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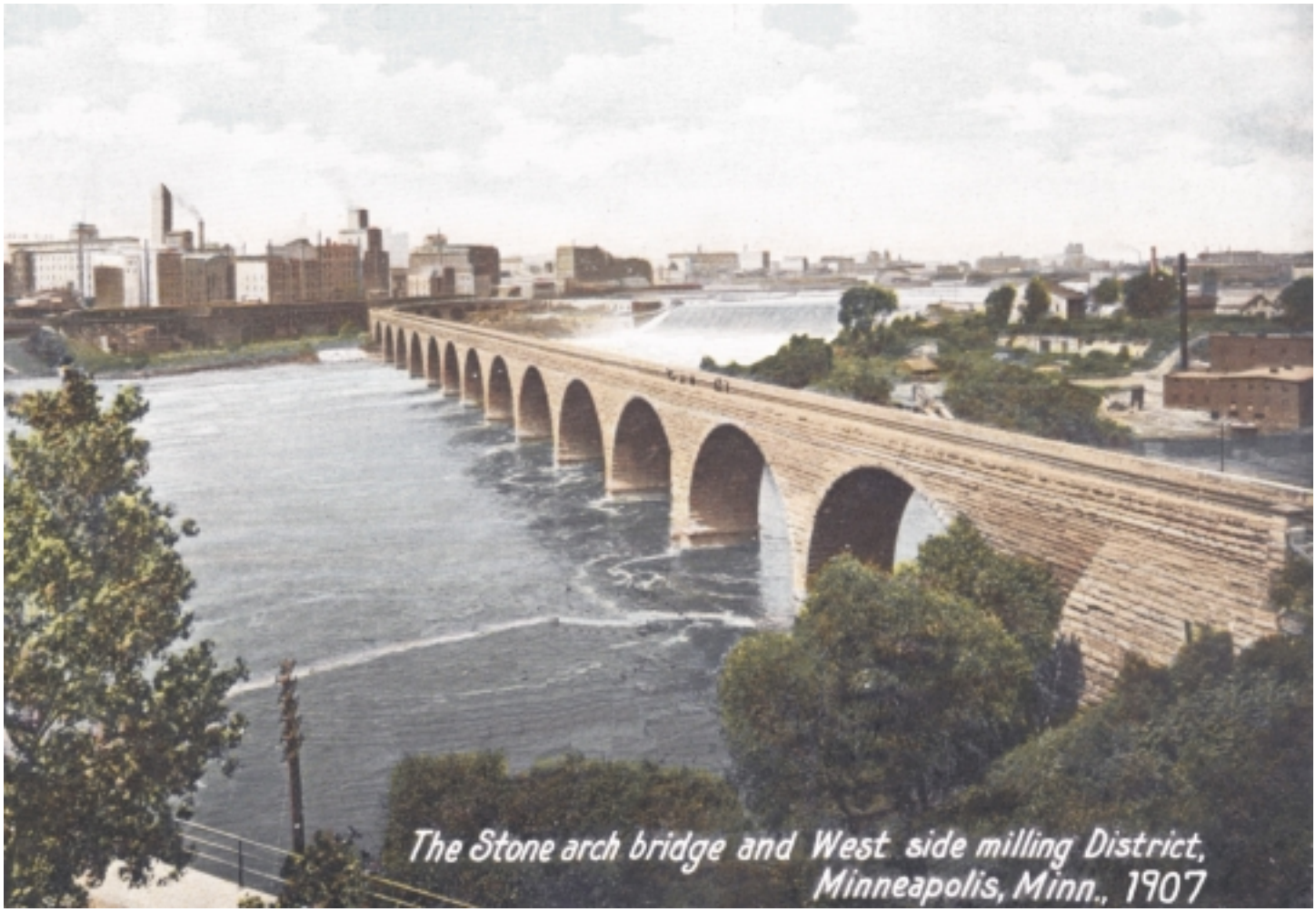
Water-Quality Assessment of Part of the Upper Mississippi River Basin, Minnesota and Wisconsin—Design and Implementation of Water-Quality Studies, 1995-98

Water-Resources Investigations Report 99-4135



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Water-Quality Assessment of Part of the Upper Mississippi River Basin, Minnesota and Wisconsin—Design and Implementation of Water-Quality Studies, 1995-98

By James R. Stark, James D. Fallon, Alison L. Fong, Robert M. Goldstein, Paul E. Hanson, Sharon E. Kroening, and Kathy E. Lee

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National Water-Quality Assessment Program

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Mounds View, Minnesota, 1999

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Water-Resources Investigations Report 99-4135

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 policy makers 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 a specific contamination problem; 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 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 59 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 59 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, Abbreviated Water-Quality Units, and Vertical Datum,

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
acre	0.004047	square kilometer
square mile (mi^2)	259.0	hectare
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
million gallons per day (Mgal/d)	.04381	cubic meters per second
degrees Fahrenheit (°F)	°C = (°F - 32)/1.8	degrees Celsius (°C)

Chemical concentrations are given in metric units. Chemical concentrations of substances in water are given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as mass (milligrams) of solute per unit volume (liter) of water. Micrograms per liter is a unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

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

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Abstract

From 1995 through 1998, water-quality and aquatic-biological samples were collected, processed, and analyzed for the U.S. Geological Survey's National Water-Quality Assessment Program in the Upper Mississippi River Basin in Minnesota and Wisconsin. Sites were selected and samples collected for integrated studies designed to provide a comprehensive description of water-quality conditions, to identify trends, and to determine the factors that affect existing conditions.

This report describes the design, site-selection, and implementation of the study. Methods used to collect, process, and analyze samples; characterize sites; and assess habitat are described. A comprehensive list of sample sites is provided. Sample analyses for water-quality studies included chlorophyll *a*, major inorganic constituents, nutrients, trace elements, tritium, radon, environmental isotopes, organic carbon, pesticides, volatile organic compounds, and other synthetic and naturally-occurring organic compounds. Aquatic-biological samples included fish, benthic macroinvertebrates, and algal enumeration and identification, as well as synthetic-organic compounds and trace elements in fish tissue.

Introduction

Goals of the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program are achieved through investigation 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 diverse hydrologic settings. More than two-thirds of the Nation's freshwater use occurs within the study units and more than two-thirds of the people served by public water-supply systems live within their boundaries. National synthesis of NAWQA data, 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 (water chemistry and aquatic communities) using nationally consistent information. Comparative studies explain differences and similarities in water-quality conditions among study units, and identify changes and trends and their causes.

Activities in each NAWQA study unit are organized around four major components:

(1) Retrospective analyses of existing water-quality and aquatic-biological data to discover the strengths and weaknesses

of available data and to set priorities for study-unit data collection;

(2) Occurrence and distribution assessments of water-quality and aquatic-biological conditions by sampling surface and ground water and aquatic biology, and evaluation of sampling results in relation to natural and human factors affecting those conditions;

(3) Long-term trend and change assessments based on a strategy derived from the results of the retrospective analysis and the occurrence and distribution assessments, using ancillary information about changes in the factors affecting water-quality and aquatic-biological conditions; and

(4) Case studies of sources, transport, fate, and effects of selected contaminants to address important questions about the processes controlling water-quality and aquatic-biological conditions.

The first six years of study in each study unit focus on retrospective analyses and occurrence and distribution components. The study is designed to address high-priority water-quality issues affecting each study unit. Following initial study-unit planning, existing water-quality data are analyzed to help guide the design of the first occurrence and distribution (intensive phase) sampling. Intensive phase efforts consist of a three-year period of increased emphasis on sampling and analysis. Water-quality data resulting from these sampling activities are interpreted and related to possible natural and human factors that affect water quality. Summary reports conclude the first phase of the study followed by activities with a lesser emphasis on sampling. Intensive phase sampling efforts are intended to recur on a ten-year interval.

The Upper Mississippi River Basin (UMIS) study unit was one of 17 studies started in 1994. This group of study units focused on nutrients, pesticides, and volatile organic compounds (VOCs). The NAWQA Program has identified the study of the occurrence and distribution of these compounds as high-priority water-quality issues for which national assessment is needed. Information generated during the retrospective analysis and the occurrence and distribution components of the second group of study units (the first group of studies began in 1991) will be synthesized into a national assessment to answer important questions about nutrients, pesticides, and VOCs in the Nation's waters.

From 1995 through 1998, about 4,200 water-quality and aquatic-biological samples from about 240 sites were collected, processed, and analyzed, using nationally consistent protocols and methods, for the NAWQA Program in the UMIS in Minnesota and Wisconsin. Water quality in the UMIS had been monitored and assessed prior to this study. The majority of these studies were designed to answer specific questions about water quality in selected areas. The assessment of water quality in the UMIS by the NAWQA Program was designed to be more comprehensive than previous studies. The NAWQA design included physical, chemical, and aquatic-biological aspects of surface-water and ground-water quality in the entire basin. A sampling strategy that met the goals of the NAWQA Program, while answering specific water-quality related questions, was the first step in a long-term comprehensive water-quality assessment of the UMIS.

A liaison committee, consisting of representatives who have water-resources responsibilities from Federal, state, and local agencies, universities, and the private sector, was established to enhance the exchange of information about water-quality issues of regional and local interest in the UMIS. This committee assisted in the scope and design of study products and the review of planning documents and reports. A complete list of agencies and organizations represented on the UMIS Liaison Committee is provided on the inside cover of this report.

Purpose and Scope

The purpose of this report is to describe the study design and implementation for the first intensive phase of the UMIS study. The water-quality sampling strategy, developed during 1994 and early 1995, was implemented from 1995 through 1998. The strategy consisted of surface-water, ground-water, and aquatic-biological sampling at study-unit-wide, intermediate, and small scales, and addressed spatial and temporal aspects of water-quality conditions. Information for each sampling approach included the following: site-selection criteria, number of sites, types of samples, general sample-collection methods, sampling frequency, characteristics measured, laboratory-determined constituents, and the contributions of the sampling approach to an integrated water-quality assessment. More specific information about sample-collection methods is available in other publications, some of which are listed in the references.

Description of the Upper Mississippi River Basin Study Unit

The 47,000 mi^2 UMIS study unit (fig. 1) includes the Mississippi River Basin upstream of Lake Pepin, including the tributary basins of the Minnesota and St. Croix Rivers. The study unit is affected by a diverse set of natural and human factors which control the areal distribution and flow of water, and the distribution and concentration of water-quality constituents. These natural and human factors were considered in the design of the study. The environmental framework of the study unit is described in detail by Stark and others (1996). A brief summary is described below.

Natural Factors

The Mississippi River in Minnesota and Wisconsin flows southward through glacial moraines and outwash plains that overlie a thick sequence of sedimentary rocks. In the northeast part of the study unit, siliceous sediments (fig. 2) were deposited by glaciers that traversed igneous and metamorphic rocks (fig. 3). The remainder of the study unit is mantled by more clay-rich, calcareous glacial sediments (fig. 2) that traversed calcareous rocks, sandstone, and shales (Ruhl, 1987). Differences in climate across the basin affect hydrology. Average annual precipitation ranges from

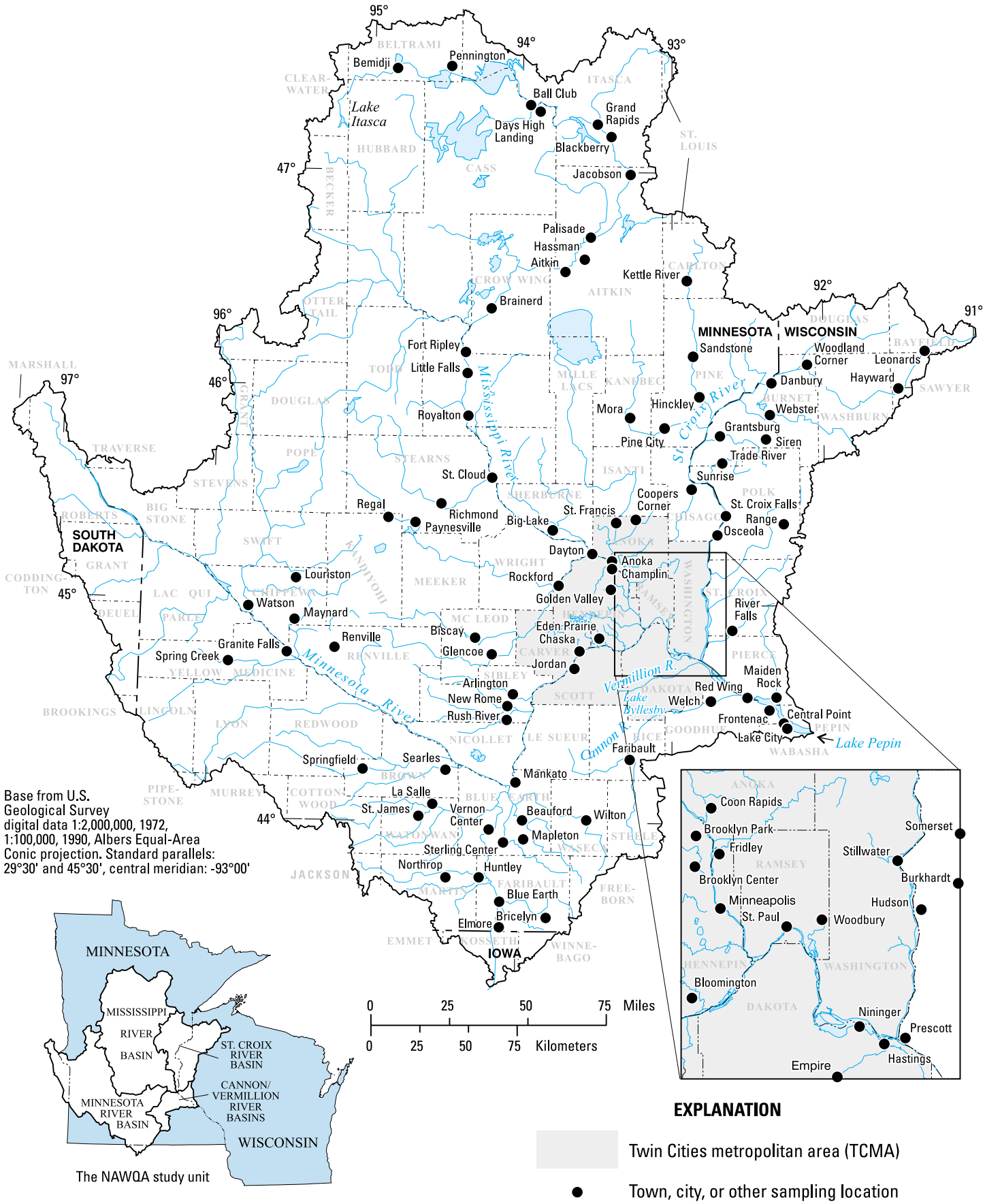


Figure 1.--Location of the Upper Mississippi River Basin study unit, Twin Cities metropolitan area, selected towns, major cities, and other sampling site locations.

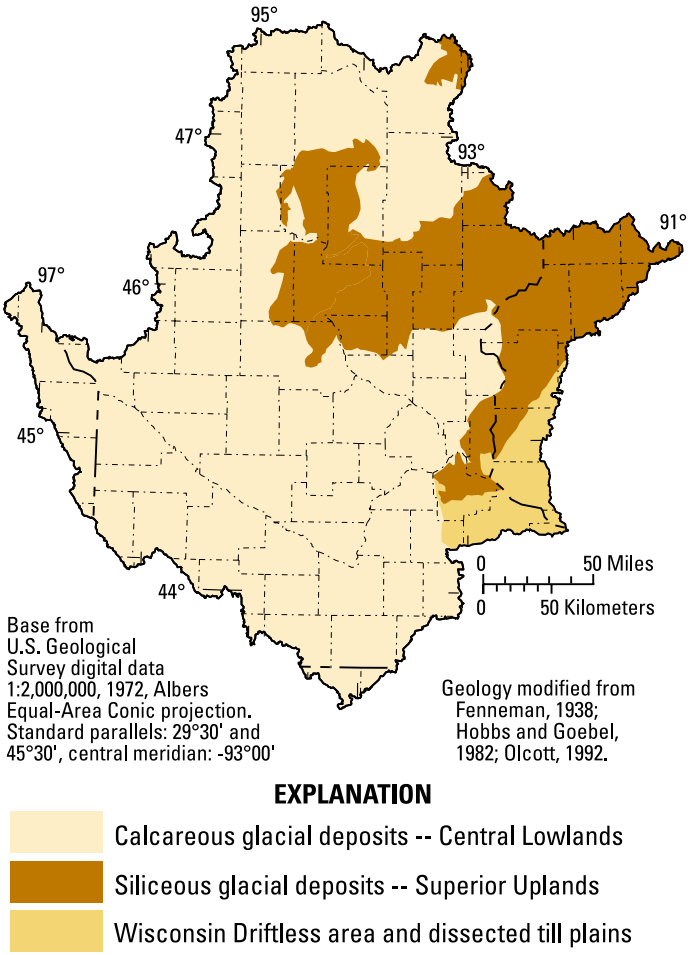


Figure 2.--Generalized glacial-deposit composition and dominant physiographic source area in the Upper Mississippi River Basin study unit.

22 inches in the west to 32 inches in the east. Mean annual runoff, which is related to precipitation and evapotranspiration, increases from west to east. Mean annual runoff ranges from less than 2 inches in the headwaters of the Minnesota River to more than 14 inches in the upper St. Croix River Basin. Streamflow is generally greatest in March through July as a result of melting snow, rains falling on melting snow, or heavy rains falling on saturated or frozen soils. Streamflow varies least in November through February, when ground-water inflow to streams is dominant, and varies most in July through October, when locally heavy rains and thunderstorms occur. Differences in precipitation, evaporation, and drainage areas lead to different discharges in major rivers. Based on the longest period of common record (1935-93), the average flow of the Mississippi River, just upstream of the Twin Cities metropolitan area (TCMA), is 7,900 ft^3/s , the average flow of the Minnesota River near its mouth is 4,060 ft^3/s, and the average flow of the St. Croix River at St. Croix Falls, Wisconsin, is 4,770 ft^3/s.

Human Factors

Population density and land use also affect hydrology, water quality, and aquatic communities. The population of the study unit in 1990 was about 3,640,000. Seventy-five percent of the population resides in the TCMA, which is located near the confluence of the Mississippi, Minnesota, and St. Croix Rivers, and comprises nearly 80 percent of all urban land in the study unit.

