Basin-Level Habitat Characteristics of Selected Streams in Central Nebraska

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U.S. GEOLOGICAL SURVEY

Open-File Report 96–361

Prepared as part of the

NATIONAL WATER-QUALITY
ASSESSMENT PROGRAM

Lincoln, Nebraska
1996

U.S. DEPARTMENT OF THE INTERIOR

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<http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html>

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public-water supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS, ABBREVIATIONS, AND DEFINITIONS

Multiply	By	To obtain
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
meter per kilometer (m/km)	5.280	foot per mile
cubic meter per second (m^3/s)	35.31	cubic foot per second
degree Celsius (°C)	([1])	degree Fahrenheit (°F)

[1]Temperature can be converted to degrees Fahrenheit (°F) or degrees Celsius (°C) by the equations:

$$°F=9/5\,(°C) + 32$$
$$°C=5/9\,(°F - 32).$$

Water Year: Water year is the 12-month period, October 1 through September 30, and is designated by the calendar year in which it ends. Thus, the year ending September 30, 1994, is called the "1994 water year."

Elevation: Elevation in this report is given in meters above sea level.

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

Basin-Level Habitat Characteristics of Selected Streams in Central Nebraska

By Ronald B. Zelt

Abstract

The goal of stream-habitat characterization is to use identified relations between habitat and other physical, chemical, or biological factors in interpreting water-quality conditions. Basin-level characterization of habitat is one component of the spatially hierarchical approach to stream-habitat description adopted by the U.S. Geological Survey's National Water-Quality Assessment Program. The Central Nebraska Basins study unit is about 78,000 square kilometers in area and includes the Loup and Elkhorn River Basins as well as basins of smaller tributaries to the Platte River. Stream-basin habitat characteristics associated with nine fixed-sampling stations were computed from conventional and digital map data. Geographic information system software was the principal analytical tool used. Basin characterizations generally were limited to only that part of each stream basin contained within the study unit. Habitat characteristics analyzed included basin size and shape, elevation, relief, drainage-network characteristics, geology, physiography, soils, land use and cover, climate, runoff, and streamflow characteristics. The report presents a tabular summary of the basin-level habitat characteristics determined for the nine selected stream basins.

INTRODUCTION

Beginning in 1991, the U.S. Congress appropriated funds for the U.S. Geological Survey (USGS) to commence full-scale implementation of the National Water-Quality Assessment (NAWQA) Program. The goals of the program include the identification, description, and explanation of major natural and human factors that affect water-quality conditions. Water-quality conditions include physical, chemical, and biological properties of the water resources under study (Leahy and others, 1990). Within NAWQA, the goal of stream-habitat characterization is to use identified relations among habitat and other physical, chemical, or biological factors in interpreting water-quality conditions (Meador and others, 1993). An understanding of the spatial and temporal patterns and extent of stream-habitat characteristics will aid investigators in achieving this NAWQA Program goal.

The approach used by NAWQA for describing stream habitat is a modification of the spatially hierarchical approach presented by Frissell and others (1986). The modified approach includes four spatial levels of habitat characterization—basin, stream segment, stream reach, and microhabitat (Meador and others, 1993). To improve the standardization of measurement techniques and the national consistency of data, procedural guidelines (Meador and others, 1993; J.C. Scott, U.S. Geological Survey, written commun., 1994) were provided for characterizing stream habitat for the NAWQA Program. These guidelines presented procedures for characterizing habitat at the basin and stream-segment scales using digital geographic information system (GIS) software and data, conventional maps, and aerial photographs.

The Central Nebraska Basins (CNB) was among the initial 20 study-unit investigations begun as part of the full-scale NAWQA Program. The CNB study unit (fig. 1) consists of the area drained by the Platte River between the confluence of the North Platte and South Platte Rivers near North Platte downstream to its confluence with the Missouri River south of Omaha (Zelt and Jordan, 1993). The study unit is about 78,000 km^2 in area and includes the Loup and Elkhorn River

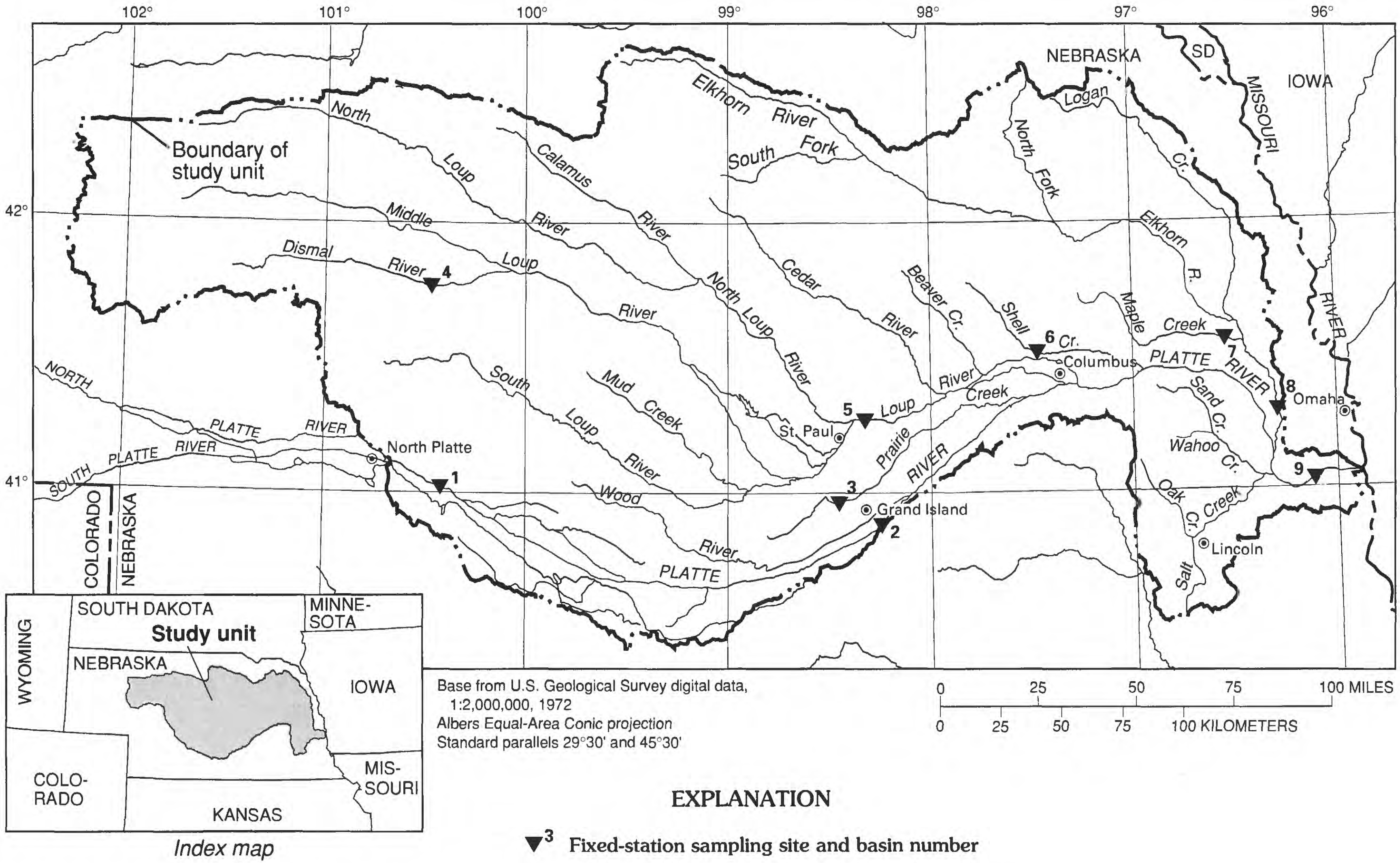


Figure 1. Central Nebraska Basins study unit and location of sampling sites at downstream end of selected stream basins.

Basins as well as basins of smaller tributaries to the Platte River. As part of the CNB study, physical, chemical, and biological samples were collected from streams at nine fixed-station sampling sites (fig. 1) beginning in 1993.

This report describes the sources of data and methods used to describe the basin-level habitat characteristics of streams associated with the nine fixed-station sampling sites operated for the CNB study. Basin characterizations were limited to only that part of each stream basin contained within the CNB study unit, except for runoff and streamflow characteristics that were based on published tabular data for the entire basin. With the exception of three sampling sites on the Platte River, each sampling site's entire drainage basin is included in the study unit. The report also contains a tabular summary of the basin-level habitat characteristics determined for the nine selected stream basins.

SOURCES OF DATA AND METHODS FOR BASIN CHARACTERIZATION

Each selected stream basin is linked with a specific USGS surface-water gaging station and associated set of data elements stored in the USGS National Water Information System (NWIS). The key data element that establishes this linkage in USGS records is the station-identification number. For each basin, the location of the USGS station was used as the "reference location" that spatially links habitat data collected at the basin level with data collected at the stream-segment, stream-reach, and microhabitat levels. Table 1 lists the identity and location of each of the nine selected fixed-station sampling sites.

Size and Shape

Digital maps of drainage-basin boundaries provided the basis for measures of basin size and shape. Line segments forming the boundary for each selected basin (or partial basin within the study unit) were retrieved from existing 1:24,000-scale digital spatial data (Rich Kern, unpublished data, on file with the Nebraska Natural Resources Commission, 1992) for basic hydrologic units (BHU) that were provided by the Nebraska Natural Resources Commission (NNRC). The documentation accompanying the BHU data set indicated that source materials for BHU compilation were paper copies of 7.5-minute USGS topographic quadrangles. The BHU boundaries were digitized by the NNRC in accordance with the technical standards and procedures of the U.S. Soil Conservation Service (1992a) and were reviewed by several collaborating agencies.

Measures of size and shape were determined as follows for each stream basin. GIS software [Environmental Systems Research Institute (ESRI), 1992)] was used to calculate the area and perimeter of each of the digital basin-boundary polygons extracted from the NNRC source.

Contributing drainage area is the part of the stream basin that generally contributes directly to surface runoff. Noncontributing areas are typified either by rapid infiltration or by drainage into closed depressions or lakes. Contributing drainage areas were calculated from published values (Boohar and others, 1995).

Basin length was measured along the longest axis of the stream basin, which was not constrained to pass through the basin outlet. Once basin length was determined, a derived characteristic, basin shape (Horton, 1932; Gordon and others, 1992), was computed as total drainage area divided by squared basin length. Basin shape is thus a unitless ratio, with elongated basins having smaller values and a circular basin ($\frac{\pi}{4}$) having the maximum value.

