for the near-bridge site near Duncan on the central Platte River; for median- and low-flow conditions relative cross-sectional areas were distributed among the Shallow-Slow, Shallow-Moderate, Intermediate-Moderate, and Intermediate-Swift niches (table 8). The Deep-Swift hydraulic niche was the predominant niche for high- and median-flow conditions for all near-bridge sites on the lower Platte River (tables 9, 10, 11, and 12). The Deep-Swift niche

**Table 9.** Median value and rank comparison among water-year periods in relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge at North Bend, Nebraska, 1934–2006.

[Tabled values for each time period are the median percentages of streamflow cross-sectional area; the 95-percent confidence intervals about the mean percentage of streamflow relative cross-sectional area are presented in Appendix 9; letter(s) following each median indicates results of rank-comparison tests among time periods within each combination of hydraulic niche and flow condition: medians within each combination of hydraulic niche and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of hydraulic niche and flow condition are equal; midpoint for the high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Intermediate-Slow | Intermediate-Moderate | Intermediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1951–61 | 0.3 a | 1.4 a | 1.4 a | 0.9 a | 3.8 a | 13.2 a | 0 a | 3.7 a | 69.1 a |
| 1966–76 | .2 a | 1.1 a | 0 b | .3 a | 2.1 a | 10.3 a | 1.7 a | 6.6 a | 77.4 a |
| 1985–95 | 2.4 a | 1.9 a | .8 ba | .8 a | 4.6 a | 12.3 a | 0 a | 5.4 a | 66.9 a |
| 1996–2006 | 1.2 a | 2.5 a | 1.8 a | .4 a | 4.6 a | 17.1 a | 0 a | 3.4 a | 66.8 a |
| *p*-value | .0610 | .6360 | .0154 | .9795 | .1883 | .6916 | .5208 | .6471 | .5919 |
| Median-flow condition | | | | | | | | | |
| 1951–61 | 4.0 a | 11.0 a | .7 a | 0 a | 8.3 a | 10.8 a | 0 a | 8.0 a | 60.2 a |
| 1966–76 | 2.2 a | 5.6 a | .6 a | 1.0 a | 7.0 a | 17.4 a | 0 a | 12.8 a | 49.1 a |
| 1985–95 | 3.2 a | 9.9 a | 1.6 a | 3.6 a | 10.8 a | 14.1 a | 0 a | 5.6 a | 46.4 a |
| 1996–2006 | 2.8 a | 9.6 a | 1.0 a | 0 a | 17.4 a | 15.4 a | 0 a | 4.7 a | 44.2 a |
| *p*-value | .7735 | .5834 | .8946 | .0807 | .1107 | .4083 | .4593 | .1100 | .2079 |
| Low-flow condition[2] | | | | | | | | | |
| 1951–61 | 5.0 a | 12.7 a | 1.4 a | 0 a | 18.2 a | 11.1 a | 0 a | 13.2 a | 31.9 a |
| 1966–76 | 5.6 a | 7.7 a | 1.4 a | 2.9 a | 11.9 b | 20.3 a | 0 a | 11.0 a | 30.6 a |
| 1985–95 | 6.0 a | 14.4 a | 0 a | 3.4 a | 23.1 a | 12.3 a | 0 a | 9.2 a | 18.6 a |
| *p*-value | .5676 | .1384 | .8963 | .3692 | **.0180** | .6049 | .8375 | .9381 | .3137 |

[1]No calculation of hydraulic-niche areas was made for the 1934–1944 period because streamflow-gaging station and discharge measurements began in April 1949.

[2]No calculation of hydraulic-niche areas was made for the low-flow condition in the 1996–2006 period because field notes were not available.

also was the predominant niche for low-flow conditions for the near-bridge sites near Ashland and at Louisville; for the near-bridge sites at North Bend and near Leshara, hydraulic niches during low-flow conditions were distributed mainly among the Shallow-Moderate, Intermediate-Moderate, Intermediate-Swift, and Deep-Swift niches.

Previous studies (Bramblett and White, 2001; Wildhaber and others, 2007) suggested that the Deep-Swift niche is the preferred habitat of the pallid sturgeon (*Scaphirhynchus albus*) and shovelnose sturgeon (*Scaphirhynchus platorynchus*) during their adult life. The habitats used by the two sturgeon species in the upper Missouri and Yellowstone Rivers included depths ranging from 2 to 48 ft, and current velocities averaged greater than 2.1 ft/s (Bramblett and White, 2001). Significant temporal differences in the relative cross-sectional area of the Deep-Swift niche were found for near-bridge sites near Ashland and at Louisville, but only for low-flow conditions (tables 11 and 12). Temporal differences in ACFD of streamflow depth and velocity for low-flow conditions for the near-bridge sites near Ashland and at Louisville are presented in figures 17 and 18. The relative cross-sectional area of the Deep-Swift niche for the near-bridge site near Ashland during the most recent period (1996–2006) was lower than during the 1951–61 and 1985–95 periods (fig. 19*A*). For the near-bridge site at Louisville, relative cross-sectional area of the Deep-Swift niche during the 1951–61 and 1996–2006 periods was lower than during the 1966–76 period (fig. 19*B*). Temporal differences indicated that any significant temporal change in relative cross-sectional area of the Deep-Swift niche of the near-bridge site near Ashland and at Louisville since the 1951–61 period had nearly disappeared during the most recent period (1996–2006). Temporal difference in relative

**Table 10.** Median value and rank comparison among water-year periods in relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge near Leshara, Nebraska, 1934–2006.

[Tabled values for each time period are the median percentages of streamflow relative cross-sectional area; the 95-percent confidence intervals about the mean percentage of streamflow cross-sectional area are presented in Appendix 10; letter(s) following each median indicates results of rank-comparison tests among time periods within each combination of hydraulic niche and flow condition: medians within each combination of hydraulic niche and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of hydraulic niche and flow condition are equal; midpoint for the high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Intermediate-Slow | Intermediate-Moderate | Intermediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1985–95 | 2.9 a | 0 a | 0 a | 2.2 a | 5.0 a | 3.9 b | 5.9 a | 0 a | 77.0 a |
| 1996–2006 | 1.0 a | 2.5 a | 0 a | 1.2 a | 6.9 a | 14.3 a | 0 a | 7.1 a | 61.6 b |
| *p*-value | .2168 | .1250 | .7812 | .2147 | .4758 | **.0066** | .4328 | .3317 | **.0255** |
| Median-flow condition | | | | | | | | | |
| 1985–95 | 1.7 a | 2.7 a | 0 a | .3 a | 3.3 a | 5.6 a | 1.2 a | 10.7 a | 68.1 a |
| 1996–2006 | 3.6 a | 4.6 a | .1 a | 0 a | 8.6 a | 12.9 a | 0 a | 6.1 a | 56.1 a |
| *p*-value | .2191 | .4870 | .5793 | .3218 | .2129 | .1435 | .3218 | .6953 | .2191 |
| Low-flow condition | | | | | | | | | |
| 1985–95 | 1.6 a | 12.8 a | 3.6 a | 2.4 a | 22.3 a | 21.5 a | 0 a | 8.2 a | 21.1 a |
| 1996–2006 | 4.9 a | 8.9 a | 0 a | 4.3 a | 24.4 a | 6.4 b | 0 a | 21.8 a | 22.8 a |
| *p*-value | .4991 | .8946 | .2284 | .8920 | .8946 | **.0388** | .4816 | .8946 | .4991 |

[1] No calculation of hydraulic-niche areas was made for the 1934–1944, 1951–1961, and 1966–1976 periods because streamflow-gaging station and discharge measurements began in June 1994.

**Table 11.** Median value and rank comparison among water-year periods in relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge near Ashland, Nebraska, 1934–2006.

[Tabled values for each time period are the median percentages of streamflow cross-sectional area; the 95-percent confidence intervals about the mean percentage of streamflow relative cross-sectional area are presented in Appendix 11; letter(s) following each median indicates results of rank-comparison tests among time periods within each combination of hydraulic niche and flow condition: medians within each combination of hydraulic niche and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of hydraulic niche and flow condition are equal; midpoint for the high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Intermediate-Slow | Intermediate-Moderate | Intermediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1934–44 | 0.9 a | 0.2 a | 0.1 a | 0.9 a | 2.0 a | 0.9 a | 4.6 a | 8.1 a | 79.6 a |
| 1951–61 | .7 a | .7 a | 2.3 a | .1 a | 2.5 a | 5.4 a | .8 b | 8.6 a | 77.5 a |
| 1985–95 | .3 a | .6 a | .6 a | .9 a | 3.7 a | 2.7 a | 0 b | 3.5 a | 83.1 a |
| 1996–2006 | .2 a | .4 a | .3 a | 0 a | 4.5 a | 4.7 a | 0 b | 4.7 a | 81.7 a |
| *p*-value | .1525 | .9114 | .2729 | .1455 | .1082 | .1593 | **.0018** | .4169 | .5415 |
| Median-flow condition | | | | | | | | | |
| 1934–44 | 3.8 a | 4.9 a | 0 a | 1.4 a | 7.3 a | 7.5 a | .9 a | 8.6 a | 60.0 a |
| 1951–61 | 1.6 a | 4.9 a | 0 a | 2.4 a | 13.9 a | 6.7 a | 0 a | 9.9 a | 6 .6 a |
| 1985–95 | 2.7 a | 4.4 a | 0 a | 1.2 a | 12.3 a | 4.3 a | 3.4 a | 9.0 a | 61.3 a |
| 1996–2006 | 3.0 a | 6.0 a | 0 a | 2.7 a | 13.4 a | 8.9 a | 0 a | 9.3 a | 50.7 a |
| *p*-value | .4922 | .2558 | .6359 | .7826 | .1763 | .4041 | .2332 | .7894 | .3543 |
| Low-flow condition | | | | | | | | | |
| 1934–44 | 6.5 a | 5.4 a | 0 a | 4.3 a | 12.3 a | 16.7 a | 1.3 a | 9.1 bc | 42.0 b |
| 1951–61 | 1.8 a | 7.3 a | 0 a | 2.6 a | 11.2 a | 6.5 a | 0 a | 9.9 c | 49.8 a |
| 1985–95 | 4.0 a | 4.8 a | 0 a | 1.6 a | 6.4 a | 4.9 a | 0 a | 15.2 ba | 55.3 a |
| 1996–2006 | 5.8 a | 5.8 a | 0 a | 5.3 a | 15.4 a | 8.8 a | 0 a | 25.8 a | 35.6 b |
| *p*-value | .0727 | .2438 | .2923 | .5945 | .3470 | .3006 | .6583 | **.0039** | **.0079** |

[1]No calculation of hydraulic-niche areas was made for the 1966–1976 period because the streamflow-gaging station was inactive until July 1988.

**Table 12.** Median value and rank comparison among water-year periods in relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge at Louisville, Nebraska, 1934–2006.

[Tabled values for each time period are the median percentages of streamflow cross-sectional area; the 95-percent confidence intervals about the mean percentage of streamflow relative cross-sectional area are presented in Appendix 12; letter(s) following each median indicates results of rank-comparison tests among time periods within each combination of hydraulic niche and flow condition: medians within each combination of hydraulic niche and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of hydraulic niche and flow condition are equal; midpoint for the high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Intermediate-Slow | Intermediate-Moderate | Intermediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| **High-flow condition** | | | | | | | | | |
| 1951–61 | 0.1 a | 1.3 a | 0 a | 0.9 a | 2.6 a | 2.2 ba | 1.1 a | 11.3 a | 80.7 a |
| 1966–76 | .5 a | .6 a | .3 a | .1 a | 2.8 a | 4.1 a | 1.4 a | 1.7 b | 87.2 a |
| 1985–95 | .2 a | .8 a | 0 a | 0 a | 2.3 a | 6.8 a | .5 a | 6.7 ba | 79.8 a |
| 1996–2006 | .3 a | .4 a | .5 a | .7 a | 2.8 a | 1.0 b | 2.0 a | 7.1 ba | 85.3 a |
| *p*-value | .2360 | .8053 | .3683 | .8217 | .9217 | **.0359** | .7284 | **.0240** | .2841 |
| **Median-flow condition** | | | | | | | | | |
| 1951–61 | 1.7 a | 4.3 a | .8 a | .3 a | 9.4 a | 8.4 a | 1.9 a | 15.6 a | 54.0 a |
| 1966–76 | 4.4 a | 4.2 a | .6 a | 1.7 a | 5.8 a | 4.1 a | 2.6 a | 9.3 a | 62.2 a |
| 1985–95 | 2.7 a | 2.9 a | 0 a | 2.2 a | 10.7 a | 9.5 a | 1.5 a | 19.7 a | 56.1 a |
| 1996–2006 | 2.5 a | 3.1 a | 0 a | .9 a | 8.3 a | 6.3 a | 5.5 a | 10.4 a | 62.5 a |
| *p*-value | .1255 | .3989 | .1347 | .4063 | .8044 | .2284 | .4911 | .6670 | .2014 |
| **Low-flow condition** | | | | | | | | | |
| 1951–61 | 4.1 a | 16.0 a | 1.5 a | 2.5 a | 25.5 a | 10.1 a | 0 a | 15.3 a | 21.6 c |
| 1966–76 | 1.3 b | 3.7 b | .8 a | 2.0 a | 3.0 c | 6.4 a | 1.5 a | 4.0 a | 65.6 a |
| 1985–95 | 4.3 a | 3.5 b | 0 a | 4.2 a | 11.9 bc | 6.2 a | 4.5 a | 27.8 a | 31.3 ba |
| 1996–2006 | 5.5 a | 7.7 b | 0 a | 2.6 a | 19.3 ba | 4.9 a | 5.5 a | 18.9 a | 25.0 bc |
| *p*-value | **.0232** | **.0011** | .2602 | .4904 | **.0101** | .2551 | .2625 | .3867 | **.0058** |

[1]No calculation of hydraulic-niche areas was made during 1934–1944 period because streamflow-gaging station and discharge measurements began in May 1953.

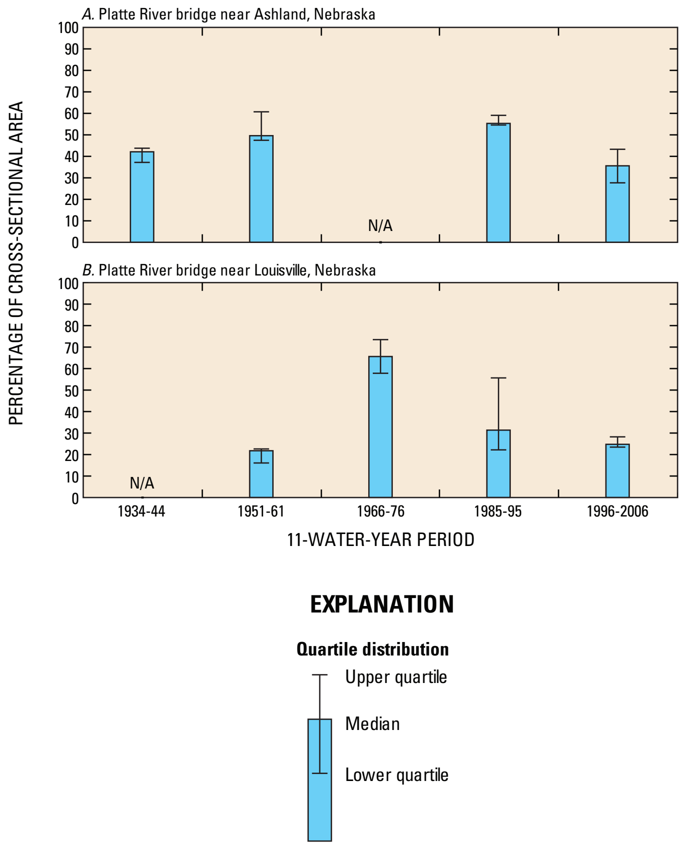



**Figure 19.** Temporal differences in relative cross-sectional area of Deep-Swift niche near the Platte River bridges near *(A)* Ashland and at *(B)* Louisville, Nebraska, 1934–2006. (No calculation of cross-sectional areas was made during 1966–76 near Ashland because streamflow-gaging station was inactive; also no calculation of cross-sectional areas was made during 1934–44 at Louisville because discharge measurements were not made during the period.)

cross-sectional area of Glide low-flow geomorphic habitat that contains the Deep-Swift hydraulic niche also indicated that the relative cross-sectional area of Glide during the 1951–61 and 1996–2006 periods was lower than during the 1966–76 period (table 13).

The predominant low-flow geomorphic habitats of the four near-bridge sites on the lower Platte River were Glide and Race, whereas Race and Riffle were the predominant low-flow geomorphic habitats for the near-bridge site near Duncan (table 13). Temporal differences in relative cross-sectional area of low-flow geomorphic habitats on the lower Platte River were evidenced only for the near-bridge site at Louisville and only in the Glide, Race, and Riffle habitats. Relative cross-sectional area of Glide habitat was higher during the 1966–76 and 1985–95 periods than during the 1951–61 and 1996–2006 periods and conversely for Race habitat (table 13). The effects of climate on temporal differences in low-flow geomorphic habitats varied with the type of geomorphic habitat. For example, the relative cross-sectional area of the Race habitat for the near-bridge site at Louisville, during the 1951–61 and 1996–2006 water-year periods (mixture of wet and drought years) was larger than that in wetter 1966–76 and 1985–95 periods. On the other hand, relative cross-sectional area of the Glide habitat in wetter 1966–76 and 1985–95 periods was larger than that in the drier 1951–61 and 1996–2006 periods. For the near-bridge site near Duncan, temporal differences in relative cross-sectional area were evidenced for the Riffle and Shoal habitats; the Riffle habitat in the mildly wet 1966–76 period was the largest among all the periods from 1934 through 2006 (table 13).

Decrease in streamflow below high-flow conditions or the decrease from median- to low-flow conditions resulted in decreased cross-sectional area of the Intermediate-Swift, Intermediate-Moderate, Shallow-Swift, Shallow-Moderate, and Deep-Swift niches for the near-bridge site near Duncan (table 14). The decrease in flow condition also resulted in the obvious, substantial decreases in area (table 14) and predominance (figs. 20, 21, 22, 23) of the Deep-Swift niche for all near-bridge sites on the lower Platte River. Increasing streamflow from median- or low-flow conditions to the high-flow condition resulted in significant decreases in cross-sectional area of the Shallow-Slow and Shallow-Moderate niches. Changing flow conditions resulted in small or no change in the relative cross-sectional area of other hydraulic niches.

## Bridge Effects on Streamflow Depth, Velocity, and Hydraulic Niches

During median-flow conditions, the streamflows were deeper for the near-bridge sites than the beyond-bridge sites at North Bend and near Ashland for the 70th or higher percentiles of the ACFD (table 15); streamflow depths for these percentiles were 2.6 ft or deeper. Streamflow depths of the near-bridge site and the beyond-bridge site at Louisville did not differ, likely because the selected cross-sectional measurements for the near-bridge site were made during a lower streamflow than those for the beyond-bridge site. The streamflows during the cross-sectional measurements of the near-bridge site were 540 to 1,400 $ft^3/s$ less than streamflows during the survey of cross sections of the beyond-bridge site.

Generally, streamflow depths for the near-bridge and beyond-bridge sites did not differ during low-flow conditions (table 16). Bridge effect on streamflow depths, being deeper for near-bridge than beyond-bridge site, at Louisville during the low-flow condition was inconclusive because the streamflows measured for the near-bridge site were 500 to 120 $ft^3/s$ larger than streamflow during the survey of cross sections of the beyond-bridge sites.

Streamflow velocity for the median-flow condition was either higher or lower for the near-bridge site than the beyond-bridge site, depending on the site location. Streamflow velocities for some percentiles (1st, 50th, 55th, 70th, and 75th) during the median-flow condition were faster for the near-bridge than for the beyond-bridge sites at North Bend, but the

**Table 13.** Median value and rank comparison among water-year periods in relative cross-sectional area of low-flow geomorphic habitats near the Platte River bridges near Duncan, North Bend, Leshara, Ashland, and Louisville, Nebraska, 1934–2006.

[Tabled values for each time period are the median percentages of streamflow cross-sectional area; the 95-percent confidence intervals about the mean percentage of streamflow relative cross-sectional area are presented in Appendix 13; letter(s) following each median indicates results of rank-comparison tests among time periods within each combination of geomorphic habitat and streamflow-gaging station: medians within each combination of streamflow-gaging station and geomorphic habitat that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of streamflow-gaging station and geomorphic habitat are equal; low-flow condition is streamflow that are equaled or exceeded 84 percent of the time; NC, not computed because data were all zeros for all water-year periods]

| Water-year period | Low-flow geomorphic habitat | | | | | |
|---|---|---|---|---|---|---|
| | Pool | Glide | Race | Riffle | Deep | Shoal |
| | | | Duncan | | | |
| 1934–44 | 0 a | 8.6 a | 47.1 a | 30.0 b | 0 a | 8.9 bc |
| 1951–61 | 0 a | 7.1 a | 43.0 a | 40.1 b | 0 a | 11.5 bac |
| 1966–76 | 0 a | 4.1 a | 16.8 a | 66.8 a | 0 a | 3.5 c |
| 1985–95 | 0 a | 2.8 a | 35.8 a | 41.3 b | 0 a | 13.1 ba |
| 1996–2006 | 0 a | 4.4 a | 37.1 a | 39.5 b | 0 a | 18.3 a |
| *p*-value | NC | .2733 | .1211 | **.0113** | NC | **.0058** |
| | | | North Bend[1] | | | |
| 1951–61 | 0 a | 31.7 a | 62.8 a | 8.6 a | 0 a | 2.6 a |
| 1966–76 | 0 a | 29.3 a | 58.7 a | 7.3 a | 0 a | 3.1 a |
| 1985–95 | 0 a | 21.9 a | 60.5 a | 14.5 a | 0 a | 3.9 a |
| *p*-value | NC | .5103 | .6305 | .1595 | .2692 | .5016 |
| | | | Leshara[2] | | | |
| 1985–95 | 0 a | 35.6 a | 60.5 a | 8.2 a | 0 a | .7 a |
| 1996–2006 | 0 a | 41.8 a | 43.8 a | 8.6 a | 0 a | 2.2 a |
| *p*-value | NC | .3336 | .4991 | .8946 | NC | .3336 |
| | | | Ashland[3] | | | |
| 1934–44 | 0 a | 54.0 a | 34.1 a | 6.2 a | 0 a | 4.8 a |
| 1951–61 | 0 a | 47.4 a | 42.3 a | 6.2 a | 0 a | 2.1 a |
| 1985–95 | 0 a | 44.4 a | 50.8 a | 2.4 a | 0 a | 8.0 a |
| 1996–2006 | 0 a | 48.1 a | 41.6 a | 4.4 a | 0 a | 5.9 a |
| *p*-value | NC | .7487 | .6731 | .0756 | .8882 | .0941 |
| | | | Louisville[4] | | | |
| 1951–61 | 0 a | 20.8 b | 64.7 a | 14.2 a | 0 a | 3.7 a |
| 1966–76 | 0 a | 63.7 a | 28.1 b | 3.5 b | 0 a | 1.1 a |
| 1985–95 | 0 a | 60.6 a | 24.9 b | 1.6 b | 4.4 a | 5.5 a |
| 1996–2006 | 0 a | 33.8 b | 56.8 a | 5.9 b | 1.9 a | 4.7 a |
| p-value | NC | **.0002** | **.0027** | **.0011** | .0932 | .2006 |

[1]No calculation of geomorphic-habitat areas was made for the 1934–1944 period because measurements were not made during the period; no calculation of geomorphic-habitat areas was made for the low-flow condition in the 1996–2006 period because discharge measurements field notes were not available.

[2]No calculation of geomorphic-habitat areas was made for the 1934–1944, 1951–1961, and 1966–1976 periods because measurements were not made during the periods.

[3]No calculation of geomorphic-habitat areas was made for the 1966–1976 period because the gaging station was inactive during the period.

[4]No calculation of geomorphic-habitat areas was made during 1934–1944 period because measurements were not made during the period.

**Table 14.** Median value and rank comparison among selected streamflow conditions in the cross-sectional area of hydraulic niches near the Platte River bridges near Duncan, North Bend, Leshara, Ashland, and Louisville, Nebraska, 1934–2006.

[Tabled values for each streamflow condition are the median of streamflow cross-sectional area, in square feet; the 95-percent confidence intervals about the mean of streamflow cross-sectional area are presented in Appendix 14; letter(s) following each median indicates results of rank-comparison tests among streamflow conditions within each combination of hydraulic niche and streamflow-gaging station; medians within each combination of hydraulic niche and streamflow-gaging station that are indexed by the same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of hydraulic niche and streamflow-gaging station are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for the median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Flow condition | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Intermediate-Slow | Intermediate-Moderate | Intermediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| **Duncan** | | | | | | | | | |
| High | 27 a | 159 b | 46 a | 10 a | 117 a | 224 a | 0 a | 53 a | 345 a |
| Median | 36 a | 183 a | 26 b | 5 a | 149 a | 89 b | 0 a | 37 a | 122 b |
| Low | 35 a | 81 c | 2 c | 3 a | 38 b | 5 c | 0 a | 0 b | 0 c |
| *p*-value | .3456 | **.0001** | **.0001** | .2638 | **.0001** | **.0001** | .0731 | **.0001** | **.0001** |
| **North Bend[1]** | | | | | | | | | |
| High | 22 b | 53 b | 30 a | 8 a | 106 a | 353 a | 0 a | 128 a | 1,851 a |
| Median | 52 a | 150 a | 16 a | 8 a | 162 a | 230 b | 0 a | 126 a | 757 b |
| Low | 47 a | 116 a | 0 a | 30 a | 136 a | 126 c | 0 a | 90 a | 272 c |
| *p*-value | **.0333** | **.0014** | .1653 | .7976 | .0631 | | .3740 | .7752 | .0001 |
| **Leshara[2]** | | | | | | | | | |
| High | 27 a | 38 a | 0 a | 48 a | 162 a | 238 a | 0 a | 108 a | 1,567 a |
| Median | 49 a | 49 a | 0 a | 0 b | 115 a | 154 a | 0 a | 140 a | 1,028 b |
| Low | 40 a | 98 a | 12 a | 32 a | 226 a | 126 a | 0 a | 145 a | 212 c |
| *p*-value | .7717 | .4620 | .7054 | **.0238** | .0661 | .3225 | .2529 | .9667 | **.0001** |
| **Ashland[3]** | | | | | | | | | |
| High | 25 b | 17 c | 12 a | 10 a | 113 b | 140 a | 0 a | 300 a | 3,286 a |
| Median | 54 a | 92 a | 0 b | 30 a | 226 a | 137 a | 0 a | 169 b a | 1,087 b |
| Low | 41 a | 67 b | 0 b | 30 a | 114 b | 82 a | 0 a | 132 b | 457 c |
| *p*-value | **.0249** | **.0001** | **.0004** | .4006 | **.0037** | **.0823** | .3729 | **.026** | **.0001** |
| **Louisville[4]** | | | | | | | | | |
| High | 14 b | 20 b | 12 a | 5 a | 106 a | 142 a | 51 a | 281 a | 3,214 a |
| Median | 61 a | 74 a | 0 a | 33 a | 181 a | 148 a | 51 a | 250 a | 1,213 b |
| Low | 47 a | 78 a | 0 a | 31 a | 190 a | 92 a | 35 a | 182 a | 302 c |
| *p*-value | **.0001** | **.0010** | .4120 | .1934 | .1104 | .2755 | .2882 | .3368 | **.0001** |

[1]No calculation of hydraulic-niche areas was made for the 1934–1944 period because measurements were not made during the period; no calculation of hydraulic-niche areas was made for the low-flow condition in the 1996–2006 period because discharge measurements field notes were not available.

[2]No calculation of hydraulic-niche areas was made for the 1934–1944, 1951–1961, and 1966–1976 periods because measurements were not made during the periods.

[3]No calculation of hydraulic-niche areas was made for the 1966–1976 period because the gaging station was inactive during the period.

[4]No calculation of hydraulic-niche areas was made during 1934–1944 period because measurements were not made during the periods.

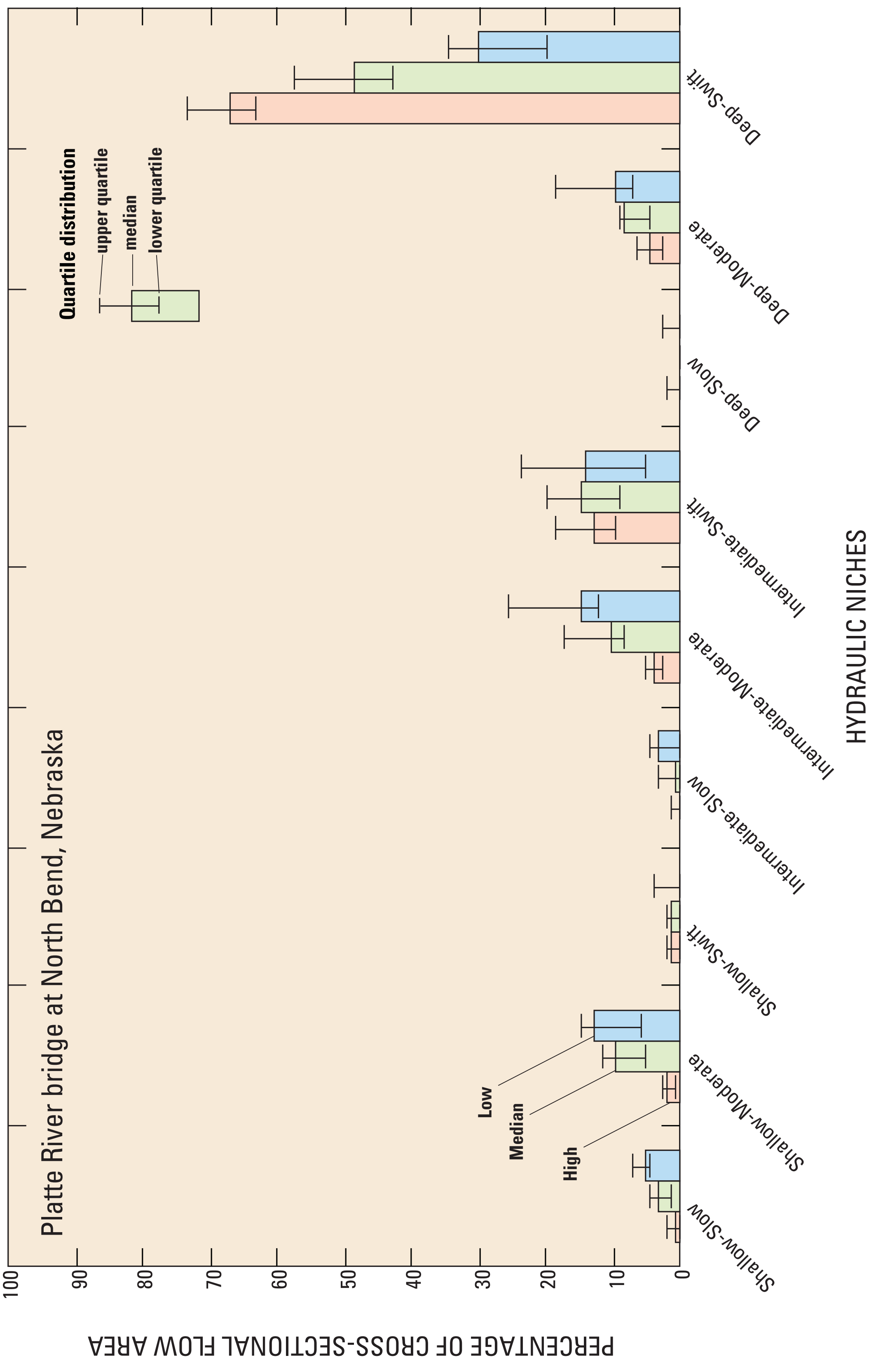



**Figure 20.** Median, lower-, and upper-quartile values of relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge at North Bend, Nebraska, 1951–2006.

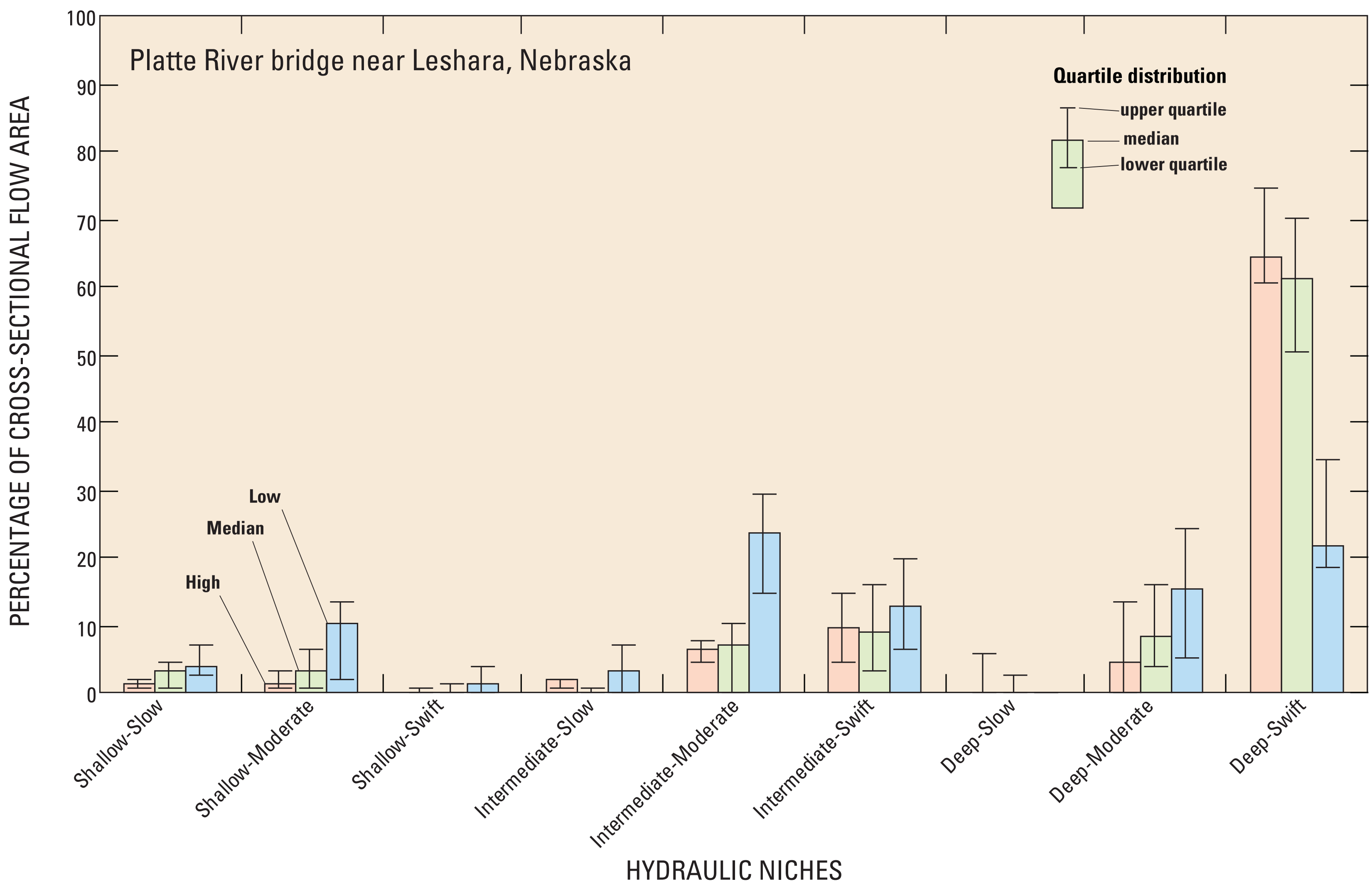



**Figure 21.** Median, lower-, and upper-quartile values of relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge near Leshara, Nebraska, 1985–2006.

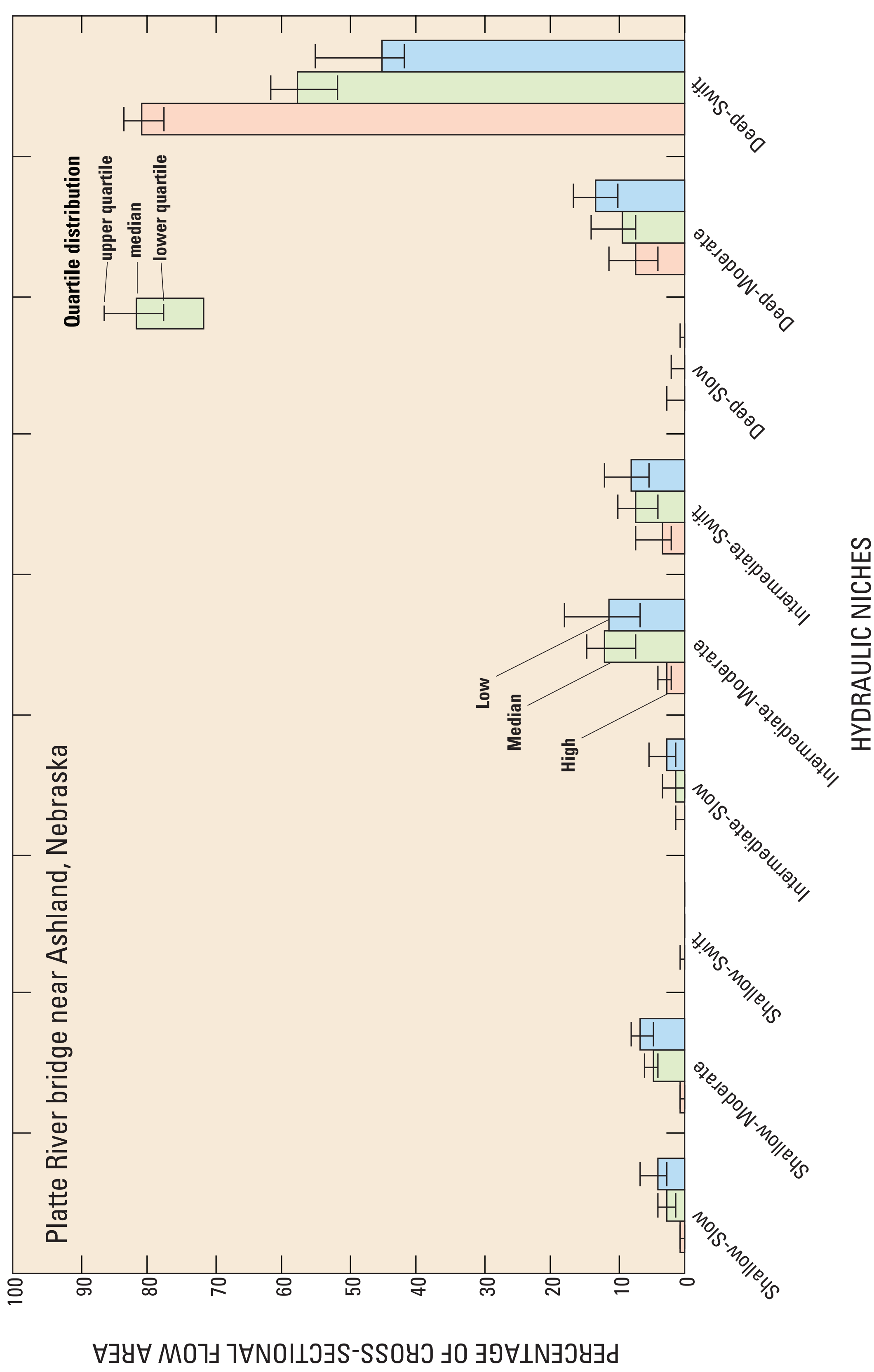



**Figure 22.** Median, lower-, and upper-quartile values of relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge near Ashland, Nebraska, 1934–2006.