Land cover in the study unit can be categorized by three zones: an agricultural zone across the southwestern one-third of the study unit, a forested zone across the northeastern one-third, and a transitional zone of forest and agriculture between these areas (fig. 4). About 63 percent of the study unit is agricultural with some rangeland. The remaining land use and land cover consists of forests (about 22 percent), water and wetlands (about 13 percent), urban land (about 2 percent), and other categories (less than 1 percent).

An average of 413 Mgal/d of water is used in the study unit—59 percent from ground-water and 41 percent from surface water. This water use is equal to about one-twelfth of the average flow of the Mississippi River upstream of the TCMA. Ultimately, most water used is returned to the rivers as wastewater, which is generally treated before being discharged. The Metropolitan Wastewater Treatment Plant downstream from St. Paul, Minnesota, is the largest point-source discharge to the Mississippi River within the study unit, discharging 225 Mgal/d (L.C. Dyste, Metropolitan Council Environmental Services, oral commun., 1996).

Water-Quality Assessment Approach

The study design for the assessment of water quality focused on natural and human factors that have an influence or a potential influence on water quality (Gilliom and others, 1995). The most significant contaminants in surface and ground water in the study unit included nutrients, pesticides, and VOCs. The UMIS study addressed several water-quality properties in different environmental media, at various spatial and temporal scales. The analyses of these data were used to relate natural and human factors to the quality of water. During an initial period (1995-98) of data collection and analysis in the UMIS, hundreds of water-quality characteristics were measured in surface-water and ground-water (Appendix A). Surface-water sampling included stream water, streambed sediment, fish tissue, and aquatic communities. Also, samples were collected from ground-water wells. These

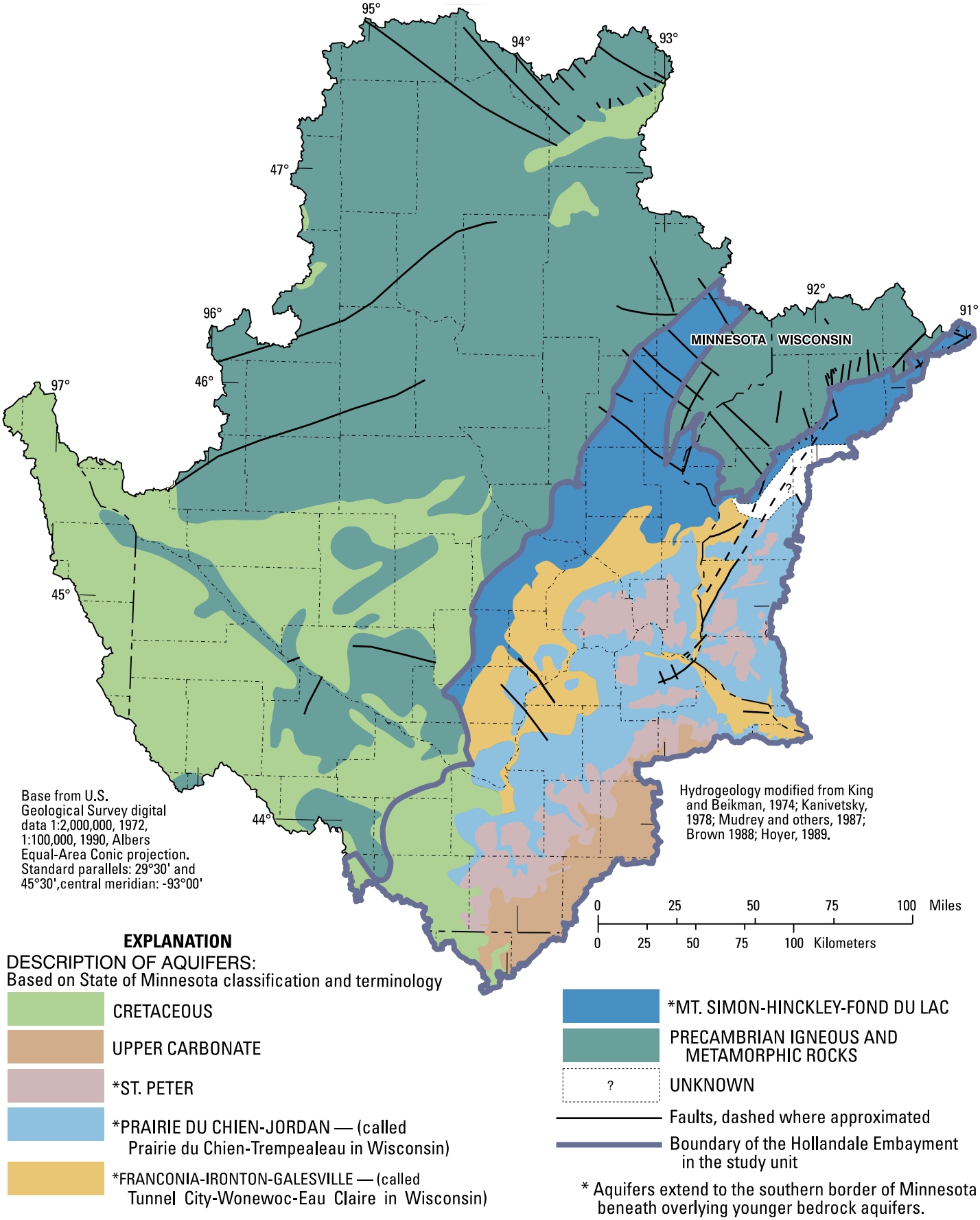


Figure 3.--Bedrock hydrogeology of the Upper Mississippi River Basin study unit.

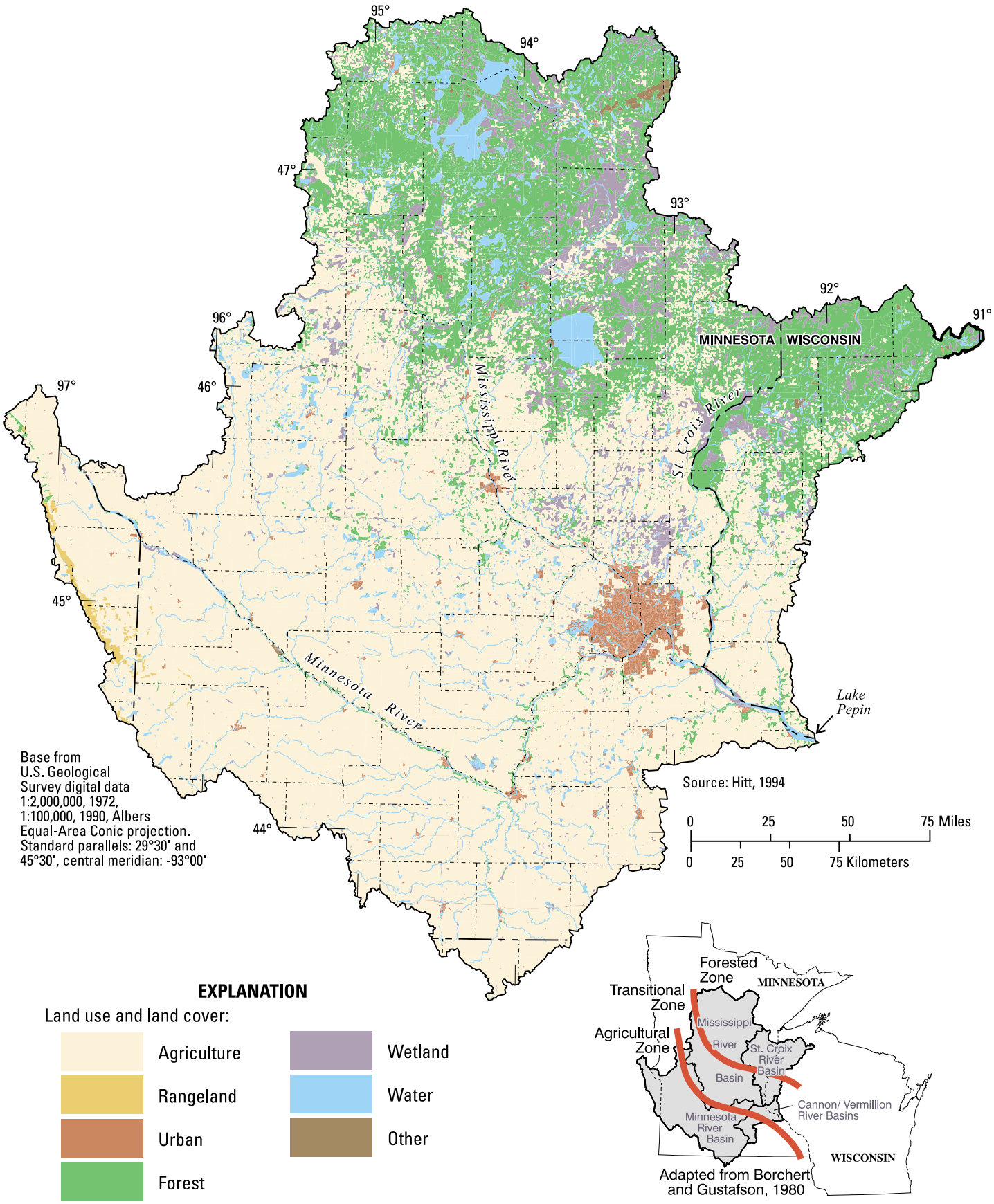


Figure 4.--Land use and land cover in the Upper Mississippi River Basin study unit.

data were analyzed in various combinations and interpreted in relation to natural and human factors to develop an integrated assessment. An intensive phase of data collection (1996-98) represented the initial step toward an integrated water-quality assessment. Subsequent intensive phases of the study will expand and complete the integrated assessment. In addition, data from other NAWQA study units, with similar integrated designs, are being combined to form regional and national assessments (Gilliom and others, 1995).

Physical characteristics measured included streamflow, ground-water levels, stream temperatures, and other characteristics that aid in the interpretation of water-quality data. Chemical characteristics included pH, dissolved oxygen, specific conductance, and concentrations of a broad range of chemical constituents including chlorophyll *a*, major inorganic constituents, nutrients, trace elements, tritium, radon, environmental isotopes, organic carbon, pesticides, VOCs, and other synthetic-organic compounds. Aquatic-biological characteristics included the quantitative description of fish, benthic macroinvertebrates, and algae, as well as synthetic-organic compounds and trace elements in fish tissue (Appendix B).

Water-quality characteristics were measured at various spatial and temporal scales. Surface-water-quality characteristics were measured in major tributaries and in the Mississippi River (draining thousands of square miles), and in intermediate and small streams (draining tens to hundreds of square miles). Water-quality characteristics in surface water were measured at a variety of sampling frequencies ranging from single synoptic samplings to weekly samplings, and during high and low streamflow conditions. Ground-water quality characteristics were measured in widely dispersed wells distributed over large areas (hundreds of square miles) and in closely spaced wells distributed over small study sites (hundreds of acres).

The environmental setting of the UMIS is complex because of the diverse natural and human factors present in the basin. These factors, in various combinations in different parts of the basin, are the principal influences on water quality. The natural and human factors that are responsible for most of the variation of water quality throughout the UMIS were identified and used to develop a framework within which to assess the water quality in the basin. In this process, sometimes referred to as stratification, the geographic distributions of the most influential natural and human factors were used to subdivide the study unit into major subareas. These subareas had relatively distinct environmental settings consisting of homogenous natural and human factors that were expected to have similar water quality. The assessment of water quality in streams and in aquifers was based on the sampling design that compared water quality within these relatively homogeneous subareas defined by subbasins or aquifer boundaries.

During the first year of the study, activities focused on compiling information that could be used for the design of the sampling network and sampling approach. A literature retrieval was completed (Andrews and others, 1996) and more than 2,000 publications were identified that related to the water resources of the UMIS. A geographic information system (GIS) data base was generated and documented. The data base included spatial data obtained from other agencies or generated from existing data. Existing analytical data for nutrients (Kroening and Andrews, 1997), pesticides (Fallon and others, 1997), and VOCs (Andrews and others, 1995) were compiled and reviewed, and formed the basis of interpretive topical reports for each of the groups of constituents.

The stratification process (Stark and others, 1996) included dividing the study unit into subareas, based on a combination of natural and human factors, and superimposing the drainage-basin and aquifer boundaries on the strata. The study unit was stratified at four levels for the surface-water component:

(1) glacial deposit composition (dominant physiographic source area)
(2) surficial geology (based on texture)
(3) general land use and land cover
(4) secondary land use.

The first level of stratification was based on the areal distribution of deposits from glacial lobes that correlate to soil mineralogy, texture, and permeability. Glacial deposits are classified as consisting predominantly of calcareous (Des Moines and Wadena Lobes) or siliceous (Superior and Rainy Lobes) deposits (Hobbs and Goebel, 1982). For each of the dominant types of glacial-deposit composition, surficial geologic deposits were divided into two strata: till plains and moraines (fine-grained deposits), and outwash and alluvium (coarse-grained deposits) (Olcott, 1992). It was assumed that the texture of surficial geologic deposits had an influence on the hydrology, water quality, and aquatic biology of streams draining those areas. The second level of stratification was land use and land cover, which was divided into five strata (Hitt, 1991; Hitt, 1994):

(1) forest
(2) mixed agriculture and forest
(3) agriculture
(4) urban
(5) wetlands and lakes.

The process of stratification resulted in numerous combinations. Only those strata considered to have the greatest effect on water quality were selected for sampling during the intensive phase of the study.

The stratification for ground-water sampling was similar to the stratification for surface water. However, for ground water the stratification was superimposed on the distribution of shallow aquifers. Ground-water studies emphasized shallow ground water where quality is most likely influenced by overlying land use and land cover. For each aquifer, the stratification formed the basis for the sampling design.

The selection of subareas for sampling was made based on recommendations of the study-unit liaison committee. Key

factors considered in the prioritization were the distribution of population and land use within the subareas and the results of retrospective analyses of existing data. Subsequent intensive phases of the study may address the remaining subareas and land uses in more detail.

Design and Implementation of Water-Quality Studies

Six sampling components (fig. 5) were included in the sampling design for the intensive phase. Three of the sampling components addressed surface water and aquatic biology, and three addressed ground water. The surface-water and aquatic-biology components included (1) stream sites that integrate multiple land uses and encompass large watersheds (integrator site network), (2) stream sites that indicate homogenous and more specific land uses (indicator site network), and (3) stream sites sampled for special studies (synoptic surveys) (fig. 6). The ground-water components (fig. 7) included (1) subunit surveys, (2) land-use studies, and (3) a flow-path study. Each component involved measurements of water-quality characteristics in one or more environmental media at one or more spatial and temporal scales. Many stream sampling sites were established at a fixed location on a stream and routinely sampled from 1996-98 for a broad range of chemical constituents, aquatic biology, and streamflow. These sites comprised both integrator and indicator sites. These sampling sites formed the basis of physical, chemical, and aquatic-biological studies within and among the different cycles of the NAWQA Program. The other components—synoptic surveys of streams and surveys of ground water—were one-time, short-term sampling events conducted from several weeks to several months. The synoptic surveys of streams were completed primarily during late spring, when nutrients and pesticides were expected to be at greatest concentrations, or late summer, when streamflows were low, to minimize variability of concentrations in streams and to minimize variability in aquatic-biological sampling.

Surface Water and Aquatic Biology

Water quality in streams was assessed through water-chemistry and aquatic-biological studies (tables A1-A8). The objectives of these studies were to: (1) evaluate spatial and temporal distribution of physical, chemical, and aquatic-biological characteristics of streams; (2) compare water quality in streams in different land-use and land-cover areas; (3) identify possible sources of contamination; and (4) establish a baseline for long-term monitoring and trend detection. Samples for water-chemistry studies were collected at two types of fixed sites—basic fixed sites and intensive fixed sites. “Basic” and “intensive” refer to the sampling frequencies and types of water-quality analyses. Basic fixed sites were sampled monthly during high flow for general water quality (physical properties, nutrients, major ions, organic carbon, and suspended sediment) and streamflow; whereas, intensive fixed sites were sampled more frequently or for additional constituents (such as pesticides, VOCs, or both). Intensive fixed site sampling allowed for the analysis of short-term variability in water quality, for more accurate load estimates, and for the determination of the presence and seasonal patterns of pesticides, VOCs, or both. Basic and intensive fixed sites were further characterized as indicator or integrator sites. Hereinafter, fixed sites will be referred to generally as fixed sites or specifically as (basic or intensive) indicator sites and (basic or intensive) integrator sites (fig. 8).

In order to aid in the evaluation of water quality, aquatic-biological studies characterized fish, benthic macroinvertebrate, and algal communities, and habitat conditions. The sampling unit for the aquatic-biological studies was a representative stream reach located near fixed sites. Two types of surveys were conducted. Fixed-site reach surveys included the collection of representative samples of fish, invertebrate and algal communities, and habitat characterization. Intensive ecological surveys provided information on spatial and temporal variability of aquatic biology and habitat characteristics for a subset of the fixed sites. Three stream reaches were selected and sampled for intensive ecological surveys to estimate within-stream variability. Temporal variability was estimated by sampling one stream reach annually.

Synoptic surveys were an important part of integrated water-quality assessments. They provided the small-scale stream chemistry and aquatic-

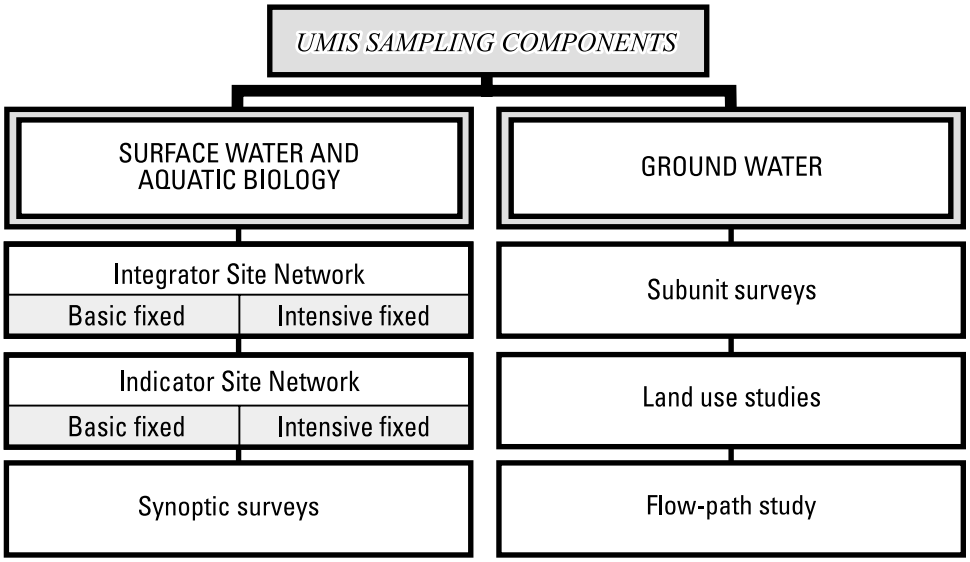


Figure 5.--Sampling design for the Upper Mississippi River Basin study unit.