Elevation and Relief

Digital elevation models (DEM) for all 1- by 1-degree quadrangles of latitude and longitude in the study unit were available (U.S. Geological Survey, 1987). GIS software was used to assemble the 1:250,000-scale quadrangle data sets into a single raster data set (90-m cell size) encompassing the entire study unit and to extract data subsets for each of the previously defined basin extents. Maximum, minimum, and areally weighted average elevation were tabulated for each basin's data subset using GIS software.

Basin relief was computed as the maximum minus minimum elevation. Relative relief (after Harvey and Eash, 1996) was computed as basin relief divided by basin perimeter. A GIS hill-shading algorithm was applied to the DEM to produce a shaded-relief map for each basin (fig. 2).

Table 1. U.S. Geological Survey surface-water gaging stations associated with selected stream basins, central Nebraska

[--, computation not performed; n.a., not applicable (regional regression equations were used)]

Fixed-station sampling site no. (fig 1.)	U.S. Geological Survey surface-water gaging station no.	Station name	Water years used for annual runoff estimates	Period of record used for streamflow charac-teristics	North latitude	West longitude
1	06766000	Platte River at Brady	1942–91	May 1937–Sept. 1989	41° 01' 08"	100° 22' 17"
2	06770500	Platte River near Grand Island	1942–94	Oct. 1933–Sept. 1993	40° 52' 28"	98° 16' 54"
3	06773050	Prairie Creek near Ovina	--	n.a.	40° 59' 03"	98° 24' 59"
4	06775900	Dismal River near Thedford	1967–94	Oct. 1966–Sept. 1993	41° 46' 45"	100° 31' 30"
5	06791150	Loup River near Palmer	[1]1963–94, [1]1928–94	n.a.	41° 16' 34"	98° 15' 05"
6	06795500	Shell Creek near Columbus	1948–94	Aug. 1947–Sept. 1975, Oct. 1977–Sept. 1993	41° 31' 33"	97° 16' 55"
7	06800000	Maple Creek near Nickerson	1952–94	Oct. 1951–Sept. 1993	41° 33' 39"	96° 32' 27"
8	06800500	Elkhorn River at Waterloo	1929–94	Apr. 1899–Nov. 1903, May 1911–Sept. 1915, Aug. 1928–Sept. 1993	41° 17' 25"	96° 17' 05"
9	06805500	Platte River at Louisville	1953–94	May 1953–Sept. 1993	41° 00' 55"	96° 09' 28"

[1]Annual runoff for Loup River near Palmer estimated as sum of annual runoff for Middle Loup and North Loup Rivers, which have differing periods of record.

Drainage Network

Stream length, as defined by Meador and others (1993), is the length of the main-stem channel from its headwaters to the reference location. Line segments forming the digital representation of the stream channel were retrieved from the 1:100,000-scale "Reach File 3" (RF3) data set (U.S. Environmental Protection Agency, 1993). An alternative source of digital hydrography data (U.S. Bureau of the Census, 1992) was used where there were line segments missing in the RF3 data. In cases where the digital hydrography data included features for both the left and right banks, the left-bank features were retrieved. GIS software was used to create a longitudinal stationing index (ESRI "Route" feature) extending from the headwaters to the reference location. The length of main-stem channel (that is, "Route" length) was calculated using the GIS software. The main-stem channel of each basin is highlighted in figure 2.

The "main channel" was defined as the main-stem channel between points 10 and 85 percent of stream length upstream from the reference location. Each basin's mean elevation and main channel slope are thus functions of the elevation at the two defined end-points of the main channel. The location of those two points and stream distance between them were computed using the 1:100,000-scale hydrography data and longitudinal stationing index. Stream-surface elevation at those two points was determined by interpolation between the published contours on 1:24,000-scale USGS topographic maps. Main-channel slope was

A. Platte River at Brady (sampling site 1, fig. 1)

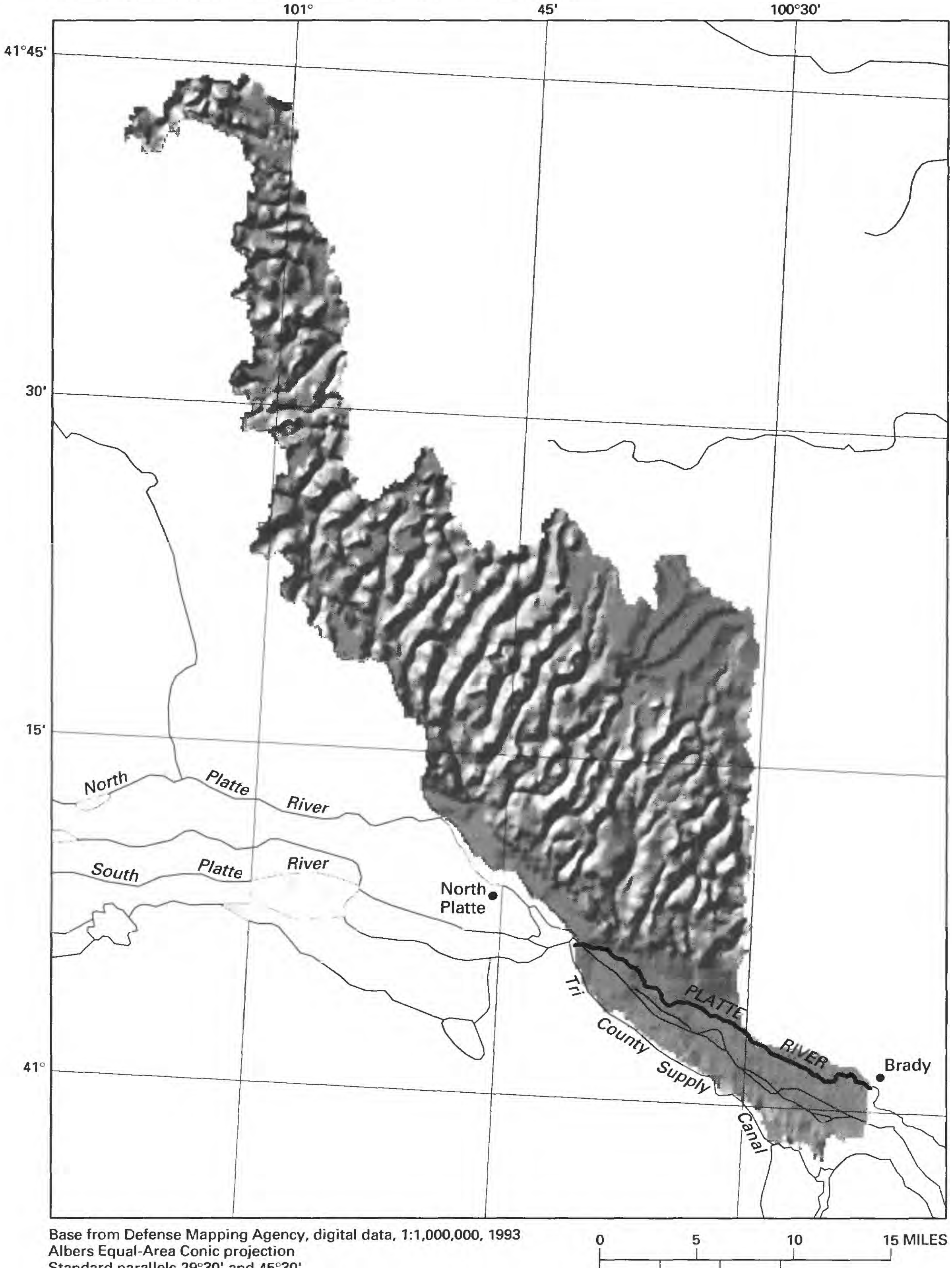
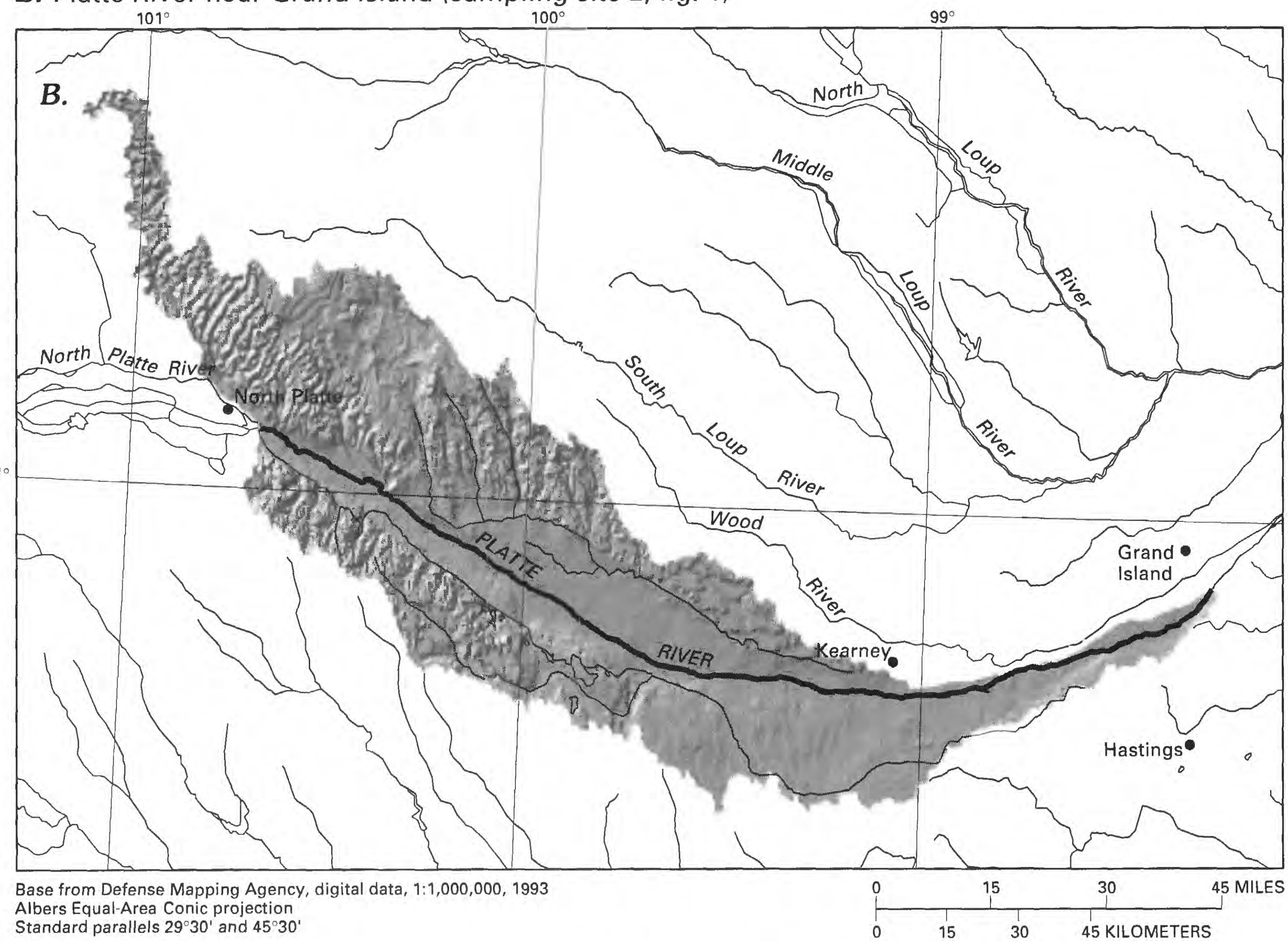