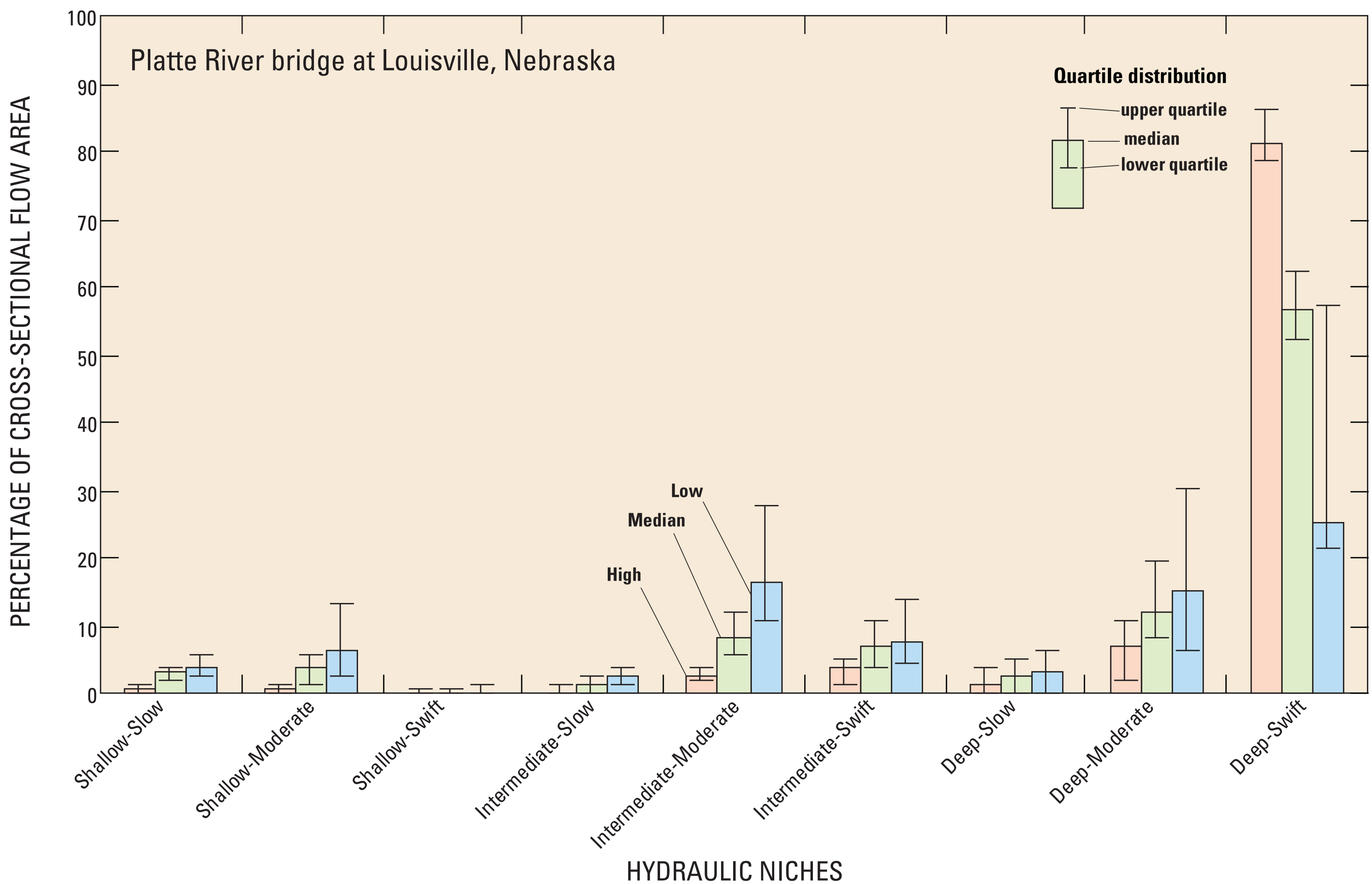



**Figure 23.** Median, lower-, and upper-quartile values of relative cross-sectional area of hydraulic niches for high-, median-, and low-flow conditions near the Platte River bridge at Louisville, Nebraska, 1951–2006.

**Table 15.** Median value and rank comparison between near-bridge and beyond-bridge sites for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for median-flow condition of the Platte River at North Bend, Ashland, and Louisville, Nebraska.

[Tabled values for each location are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 15; letter(s) following each median indicates results of rank comparison tests between the two localities for streamflow depth or velocity within each combination of streamflow-gaging station and percentile; medians within each combination of streamflow-gaging station and percentile that are indexed by the same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that the medians within each combination of streamflow-gaging station and percentile are equal; midpoint for median-flow condition is streamflow that is equaled or exceeded 50 percent of the time]

| Percentile of the area cumulative frequency distribution | North Bend | | | | | | Ashland[1] | | | Louisville | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow depth | | | Flow velocity | | | Flow depth | | | Flow depth | | | Flow velocity | | |
| | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value |
| 1 | 0.30 a | 0.30 a | 0.908 | 0.47 a | 0.23 b | **0.0133** | 0.37 a | 0.30 a | 0.6691 | 0.38 a | 0.45 a | 0.4258 | 0.23 b | 0.67 a | **0.0025** |
| 2 | .36 a | .40 a | .3502 | .59 a | .27 a | .0835 | .50 a | .49 a | .8870 | .50 a | .51 a | .4920 | .37 b | .93 a | **.0025** |
| 5 | .50 b | .60 a | **.0297** | .76 a | .67 a | .2421 | .70 a | .72 a | .6688 | .77 a | .78 a | .9116 | .78 b | 1.27 a | **.0386** |
| 10 | .70 a | .60 a | .9108 | 1.13 a | 1.19 a | >.99 | .80 a | .96 a | .3892 | 1.20 a | 1.05 a | .1496 | 1.15 a | 1.63 a | .0835 |
| 15 | .80 a | .90 a | .4258 | 1.33 a | 1.33 a | >.99 | 1.03 a | 1.09 a | .5681 | 1.43 a | 1.25 a | .0819 | 1.44 a | 1.72 a | .1516 |
| 20 | 1.00 a | 1.00 a | .6398 | 1.50 a | 1.42 a | .2443 | 1.27 a | 1.27 a | .8311 | 1.58 a | 1.40 a | .0835 | 1.66 b | 1.84 a | **.0386** |
| 25 | 1.00 a | 1.16 a | >.99 | 1.66 a | 1.64 a | .3524 | 1.50 a | 1.51 a | .5677 | 1.90 a | 1.53 a | .0835 | 1.84 a | 1.89 a | .0819 |
| 30 | 1.21 a | 1.27 a | >.99 | 1.67 a | 1.70 a | .9116 | 1.59 a | 1.72 a | .4308 | 2.11 a | 1.70 a | .4977 | 1.87 a | 1.96 a | .0835 |
| 35 | 1.34 a | 1.45 a | .6559 | 1.75 a | 1.82 a | .4996 | 1.85 a | 1.87 a | .8870 | 2.31 a | 2.12 a | .8247 | 2.00 a | 2.07 a | .2443 |
| 40 | 1.50 a | 1.60 a | .6503 | 1.89 a | 1.94 a | .6559 | 2.00 a | 2.05 a | .5680 | 2.50 a | 2.18 a | .6559 | 2.03 a | 2.14 a | .1496 |
| 45 | 1.75 a | 2.00 a | .1841 | 2.02 a | 2.01 a | >.99 | 2.12 a | 2.22 a | .4308 | 2.51 a | 2.37 a | .6559 | 2.12 a | 2.17 a | .3611 |
| 50 | 2.02 a | 2.07 a | .8247 | 2.19 a | 2.09 b | **.0386** | 2.35 a | 2.32 a | .8311 | 2.80 a | 2.55 a | .7380 | 2.20 a | 2.25 a | .8247 |
| 55 | 2.15 a | 2.23 a | .3611 | 2.23 a | 2.13 b | **.0061** | 2.44 a | 2.71 a | .7220 | 3.00 a | 2.85 a | .5742 | 2.36 a | 2.39 a | .4996 |
| 60 | 2.63 a | 2.50 a | .3590 | 2.50 a | 2.20 a | .0770 | 2.73 a | 3.14 a | .2181 | 3.49 a | 2.89 a | .2976 | 2.40 a | 2.47 a | .6559 |
| 65 | 3.19 a | 2.59 b | **.0229** | 2.53 a | 2.27 a | .0835 | 2.95 a | 3.50 a | .1061 | 3.64 a | 3.43 a | .8247 | 2.44 a | 2.52 a | .6559 |
| 70 | 3.37 a | 2.60 b | **.0023** | 2.63 a | 2.39 b | **.0025** | 4.12 a | 3.27 b | **.0354** | 3.89 a | 3.64 a | .8247 | 2.50 a | 2.61 a | .4996 |
| 75 | 3.98 a | 2.75 b | **.0023** | 2.74 a | 2.47 b | **.0386** | 4.60 a | 3.44 b | **.0142** | 4.00 a | 4.03 a | .8239 | 2.58 a | 2.72 a | .4996 |
| 80 | 4.20 a | 2.83 b | **.0025** | 2.81 a | 2.53 a | .1516 | 4.90 a | 3.61 b | **.0182** | 4.00 a | 5.14 a | .3611 | 2.65 a | 3.07 a | .3611 |
| 85 | 4.82 a | 3.09 b | **.0061** | 3.01 a | 2.64 a | .1516 | 5.08 a | 3.78 b | **.0229** | 4.15 a | 5.82 a | .0835 | 2.85 a | 3.34 a | .2443 |
| 90 | 5.11 a | 3.17 b | **.0133** | 3.08 a | 2.72 a | .1516 | 5.58 a | 4.24 b | **.0286** | 4.29 a | 6.24 a | .0835 | 3.04 a | 3.60 a | .1516 |
| 95 | 5.80 a | 3.50 b | **.0025** | 3.37 a | 2.80 a | .1516 | 6.16 a | 4.61 b | **.0084** | 5.49 a | 6.54 a | .0835 | 3.15 b | 3.67 a | **.0386** |
| 98 | 5.89 a | 3.73 b | **.0025** | 3.52 a | 2.96 a | .1516 | 6.61 a | 4.96 b | **.0064** | 5.99 a | 7.07 a | .0835 | 3.33 a | 3.72 a | .0835 |
| 99 | 5.95 a | 3.84 b | **.0025** | 3.54 a | 3.09 a | .1516 | 6.79 a | 5.18 b | **.0084** | 6.15 a | 7.21 a | .0835 | 3.35 a | 3.73 a | .0835 |

[1]Streamflow velocities were not measured for beyond-bridge site near Ashland.

**Table 16.** Median value and rank comparison between near-bridge and beyond-bridge sites for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for low-flow condition of the Platte River at North Bend, Leshara, and Louisville, Nebraska.

[Tabled values for each location are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 16; letter(s) following each median indicates results of rank comparison tests between the two localities for streamflow depth or velocity within each combination of streamflow-gaging station and percentile; medians within each combination of streamflow-gaging station and percentile that are indexed by the same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that the medians within each combination of streamflow-gaging station and percentile are equal; midpoint for low-flow condition is streamflow that is equaled or exceeded 84 percent of the time]

| Percentile of the area cumulative frequency distribution | North Bend | | | | | | Leshara[1] | | | Louisville | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow depth | | | Flow velocity | | | Flow depth | | | Flow depth | | | Flow velocity | | |
| | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value |
| 1 | 0.29 a | 0.15 b | **0.0207** | 0.35 a | 0.34 a | 0.8453 | 0.20 b | 0.42 a | **0.0388** | 0.40 a | 0.13 b | **0.0047** | 0.09 a | 0.10 a | 0.6968 |
| 2 | .33 a | .25 b | **.0092** | .46 a | .63 a | .4260 | .25 b | .52 a | **.0213** | .47 a | .20 b | **.0027** | .10 a | .15 a | .1619 |
| 5 | .45 a | .37 a | .4092 | .64 a | .87 a | .2191 | .50 b | .79 a | **.0388** | .68 a | .30 b | **.0027** | .19 a | .54 a | .2797 |
| 10 | .50 a | .45 a | .3485 | .89 a | .99 a | .4200 | .80 a | .95 a | .0840 | .97 a | .40 b | **.0041** | .48 a | .82 a | .1619 |
| 15 | .70 a | .60 a | .2129 | 1.07 a | 1.14 a | .6953 | .95 a | 1.10 a | .1052 | 1.10 a | .55 b | **.0036** | 1.14 a | 1.08 a | .7970 |
| 20 | .89 a | .70 a | .2991 | 1.20 a | 1.24 a | >.99 | 1.10 a | 1.33 a | .2281 | 1.46 a | .77 b | **.0047** | 1.31 a | 1.27 a | .6036 |
| 25 | 1.18 a | .75 b | **.0315** | 1.32 a | 1.36 a | .8453 | 1.19 a | 1.44 a | .8877 | 1.60 a | .86 b | **.0047** | 1.42 a | 1.36 a | .4287 |
| 30 | 1.26 a | .92 a | .2625 | 1.46 a | 1.49 a | >.99 | 1.27 a | 1.65 a | .6030 | 1.72 a | 1.06 b | **.0047** | 1.49 a | 1.47 a | .7958 |
| 35 | 1.37 a | 1.31 a | .5543 | 1.53 a | 1.56 a | >.99 | 1.40 a | 1.77 a | .5381 | 2.03 a | 1.20 b | **.0274** | 1.60 a | 1.53 a | .6036 |
| 40 | 1.66 a | 1.49 a | .4246 | 1.64 a | 1.65 a | .6953 | 1.43 a | 1.83 a | .7413 | 2.20 a | 1.35 b | **.0274** | 1.63 a | 1.60 a | .7958 |
| 45 | 1.70 a | 1.50 a | .5518 | 1.66 a | 1.74 a | .8449 | 1.62 a | 1.92 a | .9625 | 2.31 a | 1.48 b | **.0274** | 1.69 a | 1.70 a | .7970 |
| 50 | 1.73 a | 1.72 a | .5543 | 1.81 a | 1.72 a | .5543 | 1.80 a | 2.11 a | .8138 | 2.69 a | 1.55 b | **.0274** | 1.73 a | 1.77 a | >.99 |
| 55 | 1.91 a | 1.75 a | .5543 | 1.81 a | 1.85 a | .6944 | 1.80 a | 2.25 a | .5381 | 2.99 a | 1.70 b | **.0274** | 1.81 a | 1.84 a | .7970 |
| 60 | 2.00 a | 1.82 a | .3073 | 1.88 a | 1.89 a | .8453 | 2.00 a | 2.38 a | .5381 | 3.46 a | 1.85 b | **.0047** | 1.95 a | 1.94 a | .7970 |
| 65 | 2.00 a | 1.90 a | .4742 | 1.99 a | 1.94 a | .5543 | 2.60 a | 2.45 a | .9625 | 3.65 a | 1.99 b | **.0047** | 2.05 a | 1.99 a | .4287 |
| 70 | 2.05 a | 2.24 a | .5543 | 2.14 a | 1.98 a | .5543 | 2.64 a | 2.59 a | .9625 | 4.02 a | 2.05 b | **.0047** | 2.09 a | 2.07 a | .7970 |
| 75 | 2.22 a | 2.35 a | .4260 | 2.16 a | 2.02 a | .4260 | 2.70 a | 2.86 a | .8877 | 4.13 a | 2.12 b | **.0047** | 2.12 a | 2.19 a | .7970 |
| 80 | 2.39 a | 2.45 a | .4246 | 2.17 a | 2.09 a | .6944 | 2.89 a | 3.08 a | .8877 | 4.61 a | 2.21 b | **.0047** | 2.18 a | 2.26 a | .7970 |
| 85 | 2.55 a | 2.56 a | .4260 | 2.26 a | 2.15 a | .3136 | 2.94 a | 3.12 a | .9625 | 5.03 a | 2.45 b | **.0259** | 2.26 a | 2.33 a | .7970 |
| 90 | 2.68 a | 2.81 a | .8453 | 2.46 a | 2.21 a | .5543 | 3.27 a | 3.49 a | .5381 | 5.39 a | 2.86 b | **.0047** | 2.39 a | 2.43 a | >.99 |
| 95 | 2.79 a | 2.97 a | .8453 | 2.62 a | 2.41 a | .6953 | 3.67 a | 3.58 a | .5381 | 5.73 a | 3.19 b | **.0047** | 2.44 a | 2.52 a | .6036 |
| 98 | 3.05 a | 3.15 a | .2191 | 2.70 a | 2.45 a | .5543 | 3.85 a | 3.77 a | .5381 | 5.92 a | 3.51 b | **.0274** | 2.53 a | 2.64 a | .1619 |
| 99 | 3.08 a | 3.29 a | .0864 | 2.72 a | 2.56 a | .6953 | 3.93 a | 3.79 a | .4765 | 5.98 a | 3.63 b | **.0274** | 2.56 a | 2.72 a | .1619 |

[1]Streamflow velocities were not measured for beyond-bridge site near Leshara.

**Table 17.** Median value and rank comparison between near-bridge and beyond-bridge sites in the relative cross-sectional area of hydraulic niches for median- and low-flow conditions of the Platte River at North Bend and Louisville, Nebraska.

[Tabled values for each location are the median percentages of streamflow cross-sectional area; letter(s) following each median indicates results of rank-comparison tests between the two localities within each combination of hydraulic niche, flow condition, and streamflow-gaging station; medians within each hydraulic niche, flow condition, and streamflow-gaging station that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that the medians within each combination of hydraulic niche, flow condition, and streamflow-gaging station are equal; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Hydraulic niche | North Bend | | | | | | Louisville | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Median-flow condition | | | Low-flow condition | | | Median-flow condition | | | Low-flow condition | | |
| | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value | Near bridge | Beyond bridge | *p*-value |
| Shallow-Slow | 3.2 a | 5.4 a | 0.4996 | 5.9 a | 5.1 a | 0.8453 | 2.0 a | 1.6 a | 0.1516 | 4.3 a | 8.6 a | 0.1619 |
| Shallow-Moderate | 9.9 a | 10.4 a | .6559 | 14.4 a | 23.5 a | .2191 | 5.0 a | 2.9 a | .0835 | 3.5 b | 20.1 a | **.0047** |
| Shallow-Swift | 1.9 a | 1.6 a | .3590 | 0 a | 0 a | .6748 | 0 a | 0 a | .7612 | 0 a | 0 a | .8665 |
| Intermediate-Slow | 3.6 a | 2.6 a | .3611 | 3.3 a | 0 b | **.0379** | 2.2 a | .5 b | **.0386** | 4.2 a | .6 a | .2764 |
| Intermediate-Moderate | 10.8 a | 13.9 a | .6559 | 23.1 a | 13.3 b | **.0212** | 10.7 a | 19.1 a | .0835 | 11.9 a | 18.9 a | .2797 |
| Intermediate-Swift | 14.1 a | 7.7 a | .2443 | 12.3 a | 13.2 a | .8449 | 9.5 a | 10.1 a | .6559 | 6.2 a | 10.7 a | .2797 |
| Deep-Slow | 0 a | .4 a | .8082 | 0 a | 0 a | .6289 | 1.5 a | 0 a | .0765 | 4.5 a | 1.0 a | .1497 |
| Deep-Moderate | 5.6 a | 9.6 a | .0835 | 9.2 b | 31.9 a | **.0464** | 19.7 a | 8.2 b | **.0386** | 27.8 a | 16.2 a | .2797 |
| Deep-swift | 46.5 a | 47.3 a | >.99 | 18.5 a | 13.8 a | .6953 | 56.1 a | 54.9 a | .8247 | 31.3 a | 20.9 a | .2797 |

opposite occurred at Louisville for some other percentiles (1st, 2nd, 5th, 10th, 20th, and 95th). Streamflow velocities during low-flow conditions of the near-bridge and the beyond-bridge sites at North Bend and Louisville were similar (table 16).

Bridge effect on relative cross-sectional area of hydraulic niches was not significant for five of the nine hydraulic niches (table 17). For the median-flow condition, relative cross-sectional area of the Deep-Moderate and Intermediate-Slow hydraulic niches were significantly larger for the near-bridge sites than beyond-bridge sites only at Louisville; no bridge effect was evidenced for any hydraulic niches at North Bend. Although the predominant niche for the median-flow condition for the near-bridge and beyond-bridge sites was the Deep-Swift niche (table 17), no bridge effect was found in the relative cross-sectional area of the Deep-Swift niche. For the low-flow condition, relative cross-sectional area of the Deep-Moderate niche was larger for the beyond-bridge site than the near-bridge site at North Bend, but the converse is true for the Intermediate-Moderate niche; relative cross-sectional area of the Shallow-Moderate niche also was larger for the beyond-bridge site than the near-bridge site at Louisville.

# Potential Application of Findings

Results of this study are useful for water managers, stream ecologists, and fishery biologists. The habitats used by pallid and shovelnose sturgeon in the upper Missouri and Yellowstone Rivers included depths ranging from 2 to 48 ft, and current velocities averaged greater than 2.1 ft/s (Bramblett and White, 2001), consistent with the prevailing conceptual model of habitat requirements of these sturgeon species (Wildhaber and others, 2007). Those results indicate that the Deep-Swift hydraulic niche is the preferred hydraulic habitat of these two species during their adult life. The finding that there is no evidence of net reduction in the relative cross-sectional area of either the Deep-Swift niche or the Glide and Race habitats near the two farthest downstream bridges (near Ashland and at Louisville) is expected to be of interest to fish biologists. It may indicate that with streamflow held constant, no other large shift in the riverine system has occurred that might have caused a corresponding shift in the relative distribution of this type of hydraulic habitat. Therefore, as long as similar streamflow regime can be maintained, long-term net loss of the Deep-Swift habitat would not be expected; however, the small number of cross-sectional measurements analyzed for this report clearly limits the strength of these implications.

The finding that the cross-sectional area of some hydraulic niches shifts as streamflow condition changes is useful in maintaining fish diversity. In case of long-term drought over most of the basin (as occurred during the 1934–44 period), the study results provide first-cut information for water managers in making decisions and taking action intended to sustain fishery habitat. Cross-sectional distributions of streamflow depth and velocity for different streamflow conditions also are important for park managers in scheduling recreational activities involving canoeing or other watercraft.

The findings of this study could lead to a greater use of available discharge measurement data for hydraulic-habitat studies. Historical cross-sectional measurements near streamflow-gaging stations can be examined as a primary data set before embarking on a more spatially intensive, but costly program of streamflow-depth and -velocity data collection.

## Summary and Conclusions

As part of a collaborative study of the cumulative impacts on stream and riparian ecology of water and channel management practices in the lower Platte River, Nebraska, this report describes a study by the U.S. Geological Survey in cooperation with the Lower Platte South Natural Resources District that summarizes: (1) temporal differences in distribution of streamflow depth, velocity, and microhabitats among five discrete 11-water-year periods (1934–44, 1951–61, 1966–76, 1985–95, and 1996–2006), and (2) the effects of bridges on distribution of streamflow depth, velocity, and microhabitat of the Platte River.

Generally, in cases where temporal differences in streamflow depth and velocity were evident, at least one of the water periods from 1934 to 1995 had deeper/shallower streamflow than the recent water-year period (1996–2006). Some temporal changes indicated that any significant change (increase or decrease) in the area cumulative frequency distribution (ACFD) of streamflow depth and velocity among the water-year periods from 1934 to 1995 had disappeared during the most recent water-year period (1996–2006). Temporal differences in distributions of streamflow depth were not strongly associated with differences in either climatic conditions or the peak discharge during each period. Temporal differences in streamflow depth and velocity distributions did not necessarily result in temporal differences in distributions of most categories of the hydraulic niches or low-flow geomorphic habitats. In cases where temporal differences in relative cross-sectional area of hydraulic niches were evidenced, the differences occurred during high- and low-flow conditions, not during median-flow conditions. The temporal differences were found more frequently for hydraulic niches defined by moderate and swift velocities than for hydraulic niches defined by slow velocities. In general, any significant increase or decrease of relative cross-sectional areas of hydraulic niches during the periods from 1934 through 1995 had disappeared during the most recent period (1996–2006).

For the near-bridge site near Duncan, the farthest downstream site of the central Platte River segment, the Deep-Swift hydraulic niche was predominant only during high-flow conditions; during median- and low-flow conditions the relative cross-sectional area was distributed among the Shallow-Slow, Shallow-Moderate, Intermediate-Moderate, and Intermediate-Swift hydraulic niches. The Deep-Swift hydraulic niche was the predominant niche for all near-bridge sites on the lower Platte River for high- and median-flow conditions. The Deep-Swift niche also was the predominant niche for the near-bridge sites near Ashland and at Louisville for low-flow conditions; for the near-bridge sites at North Bend and near Leshara, streamflow cross-sectional areas during low-flow conditions were distributed among the Shallow-Moderate, Intermediate-Moderate, Intermediate-Swift, and Deep-Swift hydraulic niches.

Significant temporal differences in relative cross-sectional area of the Deep-Swift niche were found for the near-bridge sites near Ashland and at Louisville, but only for the low-flow condition. The Deep-Swift microhabitat was of special interest because it is the preferred hydraulic habitat during the adult life of the endangered pallid sturgeon (*Scaphirhynchus albus*). Relative cross-sectional area of the Deep-Swift niche for the near-bridge site near Ashland during the most recent period (1996–2006) was lower than during the 1951–61 and 1985–95 periods. For the near-bridge site at Louisville, relative cross-sectional area of the Deep-Swift niche during the 1951–61 and 1996–2006 periods was lower than during the 1966–76 period. These temporal differences indicated that any significant change in relative cross-sectional area of the Deep-Swift niche for the near-bridge sites near Ashland and at Louisville since the 1951–61 period had nearly disappeared during the most recent period (1996–2006). Temporal difference in relative cross-sectional area of the Glide low-flow geomorphic habitat that contains the Deep-Swift hydraulic niche also indicated that the relative cross-sectional area of Glide during the 1951–61 and 1996–2006 periods was lower than during the 1966–76 period. It may indicate no evidence of net reduction in the relative extent of either the Deep-Swift or the Glide (that contains the Deep-Swift) and Race habitats near the two farthest downstream bridges (near Ashland and at Louisville).

The effect of cross-sectional sites (near- versus beyond-bridge) on streamflow depth and velocity was smaller than expected for the median- and low-flow conditions. Streamflows for median-flow conditions were deeper for the near-bridge sites than beyond-bridge sites at North Bend and near Ashland only for the 70th or higher percentiles of the ACFD; the differences in streamflow velocity for median-flow conditions was inconclusive (streamflow velocity either was higher or lower near bridge than beyond bridge). Generally, for median- and low-flow conditions, the streamflow depths for the near-bridge and beyond-bridge sites at North Bend and near Leshara did not differ.

The effect of bridges on relative cross-sectional area for five of the nine hydraulic niches was not significant. Bridge effects on relative cross-sectional area of the other four hydraulic niches were more evident for the median-flow than the low-flow condition. For the median-flow condition, relative cross-sectional area of the Deep-Moderate and Intermediate-Slow hydraulic niches were significantly larger for the near-bridge site than the beyond-bridge site at Louisville; however, all hydraulic niches were not significantly different for the near-bridge site and the beyond-bridge site at North Bend. For the low-flow condition, relative cross-sectional area of the Deep-Moderate niche was larger for the beyond-bridge site than the near-bridge site at North Bend; relative cross-sectional area of the Shallow-Moderate niches was larger for the beyond-bridge site than the near-bridge site at Louisville.

Although the Deep-Swift hydraulic niche was predominant for the median-flow condition for the near-bridge and the beyond-bridge sites, the sites did not differ in relative cross-sectional area of the Deep-Swift hydraulic niche. The finding that there is no evidence of net reduction in the relative cross-sectional area of either the Deep-Swift niche or the Glide and Race habitats near the two farthest downstream bridges (near Ashland and at Louisville) is expected to be of interest to fish biologists. It may indicate that with streamflow held constant, no other large shift in the riverine system has occurred that might have caused a corresponding shift in the relative distribution of this type of hydraulic habitat; therefore, as long as similar streamflow regime can be maintained, long-term net loss of the Deep-Swift habitat would not be expected. However, the small number of cross-sectional measurements analyzed for this report clearly limits the strength of these implications. Historical cross-sectional measurements near streamflow-gaging stations can be examined as a primary data set before embarking on a more spatially intensive, but costly program of streamflow-depth and -velocity data collection.

## Acknowledgments

The authors thank Larry Hutchinson, Nebraska Game and Parks Commission, for valuable suggestions during the planning stage; Steve Scheinost, Nebraska Game and Parks Commission, and Stuart Trabant, Musetter Engineering, Fort Collins, Colorado, for the Platte River channel cross-sectional data measured downstream and upstream from bridges of interest; Colleen Campbell and Nathan Schaepe of the U.S. Geological Survey, for verification of the CSSHAD_CAL calculation output with numerous discharge measurement field notes. Thanks to the following colleagues, Robert B. Jacobson, Brenda K. Woodward, James F. Cornwall, and Rich McDonald of the U.S. Geological Survey, for reviewing the manuscript and for their constructive comments and suggestions.

## References Cited

Annear, Tom, Chisholm, Ian, Beecher, Hal, Locke, Allan, and others, 2004, Instream flows for riverine resource stewardship (revised ed.): Cheyenne, Wyo., Instream Flow Council, 267 p.

Bowen, Z.H., Bovee, K.D., and Waddle, T.J., 2003, Effects of flow regulation on shallow-water habitat dynamics and floodplain connectivity: Transactions of the American Fisheries Society, v. 132, p. 809–823.

Bramblett, R.G., and White, R.G., 2001, Habitat use and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri Rivers in Montana and North Dakota: Transactions of the American Fisheries Society, v. 130, p. 1,006–1,025.

Bunn, S.E, and Arthington, A.H., 2002, Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity: Environmental Management, v. 30, p. 492–507.

Bunn, S.E., Davies, P.M., and Mosisch, T.D., 1999, Ecosystem measures of river health and their response to riparian and catchment degradation: Freshwater Biology, v. 41, p. 333–345.

Duncan, D.B., 1955, Multiple range and multiple F tests: Biometrics, v. 11, p. 1–42.

Farm Service Agency, 2003, FSA digital orthophoto-2003-UTM-Index for the state of Nebraska: digital orthophoto available on the web, accessed January 25, 2008, at *http://dnr.ne.gov/databank/fsa03.html*

Fitzpatrick, F.A., Waite, I.R., D'Arconte, P.J., Meador, M.R., Maupin, M.A., and Gurtz, M.E., 1998, Revised methods for characterizing stream habitat in the National Water-Quality Assessment Program: U.S. Geological Survey Water-Resources Investigations Report 98–4052, 67 p.

Flynn, K.M., Kirby, W.H., and Hummel, P.R., 2006, User's Manual for Program PeakFQ Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines: U.S. Geological Survey, Techniques and Methods Book 4, Chapter B4, 42 p.

Ginting, Daniel, Zelt, R.B., and Linard, J.I., 2008, Temporal differences in the hydrologic regime of the lower Platte River, Nebraska, 1895–2006: U.S. Geological Survey Scientific Investigations Report 2007–5267, 43 p.

Helsel, D.R., and Hirsch, R.M., 1992, Statistical methods in water resources: Amsterdam, Elsevier, 529 p.

Jobson, H.E., 1989, User's manual for an open-channel streamflow model based on the diffusion analogy: U.S. Geological Survey Water-Resources Investigation Report 89–4133, 73 p.

Kondolf, G.M., and Wolman, M.G., 1993, The sizes of salmonid spawning gravels: Water Resources Research, v. 29, p. 2,275–2,285.

Kondolf, G.M., Montgomery, D.R., Piegay Herve, and Schmitt, Laurent, 2003, Geomorphic classification of rivers and streams, p. 171–204 *in* Kondolf, G.M. and Piegay, H. (eds.), Tools in fluvial geomorphology: Chichester, West Sussex, U.K., John Wiley and Sons, Ltd., 688 p.

McKenney, Rose, 1997, Formation and maintenance of hydraulic habitat units in streams of the Ozark Plateaus, Missouri and Arkansas: State College, Pennsylvania State University, Ph.D. thesis, 347 p.

Moir, H.J., Soulsby, Chris, and Youngson, A.F., 1998, Hydraulic and sedimentary characteristics of habitat utilized by Atlantic salmon for spawning in the Girnock Burn, Scotland: Fisheries Management and Ecology, v. 5, p. 241–254.

Nebraska Game and Parks Commission, 1993, Platte River instream flow: Lincoln, Nebraska Game and Parks Commission, 2 volumes, separately paged, 43 and 29 p., appendices.

Nebraska Game and Parks Commission, 2002, Analysis of proposed conservation measures, Western Sarpy and Clear Creek levee project Platte River, Nebraska: Fort Collins, Colo., Mussetter Engineering Inc., 121 p.

Nilsson, Christer, and Svedmark, Magnus, 2002, Basic principles and ecological consequences of changing water regimes-Riparian plant communities: Environmental Management, v. 30, no. 4, p. 468–480.

Peters, E.J., and Holland, R.S., 1992, Shallow-water fish community abundance and habitat use in the lower Platte River, Nebraska: University of Nebraska-Lincoln, Department of Forestry, Fisheries and Wildlife, Journal Series No. 9109.

Rabeni, C.F., and Jacobson, R.B., 1993, The importance of fluvial hydraulics to fish-habitat restoration in low-gradient alluvial streams: Freshwater Biology, v. 29, p. 211–220.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow: U.S. Geological Survey Water-Supply Paper 2175, 631 p.

SAS Institute Inc., 1990, SAS Procedures Guide, version 6, 3rd ed.: Cary, North Carolina, SAS Institute, 705 p.

Simon, Andrew, Dickerson, Wendy, and Heins, Amanda, 2004, Suspended-sediment transport rates at the 1.5-year recurrence interval for ecoregions of the United States, transport conditions at the bankfull and effective discharge?: Geomorphology, v. 58, p. 243–262.

Stalnaker, C.B., Bovee, K.D., and Waddle, T.J., 1996, Importance of the temporal aspects of habitat hydraulics to fish population studies: Regulated Rivers Research and Management, v. 12, p. 145–153.

Streeter, V.L. and Wylie, B.E., 1985, Fluid mechanics, 8th ed.: New York, McGraw-Hill Inc. 586 p.

U.S. Geological Survey, 2007, USGS surface-water daily data for Nebraska, National Water Information System: U.S. Geological Survey data available on the web, accessed May 31, 2007 at *http://waterdata.usgs.gov/ne/nwis/dv*

Wildhaber, M.L., Delonay, A.J., Papoulias, D.M., Galat, D.L., Jacobson, R.B., Simpkins, D.G., Braaten, P.J., Korschgen, C.E., and Mac, M.J., 2007, A conceptual life-history model for pallid and shovelnose sturgeon: U.S. Geological Survey Circular 1315, 18 p.

Wolman, M.G., and Gerson, R., 1978, Relative scales of time and effectiveness of climate in watershed geomorphology: Earth Surface Processes, v. 3, p. 189–208.

**Table 3.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Duncan, Nebraska, 1934–2006.

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 3; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | | High-flow condition | | | | | | | | | | | |
| Depth | 1934–44 | 0.28 a | 0.30 a | 0.40 c | 0.62 b | 0.80 b | 0.90 ba | 0.98 ba | 1.06 a | 1.19 a | 1.26 a | 1.44 a | 1.73 a |
| | 1951–61 | .27 a | .33 a | .48 bc | .60 b | .70 c | .74 c | .84 b | .93 b | 1.09 a | 1.28 a | 1.40 a | 1.50 a |
| | 1966–76 | .30 a | .38 a | .53 a | .68 b | .76 ba | .90 ba | 1.00 a | 1.00 ba | 1.18 a | 1.30 a | 1.40 a | 1.53 a |
| | 1985–95 | .29 a | .40 a | .50 ba | .80 a | .87 a | .98 a | 1.10 a | 1.10 a | 1.24 a | 1.39 a | 1.60 a | 1.67 a |
| | 1996–2006 | .20 a | .29 a | .50 bac | .60 b | .70 c | .80 bc | .92 ba | 1.00 a | 1.08 a | 1.33 a | 1.48 a | 1.60 a |
| | *p*-value | .3525 | .2482 | **.0209** | **.0005** | **.0001** | **.0043** | **.0142** | **.0373** | .5083 | .5018 | .7042 | .5613 |
| | | Median-flow condition | | | | | | | | | | | |
| Depth | 1934–44 | .20 a | .30 a | .50 a | .60 a | .62 a | .80 a | .90 a | 1.00 a | 1.00 a | 1.18 a | 1.30 a | 1.43 a |
| | 1951–61 | .20 a | .25 a | .30 c | .40 b | .47 b | .55 b | .70 b | .76 a | .89 a | .90 a | 1.05 a | 1.10 a |
| | 1966–76 | .14 a | .24 a | .34 bc | .55 a | .55 ba | .63 ba | .75 ba | .83 a | .92 a | 1.03 a | 1.10 a | 1.15 a |
| | 1985–95 | .20 a | .22 a | .38 ba | .50 a | .52 ba | .61 ba | .68 b | .75 a | .80 a | .90 a | 1.00 a | 1.09 a |
| | 1996–2006 | .19 a | .27 a | .40 ba | .50 a | .58 a | .64 ba | .71 b | .80 a | .84 a | .90 a | 1.00 a | 1.00 a |
| | *p*-value | .7337 | .8929 | **.0116** | **.0008** | **.0092** | **.0284** | **.0447** | .1483 | .2526 | .2785 | .3304 | .0962 |
| | | Low-flow condition | | | | | | | | | | | |
| Depth | 1934–44 | .14 a | .20 a | .20 a | .30 a | .42 a | .50 a | .50 a | .70 a | .78 a | .89 a | .90 a | .90 a |
| | 1951–61 | .12 a | .17 a | .20 a | .29 a | .35 a | .45 a | .53 a | .55 ba | .60 a | .67 ba | .74 ba | .83 ba |
| | 1966–76 | .10 a | .10 a | .20 a | .30 a | .30 a | .35 a | .35 a | .40 b | .43 b | .47 c | .50 c | .50 c |
| | 1985–95 | .10 a | .11 a | .20 a | .27 a | .30 a | .39 a | .45 a | .53 ba | .56 ba | .59 bc | .63 bc | .65 bc |
| | 1996–2006 | .11 a | .15 a | .21 a | .29 a | .32 a | .35 a | .45 a | .45 b | .49 b | .50 c | .52 c | .61 c |
| | *p*-value | .4333 | .1968 | .3279 | .3982 | .2764 | .1675 | .2523 | **.0429** | **.0173** | **.0070** | **.0046** | **.0056** |

**Table 3.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Duncan, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 3; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | | | | | | | High-flow condition | | | | | | |
| Velocity | 1934–44 | 0.18 a | 0.26 a | 0.73 bc | 1.02 a | 1.42 a | 1.64 a | 1.78 a | 1.87 a | 1.95 a | 2.03 a | 2.11 a | 2.15 a |
| | 1951–61 | .59 a | .73 a | 1.12 a | 1.29 a | 1.55 a | 1.61 a | 1.69 a | 1.85 a | 1.91 a | 2.00 a | 2.09 a | 2.17 a |
| | 1966–76 | .60 a | .74 a | .98 a | 1.27 a | 1.48 a | 1.68 a | 1.83 a | 1.92 a | 1.92 a | 1.99 a | 2.01 a | 2.03 a |
| | 1985–95 | .45 a | .81 a | .97 ba | 1.25 a | 1.43 a | 1.55 a | 1.66 a | 1.75 a | 1.79 a | 1.88 a | 1.91 a | 1.94 a |
| | 1996–2006 | .22 a | .39 a | .69 c | 1.18 a | 1.46 a | 1.53 a | 1.70 a | 1.74 a | 1.82 a | 2.04 a | 2.07 a | 2.12 a |
| | *p*-value | .1412 | .1711 | **.0101** | .3795 | .4782 | .2656 | .2549 | .0899 | .2293 | .2301 | .3976 | .2596 |
| | | | | | | | Median-flow condition | | | | | | |
| Velocity | 1934–44 | .31 b | .48 a | .71 a | 1.08 a | 1.30 a | 1.39 ba | 1.46 a | 1.50 ba | 1.57 a | 1.67 a | 1.90 a | 2.08 a |
| | 1951–61 | .58 a | .69 a | .89 a | 1.06 a | 1.26 a | 1.39 bac | 1.40 a | 1.51 ba | 1.63 a | 1.72 a | 1.81 a | 1.84 a |
| | 1966–76 | .44 ba | .58 a | .84 a | 1.05 a | 1.32 a | 1.45 a | 1.51 a | 1.62 a | 1.66 a | 1.73 a | 1.76 a | 1.82 a |
| | 1985–95 | .40 b | .51 a | .84 a | 1.09 a | 1.28 a | 1.31 bc | 1.40 a | 1.41 b | 1.49 a | 1.58 a | 1.69 a | 1.76 a |
| | 1996–2006 | .09 b | .28 a | .55 a | .90 a | 1.15 a | 1.28 c | 1.33 a | 1.44 b | 1.49 a | 1.55 a | 1.67 a | 1.74 a |
| | *p*-value | **.0188** | .0714 | .3388 | .5647 | .3517 | **.0321** | .1173 | **.0355** | .1281 | .1086 | .1249 | .0722 |
| | | | | | | | Low-flow condition | | | | | | |
| Velocity | 1934–44 | .19 a | .19 b | .24 b | .67 ba | .83 a | .94 a | 1.00 a | 1.13 a | 1.19 a | 1.31 a | 1.31 a | 1.43 a |
| | 1951–61 | .11 a | .26 b | .48 ba | .69 ba | .73 a | .85 a | 1.04 a | 1.14 a | 1.21 a | 1.29 a | 1.31 a | 1.37 a |
| | 1966–76 | .27 a | .45 a | .72 a | .86 a | .92 a | .99 a | 1.00 a | 1.03 a | 1.10 a | 1.18 a | 1.24 a | 1.29 a |
| | 1985–95 | .14 a | .17 b | .27 b | .40 b | .64 a | .80 a | 1.00 a | 1.10 a | 1.18 a | 1.23 a | 1.29 a | 1.35 a |
| | 1996–2006 | .13 a | .14 b | .19 b | .34 b | .47 a | .58 a | .84 a | .97 a | 1.11 a | 1.22 a | 1.26 a | 1.31 a |
| | *p*-value | .2281 | **.0222** | **.0473** | **.0402** | .2320 | .1606 | .2850 | .4732 | .8164 | .9335 | .9487 | .9275 |