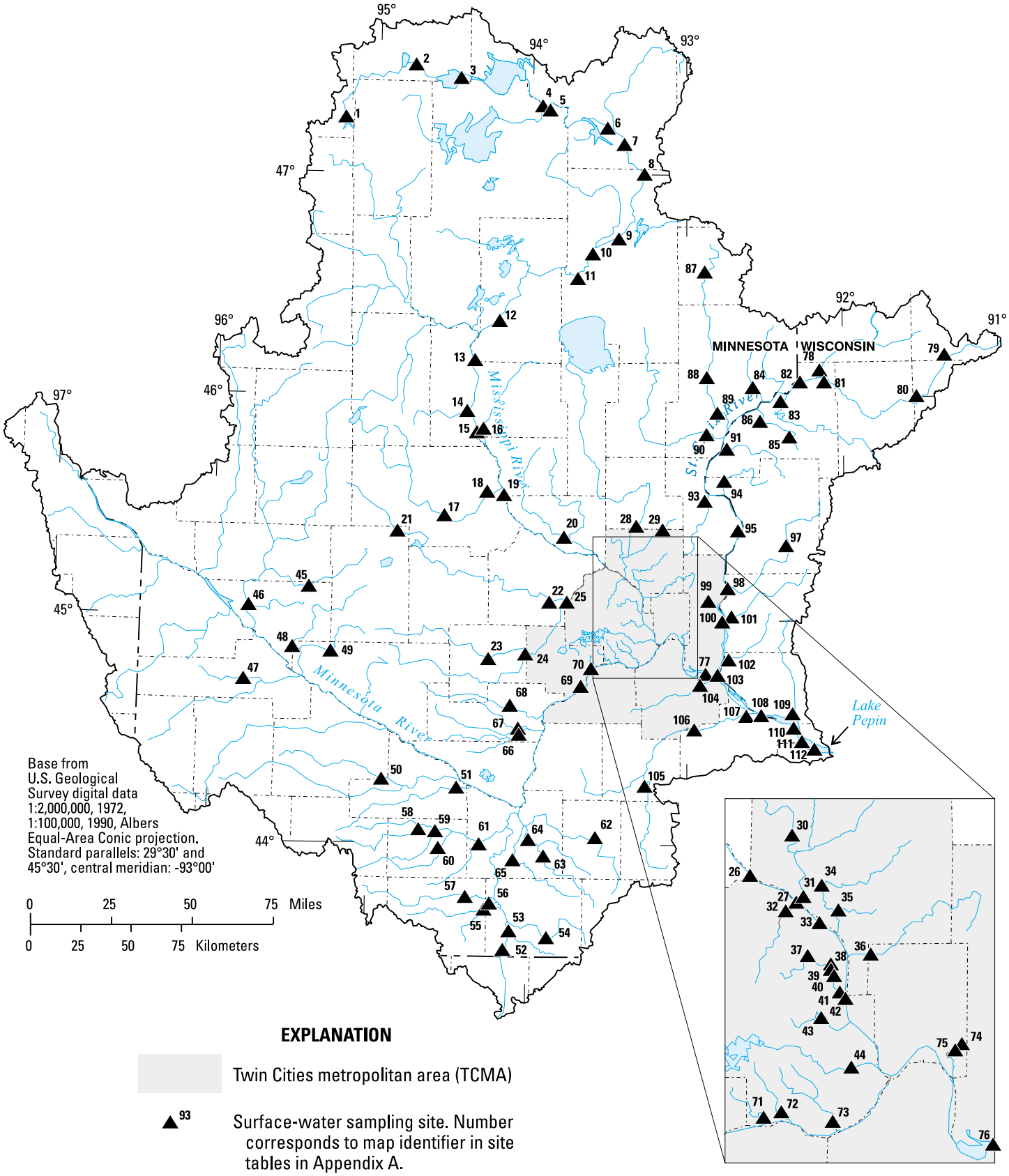


Figure 6.--Location of all surface-water and aquatic biology sampling sites in the Upper Mississippi River Basin study unit.

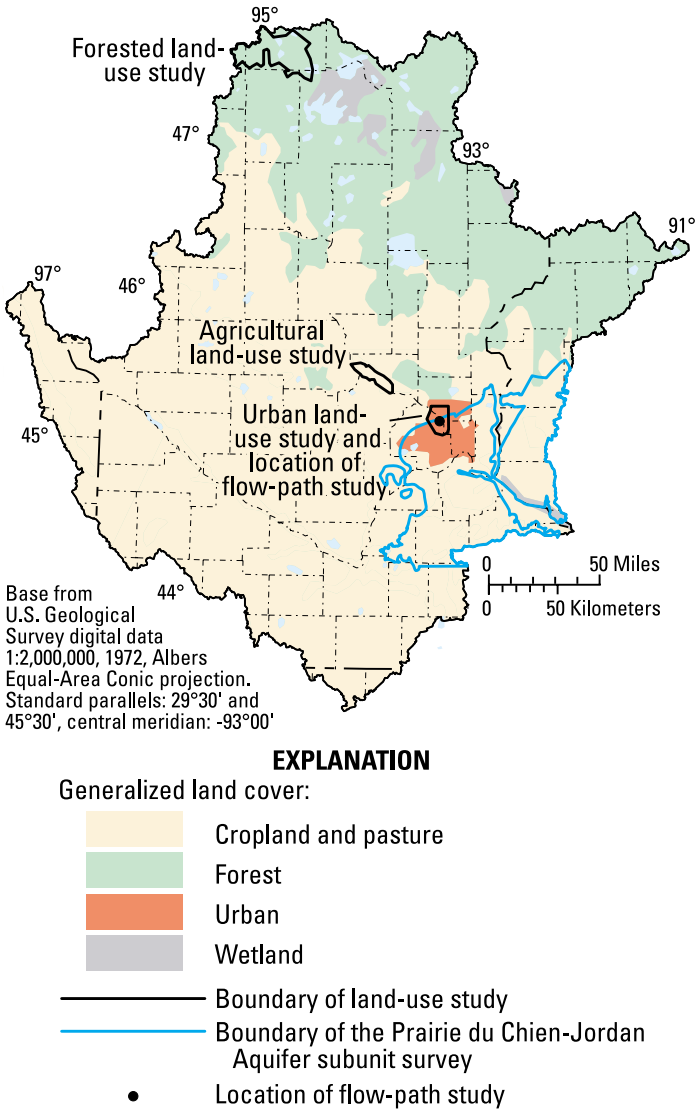


Figure 7.--Location of the ground-water studies of the Upper Mississippi River Basin study unit.

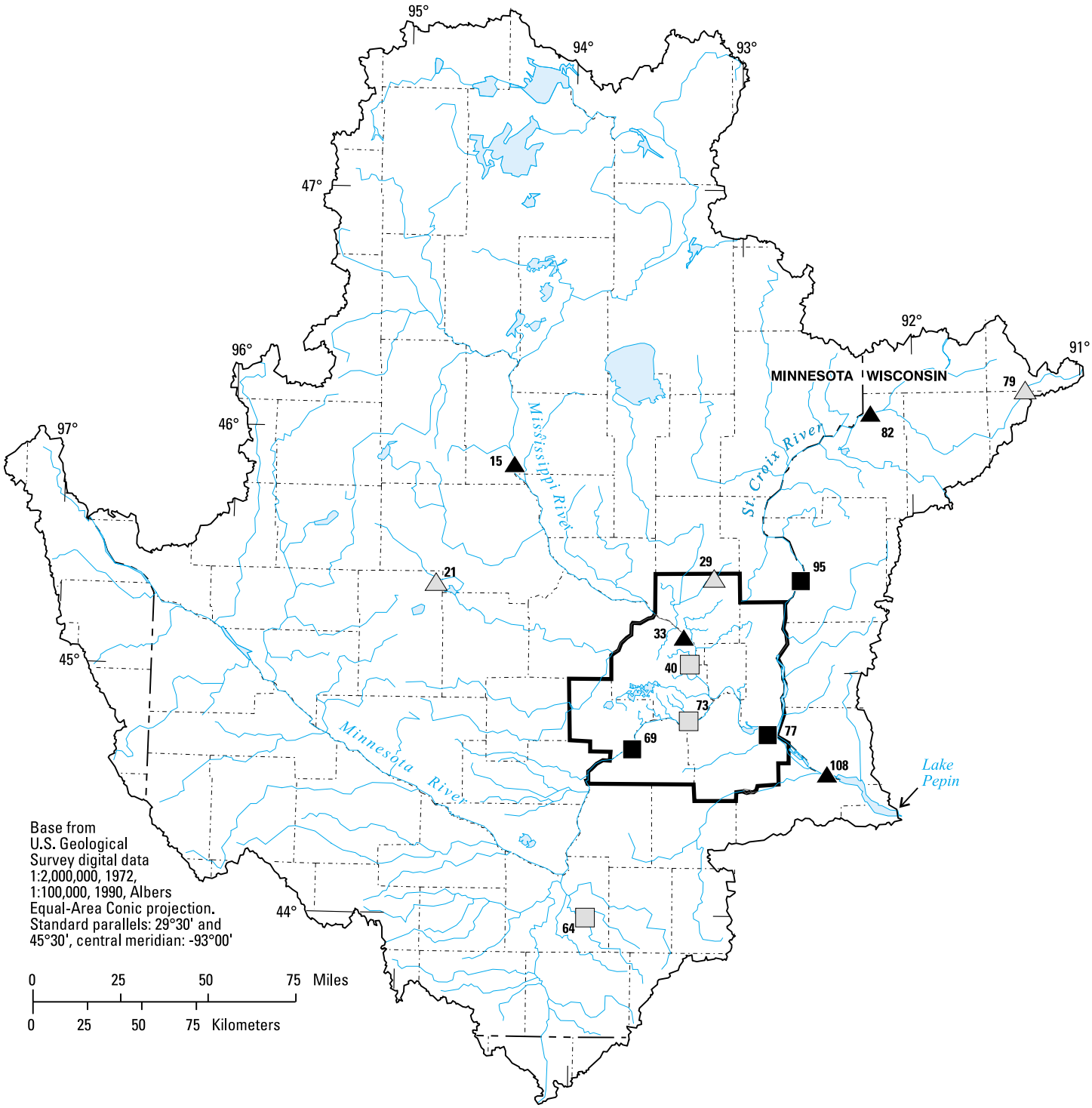
biological data needed to characterize and compare surface-water quality. Synoptic surveys provided data that was used to establish relations between stream quality and ground-water quality. Data from these surveys provided finer spatial resolution of stream chemistry and aquatic-biological data than data from the fixed-site network. Synoptic studies were used to investigate the geographic distribution of selected water-quality or ecological characteristics during specific seasons.

Integrator Site Network

Integrator sites are located on streams that drain large portions of the study unit. Water-quality samples from these sites represent the combined effects of a variety of natural and human factors that affect stream-water chemistry and aquatic biology. Basic integrator sites characterize the spatial and temporal distribution of general water-quality in relation to hydrologic conditions and contaminant sources. Intensive integrator sites are used to determine the occurrence and seasonal patterns in concentrations and transport of additional constituents including dissolved pesticides and VOCs, as well as to characterize short-term variability in general water quality.

The principal objectives of the integrator site network in the UMIS were to determine the occurrence of basic chemical constituents and aquatic biology in large streams and to determine how the constituents and communities are spatially distributed and temporally varied. A secondary objective was to relate basin stream chemistry and aquatic biology to land use and other natural and human factors. Seven integrator sites were selected (fig. 8, table A1). Two sites were near the mouths of major tributaries (Minnesota River and the St. Croix River), four were on the Mississippi River mainstem, and one was on the upper portion of the St. Croix River. Six of the sites were located at long-term USGS stream-gaging station sites. Land use upstream of the site on the Minnesota River near Jordan, Minnesota (site 69), hereinafter referred to as Jordan, is dominated by high-intensity row crop agriculture. Land use upstream of sites on the St. Croix River near Danbury, Wisconsin (site 82), and at St. Croix Falls, Wisconsin (site 95), hereinafter referred to as Danbury and St. Croix Falls, respectively, consisted primarily of forested land. The basin upstream of the site on the Mississippi River near Royalton, Minnesota (site 15), hereinafter referred to as Royalton, is predominantly forested. Intermediate Mississippi River mainstem sites near Anoka, Minnesota (site 33), and Hastings, Minnesota (site 77), are located upstream and downstream of the TCMA and are hereinafter referred to as Anoka and Hastings, respectively. The Mississippi River site at Red Wing, Minnesota (site 108), hereinafter referred to as Red Wing, is located near the downstream study unit boundary. Water-quality sampling at integrator sites began by the spring of 1996 and ended in the summer of 1998.

Most stream-water samples were collected using equal-width increment sampling methods (Edwards and Glysson, 1988; Shelton, 1994). These samples were composited from several equally-spaced vertical transects across each stream. At each vertical transect, the stream was sampled from the water surface to just above the streambed. This collection method resulted in composited samples



EXPLANATION

Boundary of the Twin Cities metropolitan area (TCMA)

Basic fixed site--number corresponds to map identifier in table A1, in Appendix A:

21 Indicator -- small steam, wadeable site

108 Integrator -- large stream, nonwadeable site

Intensive fixed site--number corresponds to map identifier in table A1, in Appendix A:

73 Indicator -- small steam, wadeable site

69 Integrator -- large stream, nonwadeable site

Figure 8.--Location of basic fixed and intensive fixed stream sampling sites (indicator and integrator) in the Upper Mississippi River Basin study unit.

that were representative of entire stream cross sections. Most samples were collected from the upstream side of bridges or from boats because of the depths of these large streams. Occasionally, grab samples were collected from near the centroid of flow when ice conditions made other sampling methods unsafe. All stream-water samples were collected with sampling equipment constructed from inert materials using clean-sampling protocols that minimized the possible introduction of contaminants during sampling and handling (Shelton, 1994). Measurements of water temperature, pH, specific conductance, dissolved oxygen, and alkalinity (tables A2, B1) were made in the field. Samples requiring further analysis were processed in the field or in the laboratory and shipped to the USGS National Water-Quality Laboratory (NWQL) in Arvada, Colorado, the USGS Sediment Laboratory in Iowa City, Iowa, or the USGS Organic Geochemistry Laboratory in Lawrence, Kansas, for analysis. Laboratory analyses included chlorophyll *a* and periphyton, major ions, nutrients, organic carbon, VOCs, pesticides, and suspended sediment (tables A2, B2-B11).

Aquatic-biological samples at integrator sites were collected using the methods described by Cuffney and others (1993a) for benthic invertebrates, Porter and others (1993) for algae, and Meador and others (1993a) for fish. These data served as indicators of the quality of water and complement physical and chemical data collected at the sites. Stream habitat (Meador and others, 1993b) was characterized in detail to provide baseline data on the environmental setting and to help identify limiting physical factors for aquatic communities. Aquatic communities were sampled along stream reaches that ranged in length from about 500 to 1,000 ft. Benthic macroinvertebrate and algae samples were collected from all benthic habitats to generate a list of taxa present within the sampling reach. Quantitative samples were collected from woody debris substrate and depositional areas. Phytoplankton were collected simultaneously with stream-water samples during 1996. Benthic-invertebrate and algae samples were sent to the NWQL for enumeration and identification. Fish were collected using boat electrofishing and seining techniques and were identified, counted, measured, weighed, and examined for external anomalies before being returned to the stream. At Danbury, three stream reaches were sampled for benthic macroinvertebrates, algae, and fish to determine the within-stream variability of aquatic communities.

Chemistry and aquatic-biological-community data collected at the integrator sites form the primary description of stream quality in large stream basins, enabling relations between stream chemistry and aquatic communities to be evaluated. The data provide large scale descriptions of stream quality at different temporal scales, laying the groundwork for future trend analyses for basin chemistry and aquatic communities.

Land-Use Indicator Stream Network

Indicator stream sites drain small watersheds (tens to hundreds of square miles) in relatively homogenous environmental settings that are dominated by a single land use. Stream-water and aquatic-biological samples from indicator sites are indicative of the land uses. The sampling of indicator sites provide a measure of the relative contributions of important individual environmental settings (strata) to overall surface-water quality in the study unit. As with the integrator sites, there are two types of indicator sites—basic and intensive.

The objectives of the land-use indicator stream network included the determination of the occurrence and distribution of basic chemical constituents and aquatic biology, the determination of the relation of water quality to land use and other factors, and the estimation of nutrient, pesticide, and/or VOC transport in the sampled streams. These objectives differed from those of the integrator site network only in terms of the size and complexity of the watershed. One important expansion of the scope of the work of the indicator site network was the greater frequency of sample collection because smaller streams tend to respond to changing environmental conditions quicker than larger streams.

Six indicator sites were selected for water-quality sampling (fig. 8, table A1). The indicator sites, and targeted land uses upstream of the sites, are: (1) Shingle Creek at Minneapolis, Minnesota (site 40)—urban area in coarse-grained Des Moines Lobe glacial outwash, hereinafter referred to as Minneapolis; (2) Nine Mile Creek at Bloomington, Minnesota (site 73)—urban area in fine-grained Des Moines Lobe glacial till, hereinafter referred as Bloomington; (3) Little Cobb River near Beauford, Minnesota (site 64)—agricultural area in fine-grained Des Moines Lobe glacial lake sediments, hereinafter referred to as Beauford; (4) North Fork Crow River above Paynesville, Minnesota (site 21)—agricultural area in Des Moines Lobe glacial outwash, hereinafter referred to as Paynesville; (5) Namekagon River at Leonards, Wisconsin (site 79)—forested area in coarse-grained Superior Lobe glacial outwash, hereinafter referred to as Leonards; and (6) Cedar Creek near Coopers Corner, Minnesota (site 29)—forested area in Des Moines Lobe glacial outwash, hereinafter referred to as Coopers Corner.