Figure 2. Shaded-relief maps of selected stream basins upstream from (*A*) Platte River at Brady, (*B*) Platte River near Grand Island, (*C*) Prairie Creek near Ovina, (*D*) Dismal River near Thedford, (*E*) Loup River near Palmer, (*F*) Shell Creek near Columbus, (*G*) Maple Creek near Nickerson, (*H*) Elkhorn River at Waterloo, and (*I*) Platte River at Louisville, Nebraska.

B. Platte River near Grand Island (sampling site 2, fig. 1)



Base from Defense Mapping Agency, digital data, 1:1,000,000, 1993
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30'

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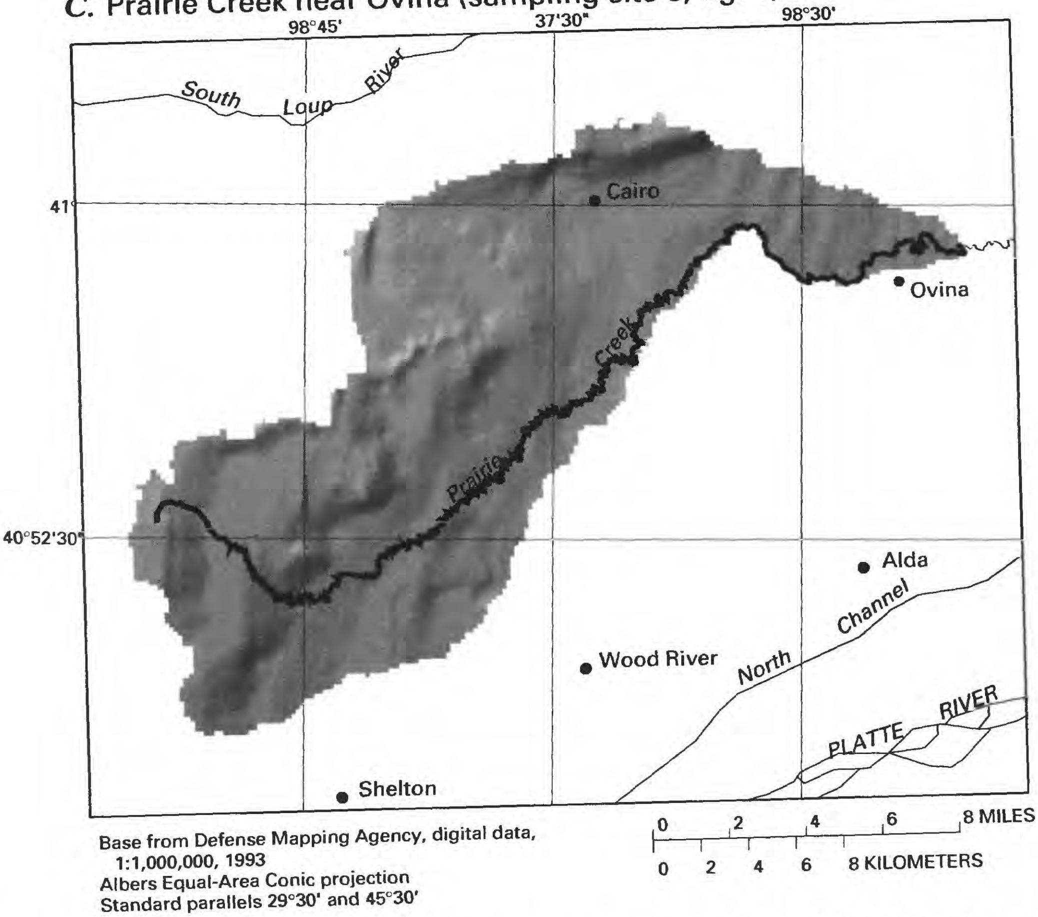
C. Prairie Creek near Ovina (sampling site 3, fig. 1)



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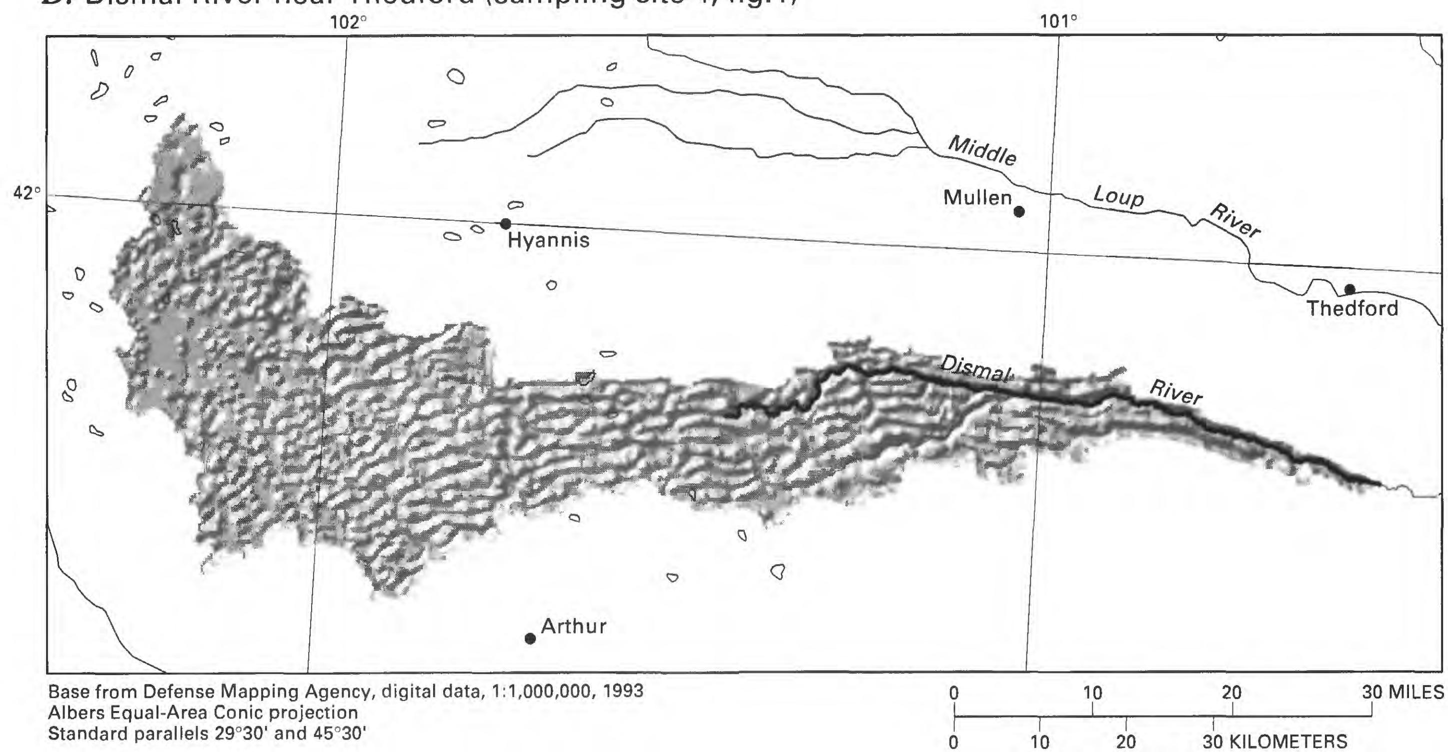
computed as the difference between the two elevations divided by the stream distance between the two points.

Drainage texture is a measure of the lateral spacing of stream channels in the basin and is defined within NAWQA as the ratio of the number of stream channels crossing through a specific land-surface-elevation plane and the length of the basin perimeter (Meador and others, 1993). The NAWQA guidelines indicated that the specific land-surface elevation to be used for each basin was the elevation represented by the most crenated contour line. Drainage texture was determined manually, with assistance from GIS analysis of raster DEM data, using the following procedure:

(1) It was not practical to examine the crenateness of all elevation contours in each selected basin. Instead, two to three crenate contours were identified for each basin by inspecting the frequency distribution of elevations in each basin. The most-crenated contour was expected to be the longest contour and thus would coincide with a peak in the frequency distribution. The spatial distribution of the identified contours was examined in relation to the stream network using GIS map displays. Elevations of contour lines selected as "most crenated" were, by basin number (table 1): basin 3, 625 m; basin 4, 1,158 m; basin 6, 564 m; basin 7, 472 m; and basin 9, 853 m. Drainage texture was not computed for basins 1, 2, 5, or 8 due to time and resource constraints.