**Table 3.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Duncan, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 3; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| | | High-flow condition | | | | | | | | | | |
| Depth | 1934–44 | 1.78 a | 2.05 a | 2.35 a | 2.95 a | 3.81 a | 4.73 a | 5.25 a | 6.27 a | 7.16 a | 7.33 a | 7.36 a |
| | 1951–61 | 1.70 a | 1.80 a | 2.00 a | 2.15 b | 2.35 b | 2.57 b | 2.82 cb | 3.15 b | 3.66 b | 4.09 b | 4.56 b |
| | 1966–76 | 1.71 a | 1.80 a | 1.80 a | 2.22 b | 2.36 b | 2.40 b | 2.50 c | 2.92 b | 3.18 b | 3.53 b | 3.66 c |
| | 1985–95 | 1.76 a | 1.80 a | 2.20 a | 2.20 b | 2.30 b | 2.43 b | 2.58 cb | 3.01 b | 3.41 b | 3.50 b | 3.50 cb |
| | 1996–2006 | 1.67 a | 1.90 a | 2.00 a | 2.14 b | 2.30 b | 2.45 b | 3.07 b | 3.30 b | 3.64 b | 4.04 b | 4.17 cb |
| | *p*-value | .9094 | .6481 | .2170 | **.0332** | **.0032** | **.0018** | **.0015** | **.0018** | **.0013** | **.0013** | **.0003** |
| | | Median-flow condition | | | | | | | | | | |
| Depth | 1934–44 | 1.51 a | 1.68 a | 1.76 a | 2.00 a | 2.32 a | 2.59 a | 3.20 a | 3.33a | 3.90 a | 3.93 a | 3.96 a |
| | 1951–61 | 1.20 a | 1.26 a | 1.42 a | 1.55 a | 1.89 a | 2.00 a | 2.26 b | 2.58 b | 2.97 b | 3.12 bc | 3.16 bc |
| | 1966–76 | 1.28 a | 1.30 a | 1.43 a | 1.57 a | 1.72 a | 1.93 a | 2.21 b | 2.32 b | 2.71 b | 2.80 c | 2.80 c |
| | 1985–95 | 1.17 a | 1.25 a | 1.36 a | 1.49 a | 1.49 a | 1.68 a | 2.18 b | 2.49 b | 2.74 b | 2.99 bc | 3.07 bc |
| | 1996–2006 | 1.03 a | 1.27 a | 1.30 a | 1.46 a | 1.77 a | 2.12 a | 2.40 b | 2.77 b | 3.53 ba | 3.94 ba | 3.97 ba |
| | *p*-value | .0681 | .0659 | .0928 | .1454 | .1953 | .0507 | **.0091** | **.0062** | **.0169** | **.0183** | **.0153** |
| | | Low-flow condition | | | | | | | | | | |
| Depth | 1934–44 | .91 a | 1.00 a | 1.01 a | 1.18 a | 1.32 a | 1.40 a | 1.40 a | 1.53 a | 1.79 a | 1.80 a | 1.80 a |
| | 1951–61 | .98 ba | 1.10 a | 1.18 a | 1.23 a | 1.25 a | 1.35 a | 1.45 a | 1.60 a | 1.60 a | 1.65 a | 1.65 a |
| | 1966–76 | .59 c | .60 b | .61 a | .68 b | .70 a | .78 a | .90 a | 1.20 a | 1.44 a | 1.51 a | 1.53 a |
| | 1985–95 | .71 bac | .80 ba | .85 a | .91 ba | .95 a | .98 a | 1.10 a | 1.14 a | 1.28 a | 1.38 a | 1.42 a |
| | 1996–2006 | .65 bc | .76 ba | .85 a | .91 ba | 1.02 a | 1.28 a | 1.47 a | 1.52 a | 1.64 a | 1.70 a | 1.73 a |
| | *p*-value | **.0134** | **.0283** | .0563 | **.0241** | .0849 | .1198 | .2106 | .2698 | .5253 | .6174 | .6249 |

**Table 3.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Duncan, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 3; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| | | High-flow condition | | | | | | | | | | |
| Velocity | 1934–44 | 2.22 a | 2.33 a | 2.39 a | 2.46 a | 2.60 a | 2.69 a | 2.74 a | 2.88 ba | 3.13 a | 3.34 a | 3.38 a |
| | 1951–61 | 2.20 a | 2.25 a | 2.36 ba | 2.38 a | 2.49 a | 2.62 a | 2.78 ba | 2.89 a | 2.99 ba | 3.04 a | 3.13 a |
| | 1966–76 | 2.04 a | 2.10 a | 2.18 b | 2.25 a | 2.34 a | 2.43 a | 2.53 c | 2.59 c | 2.78 b | 3.00 a | 3.02 a |
| | 1985–95 | 2.09 a | 2.14 a | 2.22 b | 2.29 a | 2.41 a | 2.53 a | 2.64 bc | 2.74 bc | 2.86 b | 2.86 a | 2.86 a |
| | 1996–2006 | 2.15 a | 2.22 a | 2.37 ba | 2.40 a | 2.50 a | 2.57 a | 2.61 bac | 2.70 bac | 2.98 ba | 3.13 a | 3.14 a |
| | *p*-value | .2291 | .1779 | **.0489** | .0756 | .1142 | .0507 | **.0215** | **.0096** | **.0326** | .0965 | .0750 |
| | | Median-flow condition | | | | | | | | | | |
| Velocity | 1934–44 | 2.11 a | 2.23 a | 2.32 a | 2.41 a | 2.45 a | 2.48 a | 2.53 a | 2.71 a | 2.84 a | 2.93 a | 2.96 a |
| | 1951–61 | 1.88 ba | 1.96 ba | 1.99 a | 2.02 a | 2.21 a | 2.24 a | 2.30 a | 2.42 a | 2.66 bac | 2.70 ba | 2.73 ba |
| | 1966–76 | 1.86 b | 1.87 b | 1.94 a | 2.01 a | 2.06 ba | 2.11 a | 2.23 a | 2.32 a | 2.46 bc | 2.57 ba | 2.62 ba |
| | 1985–95 | 1.80 b | 1.86 b | 1.92 a | 1.98 a | 2.00 b | 2.05 a | 2.09 a | 2.20 a | 2.38 c | 2.46 b | 2.46 b |
| | 1996–2006 | 1.85 b | 1.87 b | 1.89 a | 1.96 a | 2.08 ba | 2.11 a | 2.23 a | 2.45 a | 2.72 ba | 2.82 ba | 2.88 ba |
| | *p*-value | **.0286** | **.0372** | .0517 | .1758 | **.0276** | .1245 | .1423 | .0578 | **.0146** | **.0407** | **.0415** |
| | | Low-flow condition | | | | | | | | | | |
| Velocity | 1934–44 | 1.62 a | 1.70 a | 1.78 a | 1.79 a | 1.84 a | 1.89 a | 1.97 a | 2.09 a | 2.15 a | 2.27 a | 2.29 a |
| | 1951–61 | 1.48 a | 1.52 a | 1.63 a | 1.63 a | 1.72 a | 1.75 a | 1.79 a | 1.89 a | 2.11 a | 2.15 a | 2.15 a |
| | 1966–76 | 1.30 a | 1.31 a | 1.44 a | 1.50 a | 1.53 a | 1.63 a | 1.66 a | 1.70 a | 1.83 a | 1.84 a | 1.85 a |
| | 1985–95 | 1.36 a | 1.42 a | 1.49 a | 1.55 a | 1.57 a | 1.66 a | 1.71 a | 1.78 a | 1.86 a | 2.00 a | 2.01 a |
| | 1996–2006 | 1.45 a | 1.48 a | 1.54 a | 1.58 a | 1.67 a | 1.77 a | 1.88 a | 1.95 a | 2.02 a | 2.14 a | 2.19 a |
| | *p*-value | .9467 | .9595 | .8979 | .8756 | .7355 | .7699 | .5549 | .3027 | .2539 | .2531 | .2420 |

**Table 4.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at North Bend, Nebraska, 1934–2006.

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 4; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution: 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High-flow condition | | | | | | | | | | | |
| Depth | 1951–61 | 0.65 a | 0.80 a | 1.01 a | 1.32 a | 1.62 a | 1.81 a | 2.09 a | 2.21 a | 2.30 a | 2.50 a | 2.66 ba | 3.00 ba |
| | 1966–76 | .66 a | .93 a | 1.45 a | 1.80 a | 1.85 a | 1.98 a | 2.15 a | 2.83 a | 2.98 a | 3.19 a | 3.42 a | 3.69 a |
| | 1985–95 | .48 b | .50 b | .86 b | 1.05 b | 1.39 a | 1.65 a | 1.77 a | 2.13 a | 2.26 a | 2.48 a | 2.85 a | 3.20 a |
| | 1996–2006 | .41 b | .62 a | .86 b | 1.10 b | 1.38 a | 1.55 a | 1.69 a | 1.94 a | 2.06 a | 2.23 a | 2.44 b | 2.61 b |
| | *p*-value | **.0043** | **.0199** | **.0198** | **.0006** | .1301 | .1640 | .0818 | .0609 | .1461 | .1677 | **.0124** | **.0150** |
| | | Median-flow condition | | | | | | | | | | | |
| Depth | 1951–61 | .29 a | .40 b | .50 ba | .80 a | .90 a | 1.10 ba | 1.29 ba | 1.55 a | 1.94 a | 2.00 a | 2.40 a | 2.40 a |
| | 1966–76 | .37 a | .52 a | .81 a | 1.00 a | 1.24 a | 1.50 a | 1.65 a | 1.71 a | 2.05 a | 2.27 a | 2.50 a | 2.70 a |
| | 1985–95 | .30 a | .36 b | .50 b | .60 a | .90 a | 1.00 b | 1.00 c | 1.21 b | 1.34 b | 1.50 b | 1.75 b | 2.02 ba |
| | 1996–2006 | .32 a | .42ba | .66 ba | .80 a | .90 a | 1.08 b | 1.25 bc | 1.30 b | 1.40 b | 1.65 b | 1.85 b | 1.98 b |
| | *p*-value | .2479 | **.0322** | **.0335** | .2551 | .1223 | **.0175** | **.0023** | **.0015** | **.0005** | **.0026** | **.0073** | **.0208** |
| | | Low-flow condition[2] | | | | | | | | | | | |
| Depth | 1951–61 | .24 a | .30 a | .40 a | .70 a | .86 a | 1.00 a | 1.30 a | 1.30 a | 1.40 a | 1.60 a | 1.60 a | 1.81 a |
| | 1966–76 | .27 a | .30 a | .50 a | .75 a | .90 a | 1.09 a | 1.20 a | 1.32 a | 1.52 a | 1.60 a | 1.65 a | 1.78 a |
| | 1985–95 | .29 a | .33 a | .45 a | .50 a | .70 a | .89 a | 1.18 a | 1.26 a | 1.37 a | 1.66 a | 1.70 a | 1.72 a |
| | *p*-value | .6866 | .5234 | .6630 | .1785 | .2407 | .2670 | .7525 | .3282 | .3659 | .6509 | .7073 | .7609 |

**Table 4.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at North Bend, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 4; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution: 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | High-flow condition | | | | | | |
| Velocity | 1951–61 | 0.57 a | 0.83 a | 1.48 a | 1.95 a | 2.04 a | 2.14 a | 2.24 ba | 2.33 b | 2.40 b | 2.47 b | 2.62 b | 2.74 b |
| | 1966–76 | .56 a | .84 a | 1.31 a | 1.83 a | 2.01 a | 2.25 a | 2.60 a | 2.85 a | 2.88 a | 2.91 a | 3.04 a | 3.09 a |
| | 1985–95 | .56 a | .76 a | 1.20 a | 1.35 a | 1.90 a | 1.97 a | 2.07 b | 2.16 b | 2.35 b | 2.46 b | 2.55 b | 2.63 b |
| | 1996–2006 | .61 a | .82 a | 1.41 a | 1.81 a | 1.97 a | 2.05 a | 2.17 b | 2.28 b | 2.37 b | 2.44 b | 2.56 b | 2.63 b |
| | *p*-value | .9608 | .9148 | .2280 | .0926 | .2329 | .1050 | **.0368** | **.0092** | **.0176** | **.0196** | **.0256** | **.0364** |
| | | | | | | | Median-flow condition | | | | | | |
| Velocity | 1951–61 | .46 a | .69 a | 1.02 a | 1.21 a | 1.65 a | 1.79 a | 1.87 a | 1.98 a | 2.23 a | 2.28 a | 2.47 a | 2.53 a |
| | 1966–76 | .34 a | .43 a | .95 a | 1.33 a | 1.58 a | 1.74 a | 1.89 a | 1.99 a | 2.09 a | 2.14 a | 2.24 a | 2.38 b |
| | 1985–95 | .47 a | .59 a | .76 a | 1.13 a | 1.33 a | 1.50 a | 1.66 a | 1.67 a | 1.75 a | 1.89 a | 2.02 a | 2.19 b |
| | 1996–2006 | .45 a | .53 a | .90 a | 1.14 a | 1.36 a | 1.48 a | 1.67 a | 1.81 a | 1.97 a | 2.00 a | 2.06 a | 2.09 b |
| | *p*-value | .3156 | .4073 | .8627 | .6385 | .0739 | .0885 | .1164 | .1896 | .0989 | .1203 | .0730 | **.0119** |
| | | | | | | | Low-flow condition[2] | | | | | | |
| Velocity | 1951–61 | .39 a | .56 a | .83 a | 1.08 a | 1.24 a | 1.30 ba | 1.38 a | 1.52 a | 1.62 a | 1.83 a | 1.88 a | 1.93 a |
| | 1966–76 | .18 a | .30 a | .53 a | 1.02 a | 1.30 a | 1.50 a | 1.55 a | 1.64 a | 1.75 a | 1.84 a | 2.02 a | 2.05 a |
| | 1985–95 | .35 a | .46 a | .64 a | .89 a | 1.07 a | 1.20 b | 1.32 a | 1.46 a | 1.53 a | 1.64 a | 1.66 a | 1.72 a |
| | *p*-value | .2481 | .2969 | .1038 | .4785 | .1437 | .0417 | .1248 | .2353 | .0860 | .1312 | .1454 | .1063 |

**Table 4.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at North Bend, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 4; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at p-value less than 0.05; the p-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| | | | | | | High-flow condition | | | | | | |
| Depth | 1951–61 | 3.21 ba | 3.45 b | 3.80 b | 4.00 a | 4.24 a | 4.41 a | 4.79 a | 5.34 a | 6.04 a | 6.56 a | 6.73 a |
| | 1966–76 | 3.87 a | 4.92 a | 5.72 a | 6.18 a | 7.41 a | 7.69 a | 8.21 a | 8.55 a | 8.86 a | 9.09 a | 9.19 a |
| | 1985–95 | 3.85 a | 3.98 a | 4.34 ba | 4.68 a | 4.75 a | 5.33 a | 5.92 a | 6.64 a | 7.73 a | 8.68 a | 8.96 a |
| | 1996–2006 | 2.86 b | 2.95 b | 3.93 b | 4.22 a | 6.13 a | 6.51 a | 7.25 a | 7.92 a | 8.95 a | 9.72 a | 9.86 a |
| | *p*-value | **.0038** | **.0002** | **.0345** | .1496 | .1645 | .2312 | .2049 | .2723 | .3682 | .3114 | .3493 |
| | | | | | | Median-flow condition | | | | | | |
| Depth | 1951–61 | 2.50 a | 2.60 a | 2.80 a | 3.35 a | 4.13 a | 4.73 a | 5.25 a | 5.65 a | 5.71 a | 6.36 a | 6.58 a |
| | 1966–76 | 2.78 a | 2.99 a | 3.25 a | 3.55 a | 3.73 a | 4.59 a | 4.91 a | 5.21 a | 5.47 a | 5.58 a | 5.64 a |
| | 1985–95 | 2.15 a | 2.63 a | 3.19 a | 3.37 a | 3.98 a | 4.20 a | 4.82 a | 5.11 a | 5.80 a | 5.89 a | 5.95 a |
| | 1996–2006 | 2.00 a | 2.30 a | 2.30 a | 2.40 a | 2.61 a | 3.18 a | 3.59 a | 4.07 a | 4.34 a | 4.50 a | 4.64 a |
| | *p*-value | .0925 | .3792 | .3743 | .2173 | .1011 | .2167 | .3364 | .5482 | .4522 | .4375 | .4389 |
| | | | | | | Low-flow condition[2] | | | | | | |
| Depth | 1951–61 | 1.90 a | 1.94 a | 2.08 a | 2.21 a | 2.40 a | 2.55 a | 2.81 a | 3.22 a | 3.80 a | 4.02 a | 4.11 a |
| | 1966–76 | 1.87 a | 2.01 a | 2.18 a | 2.33 a | 2.49 a | 2.60 a | 2.84 a | 3.31 a | 3.75 a | 3.81 a | 3.83 a |
| | 1985–95 | 1.75 a | 1.82 a | 1.90 a | 2.05 a | 2.22 a | 2.39 a | 2.55 a | 2.81 a | 2.97 a | 3.05 a | 3.08 a |
| | *p*-value | .6125 | .4492 | .3815 | .3675 | .4011 | .5686 | .4503 | .3139 | .3479 | .3237 | .3237 |

**Table 4.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at North Bend, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 4; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at p-value less than 0.05; the p-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution: 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **High-flow condition** | | | | | | | | | | |
| Velocity | 1951–61 | 2.79 b | 2.86 a | 2.95 a | 3.15 ba | 3.22 b | 3.37 a | 3.58 a | 3.87 a | 4.15 a | 4.44 a | 4.54 a |
| | 1966–76 | 3.16 a | 3.22 a | 3.38 a | 3.45 a | 3.62 a | 3.77 a | 4.00 a | 4.19 a | 4.37 a | 4.62 a | 4.71 a |
| | 1985–95 | 2.89 b | 2.95 a | 3.14 a | 3.22 ba | 3.35 ba | 3.42 a | 3.60 a | 3.83 a | 4.13 a | 4.40 a | 4.45 a |
| | 1996–2006 | 2.78 b | 2.84 a | 2.89 a | 2.99 b | 3.07 b | 3.17 a | 3.43 a | 3.71 a | 3.84 a | 3.90 a | 3.92 a |
| | *p*-value | **.0391** | .0838 | .0523 | **.0404** | **.0321** | .0736 | .0762 | .3381 | .1723 | .2555 | .2196 |
| | | **Median-flow condition** | | | | | | | | | | |
| Velocity | 1951–61 | 2.71 a | 2.78 a | 2.83 a | 2.91 a | 3.08 a | 3.24 a | 3.57 a | 3.75 a | 3.99 a | 4.03 a | 4.04 a |
| | 1966–76 | 2.47 b | 2.56 ba | 2.59 a | 2.66 a | 2.79 a | 2.99 a | 3.29 a | 3.49 a | 3.64 ba | 3.74 a | 3.75 a |
| | 1985–95 | 2.23 b | 2.50 ba | 2.53 a | 2.63 a | 2.74 a | 2.81 b | 3.01 b | 3.08 b | 3.37 bc | 3.52 ba | 3.54 a |
| | 1996–2006 | 2.17 b | 2.23 b | 2.34 a | 2.42 a | 2.47 a | 2.56 b | 2.77 b | 2.77 b | 2.86 c | 3.17 b | 3.39 a |
| | *p*-value | **.0074** | **.0473** | .0761 | .9999 | .0639 | **.0028** | **.0027** | **.0019** | **.0078** | **.0289** | .1138 |
| | | **Low-flow condition[2]** | | | | | | | | | | |
| Velocity | 1951–61 | 2.00 ba | 2.16 a | 2.18 a | 2.26 a | 2.36 a | 2.47 a | 2.53 a | 2.87 a | 2.98 a | 3.00 a | 3.01 a |
| | 1966–76 | 2.18 a | 2.20 a | 2.28 a | 2.37 a | 2.47 a | 2.54 a | 2.60 a | 2.64 a | 2.73 a | 2.84 a | 2.85 a |
| | 1985–95 | 1.81 b | 1.88 a | 1.99 a | 2.14 a | 2.16 a | 2.17 a | 2.26 a | 2.46 a | 2.62 a | 2.70 a | 2.72 a |
| | *p*-value | **.0491** | .2307 | .3310 | .4492 | .4492 | .3083 | .2956 | .2767 | .1823 | .2911 | .2767 |

[1]No calculation of area cumulative frequency distribution was made for the 1934–1944 period because streamflow-gaging station and discharge measurements began in April 1949.

[2]No calculation of area cumulative frequency distribution was made for the low-flow condition in the 1996–2006 period because discharge measurements field notes were not available.

**Table 5.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Leshara, Nebraska, 1934–2006.

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 5; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | | | | | | | High-flow condition | | | | | | |
| Depth | 1985–95 | 0.50 a | 0.70 a | 1.00 a | 1.40 a | 1.65 a | 2.00 a | 2.14 a | 2.30 a | 2.43 a | 2.68 a | 2.83 a | 3.00 a |
| | 1996–2006 | .49 a | .66 a | 1.00 a | 1.20 a | 1.50 a | 1.64 b | 1.93 a | 2.08 a | 2.14 a | 2.37 a | 2.70 a | 3.00 a |
| | *p*-value | .8153 | .9068 | .8153 | .2103 | .0581 | **.0062** | .0904 | .0639 | .2168 | .4758 | .4758 | .6382 |
| | | | | | | | Median-flow condition | | | | | | |
| Depth | 1985–95 | .46 a | .57 a | .72 a | 1.28 a | 1.64 a | 2.30 a | 2.60 a | 2.70 a | 2.80 a | 2.88 a | 2.96 a | 3.26 a |
| | 1996–2006 | .29 a | .41 a | .58 a | .88 a | 1.18 a | 1.55 a | 1.71 a | 1.80 a | 1.82 a | 2.05 a | 2.49 a | 2.62 a |
| | *p*-value | .5543 | .2191 | .2609 | .1421 | .3136 | .1435 | .1435 | .1759 | .1435 | .2176 | .2191 | .2191 |
| | | | | | | | Low-flow condition | | | | | | |
| Depth | 1985–95 | .33 a | .53 a | .68 a | .81 a | .90 a | 1.00 a | 1.10 a | 1.20 a | 1.29 a | 1.40 a | 1.40 a | 1.54 a |
| | 1996–2006 | .20 a | .25 a | .50 a | .80 a | .95 a | 1.10 a | 1.19 a | 1.27 a | 1.40 a | 1.43 a | 1.62 a | 1.80 a |
| | *p*-value | .0986 | .1012 | .4964 | .8946 | .7893 | .7880 | .7893 | .7867 | .5892 | .4098 | .2591 | .4991 |
| | | | | | | | High-flow condition | | | | | | |
| Velocity | 1985–95 | .25 a | .28 a | .50 a | .96 a | 1.58 a | 2.04 a | 2.20 a | 2.34 a | 2.40 a | 2.44 a | 2.51 a | 2.61 a |
| | 1996–2006 | .57 a | .81 a | 1.22 a | 1.44 a | 1.63 a | 1.90 a | 2.03 a | 2.12 a | 2.21 a | 2.30 a | 2.38 a | 2.51 a |
| | *p*-value | .2168 | .3339 | .4758 | .1269 | .6382 | .2168 | .2168 | .3339 | .4758 | .6382 | .8153 | .6382 |
| | | | | | | | Median-flow condition | | | | | | |
| Velocity | 1985–95 | .66 a | .79 a | 1.16 a | 1.26 a | 1.58 a | 1.75 a | 2.06 a | 2.19 a | 2.29 a | 2.36 a | 2.46 a | 2.59 a |
| | 1996–2006 | .47 a | .53 a | .98 a | 1.50 a | 1.66 a | 1.80 a | 1.95 a | 2.03 a | 2.11 a | 2.22 a | 2.33 a | 2.47 a |
| | *p*-value | .3136 | .2191 | .6953 | .5543 | .8453 | .8453 | .2191 | .3136 | .3136 | .4260 | .4260 | .5543 |
| | | | | | | | Low-flow condition | | | | | | |
| Velocity | 1985–95 | .59 a | .77 a | 1.12 a | 1.29 a | 1.57 a | 1.62 a | 1.65 a | 1.67 a | 1.70 a | 1.78 a | 1.84 a | 1.90 a |
| | 1996–2006 | .27 a | .57 a | .78 a | 1.02 a | 1.18 a | 1.36 a | 1.44 a | 1.55 a | 1.63 a | 1.68 a | 1.74 a | 1.79 a |
| | *p*-value | .1012 | .3336 | .3336 | .1996 | .1996 | .1996 | .1996 | .3336 | .4991 | .8946 | .8946 | .6891 |

**Table 5.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Leshara, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 5; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| | | | | | | High-flow condition | | | | | | |
| Depth | 1985–95 | 3.40 a | 3.50 a | 3.57 a | 3.71 a | 3.98 a | 4.23 a | 4.40 a | 4.52 a | 4.67 a | 4.81 a | 4.85 a |
| | 1996–2006 | 3.14 a | 3.25 a | 3.40 a | 3.58 a | 3.93 a | 4.17 a | 4.48 a | 4.74 a | 5.33 a | 5.66 a | 5.70 a |
| | *p*-value | .4758 | .5531 | .8153 | .9068 | .8153 | >.99 | .8153 | .8153 | .8153 | >.99 | >.99 |
| | | | | | | Median-flow condition | | | | | | |
| Depth | 1985–95 | 3.36 a | 3.50 a | 3.81 a | 4.02 a | 4.14 a | 4.25 a | 4.46 a | 4.58 a | 4.89 a | 5.08 a | 5.14 a |
| | 1996–2006 | 2.74 a | 2.92 a | 3.03 a | 3.18 a | 3.41 a | 3.81 a | 4.07 a | 4.46 a | 4.81 a | 5.28 a | 5.44 a |
| | *p*-value | .2191 | .2191 | .2191 | .3662 | .2191 | .5543 | .8453 | .8453 | .8453 | .8453 | .8453 |
| | | | | | | Low-flow condition | | | | | | |
| Depth | 1985–95 | 1.76 a | 1.80 a | 1.80 a | 1.88 a | 1.96 a | 2.65 a | 3.34 a | 4.00 a | 4.34 a | 4.37 a | 4.39 a |
| | 1996–2006 | 1.80 a | 2.00 a | 2.60 a | 2.64 a | 2.70 a | 2.89 a | 2.94 a | 3.27 a | 3.67 a | 3.85 a | 3.93 a |
| | *p*-value | .4991 | .4098 | .1012 | .1012 | .3336 | .6891 | .8946 | .8946 | .8946 | .8946 | .8946 |
| | | | | | | High-flow condition | | | | | | |
| Velocity | 1985–95 | 2.67 a | 2.95 a | 3.19 a | 3.28 a | 3.31 a | 3.39 a | 3.48 a | 3.60 a | 3.77 a | 3.87 a | 4.06 a |
| | 1996–2006 | 2.58 a | 2.77 a | 2.84 a | 2.89 a | 3.04 a | 3.12 a | 3.21 a | 3.29 a | 3.54 a | 3.67 a | 3.73 a |
| | *p*-value | .8153 | .3339 | .1269 | .0639 | .2168 | .3339 | .3339 | .4758 | .4758 | .3339 | .3339 |
| | | | | | | Median-flow condition | | | | | | |
| Velocity | 1985–95 | 2.63 a | 2.69 a | 2.83 a | 2.84 a | 2.85 a | 2.89 a | 3.26 a | 3.48 a | 3.61 a | 3.68 a | 3.71 a |
| | 1996–2006 | 2.53 a | 2.59 a | 2.65 a | 2.68 a | 2.73 a | 2.76 a | 2.86 a | 3.00 a | 3.19 a | 3.29 a | 3.33 a |
| | *p*-value | .5543 | .6953 | .8453 | .8453 | .8453 | .8453 | .3136 | .2191 | .2191 | .3136 | .3136 |
| | | | | | | Low-flow condition | | | | | | |
| Velocity | 1985–95 | 2.03 a | 2.14 a | 2.15 a | 2.20 a | 2.25 a | 2.27 a | 2.37 a | 2.46 a | 2.88 a | 2.89 a | 2.90 a |
| | 1996–2006 | 1.86 a | 1.98 a | 2.02 a | 2.07 a | 2.10 a | 2.23 a | 2.38 a | 2.50 a | 2.70 a | 2.81 a | 2.83 a |
| | *p*-value | .3336 | .3336 | .3336 | .4991 | .4991 | .6891 | .8946 | .8946 | .4991 | .4991 | .4991 |

[1]No calculation of area cumulative frequency distribution was made for the 1934–1944, 1951–1961, and 1966–1976 periods because streamflow-gaging station and discharge measurements began in June 1994.

**Table 6.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Ashland, Nebraska, 1934–2006.

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 6; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | | High-flow condition | | | | | | | | | | | |
| Depth | 1934–44 | 0.65 a | 0.95 a | 1.75 a | 2.40 a | 3.01 a | 3.40 a | 3.82 a | 4.29 a | 4.63 a | 4.88 a | 5.16 a | 5.67 a |
| | 1951–61 | .60 a | .80 a | 1.07 a | 1.73 b | 2.07 a | 2.23 b | 2.59 a | 2.86 a | 3.11 a | 3.53 a | 3.92 a | 4.22 a |
| | 1985–95 | .66 a | .89 a | 1.30 a | 1.86 b | 2.15 a | 2.54 ba | 2.70 a | 3.01 a | 3.37 a | 3.65 a | 3.80 a | 4.04 a |
| | 1996–2006 | .79 a | 1.07 a | 1.30 a | 1.62 b | 2.14 a | 2.30 b | 2.50 a | 2.70 a | 2.80 a | 3.00 a | 3.49 a | 3.83 a |
| | *p*-value | .4428 | .8362 | .1049 | **.0116** | .0854 | **.0387** | .1111 | .1509 | .1258 | .0819 | .0780 | .0787 |
| | | Median-flow condition | | | | | | | | | | | |
| Depth | 1934–44 | .30 a | .40 a | .70 a | 1.09 a | 1.60 a | 1.70 a | 1.86 a | 2.04 a | 2.50 a | 2.74 a | 3.13 a | 3.30 a |
| | 1951–61 | .50 a | .58 a | .81 a | 1.05 a | 1.20 ba | 1.34 a | 1.54 ba | 1.87 ba | 2.02 bc | 2.29 bc | 2.41 b | 2.68 ba |
| | 1985–95 | .34 a | .44 a | .69 a | 1.04 a | 1.34 a | 1.53 a | 1.75 a | 2.06 a | 2.37 ba | 2.67 ba | 3.17 a | 3.40 a |
| | 1996–2006 | .37 a | .50 a | .70 a | .80 b | 1.03 b | 1.27 a | 1.50 b | 1.59 b | 1.85 c | 2.00 c | 2.12 b | 2.35 b |
| | *p*-value | .1041 | .3551 | .4881 | **.0132** | **.0213** | .0594 | **.0247** | **.0035** | **.0023** | **.0051** | **.0031** | **.0102** |
| | | Low-flow condition | | | | | | | | | | | |
| Depth | 1934–44 | .34 a | .60 a | .63 a | .85 a | 1.14 a | 1.30 a | 1.40 a | 1.50 a | 1.75 b | 1.80 b | 1.90 c | 2.20 a |
| | 1951–61 | .40 a | .50 a | .70 a | .90 a | 1.00 a | 1.30 a | 1.40 a | 1.65 a | 1.90 ba | 2.10 ba | 2.31 a | 2.50 a |
| | 1985–95 | .28 a | .41 a | .52 a | .88 a | 1.09 a | 1.48 a | 1.73 a | 1.89 a | 2.01 a | 2.10 a | 2.22 ba | 2.30 a |
| | 1996–2006 | .25 a | .34 a | .54 a | .81 a | 1.10 a | 1.26 a | 1.37 a | 1.57 a | 1.75 b | 1.85 b | 2.12 bc | 2.25 a |
| | *p*-value | .1857 | .2617 | .5245 | .8671 | .7947 | .6412 | .3477 | .2035 | **.0452** | **.0499** | **.0143** | .2133 |

**Table 6.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Ashland, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 6; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | | | | | | High-flow condition | | | | | | | |
| Velocity | 1934–44 | 0.27 b | 0.37 b | 0.72 b | 1.47 a | 1.87 a | 2.06 a | 2.26 a | 2.36 a | 2.49 a | 2.59 a | 2.67 a | 2.73 a |
| | 1951–61 | .67 ba | .94 ba | 1.46 a | 1.69 a | 1.90 a | 2.25 a | 2.29 a | 2.43 a | 2.51 a | 2.66 a | 2.77 a | 2.86 a |
| | 1985–95 | .60 ba | .87 ba | 1.29 ba | 1.90 a | 2.03 a | 2.21 a | 2.28 a | 2.38 a | 2.50 a | 2.64 a | 2.75 a | 3.00 a |
| | 1996–2006 | .92 a | 1.25 a | 1.52 a | 2.00 a | 2.11 a | 2.20 a | 2.36 a | 2.46 a | 2.70 a | 2.77 a | 2.86 a | 2.98 a |
| | *p*-value | **.0459** | **.0162** | **.0345** | .0854 | .5122 | .5396 | .6625 | .8087 | .8160 | .8554 | .9347 | .5801 |
| | | | | | | Median-flow condition | | | | | | | |
| Velocity | 1934–44 | .42 a | .52 a | .92 a | 1.31 a | 1.59 a | 1.71 a | 1.74 a | 2.03 a | 2.19 a | 2.31 a | 2.34 a | 2.46 a |
| | 1951–61 | .52 a | .64 a | .97 a | 1.29 a | 1.61 a | 1.73 a | 1.80 a | 1.87 a | 1.99 a | 2.08 a | 2.20 a | 2.28 a |
| | 1985–95 | .56 a | .69 a | .82 a | 1.03 b | 1.51 a | 1.58 a | 1.64 a | 1.83 a | 1.95 a | 2.15 a | 2.25 a | 2.33 a |
| | 1996–2006 | .35 a | .43 a | .71 a | 1.19 ba | 1.33 a | 1.44 a | 1.56 a | 1.68 a | 1.80 a | 1.92 a | 2.04 a | 2.16 a |
| | *p*-value | .3837 | .5052 | .3664 | **.0449** | .2020 | .2083 | .2507 | .1550 | .2205 | .3165 | .3816 | .3151 |
| | | | | | | Low-flow condition | | | | | | | |
| Velocity | 1934–44 | .22 a | .25 a | .58 a | .63 a | 1.12 a | 1.35 a | 1.50 a | 1.58 a | 1.69 a | 1.82 a | 1.95 a | 2.07 ba |
| | 1951–61 | .36 a | .50 a | .97 a | 1.41 a | 1.45 a | 1.67 a | 1.76 a | 1.89 a | 1.97 a | 2.08 a | 2.09 a | 2.17 a |
| | 1985–95 | .10 a | .37 a | .41 a | .95 a | 1.48 a | 1.73 a | 1.79 a | 1.89 a | 1.92 a | 1.98 a | 2.05 a | 2.20 a |
| | 1996–2006 | .20 a | .23 a | .58 a | .87 a | 1.25 a | 1.50 a | 1.61 a | 1.73 a | 1.77 a | 1.82 a | 1.84 a | 1.87 b |
| | *p*-value | .3642 | .2785 | .5052 | .5233 | .6349 | .6618 | .7410 | .5955 | .5955 | .3103 | .1153 | **.0404** |

**Table 6.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Ashland, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 6; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| High-flow condition | | | | | | | | | | | | |
| Depth | 1934–44 | 6.07 a | 6.46 a | 6.90 a | 7.39 a | 7.74 a | 8.15 ba | 8.66 ba | 9.02 a | 9.98 a | 10.6 a | 10.97 a |
| | 1951–61 | 4.66 a | 5.56 a | 6.27 a | 7.43 a | 7.93 a | 8.57 a | 9.31 a | 9.61 a | 9.95 a | 10.21 a | 10.35 a |
| | 1985–95 | 4.41 a | 4.67 a | 4.85 a | 5.15 a | 5.77 b | 7.04 b | 7.55 b | 8.16 a | 9.19 a | 9.65 a | 9.82 a |
| | 1996–2006 | 4.10 a | 4.53 a | 4.66 a | 4.94 a | 5.33 b | 6.10 b | 6.71 b | 6.85 a | 7.00 a | 8.00 a | 8.00 a |
| | *p*-value | .0630 | .1450 | .1761 | .0766 | **.0287** | **.0184** | **.0141** | .1013 | .4158 | .3350 | .2433 |
| Median-flow condition | | | | | | | | | | | | |
| Depth | 1934–44 | 3.70 a | 3.90 a | 3.99 a | 4.32 a | 5.12 a | 5.79 a | 6.34 a | 6.50 a | 6.55 a | 6.58 a | 6.67 a |
| | 1951–61 | 2.86 a | 3.43 ba | 3.90 a | 4.41 a | 4.69 a | 4.96 a | 5.12 a | 5.38 a | 5.77 a | 6.06 a | 6.30 a |
| | 1985–95 | 3.69 a | 3.82 a | 3.96 a | 4.09 a | 4.35 a | 4.78 a | 4.97 a | 5.17 a | 5.80 a | 6.31 a | 6.36 a |
| | 1996–2006 | 2.71 a | 3.14 b | 3.50 a | 4.12 a | 4.60 a | 4.90 a | 5.08 a | 5.58 a | 6.16 a | 6.61 a | 6.79 a |
| | *p*-value | .0607 | **.0422** | .3933 | .9683 | .9446 | .7837 | .4551 | .3175 | .5045 | .7212 | .6878 |
| Low-flow condition | | | | | | | | | | | | |
| Depth | 1934–44 | 2.40 a | 2.52 a | 2.70 a | 3.07 a | 3.30 a | 3.36 a | 3.51 a | 3.95 a | 4.81 a | 5.70 a | 5.70 a |
| | 1951–61 | 2.60 a | 2.76 a | 3.02 a | 3.20 a | 3.75 a | 4.00 a | 5.08 a | 5.40 a | 5.61 a | 5.72 a | 5.76 a |
| | 1985–95 | 2.47 a | 2.73 a | 2.95 a | 3.00 a | 3.11 a | 3.41 a | 3.50 a | 3.70 a | 4.00 a | 4.03 a | 4.17 a |
| | 1996–2006 | 2.52 a | 2.62 a | 2.80 a | 3.12 a | 3.37 a | 3.45 a | 3.59 a | 3.83 a | 4.23 a | 4.38 a | 4.44 a |
| | *p*-value | .6398 | .7302 | .5992 | .6855 | .5477 | .3095 | .2972 | .3164 | .3844 | .5304 | .3149 |

**Table 6.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge near Ashland, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 6; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution: 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | High-flow condition | | | | | | |
| Velocity | 1934–44 | 2.80 a | 2.89 a | 3.00 a | 3.07 a | 3.18 b | 3.36 b | 3.43 b | 3.54 b | 3.84 c | 4.05 c | 4.11 c |
| | 1951–61 | 2.94 a | 3.02 a | 3.11 a | 3.20 a | 3.36 ba | 3.62 ba | 3.85 a | 4.34 a | 4.67 a | 4.77 a | 4.87 a |
| | 1985–95 | 3.16 a | 3.28 a | 3.38 a | 3.57 a | 3.72 a | 3.82 a | 3.96 a | 4.25 a | 4.34 b | 4.46 bc | 4.55 bc |
| | 1996–2006 | 3.01 a | 3.06 a | 3.11 a | 3.32 a | 3.48 a | 3.81 a | 4.10 a | 4.34 a | 4.55 ba | 4.67 ba | 4.80 ba |
| | *p*-value | .5607 | .5650 | .4060 | .0840 | **.0365** | **.0257** | **.0123** | **.0104** | **.0002** | **.0063** | **.0326** |
| | | | | | | Median-flow condition | | | | | | |
| Velocity | 1934–44 | 2.48 a | 2.52 a | 2.60 a | 2.64 a | 2.70 b | 2.78 b | 2.81 b | 2.90 b | 3.11 a | 3.20 a | 3.30 a |
| | 1951–61 | 2.39 a | 2.49 a | 2.55 a | 2.62 a | 2.68 b | 2.80 b | 2.91 b | 2.99 b | 3.23 a | 3.37 a | 3.43 a |
| | 1985–95 | 2.42 a | 2.53 a | 2.61 a | 2.77 a | 2.92 a | 3.14 a | 3.29 a | 3.43 a | 3.54 a | 3.61 a | 3.68 a |
| | 1996–2006 | 2.26 a | 2.33 a | 2.39 a | 2.59 a | 2.76 ba | 2.92 ba | 2.96 ba | 3.04 ba | 3.20 a | 3.33 a | 3.47 a |
| | *p*-value | .7900 | .4748 | .2350 | .2564 | **.0334** | **.0357** | **.0234** | **.0428** | .1198 | .1271 | .1321 |
| | | | | | | Low-flow condition | | | | | | |
| Velocity | 1934–44 | 2.11 ba | 2.19 ba | 2.33 ba | 2.37 ba | 2.45 ba | 2.52 ba | 2.55 ba | 2.58 ba | 2.80 a | 2.84 a | 3.00 ba |
| | 1951–61 | 2.27 a | 2.36 a | 2.39 a | 2.45 a | 2.63 a | 2.77 a | 2.98 a | 3.00 a | 3.19 a | 3.24 a | 3.40 a |
| | 1985–95 | 2.21 a | 2.33 a | 2.40 a | 2.50 a | 2.63 a | 2.67 ba | 2.83 ba | 2.88 ba | 2.94 a | 3.03 a | 3.07 ba |
| | 1996–2006 | 1.93 b | 1.99 b | 2.03 b | 2.09 b | 2.18 b | 2.22 b | 2.30 b | 2.42 b | 2.52 a | 2.73 a | 2.81 b |
| | *p*-value | **.0422** | **.0215** | **.0107** | **.0182** | **.0253** | **.0265** | **.0270** | **.0499** | .0949 | .0713 | **.0460** |

[1]No calculation of area cumulative frequency distribution was made for the 1966–1976 period because the gaging station was inactive until July 1988. For the period 1951–61, records were available from 1951 through 1953.