The sites were selected to assess the effects of the characteristic land use in the watershed. Coopers Corner was sampled for a limited time (August 1996 to January 1997); whereas, the other five indicator sites were sampled for about 27 months, from April 1996 to June 1998. Sampling at Minneapolis and Beauford continued through September 1998. Streamwater samples were collected approximately monthly and more frequently during selected streamflow conditions at each site. At the intensive indicator sites at Minneapolis, Beauford, and Bloomington, sampling frequencies were increased to biweekly from January to December 1997 to assess short-term changes in water-quality conditions. Aquatic communities were sampled during August and September of each year. Habitat characterization was completed once during the intensive phase.

Samples were collected using the same protocols as at the integrator site network, except that most were collected while wading. Samples were analyzed for the same chemical constituents. Pesticides (tables A2, B7-B10) were routinely analyzed in samples collected at the intensive indicator sites at Minneapolis, Beauford, and Bloomington. VOCs (tables A2, B6) were routinely analyzed in samples collected at the urban indicator sites at Minneapolis and Bloomington, using separate collection and processing techniques (Shelton, 1997). At Minneapolis and Bloomington, three adjacent stream reaches, rather than one, were sampled for benthic invertebrates, algae, fish, and habitat to determine the spatial variability of aquatic biology on a small scale.

Stream-water-chemistry and aquatic-biological-community data from the indicator site network contributed to a comprehensive description of stream quality at the six sites and supply the small-scale and intermediate-scale components to a basin-wide evaluation of stream quality. Routine sampling frequency, and sampling as streamflow conditions were changing, provide frames of reference in which the results of synoptic samplings could be interpreted.

Synoptic Surveys

Synoptic surveys investigate the geographic distribution of selected water-quality or aquatic-biological characteristics in relation to sources and transport. The surveys are generally of short duration, with high sampling density.

Contaminant Survey of Streambed Sediments and Fish Tissue

The occurrence and distribution of trace elements and hydrophobic organic compounds in streams were determined by a survey of these contaminants in streambed sediment and fish tissue. Bed sediments and fish tissue were selected for analysis because trace elements and hydrophobic organic compounds were expected to accumulate in these media rather than in water. In addition, these analyses could provide some information about bioaccumulation of trace elements and organic contaminants within the study unit. The contaminant data, in combination with other physical data collected at some of the same sites, was used to develop a comprehensive, multidisciplinary description of stream quality for those sites.

There were two phases of the streambed sediment and fish tissue survey: the occurrence survey, which was designed to identify significant contaminants, and the distribution survey, which provided a finer spatial resolution of selected constituents and re-examined selected sites from the occurrence survey. A total of 27 sites (fig. 9, table A3) were sampled—this included three sites in Lake Pepin. Drainage areas ranged from less than 20 to 47,300 mi^2. About one-half of the sites were co-located with fixed sites (fig. 8, table A1). The remaining sites were selected to increase spatial distribution. These sampling sites were selected to maximize the probability of detection of trace-element and organic contaminants and to represent major environmental settings. Therefore, some sites were selected downstream of major metropolitan areas where sources of contamination were likely. A few sites also were selected in areas with suspected low probability of detection of contaminants.

Samples of streambed sediments were collected during low streamflow conditions in the summer and fall (July-November); 23 sites were sampled during the 1995 occurrence survey and four sites were sampled during the 1996 distribution survey. Sites 21 and 64 (fig. 9, table A3) were sampled in both surveys because suitable fish could not be collected during the initial occurrence survey.

Streambed sediment samples were collected from five to ten depositional areas within stream reaches averaging about 300 ft in length. Samples were collected using methods described by Shelton and Capel (1994). These samples were obtained from approximately the top 1 in. of streambed sediment in each depositional zone using a Teflon scoop, and were composited in a glass container. Deep-water samples were collected using an Eckman dredge, and the top 1 in. of this sample was sub-sampled using a Teflon scoop while avoiding the metal sides of the dredge. Samples were sieved to obtain only the finer-grained sediments. Streambed-sediment samples were analyzed at the USGS Branch of Geochemistry Laboratory, Denver, Colorado, for trace elements (table B12). Analyses of organic carbon, polycyclic aromatic hydrocarbons (PAHs), organochlorine and polychlorinated biphenyl (PCB) compounds, and semivolatile organic compounds in streambed sediment samples were determined by the NWQL (tables B13-B15).

Fish were collected at 25 of the 27 sites where streambed sediments were collected; only one of the three sites in Lake Pepin was sampled. Common carp (*cyprinus carpio*), white sucker (*catastomus commersoni*), and redhorse (*moxostoma sp.*) were collected by electrofishing techniques. Five fish of about the same length usually comprised each sample. Fish livers were used for analysis of trace elements and whole-fish samples were used for analysis of organic compounds (Crawford and Luoma, 1993) (tables B16-B17).

Nutrients and Suspended Sediment in Snowmelt Runoff

Nutrients and suspended sediment can adversely affect surface-water quality by contributing to eutrophication and sedimentation. Previous studies have found that concentrations of nutrients, such as nitrate, can be at or near maximum annual concentrations in snowmelt runoff. In a study of urban snowmelt in the TCMA, Oberts (1982) found that 8-20 percent of the annual total phosphorus load in small streams was contributed by snowmelt. Oberts (1990) noted, in a review of available literature, that the nature of constituents in snowmelt runoff changed—maximum concentrations of soluble constituents, such as nitrate, occurred in the first-flush while maximum concentrations of constituents associated with particulates, such as total phosphorus, occurred later. Several other agencies have sampled selected streams during all parts of the

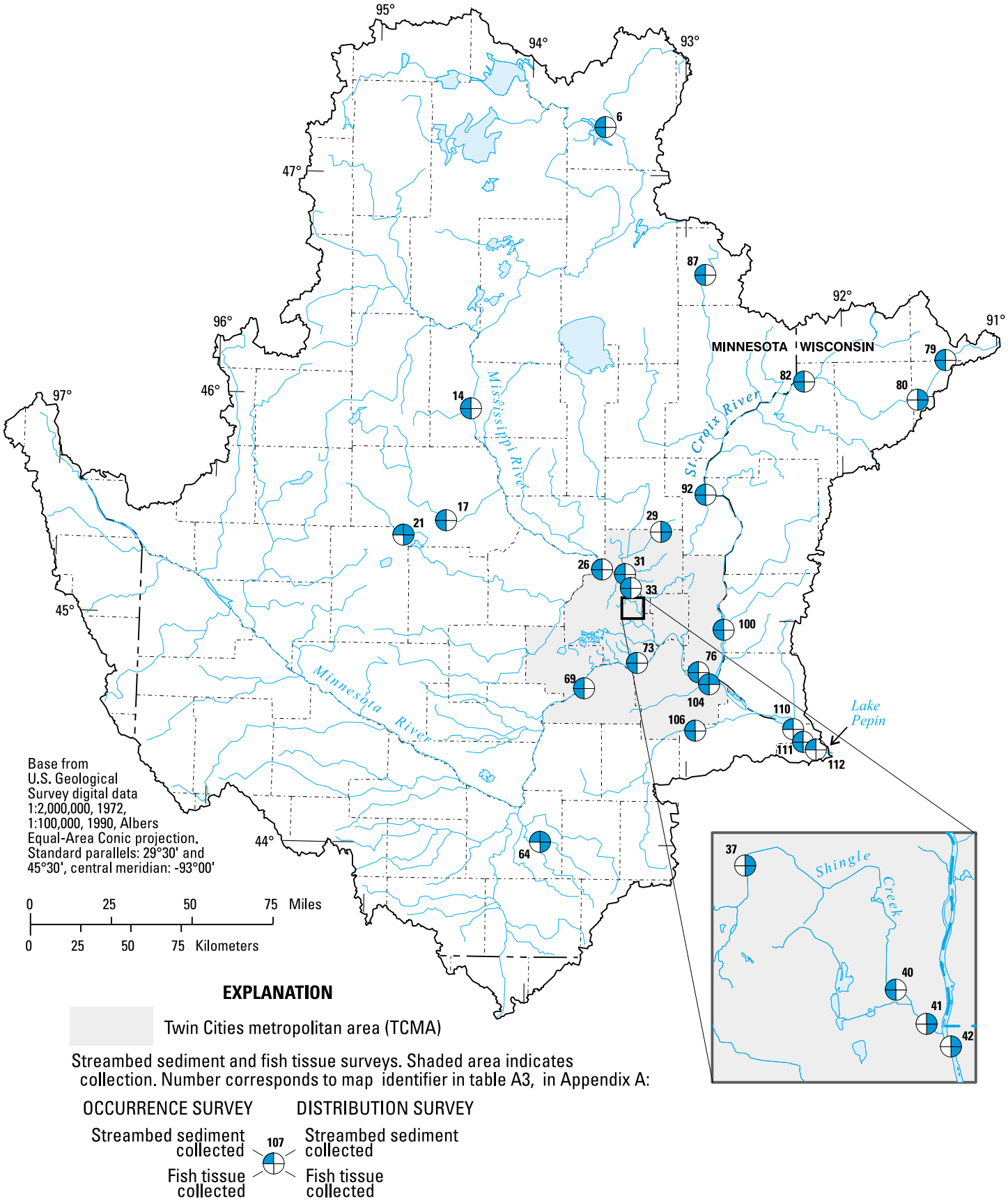


Figure 9.--Location of streambed sediment and biological tissue sampling sites in the Upper Mississippi River Basin study unit.

year, but little information existed to enable a comparison of nutrients and suspended sediment concentrations in snowmelt runoff in tributaries to the Mississippi, Minnesota, and St. Croix Rivers. Nutrient and suspended sediment data obtained for this study provide information about numerous tributaries in the study unit and greater spatial resolution about the distribution of nutrients and suspended sediment in stream water than is available from data collected at fixed sites.

A synoptic sampling of streams in the study unit was conducted in spring 1997 to characterize instantaneous concentrations and yields of nutrients and suspended sediment in streams during increasing streamflow. Secondary objectives included comparing concentrations and yields between streams draining different land uses and surficial geology, and comparing proportions of total nitrogen, total phosphorus, and suspended sediment loads contributed during snowmelt to proportions contributed annually.

Forty-one stream sites, including 12 fixed sites, were sampled (fig. 10, table A4). Streams sampled had drainage areas from 10 to 46,800 mi^2. At fixed sites, samples were collected and processed using NAWQA protocols (Shelton, 1994). At other sites, samples were collected and processed using modified protocols because this study required the sampling of a large number of sites during a short period of time. Modifications included reducing the number of equal-width-increment sampling transects to 3-5, collecting suspended-sediment samples in bottles separate from the composite samples for nutrients, and splitting composite samples for total nutrients by mixing and pouring from 3-liter bottles instead of using cone splitters. When two or more sites were sampled with the same equipment on the same day, equipment was triple rinsed with both deionized water and with native water from the following site. Equipment was cleaned according to NAWQA protocols at the end of each day. Samples were analyzed for selected nutrients and suspended sediment (tables B4, B11). Nutrient samples were chilled and shipped on ice within 48 hours to the NWQL in Arvada, Colorado. Sediment samples were shipped to a USGS Sediment Laboratory in Iowa City, Iowa, for the analysis of suspended sediment concentration and percentages of sand- and fine-sized sediment. Field measurements included stream cross sections of water temperature, pH, specific conductance, dissolved oxygen, and alkalinity (table B1). Streamflow was measured at sites lacking established stage-discharge relations. Stream stage was measured before and after sampling to document changing stage conditions.

At fixed sites, additional samples were collected throughout the snowmelt hydrograph so that concentrations and yields during increasing streamflow could be compared to concentrations and yields during other streamflow conditions.

Water-Quality and Aquatic Communities in Streams Draining Agricultural Areas

Twenty-four sites in the Minnesota River Basin (fig. 11, table A5) were selected as part of a synoptic study conducted in the UMIS, Eastern Iowa Basins, and the Lower Illinois River Basin NAWQA study units. The objective of the study was to determine how water-quality indicators (nutrient concentrations, herbicide concentrations, suspended-sediment concentrations, aquatic-biological condition, and net primary productivity) differ in streams draining high-intensity corn and soybean row-crop areas in response to changes in local-scale riparian cover and to basin-scale soil conditions.

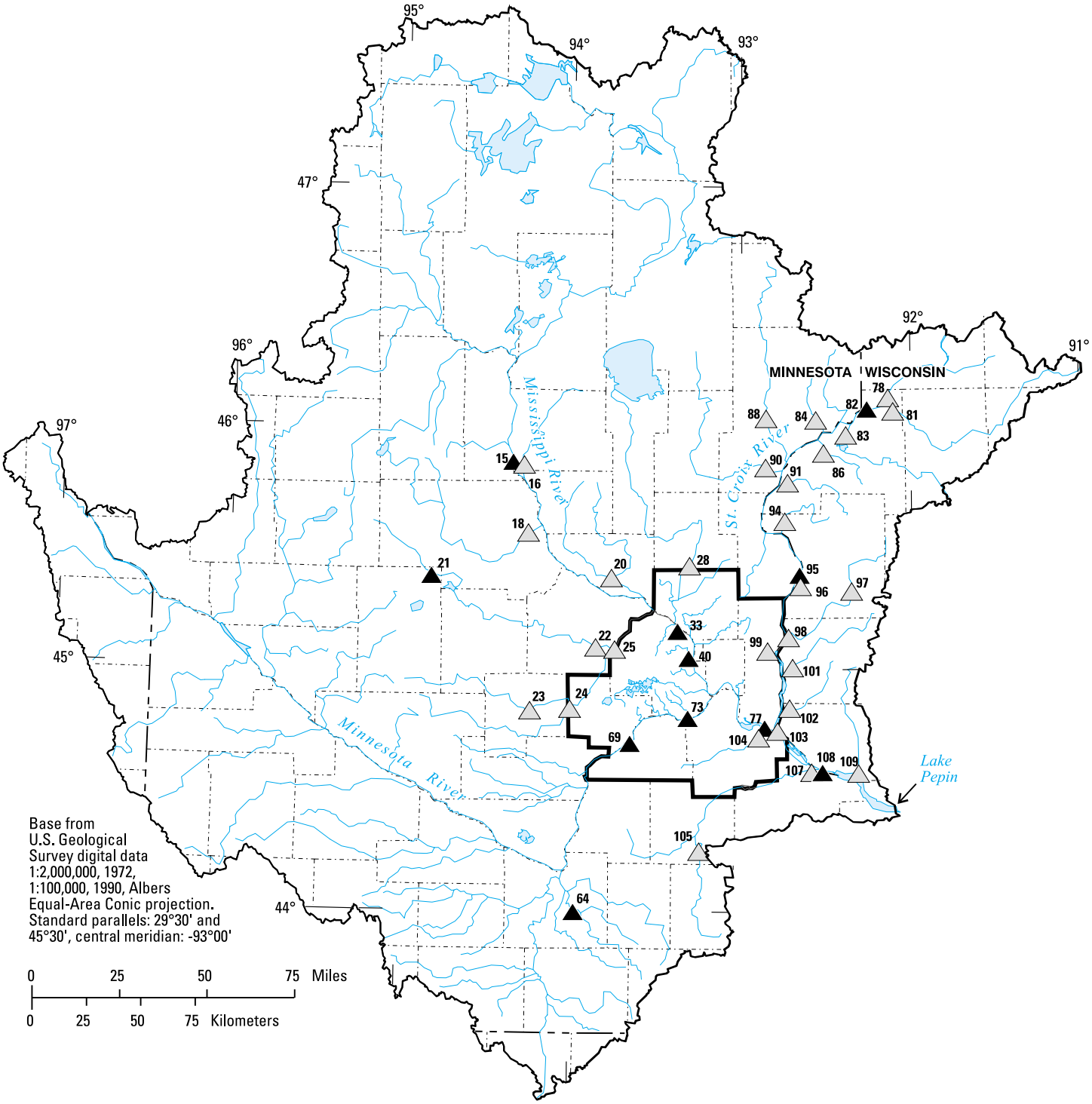
Intensive agriculture can alter water quality and aquatic communities in streams. This alteration is thought to be the result of nutrient and organic enrichment, increased turbidity resulting from the acceleration of erosion and sedimentation, and increased light penetration and water temperature because of the removal of riparian cover. Stream basin alterations may contribute to the excessive growth of aquatic vegetation, increased algal productivity, reduced species richness and diversity, and shifts in community composition.

Soil characteristics in stream basins influence the delivery of water, sediment, and contaminants to streams, which affects runoff, base flow, and water quality. Well-drained soils are likely to transport nutrients and other contaminants to ground water that discharges to streams. In poorly drained soils, nutrients and other contaminants generally reach streams through overland flow.

Wooded riparian areas can influence water quality by providing a barrier between agricultural fields and streams. This barrier may moderate nutrient and sediment delivery to streams (Lowrance and others, 1984; Puckett and others, 1993). Wooded riparian areas also moderate water temperature, stabilize stream banks, and serve as a source for instream woody debris (instream habitat) and overhead cover for aquatic communities.

Site selection was determined by basin size, land use and land cover, riparian cover, and soil conditions. Streams with drainage areas from 60 to 317 mi^2 and with greater than 87 percent agricultural land use were sampled. Twenty-four sites were then divided into four categories based on riparian cover and soil conditions. Approximately six sites were chosen in each of these four categories (fig. 11): high runoff potential and wooded riparian cover, low runoff potential and wooded riparian cover, high runoff potential and open riparian cover, and low runoff potential and open riparian cover.