(2) Once a specific elevation had been selected as the most-crenated contour, visual analysis was performed using either 1:24,000-scale USGS topographic quadrangles covering the basin or 1:100,000-scale digital hydrography data plotted on the 1:250,000-scale DEM (shaded to high-

D. Dismal River near Thedford (sampling site 4, fig.1)



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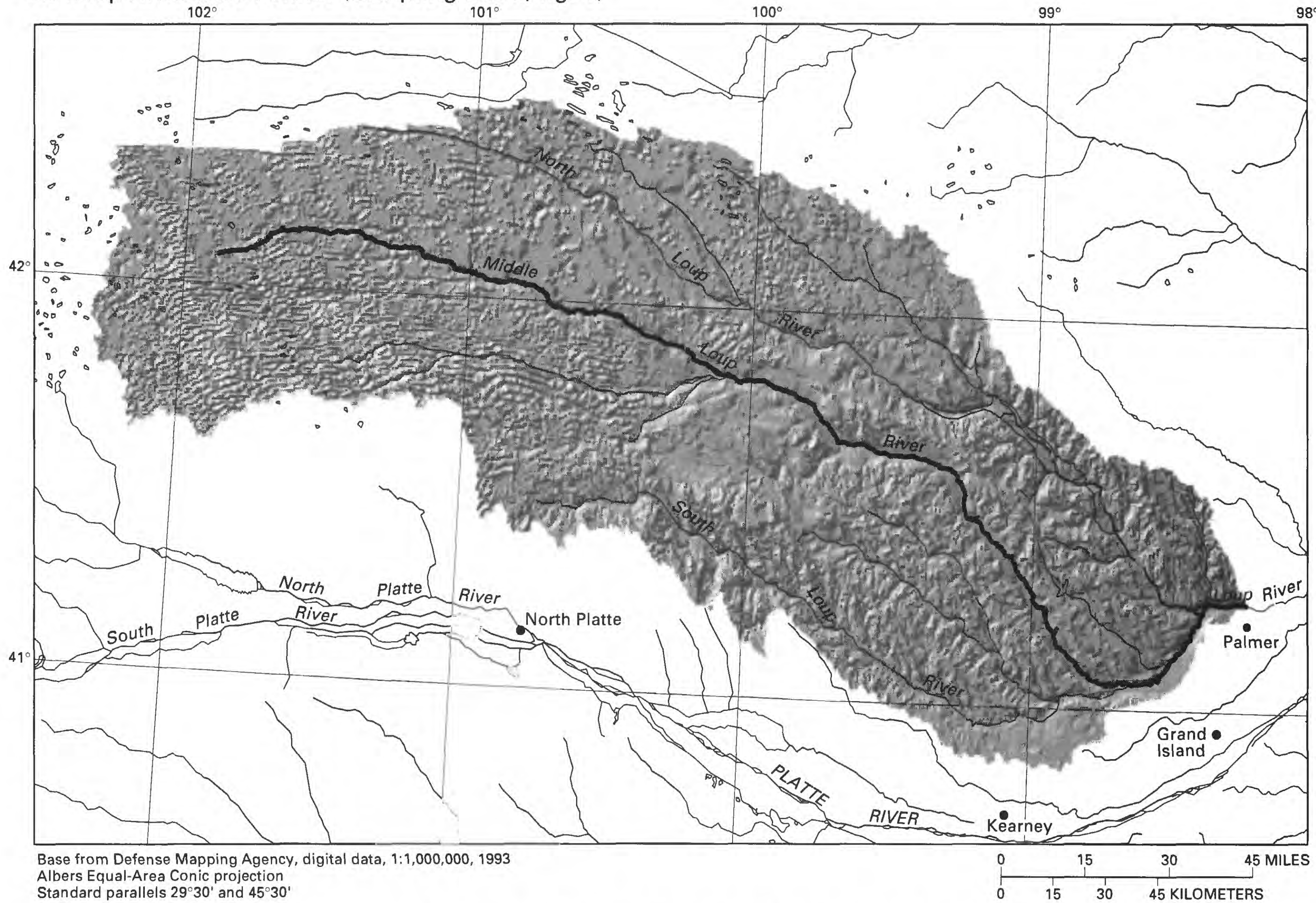
E. Loup River near Palmer (sampling site 5, fig. 1)



Base from Defense Mapping Agency, digital data, 1:1,000,000, 1993
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30'

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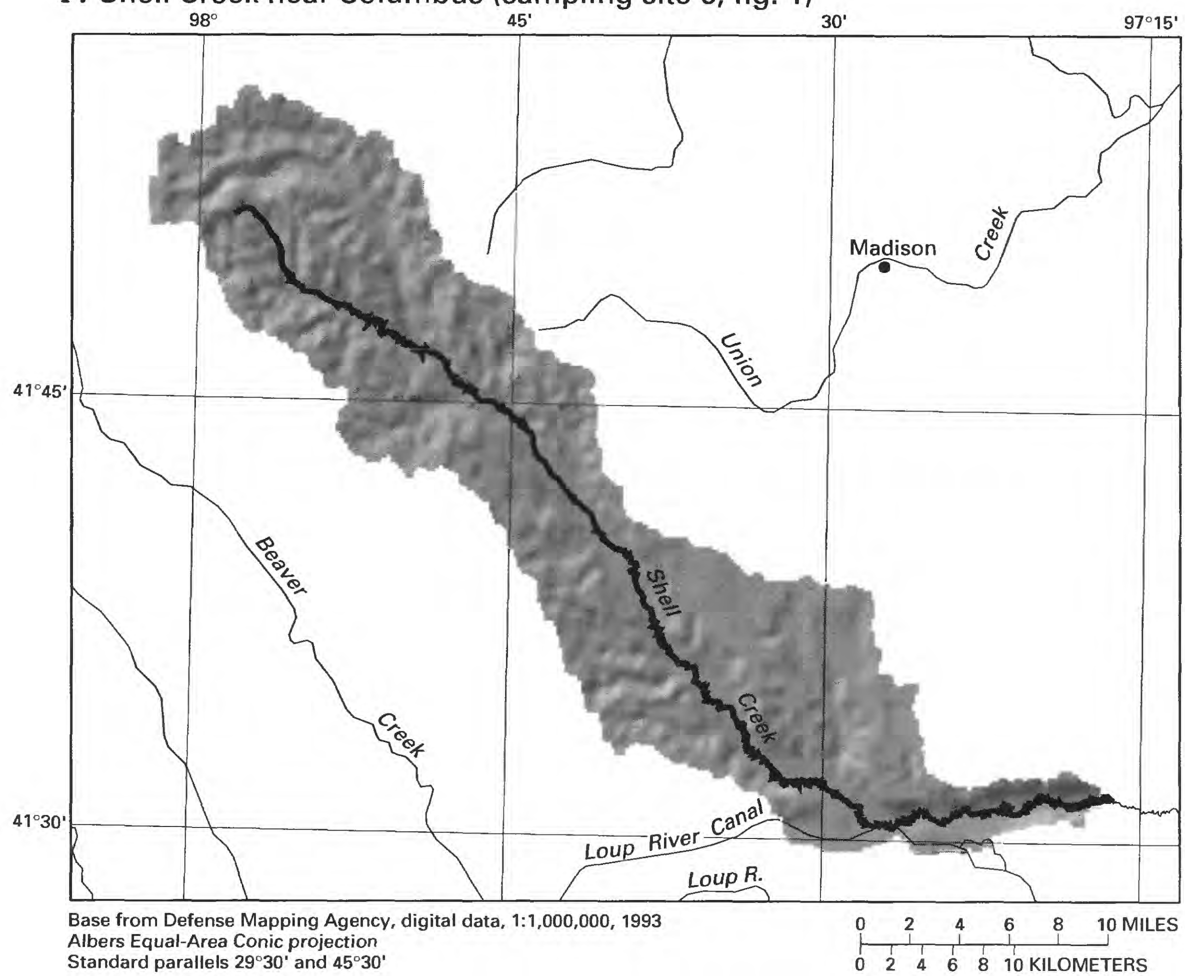
F. Shell Creek near Columbus (sampling site 6, fig. 1)



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light the area above the selected elevation). Points where stream channels intersected the selected crenate contour were identified and manually enumerated in either case.

(3) The number of points where stream channels crossed the crenated contour was divided by the basin perimeter to derive the basin drainage texture.

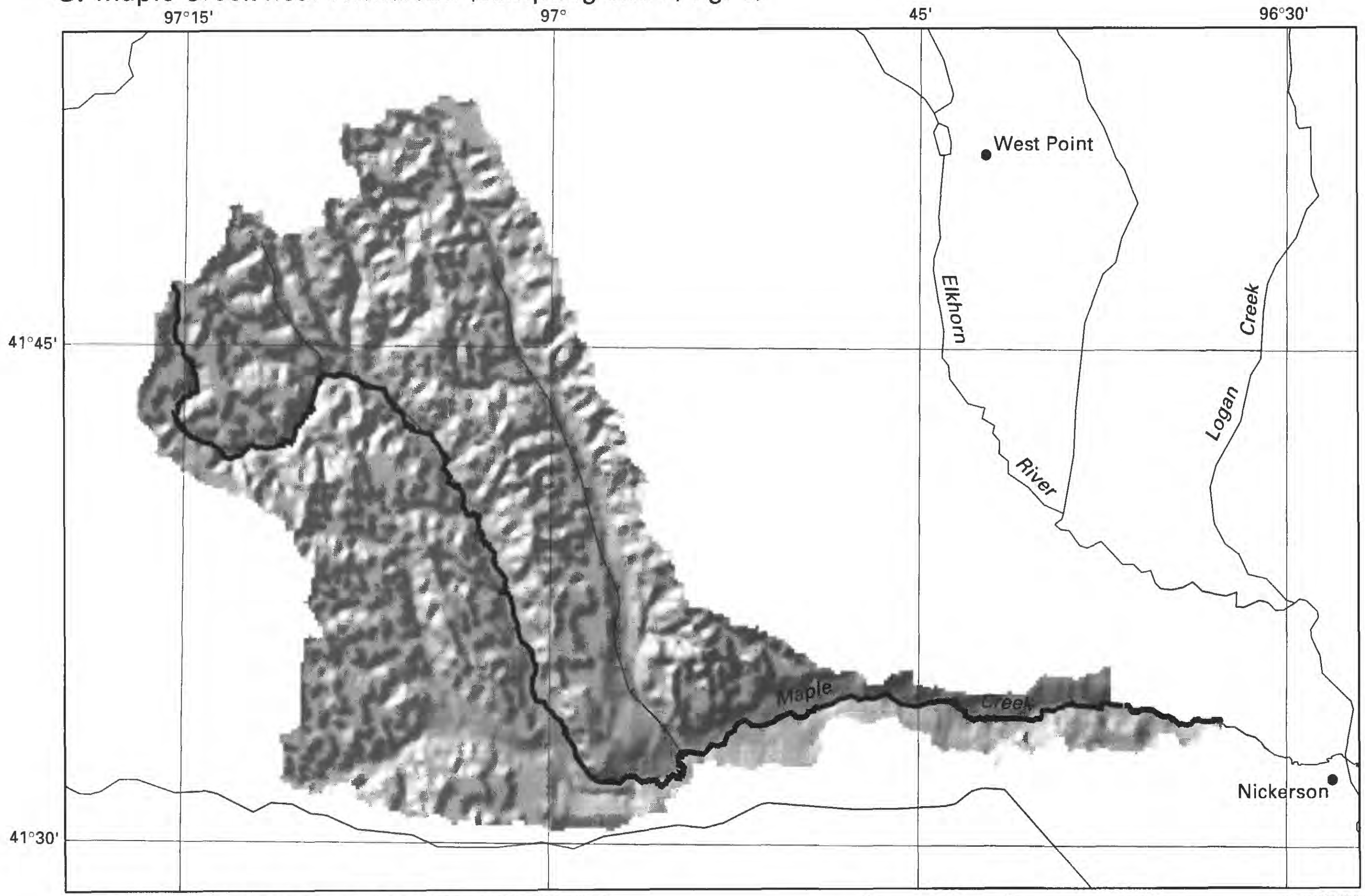
Integrated Environmental Settings

Two sources of data were available that show the geographic distribution of environmental settings. These settings integrate many interrelated characteristics, such as hydrologic, geologic, physiographic, water-use, and land-use features (Huntzinger and Ellis, 1993).