**Table 7.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at Louisville, Nebraska, 1934–2006.

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 7; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | | | | | | | High-flow condition | | | | | | |
| Depth | 1951–61 | 0.76 a | 0.92 a | 1.51 a | 2.01 a | 2.30 a | 2.76 a | 3.09 a | 3.20 a | 3.45 a | 3.66 c | 3.80 a | 3.83 b |
| | 1966–76 | .51 a | .96 a | 1.25 a | 1.83 a | 2.10 a | 2.50 a | 3.00 a | 3.20 a | 3.99 a | 4.76 a | 5.37 a | 5.96 a |
| | 1985–95 | .56 a | .88 a | 1.11 a | 1.73 a | 2.03 a | 2.37 a | 2.66 a | 3.11 a | 3.37 a | 3.63 bc | 3.92 a | 4.36 b |
| | 1996–2006 | .80 a | 1.12 a | 1.70 a | 2.16 a | 2.49 a | 2.64 a | 3.38 a | 3.54 a | 4.00 a | 4.25 ba | 4.40 a | 4.50 ba |
| | *p*-value | .7085 | .7495 | .4164 | .2373 | .1851 | .4362 | .5037 | .3709 | .1768 | **.0088** | .0510 | **.0326** |
| | | | | | | | Median-flow condition | | | | | | |
| Depth | 1951–61 | .40 a | .50 a | .80 a | 1.10 a | 1.29 a | 1.50 a | 1.90 a | 2.00 a | 2.00 a | 2.30 a | 2.60 a | 2.69 a |
| | 1966–76 | .43 a | .57 a | .72 a | .99 a | 1.21 a | 1.45 a | 1.73 a | 2.93 a | 3.14 a | 3.39 a | 4.02 a | 5.23 a |
| | 1985–95 | .38 a | .50 a | .77 a | 1.20 a | 1.43 a | 1.58 a | 1.90 a | 2.11 a | 2.31 a | 2.50 a | 2.51 a | 2.80 a |
| | 1996–2006 | .45 a | .60 a | .88 a | 1.17 a | 1.40 a | 1.80 a | 2.08 a | 2.18 a | 2.29 a | 2.39 a | 2.64 a | 2.80 a |
| | *p*-value | .5759 | .6152 | .8907 | .7561 | .5494 | .3670 | .4276 | .4262 | .6303 | .6050 | .6442 | .4341 |
| | | | | | | | Low-flow condition | | | | | | |
| Depth | 1951–61 | .26 b | .30 c | .40 c | .70 b | .73 c | .86 b | 1.00 b | 1.20 c | 1.32 c | 1.40 c | 1.50 c | 1.60 c |
| | 1966–76 | .49 a | .72 a | .87 a | 1.05 a | 1.25 a | 1.43 a | 1.71 a | 2.45 a | 3.01 a | 3.31 a | 3.60 a | 3.72 a |
| | 1985–95 | .40 ba | .47 ba | .68 ba | .97 a | 1.10 ba | 1.46 a | 1.60 a | 1.72 ba | 2.03 ba | 2.20 ba | 2.31 a | 2.69 a |
| | 1996–2006 | .20 b | .31 bc | .60 b | .80 ba | 1.00 b | 1.30 a | 1.40 a | 1.52 b | 1.60 b | 1.73 b | 1.97 b | 2.01 b |
| | *p*-value | **.0181** | **.0014** | **.0005** | **.0095** | **.0003** | **.0028** | **.0012** | **.0002** | **.0006** | **.0006** | **.0001** | **.0001** |

**Table 7.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at Louisville, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 7; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | | | | | | | High-flow condition | | | | | | |
| Velocity | 1951–61 | 0.81 a | 0.97 a | 1.35 a | 1.53 a | 1.99 a | 2.08 a | 2.24 a | 2.32 a | 2.49 a | 2.53 b | 2.65 b | 2.75 b |
| | 1966–76 | .30 a | .70 ba | 1.46 a | 2.03 a | 2.14 a | 2.26 a | 2.50 a | 2.60 a | 2.66 a | 2.94 a | 3.10 a | 3.18 a |
| | 1985–95 | .58 a | .91 a | 1.17 a | 1.79 a | 2.04 a | 2.29 a | 2.34 a | 2.40 a | 2.50 a | 2.67 ba | 2.75 ba | 2.82 b |
| | 1996–2006 | .34 a | .50 b | 1.00 a | 1.75 a | 1.95 a | 2.30 a | 2.33 a | 2.41 a | 2.47 a | 2.52 b | 2.55 b | 2.66 b |
| | *p*-value | .1372 | **.0191** | .9519 | .4834 | .6619 | .5560 | .6863 | .7337 | .5059 | .0352 | .0165 | .0178 |
| | | | | | | | Median-flow condition | | | | | | |
| Velocity | 1951–61 | .69 a | .80 a | .97 a | 1.26 a | 1.45 a | 1.73 a | 1.80 a | 1.87 a | 1.94 a | 2.02 a | 2.11 a | 2.14 a |
| | 1966–76 | .29 a | .37 b | .71 a | 1.03 a | 1.34 a | 1.64 a | 1.82 a | 1.93 a | 2.06 a | 2.29 a | 2.32 a | 2.50 a |
| | 1985–95 | .23 a | .37 b | .78 a | 1.15 a | 1.44 a | 1.66 a | 1.84 a | 1.87 a | 2.00 a | 2.03 a | 2.12 a | 2.20 a |
| | 1996–2006 | .24 a | .29 b | .61 a | .90 a | 1.26 a | 1.49 a | 1.73 a | 2.02 a | 2.13 a | 2.14 a | 2.15 a | 2.20 a |
| | *p*-value | .1060 | **.0052** | .4881 | .3338 | .1973 | .2111 | .9705 | .8044 | .8981 | .6534 | .8665 | .7703 |
| | | | | | | | Low-flow condition | | | | | | |
| Velocity | 1951–61 | .33 a | .41 a | .86 a | 1.12 a | 1.36 a | 1.41 ba | 1.50 ba | 1.57 ba | 1.60 b | 1.70 b | 1.76 b | 1.80 b |
| | 1966–76 | .42 a | .50 a | .68 a | 1.34 a | 1.64 a | 1.77 a | 1.87 a | 1.95 a | 2.06 a | 2.22 a | 2.32 a | 2.40 a |
| | 1985–95 | .09 b | .10 b | .19 a | .48 b | 1.14 a | 1.31 ba | 1.42 b | 1.49 b | 1.60 b | 1.63 b | 1.69 b | 1.73 b |
| | 1996–2006 | .19 b | .28 b | .54 a | .74 b | 1.02 a | 1.19 b | 1.36 b | 1.39 b | 1.48 b | 1.57 b | 1.64 b | 1.78 b |
| | *p*-value | **.0001** | **.0019** | .0672 | **.0033** | .0517 | **.0226** | **.0301** | **.0085** | **.0056** | **.0162** | **.0149** | **.0286** |

**Table 7.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at Louisville, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 7; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| | | | | | | High-flow condition | | | | | | |
| Depth | 1951–61 | 4.00 b | 4.10 b | 4.19 b | 4.37 b | 4.67 b | 5.14 c | 5.30 c | 5.83 b | 6.41 b | 6.92 b | 7.11 a |
| | 1966–76 | 7.47 a | 7.96 a | 8.29 a | 8.47 a | 9.34 a | 9.90 a | 1.0 | 1.67 a | 11.6 a | 12.14 a | 12.3 a |
| | 1985–95 | 4.85 b | 5.45 ba | 5.92 ba | 6.50 ba | 6.94 b | 7.63 b | 8.04 b | 8.80 b | 10.08 b | 10.7 b | 11.0 a |
| | 1996–2006 | 5.00 b | 5.38 b | 5.71 b | 5.94 b | 6.55 b | 6.88 cb | 7.27 cb | 8.49 b | 9.53 b | 11.11 ba | 11.3 a |
| | *p*-value | **.0142** | **.0133** | **.0100** | **.0071** | **.0021** | **.0027** | **.0016** | **.0069** | **.0183** | **.0404** | .0680 |
| | | | | | | Median-flow condition | | | | | | |
| Depth | 1951–61 | 3.27 a | 3.44 a | 3.61 b | 3.80 b | 4.10 b | 4.26 b | 4.94 b | 5.64 a | 6.77 a | 6.95 a | 6.98 a |
| | 1966–76 | 6.32 a | 6.59 a | 6.69 a | 6.93 a | 7.17 a | 7.72 a | 8.53 a | 8.73 a | 8.76 a | 8.88 a | 8.89 a |
| | 1985–95 | 3.00 a | 3.49 a | 3.64 b | 3.89 b | 4.00 b | 4.00 b | 4.15 b | 4.29 a | 5.49 a | 5.99 a | 6.15 a |
| | 1996–2006 | 3.10 a | 3.24 a | 3.54 b | 3.70 b | 4.00 b | 4.24 b | 5.12 ba | 6.75 a | 7.51 a | 7.62 a | 7.66 a |
| | *p*-value | .2592 | .0734 | **.0235** | **.0236** | **.0212** | **.0378** | **.0366** | .0551 | .0601 | .1941 | .1229 |
| | | | | | | Low-flow condition | | | | | | |
| Depth | 1951–61 | 1.72 c | 1.80 c | 2.00 b | 2.19 b | 2.24 b | 2.73 c | 3.01 c | 3.40 b | 3.52 b | 3.63 b | 3.67 b |
| | 1966–76 | 3.79 a | 4.07 a | 4.22 a | 4.36 a | 4.68 a | 5.02 a | 5.10 a | 5.19 a | 5.32 a | 5.40 a | 5.42 a |
| | 1985–95 | 2.99 a | 3.46 a | 3.65 a | 4.02 a | 4.13 a | 4.61 ba | 5.03 ba | 5.39 a | 5.73 a | 5.92 a | 5.98 a |
| | 1996–2006 | 2.17 b | 2.30 b | 2.40 b | 2.43 b | 2.72 b | 2.88 bc | 2.92 bc | 3.34 ba | 3.99 ba | 4.11 ba | 4.20 ba |
| | *p*-value | **.0001** | **.0001** | **.0002** | **.0009** | **.0009** | **.0099** | **.0180** | **.0373** | **.0072** | **.0121** | **.0201** |

**Table 7.** Median value and rank comparison among water-year periods for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for high-, median-, and low-flow conditions near the Platte River bridge at Louisville, Nebraska, 1934–2006.—Continued

[Tabled values for each time period are the median of streamflow depth or velocity; depth in feet; velocity in feet per second; the 95-percent confidence intervals about the mean of streamflow depth or velocity are presented in Appendix 7; letter(s) following each median indicates results of rank comparison tests among time periods within each combination of flow condition and percentile of the area cumulative frequency distribution; medians within each combination of percentile and flow condition that are indexed by same letter are not significantly different (alpha=0.05); bold *p*-values and highlighted cells indicate significant differences at *p*-value less than 0.05; the *p*-value is the probability of incorrectly rejecting the hypothesis that all medians within each combination of percentile and flow condition are equal; midpoint for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Variable | Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| | | | | | | High-flow condition | | | | | | |
| Velocity | 1951–61 | 2.81 b | 2.87 b | 2.94 b | 3.07 b | 3.16 b | 3.28 c | 3.35 b | 3.40 b | 3.61 b | 4.06 bc | 4.09 bc |
| | 1966–76 | 3.39 a | 3.47 a | 3.51 a | 3.60 a | 3.70 a | 3.82 a | 3.92 a | 4.37 a | 4.51 a | 4.65 a | 4.70 a |
| | 1985–95 | 3.00 b | 3.15 b | 3.32 ba | 3.49 ba | 3.55 ba | 3.81 ba | 4.04 a | 4.27 a | 4.33 a | 4.42 ba | 4.51 ba |
| | 1996–2006 | 2.76 b | 2.82 b | 2.86 b | 3.01 b | 3.19 b | 3.29 bc | 3.33 b | 3.41 b | 3.47 b | 3.49 c | 3.53 c |
| | *p*-value | **.0047** | **.0061** | **.0170** | **.0063** | **.0141** | **.0117** | **.0022** | **.0046** | **.0065** | **.0043** | **.0072** |
| | | | | | | Median-flow condition | | | | | | |
| Velocity | 1951–61 | 2.22 a | 2.36 b | 2.49 b | 2.55 b | 2.69 b | 2.76 b | 2.76 b | 2.92 b | 3.07 b | 3.16 b | 3.28 b |
| | 1966–76 | 2.68 a | 2.89 a | 3.09 a | 3.27 a | 3.43 a | 3.55 a | 3.62 a | 3.68 a | 3.80 a | 4.26 a | 4.42 a |
| | 1985–95 | 2.36 a | 2.40 b | 2.44 b | 2.50 b | 2.58 b | 2.65 b | 2.85 b | 3.04 b | 3.15 b | 3.33 b | 3.35 b |
| | 1996–2006 | 2.24 a | 2.30 b | 2.39 b | 2.53 b | 2.59 b | 2.73 b | 2.79 b | 2.81 b | 2.88 b | 3.08 b | 3.15 b |
| | *p*-value | .4928 | **.0422** | **.0163** | **.0151** | **.0049** | **.0086** | **.0108** | **.0071** | **.0051** | **.0047** | **.0034** |
| | | | | | | Low-flow condition | | | | | | |
| Velocity | 1951–61 | 1.86 b | 1.92 b | 1.96 b | 2.04 b | 2.10 b | 2.18 b | 2.25 b | 2.37 b | 2.55 b | 2.64 b | 2.69 b |
| | 1966–76 | 2.55 a | 2.59 a | 2.66 a | 2.79 a | 2.92 a | 2.95 a | 3.01 a | 3.07 a | 3.20 a | 3.34 a | 3.39 a |
| | 1985–95 | 1.81 b | 1.95 b | 2.05 b | 2.09 b | 2.12 b | 2.18 b | 2.26 b | 2.39 b | 2.44 b | 2.53 b | 2.56 b |
| | 1996–2006 | 1.88 b | 1.94 b | 1.99 b | 2.00 b | 2.16 b | 2.22 b | 2.36 b | 2.48 b | 2.67 b | 2.77 b | 2.80 b |
| | *p*-value | **.0189** | **.0126** | **.0147** | **.0151** | **.0186** | **.0071** | **.0125** | **.0104** | **.0083** | **.0089** | **.0089** |

[1]No calculation of area cumulative frequency distribution was made during the 1934–1944 period because streamflow-gaging station and discharge measurement began in May 1953. Data from October 1961 to September 1973 were excluded from analysis because the streamflow-gaging station was temporarily relocated to South Bend, Nebraska.

# Appendixes

**Appendix 1.** List of selected cross-sectional measurement dates by flow condition and target water year near the Platte River bridges near Duncan, North Bend, Leshara, Ashland, and Louisville, Nebraska.

[--, no data; midpoint (not listed) for the high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for the median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Flow condition | Target water year | | | | |
|---|---|---|---|---|---|
| | 1938 | 1955 | 1971 | 1993 | 2003 |
| | | | Duncan | | |
| High | 11/22/1933 | 12/6/1951 | 3/6/1968 | 1/17/1990 | 12/5/1995 |
| | 2/20/1935 | 5/07/1952 | 11/4/1969 | 5/16/1990 | 8/9/1996 |
| | 3/14/1935 | 6/4/1952 | 4/14/1971 | 6/13/1991 | 8/31/1999 |
| | 4/20/1943 | 4/13/1953 | 11/30/1971 | 8/9/1993 | 5/2/2000 |
| | 6/9/1943 | 5/14/1953 | 11/21/1972 | 9/20/1993 | 3/27/2001 |
| | 3/15/1944 | 2/15/1954 | -- | 11/2/1993 | -- |
| | -- | 4/22/1958 | -- | 2/21/1995 | -- |
| Median | 5/11/1935 | 6/1/1953 | 6/3/1970 | 5/14/1991 | 7/10/1996 |
| | 11/19/1935 | 6/8/1953 | 10/6/1970 | 7/10/1991 | 7/2/1998 |
| | 6/15/1937 | 11/16/1953 | 11/17/1970 | 5/6/1993 | 11/1/2000 |
| | 5/20/1938 | 12/8/1953 | 10/19/1971 | 5/24/1993 | 2/16/2005 |
| | 6/9/1938 | 3/16/1954 | -- | 8/26/1993 | 6/15/2005 |
| | -- | 4/5/1954 | -- | 5/11/1994 | -- |
| | -- | 4/4/1955 | -- | -- | -- |
| Low | 4/27/1935 | 6/20/1953 | 6/18/1968 | 7/17/1985 | 6/5/2002 |
| | 7/15/1938 | 11/15/1955 | 7/31/1968 | 8/15/1990 | 11/17/2004 |
| | 10/13/1938 | 12/18/1955 | 8/12/1969 | 7/31/1991 | 11/1/2005 |
| | -- | 8/6/1958 | 7/19/1972 | 10/8/1991 | 11/22/2005 |
| | -- | -- | 9/25/1974 | -- | -- |
| | | | North Bend | | |
| High | -- | 4/7/1952 | 4/22/1970 | 11/14/1991 | 11/2/1995 |
| | -- | 3/9/1953 | 5/17/1972 | 3/13/1992 | 8/20/1996 |
| | -- | 5/21/1957 | 10/25/1973 | 6/17/1993 | 11/7/1997 |
| | -- | 4/10/1958 | 5/20/1974 | 8/9/1993 | 12/2/1997 |
| | -- | 7/1/1959 | -- | 9/8/1993 | 2/27/1998 |
| | -- | -- | -- | 12/10/1993 | 11/5/1998 |
| Median | -- | 4/19/1955 | 6/11/1969 | 5/14/1991 | 6/23/2003 |
| | -- | 5/26/1954 | 7/23/1969 | 7/13/1991 | 11/17/2004 |
| | -- | 5/31/1955 | 9/23/1969 | 10/8/1991 | 8/31/2005 |
| | -- | 6/7/1954 | 5/12/1970 | 4/14/1992 | 10/12/2005 |
| | -- | 6/23/1954 | 4/13/1971 | 7/14/1992 | 1/4/2006 |
| | -- | -- | 10/19/1971 | -- | -- |
| Low | -- | 7/7/1953 | 8/1/1968 | 7/5/1988 | -- |
| | -- | 8/17/1954 | 9/5/1969 | 9/11/1990 | -- |
| | -- | 9/1/1954 | 7/17/1970 | 8/13/1991 | -- |
| | -- | 9/21/1954 | 6/28/1972 | 5/14/1992 | -- |
| | -- | 9/9/1958 | 7/19/1972 | -- | -- |
| | -- | -- | 9/10/1974 | -- | -- |

**Appendix 1.** List of selected cross-sectional measurement dates by flow condition and target water year near the Platte River bridges near Duncan, North Bend, Leshara, Ashland, and Louisville, Nebraska.—Continued

[--, no data; midpoint (not listed) for the high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for the median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Flow condition | Target water year | | | | |
|---|---|---|---|---|---|
| | 1938 | 1955 | 1971 | 1993 | 2003 |
| | | | Leshara | | |
| High | -- | -- | -- | 10/26/1993 | 3/20/1996 |
| | -- | -- | -- | 3/23/1994 | 8/5/1998 |
| | -- | -- | -- | 12/23/1994 | 10/6/1999 |
| | -- | -- | -- | -- | 4/2/2001 |
| | -- | -- | -- | -- | 5/26/2004 |
| | -- | -- | -- | -- | 6/14/2005 |
| Median | -- | -- | -- | 7/25/1994 | 10/23/1995 |
| | -- | -- | -- | 11/21/1994 | 5/31/2000 |
| | -- | -- | -- | 8/8/1995 | 6/7/2001 |
| | -- | -- | -- | 9/26/1995 | 3/29/2002 |
| | -- | -- | -- | -- | 3/31/2003 |
| | -- | -- | -- | -- | 12/3/2003 |
| Low | -- | -- | -- | 5/26/1994 | 7/2/2001 |
| | -- | -- | -- | 9/12/1994 | 8/8/2001 |
| | -- | -- | -- | 9/1/1995 | 9/6/2002 |
| | -- | -- | -- | -- | 10/1/2002 |
| | -- | -- | -- | -- | 10/8/2004 |
| | | | Ashland | | |
| High | 6/13/1935 | 6/21/1951 | -- | 7/27/1992 | 3/14/1996 |
| | 6/24/1935 | 5/29/1952 | -- | 3/23/1993 | 6/15/2001 |
| | 9/14/1938 | 5/8/1953 | -- | 4/26/1993 | 3/14/2002 |
| | 2/28/1944 | 5/11/1953 | -- | 4/28/1995 | 6/11/2003 |
| | -- | -- | -- | -- | 6/9/2005 |
| Median | 12/8/1935 | 8/28/1952 | -- | 11/27/1989 | 6/4/2002 |
| | 4/10/1936 | 10/27/1952 | -- | 11/29/1991 | 11/5/2002 |
| | 5/2/1936 | 10/30/1952 | -- | 5/26/1992 | 3/26/2003 |
| | -- | 11/3/1952 | -- | 9/29/1992 | 6/27/2003 |
| | -- | 11/6/1952 | -- | 6/1/1994 | 9/16/2003 |
| | -- | 11/10/1952 | -- | -- | 12/1/2003 |
| Low | 6/12/1937 | 9/16/1952 | -- | 5/15/1989 | 9/5/2000 |
| | 11/5/1937 | 9/25/1952 | -- | 6/12/1989 | 9/4/2002 |
| | 11/10/1937 | 9/29/1952 | -- | 8/30/1989 | 10/12/2004 |
| | -- | 10/3/1952 | -- | 8/28/1990 | 7/18/2005 |
| | -- | 10/6/1952 | -- | 9/25/1990 | -- |
| | | | Louisville | | |
| High | -- | 5/15/1953 | 10/23/1973 | 3/2/1987 | 2/14/1996 |
| | -- | 6/4/1954 | 11/26/1973 | 4/28/1987 | 9/27/1996 |
| | -- | 3/19/1956 | 3/15/1974 | 5/29/1991 | 2/16/2005 |
| | -- | 5/21/1957 | 3/27/1974 | 3/17/1995 | 4/27/2005 |
| | -- | 6/1/1957 | 4/25/1974 | -- | 6/8/2005 |
| Median | -- | 4/9/1954 | 8/2/1973 | 11/27/1989 | 12/3/2001 |
| | -- | 4/12/1954 | 9/13/1973 | 11/29/1991 | 6/5/2003 |
| | -- | 6/11/1954 | 1/10/1974 | 5/26/1992 | 6/27/2003 |
| | -- | 8/25/1954 | 6/20/1974 | 6/23/1992 | 4/15/2004 |
| | -- | 4/15/1955 | -- | 9/29/1992 | 3/17/2005 |
| Low | -- | 11/2/1953 | 7/5/1974 | 7/14/1988 | 9/4/2002 |
| | -- | 11/6/1953 | 8/15/1974 | 5/16/1989 | 8/7/2003 |
| | -- | 8/13/1954 | 9/6/1974 | 7/27/1989 | 10/28/2003 |
| | -- | 7/5/1955 | 9/19/1974 | 8/29/1989 | 10/12/2004 |
| | -- | 7/12/1955 | -- | -- | 7/11/2005 |

**Appendix 2.** Date and maximum instantaneous peak discharge, and the daily-mean discharge on the date of the maximum peak discharge that occurred before the latest selected cross-sectional measurement date, by the Platte River streamflow-gaging station and target water year.

[$ft^3/s$, cubic feet per second]

| Streamflow-gaging station | Water-year period | Target water year | Latest selected measurement date | Maximum peak discharge prior to date of latest measurement, in $ft^3/s$ | Maximum peak discharge, in $ft^3/s$ | Maximum daily discharge, in $ft^3/s$ |
|---|---|---|---|---|---|---|
| Duncan | 1934–1944 | 1938 | 3/15/1944 | 6/7/1935 | 30,000 | 21,000 |
| | 1951–1961 | 1955 | 8/06/1958 | 3/10/1952 | 10,000 | 9,360 |
| | 1966–1976 | 1971 | 9/25/1974 | 6/15/1967 | 24,700 | 22,300 |
| | 1985–1995 | 1993 | 2/21/1995 | 3/11/1993 | 18,000 | 16,000 |
| | 1996–2006 | 2003 | 11/22/2005 | 4/9/1998 | 14,700 | 13,700 |
| North Bend | 1951–1961 | 1955 | 7/01/1959 | 6/17/1957 | 44,200 | 39,100 |
| | 1966–1976 | 1971 | 9/10/1974 | 6/16/1967 | 75,200 | 64,900 |
| | 1985–1995 | 1993 | 12/10/1993 | 3/10/1993 | 97,800 | 82,300 |
| | 1996–2006 | 2003 | 1/04/2006 | 6/28/1999 | 44,700 | 38,100 |
| Leshara | 1985–1995 | 1993 | 9/26/1995 | 5/28/1995 | 35,300 | 18,300 |
| | 1996–2006 | 2003 | 6/14/2005 | 6/2/19999 | 32,600 | 28,800 |
| Ashland | 1934–1944 | 1938 | 2/28/1944 | 6/14/1943 | 56,000 | 35,000 |
| | 1966–1976 | 1955 | 5/11/1953 | 6/1/1951 | 49,900 | 44,100 |
| | 1985–1995 | 1993 | 4/28/1995 | 3/10/1993 | 130,000 | 110,000 |
| | 1996–2006 | 2003 | 7/18/2005 | 6/28/1999 | 49,100 | 41,000 |
| Louisville | 1951–1961 | 1955 | 6/1/1957 | 5/12/1953 | 33,000 | 24,568 |
| | 1966–1976 | 1971 | 9/19/1974 | 6/16/1967 | 120,000 | 114,000 |
| | 1985–1995 | 1993 | 3/17/1995 | 7/25/1993 | 160,000 | 138,000 |
| | 1996–2006 | 2003 | 7/11/2005 | 6/28/1999 | 57,100 | 50,500 |

**Appendix 3.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period near the Platte River bridge near Duncan, Nebraska, 1934–2006.

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period | Percentile of area cumulative frequency distribution | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| Depth for high-flow condition | | | | | | | | | | | | | | |
| 1934–44 | 0.2–0.3 | 0.3–0.3 | 0.4–0.5 | 0.5–0.7 | 0.7–0.8 | 0.7–0.8 | 0.9–1.1 | 0.9–1.1 | 1.1–1.3 | 1.2–1.5 | 1.3–1.8 | 1.5–1.9 | 1.5–2.7 | 1.6–3.0 |
| 1951–61 | 0.2–0.3 | 0.3–0.4 | 0.4–0.5 | 0.6–0.6 | 0.7–0.7 | 0.7–0.8 | 0.8–0.9 | 0.8–0.9 | 0.8–0.9 | 1.1–1.4 | 1.3–1.5 | 1.3–1.7 | 1.5–1.9 | 1.7–2.0 |
| 1966–76 | 0.2–0.3 | 0.3–0.5 | 0.5–0.6 | 0.6–0.7 | 0.7–0.9 | 0.7–0.9 | 0.9–1.1 | 0.9–1.3 | 0.9–1.3 | 1.2–1.4 | 1.2–1.7 | 1.3–1.8 | 1.4–2.0 | 1.5–2.1 |
| 1985–95 | 0.2–0.4 | 0.3–0.5 | 0.5–0.7 | 0.7–0.8 | 0.7–0.8 | 0.9–1.1 | 0.9–1.1 | 0.9–1.1 | 1.1–1.4 | 1.3–1.6 | 1.4–1.7 | 1.5–1.8 | 1.5–1.9 | 1.6–2.0 |
| 1996–2006 | 0.1–0.3 | 0.2–0.4 | 0.4–0.6 | 0.5–0.7 | 0.6–0.7 | 0.7–0.9 | 0.8–1.1 | 0.8–1.1 | 0.8–1.1 | 1.2–1.4 | 1.4–1.6 | 1.5–1.8 | 1.6–1.8 | 1.8–2.0 |
| Depth for median-flow condition | | | | | | | | | | | | | | |
| 1934–44 | 0.2–0.3 | 0.2–0.3 | 0.4–0.5 | 0.5–0.6 | 0.6–0.7 | 0.6–0.7 | 0.8–1.1 | 0.9–1.2 | 0.9–1.3 | 0.9–1.3 | 1.1–1.5 | 1.3–1.6 | 1.4–1.7 | 1.5–1.8 |
| 1951–61 | 0.2–0.2 | 0.2–0.3 | 0.3–0.3 | 0.4–0.4 | 0.4–0.5 | 0.5–0.6 | 0.6–0.7 | 0.7–0.8 | 0.8–0.9 | 0.8–0.9 | 0.9–1.1 | 0.9–1.1 | 1.1–1.4 | 1.2–1.5 |
| 1966–76 | 0.1–0.3 | 0.2–0.3 | 0.3–0.4 | 0.4–0.6 | 0.4–0.6 | 0.5–0.8 | 0.6–0.9 | 0.6–0.9 | 0.7–1.1 | 0.8–1.2 | 0.9–1.3 | 0.9–1.3 | 1.1–1.4 | 1.1–1.6 |
| 1985–95 | 0.2–0.2 | 0.2–0.3 | 0.3–0.5 | 0.5–0.5 | 0.5–0.6 | 0.6–0.7 | 0.6–0.8 | 0.7–0.9 | 0.7–0.9 | 0.8–1.1 | 0.9–1.1 | 0.9–1.1 | 0.9–1.1 | 1.1–1.3 |
| 1996–2006 | 0.2–0.3 | 0.2–0.3 | 0.3–0.5 | 0.5–0.6 | 0.5–0.7 | 0.6–0.7 | 0.6–0.8 | 0.6–1.1 | 0.6–1.3 | 0.7–1.3 | 0.8–1.5 | 0.8–1.6 | 0.9–1.6 | 0.9–1.6 |
| Depth for low-flow condition | | | | | | | | | | | | | | |
| 1934–44 | 0.1–0.2 | 0.2–0.3 | 0.1–0.6 | 0.2–0.6 | 0.3–0.7 | 0.4–0.8 | 0.4–0.8 | 0.4–0.8 | 0.4–0.8 | 0.7–1.1 | 0.8–1.1 | 0.7–1.2 | 0.7–1.3 | 0.8–1.3 |
| 1951–61 | 0.1–0.2 | 0.1–0.2 | 0.1–0.2 | 0.3–0.3 | 0.3–0.4 | 0.4–0.5 | 0.4–0.7 | 0.4–0.9 | 0.5–0.9 | 0.5–0.9 | 0.5–0.9 | 0.7–1.1 | 0.8–1.2 | 0.8–1.3 |
| 1966–76 | 0.1–0.1 | 0.1–0.3 | 0.2–0.3 | 0.2–0.4 | 0.2–0.4 | 0.3–0.5 | 0.3–0.5 | 0.3–0.5 | 0.4–0.5 | 0.4–0.6 | 0.4–0.6 | 0.5–0.7 | 0.5–0.7 | 0.5–0.8 |
| 1985–95 | 0.1–0.1 | 0.1–0.1 | 0.2–0.2 | 0.2–0.3 | 0.2–0.4 | 0.3–0.5 | 0.3–0.6 | 0.4–0.7 | 0.4–0.7 | 0.5–0.8 | 0.5–0.8 | 0.5–0.9 | 0.6–0.9 | 0.6–0.9 |
| 1996–2006 | 0.1–0.1 | 0.1–0.2 | 0.2–0.2 | 0.2–0.4 | 0.3–0.4 | 0.3–0.4 | 0.4–0.5 | 0.4–0.5 | 0.5–0.5 | 0.5–0.6 | 0.5–0.6 | 0.6–0.7 | 0.6–0.8 | 0.6–0.9 |
| Velocity for high-flow condition | | | | | | | | | | | | | | |
| 1934–44 | 0.0–0.5 | 0–0.6 | 0–0.6 | 0.6–1.3 | 1.1–1.6 | 1.3–1.8 | 1.4–1.9 | 1.6–2.1 | 1.7–2.1 | 1.8–2.2 | 1.9–2.2 | 2.0–2.3 | 2.1–2.3 | 2.2–2.5 |
| 1951–61 | 0.4–0.7 | 0.4–0.7 | 0.9–1.2 | 1.2–1.4 | 1.4–1.6 | 1.5–1.7 | 1.6–1.8 | 1.8–1.9 | 1.9–2.0 | 2.0–2.1 | 2.0–2.1 | 2.1–2.2 | 2.2–2.3 | 2.2–2.3 |
| 1966–76 | 0.2–0.3 | 0.3–0.5 | 0.5–0.6 | 0.6–0.7 | 0.7–0.9 | 0.7–0.9 | 0.9–1.1 | 0.9–1.3 | 0.9–1.3 | 1.2–1.4 | 1.2–1.7 | 1.3–1.8 | 1.4–2.0 | 1.5–2.1 |
| 1985–95 | 0.3–0.7 | 0.4–0.9 | 0.6–1.2 | 0.9–1.4 | 1.2–1.5 | 1.3–1.6 | 1.5–1.7 | 1.6–1.8 | 1.7–1.9 | 1.7–2.0 | 1.8–2.1 | 1.9–2.1 | 1.9–2.2 | 2.0–2.2 |
| 1996–2006 | 0.1–0.5 | 0.2–0.6 | 0.4–0.8 | 0.8–1.4 | 1.3–1.5 | 1.4–1.6 | 1.5–1.8 | 1.6–1.8 | 1.7–1.9 | 1.9–2.1 | 2.0–2.1 | 2.1–2.2 | 2.1–2.4 | 2.1–2.4 |
| Velocity for median-flow condition | | | | | | | | | | | | | | |
| 1934–44 | 0.1–0.5 | 0.1–0.6 | 0.5–0.9 | 0.5–0.9 | 1.2–1.4 | 1.3–1.5 | 1.4–1.6 | 1.5–1.7 | 1.5–1.7 | 1.6–1.8 | 1.8–2.0 | 1.8–2.1 | 2.0–2.2 | 2.0–2.3 |
| 1951–61 | 0.5–0.6 | 0.5–0.7 | 0.5–0.7 | 0.9–1.2 | 1.1–1.4 | 1.2–1.5 | 1.3–1.5 | 1.5–1.6 | 1.6–1.7 | 1.6–1.8 | 1.7–1.9 | 1.8–1.9 | 1.8–2.0 | 1.9–2.1 |
| 1966–76 | 0.3–0.7 | 0.4–0.8 | 0.4–0.8 | 0.9–1.2 | 1.1–1.4 | 1.4–1.5 | 1.5–1.6 | 1.6–1.7 | 1.6–1.7 | 1.6–1.8 | 1.7–1.8 | 1.7–1.9 | 1.8–1.9 | 1.8–2.0 |
| 1985–95 | 0.1–0.5 | 0.3–0.6 | 0.3–0.6 | 0.9–1.2 | 1.1–1.3 | 1.2–1.4 | 1.3–1.5 | 1.3–1.5 | 1.4–1.6 | 1.5–1.6 | 1.6–1.7 | 1.6–1.8 | 1.7–1.9 | 1.7–1.9 |
| 1996–2006 | 0–0.3 | 0.2–0.4 | 0.4–0.8 | 0.7–1.1 | 0.7–1.1 | 1.1–1.3 | 1.3–1.4 | 1.4–1.5 | 1.4–1.7 | 1.5–1.8 | 1.6–1.9 | 1.6–2.0 | 1.7–2.0 | 1.7–2.0 |
| Velocity for low-flow condition | | | | | | | | | | | | | | |
| 1934–44 | 0–0.3 | 0–0.3 | 0.2–0.3 | 0.6–0.7 | 0.8–0.9 | 0.8–0.9 | 0.8–0.9 | 1.1–1.2 | 1.1–1.4 | 1.1–1.6 | 1.1–1.6 | 1.2–1.8 | 1.2–1.9 | 1.2–1.9 |
| 1951–61 | 0–0.3 | 0.1–0.4 | 0.1–0.7 | 0.1–0.7 | 0.2–1.2 | 0.4–1.2 | 0.6–1.4 | 0.7–1.4 | 0.8–1.5 | 0.8–1.5 | 0.9–1.6 | 0.9–1.6 | 0.9–1.6 | 1.1–1.8 |
| 1966–76 | 0.2–0.4 | 0.4–0.5 | 0.5–0.8 | 0.7–0.9 | 0.8–1.1 | 0.9–1.2 | 0.9–1.3 | 0.9–1.4 | 0.9–1.4 | 1.1–1.5 | 1.1–1.6 | 1.1–1.6 | 1.2–1.6 | 1.2–1.6 |
| 1985–95 | 0–0.3 | 0–0.4 | 0.1–0.5 | 0.3–0.6 | 0.5–0.9 | 0.6–1.1 | 0.9–1.2 | 0.9–1.2 | 0.9–1.2 | 1.1–1.5 | 1.2–1.5 | 1.3–1.6 | 1.3–1.6 | 1.3–1.6 |
| 1996–2006 | 0–0.3 | 0–0.3 | 0.1–0.4 | 0.2–0.6 | 0.2–0.7 | 0.4–0.8 | 0.4–0.8 | 0.7–1.1 | 0.8–1.2 | 0.8–1.2 | 1.1–1.5 | 1.2–1.5 | 1.3–1.6 | 1.3–1.6 |

**Appendix 3.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period near the Platte River bridge near Duncan, Nebraska, 1934–2006.—Continued