Percent wooded riparian cover within a stream segment was determined using digital raster graphics (DRGs) at the 1:24,000 scale (Sorenson and others, 1999) and updated using aerial photographs. To standardize the area of influence, the base-10 logarithm of watershed drainage area (in square miles) was calculated and the result used as the segment length (in miles). For example, a stream draining 100 mi^2 would have a base-10 logarithm equal to 2, and therefore would have a segment length of 2 mi. Segment width was set at 328 ft (100 meters) on both sides of the center of the stream. Sites were classified as open if less than 10 percent of the area within the



EXPLANATION

Sampling site--number corresponds to map identifier in table A4, in Appendix A:

23 Site with one sample collected

73 Site with three or more samples collected

Figure 10.--Location of the snowmelt synoptic sampling sites in the Upper Mississippi River Basin study unit.

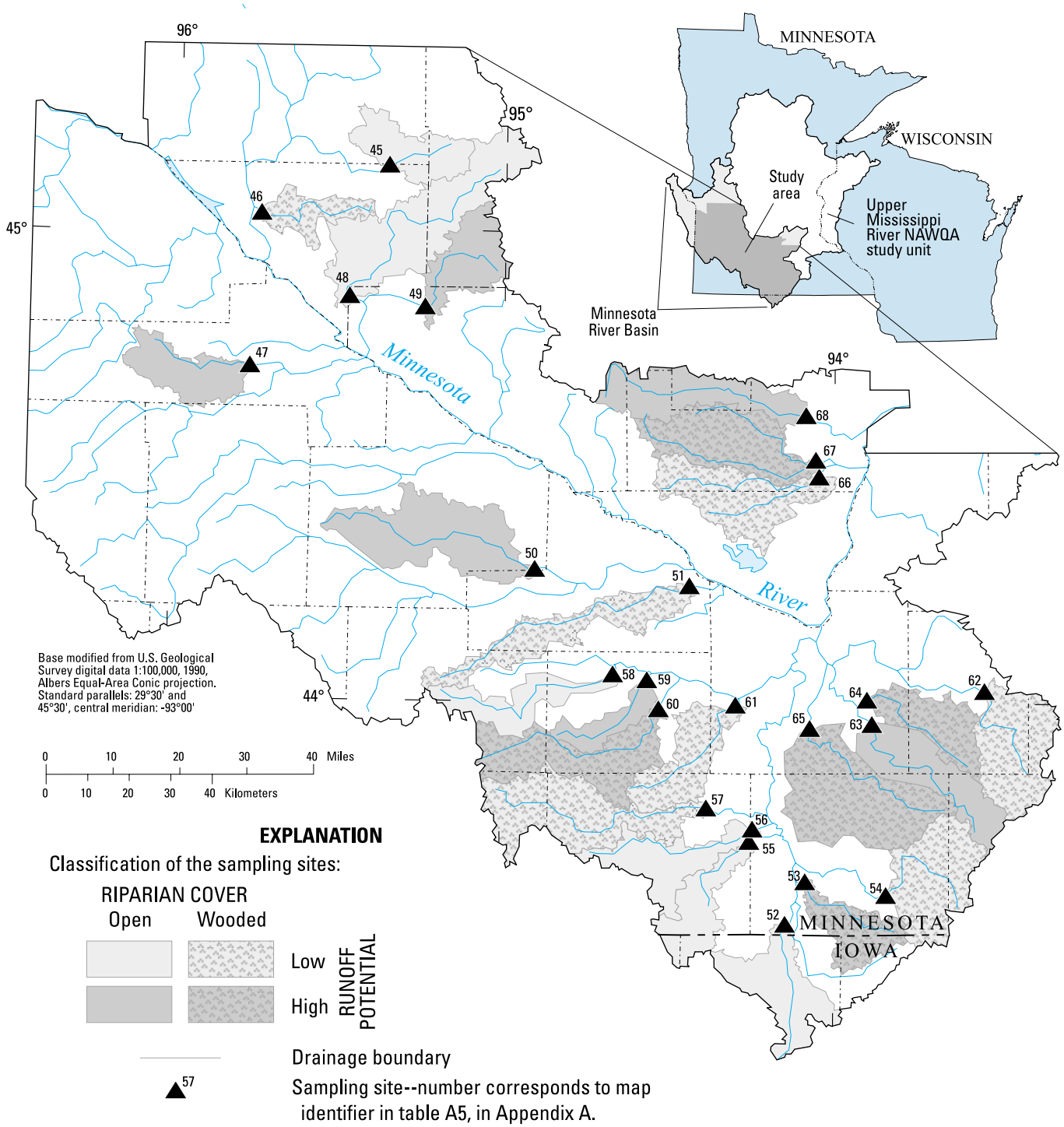


Figure 11.--Location of the agricultural synoptic sampling sites of the Upper Mississippi River Basin study unit.

segment had wooded riparian cover and classified as wooded if more than 28 percent of the area within the segment had wooded riparian cover.

The U.S. Department of Agriculture's state soil geographic data base (STATSGO), along with modified soil characterization data (Wolock, 1997), were used to characterize soils in this study. Within STATSGO, "hydrologic soil group" is a computed variable that classifies soils based on runoff producing characteristics or runoff potentials. Runoff potential is a measure of the inherent capacity of a soil to permit infiltration. Soils are classified into four separate groups: A, B, C, and D. Soils in the A group are characterized as having high infiltration rate when thoroughly wet and having low runoff potential (U.S. Department of Agriculture, 1991). Soils in the D group are characterized as the opposite of A soils, having a low

infiltration rate and having high runoff potential (U.S. Department of Agriculture, 1991). For this study, hydrologic soil groups A and B were classified as low runoff potential soils and C and D were classified as high runoff potential soils. Sites were classified as having either low or high runoff potential based on the percentage of hydrologic soil groups A and B in their respective basin. The percentages were from 50 to 97 percent A and B soils for low runoff potential sites, and from 0 to 31 percent A and B soils for high runoff potential sites.

Water samples were collected and processed according to NAWQA protocols (Shelton, 1994). Constituents analyzed included major ions, nutrients, dissolved and suspended organic carbon, pesticides, and suspended sediment (tables B3-B5, B7-B11). Chlorophyll *a* (periphyton and phytoplankton) concentrations were analyzed using USEPA method 445 (Arar and Collins, 1992) at the USGS laboratories in Mounds View, Minnesota, or Iowa City, Iowa (table B2). All aquatic-biological collections and habitat characterizations were made along a sampling reach of approximately 20 times the mean channel width. Benthic macroinvertebrates and periphyton were sampled from woody debris substrate and fish were sampled using electrofishing equipment using NAWQA protocols (Meador and others, 1993a; and Sorenson and others, 1999). Fish were identified in the field to species level, measured, and weighed. Fish that were not identified in the field were preserved and sent to the Bell Museum of Natural History, Minneapolis, Minnesota, for identification. Benthic macroinvertebrates and periphyton were collected from woody debris and sent to the NWQL for identification and enumeration. Physical habitat measurements included stream width, depth, point velocity, substrate characterization, light penetration, instream cover (woody debris, macrophytes, boulders, undercut banks, and overhanging vegetation), and bank characterization (Sorenson and others, 1999).

The multi-study unit effort allowed for study over a broad geographic area with increased sample size and replication. The study also allowed for expansion of spatial coverage of water-quality conditions in the UMIS during critical, low-flow conditions.

Water Quality and Aquatic Communities in Streams Draining Urban Areas

Urbanization can have a significant effect on both the water quality and aquatic communities of streams. Urban stream channels, in response to human modifications, tend to be deeper, straighter, wider, and more homogenous than stream channels in more undisturbed settings (Booth and Reinelt, 1993). Consequences of stream modification may include increased water temperatures, rapid changes in stream flow during runoff events, and degradation of habitat for fish and other aquatic organisms. An increase in impervious areas in urban watersheds can also compound these problems by increasing runoff and by allowing stormwater to reach streams faster than in non-urban areas. Urban nonpoint-source contaminants resulting from automobiles, construction activities, lawns, atmospheric deposition, street debris, and animal and plant refuse can contribute to water-quality degradation in urban streams (Hambrook and others, 1997). Point and nonpoint discharges of dissolved solids, nutrients, bacteria, trace elements, and pesticides may also inhibit growth, reproduction, and diversity of aquatic organisms (Pope and Putnam, 1997).

The urban synoptic survey was conducted to characterize the water quality and aquatic communities in 13 TCMA streams at low-flow conditions during September 1997 (fig. 12, table A6). Thirteen wadeable warm-water streams with drainage areas ranging from 9.9 to 152 mi^2 in the TCMA were sampled. Sites were selected along a gradient of urbanization in the drainage area upstream of the sample location. All streams were tributaries to the Minnesota or Mississippi Rivers. Sampling methods and types were similar to those used for streams draining agricultural areas (described in the previous section). The study provided more water-chemistry and aquatic-community information about urban streams than was available from data collected at fixed indicator stream sites.

Water Quality and Aquatic Communities in the Mississippi River Mainstem

The Mississippi River is the source of drinking water for the cities of St. Cloud, Minneapolis, and St. Paul and for some suburban communities of the TCMA. Within the study unit, the Mississippi River also is used for municipal and industrial power generation, disposal of treated municipal and industrial wastes, transportation, and recreation. Both recreational and commercial fisheries are important industries along the Mississippi River. This study was designed to characterize the water quality and aquatic communities from the source at Lake Itasca to Red Wing, Minnesota. Data collected as part of this study, combined with other studies and data collected from the fixed sites, will allow an assessment of the water quality and aquatic communities along the entire length of the Upper Mississippi River in the study unit. In addition to fixed sites, additional sites were selected on the part of the Mississippi River upstream of the TCMA because less information has been collected on this part of the river. Within the study unit, the most recently published studies of the water quality in the Mississippi River have focused on the reach from the TCMA to Lake Pepin (Metropolitan Waste Control Commission, 1993; Minnesota Pollution Control Agency, 1993; Meade, 1995).

Nineteen sites on the Mississippi River, including four fixed sites, were sampled as part of this study during the seasonally low streamflow conditions in July and August of 1998. Twelve of the sites also were surveyed for aquatic invertebrates and fish. Sites were located downstream of major tributaries and cities (fig. 13, table A7). Equal-width increment samples were collected and processed using NAWQA protocols (Shelton, 1994). Samples were analyzed to determine concentrations of chlorophyll *a*, major ions, nutrients, organic carbon, pesticides, suspended sediment, and a suite of organic compounds (including caffeine,

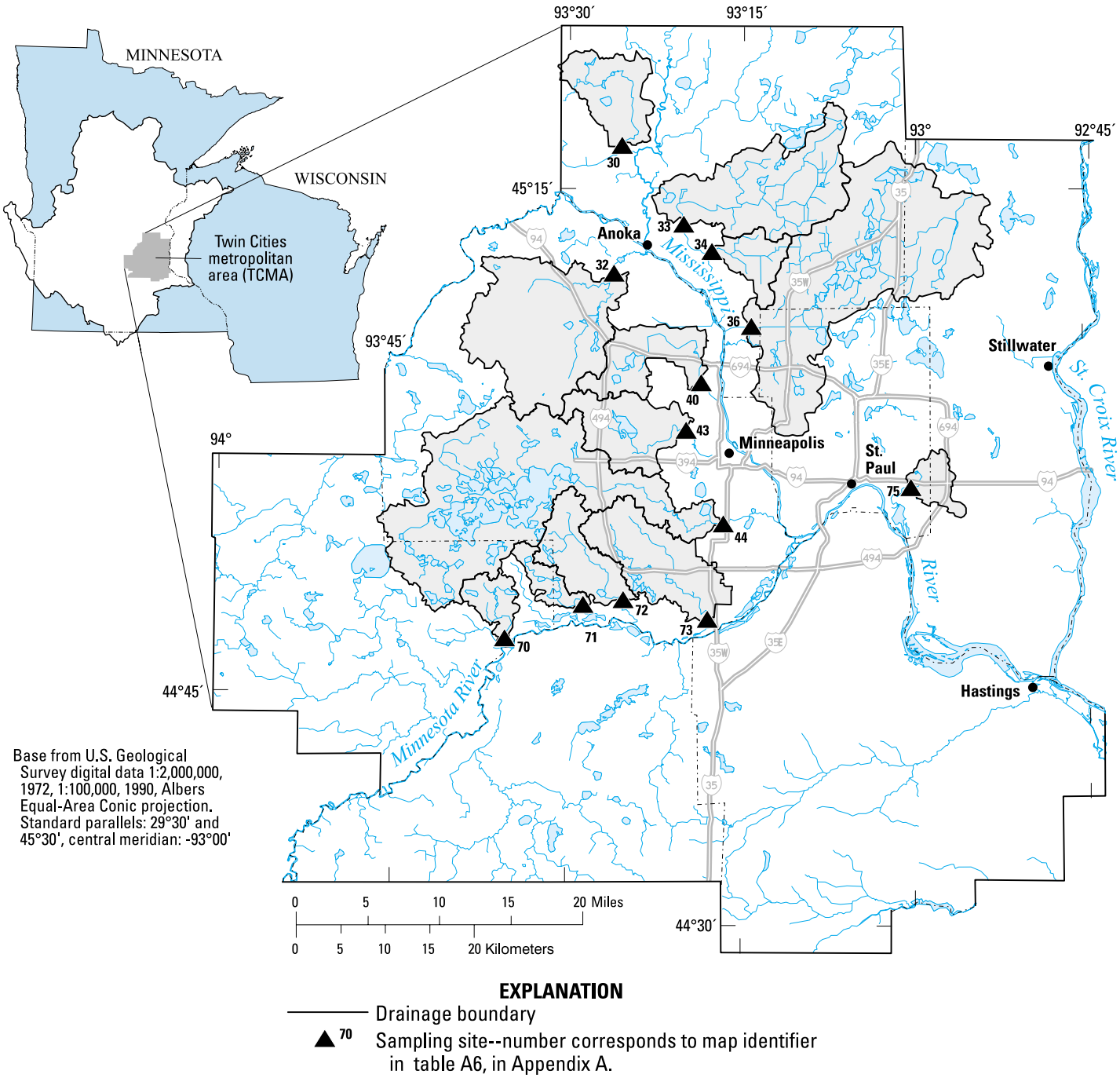


Figure 12.--Location of the urban synoptic sampling sites in the Upper Mississippi River Basin study unit.

nonyl-phenols, and cholesterol) that are indicative of contamination from wastewater (tables B2-B5, B7-B11, B18). Major ions, nutrients, organic carbon, pesticides, and other organic compound analyses were done by the NWQL. Suspended-sediment concentrations were determined at the USGS Sediment Laboratory in Iowa City, Iowa. Chlorophyll *a* was analyzed in the USGS laboratory in Mounds View, Minnesota, using the methods of Arar and Collins (1992). Fish community samples were collected using boat electrofishing equipment in two passes along a 2,500-ft stream reach near the water-collection site using NAWQA protocols (Meador and others, 1993a). Invertebrates were collected from woody debris within the stream reach using a modification of U.S. Environmental Protection Agency rapid bioassessment protocol II (U.S. Environmental Protection Agency, 1989).

Ground Water

Ground water is an important source of drinking water in rural portions of the study unit and in the suburban areas of the TCMA. Most rural residents obtain their water supply from wells. Most ground-

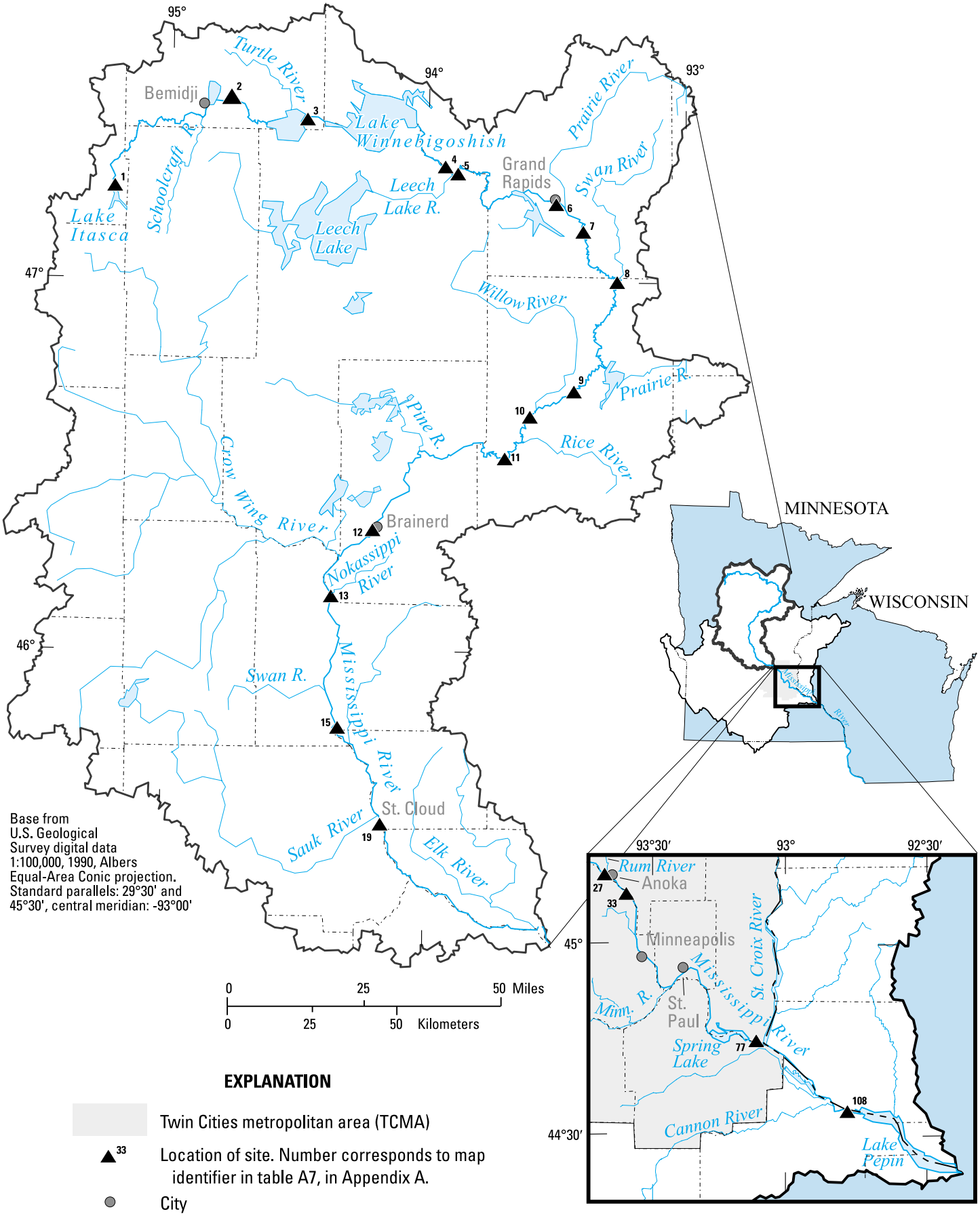


Figure 13.--Location of the Mississippi River mainstem synoptic sampling sites in the Upper Mississippi River Basin study unit.

water withdrawals in the TCMA are from glacial deposits or from the Prairie du Chien-Jordan bedrock aquifer. The Prairie du Chien-Jordan aquifer, consisting of the Prairie du Chien Group (a dolomite) and the underlying Jordan Sandstone, is the most important aquifer in terms of water supply. This aquifer is susceptible to contamination from activities that occur at the land surface. Wells completed in the aquifer generally are less than 350 feet deep. Thus, for public-health-related reasons, it is important that ground water in this aquifer be included in an integrated water-quality assessment. In addition, because a significant portion of streamflow in the basin is derived from ground-water base flow to streams, the inclusion of ground water in an assessment also contributes to the understanding of stream-water quality.