Central Nebraska Basins Study Subunits

The CNB study unit was divided into four major environmental subunits (fig. 3) defined by similarities in surficial deposits, morphology, land use, and hydrogeology (Huntzinger and Ellis, 1993). A digital vector map of these subunits was assembled from digital maps of general soils (U.S. Soil Conservation Service, 1992b) and glacial deposits (adapted from Dreeszen, 1970).

G. Maple Creek near Nickerson (sampling site 7, fig. 1)



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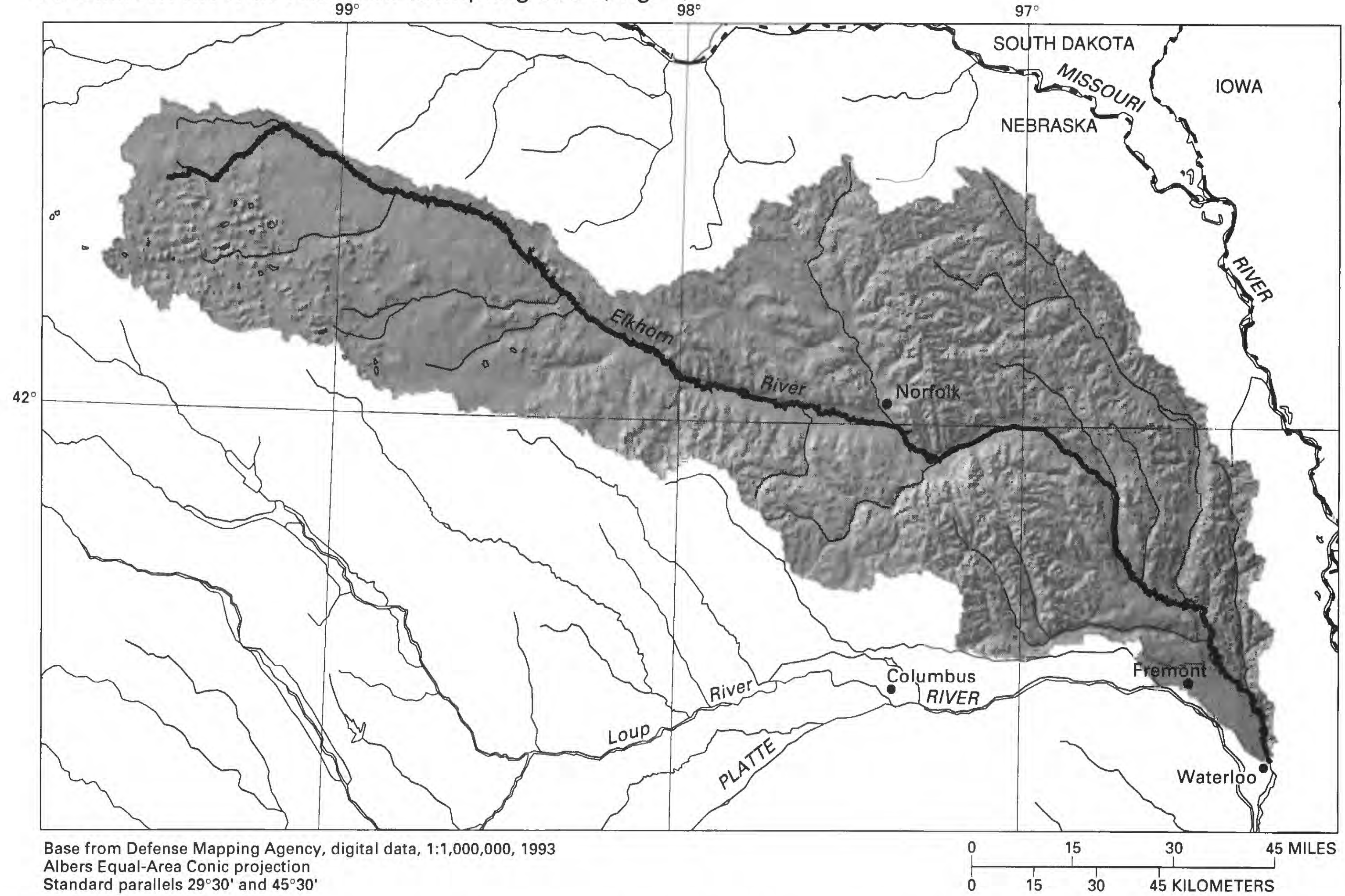
H. Elkhorn River at Waterloo (sampling site 8, fig. 1)



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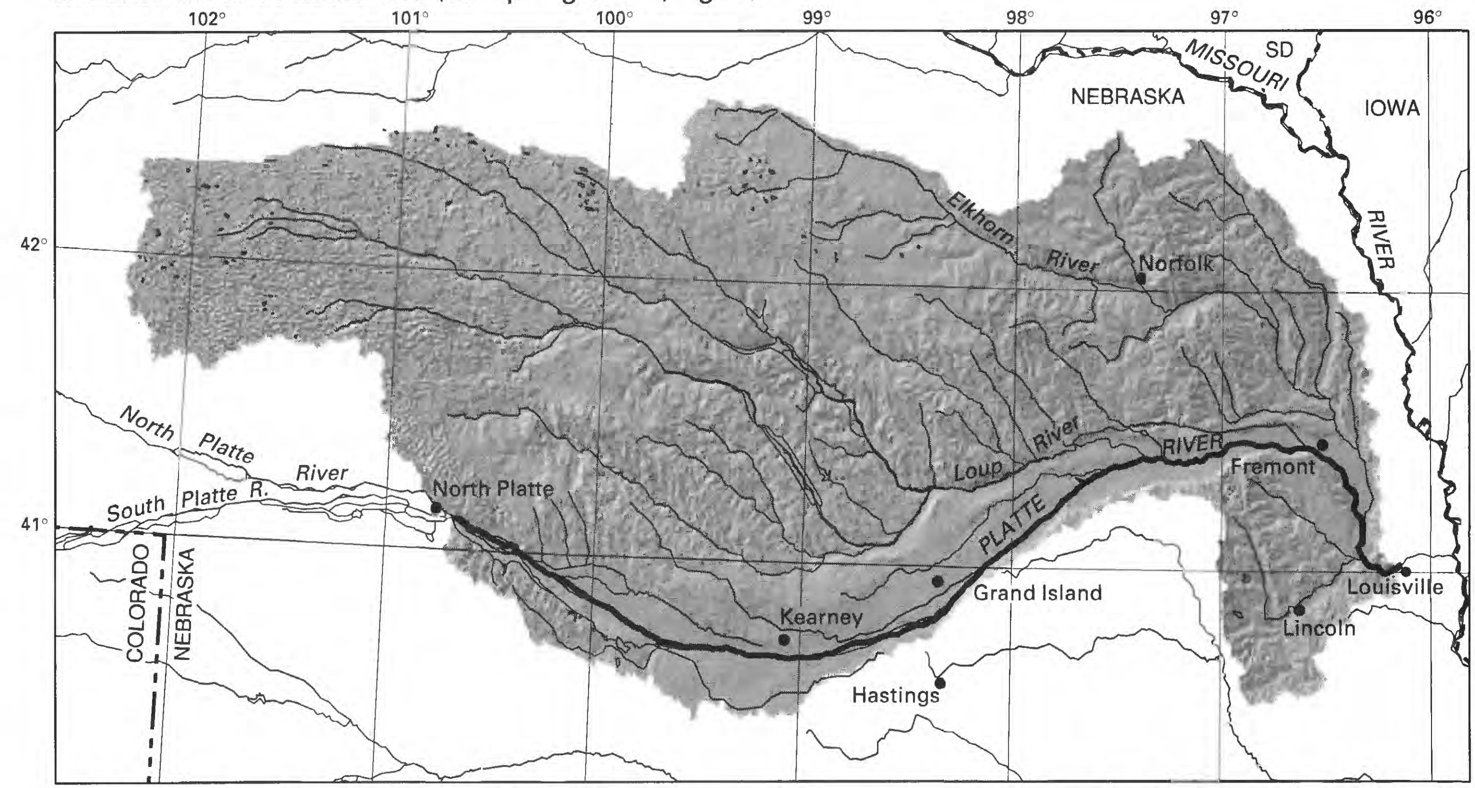
I. Platte River at Louisville (sampling site 9, fig. 1)