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period | Percentile of area cumulative frequency distribution | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 99 |
| Depth for high-flow condition | | | | | | | | |
| 1934–44 | 1.9–3.5 | 2.3–4.3 | 3.0–5.0 | 3.8–5.9 | 4.1–6.6 | 4.7–7.5 | 5.8–8.7 | 6.0–8.7 |
| 1951–61 | 1.9–2.1 | 2.0–2.3 | 2.1–2.5 | 2.4–2.9 | 2.6–3.2 | 3.0–3.5 | 3.8–4.8 | 4.1–5.2 |
| 1966–76 | 1.6–2.2 | 1.8–2.4 | 2.0–2.5 | 2.0–2.5 | 2.3–2.8 | 2.5–3.1 | 3.1–3.8 | 3.1–3.8 |
| 1985–95 | 1.7–2.2 | 1.8–2.3 | 1.9–2.5 | 2.0–2.8 | 2.2–3.2 | 2.5–3.5 | 2.9–4.5 | 2.9–4.6 |
| 1996–2006 | 1.8–2.3 | 1.9–2.5 | 2.1–2.7 | 2.2–3.0 | 2.7–3.3 | 2.9–3.9 | 3.2–4.8 | 3.2–4.9 |
| Depth for median-flow condition | | | | | | | | |
| 1934–44 | 1.7–2.0 | 1.9–2.2 | 2.0–2.7 | 2.3–3.2 | 2.9–3.8 | 3.2–4.1 | 3.6–5.1 | 3.7–5.3 |
| 1951–61 | 1.3–1.6 | 1.4–1.8 | 1.6–2.0 | 1.8–2.2 | 2.0–2.4 | 2.3–2.8 | 2.8–3.8 | 2.8–3.9 |
| 1966–76 | 1.2–1.7 | 1.4–1.8 | 1.5–1.9 | 1.6–2.1 | 1.8–2.4 | 2.0–2.5 | 2.5–3.3 | 2.5–3.3 |
| 1985–95 | 1.2–1.5 | 1.3–1.8 | 1.3–2.2 | 1.4–2.4 | 1.7–2.6 | 1.9–2.9 | 2.5–3.7 | 2.5–3.8 |
| 1996–2006 | 1.1–1.9 | 1.2–2.1 | 1.3–2.3 | 1.7–2.7 | 1.9–3.0 | 2.2–3.4 | 3.3–4.6 | 3.4–4.9 |
| Depth for low-flow condition | | | | | | | | |
| 1934–44 | 0.8–1.5 | 0.8–2.0 | 0.6–2.8 | 0.5–3.3 | 0.5–3.7 | 0.7–4.0 | 0.9–4.0 | 0.9–4.0 |
| 1951–61 | 0.9–1.4 | 0.9–1.4 | 0.9–1.6 | 0.9–1.6 | 0.9–1.6 | 1.1–2.0 | 1.2–2.2 | 1.2–2.3 |
| 1966–76 | 0.5–0.9 | 0.5–0.9 | 0.5–0.9 | 0.6–1.1 | 0.7–1.4 | 0.9–1.5 | 0.9–1.5 | 0.9–1.5 |
| 1985–95 | 0.6–0.9 | 0.6–0.9 | 0.8–1.1 | 0.9–1.1 | 0.9–1.2 | 0.9–1.2 | 1.2–1.5 | 1.2–1.5 |
| 1996–2006 | 0.6–0.9 | 0.6–0.9 | 0.8–1.1 | 0.8–1.8 | 0.9–2.1 | 0.9–2.2 | 1.2–2.3 | 1.3–2.3 |
| Velocity for high-flow condition | | | | | | | | |
| 1934–44 | 2.3–2.6 | 2.4–2.8 | 2.5–2.9 | 2.6–2.9 | 2.6–3.0 | 2.8–3.1 | 3.1–3.5 | 3.1–3.5 |
| 1951–61 | 2.3–2.4 | 2.3–2.5 | 2.4–2.6 | 2.5–2.7 | 2.6–2.8 | 2.8–3.0 | 2.9–3.2 | 3.0–3.3 |
| 1966–76 | 1.6–2.2 | 1.8–2.4 | 2.0–2.5 | 2.0–2.5 | 2.3–2.8 | 2.5–3.1 | 3.1–3.8 | 3.1–3.8 |
| 1985–95 | 2.1–2.3 | 2.1–2.4 | 2.2–2.5 | 2.3–2.6 | 2.4–2.7 | 2.5–2.9 | 2.6–3.1 | 2.7–3.1 |
| 1996–2006 | 2.2–2.6 | 2.3–2.6 | 2.4–2.7 | 2.4–2.8 | 2.4–2.9 | 2.5–3.1 | 3.0–3.4 | 3.0–3.4 |
| Velocity for median-flow condition | | | | | | | | |
| 1934–44 | 2.1–2.4 | 2.1–2.5 | 2.2–2.5 | 2.2–2.6 | 2.3–2.7 | 2.5–2.9 | 2.8–3.2 | 2.9–3.2 |
| 1951–61 | 1.9–2.2 | 2.0–2.2 | 2.1–2.4 | 2.2–2.4 | 2.2–2.5 | 2.3–2.6 | 2.6–2.9 | 2.7–3.0 |
| 1966–76 | 1.9–2.0 | 2.0–2.1 | 2.0–2.1 | 2.1–2.1 | 2.1–2.4 | 2.2–2.5 | 2.2–3.3 | 2.2–3.4 |
| 1985–95 | 1.8–2.0 | 1.8–2.1 | 1.8–2.1 | 1.9–2.2 | 1.9–2.3 | 2.0–2.4 | 2.3–2.6 | 2.3–2.6 |
| 1996–2006 | 1.8–2.1 | 1.8–2.2 | 1.9–2.3 | 1.9–2.4 | 2.1–2.5 | 2.2–2.8 | 2.5–3.2 | 2.5–3.2 |
| Velocity for low-flow condition | | | | | | | | |
| 1934–44 | 1.3–2.1 | 1.5–2.0 | 1.6–2.0 | 1.6–2.1 | 1.7–2.1 | 1.9–2.2 | 2.2–2.4 | 2.2–2.4 |
| 1951–61 | 1.3–1.9 | 1.3–1.9 | 1.4–1.9 | 1.5–1.9 | 1.6–2.0 | 1.7–2.3 | 1.9–2.5 | 2.0–2.5 |
| 1966–76 | 1.3–1.7 | 1.3–1.8 | 1.4–1.8 | 1.4–1.8 | 1.5–1.9 | 1.6–1.9 | 1.7–2.2 | 1.7–2.2 |
| 1985–95 | 1.4–1.7 | 1.5–1.7 | 1.5–1.7 | 1.6–1.8 | 1.6–2.0 | 1.6–2.1 | 1.7–2.4 | 1.8–2.4 |
| 1996–2006 | 1.4–1.7 | 1.5–1.7 | 1.5–1.8 | 1.6–1.9 | 1.6–2.0 | 1.7–2.1 | 2.0–2.2 | 1.9–3.0 |

**Appendix 4.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridges at North Bend, Nebraska, 1934–2006.

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 |
| **Depth for high-flow condition** | | | | | | | | | | | | | |
| 1951–61 | 0.6–0.7 | 0.7–0.8 | 0.7–0.8 | 1.2–1.4 | 1.4–1.8 | 1.6–2.0 | 1.9–2.2 | 2.0–2.4 | 2.1–2.6 | 2.3–2.8 | 2.5–2.9 | 2.6–3.2 | 2.8–3.6 |
| 1966–76 | 0.4–1.2 | 0.5–1.5 | 0.9–1.9 | 1.3–2.5 | 1.1–3.4 | 1.3–3.5 | 1.4–3.7 | 1.8–4.1 | 1.9–4.3 | 2.2–4.5 | 2.4–4.8 | 2.8–5.0 | 3.0–5.1 |
| 1985–95 | 0.4–0.5 | 0.4–0.6 | 0.4–0.6 | 0.4–0.6 | 1.3–1.5 | 1.6–1.8 | 1.7–2.0 | 2.0–2.3 | 2.1–2.4 | 2.2–2.8 | 2.7–3.0 | 2.9–3.5 | 3.3–4.2 |
| 1996–2006 | 0.3–0.5 | 0.5–0.7 | 0.5–0.7 | 0.5–0.7 | 1.3–1.5 | 1.4–1.7 | 1.6–1.9 | 1.7–2.0 | 1.9–2.2 | 2.1–2.4 | 2.2–2.5 | 2.3–2.8 | 2.4–3.0 |
| **Depth for median-flow condition** | | | | | | | | | | | | | |
| 1951–61 | 0.2–0.3 | 0.3–0.4 | 0.4–0.7 | 0.4–0.7 | 0.8–1.2 | 0.9–1.3 | 1.2–1.6 | 1.4–1.8 | 1.6–2.1 | 1.7–2.4 | 2.0–2.8 | 2.2–3.0 | 2.2–3.4 |
| 1966–76 | 0.3–0.5 | 0.4–0.6 | 0.4–0.6 | 0.8–1.2 | 0.8–1.2 | 1.2–1.6 | 1.5–1.9 | 1.6–2.2 | 1.7–2.5 | 1.9–2.6 | 2.1–2.9 | 2.2–3.2 | 2.3–3.2 |
| 1985–95 | 0.2–0.4 | 0.3–0.4 | 0.4–0.6 | 0.5–0.9 | 0.5–0.9 | 0.8–1.2 | 0.9–1.3 | 1.1–1.5 | 1.2–1.6 | 1.3–1.8 | 1.6–2.0 | 1.8–2.4 | 1.9–2.4 |
| 1996–2006 | 0.2–0.4 | 0.3–0.6 | 0.5–0.7 | 0.7–0.9 | 0.7–0.9 | 0.7–.9 | 1.2–1.3 | 1.2–1.4 | 1.3–1.5 | 1.4–1.7 | 1.5–2.0 | 1.6–2.2 | 1.5–2.9 |
| **Depth for low-flow condition[2]** | | | | | | | | | | | | | |
| 1951–61 | 0.2–0.4 | 0.2–0.4 | 0.3–0.7 | 0.5–0.9 | 0.7–1.1 | 0.8–1.2 | 0.8–1.2 | 1.1–1.5 | 1.2–1.6 | 1.2–1.7 | 1.3–1.8 | 1.4–2.2 | 1.6–2.3 |
| 1966–76 | 0.1–0.3 | 0.2–0.4 | 0.4–0.6 | 0.4–0.6 | 0.6–1.5 | 0.8–1.7 | 0.9–1.8 | 1.1–2.0 | 1.2–2.3 | 1.2–2.6 | 1.3–2.7 | 1.4–2.8 | 1.5–3.0 |
| 1985–95 | 0.2–0.3 | 0.3–0.4 | 0.4–0.5 | 0.5–0.6 | 0.6–0.8 | 0.6–0.8 | 0.9–1.3 | 0.9–1.4 | 0.9–1.4 | 1.1–1.9 | 1.1–1.9 | 1.2–2.0 | 1.2–2.2 |
| **Velocity for high-flow condition** | | | | | | | | | | | | | |
| 1951–61 | 0.5–0.9 | 0.6–1.2 | 1.4–1.9 | 1.8–2.1 | 1.9–2.2 | 2.0–2.3 | 2.1–2.4 | 2.1–2.4 | 2.2–2.5 | 2.3–2.6 | 2.4–2.8 | 2.5–2.9 | 2.5–3.1 |
| 1966–76 | 0.2–0.8 | 0.2–0.8 | 0.9–1.6 | 1.7–2.1 | 1.9–2.4 | 2.1–2.5 | 2.3–2.8 | 2.6–3.1 | 2.6–3.2 | 2.7–3.2 | 2.9–3.2 | 3.0–3.3 | 3.0–3.3 |
| 1985–95 | 0.2–0.8 | 0.3–1.1 | 0.6–1.5 | 1.1–1.7 | 1.4–2.1 | 1.6–2.2 | 1.8–2.3 | 2.0–2.4 | 2.2–2.5 | 2.3–2.7 | 2.4–2.8 | 2.6–2.8 | 2.8–3.0 |
| 1996–2006 | 0.5–0.7 | 0.6–1.1 | 0.6–1.1 | 1.5–1.9 | 1.7–2.1 | 2.0–2.1 | 2.1–2.2 | 2.2–2.3 | 2.3–2.4 | 2.3–2.5 | 2.5–2.6 | 2.5–2.8 | 2.6–3.0 |
| **Velocity for median-flow condition** | | | | | | | | | | | | | |
| 1951–61 | 0.4–0.7 | 0.5–0.8 | 0.8–1.4 | 1.1–1.5 | 1.5–1.8 | 1.6–1.9 | 1.8–2.0 | 1.9–2.3 | 2.0–2.5 | 2.1–2.7 | 2.2–2.8 | 2.4–2.9 | 2.5–3.0 |
| 1966–76 | 0.1–0.6 | 0.1–0.8 | 0.8–1.2 | 1.1–1.5 | 1.3–1.7 | 1.4–1.9 | 1.5–2.0 | 1.7–2.1 | 1.8–2.2 | 1.8–2.3 | 1.9–2.4 | 2.0–2.5 | 2.2–2.6 |
| 1985–95 | 0.3–0.7 | 0.5–0.8 | 0.6–1.2 | 0.8–1.4 | 1.3–1.5 | 1.5–1.6 | 1.6–1.8 | 1.6–1.9 | 1.7–2.0 | 1.8–2.1 | 1.9–2.2 | 2.1–2.3 | 2.2–2.4 |
| 1996–2006 | 0.2–0.8 | 0.4–0.8 | 0.7–1.1 | 1.1–1.3 | 1.3–1.4 | 1.4–1.6 | 1.6–1.7 | 1.8–1.9 | 1.9–2.0 | 2.0–2.1 | 2.0–2.2 | 2.0–2.2 | 2.1–2.3 |
| **Velocity for low-flow condition[2]** | | | | | | | | | | | | | |
| 1951–61 | 0.3–0.6 | 0.5–0.7 | 0.5–0.7 | 0.9–1.2 | 1.2–1.3 | 1.2–1.5 | 1.3–1.6 | 1.4–1.7 | 1.6–1.8 | 1.7–2.0 | 1.8–2.2 | 1.8–2.2 | 1.9–2.3 |
| 1966–76 | 0–0.4 | 0.1–0.6 | 0.5–0.8 | 0.8–1.1 | 0.8–1.1 | 1.2–1.7 | 1.2–1.7 | 1.3–1.9 | 1.4–2.0 | 1.5–2.1 | 1.7–2.1 | 1.9–2.1 | 2.0–2.3 |
| 1985–95 | 0.2–0.4 | 0.3–0.5 | 0.5–0.7 | 0.5–0.7 | 0.5–0.7 | 1.2–1.3 | 1.3–1.4 | 1.4–1.5 | 1.5–1.6 | 1.5–1.8 | 1.6–1.8 | 1.6–1.9 | 1.7–2.0 |

**Appendix 4.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridges at North Bend, Nebraska, 1934–2006.—Continued

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 60 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| **Depth for high-flow condition** | | | | | | | | | |
| 1951–61 | 3.0–3.8 | 3.3–4.6 | 3.8–5.3 | 3.9–6.9 | 4.3–7.5 | 4.8–7.9 | 5.5–8.4 | 5.9–8.6 | 6.1–8.8 |
| 1966–76 | 4.0–5.5 | 4.5–7.9 | 5.0–9.0 | 5.2–10.3 | 5.5–11.1 | 5.7–11.3 | 6.2–11.4 | 6.4–11.8 | 6.5–11.9 |
| 1985–95 | 3.6–4.7 | 4.1–5.2 | 4.3–5.4 | 4.6–5.8 | 4.9–6.3 | 5.3–7.2 | 6.3–8.6 | 7.0–9.3 | 7.2–9.5 |
| 1996–2006 | 2.6–3.2 | 3.3–6.0 | 4.4–7.0 | 4.9–7.8 | 5.6–8.3 | 6.3–9.3 | 7.1–10 | 7.8–10.5 | 8.0–10.7 |
| **Depth for median-flow condition** | | | | | | | | | |
| 1951–61 | 2.4–3.5 | 2.8–4.3 | 3.3–5.6 | 3.5–6.1 | 3.8–6.4 | 4.1–6.8 | 4.2–7.0 | 4.7–7.3 | 4.9–7.4 |
| 1966–76 | 2.5–3.4 | 3.0–3.8 | 3.2–4.0 | 3.7–5.0 | 4.0–5.5 | 4.2–5.7 | 4.4–6.3 | 4.6–6.5 | 4.6–6.5 |
| 1985–95 | 2.2–3.0 | 3.0–3.6 | 3.1–4.5 | 3.4–5.1 | 3.6–5.5 | 3.8–5.9 | 4.4–6.2 | 5.1–6.4 | 5.4–6.5 |
| 1996–2006 | 1.7–3.3 | 2.0–3.6 | 2.2–3.9 | 2.6–4.2 | 3.0–4.6 | 3.3–5.2 | 3.6–5.5 | 4.1–5.8 | 4.2–6.0 |
| **Depth for low-flow condition[2]** | | | | | | | | | |
| 1951–61 | 1.7–2.4 | 2.0–3.5 | 2.1–3.7 | 2.3–4.0 | 2.5–4.4 | 2.7–4.6 | 3.0–4.8 | 3.2–5.2 | 3.2–5.3 |
| 1966–76 | 1.7–3.2 | 1.8–4.5 | 1.9–4.8 | 2.0–5.1 | 2.1–5.2 | 2.5–5.4 | 2.7–5.7 | 2.9–5.8 | 2.9–5.8 |
| 1985–95 | 1.3–2.2 | 1.5–2.5 | 1.7–2.6 | 1.8–2.8 | 1.9–3.0 | 2.1–3.2 | 2.2–3.4 | 2.3–3.5 | 2.5–3.4 |
| **Velocity for high-flow condition** | | | | | | | | | |
| 1951–61 | 2.7–3.1 | 3.0–3.3 | 3.1–3.4 | 3.3–3.6 | 3.3–3.8 | 3.4–4.2 | 3.7–4.5 | 3.8–4.6 | 3.9–4.7 |
| 1966–76 | 3.1–3.4 | 3.2–3.8 | 3.4–4.0 | 3.5–4.0 | 3.7–4.3 | 3.9–4.4 | 4.0–4.6 | 4.1–4.9 | 4.2–5.0 |
| 1985–95 | 2.8–3.1 | 3.1–3.4 | 3.2–3.6 | 3.3–3.7 | 3.4–3.8 | 3.6–4.1 | 3.8–4.4 | 3.9–4.7 | 4.0–4.7 |
| 1996–2006 | 2.7–3.0 | 2.8–3.2 | 3.0–3.3 | 3.0–3.4 | 3.1–3.7 | 3.3–3.9 | 3.5–4.1 | 3.5–4.3 | 3.6–4.4 |
| **Velocity for median-flow condition** | | | | | | | | | |
| 1951–61 | 2.5–3.1 | 2.6–3.2 | 2.7–3.4 | 2.9–3.6 | 3.1–3.8 | 3.2–3.9 | 3.4–4.2 | 3.5–4.3 | 3.6–4.3 |
| 1966–76 | 2.2–2.8 | 2.4–3.0 | 2.5–3.1 | 2.9–3.2 | 3.1–3.4 | 3.3–3.6 | 3.4–3.8 | 3.5–4.0 | 3.5–4.1 |
| 1985–95 | 2.3–2.6 | 2.5–2.8 | 2.6–3.0 | 2.6–3.0 | 2.6–3.2 | 2.8–3.3 | 3.0–3.5 | 3.1–3.9 | 3.2–3.9 |
| 1996–2006 | 2.2–2.3 | 2.4–2.6 | 2.4–2.6 | 2.5–2.8 | 2.6–3.0 | 2.7–3.0 | 2.8–3.3 | 3.0–3.4 | 3.2–3.5 |
| **Velocity for low-flow condition[2]** | | | | | | | | | |
| 1951–61 | 2.0–2.4 | 2.1–2.5 | 2.2–2.8 | 2.3–2.9 | 2.4–3.0 | 2.6–3.1 | 2.8–3.3 | 2.8–3.3 | 2.9–3.3 |
| 1966–76 | 2.1–2.3 | 2.2–2.5 | 2.4–2.6 | 2.4–2.7 | 2.4–2.8 | 2.5–2.8 | 2.6–2.9 | 2.7–3.0 | 2.7–3.0 |
| 1985–95 | 1.7–2.2 | 1.9–2.4 | 1.9–2.5 | 1.9–2.6 | 2.1–2.7 | 2.1–2.9 | 2.3–3.0 | 2.4–3.1 | 2.4–3.1 |

[1] No calculation of area cumulative frequency distribution was made for the 1934–1944 period because streamflow-gaging station and discharge measurements began in April 1949.

[2] No calculation of area cumulative frequency distribution was made for the low-flow condition in the 1996–2006 period because discharge measurements field notes were not available.

**Appendix 5.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridge near Leshara, Nebraska, 1934–2006.

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| Depth for high-flow condition | | | | | | | | | | | | |
| 1985–95 | 0.3–0.8 | 0.3–0.8 | 0.5–1.3 | 1.3–1.5 | 1.5–2.0 | 2.0–2.0 | 1.9–2.5 | 2.1–2.6 | 2.3–2.6 | 2.5–2.8 | 2.5–3.1 | 2.6–3.2 |
| 1996–2006 | 0.3–0.6 | 0.5–0.9 | 0.7–1.2 | 1.1–1.4 | 1.4–1.6 | 1.6–1.8 | 1.8–2.0 | 1.9–2.2 | 2.0–2.4 | 2.2–2.7 | 2.3–2.9 | 2.5–3.1 |
| Depth for median-flow condition | | | | | | | | | | | | |
| 1985–95 | 0.1–1.4 | 0.2–1.5 | 0.2–2.0 | 0.7–2.5 | 1.1–2.6 | 1.6–3.1 | 1.7–3.3 | 1.8–3.6 | 1.9–3.8 | 2.0–4.0 | 2.1–4.1 | 2.2–4.4 |
| 1996–2006 | 0.2–0.6 | 0.3–0.9 | 0.4–1.1 | 0.7–1.3 | 0.7–1.3 | 1.3–2.0 | 1.4–2.2 | 1.5–2.4 | 1.5–2.6 | 1.7–2.8 | 1.9–3.0 | 2.0–3.2 |
| Depth for low-flow condition | | | | | | | | | | | | |
| 1985–95 | 0.3–0.4 | 0.3–0.7 | 0.3–0.7 | 0.4–1.4 | 0.5–1.4 | 0.5–1.6 | 0.7–1.8 | 0.8–1.9 | 0.8–1.9 | 1.1–1.9 | 1.1–2.0 | 1.2–2.0 |
| 1996–2006 | 0.2–0.3 | 0.2–0.4 | 0.5–0.6 | 0.6–0.9 | 0.8–1.1 | 0.9–1.3 | 0.9–1.3 | 1.1–1.8 | 1.2–1.9 | 1.3–2.0 | 1.4–2.3 | 1.5–2.5 |
| Velocity for high-flow condition | | | | | | | | | | | | |
| 1985–95 | 0.1–0.5 | 0.2–0.6 | 0.3–0.7 | 0.8–1.4 | 1.3–2.0 | 1.9–2.2 | 2.0–2.3 | 2.0–2.5 | 2.0–2.6 | 2.0–2.6 | 2.1–2.7 | 2.2–2.9 |
| 1996–2006 | 0.2–0.7 | 0.3–1.1 | 0.4–1.4 | 1.2–1.7 | 1.5–1.9 | 1.8–2.0 | 1.9–2.1 | 2.0–2.2 | 2.1–2.3 | 2.3–2.4 | 2.3–2.5 | 2.4–2.6 |
| Velocity for median-flow condition | | | | | | | | | | | | |
| 1985–95 | 0.4–0.8 | 0.4–1.2 | 0.8–1.6 | 0.9–2.0 | 1.3–2.2 | 1.5–2.3 | 1.8–2.4 | 1.9–2.5 | 1.9–2.6 | 2.0–2.7 | 2.1–2.9 | 2.1–3.1 |
| 1996–2006 | 0.3–0.6 | 0.4–0.6 | 0.4–0.6 | 1.3–1.6 | 1.5–1.8 | 1.6–1.9 | 1.8–2.0 | 1.9–2.1 | 2.0–2.2 | 2.1–2.3 | 2.2–2.4 | 2.3–2.6 |
| Velocity for low-flow condition | | | | | | | | | | | | |
| 1985–95 | 0.3–0.7 | 0.3–0.7 | 0.6–1.4 | 0.9–1.5 | 0.9–1.8 | 1.1–1.8 | 1.2–1.8 | 1.4–1.8 | 1.4–1.8 | 1.5–1.9 | 1.7–2.0 | 1.8–2.0 |
| 1996–2006 | 0.1–0.4 | 0.2–0.7 | 0.2–0.7 | 0.7–1.2 | 0.9–1.3 | 0.9–1.3 | 1.1–1.5 | 1.3–1.6 | 1.5–1.7 | 1.6–1.8 | 1.6–2.0 | 1.7–2.0 |

**Appendix 5.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridge near Leshara, Nebraska, 1934–2006—Continued

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| Depth for high-flow condition | | | | | | | | | | | |
| 1985–95 | 2.8–3.6 | 3.0–3.7 | 3.0–3.8 | 3.0–4.1 | 3.3–4.5 | 3.4–4.9 | 3.4–5.2 | 3.8–5.5 | 3.9–6.2 | 4.1–6.8 | 4.1–7.1 |
| 1996–2006 | 2.7–3.4 | 2.8–3.5 | 2.9–3.8 | 3.2–4.1 | 3.5–4.4 | 3.8–4.5 | 4.1–4.9 | 4.4–5.1 | 4.8–5.9 | 4.8–6.6 | 4.8–6.9 |
| Depth for median-flow condition | | | | | | | | | | | |
| 1985–95 | 2.3–4.5 | 2.4–4.6 | 2.5–5.0 | 2.5–5.6 | 2.8–5.7 | 2.9–5.8 | 3.2–6.0 | 3.4–6.3 | 3.6–6.9 | 3.7–7.2 | 3.7–7.3 |
| 1996–2006 | 2.1–3.4 | 2.2–3.7 | 2.4–3.7 | 2.6–3.9 | 2.7–4.3 | 3.2–4.7 | 3.4–5.5 | 3.7–6.2 | 4.1–6.7 | 4.3–7.0 | 4.4–7.2 |
| Depth for low-flow condition | | | | | | | | | | | |
| 1985–95 | 1.4–2.1 | 1.4–2.1 | 1.5–2.1 | 1.4–2.6 | 1.4–3.6 | 1.6–4.3 | 2.0–4.8 | 2.5–5.2 | 2.7–5.7 | 2.7–6.0 | 2.7–6.1 |
| 1996–2006 | 1.5–2.8 | 1.6–3.0 | 1.9–3.1 | 2.0–3.3 | 2.1–4.0 | 2.3–4.2 | 2.5–4.3 | 3.0–4.6 | 3.2–5.0 | 3.2–5.3 | 3.2–5.4 |
| Velocity for high-flow condition | | | | | | | | | | | |
| 1985–95 | 2.4–3.0 | 2.7–3.1 | 2.9–3.3 | 3.0–3.4 | 2.9–3.8 | 2.9–3.9 | 3.0–4.0 | 3.1–4.1 | 3.2–4.2 | 3.3–4.3 | 3.4–4.4 |
| 1996–2006 | 2.5–2.7 | 2.6–2.9 | 2.6–3.0 | 2.7–3.1 | 2.8–3.2 | 2.9–3.3 | 3.0–3.4 | 3.1–3.7 | 3.3–3.8 | 3.3–3.9 | 3.4–3.9 |
| Velocity for median-flow condition | | | | | | | | | | | |
| 1985–95 | 2.2–3.1 | 2.3–3.2 | 2.4–3.3 | 2.4–3.3 | 2.4–3.4 | 2.5–3.5 | 2.7–3.7 | 2.9–4.1 | 3.0–4.3 | 3.1–4.4 | 3.1–4.4 |
| 1996–2006 | 2.3–2.7 | 2.4–2.7 | 2.5–2.8 | 2.5–2.8 | 2.6–2.9 | 2.6–3.0 | 2.7–3.1 | 2.8–3.2 | 3.0–3.4 | 3.0–3.5 | 3.1–3.6 |
| Velocity for low-flow condition | | | | | | | | | | | |
| 1985–95 | 1.9–2.1 | 2.0–2.3 | 2.1–2.3 | 2.1–2.4 | 2.1–2.4 | 2.2–2.5 | 2.2–2.7 | 2.3–2.8 | 2.5–3.0 | 2.5–3.1 | 2.6–3.0 |
| 1996–2006 | 1.7–2.1 | 1.8–2.2 | 1.8–2.3 | 1.9–2.4 | 1.9–2.5 | 2.0–2.6 | 2.1–2.7 | 2.2–2.8 | 2.4–2.9 | 2.5–2.9 | 2.5–3.0 |

[1]No calculation of area cumulative frequency distribution was made for the 1934–1944, 1951–1961, and 1966–1976 periods because streamflow-gaging station and discharge measurements began in June 1994.

**Appendix 6.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridge near Ashland, Nebraska, 1934–2006.

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| Depth for high-flow condition | | | | | | | | | | | | |
| 1934–44 | 0.5–0.9 | 0.7–1.2 | 1.5–2.0 | 2.2–2.7 | 2.5–3.4 | 2.9–3.8 | 3.2–4.3 | 3.6–4.7 | 3.9–5.0 | 4.3–5.3 | 4.7–5.5 | 5.1–6.0 |
| 1951–61 | 0.5–0.8 | 0.6–1.2 | 0.8–1.4 | 1.6–1.9 | 1.8–2.4 | 2.0–2.6 | 2.1–3.4 | 2.2–3.7 | 2.4–3.8 | 2.8–4.0 | 3.7–4.0 | 4.0–4.3 |
| 1985–95 | 0.5–0.9 | 0.7–1.2 | 1.0–1.6 | 1.6–2.1 | 1.9–2.4 | 2.3–2.8 | 2.3–3.0 | 2.6–3.4 | 2.9–3.8 | 3.2–4.3 | 3.3–4.6 | 3.4–4.8 |
| 1996–2006 | 0.7–1.0 | 0.8–1.3 | 1.0–1.7 | 1.3–2.0 | 1.7–2.7 | 1.9–3.0 | 2.2–3.3 | 2.1–4.2 | 2.2–4.3 | 2.3–5.0 | 2.8–5.4 | 3.1–5.5 |
| Depth for median-flow condition | | | | | | | | | | | | |
| 1934–44 | 0.1–0.8 | 0.3–0.8 | 0.4–1.3 | 0.7–2.0 | 1.1–2.2 | 1.3–2.2 | 1.5–2.4 | 1.8–2.4 | 2.3–2.6 | 2.6–2.9 | 2.7–3.7 | 2.8–4.3 |
| 1951–61 | 0.4–0.6 | 0.5–0.7 | 0.7–0.9 | 1.0–1.1 | 1.2–1.3 | 1.3–1.4 | 1.4–1.6 | 1.7–2.0 | 1.9–2.1 | 2.1–2.4 | 2.3–2.5 | 2.5–3.2 |
| 1985–95 | 0.3–0.4 | 0.4–0.5 | 0.5–1.0 | 0.9–1.3 | 1.2–1.7 | 1.3–2.1 | 1.5–2.2 | 1.8–2.5 | 2.1–2.7 | 2.3–3.1 | 2.7–3.6 | 3.0–3.8 |
| 1996–2006 | 0.3–0.4 | 0.5–0.5 | 0.6–0.8 | 0.7–0.9 | 0.9–1.2 | 1.1–1.4 | 1.2–1.5 | 1.5–1.7 | 1.7–2.0 | 1.8–2.2 | 1.9–2.5 | 2.1–2.8 |
| Depth for low-flow condition | | | | | | | | | | | | |
| 1934–44 | 0.2–0.5 | 0.3–0.7 | 0.4–0.8 | 0.6–1.0 | 0.8–1.3 | 1.0–1.4 | 1.1–1.6 | 1.2–1.8 | 1.4–1.9 | 1.8–1.9 | 1.9–1.9 | 1.9–2.6 |
| 1951–61 | 0.3–0.5 | 0.4–0.6 | 0.6–0.7 | 0.8–1.0 | 0.9–1.2 | 1.1–1.4 | 1.2–1.7 | 1.3–1.9 | 1.6–2.3 | 1.7–2.5 | 2.1–2.7 | 2.4–3.0 |
| 1985–95 | 0.2–0.5 | 0.4–0.5 | 0.5–0.8 | 0.8–1.0 | 1.0–1.3 | 1.2–1.8 | 1.4–2.0 | 1.6–2.3 | 1.8–2.6 | 2.0–2.8 | 2.0–2.9 | 2.1–3.0 |
| 1996–2006 | 0.2–0.3 | 0.3–0.4 | 0.5–0.6 | 0.7–1.0 | 0.9–1.2 | 1.0–1.5 | 1.2–1.6 | 1.4–1.7 | 1.5–2.0 | 1.6–2.0 | 1.7–2.3 | 1.8–2.6 |
| Velocity for high-flow condition | | | | | | | | | | | | |
| 1934–44 | 0.1–0.5 | 0.2–0.5 | 0.4–1.1 | 1.1–1.8 | 1.5–2.2 | 1.7–2.4 | 1.8–2.6 | 2.1–2.7 | 2.2–2.9 | 2.3–2.9 | 2.5–3.0 | 2.5–3.1 |
| 1951–61 | 0.2–1.0 | 0.8–1.1 | 1.3–1.6 | 1.5–1.9 | 1.7–2.1 | 2.1–2.3 | 2.1–2.4 | 2.3–2.6 | 2.4–2.6 | 2.5–2.8 | 2.6–2.9 | 2.7–3.0 |
| 1985–95 | 0.1–1.1 | 0.2–1.5 | 0.8–1.8 | 1.5–2.1 | 1.8–2.2 | 1.9–2.5 | 2.0–2.7 | 2.2–2.7 | 2.3–2.9 | 2.5–3.0 | 2.6–3.0 | 2.9–3.1 |
| 1996–2006 | 0.9–1.2 | 1.1–1.4 | 1.3–1.6 | 1.7–2.3 | 1.9–2.5 | 2.1–2.7 | 2.2–2.7 | 2.3–2.8 | 2.4–2.9 | 2.5–3.0 | 2.6–3.1 | 2.6–3.3 |
| Velocity for median-flow condition | | | | | | | | | | | | |
| 1934–44 | 0.3–0.6 | 0.2–1.5 | 0.6–1.7 | 1.0–1.9 | 1.2–2.1 | 1.4–2.2 | 1.6–2.3 | 1.8–2.3 | 1.9–2.5 | 2.0–2.5 | 2.1–2.5 | 2.2–2.6 |
| 1951–61 | 0.4–0.7 | 0.4–0.9 | 0.9–1.1 | 1.3–1.4 | 1.5–1.8 | 1.7–1.8 | 1.7–1.9 | 1.8–2.0 | 1.9–2.1 | 2.0–2.2 | 2.1–2.4 | 2.2–2.4 |
| 1985–95 | 0.3–0.7 | 0.4–0.7 | 0.6–0.9 | 0.8–1.2 | 1.3–1.6 | 1.4–1.8 | 1.5–1.8 | 1.6–1.9 | 1.7–2.0 | 1.8–2.2 | 1.9–2.3 | 2.0–2.5 |
| 1996–2006 | 0.3–0.5 | 0.3–0.6 | 0.6–1.0 | 0.8–1.4 | 0.9–1.7 | 1.0–1.8 | 1.2–1.9 | 1.5–1.9 | 1.7–2.0 | 1.9–2.1 | 2.0–2.2 | 2.1–2.3 |
| Velocity for low-flow condition | | | | | | | | | | | | |
| 1934–44 | 0–0.2 | 0–0.4 | 0.5–0.7 | 0.7–1.0 | 0.9–1.4 | 1.2–1.6 | 1.3–1.8 | 1.4–2.0 | 1.5–2.0 | 1.6–2.1 | 1.8–2.2 | 1.9–2.3 |
| 1951–61 | 0.2–0.5 | 0.3–0.6 | 0.5–1.2 | 0.7–1.6 | 1.0–1.7 | 1.0–1.9 | 1.2–2.1 | 1.4–2.1 | 1.6–2.1 | 1.7–2.2 | 1.9–2.2 | 2.0–2.3 |
| 1985–95 | 0–0.4 | 0.1–0.7 | 0.2–0.9 | 0.5–1.3 | 1.0–1.7 | 1.2–1.8 | 1.4–1.9 | 1.6–2.0 | 1.6–2.0 | 1.8–2.1 | 2.0–2.2 | 2.1–2.3 |
| 1996–2006 | 0.1–0.3 | 0.1–0.4 | 0.5–0.7 | 0.8–1.0 | 1.0–1.4 | 1.2–1.8 | 1.3–1.8 | 1.4–1.9 | 1.5–1.9 | 1.6–1.9 | 1.7–2.0 | 1.8–2.0 |

**Appendix 6.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridge near Ashland, Nebraska, 1934–2006.—Continued

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| Depth for high-flow condition | | | | | | | | | | | |
| 1934–44 | 5.6–6.2 | 6.1–6.9 | 6.5–7.3 | 7.1–7.8 | 7.1–8.8 | 7.5–9.7 | 7.8–10.4 | 8.1–11.4 | 9.2–11.8 | 9.9–12.2 | 10.3–12.8 |
| 1951–61 | 4.6–4.7 | 5.0–6.0 | 5.6–6.8 | 6.6–7.9 | 7.6–8.7 | 8.0–10 | 8.5–11.1 | 8.7–12.2 | 8.7–13.6 | 8.8–14.1 | 8.9–14.2 |
| 1985–95 | 3.6–5.4 | 3.7–6.1 | 4.0–6.4 | 4.3–6.7 | 5.0–7.1 | 5.7–8.0 | 5.9–8.6 | 6.2–9.4 | 6.7–11.2 | 6.9–12.5 | 7.0–12.6 |
| 1996–2006 | 3.4–5.7 | 3.8–6.0 | 4.0–6.6 | 4.4–6.8 | 4.8–7.4 | 5.5–7.9 | 5.8–8.4 | 6.1–9.3 | 6.4–10 | 6.9–10.4 | 7.0–10.4 |
| Depth for median–flow condition | | | | | | | | | | | |
| 1934–44 | 2.8–4.8 | 3.4–4.9 | 3.5–5.0 | 3.8–5.1 | 4.4–5.4 | 4.7–6.2 | 5.6–6.7 | 5.8–7.3 | 5.8–7.6 | 6.1–7.8 | 6.2–7.8 |
| 1951–61 | 2.6–3.7 | 3.0–4.1 | 3.5–4.6 | 3.8–5.3 | 4.0–5.8 | 4.1–5.9 | 4.3–6.0 | 4.5–6.3 | 4.8–6.7 | 5.2–7.1 | 5.7–7.3 |
| 1985–95 | 3.5–3.9 | 3.6–4.1 | 3.7–4.2 | 3.8–4.7 | 4.0–4.9 | 4.2–5.3 | 4.4–5.9 | 4.6–6.1 | 5.1–6.5 | 5.4–7.0 | 5.5–7.2 |
| 1996–2006 | 2.2–3.2 | 2.8–3.5 | 3.2–4.0 | 3.6–5.2 | 4.0–5.5 | 4.3–5.7 | 4.5–5.9 | 5.0–6.3 | 5.7–6.9 | 6.1–7.4 | 6.3–7.6 |
| Depth for low–flow condition | | | | | | | | | | | |
| 1934–44 | 1.6–4.0 | 2.0–4.1 | 2.0–4.4 | 2.2–4.5 | 2.4–4.8 | 2.4–5.3 | 2.4–5.8 | 2.6–6.1 | 3.0–6.4 | 3.3–7.0 | 4.1–6.8 |
| 1951–61 | 2.5–3.3 | 2.6–3.6 | 2.9–4.0 | 3.0–4.4 | 3.4–4.8 | 3.8–4.9 | 4.2–5.5 | 4.4–6.0 | 4.6–6.5 | 5.0–6.9 | 5.3–7.1 |
| 1985–95 | 2.3–3.0 | 2.4–3.1 | 2.6–3.3 | 2.8–3.5 | 2.9–3.7 | 3.0–4.1 | 3.1–4.4 | 3.3–4.7 | 3.6–4.9 | 3.9–5.3 | 4.0–5.4 |
| 1996–2006 | 1.9–2.9 | 2.0–3.5 | 2.2–3.8 | 2.3–4.3 | 2.4–5.0 | 2.7–5.4 | 2.8–5.5 | 2.8–6.1 | 2.8–7.1 | 2.8–7.8 | 2.8–8.0 |
| Velocity for high–flow condition | | | | | | | | | | | |
| 1934–44 | 2.6–3.1 | 2.7–3.3 | 2.8–3.4 | 2.9–3.4 | 3.1–3.5 | 3.2–3.6 | 3.2–3.6 | 3.3–3.8 | 3.5–4.1 | 3.6–4.5 | 3.7–4.6 |
| 1951–61 | 2.8–3.1 | 2.9–3.2 | 2.9–3.5 | 3.0–3.5 | 3.3–3.7 | 3.5–3.8 | 3.6–4.2 | 4.1–4.7 | 4.5–5.1 | 4.6–5.2 | 4.6–5.3 |
| 1985–95 | 3.0–3.2 | 3.1–3.4 | 3.3–3.6 | 3.4–3.7 | 3.6–3.8 | 3.7–3.9 | 3.8–4.1 | 4.1–4.4 | 4.2–4.5 | 4.3–4.6 | 4.4–4.6 |
| 1996–2006 | 2.7–3.4 | 2.8–3.5 | 3.0–3.7 | 3.1–3.9 | 3.4–4.0 | 3.6–4.2 | 3.8–4.4 | 4.1–4.6 | 4.3–4.8 | 4.3–5.1 | 4.4–5.2 |
| Velocity for median–flow condition | | | | | | | | | | | |
| 1934–44 | 2.3–2.6 | 2.4–2.6 | 2.5–2.7 | 2.5–2.8 | 2.6–2.8 | 2.7–2.9 | 2.8–2.9 | 2.8–3.0 | 2.9–3.2 | 3.0–3.3 | 3.1–3.4 |
| 1951–61 | 2.2–2.5 | 2.3–2.6 | 2.4–2.6 | 2.4–2.7 | 2.5–2.8 | 2.7–2.9 | 2.9–3.0 | 2.9–3.2 | 3.0–3.6 | 3.1–3.8 | 3.3–3.9 |
| 1985–95 | 2.1–2.5 | 2.2–2.7 | 2.3–2.8 | 2.4–3.0 | 2.5–3.1 | 2.7–3.2 | 3.0–3.4 | 3.1–3.5 | 3.2–3.6 | 3.3–3.7 | 3.3–3.8 |
| 1996–2006 | 2.2–2.4 | 2.3–2.5 | 2.4–2.5 | 2.5–2.7 | 2.6–2.9 | 2.8–3.1 | 2.8–3.2 | 2.9–3.3 | 3.1–3.5 | 3.2–3.6 | 3.3–3.7 |
| Velocity for low-flow condition | | | | | | | | | | | |
| 1934–44 | 2.0–2.3 | 2.1–2.3 | 2.2–2.4 | 2.3–2.4 | 2.3–2.6 | 2.3–2.9 | 2.4–3.0 | 2.4–3.0 | 2.6–3.2 | 2.7–3.3 | 2.8–3.4 |
| 1951–61 | 2.1–2.4 | 2.2–2.5 | 2.2–2.5 | 2.3–2.6 | 2.6–2.6 | 2.7–3.0 | 2.8–3.2 | 2.8–3.3 | 3.0–3.4 | 3.1–3.5 | 3.2–3.7 |
| 1985–95 | 2.1–2.4 | 2.2–2.5 | 2.2–2.5 | 2.3–2.7 | 2.3–2.8 | 2.3–2.8 | 2.5–3.0 | 2.5–3.1 | 2.6–3.2 | 2.7–3.4 | 2.7–3.4 |
| 1996–2006 | 1.8–2.0 | 1.9–2.0 | 2.0–2.1 | 2.1–2.1 | 2.1–2.2 | 2.2–2.2 | 2.2–2.5 | 2.3–2.7 | 2.4–2.8 | 2.6–3.0 | 2.6–3.0 |

[1]No calculation of area cumulative frequency distribution was made for the 1966–1976 period because the streamflow-gaging station was inactive until July 1988.