Ground-water quality was assessed for aquifer/land use combinations using three sampling strategies: (1) regional studies of selected major aquifers (subunit surveys), (2) targeted-area studies in selected land-use areas (land-use studies), and (3) a localized study of processes occurring along shallow ground-water flow paths (flow-path study). These studies and surveys emphasize shallow ground water, the quality of which is likely influenced by overlying land use and land cover. Stratification for ground-water sampling was based on the spatial distribution of shallow surficial, buried sand and gravel, and bedrock aquifers. As with the stratification of surface water, the first level of stratification was the glacial deposit composition, followed by the type of surficial geology (till or outwash). Within the areas delineated by stratification, an additional level was added to differentiate among aquifers. For each aquifer, general land use and land cover were also used as a basis for the study design for the ground-water component. Investigation of potential contamination of aquifers by nutrients, pesticides, and VOCs was the primary objective of the land-use studies and subunit surveys. The flow-path study was intended to assess changes in ground-water chemistry along a ground-water flow path.

Subunit Surveys

Subunit surveys during the intensive phase of the NAWQA Program in the UMIS involved sampling domestic wells completed in the Prairie du Chien-Jordan aquifer in Minnesota and Wisconsin. The wells were differentiated into groups in which the aquifer is confined by other bedrock units or by glacial deposits, and in which it is unconfined. The survey had two major objectives. The first was to determine the ground-water chemistry in the confined and unconfined portions of the aquifer. The second was to relate differences in ground-water chemistry to natural and human factors, including type of rock and land use and land cover.

The 25 sampled domestic wells (fig. 14, tables A9 and A10) in each portion of the aquifer (confined and unconfined) were selected using a GIS-based random, equal-area algorithm (Scott, 1990). For the Minnesota portion of the survey areas, the County Well-Index data base of the Minnesota Geological Survey and the Ground-Water Site Inventory (GWSI) data base of the USGS were used to compile a list of suitable wells, from which primary and alternate wells were randomly selected for unconfined and confined areas of the aquifer. For the Wisconsin portion of the survey areas, relatively few suitable wells were listed in GWSI. Suitable wells near randomly-selected sampling locations were identified from well logs supplied by the Wisconsin Department of Natural Resources. Specific well-selection criteria included well depth, well log, absence of water-treatment systems, and existing submersible pumps, as recommended by Lapham and others (1995).

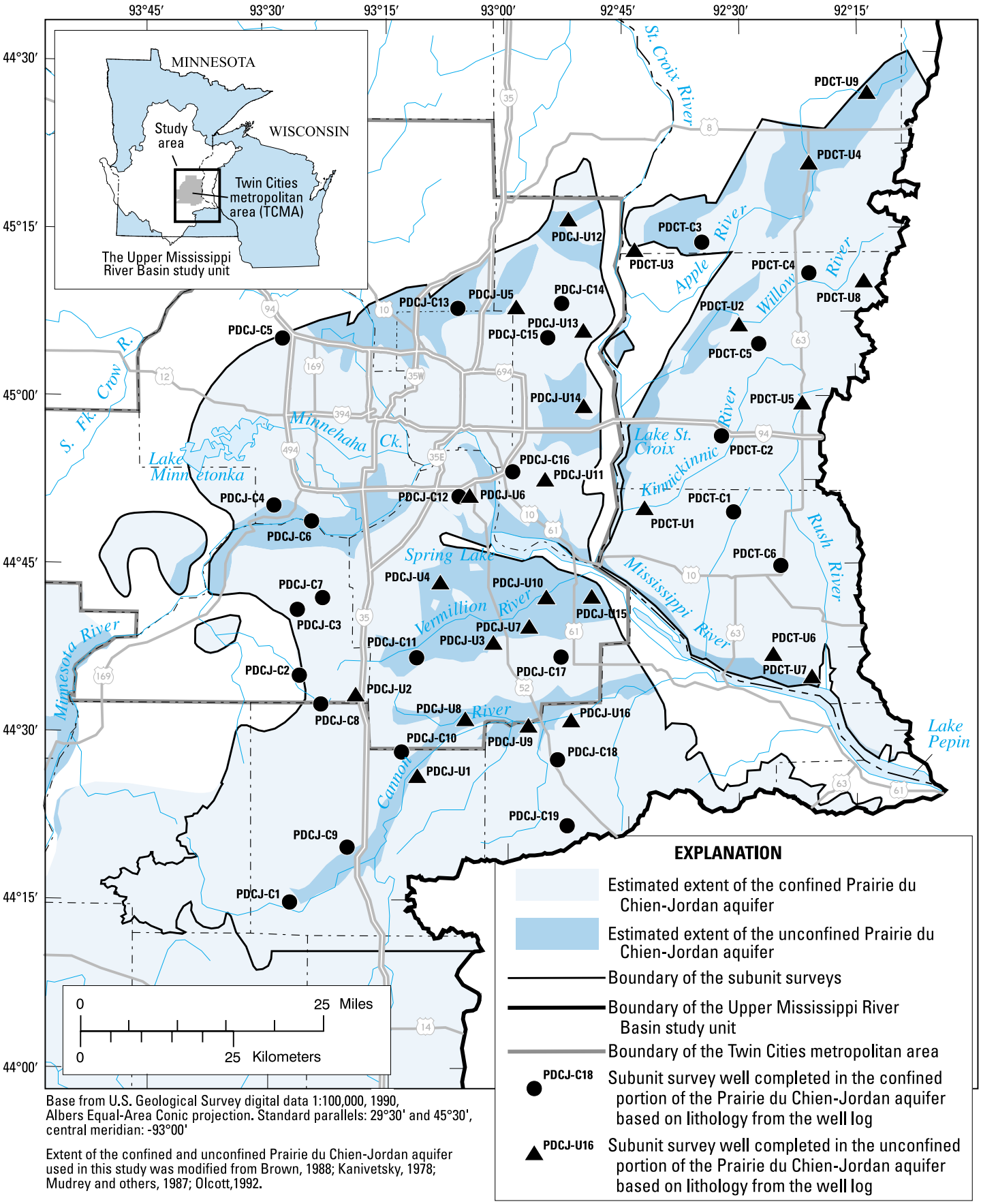
Water samples were collected during the summer of 1996. A single sample was collected from each well. Before the sample was collected, the well was purged and pumped until water temperature, pH, specific conductance, turbidity, and dissolved oxygen stabilized. All equipment that came in contact with the water sample was constructed from inert materials, and all samples were processed using clean-sample protocols as described in Koterba and others (1995). The samples were shipped to NWQL for analysis for major ions, nutrients, dissolved organic carbon, VOCs, selected pesticides, trace elements, tritium, and radon (tables B3-B10, B19-B21). Well characteristics were documented and land uses within a 1,640-ft radius surrounding each well were mapped.

Subunit surveys of ground water provided an important role in an integrated water-quality assessment of the UMIS. The surveys provided data that can be used to compare and contrast ground-water quality in the aquifer. The results of the surveys were used to determine the relation between the ground-water quality and natural and human factors affecting the aquifer, including the effects of confinement. The two subunit surveys were used to understand ground-water chemistry as water and contaminants move downward from the land surface into the aquifer.

Land-Use Studies

Land-use studies were designed to determine the extent to which shallow ground-water quality was influenced by land use and land cover and hydrogeologic setting. The studies were conducted in areas where ground water represents a current or potential source of water supply and where current or potential contamination of ground water from surface sources was possible. Land-use studies were limited in areal extent (tens of square miles) and were located where both land use and hydrogeologic settings were relatively homogenous. The studies focused on surficial sand and gravel aquifers. Three studies were completed in the UMIS: urban, agricultural, and forested. Well locations were selected at random using the method described by Scott (1990). The wells in all three studies were sampled using the same protocols used in the subunit surveys, which are described by Koterba and others (1995).

The urban land-use study was located in a residential/commercial area in the northwestern portion of the TCMA (fig. 15, table A11). The objective of the study was to characterize the effects of urban land use on shallow ground-water quality in an unconfined surficial sand and gravel



Base from U.S. Geological Survey digital data 1:100,000, 1990, Albers Equal-Area Conic projection. Standard parallels: 29°30' and 45°30', central meridian: -93°00'

Extent of the confined and unconfined Prairie du Chien-Jordan aquifer used in this study was modified from Brown, 1988; Kanivetsky, 1978; Mudrey and others, 1987; Olcott,1992.

Figure 14 .--Location of wells completed in the Prairie du Chien-Jordan aquifer sampled for the subunit surveys of the Upper Mississippi River Basin study unit.

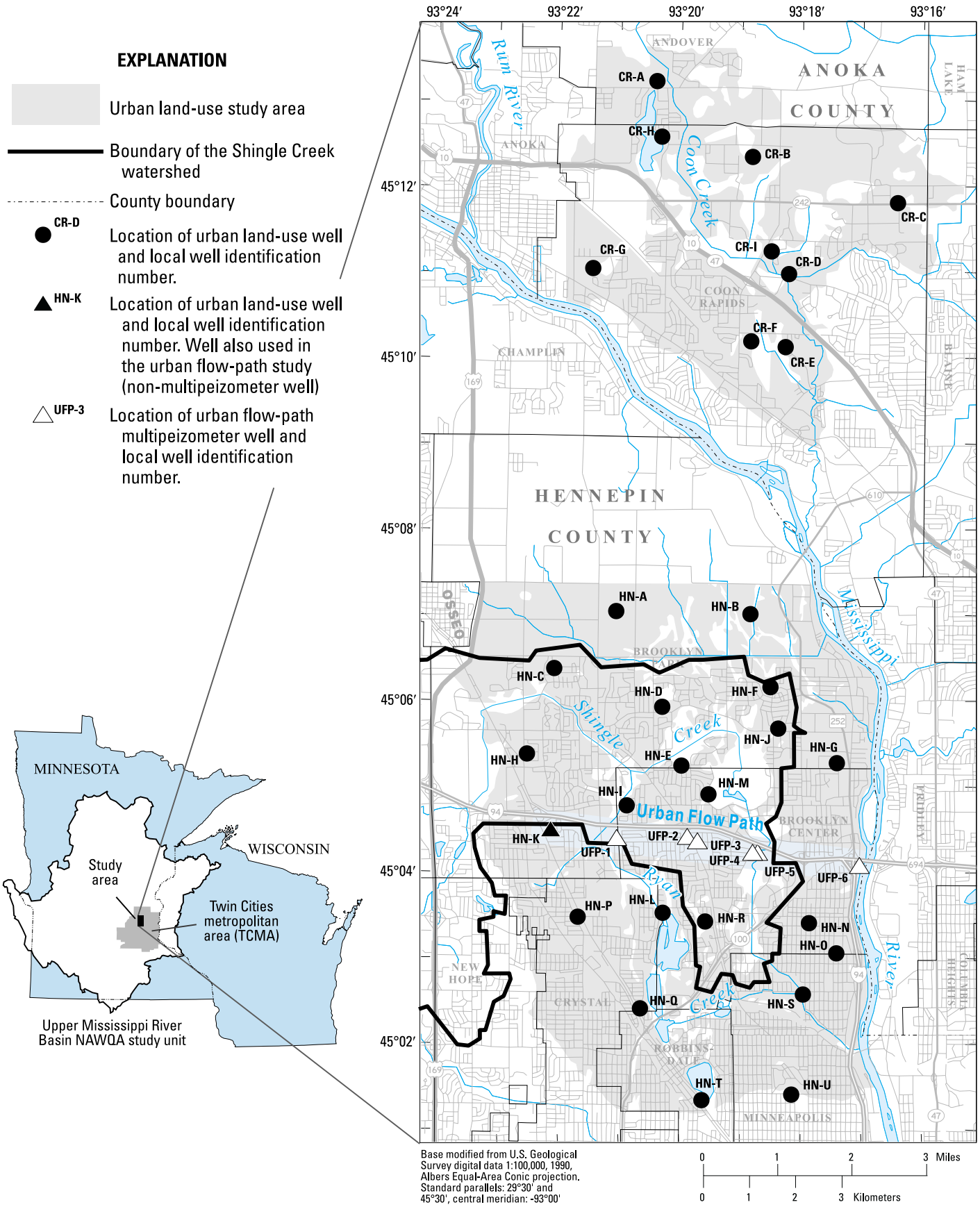


Figure 15.--Location of wells sampled for the urban land-use study and the urban flow-path study of the Upper Mississippi River Basin study unit.

aquifer. In the spring of 1996, 30 shallow wells were installed with screens at the water table using protocols from Lapham and others (1995). Soil samples were collected from the vadose zone and at the water table for analysis of pH, grain-size, and organic-carbon content. The samples were collected in the summer of 1996. Water samples from the wells were sent to NWQL and analyzed for major ions, nutrients, dissolved organic carbon, VOCs, selected pesticides, trace elements, tritium, and radon (tables B3-B10, B19-B21).

The agricultural land-use study was located in part of the Anoka Sand Plain (an unconfined surficial sand and gravel aquifer) northwest of the TCMA (fig. 16, table A12). Twenty wells were installed as part of the study in the fall 1997, with screens set at the water table using protocols from Lapham and others (1995). Soil samples were collected from the vadose zone and at the water table for analysis of pH, grain-size, and organic-carbon content. The wells, along with ten existing wells, were sampled in the summer of 1998 to characterize the effects of agricultural land use on shallow ground-water quality. The water samples from the wells were sent to NWQL and analyzed for major ions, nutrients, dissolved organic carbon, VOCs, selected pesticides, tritium, and nitrogen isotopes (tables B3-B10, B20, B22).

The forested land-use study was located in the northern part of the study unit in an unconfined surficial sand and gravel aquifer (fig. 17, table A13). Fourteen existing monitoring wells and one new monitoring well were sampled in the summer 1998 to characterize the effects of forested land use on shallow ground-water quality. Water samples were sent to NWQL and analyzed for major ions, nutrients, dissolved organic carbon, VOCs, selected pesticides, and tritium (tables B3-B10, B20).

Flow-Path Study

The flow-path study characterized the spatial (vertical and horizontal) changes in ground-water quality along a ground-water flow path in an urban land-use setting. The flow-path study had three major objectives. The first was to determine the occurrence, spatial distribution, and temporal variability of selected contaminants in ground water along a ground-water flow path from recharge area to discharge area. The second objective was to relate the occurrence and distribution of the ground-water contaminants to land use and other factors. The third objective was to develop an understanding of the transport of the contaminants from land surface to the ground-water flow system and from the ground-water flow system to streams. Part of this objective involved the estimation of the time it takes for contaminants to move through the ground-water-flow system to nearby streams. Flow-path studies help to develop an understanding of how the chemistry of ground water evolves as a result of physical, chemical, and aquatic-biological processes, and human factors.

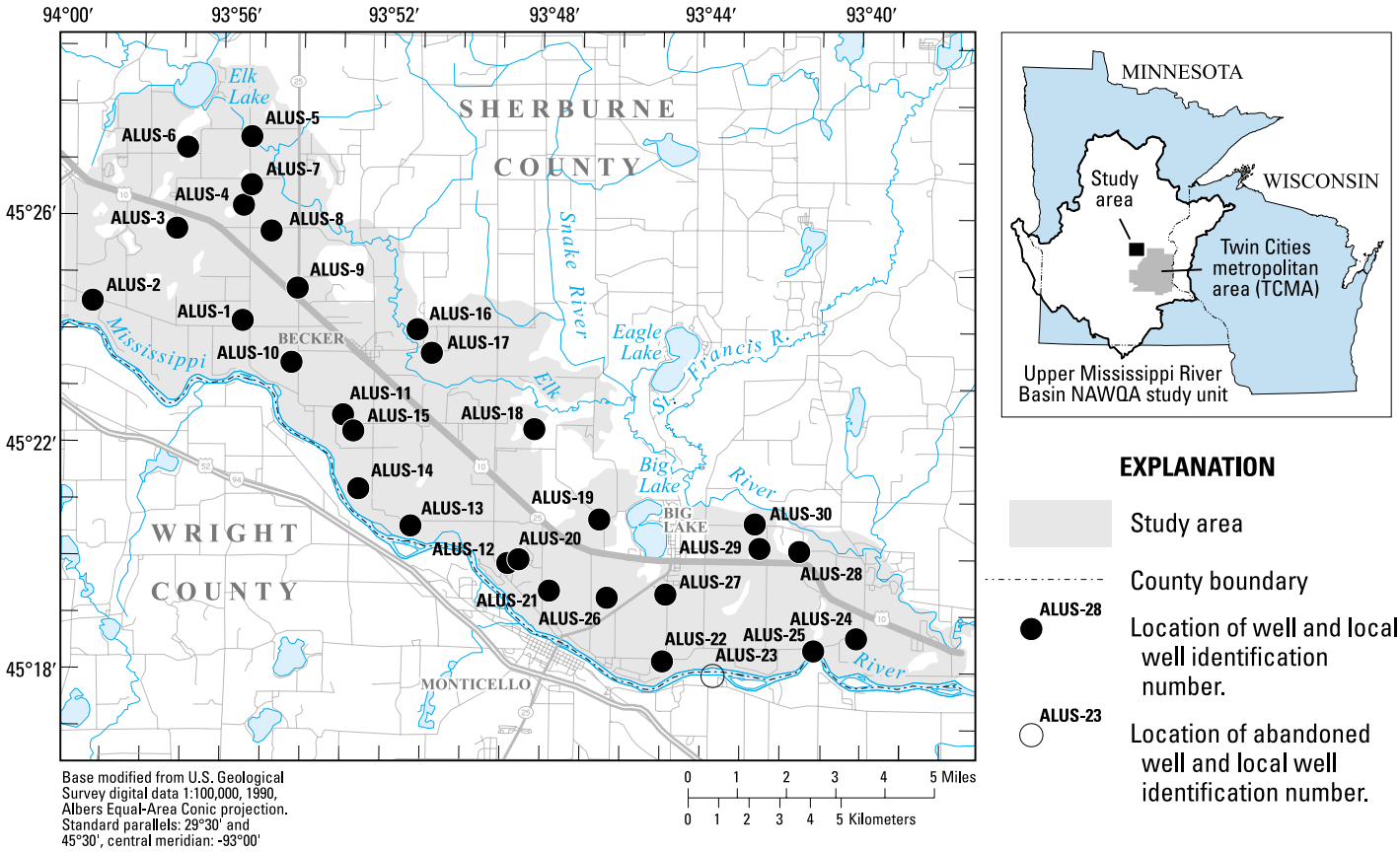


Figure 16.--Location of wells sampled for the agricultural land-use study of the Upper Mississippi River Basin study unit.