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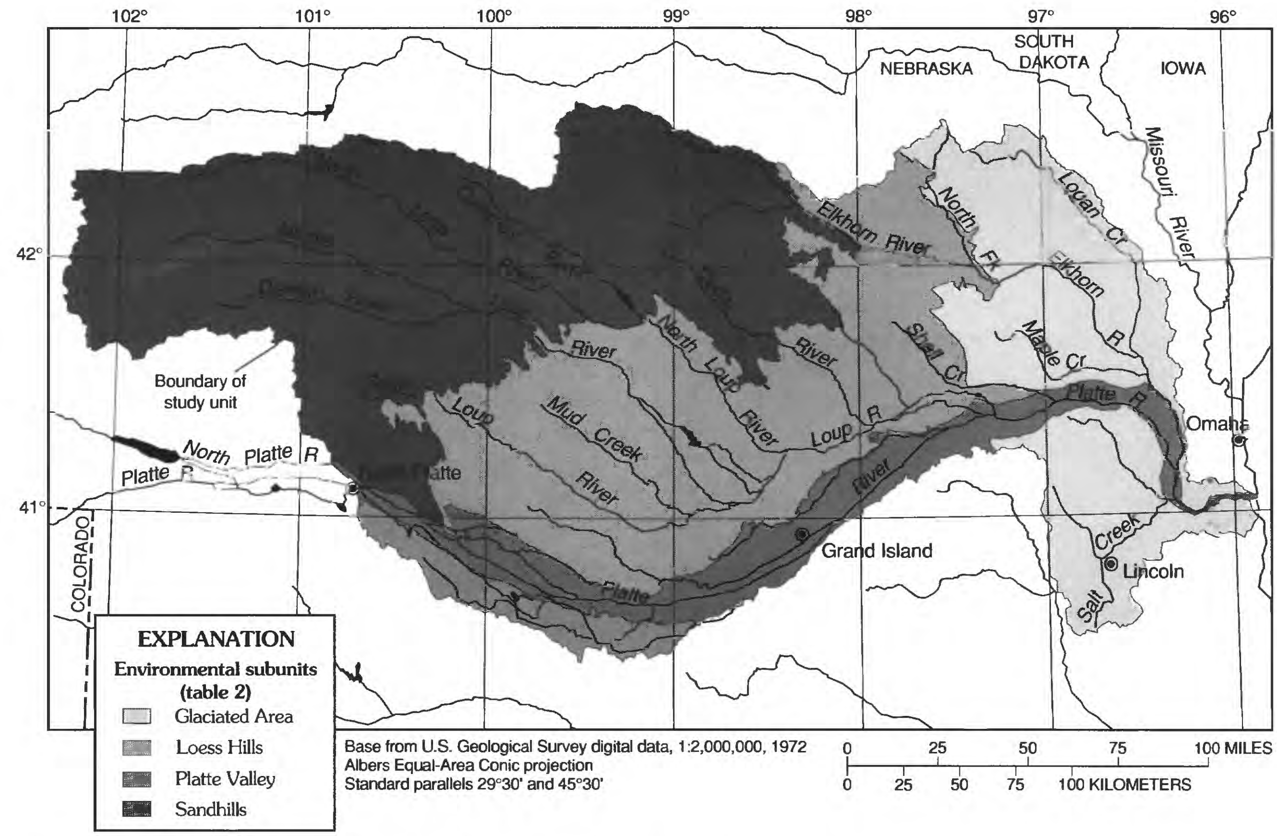

Figure 3. Environmental subunits of the Central Nebraska Basins study unit.

Ecoregions

Ecoregions are based on patterns of a combination of integrative factors including land use, morphology, natural vegetation, and soils (Omernik, 1987). At a scale of 1:7,500,000, Omernik (1987) mapped the principal ecoregions of the United States. A digital version of the map (Naomi Nakagaki, U.S. Geological Survey, unpublished data, 1991) was acquired in a vector polygon format. A raster data set having 500-m spatial resolution was produced using GIS software. The GIS maps of basin boundaries were used to extract subsets of the ecoregions data for each selected basin so that the area of each mapped region could be tabulated for each basin.

Bedrock Geology

King and Beikman (1974) mapped the bedrock geology of the United States at a scale of 1:2,500,000. A digital version of the Nebraska part of the King and Beikman map was acquired from the NAWQA Program (Naomi Nakagaki, U.S. Geological Survey, unpublished data, 1992). This polygon data set was converted to a raster GIS data set having spatial resolution of 500 m. The GIS maps of basin boundaries were used to extract subsets of the geologic data for each selected basin so that the area of each mapped geologic unit could be tabulated for each basin.

Physiography

Physiography refers to the physical features of the Earth's surface. Two sources of physiographic data were summarized for the selected stream basins.

Physical Divisions

The CNB study unit lies entirely within the Interior Plains Division, but spans two physiographic provinces (Fenneman and Johnson, 1946)—the Dissected Till Plains Section of the Central Lowland Province includes the eastern part of the study unit, and the High Plains Section of the Great Plains Province includes the western part of the study unit. A digital vector map (G.P. Thelin, U.S. Geological Survey, unpublished data, 1992) of Fenneman's physical divisions was created at a nominal scale of 1:7,000,000. This polygon data set was converted to a raster GIS data set having spatial resolution of 500 m. The GIS maps of basin boundaries were used to extract subsets of the physical-divisions data for each selected basin so that the area of each mapped major division, province, and section could be tabulated for each basin.

Major Land Resource Areas

Major land resource areas (MLRA) (U.S. Soil Conservation Service, 1981) are geographic areas characterized by a particular pattern of soils, climate, water resources, and land cover. A digital vector map (Naomi Nakagaki, U.S. Geological Survey, unpublished data, 1991) of MLRA was acquired at a nominal scale of 1:2,000,000. This polygon data set was converted to a raster GIS data set having spatial resolution of 500 m. The GIS maps of basin boundaries were used to extract subsets of the MLRA data for each selected basin so that the area of each mapped resource area could be tabulated for each basin.

Selected Generalized Soils

Digital spatial data defining the generalized soil map units in Nebraska were produced by the U.S. Soil Conservation Service (1992b). The polygon data were digitized from 1:250,000-scale maps having limited spatial resolution but that are the most detailed consistent source for soils data across the CNB study unit. The polygon data set was converted to a raster GIS data set having a spatial resolution of 500 m. The GIS maps of basin boundaries were used to extract subsets of the soils data for each selected basin so that the area of each map unit could be tabulated for each basin.

Because numerous generalized soil map units cover very small percentages of each stream basin, the relative areal extent of generalized soils was tabulated only for selected soils. Only those generalized soils that compose more than 2 percent of any selected basin, or that compose more than 1 percent of the CNB study unit, were tabulated.

Land Use and Land Cover

Many studies have found significant relations between water-quality characteristics and basin-level land-use and land-cover characteristics. Because of its importance for understanding the water-quality data collected for the CNB study, extra effort was made to describe land use and land cover in the stream basins of interest in the study unit. Four sources of this information were summarized by basin.

Land-Cover Sampling of 1993–94

The CNB study unit was divided into 13 land-cover strata on the basis of seasonally distinct land-cover regions (U.S. Geological Survey and University of Nebraska-Lincoln, 1993), which were derived from GIS processing of 1990 satellite imagery. There were some areas of the study unit that were not included in any of the 13 strata. The digital map of land-cover strata had a spatial resolution of 1 km.

Observed land cover in 1993 or 1994 was recorded onsite at sampling sites selected within each stratum. The average land-cover characteristics of each stratum were computed from the sampling results (Zelt, Dugan, and Kelley, 1995). GIS processing was performed to tabulate the percentage of each selected basin covered by each land-cover stratum. Areally weighted estimates of selected land-cover characteristics for each basin were computed from the average strata characteristics and the percentage of the basin covered by each stratum. The selected characteristics were corn, row crops (for the CNB study unit, those are corn, sorghum, and soybeans), and grasses. Those characteristics were found by Zelt, Brown, and Kelley (1995) to have the most accurate areal estimates on the basis of the sampling results. Areas not included in the 13 land-cover strata, and therefore not sampled, were assumed to contain no row crops but to be about half covered by grasses.

National Resources Inventory of 1992

In 1992, the U.S. Department of Agriculture's Soil Conservation Service (SCS) inventoried land use and land cover, among other natural resource characteristics, on non-Federal rural land in the United States as part of its national resources inventory (NRI) (U.S. Soil Conservation Service, 1994). Within the CNB study unit, records from 9,384 sample points make up the 1992 NRI data set. Each sample point's location is geocoded only for county, MLRA (U.S. Soil Conservation Service, 1981), and USGS hydrologic cataloging unit (Seaber and others, 1986).

Digital maps of county boundaries (U.S. Bureau of the Census, 1992), MLRAs (Naomi Nakagaki, U.S.

Geological Survey, unpublished data, 1991), and hydrologic cataloging units (U.S. Soil Conservation Service, Lincoln, Nebr., unpublished data, 1993) were mutually registered and visually analyzed to select a subset of the geometric intersection of the three data sets that best represented each of the basins of interest. Then, the NRI sample-point records for each basin subset were summarized with respect to selected land-use and land-cover characteristics.

Land Use and Land Cover of 1973–81

When compared with either the 1992 or 1993–94 data sets just discussed, the USGS land-use and land-cover data (U.S. Geological Survey, 1986) are more spatially detailed but also more dated; the 1- by 2-degree quadrangles covering the CNB study unit were interpreted from aerial photography from 1973–81. The USGS data, having a nominal scale of 1:250,000, are not a large-scale source yet were the most spatially detailed with consistent coverage of the entire study unit.

Eleven of the quadrangle data sets (U.S. Geological Survey, 1979a, b, c, d, e, f, g; 1981; 1982a, b, c) were acquired for the purpose of computing basin-level land-use characteristics. The quadrangle data sets, as digital vector files, were processed individually using GIS software to produce raster data sets having a spatial resolution of 100 m and encoding the Level II land-use and land-cover class (Anderson and others, 1976). A single land-use data set then was produced by mosaicking the 11 quadrangle data sets. Finally, subsets of the land-use data were extracted for each selected basin using GIS basin maps. The percentage of each basin covered by each land-use and land-cover class was computed using GIS software.

Natural Vegetation

The potential natural vegetation of the United States is mapped (Kuchler, 1964) at a scale of 1:3,168,000. Potential natural vegetation is defined by Kuchler as "...vegetation that would exist today if man were removed from the scene and if plant succession after his removal were telescoped into a single moment." Potential natural vegetation is thus the expected natural land cover of an area. Kuchler's classification of vegetation is based on whether plants are woody or herbaceous and, if woody, on whether they are broadleaf or needleleaf, evergreen or deciduous. A digital vector data set (G.P. Thelin, U.S. Geological Survey, unpublished data, 1991) was provided for computation of basin-level vegetation characteristics that were of interest to the NAWQA Program for national-scale assessment.

A raster GIS version of the digital vector data was produced using 500-m grid cells, although the resolution of the vector map polygons probably is not that fine. The GIS maps of basin boundaries then were used to extract subsets of the natural vegetation data set for each selected basin. The percentage of each basin covered by each natural vegetation class of interest was computed using GIS software.