**Appendix 7.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridge at Louisville, Nebraska, 1934–2006.

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| Depth for high-flow condition | | | | | | | | | | | | |
| 1951–61 | 0.6–0.9 | 0.8–1.1 | 1.3–1.7 | 1.6–2.2 | 2.2–2.5 | 2.4–3.0 | 2.6–3.3 | 2.7–3.5 | 2.9–3.8 | 3.1–4.0 | 3.3–4.5 | 3.4–4.9 |
| 1966–76 | 0.4–0.7 | 0.7–1.2 | 1.0–1.7 | 1.5–2.1 | 1.8–2.3 | 2.3–2.6 | 2.7–3.6 | 2.9–4.3 | 3.6–4.9 | 4.0–6.3 | 4.2–7.3 | 5.0–7.7 |
| 1985–95 | 0.4–1.0 | 0.5–1.4 | 0.9–1.5 | 1.4–2.1 | 1.7–2.8 | 1.9–3.2 | 2.0–3.5 | 2.3–4.1 | 3.0–4.4 | 3.1–4.8 | 3.3–5.3 | 3.5–6.0 |
| 1996–2006 | 0.5–0.9 | 0.8–1.3 | 1.2–2.0 | 2.0–2.2 | 2.4–2.6 | 2.5–2.9 | 3.1–3.4 | 3.4–3.8 | 3.7–4.1 | 4.0–4.4 | 4.1–4.6 | 4.2–5.0 |
| Depth for median-flow condition | | | | | | | | | | | | |
| 1951–61 | 0.3–0.4 | 0.4–0.6 | 0.6–0.9 | 0.9–1.2 | 1.2–1.4 | 1.4–1.7 | 1.6–2.0 | 1.7–2.3 | 1.8–2.5 | 2.0–2.7 | 2.3–3.0 | 2.5–3.2 |
| 1966–76 | 0.4–0.5 | 0.4–0.7 | 0.4–1.2 | 0.6–1.6 | 0.7–2.0 | 0.9–2.2 | 1.3–2.9 | 1.8–4.1 | 1.8–4.8 | 2.1–5.1 | 2.4–5.7 | 3.2–6.4 |
| 1985–95 | 0.3–0.6 | 0.5–0.6 | 0.7–1.0 | 1.1–1.5 | 1.3–1.7 | 1.5–1.9 | 1.7–2.1 | 1.8–2.3 | 2.2–2.5 | 2.4–2.8 | 2.5–3.0 | 2.6–3.2 |
| 1996–2006 | 0.4–0.5 | 0.5–0.7 | 0.8–0.9 | 1.1–1.3 | 1.2–1.6 | 1.7–1.9 | 1.9–2.2 | 2.1–2.3 | 2.2–2.4 | 2.2–2.7 | 2.4–3.1 | 2.6–3.5 |
| Depth for low-flow condition | | | | | | | | | | | | |
| 1951–61 | 0.2–0.3 | 0.2–0.4 | 0.4–0.5 | 0.6–0.7 | 0.7–0.8 | 0.8–.9 | 1.0–1.1 | 1.0–1.3 | 1.1–1.4 | 1.2–1.5 | 1.3–1.6 | 1.5–1.8 |
| 1966–76 | 0.3–0.7 | 0.5–1.1 | 0.5–1.8 | 0.6–2.1 | 0.8–2.5 | 0.8–2.9 | 1.2–3.1 | 1.8–3.4 | 2.1–3.7 | 2.3–4.0 | 2.7–4.2 | 3.2–4.2 |
| 1985–95 | 0.2–0.6 | 0.4–0.6 | 0.6–0.9 | 0.8–1.2 | 1.0–1.3 | 1.2–1.7 | 1.3–1.9 | 1.4–2.5 | 1.3–3.6 | 1.4–4.0 | 1.5–4.2 | 1.8–4.4 |
| 1996–2006 | 0.2–0.3 | 0.3–0.5 | 0.5–0.7 | 0.7–1.0 | 0.9–1.2 | 1.1–1.5 | 1.2–1.6 | 1.4–1.8 | 1.4–2.0 | 1.5–2.1 | 1.7–2.2 | 1.8–2.3 |
| Velocity for high-flow condition | | | | | | | | | | | | |
| 1951–61 | 0.6–1.0 | 0.8–1.0 | 1.1–1.4 | 1.3–1.9 | 1.5–2.2 | 1.7–2.4 | 1.8–2.5 | 1.9–2.6 | 2.0–2.7 | 2.1–2.8 | 2.3–2.8 | 2.4–2.9 |
| 1966–76 | 0–0.9 | 0.1–1.1 | 0.6–1.8 | 1.6–2.2 | 1.8–2.4 | 2.1–2.5 | 2.2–2.7 | 2.3–2.7 | 2.5–2.8 | 2.8–3.0 | 2.9–3.1 | 3.0–3.2 |
| 1985–95 | 0.4–0.8 | 0.8–1.1 | 0.9–1.5 | 1.7–1.9 | 1.9–2.2 | 2.1–2.4 | 2.2–2.5 | 2.2–2.6 | 2.3–2.6 | 2.5–2.8 | 2.6–2.9 | 2.7–3.0 |
| 1996–2006 | 0.2–0.5 | 0.4–0.6 | 0.8–1.4 | 1.6–1.9 | 1.8–2.2 | 2.0–2.5 | 2.0–2.6 | 2.2–2.7 | 2.3–2.7 | 2.4–2.8 | 2.4–2.8 | 2.5–3.0 |
| Velocity for median-flow condition | | | | | | | | | | | | |
| 1951–61 | 0.4–0.9 | 0.6–0.9 | 0.7–1.1 | 1.1–1.4 | 1.4–1.6 | 1.6–1.8 | 1.7–1.9 | 1.8–2.0 | 1.9–2.1 | 2.0–2.2 | 2.0–2.2 | 2.1–2.3 |
| 1966–76 | 0.1–0.4 | 0.1–0.5 | 0.4–0.8 | 0.8–1.2 | 1.1–1.6 | 1.5–1.8 | 1.6–2.0 | 1.8–2.2 | 1.9–2.3 | 2.0–2.6 | 2.0–2.6 | 2.1–3.0 |
| 1985–95 | 0.2–0.4 | 0.3–0.5 | 0.6–1.2 | 1.0–1.6 | 1.4–1.7 | 1.6–1.8 | 1.8–1.9 | 1.9–2.0 | 1.9–2.1 | 2.0–2.2 | 2.0–2.3 | 2.2–2.4 |
| 1996–2006 | 0.2–0.3 | 0.2–0.4 | 0.4–1.0 | 0.7–1.2 | 1.1–1.4 | 1.4–1.6 | 1.6–1.9 | 1.7–2.1 | 1.8–2.2 | 1.9–2.3 | 2.0–2.4 | 2.0–2.4 |
| Velocity for low-flow condition | | | | | | | | | | | | |
| 1951–61 | 0.3–0.5 | 0.3–0.7 | 0.5–1.0 | 1.0–1.2 | 1.1–1.4 | 1.3–1.5 | 1.4–1.6 | 1.5–1.7 | 1.5–1.7 | 1.6–1.8 | 1.7–1.8 | 1.7–1.9 |
| 1966–76 | 0.2–0.8 | 0.2–1.4 | 0.2–1.7 | 0.9–1.9 | 1.2–2.2 | 1.4–2.4 | 1.4–2.5 | 1.6–2.5 | 1.8–2.7 | 1.9–2.8 | 2.0–2.9 | 2.2–2.9 |
| 1985–95 | 0–0.1 | 0–0.2 | 0.1–0.4 | 0.3–0.8 | 0.7–1.4 | 1.1–1.6 | 1.2–1.8 | 1.2–2.0 | 1.4–2.0 | 1.4–2.0 | 1.5–2.1 | 1.5–2.2 |
| 1996–2006 | 0.1–0.3 | 0.1–0.4 | 0.2–0.7 | 0.3–1.0 | 0.7–1.2 | 0.9–1.3 | 1.3–1.4 | 1.3–1.5 | 1.4–1.6 | 1.5–1.7 | 1.6–1.7 | 1.7–1.9 |

**Appendix 7.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity, by streamflow condition and water-year period, from selected cross-sectional measurements near the Platte River bridge at Louisville, Nebraska, 1934–2006.—Continued

[Tabled values are the 95-percent confidence interval about the mean of streamflow depth or velocity; depth in feet; velocity in feet per second; midpoint (not listed) for high-flow condition equals peak flow that occurs with 99 percent probability per year; midpoints (not listed) for median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Percentile of area cumulative frequency distribution | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 | 99 |
| Depth for high-flow condition | | | | | | | | | | | |
| 1951–61 | 3.5–5.3 | 3.5–6.0 | 3.6–6.2 | 3.7–6.4 | 3.9–6.7 | 4.1–6.9 | 4.5–7.1 | 5.0–8.2 | 5.1–10.5 | 5.6–11.1 | 5.7–11.3 |
| 1966–76 | 5.8–8.3 | 6.2–8.6 | 6.6–8.9 | 7.1–9.5 | 8.0–10.3 | 8.5–11 | 8.9–11.9 | 9.4–12.2 | 10.8–12.6 | 11.2–13 | 11.3–13.2 |
| 1985–95 | 3.9–6.6 | 4.5–6.9 | 4.9–7.3 | 5.5–7.5 | 5.8–7.9 | 6.1–8.5 | 6.4–8.9 | 7.0–9.7 | 8.0–10.9 | 9.3–11.4 | 9.5–11.6 |
| 1996–2006 | 4.5–5.4 | 4.9–5.7 | 5.5–6.0 | 5.8–6.4 | 6.2–7.0 | 6.6–7.5 | 7.1–8.0 | 7.7–9.0 | 8.6–10.7 | 9.8–11.4 | 10.2–11.7 |
| Depth for median–flow condition | | | | | | | | | | | |
| 1951–61 | 2.8–3.5 | 3.0–3.6 | 3.2–3.8 | 3.5–4.0 | 4.0–4.2 | 4.0–4.7 | 4.3–5.3 | 4.7–6.0 | 5.3–7.1 | 5.6–7.3 | 5.7–7.3 |
| 1966–76 | 3.8–7.3 | 4.3–7.5 | 4.7–7.7 | 5.0–8.2 | 5.1–8.4 | 5.5–9.0 | 6.1–9.9 | 6.3–10 | 6.3–10.1 | 6.5–10.2 | 6.8–10.2 |
| 1985–95 | 2.7–3.5 | 3.0–3.6 | 3.1–3.9 | 3.2–4.1 | 3.2–4.5 | 3.2–5.0 | 3.4–5.3 | 3.6–6.1 | 4.2–6.9 | 4.6–7.2 | 4.7–7.3 |
| 1996–2006 | 2.8–3.6 | 3.0–3.8 | 3.4–4.1 | 3.5–4.5 | 3.8–4.9 | 4.0–5.2 | 4.3–6.3 | 4.8–7.2 | 5.6–8.1 | 5.9–8.3 | 6.0–8.4 |
| Depth for low–flow condition | | | | | | | | | | | |
| 1951–61 | 1.6–1.9 | 1.7–2.0 | 1.8–2.1 | 1.9–2.3 | 2.0–2.4 | 2.3–2.8 | 2.5–3.1 | 2.6–3.5 | 2.8–3.6 | 3.1–3.8 | 3.2–3.9 |
| 1966–76 | 3.6–4.3 | 3.8–4.4 | 3.9–4.6 | 4.0–4.7 | 4.0–5.2 | 4.1–5.8 | 4.1–6.2 | 4.2–6.3 | 4.4–6.4 | 4.5–6.4 | 4.5–6.5 |
| 1985–95 | 2.0–4.7 | 2.3–5.0 | 2.5–5.2 | 2.7–5.5 | 2.8–5.5 | 3.2–5.8 | 3.4–6.2 | 3.9–6.5 | 4.2–7.2 | 4.3–7.5 | 4.3–7.5 |
| 1996–2006 | 1.9–2.4 | 2.0–2.6 | 2.0–2.7 | 2.0–3.3 | 2.2–3.6 | 2.2–4.0 | 2.3–4.2 | 2.6–4.8 | 3.0–5.4 | 3.1–5.8 | 3.1–5.9 |
| Velocity for high–flow condition | | | | | | | | | | | |
| 1951–61 | 2.5–3.0 | 2.6–3.0 | 2.7–3.1 | 2.9–3.2 | 3.0–3.2 | 3.1–3.3 | 3.1–3.5 | 3.2–3.7 | 3.4–4.0 | 3.8–4.2 | 3.9–4.3 |
| 1966–76 | 3.2–3.5 | 3.3–3.6 | 3.3–3.8 | 3.5–3.9 | 3.5–4.1 | 3.6–4.2 | 3.9–4.3 | 4.2–4.5 | 4.4–4.7 | 4.6–4.7 | 4.7–4.8 |
| 1985–95 | 2.8–3.1 | 2.9–3.3 | 3.0–3.6 | 3.1–3.8 | 3.2–3.8 | 3.4–4.0 | 3.5–4.5 | 3.6–4.8 | 3.8–5.0 | 3.9–5.0 | 3.9–5.1 |
| 1996–2006 | 2.6–3.1 | 2.6–3.2 | 2.7–3.3 | 2.8–3.4 | 2.9–3.5 | 2.9–3.5 | 3.0–3.6 | 3.1–3.8 | 3.2–4.0 | 3.3–4.1 | 3.3–4.2 |
| Velocity for median–flow condition | | | | | | | | | | | |
| 1951–61 | 2.2–2.4 | 2.3–2.4 | 2.5–2.5 | 2.5–2.6 | 2.6–2.7 | 2.7–2.9 | 2.7–3.0 | 2.8–3.0 | 3.0–3.2 | 3.0–3.4 | 3.1–3.5 |
| 1966–76 | 2.3–3.2 | 2.5–3.4 | 2.7–3.5 | 2.9–3.6 | 3.0–3.8 | 3.2–4.0 | 3.2–4.2 | 3.3–4.4 | 3.5–4.6 | 3.8–4.9 | 3.9–5.0 |
| 1985–95 | 2.2–2.4 | 2.3–2.6 | 2.3–2.6 | 2.4–2.7 | 2.5–2.7 | 2.6–2.9 | 2.7–3.1 | 2.8–3.3 | 2.9–3.6 | 3.0–3.8 | 3.1–3.8 |
| 1996–2006 | 2.1–2.5 | 2.1–2.6 | 2.2–2.7 | 2.3–2.7 | 2.4–2.8 | 2.5–2.9 | 2.5–3.0 | 2.6–3.1 | 2.7–3.1 | 2.9–3.2 | 2.9–3.4 |
| Velocity for low–flow condition | | | | | | | | | | | |
| 1951–61 | 1.8–1.9 | 1.9–2.0 | 1.9–2.1 | 2.0–2.1 | 2.0–2.2 | 2.1–2.3 | 2.1–2.4 | 2.3–2.5 | 2.4–2.6 | 2.5–2.7 | 2.6–2.8 |
| 1966–76 | 2.4–3.0 | 2.4–3.0 | 2.5–3.0 | 2.6–3.1 | 2.7–3.2 | 2.8–3.2 | 2.8–3.3 | 3.0–3.3 | 3.0–3.4 | 3.2–3.6 | 3.2–3.7 |
| 1985–95 | 1.6–2.3 | 1.7–2.4 | 1.8–2.5 | 1.8–2.6 | 1.9–2.6 | 2.0–2.6 | 2.1–2.6 | 2.2–2.8 | 2.3–2.8 | 2.4–2.9 | 2.4–2.9 |
| 1996–2006 | 1.8–1.9 | 1.8–2.0 | 1.8–2.1 | 1.9–2.1 | 2.0–2.3 | 2.0–2.4 | 2.1–2.5 | 2.3–2.6 | 2.4–2.8 | 2.5–2.9 | 2.5–3.0 |

[1]No calculation of area cumulative frequency distribution was made during the 1934–1944 period because streamflow-gaging station and discharge measurements began in May 1953.

**Appendix 8.** The 95-percent confidence interval of relative cross-sectional area of hydraulic niches, by streamflow condition and water-year period, near the Platte River bridge near Duncan, Nebraska, 1934–2006.

[Hydraulic niche definitions from Peters and Holland (1992); tabled values are the 95-percent confidence interval for the mean percentage of relative cross-sectional area; range of high-flow condition centers on peak flow that occurs with 99-percent probability per year; centers of median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Inter-mediate-Slow | Inter-mediate-Moderate | Inter-mediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1934–44 | 3.2–5.6 | 8.3–18.4 | 3.4–7.7 | 1.1–5.1 | 7.2–12.8 | 16.1–26.1 | 0.9–4.3 | 0.1–8.7 | 32.8–40.3 |
| 1951–61 | 0.4–4.9 | 14.8–22.3 | 5.8–10.5 | 0.4–2.4 | 7.3–14.2 | 15.5–23.0 | 0 | 3.3–6.7 | 30.2–38.4 |
| 1966–76 | 0.4–3.8 | 10.3–18.0 | 1.9–10.0 | 0.2–3.9 | 11.8–22.2 | 15.7–30.8 | 0.5–1.4 | 0.7–10.8 | 24.4–36.9 |
| 1985–95 | 0.8–4.0 | 8.9–15.2 | 0.5–5.5 | 0.3–3.2 | 14.4–30.7 | 14.9–31.4 | 0.2–2.0 | 5.3–12.3 | 16.3–35.2 |
| 1996–2006 | 2.2–6.2 | 13.2–17.7 | 1.5–5.2 | 0.1–3.9 | 4.2–17.0 | 19.3–31.9 | 0.3–3.3 | 0.4–10.8 | 25.6–37.7 |
| Median-flow condition | | | | | | | | | |
| 1934–44 | 4.5–10.4 | 11.9–24.4 | 0.6–8.9 | 0.6–3.4 | 12.1–24.9 | 12.1–22.0 | 0.3–1.0 | 0.2–15.7 | 18.1–33.4 |
| 1951–61 | 4.1–9.5 | 24.2–36.3 | 1.6–7.2 | 0.4–2.5 | 12.7–23.5 | 11.6–20.2 | 0 | 0.8–7.5 | 12.3–26.4 |
| 1966–76 | 1.6–3.6 | 17.2–42.9 | 0.1–7.9 | 0.3–8.5 | 20.2–30.1 | 2.9–22.5 | 0 | 1.6–8.9 | 7.2–24.6 |
| 1985–95 | 1.7–10.1 | 23.3–38.8 | 0.3–5.6 | 0.3–1.6 | 15.5–33.2 | 7.1–21.9 | 0.3–3.0 | 4.0–14.2 | 2.0–17.6 |
| 1996–2006 | 2.7–14.1 | 20.2–36.0 | 1.5–7.0 | 0.8–4.5 | 14.3–30.0 | 4.1–12.4 | 0.3–2.3 | 2.5–11.3 | 7.6–30.7 |
| Low-flow condition | | | | | | | | | |
| 1934–44 | 10.6–19.5 | 11.1–49.3 | 0.5–4.6 | 4.8–7.8 | 12.9–29.9 | 8.9–20.6 | 0 | 0.3–31.8 | 0 |
| 1951–61 | 10.5–26.4 | 12.8–45.7 | 0.6–7.2 | 0.7–31.1 | 20.2–33.6 | 0.3–17.8 | 0 | 0.8–5.4 | 0 |
| 1966–76 | 10.1–25.0 | 51.0–74.8 | 0.5–5.5 | 0.2–2.1 | 1.2–19.5 | 0.9–12.0 | 0 | 0.6–5.0 | 0 |
| 1985–95 | 10.1–24.5 | 40.0–65.4 | 0.4–3.3 | 0.5–10.5 | 11.8–28.1 | 0.1–9.3 | 0 | 0 | 0 |
| 1996–2006 | 23.7–36.1 | 24.4–55.1 | 0.6–5.1 | 0.6–5.1 | 8.8–22.0 | 0.3–3.5 | 0 | 0.5–13.8 | 0.7–9.0 |

**Appendix 9.** The 95-percent confidence interval of relative cross-sectional area of hydraulic niches, by streamflow condition and water-year period, near the Platte River bridge at North Bend, Nebraska, 1934–2006.

[Hydraulic niche definitions from Peters and Holland (1992); tabled values are the 95-percent confidence intervals for the mean percentage of relative cross-sectional area; range of high-flow condition centers on peak flow that occurs with 99-percent probability per year; centers of median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Inter-mediate-Slow | Inter-mediate-Moderate | Inter-mediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1951–61 | 0–1.2 | 0.5–2.4 | 0.5–2.4 | 0.1–1.7 | 1.3–6.1 | 6.1–21.4 | 0.3–1.0 | 1.2–10.9 | 63.4–80.2 |
| 1966–76 | 0–0.7 | 0.3–3.8 | 0 | 0.1–1.2 | 0.6–3.1 | 2.4–23.8 | 0.1–4.6 | 1.7–10.0 | 62.7–86.0 |
| 1985–95 | 1.0–3.4 | 0.6–4.9 | 0.2–1.8 | 0.2–1.5 | 1.7–10.0 | 8.2–16.6 | 0.4–3.4 | 2.0–8.5 | 61.6–74.8 |
| 1996–2006 | 0.4–1.9 | 1.4–4.3 | 1.3–2.2 | 0.1–1.7 | 3.4–7.8 | 10.6–24.8 | 0.7–3.3 | 1.9–4.7 | 62.5–68.6 |
| Median-flow condition | | | | | | | | | |
| 1951–61 | 2.5–4.7 | 7.1–13.7 | 0–2.1 | 0.3–9.0 | 6.2–11.5 | 8.4–15.5 | 0.2–6.0 | 2.0–11.6 | 47.1–66.9 |
| 1966–76 | 0.9–3.7 | 2.9–9.9 | 0.1–1.5 | 0.4–2.2 | 3.3–14.8 | 7.2–22.6 | 0.6–3.8 | 8.3–19.3 | 39.1–60.4 |
| 1985–95 | 1.4–5.5 | 3.7–21.1 | 0.4–4.3 | 0.8–4.3 | 8.8–19.4 | 6.3–18.0 | 0.2–1.8 | 4.8–8.3 | 38.7–53.2 |
| 1996–2006 | 0.6–6.6 | 5.6–12.8 | 0.1–1.9 | 0.4–3.7 | 12.5–19.3 | 14.5–21.6 | 0 | 2.7–9.6 | 39.1–49.8 |
| Low-flow condition[2] | | | | | | | | | |
| 1951–61 | 3.2–6.4 | 5.2–17.8 | 0.1–3.6 | 0.3–3.4 | 14.7–27.2 | 5.6–20.1 | 0.4–3.1 | 3.9–18.3 | 21.9–46.3 |
| 1966–76 | 4.0–7.3 | 3.3–11.8 | 0.1–4.7 | 1.2–5.9 | 6.4–16.9 | 10.0–29.1 | 0.2–9.8 | 6.7–18.0 | 19.0–49.0 |
| 1985–95 | 4.1–9.1 | 7.9–27.6 | 0.5–4.7 | 2.5–5.1 | 16.6–27.6 | 3.9–26.3 | 0.7–2.1 | 2.4–26.7 | 4.1–31.6 |

[1]No calculation of hydraulic-niche areas was made for the 1934–1944 period because streamflow-gaging station and discharge measurements began in April 1949.

[2]No calculation of hydraulic-niche areas was made in the 1996–2006 period because discharge measurements field notes were not available.

**Appendix 10.** The 95-percent confidence interval of relative cross-sectional area of hydraulic niches, by streamflow condition and water-year period, near the Platte River bridge near Leshara, Nebraska, 1934–2006.

[Hydraulic niche definitions from Peters and Holland (1992); tabled values are the 95-percent confidence intervals for the mean percentage of relative cross-sectional area; range of high-flow condition centers on peak flow that occurs with 99-percent probability per year; centers of median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Inter-mediate-Slow | Inter-mediate-Moderate | Inter-mediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1985–95 | 0.6–4.4 | 0.6–1.7 | 0.3–8 | 1.4–4.0 | 2.4–7.6 | 0–5.7 | 0–9.1 | 0.4–16.5 | 64.7–87.2 |
| 1996–2006 | 0.7–1.5 | 1.0–4.1 | 0.1–1.1 | 0.3–2.0 | 4.9–8.1 | 10.3–19.3 | 0.6–5.2 | 3.1–13.1 | 58.1–68.0 |
| Median-flow condition | | | | | | | | | |
| 1985–95 | 0.1–4.0 | 0.4–5.2 | 0.4–1.3 | 0.4–1.9 | 0.5–7.8 | 1.2–13.1 | 0.4–7.3 | 1.6–21.3 | 54.0–83.6 |
| 1996–2006 | 1.9–5.6 | 1.3–9.5 | 0.2–1.7 | 0.2–7 | 3.0–14.5 | 6.1–26.2 | 0.6–2.0 | 3.6–14.5 | 43.7–66.8 |
| Low-flow condition | | | | | | | | | |
| 1985–95 | 0.4–8.8 | 0.8–17.6 | 0–4.8 | 0.4–8.7 | 13.3–34.4 | 15.9–24.2 | 0 | 1.3–26.0 | 13.2–33.6 |
| 1996–2006 | 3.4–7.0 | 2.8–13.4 | 0.3–2.7 | 0.8–11.6 | 10.6–36.0 | 2.4–13.9 | 0.2–6.9 | 4.1–32.5 | 12.9–43.1 |

[1]No calculation of hydraulic-niche areas was made for the 1934–1944, 1951–1961, and 1966–1976 periods because streamflow-gaging station and discharge measurements began in June 1994.

**Appendix 11.** The 95-percent confidence interval of relative cross-sectional area of hydraulic niches, by streamflow condition and water-year period, near the Platte River bridge near Ashland, Nebraska, 1934–2006.

[Hydraulic niche definitions from Peters and Holland (1992); tabled values are the 95-percent confidence intervals for the mean percentage of relative cross-sectional area; range of high-flow condition centers on peak flow that occurs with 99-percent probability per year; centers of median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively.]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Inter-mediate-Slow | Inter-mediate-Moderate | Inter-mediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow conditions | | | | | | | | | |
| 1934–44 | 0.6–1.6 | 0.1–0.8 | 0.1–0.6 | 0.3–1.5 | 0.5–2.7 | 0.3–3.2 | 2.6–6.7 | 4.2–15.5 | 74.3–85.5 |
| 1951–61 | 0.1–1.5 | 0.1–1.6 | 0.6–3.0 | 0.5–1.8 | 1.2–3.9 | 2.5–8.5 | 0.2–1.2 | 6.5–12.3 | 75.7–79.8 |
| 1985–95 | 0.2–0.5 | 0.1–1.3 | 0.1–0.9 | 0.3–2.9 | 2.2–4.8 | 0–8.3 | 0.7–2.2 | 0.6–10.9 | 77.0–88.9 |
| 1996–2006 | 0–0.8 | 0.3–2.4 | 0.1–1.0 | 0.1–0.2 | 2.7–5.5 | 2.4–10.6 | 0 | 0.5–10.4 | 77.4–86.6 |
| Median-flow conditions | | | | | | | | | |
| 1934–44 | 0.2–5.3 | 2.1–6.0 | 0.2–0.7 | 0–1.9 | 0–10.9 | 3.3–11.8 | 0–1.5 | 5.4–17.8 | 48.9–84.4 |
| 1951–61 | 0.6–3.5 | 3.5–6.0 | 0.1–0.4 | 1.1–3.5 | 10.1–16.7 | 3.2–12.6 | 0 | 6.4–14.9 | 55.3–62.4 |
| 1985–95 | 1.9–3.0 | 2.0–5.0 | 0.6–1.8 | 0.3–4.1 | 5.9–20.8 | 0.1–6.9 | 0.1–8.1 | 2.3–26.3 | 49.0–63.0 |
| 1996–2006 | 2.3–6.1 | 4.7–13.1 | 0 | 0.1–7.8 | 5.8–19.3 | 5.5–14.1 | 0.4–3.4 | 4.1–11.5 | 45.3–58.4 |
| Low-flow conditions | | | | | | | | | |
| 1934–44 | 5.8–7.7 | 1.1–11.2 | 0.2–0.7 | 0.1–8.2 | 5.9–18.7 | 5.0–28.3 | 0.2–2.9 | 6.8–15.9 | 37.0–45.0 |
| 1951–61 | 1.1–3.5 | 6.5–10.2 | 0.4–1.9 | 1.1–3.9 | 6.0–16.4 | 5.2–11.9 | 0.5–13.9 | 5.6–11.6 | 43.3–62.9 |
| 1985–95 | 2.0–6.8 | 4.0–6.6 | 0 | 0.4–7.1 | 2.0–15.9 | 0.3–9.9 | 0.1–6.5 | 11.9–19.8 | 49.5–59.9 |
| 1996–2006 | 3.7–7.6 | 2.3–9.0 | 0 | 2.7–6.8 | 9.7–24.0 | 2.3–12.1 | 0.2–0.5 | 16.0–32.4 | 26.8–44.3 |

[1]No calculation of hydraulic-niche areas was made for the 1966–1976 period because the streamflow-gaging station was inactive until July 1988.

**Appendix 12.** The 95-percent confidence interval of relative cross-sectional area of hydraulic niches, by streamflow condition and water-year period, near the Platte River bridge at Louisville, Nebraska, 1934–2006.

[Hydraulic niche definitions from Peters and Holland (1992); tabled values are the 95-percent confidence intervals for the mean percentage of relative cross-sectional area; range of high-flow condition centers on peak flow that occurs with 99-percent probability per year; centers of median- and low-flow conditions are streamflows that are equaled or exceeded 50 and 84 percent of the time, respectively]

| Water-year period[1] | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Inter-mediate-Slow | Inter-mediate-Moderate | Inter-mediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| High-flow condition | | | | | | | | | |
| 1951–61 | 0–0.8 | 0.2–1.6 | 0–0.4 | 0.1–1.1 | 1.6–3.6 | 0.4–6.8 | 0.1–2.5 | 5.1–23.4 | 66.6–85.8 |
| 1966–76 | 0.3–1.3 | 0.1–1.7 | 0–0.6 | 0.3–1.5 | 1.3–7.8 | 2.5–5.3 | 0.1–4.2 | 1.3–2.8 | 78.3–91.1 |
| 1985–95 | 0.1–0.7 | 0–1.9 | 0.2–0.7 | 0.4–1.2 | 0.1–8.5 | 3.1–11.6 | 0.9–4.1 | 2.0–10.7 | 74.7–82.4 |
| 1996–2006 | 0.3–2.4 | 0.1–1.1 | 0.2–0.9 | 0.1–1.1 | 0.8–4.7 | 0.4–1.6 | 1.0–3.3 | 2.8–14.3 | 75.5–90.0 |
| Median-flow condition | | | | | | | | | |
| 1951–61 | 1.3–3.1 | 3.1–7.0 | 0.1–1.2 | 0.1–1.6 | 3.9–17.7 | 6.0–13.3 | 0.8–4.5 | 9.8–19.4 | 50.8–56.4 |
| 1966–76 | 3.1–5.4 | 0.4–11.0 | 0.1–1.4 | 0.3–3.2 | 0.3–15.2 | 2.6–6.2 | 0.2–5.7 | 3.8–18.0 | 52.4–72.3 |
| 1985–95 | 1.7–3.5 | 1.6–3.6 | 0–0.2 | 1.0–3.1 | 7.0–12.2 | 5.0–11.2 | 0.1–3.3 | 11.0–23.1 | 53.4–59.1 |
| 1996–2006 | 1.6–3.8 | 1.6–4.8 | 0 | 0.2–3.8 | 4.1–12.4 | 2.1–10.5 | 1.5–7.9 | 4.2–24.9 | 46.2–70.8 |
| Low-flow condition | | | | | | | | | |
| 1951–61 | 2.5–5.0 | 13.8–17.7 | 0.6–2.4 | 0.1–7.4 | 21.0–30.8 | 7.0–20.2 | 0.7–2.2 | 11.6–18.5 | 15.9–24.0 |
| 1966–76 | 0.4–2.5 | 0.6–6.9 | 0.1–1.8 | 0.5–3.0 | 0.6–11.8 | 0.5–17.8 | 0.8–6.0 | 0.6–24.9 | 56.7–74.7 |
| 1985–95 | 2.6–6.9 | 1.9–5.6 | 0.6–2.0 | 2.1–5.5 | 3.6–23.7 | 1.3–12.3 | 0.9–6.8 | 10.2–37.6 | 14.4–63.3 |
| 1996–2006 | 3.5–7.4 | 3.4–9.5 | 0–0.1 | 1.4–4.4 | 12.2–32.5 | 2.4–11.6 | 1.0–10.9 | 7.9–44.2 | 15.7–32.1 |

[1]No calculation of hydraulic-niche areas was made during the 1934–1944 period because the streamflow-gaging station and discharge measurements began in May 1953.

**Appendix 13.** The 95-percent confidence interval of relative cross-sectional area of low-flow geomorphic habitats, by water-year period, near the Platte River bridges near Duncan, North Bend, Leshara, Ashland, and Louisville, Nebraska, 1934–2006.

[Low-flow geomorphic habitat classes are modified Rabeni and Jacobson (1993) and McKenney (1997); tabled values are the 95-percent confidence intervals for the mean percentage of cross-sectional area; range of low-flow conditions is centered on streamflow that is equaled or exceeded 84 percent of the time]

| Water-year period | Low-flow geomorphic habitat | | | | | |
|---|---|---|---|---|---|---|
| | Pool | Glide | Race | Riffle | Deep | Shoal |
| **Duncan** | | | | | | |
| 1934–44 | 0 | 0.1–35.6 | 42.2–54.2 | 10.5–40.9 | 0 | 7.7–10.0 |
| 1951–61 | 0 | 0.2–31.7 | 35.0–51.6 | 13.8–49.4 | 0 | 4.5–18.2 |
| 1966–76 | 0 | 1.5–9.3 | 7.1–37.6 | 53.5–81.3 | 0 | 2.5– 7.1 |
| 1985–95 | 0 | 0.4–6.6 | 28.1–55.6 | 28.8–54.3 | 0 | 9.6–17.4 |
| 1996–2006 | 0 | 0.3–15.0 | 21.7–43.8 | 18.2–63.4 | 0 | 11.6–27.5 |
| **North Bend[1]** | | | | | | |
| 1951–61 | 0 | 18.0–41.8 | 46.7–69.7 | 4.5–14.7 | 0 | 1.1–3.5 |
| 1966–76 | 0 | 21.1–56.9 | 30.2–66.1 | 4.2–12.7 | 0 | 2.0–5.4 |
| 1985–95 | 0 | 10.9–35.7 | 49.0–66.0 | 9.2–22.0 | 0.2–0.5 | 1.2–5.6 |
| **Leshara[2]** | | | | | | |
| 1985–95 | 0 | 18.2–42.4 | 38.6–76.9 | 0.0–18.9 | 0 | 0.3–6.4 |
| 1996–2006 | 0 | 23.7–62.6 | 27.6–63.4 | 3.5–12.1 | 0 | 0.4–6.8 |
| **Ashland[3]** | | | | | | |
| 1934–44 | 0 | 38.6–61.2 | 27.9–50.3 | 4.4–7.2 | 0 | 3.9–6.6 |
| 1951–61 | 0 | 42.3–59.2 | 26.7–51.7 | 4.2–7.7 | 0.2–6.2 | 0.9–3.2 |
| 1985–95 | 0 | 32.0–61.0 | 30.0–59.3 | 1.1–3.6 | 0.7–2.1 | 2.7–8.8 |
| 1996–2006 | 0 | 34.8–57.3 | 34.9–52.5 | 1.3– 7.9 | 0.6–1.7 | 2.9– 7.2 |
| **Louisville[4]** | | | | | | |
| 1951–61 | 0 | 13.7–28.9 | 52.3–71.0 | 11.2–15.3 | 0.7–2.2 | 1.8–4.5 |
| 1966–76 | 0 | 51.7–81.3 | 10.2–42.6 | 1.2–5.4 | 0 | 0.2–4.0 |
| 1985–95 | 0 | 42.4–75.5 | 13.6–44.2 | 0–5.7 | 0.6–8.4 | 3.1–6.5 |
| 1996–2006 | 0 | 22.7–45.4 | 40.3–64.9 | 2.8–6.7 | 0.4–6.9 | 2.0– 7.2 |

[1]No calculation of geomorphic-habitat areas was made for the 1934–1944 period because streamflow-gaging station and discharge measurements began in April 1949; no calculation of geomorphic-habitat areas was made for the low-flow condition in the 1996–2006 period because discharge measurements field notes were not available.

[2]No calculation of geomorphic-habitat areas was made for the 1934–1944, 1951–1961, and 1966–1976 periods because streamflow-gaging station and discharge measurements began in June 1994.

[3]No calculation of geomorphic-habitat areas was made for the 1966–1976 period because the streamflow-gaging station was inactive until July 1988.

[4]No calculation of geomorphic-habitat areas was made during the 1934–1944 period because streamflow-gaging station and discharge measurements began in May 1953.

**Appendix 14.** The 95-percent confidence interval of cross-sectional area of hydraulic niches, by flow condition, near the Platte River bridges near Duncan, North Bend, Leshara, Ashland, and Louisville, Nebraska, 1934–2006.

[Hydraulic niche definitions from Peters and Holland (1992); tabled values are the 95-percent confidence intervals for the mean of cross-sectional area, in square feet; the gaging station at Louisville was temporarily moved from its initial and present location]

| Streamflow conditions | Hydraulic niche | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shallow-Slow | Shallow-Moderate | Shallow-Swift | Inter-mediate-Slow | Inter-mediate-Moderate | Inter-mediate-Swift | Deep-Slow | Deep-Moderate | Deep-Swift |
| **Duncan** | | | | | | | | | |
| High | 23–41 | 135–172 | 42–69 | 11–27 | 117–178 | 201–257 | 2–15 | 42–78 | 297–359 |
| Median | 33–56 | 166–218 | 18–37 | 5–19 | 126–169 | 77–115 | 0–7 | 29–61 | 96–152 |
| Low | 31–45 | 70–101 | 2–7 | 1–17 | 27–43 | 5–18 | 0 | 0–13 | 0–4 |
| **North Bend[1]** | | | | | | | | | |
| High | 18–46 | 39–86 | 20–43 | 12–32 | 82–167 | 302–491 | 11–61 | 91–183 | 1,814–2,014 |
| Median | 35–65 | 108–188 | 8–29 | 11–34 | 146–225 | 179–268 | 0–22 | 96–173 | 699–842 |
| Low | 41–61 | 69–143 | 7–30 | 16–38 | 124–197 | 99–196 | 99–42 | 75–154 | 195–349 |
| **Leshara[2]** | | | | | | | | | |
| High | 20–57 | 16–76 | 0–20 | 20–61 | 113–178 | 143–382 | 15–134 | 65–288 | 1,486–1,787 |
| Median | 29–76 | 29–118 | 0–22 | 0–16 | 45–180 | 96–327 | 96–59 | 87–250 | 861–1,185 |
| Low | 25–65 | 42–123 | 4–28 | 7–86 | 147–308 | 67–177 | 67–42 | 68–253 | 160–349 |
| **Ashland[3]** | | | | | | | | | |
| High | 16–38 | 12–49 | 12–48 | 8–49 | 91–155 | 107–262 | 15–102 | 205–406 | 3,195–3,395 |
| Median | 38–70 | 74–137 | 74–10 | 19–72 | 168–283 | 95–181 | 6–54 | 140–270 | 1,002–1,156 |
| Low | 34–58 | 52–79 | 52–6 | 22–50 | 90–156 | 56–121 | 56–53 | 114–189 | 427–536 |
| **Louisville[4]** | | | | | | | | | |
| High | 11–42 | 17–46 | 6–19 | 10–35 | 87–190 | 88–210 | 38–103 | 176–448 | 3,038–3,332 |
| Median | 49–73 | 56–114 | 2–12 | 19–49 | 139–249 | 116–193 | 38–90 | 233–383 | 1,141–1,308 |
| Low | 34–59 | 61–124 | 3–15 | 23–50 | 145–271 | 70–147 | 17–61 | 143–307 | 300–540 |

[1]No calculation of hydraulic-niche areas was made for the 1934–1944 period because streamflow-gaging station and discharge measurements began in April 1949; no calculation of hydraulic-niche areas was made for the low-flow condition in the 1996–2006 period because discharge measurements field notes were not available.