When these processes are identified and quantified, the resultant understanding can be extrapolated upward in scale to assist in the interpretation of the results of larger studies such as land-use studies. A flow-path study area was selected in an urban setting in glacial outwash in the northwestern portion of the TCMA (fig. 15, table A14). The flow path was within the urban land-use study and partly within the Shingle Creek urban indicator stream basin (fig. 15).

During the flow-path study, data were collected from wells along a transect that was approximately 4 mi in length. The transect extended from the western edge of the surficial aquifer to the aquifer's discharge area at the Mississippi River. In May and June 1997, six multiport piezometers were installed along the transect. Four ports were completed in each piezometer at depths varying over the thickness of the aquifer. Soil samples were collected from the vadose zone for analysis of grain-size, pH, and organic-carbon content. From one to four ports were sampled (all ports below the water table) for a variety of constituents and compounds. Water temperature, pH, specific conductance, dissolved oxygen, turbidity, and alkalinity were measured in the field in all samples. Samples were sent to the NWQL for analysis of major ions, nutrients, dissolved organic carbon, VOCs, selected pesticides, tritium, and radon (tables B3-B10, B20-B21). Samples were also analyzed for dissolved gases and chlorofluorocarbons (Busenberg and Plummer, 1992; Busenberg and others, 1993). In addition, most samples were analyzed for nitrite plus nitrate, nitrite, iron, and sulfur using field assay techniques. Concentrations of tritium and selected chlorofluorocarbon compounds in ground water were

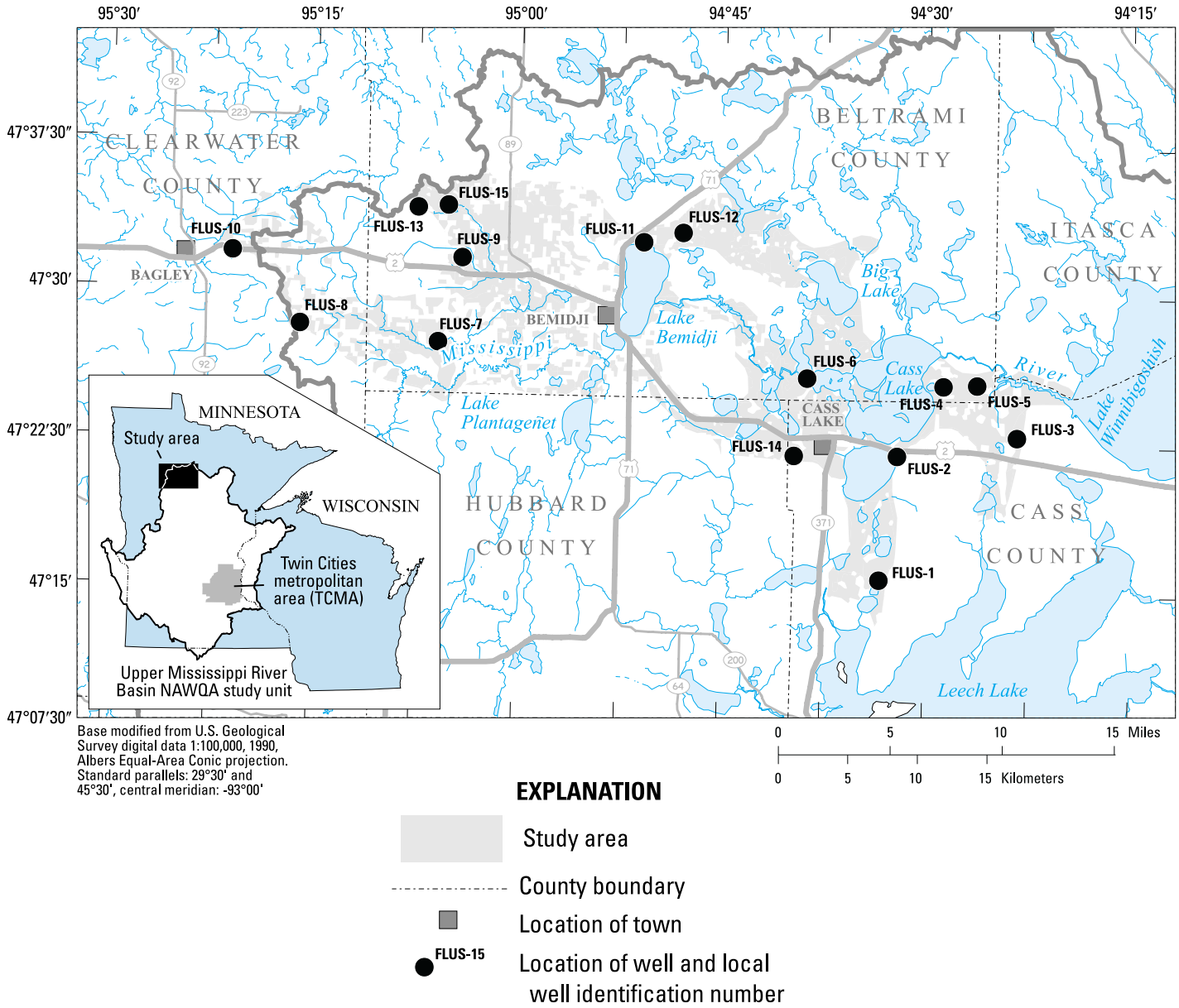


Figure 17.--Location of wells sampled for the forested land-use study of the Upper Mississippi River Basin study unit.

analyzed to evaluate ground-water age at various depths and distances along ground-water flow paths.

This flow-path study provided detailed information needed to evaluate regional ground-water quality in the surficial sand and gravel aquifer and related ground-water quality to depth and land use. The study also provided information that could be used to determine the relation between ground-water quality and stream-water quality. Finally, the data collected during the flow-path study could be used for possible trend analysis of ground-water quality in the study area, and to investigate how ground-water quality is influenced by changes in land-use practices over time.

Quality Assurance

Information about the quality of the surface water, ground water, and aquatic-biological data was necessary for a proper assessment of the UMIS. Bias and variability may exist in the data as a result of sampling methods, analytical methods, sample-matrix effects, or constituent degradation and may affect interpretation of the data. The amount of bias and variability from these sources was quantified by routinely collecting field blank, trip blank, replicate, and field matrix-spike samples. Collection frequencies for quality-control samples are described by Mueller and others (1997). Generally, the collection frequency was one quality-control sample for each 15 environmental samples. For the ground-water surveys and studies, the recommendations for quality-control samples from Koterba and others (1995) were followed. Quality control samples included a variety of blanks, replicates, and spikes (pesticides and VOCs). Depending on the constituents analyzed, between 5 and 10 percent of the samples were for quality control. Replicates or spiked replicates were collected immediately following or during the collection of the environmental samples. Replicate samples were collected for major ions, nutrients, dissolved organic carbon, radon, pesticides and VOCs. Replicates for pesticides and VOCs were spiked with a solution prepared by the NWQL specifically for these analytical groupings.

Both field collection and laboratory quality-assurance and quality-control procedures were followed to ensure the quality of aquatic-biological data collected as part of the NAWQA Program. Standardized protocols for collection of fish (Meador and others, 1993a), benthic macroinvertebrates (Cuffney and others, 1993a), algae (Porter and others, 1993) and instream habitat characterization (Meador and others, 1993b) were followed to maintain national consistency. At selected sites, fish, algae, invertebrates, and instream habitat were sampled yearly to assess temporal variability, and sampled at more than one reach at a subset of sites to assess spatial variability. Approximately 10 percent of both algae and invertebrate samples were split in the field and replicates analyzed for quality assurance and quality control. An ichthyologist was present for fish collections to ensure proper identification of fish species. Voucher specimens of selected fish were sent to a second ichthyologist to verify fish identification. Procedures of the laboratory quality assurance of benthic macroinvertebrate identification are described by Cuffney and others (1993b).

Summary

From 1995 through 1998, about 4,200 water-quality and aquatic-biological samples from about 240 sites were collected, processed and analyzed for the U.S. Geological Survey's National Water-Quality Assessment Program in the Upper Mississippi River Basin in Minnesota and Wisconsin. Sites were selected and samples collected for integrated water-quality and aquatic-biological studies designed to provide a comprehensive, nationally consistent description of current water-quality conditions, to begin the identification of trends in water quality, and to determine the major factors that affect measured water quality. To achieve this, stream-water, ground-water, streambed-sediment, and aquatic-biological samples were collected, and aquatic habitat assessments were conducted at selected sites.

This report describes the water-quality study design, site-selection strategy, and implementation steps used to obtain water-quality and related data. Methods employed to collect, process, and analyze samples, characterize sites, and assess habitat are described. A comprehensive list of all sites employed in these studies, and their characteristics, is provided. Sample analyses conducted for the water-quality studies described in this report included chlorophyll *a*, major inorganic constituents, nutrients, trace elements, tritium, radon, environmental isotopes, organic carbon, pesticides, volatile organic compounds, and other synthetic and naturally-occurring organic compounds, as well as measured or observed physical properties and habitat characteristics. Aquatic-biological samples collected included fish, benthic macroinvertebrates, and algal enumeration and identification, as well as synthetic-organic compounds and trace elements in fish tissue. Ancillary data important for data analyses and interpretation include land use and land cover, geology, soils, climate, and physical habitat.

References

American Society for Testing Materials, 1996, Annual book of ASTM standards, section II, Water and Environmental Technology: v. 11.02, D5072-92, p. 674-676.

Andrews, W.J., Fallon, J.D., and Kroening, S.E., 1995, Water-quality assessment of the Upper Mississippi River Basin, Minnesota and Wisconsin—Volatile organic compounds in surface and ground water, 1978-94: U.S. Geological Survey Water-Resources Investigations Report 95-4216, 39 p.

Andrews, W.J., Fallon, J.D., Kroening, S.E., Lee, K.E., and Stark, J.R.,1996, Water-quality assessment of part of the Upper Mississippi River Basin, Minnesota and Wisconsin—Review of selected literature: U.S. Geological Survey Water-Resources Investigations Report 96-4149, 21 p.

Arar, E.J., and Collins, G.G., 1992, Method 445.0—In vitro determination of chlorophyll *a* and phaeophytin in marine and freshwater phytoplankton by fluorescence, *in* Methods for determination of chemical substances in marine and estuarine environmental samples: U.S. Environmental Protection Agency Report 600/R-92/121, p. 445.0-1-445.0-9.

Arbogast, B.F., ed., 1990, Quality assurance manual for the Branch of Geochemistry, U.S. Geological Survey: U.S. Geological Survey Open-File Report 90-668, 184 p.

Booth, D.B., and Reinelt, L.E., 1993, Consequences of urbanization on aquatic systems—Measured effects, degradation thresholds, and corrective strategies: Watershed '93—A national conference on watershed management, Alexandria, Virginia, 1993, [Proceedings] p. 545-550

Borchert, J.R. and Gustafson, N.C., 1980, Atlas of Minnesota—Resources and settlement, 3rd ed.: Center for Urban Development and Regional Affairs, Minneapolis, Minnesota, 309 p.

Brenton, R.W., and Arnett, T.L., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of dissolved organic carbon by UV-promoted persulfate oxidation and infrared spectrometry: U.S. Geological Survey Open-File Report 92-480, 12 p.

Britton, L.J., and Greeson, P.E., eds., 1989, Methods for collection and analysis of aquatic biological and microbiological samples: Techniques of Water-Resources Investigations of the U.S. Geological Survey, book 5, chapter A4, p. 223-225.

Brown, B.A., 1988, Bedrock geology of Wisconsin: Wisconsin Geological and Natural History Survey Map 88-7, 1 sheet.

Busenberg, E., and Plummer, L.N., 1992, Use of chlorofluorocarbons (CCl_3F and CCl_2F_2) as hydrologic tracers and age dating tools—The alluvium and terrace systems of central Oklahoma: Water Resources Research, v. 28, no. 9, p. 2257-2283.

Busenberg, E., Weeks, E.P., Plummer, L.N., and Bartholomay, R.C., 1993, Age dating water by use of chlorofluorocarbons (CCl_3F and CCl_2F_2), and distribution of chlorofluorocarbons in the unsaturated zone, Snake River Plain aquifer, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 93-4054, 47 p.

Connor, B.F., Rose, D.L., Noriega, M.C., Murtagh, L.K., and Abney, S.R., 1998, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of 86 volatile organic compounds in water by gas chromatography/mass spectrometry, including detections less than reporting limits: U.S. Geological Survey Open-File Report 97-829, 78 p.

Crawford, J.K., and Luoma, S.N., 1993, Guidelines for studies of contaminants in biological tissues for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 92-494, 62 p.

Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993a, Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-406, 66 p.

_____, 1993b, Guidelines for the processing and quality assurance of benthic invertebrate samples collected as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-407.

Edwards, T.K. and Glysson, D. G., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Open-File Report 86-531, 118 p.

Faires, L.M., 1993, Methods of analysis by the U.S. Geological Survey National Water-Quality Laboratory—Determination of metals in water by inductively coupled-plasma mass spectrometry: U.S. Geological Survey Open-File Report 92-634, 28 p.

Fallon, J.D., Fong, A.L., and Andrews, W.J., 1997, Water-quality assessment of part of the Upper Mississippi River Basin, Minnesota and Wisconsin—Pesticides in streams, streambed sediment, and ground water, 1974-94: U.S. Geological Survey Water-Resources Investigations Report 97-4141, 53 p.

Fenneman, N.M., 1938, Physiography of Eastern United States: McGraw-Hill, New York, 691 p.

Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125, 217 p.

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: Techniques of water-resources investigations of the U.S. Geological Survey, book 5, chapter A1, 545 p.

Foreman, W.T., Connor, B.F., Furlong, E.T., Vaught, D.G., and Merlen, L.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of organochlorine pesticides and polychlorinated biphenyls in bottom sediment by solvent extraction, gel permeation chromatographic fractionation, and capillary-column gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 95-140, 78 p.

Furlong, W.T., Vaught, D.G., Merlen, L.M., Foreman, W.T., and Gates, P.M., 1996, Methods of analysis by the U.S. Geological Survey Water Quality Laboratory—Determination of semivolatile organic compounds in bottom sediment by solvent extraction, gel permeation chromatographic fractionation, and capillary-column gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 95-719, 67 p.

Gilliom, R.J., Alley, W.M., and Gurtz, M.E., 1995, Design of the National Water-Quality Assessment Programs—Occurrence and distribution of water-quality conditions: U.S. Geological Survey Circular 112, 33 p.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chapter C1, 58 p.

Hambrook, J.A., Koltun, G.F., Palcsak, B.B., and Tertuliani, J.S., 1997, Hydrologic disturbance and response of aquatic biota in Big Darby Creek Basin, Ohio: U.S. Geological Survey Water-Resources Investigations Report 96-4315, 82 p.

Hitt, K.J., 1991, Digital map file of major land uses in the United States: U.S. Geological Survey, Reston, Virginia, scale 1:7,500,000.

_____, 1994, Refining 1970's land-use data with 1990 population data to indicate new residential development: US. Geological Survey Water-Resources Investigations Report 94-4250, 15 p.

Hobbs, H.C., and Goebel, J.E., 1982, Geologic Map of Minnesota—Quaternary geology: Minnesota Geological Survey State Map Series S-1, 1 sheet.

Hoffman, G.L., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Preparation procedure for aquatic biological material determined for trace metals: U.S. Geological Survey Open-File Report 96-362, 42 p.

Hoyer, B., 1989, Geology map of Iowa: Iowa Department of Natural Resources, Iowa City, Iowa.

Kalkhoff, S.J., Kolpin, D.W., Thurman, E.M., Ferrer, I., and Barcelo, D., 1998, Degradation of chloroacetanilide herbicides—the prevalence of sulfonic and oxanilic acid metabolites in Iowa ground waters and surface waters: Environmental Science and Technology, v. 32, no. 11, p. 1738-1740.

Kanivetsky, R., and Walton, M., 1979, Hydrogeologic map of Minnesota bedrock hydrogeology—A discussion to accompany Minnesota Geological Survey State Map Series S-2: Minnesota Geological Survey, 11 p.

King, P.B., and Beikman, H.M., compilers, 1974, Geologic map of the United States: U.S. Geological Survey, scale 1:2,500,000, 2 sheets

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Ground-water data collection protocols and procedures for the National Water-Quality Assessment Program—Collection and documentation of water-quality samples and related data: U.S. Geological Survey Open-File Report 95-399, 113 p.

Kroening, S.E., and Andrews, W.J., 1997, Water-quality assessment of part of the Upper Mississippi River Basin, Minnesota and Wisconsin—Nitrogen and phosphorus in streams, streambed sediment, and ground water, 1971-94: U.S. Geological Survey Water-Resources Investigations Report 97-4107, 61 p.