Climate

Climatic data were obtained from three sources. Precipitation and temperature normals for Nebraska climate stations were published by Owenby and Ezell (1992); those data are also distributed electronically and were obtained in that form. Monthly precipitation data for Nebraska climate stations (in both the cooperative and National Weather Service networks) are available electronically via Internet retrieval. The April 28, 1995, version of the Nebraska data set was retrieved from the National Climatic Data Center's Internet site. Free-water-surface evaporation maps for the United States were published by Farnsworth and others (1982).

Precipitation

Mean annual precipitation data for 1961–90 for 210 climate stations were processed using a finite-difference interpolation technique (ESRI "Topogrid" command) that is based on Hutchinson (1989) to produce a raster GIS data set encompassing the CNB study unit. The same interpolation method was used with mean monthly precipitation data to produce raster GIS data sets for May, June, and July precipitation for 1961–90. Precipitation during those 3 months is particularly relevant for water-quality assessment in agricultural areas of the Midwest (Goolsby and others, 1991; Stamer, 1996).

Monthly precipitation data for 1992–94 for 219 climate stations were processed using inverse-distance-weighted interpolation to produce 36 raster GIS data sets—one per month. By this method, climate stations with no data for a specific month were excluded from processing only for that month. Raster GIS data sets of annual precipitation for 1992, 1993, and 1994 were calculated by summing the monthly raster data sets for each respective year. Raster GIS data sets of May–July monthly departure from normal precipitation were calculated by subtracting the mean monthly precipitation data set from the respective monthly precipitation data set.

All raster GIS data sets produced for precipitation data had a spatial resolution of 1 km. Finally, the GIS maps of basin boundaries were used to extract precipitation data subsets for each selected basin. The area-weighted basin average for each precipitation characteristic of interest was computed using GIS software.

Temperature

Mean annual temperature data for 1961–90 for 125 climate stations were processed using the finite-difference interpolation technique to produce a raster GIS data set encompassing the CNB study unit. The GIS maps of basin boundaries were used to extract subsets of the temperature data set for each selected basin. GIS software computed the area-weighted basin average of mean annual temperature. Raster GIS processing again used a spatial resolution of 1 km.

Evaporation

Published mean annual free-water-surface evaporation maps for 1956–70 (Farnsworth and others, 1982) at about 1:5,000,000 scale were the basis for calculating average evaporation for the selected drainage basins. For the CNB study unit, published evaporation isopleths were at irregular intervals. Although 5.08-cm isopleth intervals were common, intervals twice as large were encountered. A digital GIS version of the isopleth map (D.W. Litke, U.S. Geological Survey, written commun., 1991) was processed using linear interpolation (ESRI "Arctin" and "Tinlattice" commands) to produce a raster GIS data set encompassing the CNB study unit. The GIS maps of basin boundaries were used to extract evaporation data subsets for each selected basin. The area-weighted basin average of mean annual evaporation was computed using GIS software. Raster GIS processing again used a spatial resolution of 1 km.

Runoff and Streamflow

The final two sets of basin-level characteristics summarized in this report are important components of water-balance equations. Runoff and streamflow characteristics of the selected basins were computed from streamflow data collected at the respective reference locations.

Runoff

Mean annual runoff values were based on streamflow summary statistics and total upstream drainage areas published for the selected sampling sites (Boohar and others, 1992; 1995), with one exception—no streamflow record exists for Loup River near Palmer (sampling site 5, fig. 1). However, an estimate of mean annual runoff was made on the basis of the sum of the published information for Middle Loup River at St. Paul and North Loup River near St. Paul. Runoff for Prairie Creek near Ovina (sampling site 3, fig. 1) was not characterized due to insufficient streamflow data.

Mean annual runoff was computed as the ratio of mean annual discharge to total upstream drainage area. Runoff values computed from those data are not adjusted for storage or diversions. The period of record for the published discharge statistic varies among the selected sampling sites (table 1), and the estimate for Loup River near Palmer was based on data from two gaging stations having differing periods of streamflow record.

Streamflow

Estimates of selected streamflow characteristics (M.C. Rowan, U.S. Geological Survey, written commun., 1994) either were computed from data retrieved from the NWIS peak-values file and daily-values file, or were based on published information (Beckman, 1976).

Peak flow and 7-day low flow for a series of recurrence intervals are streamflow characteristics of interest to the NAWQA Program (J.C. Scott, U.S. Geological Survey, written commun., 1994). Table 1 lists the period of streamflow record used for determining each basin's streamflow characteristics.

Peak flow

Estimated peak flow was computed for the 1-, 2-, 5-, 10-, 25- and 50-year recurrence intervals where available data permitted. Computations were performed using the ANNIE computer program (Lumb and others, 1990) developed by the USGS. Estimates were based on published USGS regional regression equations where sufficient streamflow data were not available. However, the regional regression publication did not include equations for the 1-year peak flow.

Peak-flow characteristics for Prairie Creek near Ovina (sampling site 3, fig. 1) and Loup River near Palmer (sampling site 5, fig. 1) were estimated using equations developed from the published information. The estimates for Prairie Creek were made using the equations Beckman (1976, p. 22) reported for a part of the Loess Hills (fig. 3) that includes the Prairie Creek Basin. The variables in those equations are: (1) total drainage area upstream from the reference location; (2) maximum 24-hour, 50-year rainfall; and (3) main-stem stream length upstream from the reference location. The estimates for Loup River near Palmer were made using the equations Beckman (1976, p. 13) reported for the Sandhills environmental subunit (fig. 3). The variables in those equations are: (1) contributing drainage area upstream from the reference location; (2) maximum 24-hour, 50-year rainfall; and (3) average main channel slope between the points 10 and 85 percent of the stream length upstream from the reference location.

Low flow

Estimated 7-day low flow was computed for 2-, 5-, 10-, and 25-year recurrence intervals, where available streamflow data permitted. Computations were performed using the ANNIE computer program (Lumb and others, 1990) developed by the USGS. Available streamflow records for Prairie Creek near Ovina (sampling site 3, fig. 1) and Loup River near Palmer (sampling site 5, fig. 1) were insufficient to permit estimation of low-flow characteristics.

BASIN-LEVEL HABITAT CHARACTERISTICS OF SELECTED STREAMS

The results of the various computations are summarized in table 2. The selected basin-level habitat characteristics are tabulated by characteristic group in the same order that sources of data and methods of analysis were presented. The columns of basin characteristics are arranged in downstream order of the reference locations.

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Table 2. Summary of basin-level habitat characteristics of selected streams, central Nebraska

[Only that part of the drainage basin within the study unit is included; values are percentages of drainage area unless specified otherwise; percentages may not sum to 100 due to rounding or partial listing of categories; --, computation not performed; km^2, square kilometers; km, kilometers; m, meters; m/km, meters per kilometer; mm, millimeters; °C, degrees Celsius; cm, centimeters; m^3/s, cubic meters per second]

Characteristic or category (unit of measurement)	Sampling-site number ( ) and name (fig. 1, table 1) (1) Platte River at Brady	(2) Platte River near Grand Island	(3) Prairie Creek near Ovina	(4) Dismal River near Thedford	(5) Loup River near Palmer	(6) Shell Creek near Columbus	(7) Maple Creek near Nickerson	(8) Elkhorn River at Waterloo	(9) Platte River at Louisville
Size and shape									
Total drainage area (km^2)	1,430	8,460	364	2,500	32,900	762	955	18,000	78,100
Contributing drainage area (km^2)	--	8,170	--	78	12,100	762	955	15,200	51,700
Basin perimeter (km)	354	987	117	555	1,433	223	232	1,133	2,260
Basin length (km)	104	258	37.4	148	352	74.6	68.3	312	526
Basin shape (unitless)	.13	.13	.26	.11	.27	.14	.20	.18	.28
Elevation and relief									
Maximum elevation (m)	1,123	1,123	655	1,280	1,292	636	539	823	1,292
Minimum elevation (m)	804	558	571	853	520	437	364	337	307
Mean elevation (m)	933	802	614	1,128	871	535	465	540	705
Basin relief (m)	319	565	84	427	772	199	175	486	985
Relative relief (m/km)	.90	.57	.72	.77	.54	.89	.75	.43	.44
Drainage network									
Main-stem stream length (km)	31.9	240	77.8	105	431	124	105	486	498
Main-channel mean elevation (m)	822	694	592	951	774	487	427	498	551
Main-channel mean slope, (m/km)	1.12	1.19	.669	2.15	1.31	.940	1.12	.761	1.10
Drainage texture (km^{-1})									
1:24,000 scale	--	--	.47	--	--	.45	.95	--	--
1:100,000 scale	--	--	.15	0	--	.28	.43	--	.13
Integrated environmental setting									
Environmental subunits (fig. 3)									
Glaciated Area	0	0	0	0	0	2	100	48	18
Loess Hills	.8	44	63	0	35	98	0	21	33
Platte Valley	15	33	37	0	0	0	0	1.6	9
Sandhills	84	23	0	100	65	0	0	30	40
Ecoregions									
Central Great Plains	0	60	100	0	32	84	52	8	34
Nebraska Sandhills	100	40	0	100	68	0	0	23	42
Northeastern Great Plains	0	0	0	0	0	0	0	5	1.1
Northern Glaciated Plains	0	0	0	0	0	16	0	44	10

Table 2. Summary of basin-level habitat characteristics of selected streams, central Nebraska—Continued

Characteristic or category (unit of measurement)	Sampling-site number ( ) and name (fig. 1, table 1)								
	(1) Platte River at Brady	(2) Platte River near Grand Island	(3) Prairie Creek near Ovina	(4) Dismal River near Thedford	(5) Loup River near Palmer	(6) Shell Creek near Columbus	(7) Maple Creek near Nickerson	(8) Elkhorn River at Waterloo	(9) Platte River at Louisville
Integrated environmental setting—Continued									
Ecoregions—Continued									
Western Corn Belt Plains	0	0	0	0	0	0	48	20	12
Bedrock geology									
Pliocene (Tertiary)	100	95	83	100	100	45	0	55	75
Oligocene (Tertiary)	0	0	0	0	0	0	0	.8	.2
Woodbine and Tuscaloosa Groups (Upper Cretaceous)	0	0	0	0	0	0	26	14	9
Washita Group (Lower Cretaceous)	0	4	17	0	.2	0	0	0	1.4
Fredericksburg Group (Lower Cretaceous)	0	.8	0	0	0	55	74	30	13
Permian	0	0	0	0	0	0	0	0	.5
Upper Pennsylvanian	0	0	0	0	0	0	0	0	.8
Physiography									
Physical divisions									
Dissected Till Plains	0	0	0	0	0	0	100	49	19
High Plains	100	100	100	100	100	100	0	51	81
Major land resource areas									
Central High Tableland	16	5	0	0	0	0	0	0	.6
Central Loess Plains	0	19	0	0	0	0	0	0	2
Central Nebraska Loess Hills	2	37	100	0	36	0	0	0	26
Dakota-Nebraska Eroded Tableland	0	0	0	0	0	0	0	4	.8
Loess Uplands and Till Plains	0	0	0	0	0	100	100	69	23
Nebraska-Kansas Loess-Drift Hills	0	0	0	0	0	0	0	1.3	6
Nebraska Sandhills	81	21	0	100	64	0	0	26	38
Rolling Plains and Breaks	0	17	0	0	0	0	0	0	1.9
Selected generalized soils									
Belfore-Moody-Fillmore	0	0	0	0	0	10	.2	.9	.5
Coly-Uly-Hobbs	.9	16	0	0	14	0	0	0	9
Hord-Cozad-Hobbs	2	14	0	0	2	0	0	0	.3