[2]No calculation of hydraulic-niche areas was made for the 1934–1944, 1951–1961, and 1966–1976 periods because streamflow-gaging station and discharge measurements began in June 1994.

[3]No calculation of hydraulic-niche areas was made for the 1966–1976 period because the streamflow-gaging station was inactive until July 1988.

[4]No calculation of hydraulic-niche areas was made during the 1934–1944 period because streamflow-gaging station and discharge measurements began in May 1953.

**Appendix 15.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for median-flow condition for the near-bridge and beyond-bridge sites on the Platte River at North Bend, Louisville, and Ashland, Nebraska, 1934–2006.

[Tabled values are the 95-percent confidence intervals for the mean depth or velocity; depth in feet; velocity in feet per second; high-flow conditions centered on peak flow that occurs with 99-percent probability per year; centers of median flow condition are streamflows that are equaled or exceeded 50 percent of the time]

| Percentile of area cumulative frequency distribution | North Bend | | | | Ashland[1] | | Louisville | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Depth | | Velocity | | Depth | | Depth | | Velocity | |
| | Near bridge | Beyond bridge | Near bridge | Beyond bridge | Near bridge | Beyond bridge | Near bridge | Beyond bridge | Near bridge | Beyond bridge |
| 1 | 0.2–0.4 | 0.3–0.3 | 0.3–0.7 | 0.1–0.4 | 0.3–0.4 | 0.1–0.3 | 0.3–0.5 | 0.3–0.7 | 0.1–0.4 | 0.6–0.8 |
| 2 | 0.3–0.4 | 0.3–0.4 | 0.5–0.8 | 0.2–0.5 | 0.5–0.5 | 0.2–0.4 | 0.5–0.6 | 0.4–0.9 | 0.3–0.4 | 0.7–1.0 |
| 5 | 0.4–0.6 | 0.5–0.6 | 0.6–1.2 | 0.5–1.0 | 0.6–0.8 | 0.6–0.7 | 0.7–1.0 | 0.7–1.0 | 0.6–1.1 | 1.0–1.6 |
| 10 | 0.5–0.9 | 0.6–0.7 | 0.8–1.4 | 1.0–1.3 | 0.7–0.9 | 0.8–1.5 | 1.1–1.4 | 1.0–1.1 | 1.0–1.5 | 1.4–1.8 |
| 15 | 0.7–1.0 | 0.7–0.9 | 1.3–1.5 | 1.3–1.4 | 0.9–1.2 | 0.9–1.9 | 1.3–1.7 | 1.2–1.4 | 1.3–1.7 | 1.5–1.8 |
| 20 | 0.8–1.2 | 0.9–1.0 | 1.5–1.6 | 1.3–1.6 | 1.1–1.4 | 1.0–2.0 | 1.5–1.8 | 1.2–1.7 | 1.5–1.8 | 1.8–1.9 |
| 25 | 0.9–1.3 | 1.0–1.2 | 1.6–1.8 | 1.6–1.7 | 1.2–1.5 | 1.3–2.2 | 1.7–2.1 | 1.4–1.9 | 1.7–1.9 | 1.9–1.9 |
| 30 | 1.1–1.5 | 1.1–1.3 | 1.6–1.9 | 1.7–1.7 | 1.5–1.7 | 1.6–2.2 | 1.9–2.2 | 1.5–2.1 | 1.8–1.9 | 1.9–2.0 |
| 35 | 1.2–1.6 | 1.3–1.5 | 1.7–2.0 | 1.7–1.9 | 1.7–2.0 | 1.7–2.3 | 2.2–2.5 | 1.6–2.8 | 1.9–2.1 | 2.0–2.1 |
| 40 | 1.3–1.8 | 1.6–1.6 | 1.8–2.1 | 1.8–2.0 | 1.8–2.2 | 1.8–2.5 | 2.3–2.8 | 1.4–3.8 | 2.0–2.1 | 2.1–2.2 |
| 45 | 1.6–2.0 | 1.9–2.0 | 1.9–2.2 | 1.9–2.1 | 1.9–2.5 | 1.9–2.7 | 2.4–3.0 | 1.5–4.1 | 2.0–2.2 | 2.1–2.3 |
| 50 | 1.8–2.4 | 2.0–2.2 | 2.1–2.3 | 2.0–2.1 | 2.1–2.8 | 2.1–2.7 | 2.6–3.1 | 1.5–4.3 | 2.1–2.3 | 2.1–2.4 |
| 55 | 1.9–2.4 | 2.1–2.5 | 2.2–2.4 | 2.0–2.2 | 2.2–3.2 | 2.1–2.9 | 2.8–3.4 | 1.8–4.6 | 2.2–2.4 | 2.2–2.5 |
| 60 | 2.2–3.0 | 2.3–2.6 | 2.3–2.6 | 2.1–2.3 | 2.8–3.5 | 2.2–3.1 | 3.1–3.6 | 1.8–4.8 | 2.2–2.5 | 2.3–2.6 |
| 65 | 2.7–3.3 | 2.5–2.6 | 2.3–2.7 | 2.2–2.4 | 3.2–4.0 | 2.3–3.4 | 3.2–3.9 | 2.1–5.2 | 2.3–2.5 | 2.3–2.7 |
| 70 | 3.0–3.6 | 2.5–2.7 | 2.5–2.8 | 2.3–2.4 | 3.6–5.2 | 2.4–3.6 | 3.3–4.0 | 2.3–5.3 | 2.4–2.6 | 2.3–2.9 |
| 75 | 3.1–4.5 | 2.7–2.8 | 2.6–3.0 | 2.3–2.5 | 4.0–5.5 | 2.4–4.1 | 3.4–4.4 | 2.7–5.5 | 2.5–2.7 | 2.4–3.0 |
| 80 | 3.4–5.1 | 2.8–3.0 | 2.6–3.0 | 2.5–2.6 | 4.3–5.7 | 2.5–4.5 | 3.4–4.8 | 3.6–6.1 | 2.5–2.8 | 2.6–3.3 |
| 85 | 3.6–5.5 | 2.9–3.2 | 2.6–3.2 | 2.6–2.7 | 4.5–5.9 | 2.7–4.7 | 3.7–5.2 | 4.7–7.4 | 2.6–3.0 | 2.7–3.7 |
| 90 | 3.8–5.9 | 3.0–3.5 | 2.8–3.3 | 2.7–2.7 | 5.0–6.3 | 2.9–5.0 | 3.9–5.9 | 5.1–8.1 | 2.8–3.2 | 2.9–3.8 |
| 95 | 4.4–6.2 | 3.3–3.7 | 3.0–3.5 | 2.7–2.9 | 5.7–6.9 | 3.2–5.3 | 4.5–6.6 | 5.7–8.6 | 2.9–3.5 | 3.4–3.9 |
| 98 | 5.1–6.4 | 3.4–4.0 | 3.1–3.9 | 2.9–3.0 | 6.1–7.4 | 3.5–5.8 | 4.9–6.9 | 6.3–8.8 | 3.1–3.6 | 3.6–4.0 |
| 99 | 5.4–6.5 | 3.5–4.2 | 3.2–3.9 | 3.0–3.1 | 6.3–7.6 | 3.5–5.9 | 5.1–7.0 | 6.4–8.9 | 3.1–3.7 | 3.6–4.0 |

[1]Streamflow velocities were not measured for beyond-bridge site near Ashland.

**Appendix 16.** The 95-percent confidence interval for selected percentiles of the area cumulative frequency distribution of streamflow depth and velocity for low-flow condition for the near-bridge and beyond-bridge sites on the Platte River at North Bend, Louisville, and Leshara, Nebraska, 1934–2006.

[Tabled values are the 95-percent confidence intervals for the mean depth or velocity; depth in feet; velocity in feet per second; high-flow conditions centered on peak flow that occurs with 99-percent probability per year; centers of low-flow condition are streamflows that are equaled or exceeded 84 percent of the time]

| Percentile of area cumulative frequency distribution | North Bend | | | | Leshara[1] | | Louisville | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Depth | | Velocity | | Depth | | Depth | | Velocity | |
| | Near bridge | Beyond bridge | Near bridge | Beyond bridge | Near bridge | Beyond bridge | Near bridge | Beyond bridge | Near bridge | Beyond bridge |
| 1 | 0.2–0.3 | 0.1–0.2 | 0.2–0.4 | 0.1–0.7 | 0.2–0.3 | 0.3–0.6 | 0.2–0.6 | 0.1–0.2 | 0–0.1 | 0–0.4 |
| 2 | 0.3–0.4 | 0.1–0.3 | 0.3–0.5 | 0.3–0.8 | 0.4–0.4 | 0.4–0.7 | 0.4–0.6 | 0.2–0.3 | 0–0.2 | 0–0.5 |
| 5 | 0.4–0.5 | 0.3–0.5 | 0.5–0.7 | 0.3–0.8 | 0.6–0.6 | 0.6–0.9 | 0.6–0.9 | 0.2–0.3 | 0.1–0.4 | 0.2–0.8 |
| 10 | 0.5–0.6 | 0.3–0.6 | 0.5–0.7 | 0.8–1.1 | 0.8–0.9 | 0.9–1.1 | 0.8–1.2 | 0.3–0.4 | 0.3–0.8 | 0.2–0.8 |
| 15 | 0.6–0.8 | 0.5–0.7 | 0.5–0.7 | 0.9–1.3 | 0.8–0.9 | 0.9–1.1 | 0.8–1.2 | 0.5–0.6 | 0.7–1.4 | 0.2–0.8 |
| 20 | 0.6–0.8 | 0.6–0.8 | 1.2–1.3 | 1.1–1.3 | 1.2–1.3 | 1.1–1.4 | 1.2–1.7 | 0.6–0.9 | 1.1–1.6 | 1.2–1.3 |
| 25 | 0.9–1.3 | 0.7–0.9 | 1.3–1.4 | 1.2–1.5 | 1.3–1.7 | 1.3–1.6 | 1.3–1.9 | 0.7–1.1 | 1.2–1.8 | 1.3–1.4 |
| 30 | 0.9–1.4 | 0.8–1.1 | 1.4–1.5 | 1.3–1.6 | 1.4–1.8 | 1.4–1.8 | 1.4–2.5 | 0.8–1.3 | 1.2–2.0 | 1.3–1.5 |
| 35 | 0.9–1.4 | 0.8–1.1 | 1.5–1.6 | 1.4–1.7 | 1.3–1.9 | 1.5–1.9 | 1.3–3.6 | 0.9–1.5 | 1.4–2.0 | 1.4–1.6 |
| 40 | 1.1–1.9 | 1.1–1.8 | 1.5–1.8 | 1.5–1.8 | 1.4–2.0 | 1.6–2.0 | 1.4–4.0 | 1.1–1.7 | 1.4–2.0 | 1.5–1.7 |
| 45 | 1.1–1.9 | 1.2–1.9 | 1.6–1.8 | 1.6–1.8 | 1.5–2.3 | 1.7–2.1 | 1.5–4.2 | 1.2–1.9 | 1.5–2.1 | 1.6–1.8 |
| 50 | 1.2–2.0 | 1.4–2.1 | 1.6–1.9 | 1.6–1.9 | 1.8–2.5 | 1.8–2.2 | 1.8–4.4 | 1.3–2.0 | 1.5–2.2 | 1.6–1.9 |
| 55 | 1.2–2.2 | 1.5–2.2 | 1.7–2.0 | 1.7–1.9 | 2.0–2.8 | 2.0–2.4 | 2.0–4.7 | 1.4–2.1 | 1.6–2.3 | 1.7–1.9 |
| 60 | 1.3–2.2 | 1.8–2.2 | 1.7–2.2 | 1.7–2.0 | 2.3–3.0 | 2.1–2.6 | 2.3–5.0 | 1.5–2.2 | 1.7–2.4 | 1.8–2.0 |
| 65 | 1.3–2.4 | 1.9–2.3 | 1.8–2.3 | 1.8–2.0 | 2.5–3.1 | 2.3–2.8 | 2.5–5.2 | 1.7–2.3 | 1.8–2.5 | 1.8–2.1 |
| 70 | 1.5–2.5 | 2.0–2.5 | 1.9–2.4 | 1.8–2.1 | 2.7–3.3 | 2.4–3.0 | 2.7–5.5 | 1.8–2.3 | 1.8–2.6 | 1.9–2.2 |
| 75 | 1.7–2.6 | 2.2–2.6 | 1.9–2.5 | 1.9–2.1 | 2.8–4.0 | 2.5–3.2 | 2.8–5.5 | 2.0–2.4 | 1.9–2.6 | 2.0–2.3 |
| 80 | 1.8–2.8 | 2.3–2.8 | 1.9–2.6 | 1.9–2.2 | 3.2–4.2 | 2.7–3.5 | 3.2–5.8 | 2.0–2.6 | 2.0–2.6 | 2.0–2.4 |
| 85 | 1.9–3.0 | 2.4–3.1 | 2.1–2.7 | 2.0–2.3 | 3.4–4.3 | 2.8–3.6 | 3.4–6.2 | 2.2–2.9 | 2.1–2.6 | 2.1–2.5 |
| 90 | 2.1–3.2 | 2.5–3.3 | 2.1–2.9 | 2.0–2.4 | 3.9–4.6 | 3.0–3.8 | 3.9–6.5 | 2.5–3.2 | 2.2–2.8 | 2.2–2.6 |
| 95 | 2.2–3.4 | 2.6–3.5 | 2.3–3.0 | 2.2–2.6 | 4.2–5.0 | 3.3–4.0 | 4.2–7.2 | 2.8–3.6 | 2.3–2.8 | 2.3–2.9 |
| 98 | 2.3–3.5 | 3.0–3.7 | 2.4–3.1 | 2.2–2.6 | 4.3–5.3 | 3.4–4.1 | 4.3–7.5 | 3.1–3.9 | 2.4–2.9 | 2.5–3.0 |
| 99 | 2.5–3.4 | 3.1–3.9 | 2.4–3.1 | 2.3–2.7 | 4.3–5.4 | 3.4–4.2 | 4.3–7.5 | 3.2–3.9 | 2.4–2.9 | 2.6–3.0 |

[1]Streamflow velocities were not measured for beyond-bridge site near Leshara.

# Appendix 17. Cross Sectional Hydraulic Habitat Distribution Calculator (CSHHAD_CAL) Documentation

The CSHHAD_CAL is a spreadsheet-based computer program developed by the U.S. Geological Survey (USGS) in cooperation with the Lower Platte South Natural Resources District. The program was developed and works within Excel version 2003 for Windows (Microsoft, Redmond, Wash.) operating system. The program has not been tested for use within Excel version 2007 for Windows; the program will not work for other operating-system platforms. The CSHHAD_CAL was originally designed to analyze historical streamflow cross sections for the Lower Platte River Cumulative Impact Study (CIS). All intermediate and final calculation outputs are placed in the same workbooks and worksheets as the input data. Outputs include: hydraulic-area- and hydraulic-width-weighted cumulative frequency distributions of various metrics of hydraulic habitat, distribution among pre-specified habitat categories, and general cross-sectional information. The output also includes the descriptive statistics summarizing central tendency and the spread of the cumulative frequency distribution of each metric among multiple sets of cross-sectional measurements. Graphical representation of outputs is included.

The CSHHAD_CAL may be used for screening of changes to channel geometry, when discharge measurements have been collected over a period of time. The tool provides insight into hydraulic habitat types and changes. This tool will provide the first-level analysis in evaluating a river reach that includes (or is nearby) a streamflow-gaging station, which usually has historical streamflow depth and velocity data. A word of caution is emphasized for using the CSHHAD_CAL in a reach-level habitat analysis. Users can apply the analysis provided in CSHHAD_CAL only if the statistics of a set of cross sections can describe the reach as a whole. In other words, the users must be statistically confident that the cross-sections are representative of all possible cross sections within the reach. The analysis provided by the CSHHAD_CAL may not be appropriate if the cross sections cannot represent the reach or the changes in the reach as a whole.

## Background

For the lower Platte River CIS, the USGS analyzed more than 300 cross-sectional transects that had been originally collected as discharge measurements to determine whether any temporal differences existed in cross-sectional distributions of water depth, velocity, and hydraulic habitats among five selected decadal periods. In the early stage of the CIS project, it was quickly realized that calculation of metrics and frequency distributions for so many cross sections was time consuming. This prompted development of a spreadsheet-based computer program to expedite the calculation of hydraulic metrics for the hundreds of measured streamflow cross sections. The CSHHAD_CAL is intended for use by individual(s) using the cross-sectional data of wetted channels for characterizing the distribution of water depth, velocity, and other metrics calculated based on water depth and velocity. Until the recent advent of computerized loggers, these streamflow cross-sectional data were routinely recorded on the USGS Form 9-275F or other equivalent forms for discharge and cross-sectional measurement notes. The CSHHAD_CAL will enable users to achieve consistent and rapid streamflow cross-sectional data analysis; therefore, its use saves time for other project tasks.

## Purpose and Scope

The purpose of this Appendix is to describe the development and provide the user guidance for the application of CSHHAD_CAL within Excel version 2003 for Windows (Microsoft, Redmond, Wash.) operating system. The scope of program applicability includes streamflow cross-sectional discharge measurements recorded on the USGS Form 9-275F or other equivalent forms containing streamflow cross-sectional notes. These records include the distance from a reference point, water depth, velocity, streamflow-angle coefficient, left and right edges of water, left and right edges of channel interruptions (sandbars, islands, and piers), and (optionally) water temperature or stage.

## Data and Methodology

Stream discharge measurements and surveys of streambed and water-surface elevations are two possible data sources for CSHHAD_CAL input. Stream discharge is determined by measuring water depth and velocity at many locations while traversing the wetted-channel cross section. USGS technicians routinely record the cross-sectional measurement information on the USGS Form 9-275F, whereas other agencies may use a different form(s).

### Discharge Measurement Field Notes

The USGS field note form (Form 9-275F) consists of two primary parts, general and summary information on the front page and detailed observation-vertical measurement data on the remaining pages. Examples of information from an actual discharge measurement on June 27, 2003, for the Platte River streamflow-gaging station near Ashland, Nebraska (fig. 1), are presented in figures 3 and 4.

General information on the front page (fig. 3) includes station identification, date and time of measurement, discharge calculation summary, and the information about conditions affecting measurements or stage-discharge relation. Details of the subsection (observation vertical) measurements on the remaining pages of the discharge-measurement field notes are organized in separate columns (fig. 4). These include the horizontal distance from a reference point, water depth, velocity, and streamflow-angle coefficient. Also included in the observations are left and right edges of water, and left and right edges of channel interruptions (sandbars, islands, and piers) as annotated in figure 4. In addition to the observation-vertical measurements, details of manual calculations are recorded on the remaining pages. These calculations are used to obtain the summary discharge information, which is displayed on the front page of the discharge-measurement field note. Twenty-five to 70 subsections (observation verticals) commonly are measured for a wide channel, depending on streamflow and other complexities, such as sandbars, islands, and other flow interruptions, so that the discharge at each subsection is composed of no more than 5 to 10 percent of the total discharge. An example of cross-sectional data density for one representative discharge measurement is presented in figure 5.

## Other Cross-Sectional Data

The CSHHAD_CAL input format is not designed to handle raw streambed- and water-surface-elevation survey data. Nevertheless, streambed- and water-surface-elevation data—collected with combinations of survey equipment such as total-station system, global positioning system (GPS) receivers, acoustic Doppler current profilers (ADCP), acoustic Doppler velocity (ADV) meters, or other current meters—may be processed and formatted for input. Processing commonly is needed to obtain streamflow cross-sectional information [the distance from a reference point, water depth, velocity, streamflow-line-angle coefficient, left and right edges of water, and left and right edges of channel interruptions (sandbars, islands, and piers)]. For example, water depth may need to be computed as the difference between water-surface and streambed elevation.

# Methodology of Metric Calculation for Cross-Sectional Subsections

The cross-sectional transect measurements (observation verticals) divide the wetted cross section into many subsections. A simplified diagram of observation verticals and subsections within a cross section is presented in figure 6. The approach to metrics calculation for each subsection is based on the present-day method (center of subsection) wherein the observation vertical is located within the subsection it represents. The "center of subsection" approach resulted in two different kinds of subsections, that is, edge water and open or non-edge water (fig. 6). Edge-water subsections are subsections that are bounded by a shoreline, the interface between water and a riverbank, or water and a channel interruption (sandbar, island, or pier). Each channel interruption forms two edge-water subsections, one on the left and the other one on the right side of the channel interruption (fig. 6). Although discharge from edge-water subsections near river banks, sandbars, or islands, is small and thus is excluded in manual discharge calculations (fig. 4), the CSHHAD_CAL includes the unmeasured discharge and other metrics of the edge-water subsections because the edge water is an important component of shallow and slow hydraulic habitat for small fish such as minnows (Peters and Holland, 1992).

### Wetted Width

Subsection wetted width (ft) is one-half the distance (midpoint) between a vertical and its two (left and right) neighboring verticals (fig. 6; column C of fig. 4). Total wetted width is the sum of all subsections' wetted widths. Wetted-width fraction (in percent) for a subsection is the ratio of subsection wetted width to the total wetted width multiplied by 100. The sum of the wetted-width fractions for a cross section equals 100. Dry width is the total width of channel interruptions such as sandbars, islands, and bridge piers. Sandbar width is the total width of sandbar(s). Island width is the total width of island(s).

### Depth and Velocity

For non-edge or open-water subsections, depth (ft) refers to the measured depth of water. Depending on the depth of a subsection, one or two velocity measurements normally are made (fig. 6). If only one velocity (ft/s) measurement is needed, the velocity measured at six-tenths of depth below the surface is used as the average velocity for the subsection (column F of fig. 4). If two velocity measurements are necessary, the arithmetic average of velocity measurements at two-tenths and eight-tenths of depth below the surface (column E of fig. 4) is used as the average velocity for the subsection (column F of fig. 4). The adjusted average velocity (column G of fig. 4) is the average velocity multiplied by an adjustment factor (column A of fig. 4). The adjustment factor is used to correct for streamflow directions that are not orthogonal to the cross-section line. The adjustment factor equals unity if streamflow direction is orthogonal to the cross-section line and other wise is equal to the cosine of the angle between the current and a perpendicular to the measurement section (Rantz and others, 1982).

For the edge-water subsection, depth and velocity are approximated from the adjacent subsection depth and velocity. Streamflow cross-sectional data measured from bridges frequently contain channel interruptions involving piers. When viewed as vertical cross sections, from left to right, facing downstream of the bridge, five possible in-channel flow interruptions are anticipated:

1. Left edge of sandbar (or island) to right edge of sandbar (or island).

2. Left edge of sandbar (or island) to right edge of pier indicating that the sandbar (or island) ends at the pier.
3. Left edge of pier to the right edge of sandbar (or island) indicating that the sandbar (or island) starts at the pier.
4. Left edge to right edge of a single pier.
5. Left edge of one pier to the right edge of another pier indicating that a sandbar (or island) extends from one pier to the other.

The unmeasured depth and velocity profiles of the edge-water subsection adjacent to a bank, sandbar, or island are not known. Therefore, the depth and velocity of each edge-water subsection adjacent to a shoreline are estimated to be 0.25 times the depth and velocity of its adjacent vertical. It is based on the assumption that the shape of depth and velocity profile of the edge-subsection is like a triangle and depth or velocity along the base is proportional with the distance from the adjacent vertical. Note that edge-water subsection wetted width (ft) is one-half the distance between shoreline and neighboring vertical. The estimated depth and velocity of edge-water subsection at piers are estimated to be equal with the streamflow depth and velocity of the closest subsection.

### Hydraulic Area

The wetted width multiplied by depth (fig. 6; column D of fig. 4) for a subsection corresponds to a rectangle representing the hydraulic area of the subsection (fig. 6; column H of fig. 4). The sum of all subsection areas equals the total hydraulic area. Areal fraction (in percent) for a subsection is the area of the subsection divided by the total hydraulic area and then multiplied by 100. The sum of all areal fractions equals 100 percent.

### Discharge

The hydraulic area multiplied by the adjusted-average velocity (column G of fig. 4) for a subsection equals the discharge ($ft^3/s$) for the subsection (column I of fig. 4). The sum of all subsection discharges equals the total discharge. Discharge fraction (in percent) for a subsection is the discharge from the subsection divided by the total discharge and then multiplied by 100. The sum of all subsections discharge fractions for a cross section equals 100.

### Unit Discharge

Unit discharge ($ft^2/s$) of a subsection refers to depth multiplied by the adjusted-average velocity of the subsection. It is an estimate of the discharge per unit of hydraulic width.

### Froude Number

Moir and others (1998) found that combinations of depth and velocity utilized for spawning by trout and salmon generally followed lines of constant Froude number. The Froude number may be a more useful and general indicator of hydraulic habitat than the individual values of depth and velocity. The nature of streamflow, rapid or tranquil, depends upon whether the Froude number (F), is greater or less than unity (Streeter, 1985). The Froude number corresponds to the ratio between kinetic force and hydrostatic force, and is defined by

$$F = \frac{V}{\sqrt{gD_h}}, \quad (2)$$

where $V$ is flow velocity, $g$ denotes gravitational acceleration, and $D_h$ is hydraulic depth, which is equal to flow depth in a wide natural channel.

### Reynolds Number

A critical Reynolds number ($R_e$), indicates whether streamflow is laminar or turbulent. Reynolds number is defined as

$$R_e = \frac{VR}{\nu} \quad (3)$$

where $V$ is flow velocity, $R$ is hydraulic radius, and $\nu$ is kinematic viscosity. Because the kinematic viscosity is temperature-dependent, the user must provide water temperature.

### Summary of Total and Average Values of Metrics for a Cross Section

The calculator provides the summary of total and average values of metrics for a cross section. The total wetted width, total hydraulic area, and total discharge have been described in the previous section. Other metrics include:

1. Cross-sectional mean velocity, which equals total discharge divided by total hydraulic area.
2. Mean water depth, which equals the total hydraulic area divided by total wetted width.
3. Number of non-water bodies in the channel, which equals the number of sandbars and/or islands.
4. Number of channels, which equals the number of non-water bodies (sandbar and/or island) plus one.

## Construction of Cumulative Frequency Distribution for Metrics

A cumulative frequency distribution for some hydraulic habitat metrics (water depth, velocity, discharge, unit discharge, Froude number, and Reynolds number) is constructed based on areal fraction or width fraction of each subsection.

Plotting positions of a response variable (or metric) and cumulative-areal or -width percentage generates a curve similar to a cumulative frequency distribution, that is the hydraulic-area-weighted cumulative frequency distribution (ACFD) or hydraulic-width-weighted cumulative frequency distribution (WCFD) for the metric.

The areal and width fractions (as percentage of total hydraulic area and width, respectively) of each wetted subsection are first calculated as described previously. Subsections are then sorted by a metric in ascending order and ranked from the smallest to the largest value of the metric. For example, the subsections are sorted from the shallowest to the deepest (for depth metric); and afterwards, the subsections are sorted from the slowest to the fastest (for velocity metric). For illustration purposes, calculations for the ACFD are used.

Cumulative-areal fraction for each sorted subsection was derived as

$$CA_i = \sum_{1}^{n} A_i \tag{4}$$

where $i$ is the ascending ranking of subsections (for example, $i$=1 for the shallowest and $i$=$n$ for the deepest), $n$ is the total number of subsections, and $CA_i$ is the cumulative-areal fraction (percentile) for the $i$th-ranked subsection. The value of $CA_n$ equals 100. As an example, the ACFD of water depth for the discharge measurement on June 27, 2003 (fig. 4) is presented in figure 7.

Analysis and interpretation of cumulative frequency distributions is commonly based on selected percentiles of the cumulative frequency distribution. For this reason the cumulative frequency distribution of each metric is interpolated for "commonly selected" percentiles, that is for the 1st, 2nd, 98th, 99th, and every fifth percentile from the 5th through the 95th percentiles. The estimated value of each metric for each of the selected percentiles was derived from linear interpolation of two neighboring values, which enclosed the percentile. An example of an ACFD for water depth interpolated from original depth distribution of the measured subsections (fig. 4) is presented in figure 7, which demonstrates that the interpolated ACFD closely fits the original ACFD.

## Calculation of Hydraulic Habitat Distribution

The CSHHAD_CAL calculates cross-sectional distributions of hydraulic habitat solely on the basis of depth-velocity categorical classification. As coded, the CSHHAD_CAL applies two differing systems of hydraulic habitat classification that correspond to the subheadings that organize the descriptions in this section.

### Classification of Fishery Habitats using Hydraulic Niches

The hydraulic-niche approach to fishery-habitat classification segregates the physical dimensions of a river reach or cross section into nine discrete depth and velocity combinations. Following Peters and Holland (1992), water depths were divided into three classes: shallow (less than 1 ft), intermediate (1-2 ft), and deep (greater than 2 ft). Streamflow velocities also were divided into three classes: slow (less than 1 ft/s), moderate (1-2 ft/s), and swift (greater than 2 ft/s). The hydraulic niches preferred by selected fish species from the lower Platte River, Nebraska, are listed in table 2. To aid the reader, descriptive names were applied to the hydraulic niches as two-word labels; the first word indicates depth class and the second word indicates velocity class. For example, the hydraulic niche with streamflow between 1-2 ft deep and velocity slower than 1 ft/s was labeled "Intermediate-Slow."

### Low-Flow Geomorphic Habitat Classification

The geomorphic habitat classifications of Rabeni and Jacobson (1993) and McKenney (1997) were modified to be solely based on the discrete depth and velocity combinations as presented in figure 8. The depth and velocity ranges for each class were fixed, except for the "Pool" hydraulic habitat. For the "Pool" habitat, the range of water depths varied with total wetted width; the water depth minimum was computed as one percent of the total wetted width.

## Descriptive Statistics for Metrics of Hydraulic Habitat Distribution

Descriptive statistics for a set of cross-sectional measurements can be derived after the calculation of cumulative frequency distributions of habitat metrics for each cross section is completed. In this case, descriptive statistics are derived for the 1st, 2nd, 98th, 99th, and every fifth percentile from the 5th through the 95th percentiles. Descriptive statistics calculated by the CSHHAD_CAL are the mean, median, and upper and lower boundary of the 95-percent confidence interval for the mean. The graphical representation of several descriptive statistics also is generated. Descriptive statistics provide information on the central tendency, the skewness (mean/median), and the spread of habitat metric values for a set of cross-sectional measurements.

# CSHHAD_CAL User's Guide

This user's guide describes the processing workflow for hydraulic habitat metric calculations using CSHHAD_CAL. Examples of cross-sectional data are supplied in two separate Excel files (Appendixes 19 and 20) for users to familiarize themselves with input data format requirements and for use with the calculator in running practice calculations. Also, the examples demonstrate that a set of cross-sectional measurements can be separated into several files (especially for a set that contains more than 256 cross sections).

## Preparing Cross-Sectional Data for Input

In the input data files, the measurement data are entered into one worksheet for each measured cross section; each worksheet should be named to differentiate one cross-section measurement from another (for example, Appendixes 19 and 20). In other words, the calculator processes hydraulic habitat one cross section at a time. It is designed to encourage the user to carefully evaluate the accuracy of the data for each cross section. One workbook (Excel file) can contain a maximum of 256 worksheets. Group(s) of cross sections can be placed in separate workbooks. In order to differentiate one group of cross sections from other group(s), it is good practice to group the cross sections in separate files (for example, grouping based on site, time, or site-time combination). This will be useful for obtaining descriptive statistics for a particular group or groups.

Cross-sectional data in a worksheet **MUST** follow the format as shown in figure A17–1. Data format must follow these requirements:

1. The first row is reserved only for column headings.
2. Cross-sectional data starts in row 2. Each row contains the measured data for one subsection of the cross section.
3. A blank row will signify the end of data for the cross section.
4. The first three letters (case insensitive) of the column heading for Column “A,” “B,” and “C” must be “Sta,” “Mea,” and “Dat” which stand for station, measurement number, and date. User can use more letters after the first three letters for a more descriptive column heading. For example, “StaID” or “station number” will work equally as “STA” or “staid”. The combination of the three columns forms a unique identifier for a cross section. Using different headings for any one of the three columns will result in no calculation and exclusion of the cross section from descriptive statistics calculation. This is another practical way to exclude certain cross section(s) from a group of cross sections in statistical calculation as discussed later. Adding any prefix or otherwise changing the first three letters of the three identifying-column headings (for example “xStation”) will exclude the cross section from further processing.
5. Column “D” is the distance from the initial point (commonly streambank). A valid distance is mandatory (blank cell is not allowed), and only numeric values are supported. No empty distance data (blank cell) is allowed. The distance can be in ascending order, assumed to represent that the cross-sectional measurement started from the left side of the streambank facing downstream (USGS convention); or in descending order, assumed to represent that the cross-sectional measurement started from the right bank facing downstream.
6. Column “E” is for water depth. Note in figure A17–1 that water depth is zero at the shorelines for left and right edges of water (LEW and REW), left and right edges of sandbars (LES, RES), left and right edges of island (LEI, REI).
7. Columns “F” and “H” are the relative depth of velocity measurements. Depending on the water depth of an observation vertical, one or two velocity measurements commonly are made (fig. 4). If only one velocity measurement is needed, the velocity is measured at six-tenths of depth measured from the surface. If two velocity measurements are needed, velocities are measured at two-tenths and eight-tenths of depth. Columns “F” and “H” are only for clarifying information and are not used for calculation. These columns can be left blank if desired.
8. Column “G” is the velocity measured at two-tenths or six-tenths of depth, whereas Column “I” is the velocity measured at eight-tenths of depth. If velocity was measured at one depth only, leave the other column (G or I) blank (not zero).
9. Column “J” is the vertical position coefficient. Default value is 1 (blank indicates value equals 1). Use of timed floating objects to estimate surface velocity is an example case where a vertical position coefficient was needed.
10. Column “K” is the horizontal angle coefficient. Default value is 1 (blank indicates value equals 1).
11. Column “L” is for the channel interruption code and is used whenever one edge of a subsection encounters a channel interruption. Note that each interruption has two edges and will require a code in both subsections. Text in column “L” **must** use three-letter acronyms to indicate edges of interruption, that is LEW and REW for the streambanks, LES and RES for sandbar, LEI and REI for island, and LEP and REP for pier. Input data also must have left and right edges of water (LEW and REW) indicated in column “L”. Note in figure A17–1 that depth and velocity at the shoreline for the left and right edges of water (LEW and REW), and left and right edges of sandbar (LES and RES) have zero values. Water depth at left or right edges of pier (LEP and REP) can be zero or non-zero.

## Getting Started

To begin, open the Excel version 2003 application for Windows operating system. The level of security in Excel must be set to “Medium” to enable running the macros. To change the security level, from the Excel menu, select <Tools> <Macro><Security>, then select the “Medium” option button and click “Ok” button (fig. A17–2).

Copy the Excel file named “CSHHAD.xls” (Appendix 18) into your computer. Open the CSHHAD.xls spreadsheet

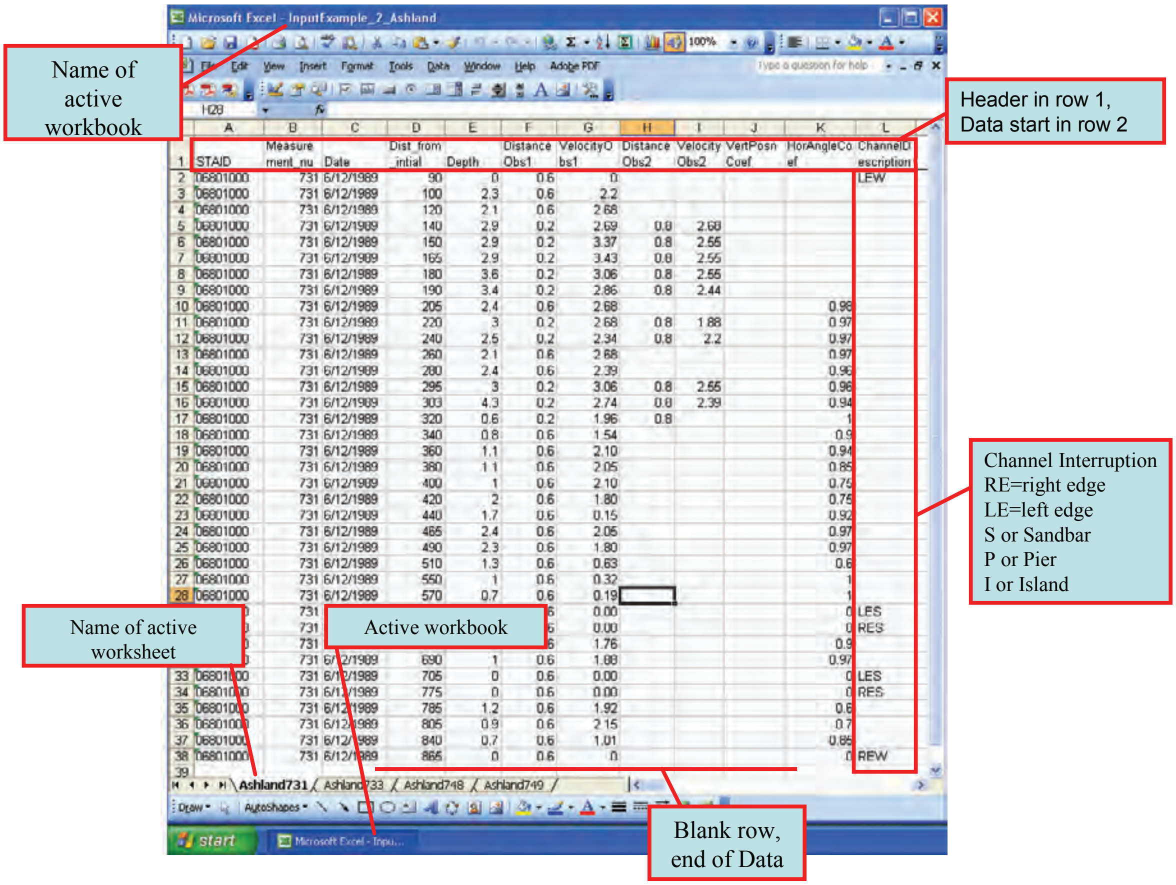



**Figure A17–1.** Active Excel worksheet in an active workbook showing cross-sectional data input format for calculator.

that contains Visual Basic Application (VBA) macros and a graphical user interface. Do not save the CSHHAD as a different name because the workbook name is coded in the program. If saved as a different name, the program will not work; running the program will open a message box indicating error information. If this occurs, select the button “End” of the error message box, rename the file as “CSHHAD.xls,” and reopen the file.

After opening the “CSHHAD.xls” to load the calculator, the user must select “Enable Macros” if a message box entitled “Security Warning” is displayed. After opening, the menus “River Channel” and “Channel Statistics” will be added to the Excel menu bar (fig. A17–3).

## Running Calculator for Each Cross Section

To run the calculator for a cross section, select the “River Channel” menu and then the menu item “Calculator.” This will open a tool-box menu, entitled “Stream Cross Section Calculator” (fig. A17–4). The tool box can be dragged to different places on the screen.

12. Open Data File. Click this button to open and activate an Excel workbook containing cross sections (for example, Input_Example_2_Ashland.xls in Appendix 20). A message box will prompt the user to select a worksheet to be processed; click the “OK” button. Select the worksheet containing the cross-sectional-data input (for example, worksheet “Ashland731” shown in figure A17–1). If the workbook containing cross-sectional data is already open, then activate the workbook and select the worksheet containing the cross-section data to be processed. Note that one cross section is stored in one worksheet, and the calculator will calculate hydraulic habitat metrics only for the active worksheet.

13. Check Data. Click this button to perform data checking. Before proceeding, the calculator will validate the data in the active worksheet, and display messages to warn the user if certain values are unexpected, do not appear to make sense, or if changes are necessary in the input data. These messages help to ensure that cross-sectional data entry is correct. Proceeding with erroneous data will either result in invalid results or can cause the program to stop and display a message box with error information. If this occurs, select the button “End” of the error message box.

14. Water Temperature in Degrees Fahrenheit. Water temperature is used to determine the kinematic viscosity of depth for use in Reynolds number calculations. Water temperature is initialized to an arbitrary value after opening the

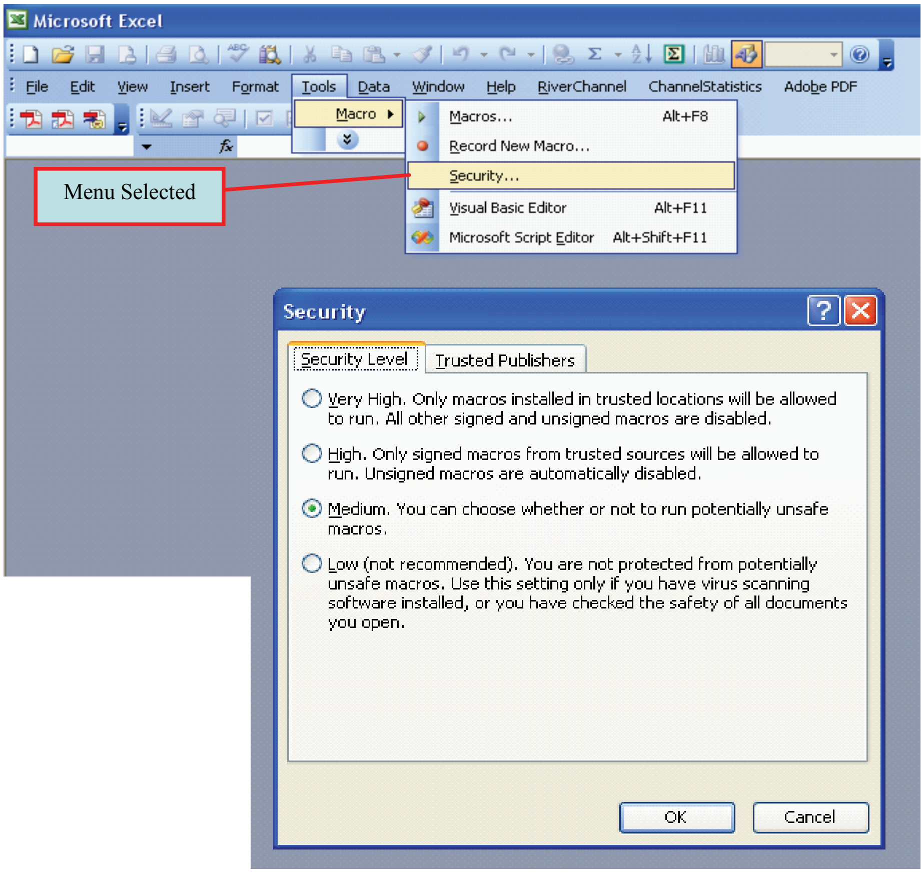



**Figure A17–2.** Setting Excel macro security to medium level prior to running macros.

"Stream Cross Section Calculator" tool box (fig. A17–4). Note, the arbitrary value is the arbitrary water temperature supplied by the user during the last entry; user may select and specify the arbitrary temperature if measured water temperature is not available or if the user is not interested in calculation of the Reynolds number. To select an arbitrary value, click the option button labeled "Use Arbitrary Value" and type an arbitrary temperature into the text box. This value will be stored and can be used for every cross section, as long as the option button "Use Arbitrary Value" is selected.

15. When measured water temperature data is available, user may click the option button labeled "Use Measured Value" and enter the temperature value into the corresponding text box. By selecting the option button labeled "Use Measured Value," user must enter the measured value through the corresponding text box or directly type the value into cell "X2" of the active cross-sectional-data worksheet.

16. Calculate Worksheet. Click this button to have the calculator compute all hydraulic habitat metrics. If user does not provide water temperature appropriately (for example, user selects the option button labeled "Use Measured Value" but does not supply temperature value), a message box will prompt user to supply the temperature. If this occurs, type the temperature and click the "Calculate Worksheet" action button again. Note that the calculator will process only worksheets containing input data that meet the naming requirement for column headings, that is, the first three letters (case insensitive) of the names for Column "A," "B," and "C" must be "Sta," "Mea," and "Dat." Outputs for intermediate and final calculations are placed in columns "M" through "FK." Repeat steps 2 through 3 for any remaining worksheets in a group by selecting each worksheet in turn (examples are worksheets "Ashland733," "Ashland748," and "Ashland749") in the Input_Example_2_Ashland.xls workbook (fig. A17–1).

17. Channel Properties. If the cross-sectional summary of channel features and measured discharge is needed, clicking this tool-box menu button will display message boxes providing this information concerning the active data set.

## Viewing Graphical Representations of Calculated Metrics

After completion of tool box step 4 (Calculate Worksheet), graphs of the cumulative frequency distribution of the habitat metrics for each cross section can be generated. From

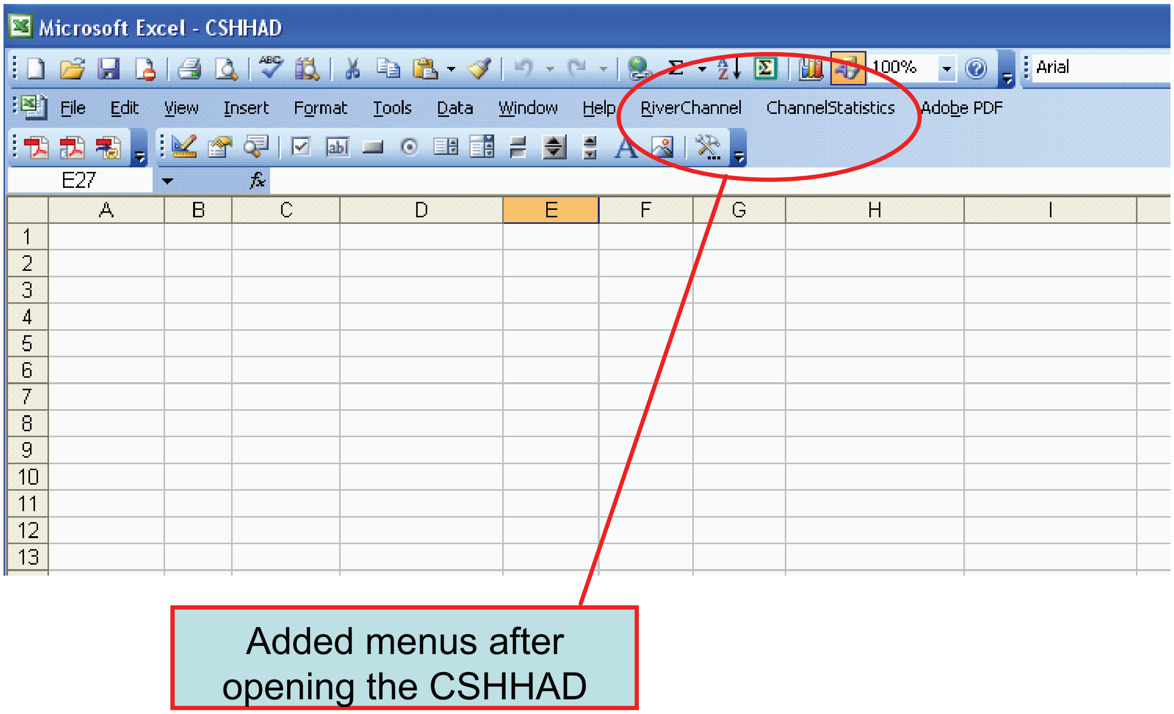



**Figure A17–3.** Opening the CSHHAD.xls file displays two menus: "River Channel" and "Channel Statistics."

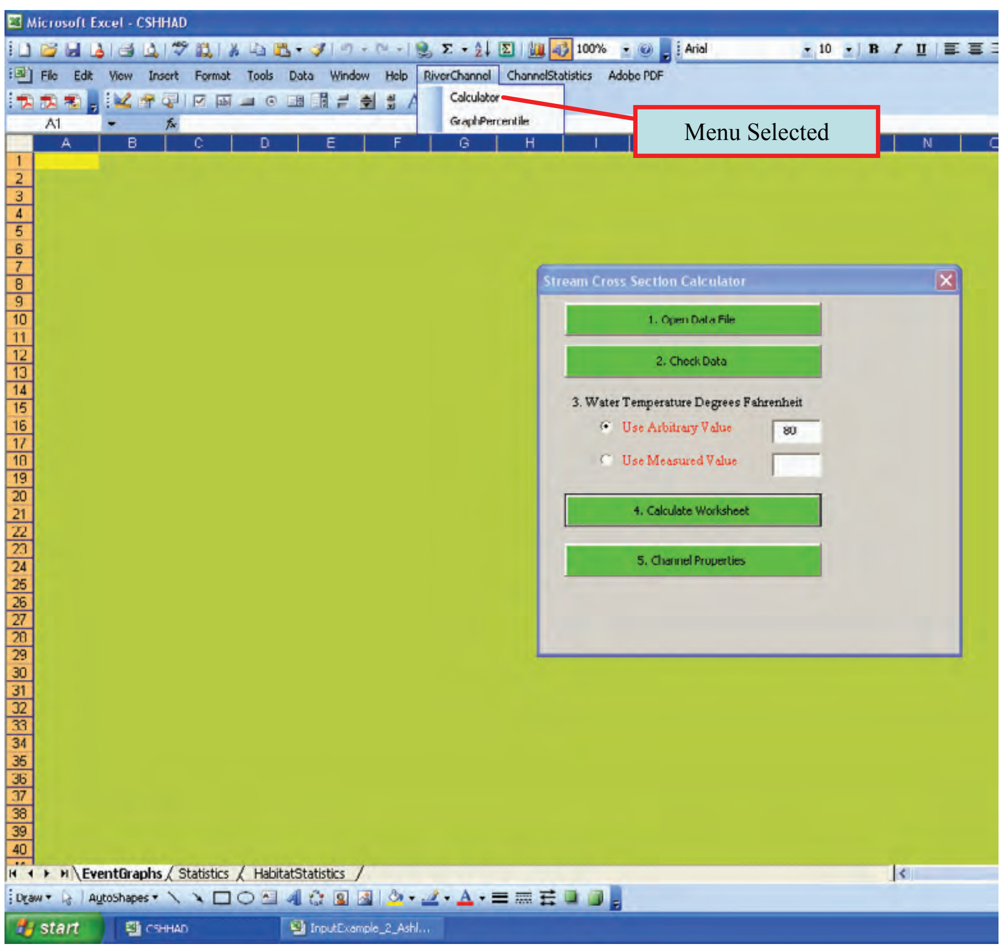



**Figure A17–4.** Tool box entitled "Stream Cross Section Calculator."

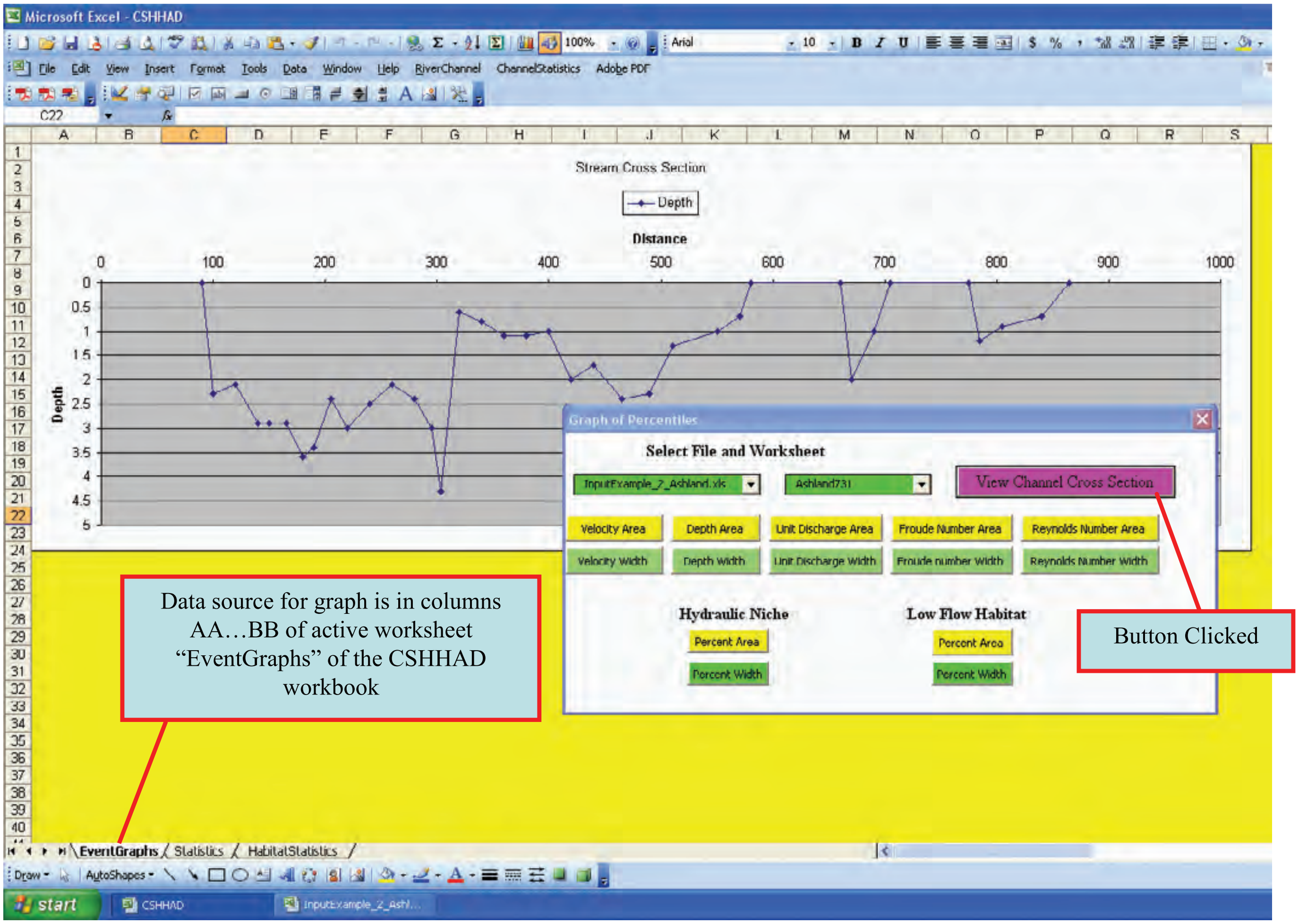



**Figure A17–5.** Representation of a cross-sectional depth profile (Note: Clicking button activates the workbook "CSHHAD" and worksheet "EventGraphs;" the workbook containing cross-sectional data is no longer active. The tool box entitled "Graph of Percentiles" can be dragged elsewhere or closed.

the Excel menu bar, select <River Channel> <Graph Percentile>. A tool box, entitled "Graph of Percentiles," will open (fig. A17–5). This tool box can be dragged to elsewhere on the screen for a better view of the graph. Note that the worksheet "EventGraphs" of the CSHHAD.xls workbook becomes active, while the workbook(s) containing the cross-sectional data is no longer active. To avoid clutter, close the "Stream Cross Section Calculator" tool box by clicking the "X" on the box corner). At this stage, the calculator has a list of names of the workbook(s) and worksheet(s) containing cross-sectional data sets.

1. Select the file and the worksheet for the cross section of interest from the two drop-down lists. The "File" drop-down list includes all open Excel files that contain cross-sectional data. The "Worksheet" drop-down list includes all worksheets containing cross-sectional data sets that meet the naming requirement of input columns.

2. Click the "View Channel Cross Section" button to view a water-depth profile of the cross section and review the data density (fig. A17–5). If no graph is displayed, this indicates that frequency distribution for the selected habitat metric for the cross section has not been previously calculated as described in the section, "Running Calculator for Each Cross Section."

3. Click any action button to graph the corresponding ACFD or WCFD of the habitat metric or the distribution of hydraulic habitat categories. For example, clicking the "Depth Area" button will graph the ACFD of water depth (fig. A17–6). Clicking the "Velocity Width" button will graph the WCFD frequency distribution of streamflow velocity (fig. A17–7). Clicking the "Percent Area" button under "Hydraulic Niche" will graph the areal percentage distribution among all hydraulic niche categories (fig. A17–8). Clicking the "Percent Area" button under "Low Flow Habitat" will graph the areal percentage distribution among all low-flow geomorphic habitat categories (fig. A17–9). If no graph is displayed, this indicates that the frequency distribution for the selected habitat metrics or habitat classification for the cross section has

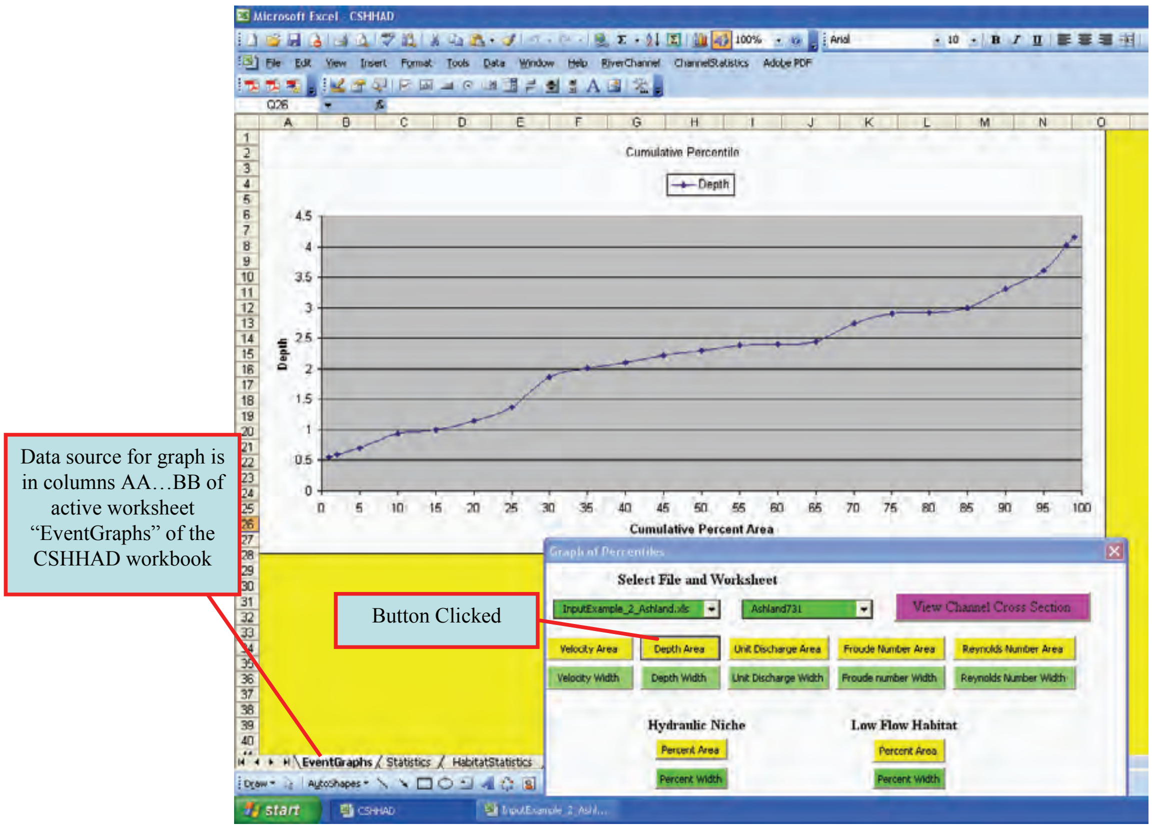



**Figure A17–6.** Hydraulic-area-weighted cumulative frequency distribution for water depth.

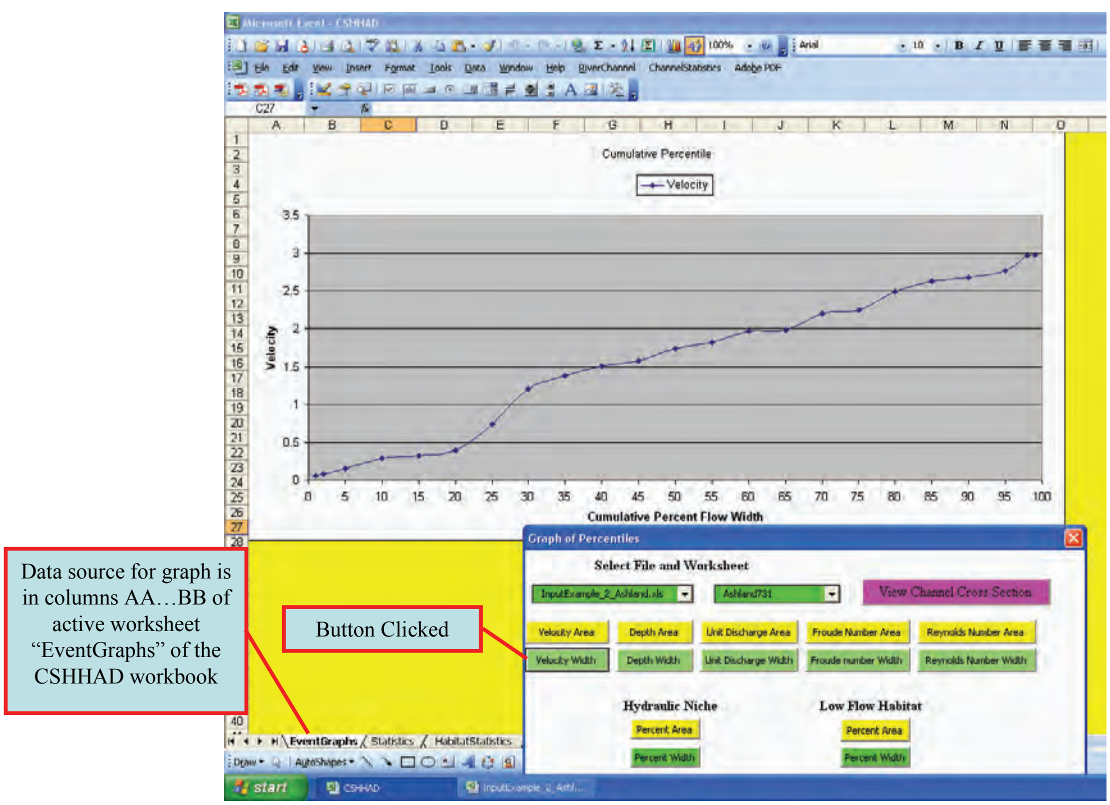



**Figure A17–7.** Hydraulic-width-weighted cumulative frequency distribution of streamflow velocity for a cross section.

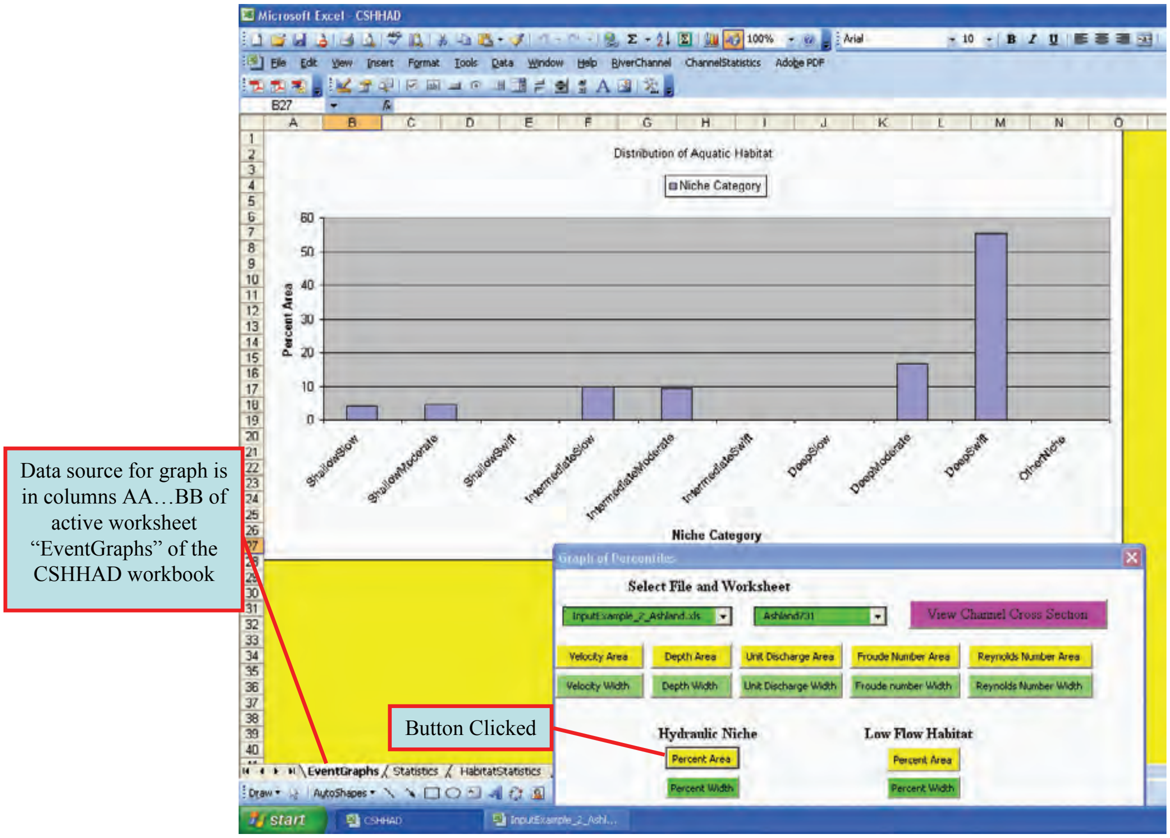



**Figure A17–8.** Areal percentage distribution among hydraulic-niche categories for a cross section.

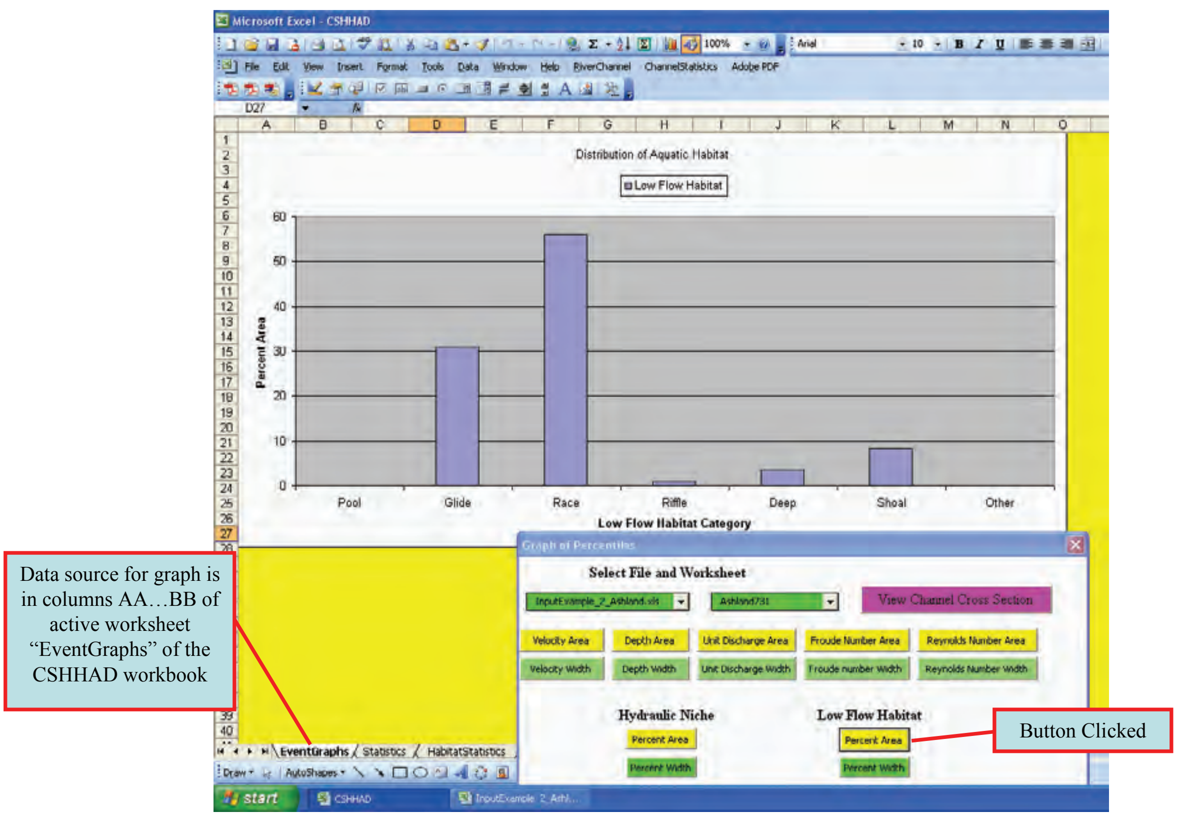



**Figure A17–9.** Areal percentage distribution among low-flow geomorphic-habitat categories for a cross section.

not been previously calculated as described in the section, “Running Calculator for Each Cross Section.”

## Calculating Descriptive Statistics for a Group of Cross Sections

One Excel workbook can contain a maximum of 256 worksheets. If a group of cross sections includes more than 256 cross sections (or discharge measurements), the group can be split into two or more workbooks. Different groups of cross sections can be placed in separate workbooks. Grouping cross sections in separate workbooks helps to differentiate one group of cross sections from another group(s) (for example, grouping based on site, time, or site-time combination), which will facilitate summary descriptive statistics.

### Excluding Cross Sections from Statistical Analysis

Exclusion of cross sections from statistical calculations can be accomplished at the workbook level or the worksheet level. At the workbook level, only workbooks containing cross sections that are to be included in the statistical calculations should be opened. In other words, exclusion of all cross sections contained in a workbook (workbook-level exclusion) is achieved by closing the workbook. At the worksheet level, exclusion of cross sections can be readily achieved by modifying the column heading of one or more cross-sectional identifiers. For each cross section (worksheet), the first three letters (case insensitive) of the column headings for columns “A,” “B,” and “C” must be “Sta,” “Mea,” and “Dat” (fig. A17–1). If any of these column headings differ from the requirement, the cross section will be excluded from statistical calculations. For example, by adding the prefix letter “x” as one of the first three letters in the column heading (for example “xStation”) the cross section will be excluded from statistical analyses.

Exclusion at workbook or worksheet level will be reflected in the drop-down list of files and worksheets. The names of workbooks and worksheets containing the cross-sectional data available to be used in calculations is updated and reflected in the “File” drop-down list and “Worksheet” dropdown list discussed previously (step 1 in section “Viewing Graphical Representations of Calculated Metrics”).

### Descriptive Statistics and Graphs

To avoid cluttering the screen, the user may close the other calculator’s tool box (click the “X” on the top-right corner of the tool box). From Excel menu bar, select <Channel Statistics> <StatisticsPercentile>. A tool box, entitled “Statistics of Cumulative Percentiles,” will open (fig. A17–10). This tool box can be dragged elsewhere on the screen for a better view. Each action button included in this tool box executes subroutines that calculates statistics or graphical summaries for the active groups of cross sections.

1. Click the “Derive Statistics For Percentiles” button to derive the mean, median, and lower and upper boundary of the 95-percent-confident interval for the mean of habitat metrics. Observe that the “CSHHAD.xls” and the “Statistics” worksheets become active.

2. Click one of the metric-Area or metric-Width buttons to graph the ACFD or WCFD of the respective metric. The graphed data are placed in columns “AS” through “DE” of the “Statistics” worksheet. For example, clicking the “Velocity Width” button will graph the mean, median, and lower and upper boundary of the 95-percent-confidence interval for the mean of the hydraulic-width-weighted cumulative frequency distribution of streamflow velocity for the active group of cross sections (fig. A17–10). The user can check the graphed data by highlighting (by clicking) any line symbol on the graph (for example, the median of “Velocity Width” graph). The address of cells where graphed data are placed, (for example, SERIES (“Median”,Statistics!$AS$2:$AS$24,Statistics!$BE$2:$BE$24,2), is displayed below Excel menu bar (above the chart). Also, while the line symbol is highlighted, scroll (slide the horizontal scroll bar to the right) the “Statistics” worksheet to the right and observe that the graphed data fields in columns “AS” and “BE” are highlighted.

3. Click the “Derive Statistics for Habitat” button (fig. A17–11) to derive the means, medians, and lower and upper boundary of the 95-percent-confidence interval for the mean of the distribution of all hydraulic habitats. Observe that the “CSHHAD.xls” workbook and the “HabitatStatistics” worksheet become active. The descriptive statistics for all habitat categories calculated metrics are placed in cells (highlighted in yellow) of columns “BA” through “BZ” of the active worksheet. The summary statistics are listed by habitat categories, beginning with column “BA” of the active group of cross sections. Each summary is calculated both for the hydraulic-area-weighted or hydraulic-width-weighted distribution among all habitat categories. Note that graphical summaries of hydraulic habitat descriptive statistics are in development, and are not included in this release of CSHHAD_CAL.

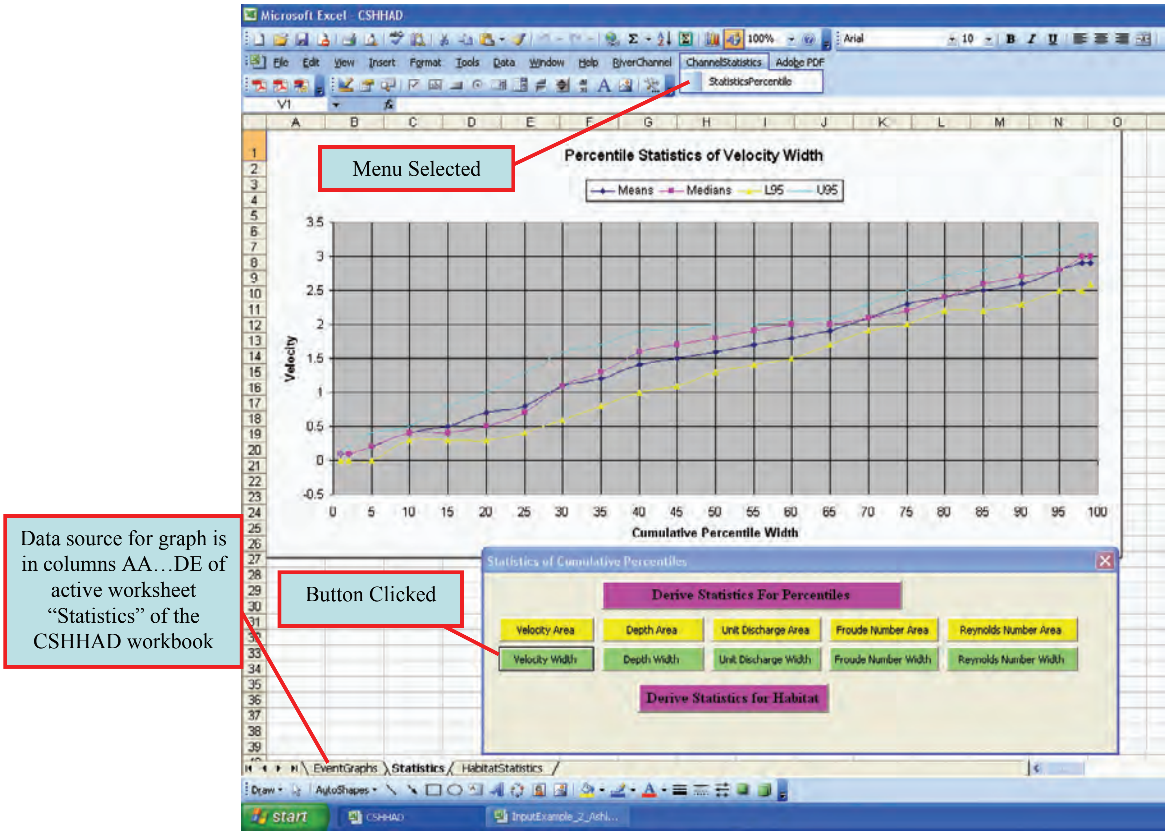



**Figure A17–10.** Summary of descriptive statistics for hydraulic-width-weighted cumulative frequency distribution of streamflow velocity for a group of cross sections.

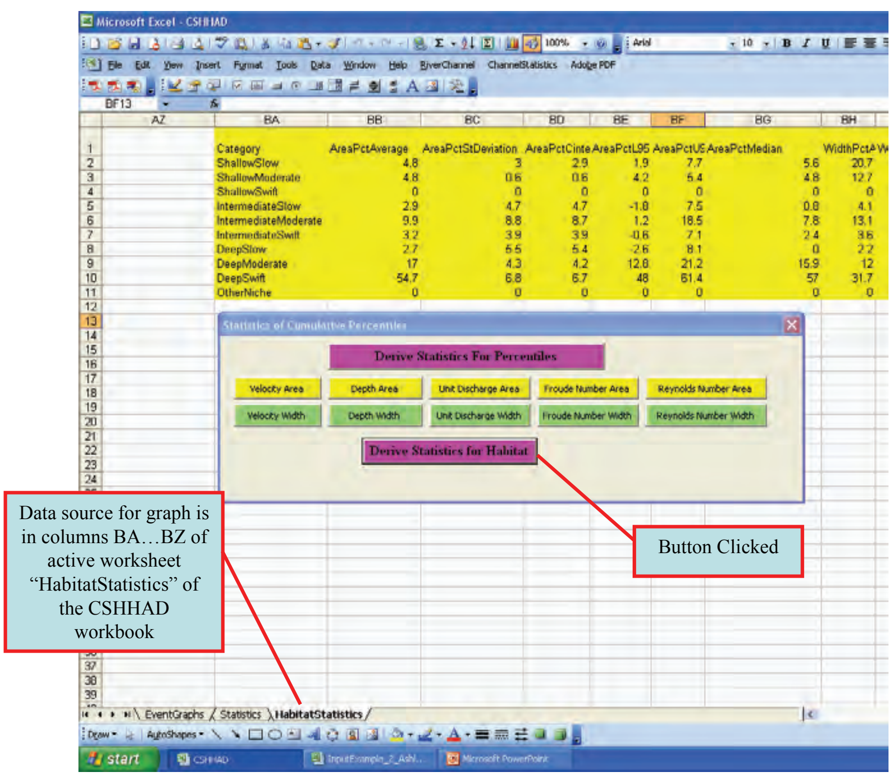


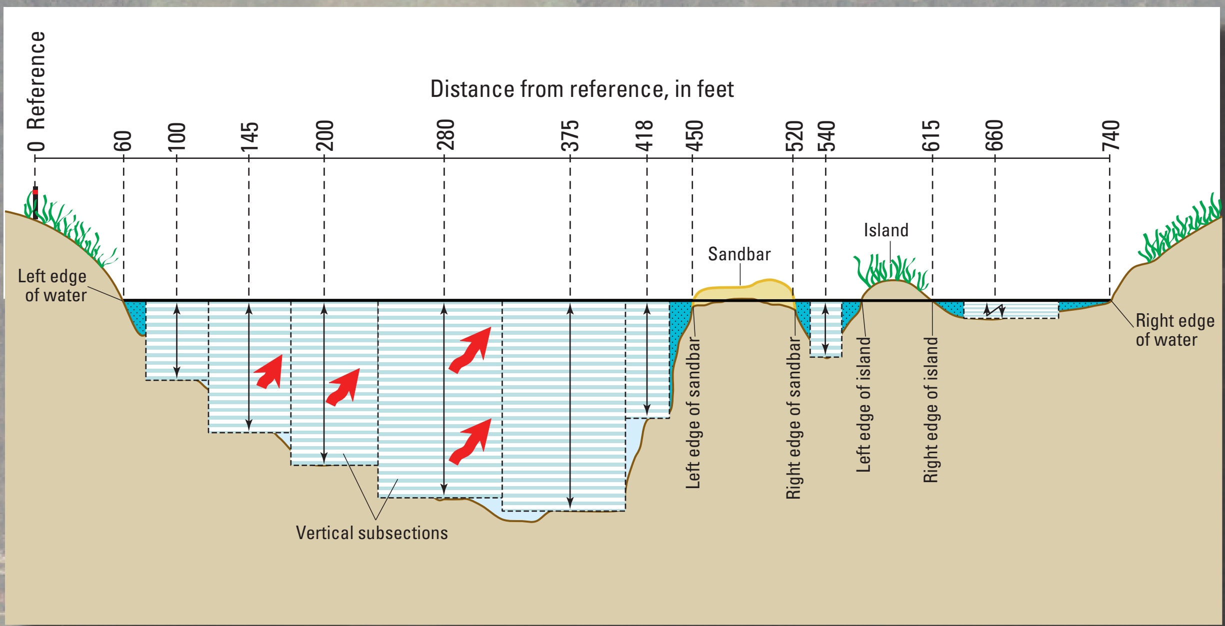

**Figure A17–11.** Summary of descriptive statistics among hydraulic habitat for a group of cross sections.

Publishing support provided by:
Rolla Publishing Service Center

For more information concerning this publication, contact:
Director, USGS Nebraska Water Science Center
5231 South 19th Street
Lincoln, NE 68512
(402) 328–4100

Or visit the Nebraska Water Science Center Web site at:
*http://ne.water.usgs.gov*

**Back cover:** Simplified water cross section showing verticals, subsections, and channel interruptions facing downstream.





Ginting—**Differences in Flow Depth and Velocity and Hydraulic Microhabits Near Bridges of Lower Platte River**—Scientific Investigations Report 2008–5054