Table 2. Summary of basin-level habitat characteristics of selected streams, central Nebraska—Continued

Characteristic or category (unit of measurement)	Sampling-site number ( ) and name (fig. 1, table 1)								
	(1) Platte River at Brady	(2) Platte River near Grand Island	(3) Prairie Creek near Ovina	(4) Dismal River near Thedford	(5) Loup River near Palmer	(6) Shell Creek near Columbus	(7) Maple Creek near Nickerson	(8) Elkhorn River at Waterloo	(9) Platte River at Louisville
Selected generalized soils—Continued									
Els-Valentine-Ipage	0	0	0.9	0	0	0	0	8	2
Elsmere-Ipage-Loup	0	0	0	0	.1	0	0	8	2
Gibbon-Luton-Saltine	0	0	0	0	0	0	0	1.4	1.1
Gothenburg-Platte-Lex	4	6	0	0	0	0	0	0	.9
Hersh-Valentine-Holdrege	0	1.4	11	0	2	0	0	0	1.5
Hobbs-Hord-Hall	0	0	0	0	1.4	20	0	3	1.9
Holdrege-Detroit-Butler	.4	11	0	0	1.1	0	0	0	1.7
Holdrege-Hall-Uly	0	3	2	0	.9	0	0	0	.9
Hord-Hall-Wood River	0	1.3	16	0	0	0	0	0	1.0
Inavale-Boel-Loup	0	0	0	0	2	0	0	.5	1.3
Kenesaw-Hersh-Coly	0	4	7	0	.7	0	0	0	.9
Kennebec-Wabash-Zook	0	0	0	0	0	0	22	7	2
Lawet-Elsmere-Orwet	3	.6	0	0	0	0	0	.7	.2
Lawet-Lex-Wann	5	3	0	0	0	0	0	.4	.4
Moody-Fillmore-Nora	0	0	0	0	0	1.4	8	1.8	.7
Moody-Nora-Judson	0	0	0	0	0	0	9	13	3
Nora-Crofton-Moody	0	0	0	0	0	69	49	14	7
Nora-Moody-Judson	0	0	0	0	0	0	13	7	1.7
Sharpsburg-Pawnee-Judson	0	0	0	0	0	0	0	0	2
Thurman-Boelus-Valentine	0	0	0	0	0	0	0	10	2
Uly-Coly-Holdrege	0	4	21	0	6	0	0	0	4
Uly-Holdrege-Coly	0	3	13	0	.8	0	0	0	.7
Valentine-Dunday-Ipage	9	3	0	2	3	0	0	.5	2
Valentine-Els-Ipage	0	0	0	0	2	0	0	5	3
Valentine-Els-Loup	0	0	0	27	13	0	0	3	6

Table 2. Summary of basin-level habitat characteristics of selected streams, central Nebraska—Continued

Characteristic or category (unit of measurement)	Sampling-site number ( ) and name (fig. 1, table 1)								
	(1) Platte River at Brady	(2) Platte River near Grand Island	(3) Prairie Creek near Ovina	(4) Dismal River near Thedford	(5) Loup River near Palmer	(6) Shell Creek near Columbus	(7) Maple Creek near Nickerson	(8) Elkhorn River at Waterloo	(9) Platte River at Louisville
Selected generalized soils—Continued									
Valentine-Els-Wildhorse	0	0	0	4	0.7	0	0	0	0.3
Valentine-Hersh-Libory	1.6	4	0	0	1.5	0	0	0	1.1
Valentine-Ipage-Els	9	1.6	0	60	25	0	0	2	11
Valentine-Simeon-Hersh	64	18	0	5	19	0	0	.3	12
Valentine-Thurman-Doger	0	.3	6	0	.4	0	0	2	1.4
Wann-Gibbon-Leshara	0	3	0	0	.2	0	0	.6	1.5
Wood River-Hall-Hord	0	1.0	22	0	0	0	0	0	.4
Land use and land cover									
Land-cover sampling, 1993–94									
Row crops	4	31	66	.3	8	62	68	49	28
Corn	2	20	42	.2	6	40	43	31	19
Grasses	89	54	22	94	85	19	17	36	60
National resources inventory, 1992									
Cropland	--	41	65	1	14	76	76	56	36
Row crops	--	31	59	.2	9	68	66	47	29
Corn	--	28	52	.2	7	55	42	32	21
Pasture and range	--	49	19	95	81	7	14	33	54
Land use and land cover, 1973–81									
Cropland and pasture	14	50	92	6	26	98	99	84	55
Forest, deciduous	<.1	<.1	0	<.1	<.1	0	<.1	.6	.2
Rangeland, herbaceous	84	45	8	93	73	1.1	.1	14	43
Urban or built-up land	.5	.8	.3	0	.1	.4	.3	.7	.8
Water—lakes and reservoirs	.1	.2	0	.3	.2	0	0	.1	.2
Wetland, forested	2	3	0	0	.1	0	0	.2	.6
Wetland, nonforested	<.1	.5	0	.4	.2	0	0	.1	.3
Natural vegetation									
Bluestem Prairie	0	0	0	0	0	100	97	51	22
Nebraska Sandhills Prairie	86	25	5	100	65	0	0	24	40
Northern Flood-Plain Forest	14	24	0	0	.3	0	3	11	8

Table 2. Summary of basin-level habitat characteristics of selected streams, central Nebraska—Continued

Characteristic or category (unit of measurement)	Sampling-site number ( ) and name (fig. 1, table 1) (1) Platte River at Brady	(2) Platte River near Grand Island	(3) Prairie Creek near Ovina	(4) Dismal River near Thedford	(5) Loup River near Palmer	(6) Shell Creek near Columbus	(7) Maple Creek near Nickerson	(8) Elkhorn River at Waterloo	(9) Platte River at Louisville
Land use and land cover—Continued									
Natural vegetation—Continued									
Wheatgrass-Bluestem-Needlegrass Prairie	0.1	52	95	0	35	0	0	14	29
Climate									
Annual precipitation (mm)									
Mean annual, 1961–90	509	564	639	477	562	685	727	657	614
Annual, 1992	537	561	658	460	559	707	795	790	654
Annual, 1993	694	812	949	631	766	932	915	881	841
Annual, 1994	504	558	620	465	557	677	666	684	614
Monthly precipitation (mm)									
Mean May, 1961–90	90.9	94.0	101	86.4	89.7	101	112	97.0	94.7
Mean June, 1961–90	86.1	97.0	104	78.5	90.9	113	91.4	107	98.8
Mean July, 1961–90	79.2	80.5	76.2	76.5	81.0	84.0	77.2	80.8	81.0
May 1992 departure from normal	-45.2	-56.4	-34.0	-66.3	-59.7	-17.0	-32.3	-25.4	-45.0
June 1992 departure from normal	3.8	-19.0	6.9	40.6	13.2	-21.1	-2.3	.5	.8
July 1992 departure from normal	13.5	53.3	52.3	23.9	34.8	72.6	92.5	61.0	55.4
May 1993 departure from normal	-24.4	-14.0	-5.8	-27.7	-6.6	12.7	-2.8	10.2	-.1
June 1993 departure from normal	51.3	56.1	92.5	29.0	52.6	35.1	25.9	28.7	49.0
July 1993 departure from normal	79.8	140	207	40.4	94.2	159	179	141	130
May 1994 departure from normal	-66.5	-67.8	-69.8	-47.8	-60.5	-74.4	-83.3	-67.1	-64.3
June 1994 departure from normal	37.8	16.0	-7.1	-7.1	7.4	3.6	-27.4	21.1	15.2
July 1994 departure from normal	52.1	65.0	71.6	57.2	68.3	104	104	80.8	73.4
Mean temperature (°C)									
Mean annual, 1961–90	8.9	9.6	9.6	8.4	8.8	9.1	9.6	9.1	9.2
Free-water-surface evaporation (cm)									
Mean annual, 1956–70	122	123	120	122	120	114	110	112	117
Runoff and Streamflow									
Runoff (mm)									
Mean annual	4.75	9.33	--	70.8	56.9	55.1	68.6	62.7	27.2

Table 2. Summary of basin-level habitat characteristics of selected streams, central Nebraska—Continued

Characteristic or category (unit of measurement)	(1) Platte River at Brady	(2) Platte River near Grand Island	(3) Prairie Creek near Ovina	(4) Dismal River near Thedford	(5) Loup River near Palmer	(6) Shell Creek near Columbus	(7) Maple Creek near Nickerson	(8) Elkhorn River at Waterloo	(9) Platte River at Louisville
Runoff and Streamflow—Continued									
Peak flow (m^3/s) for indicated recurrence interval									
1 year	22.6	51.0	--	6.97	--	5.83	37.4	60.0	309
2 year	97.7	190	16.9	8.75	287	43.3	81.8	323	1,380
5 year	221	326	42.5	11.8	609	83.0	166	663	2,360
10 year	374	436	68.1	15.0	943	119	267	957	3,090
25 year	538	600	115	21.9	1,560	168	430	1,370	4,160
50 year	683	770	163	30.0	2,220	223	569	1,780	4,760
Seven-day low flow (m^3/s) for indicated recurrence interval									
2 year	2.80	2.15	--	4.96	--	.139	.0552	7.48	36.5
5 year	2.24	.651	--	4.67	--	.0736	.0156	4.64	20.2
10 year	1.87	.340	--	4.47	--	.0595	.0093	3.60	14.0
25 year	.793	.187	--	4.39	--	.0496	.0057	2.78	8.21

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