Lapham, W.W., Wilde, F.D., and Koterba, M.T., 1995, Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program—Selection, installation, and documentation of wells and collection of related data: U.S. Geological Survey Open-File Report 95-398, 69 p.

Leiker, T.J., Madsen, J.E., Deacon, J.R., and Foreman, W.T., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of chlorinated pesticides in aquatic tissue by capillary-column gas chromatography with electron-capture detection: U.S. Geological Survey Open-File Report 94-710, 42 p.

Lowrance, R., Todd, R., Fail, J. Jr., Hendrickson, O. Jr., Leonard, R., and Asmussen, L., 1984, Riparian forests as nutrient filters in agricultural watersheds: Bioscience, v. 34, no. 6, p. 374-377.

Meade, R.H. ed., 1995, Contaminants in the Mississippi River, 1987-92: U.S. Geological Survey Circular 1133, 140 p.

Meador, M.R., Cuffney, T.F., and Gurtz. M. E., 1993a, Methods for sampling fish communities as part of the National Water Quality Assessment Program: U.S. Geological Survey Open-File Report 93-104, 40 p.

Meador, M.R., Hupp, C.R., Cuffney, T.F., and Gurtz, M.E., 1993b, Methods for characterizing stream habitat as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-408, 48 p.

Metropolitan Waste Control Commission, 1993, Mississippi River phosphorus study report: Section 1, Summary and Recommendations, 43 p.

Minnesota Pollution Control Agency, 1993, Mississippi River phosphorus study, Section 7, Lake Pepin and Mississippi River BATHTUB

modeling: Minnesota Pollution Control Agency, St. Paul, Minnesota, 61 p.

Miyaki, Y., Wada, E., 1967, The abundance ratio of N-15/N-14 in marine environments: Records of Oceanography, Works in Japan, v. 9, p. 37-53.

Mudrey, M.G., Jr., LaBarge, G.A., Myers, P.E., and Cordua, W.S., 1987, Bedrock geology of Wisconsin: Wisconsin Geological and Natural History Survey Map 87-11a, 2 sheets.

Mueller, D.K., Martin, J.D, and Lopes, T.J., 1997, Quality-control design for surface-water sampling in the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 97-223, 17 p.

Myers, D.N., and Wilde, F.D., eds., 1997, Biological indicators, chap. A7 *of* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, Handbooks for Water-Resources Investigations, book 9, 48 p.

Oberts, G.L., 1982, Water resources management, Nonpoint source pollution technical report: Metropolitan Council Report 10-82-016, 253 p.

_____, 1990, Design considerations for management of urban runoff in wintry conditions: International Conference on Urban Hydrology Under Wintry Conditions, Narvik, Norway, 1990 [Proceedings], 27 p.

Olcott, P.G., 1992, Ground-water atlas of the United States, Segment 9, Iowa, Michigan, Minnesota, and Wisconsin: U.S. Geological Survey Hydrologic Investigations Atlas 730-J, 31 p., scale 1:250,000 and 1:500,000.

Östlund, H.G., and Dorsey, H.G., 1975, Rapid electrolytic enrichment of hydrogen gas proportional counting of tritium: International conference on low radioactivity measurement and applications, High Tatras, Czechoslovakia, 1975 [Proceedings], 6 p.

Pope, L.M., and Putnam, J.E., 1997, Effects of urbanization on water quality in the Kansas River, Shunganunga Creek Basin, and Soldier Creek, Topeka, Kansas, October 1993 through September 1995: U.S. Geological Survey Water-Resources Investigations Report 97-4045, 84 p.

Porter, S.D., Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993, Methods for collecting algal samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-409, 38 p.

Puckett, L.J., Woodside, M.D., Libby, B., and Schening, M.R., 1993, Sinks for trace elements, nutrients, and sediments in wetlands of the Chickahominy River near Richmond, Virginia: The Society of Wetland Scientists, v. 13, no. 12, p. 105-114.

Rittenberg, D., 1947, The preparation of gas samples for mass spectrographic isotope analysis, *in* Wilson, D.W., ed., Preparation and measurement of isotopic tracers: Edwards, Ann Arbor, Mich., 108 p.

Ruhl, J.F., 1987, Hydrogeologic and water-quality characteristics of glacial-drift aquifers in Minnesota: U.S. Geological Survey Water-Resources Investigations Report 87-4224, 2 pls.

Scott, J.C., 1990, Computerized stratified random site-selection approaches for design of a ground-water-quality sampling network: U.S. Geological Survey Water-Resources Investigations Report 90-4101, 109 p.

Shelton, L.R., 1994, Field guide for collecting and processing stream-water samples for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-455, 42 p.

____, 1997, Field guide for collecting samples for analysis of volatile organic compounds in stream-water for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 97-401, 14 p.

Shelton, L.R., and Capel, P.D, 1994, Guidelines for collecting and processing samples of streambed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-458, 20 p.

Sorenson, S.K., Porter, S.D., Akers, K.B., Harris, M.A., Kalkhoff, S.J., Lee, K.E., Roberts, L.R., Terrio, P.J., 1999, Water quality and habitat conditions in upper Midwest streams in relation to riparian vegetation and soil characteristics, August 1997—Study Design, Methods, and Data: U.S. Geological Survey Open-File Report 99-202, 53 p.

Stark, J.R., Andrews, W.J., Fallon, J.D., Fong, A.L., Goldstein, R.M., Hanson, P.E., Kroening, S.E., and Lee, K.E., 1996, Water-quality assessment of part of the Upper Mississippi River Basin, Minnesota and Wisconsin—Environmental setting and study design: U.S. Geological Survey Water-Resources Investigations Report 96-4098, 62 p.

Thurman, E.M., Goolsby, D.A., Aga, D.S., Pomes, M.L., and Meyer, M.T., 1996, Occurrence of alachlor and its sulfonated metabolite in rivers and reservoirs of the Midwestern United States—the importance of sulfonation in the transport of chloroacetanilide herbicides: Environmental Science and Technology, v. 30, no. 2, p. 569-574.

Thurman, E.M., Goolsby, D.A., Meyer, M.T., Mills, M.S., Pomes, M.L., and Kolpin, D.W., 1992, A reconnaissance study of herbicides and their metabolites in surface water of the Midwestern United States using immunoassay and gas chromatography/mass spectrometry: Environmental Science and Technology, v. 26, no. 12, p. 2440-2447.

U.S. Department of Agriculture, 1991, revised July 1994, State Soil Geographic Database (STATSGO) data user guide: Soil Conservation

Service Miscellaneous Publication 1492, 88 p.

U.S. Environmental Protection Agency, 1989, Rapid bioassessment protocols for use in streams and rivers—Benthic macroinvertebrates and fish: U.S. Environment Protection Agency Publication EPA/440/4-89/001, variously paged.

Vogel, A.I., 1961, Quantitative inorganic analysis: John Wiley and Sons, New York, 1216 p.

Werner, S.L., Burkhardt, M.R., DeRusseau, S.L., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by Carbopak-B solid-phase extraction and high-performance liquid chromatography: U.S. Geological Survey Open-File Report 96-216, 42 p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., eds., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chapter A3, 80 p.

Wolock, D.M., 1997, STATSGO soil characteristics for the conterminous United States: U.S. Geological Survey Open-File Report 97-656, digital data set.

Zaugg, S.D., Sandstrom, M.W., Smith S.G., and Fehlberg, K.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of pesticides in water by C-18 solid-phase extraction and capillary-column gas chromatography-mass spectrometry with selected-ion monitoring: U.S. Geological Survey Open-File Report 95-181, 60 p.

Glossary

The terms in this glossary were compiled from numerous sources. Some definitions have been modified and may not be the only valid ones for these terms.

Algae - Chlorophyll-bearing nonvascular, primarily aquatic species that have no true roots, stems, or leaves; most algae are microscopic, but some species can be as large as vascular plants.

Ammonia - A compound of nitrogen and hydrogen (NH_3) that is a common by-product of animal waste. Ammonia readily converts to nitrate in soils and streams.

Aquifer - A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Concentration - The amount or mass of a substance present in a given volume or mass of sample. Usually expressed as microgram per liter (water sample) or micrograms per kilogram (sediment or tissue sample).

Constituent - A chemical or biological substance in water, sediment, or biota that can be measured by an analytical method.

Cubic foot per second (ft^3/s or cfs) - Rate of water discharge representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.2832 cubic meter per second.

Discharge - Rate of fluid flow passing a given point at a given moment in time, expressed as volume per unit of time.

Dissolved solids - Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is a indicator of salinity or hardness.

Ecological studies - Studies of aquatic communities and aquatic habitat characteristics to evaluate the effects of physical and chemical characteristics of water and hydrologic conditions on aquatic biology and to determine how aquatic-biological and habitat characteristics differ among environmental settings in the NAWQA Study Units.

Eutrophication - The process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen.

Ground water - In general, any water that exists beneath the land surface, but more commonly applied to water in fully saturated soils and geologic formations.

Habitat - The part of the physical environment where plants and animals live.

Herbicide - A chemical or other agent applied for the purpose of killing undesirable plants. *See also* Pesticide.

Insecticide - A substance or mixture of substances intended to destroy or repel insects.

Load - General term that refers to a material or constituent in solution, suspension, or in transport; usually expressed in terms of mass or volume.

Mean - The average of a set of observations, unless otherwise specified.

Micrograms per liter (µg/L) - A unit expressing the concentration of constituents in solution as weight (micrograms) of solute per unit volume (liter) of water; equivalent to one part per billion in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Milligrams per liter (mg/L) - A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Nitrate - An ion consisting of nitrogen and oxygen (NO_3^-). Nitrate is a plant nutrient and is very mobile in soils.

Nonpoint source - A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint source pollution.

Nutrient - Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Organochlorine insecticide - A class of organic insecticides containing a high percentage of chlorine. Includes dichlorodiphenylethanes (such as DDT), chlorinated cyclodienes (such as chlordane), and chlorinated benzenes (such as lindane). Most organochlorine insecticides were banned because of their carcinogenicity, tendency to bioaccumulate, and toxicity to wildlife.

Outwash - Soil material washed by glacial meltwater and deposited on gently sloping land.

Pesticide - A chemical applied to crops, rights-of-way, lawns or residences to control weeds, insects, fungi, nematodes, rodents or other "pests."

Phosphorus - A nutrient essential for growth that can play a key role in stimulating aquatic growth in lakes and streams.

Polychlorinated biphenyls (PCBs) - A mixture of chlorinated derivatives of biphenyl, marketed under the trade name Aroclor with a number designating the chlorine content (such as Aroclor 1260). PCBs were used in transformers and capacitors for insulating purposes and in gas pipeline systems as a lubricant. Further sale for new use was banned by law in 1979.

Polycyclic aromatic hydrocarbon (PAH) - A class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of unburned coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

Radon - A naturally occurring, colorless, odorless, radioactive gas formed by the disintegration of the element radium; damaging to human lungs when inhaled.

Recharge - Water that infiltrates the ground and reaches the saturated zone.

Riparian - Areas adjacent to rivers and streams with a high density, diversity, and

productivity of plant and animal species relative to nearby uplands.

Semivolatile organic compound (SVOC) - Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs).

Shallow ground water - In this report, refers to water (generally, aged less than 20 years) that is within 10 feet below the water table.

Streambed sediment - The material that temporarily is stationary in the bottom of a stream or other watercourse.

Surficial aquifer - An aquifer located within close proximity to the land surface (as compared to locally deep ground-water aquifers) in which recently recharged ground water is commonly susceptible to contamination from activities on the land surface.

Suspended sediment - Particles of rock, sand, soil, and organic detritus carried in suspension in the water column, in contrast to sediment that moves on or near the streambed.

Trace element - An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Volatile organic compounds (VOCs) - Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Water table - The point below the land surface where ground water is first encountered and below which the earth is saturated. Depth to the water table varies widely across the country.

Wetlands - Ecosystems whose soil is saturated for long periods seasonally or continuously, including marshes, swamps, and ephemeral ponds.

Yield - The mass of material or constituent transported by a river in a specified period of time divided by the drainage area of the river basin.

Appendix A—Site Characteristics for Sampling Sites

Table A1. Site characteristics for basic fixed stream sampling sites

[Minn., Minnesota; mi^2, square mile; Wis., Wisconsin]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
15	05267000	Mississippi River near Royalton, Minn.	45°51’40”	094°21’30”	Morrison	Outwash-Alluvium	Calcareous	0.6	25	49	8.6	16	0.9	11600
21	05276005	North Fork Crow River above Paynesville, Minn.	45°22’38”	094°47’00”	Kandiyohi	Outwash-Alluvium	Calcareous	0.3	90	2.1	1.7	5.6	0.1	232
29	05286290	Cedar Creek near Coopers Corner, Minn.	45°23’31”	093°12’44”	Anoka	Outwash-Alluvium	Calcareous	0.1	69	7.8	0	23	0	27.3
33	05288500	Mississippi River near Anoka, Minn.	45°07’36”	093°17’48”	Hennepin	Outwash-Alluvium	Calcareous	1.1	45	34	7.6	12	0.7	19200
40	05288705	Shingle Creek at Queen Ave. in Minneapolis, Minn.	45°03’00”	093°18’36”	Hennepin	Outwash-Alluvium	Calcareous	71	20	0.9	4.0	0.7	3.5	28.2
64	05320270	Little Cobb River near Beauford, Minn.	43°59’48”	093°54’30”	Blue Earth	Till plain-Moraine	Calcareous	0.2	94	0.5	0.6	4.0	0	130
69	05330000	Minnesota River near Jordan, Minn.	44°41’35”	093°38’30”	Carver	Till plain-Moraine	Calcareous	0.9	94	1.7	2.2	1.1	0.2	16200
73	05330902	Nine Mile Creek near James Circle at Bloomington, Minn.	44°48’26”	093°18’05”	Hennepin	Till plain-Moraine	Calcareous	87	5.7	2.2	3.7	1.7	0	44.6
77	05331580	Mississippi River below Lock & Dam #2 at Hastings, Minn.	44°44’48”	092°51’08”	Dakota	Till plain-Moraine	Calcareous	2.5	66	18	5.2	7.1	0.4	37000
79	05331833	Namekagon River at Leonards, Wis.	46°10’18”	091°19’50”	Bayfield	Outwash-Alluvium	Siliceous	0.7	1.8	78	6.3	12	1.0	128
82	05333500	St. Croix River near Danbury, Wis.	46°04’28”	092°14’50”	Burnett	Outwash-Alluvium	Siliceous	0.3	4.9	79	4.0	12	0.3	1510
95	05340500	St. Croix River at St. Croix Falls, Wis.	45°24’25”	092°38’49”	Polk	Till plain-Moraine	Siliceous	0.4	26	56	2.8	14	0.2	6149
108	05355250	Mississippi River at Red Wing, Minn.	44°36’36”	092°36’36”	Goodhue	Till plain-Moraine	Calcareous	2.3	62	23	4.8	7.8	0.4	46800

[1]Percentages associated with each site may not total 100 percent because of rounding.

Table A2. Types of samples collected and analyzed at all stream sites

[X, sampled or analyzed routinely; x, sampled or analyzed once or occasionally; --, not sampled or analyzed; PCB, polychlorinated biphenyl; BNA, base-neutral-acid extractable; SVOC, semivolatile organic compound; codes in parentheses of column headings refer to tables describing methods in Appendix B]

			Water								Streambed sediment					Fish Tissue		Biological Communities			Field Measurements				
Map identifier	Site identifier	Site name	Chlorophyll *a* (B2)	Fecal coliform bacteria	Major ions and inorganic constituents (B3)	Nutrients (B4)	Organic carbon (B5)	Pesticides (B7-B10)	Volatile organic compounds (B6)	Suspended sediment (B11)	Trace elements and other constituents (B12)	Organic carbon (B13)	Organochlorine and PCB compounds (B14)	BNA extractable and SVOCs (B15)	Streambed sediment size (B11)	Trace elements (B16)	Organochlorine and PCB compounds (B17)	Fish	Invertebrates	Algae	Physical and chemical properties (B1)	Continuous streamflow monitoring	Continuous water temperature monitoring (B1)	Continuous specific conductance (B1)	Habitat surveys
1	05200020	Mississippi River at Hwy 200 near Lake Itasca, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
2	05200510	Mississippi River near Bemidji, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
3	05200940	Mississippi River near Pennington, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
4	05201550	Mississippi River at Hwy 2 near Ball Club, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
5	05210000	Mississippi River at Days High Landing near Deer River, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
6	05211000	Mississippi River at Grand Rapids, Minn.	x	--	x	x	x	x	--	x	x	x	x	x	x	x	x	x	x	--	x	--	--	--	x
7	05213500	Mississippi River near Blackberry, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
8	05217600	Mississippi River at Jacobson, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
9	05220600	Mississippi River at Palisade, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
10	05221060	Mississippi River at Hwy 169 near Hassman, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
11	05227500	Mississippi River at Aitkin, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
12	05242300	Mississippi River at Brainerd, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
13	05261000	Mississippi River near Fort Ripley, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
14	05263500	Mississippi River below Little Falls, Minn.	x	--	x	x	x	x	--	x	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
15	05267000	Mississippi River near Royalton, Minn.	X	--	X	X	X	x	--	X	--	--	--	--	--	--	--	X	X	X	X	X	X	--	x
16	05268000	Platte River at Royalton, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--

Table A2. Types of samples collected and analyzed at all stream sites--Continued

[X, sampled or analyzed routinely; x, sampled or analyzed once or occasionally; --, not sampled or analyzed; PCB, polychlorinated biphenyl; BNA, base-neutral-acid extractable; SVOC, semivolatile organic compound; codes in parentheses of column headings refer to tables describing methods in Appendix B]

			Water								Streambed sediment					Fish Tissue		Biological Communties			Field Measurements				
Map identifier	Site identifier	Site name	Chlorophyll *a* (B2)	Fecal coliform bacteria	Major ions and inorganic constituents (B3)	Nutrients (B4)	Organic carbon (B5)	Pesticides (B7-B10)	Volatile organic compounds (B6)	Suspended sediment (B11)	Trace elements and other constituents (B12)	Organic carbon (B13)	Organochlorine and PCB compounds (B14)	BNA extractable and SVOCs (B15)	Streambed sediment size (B11)	Trace elements (B16)	Organochlorine and PCB compounds (B17)	Fish	Invertebrates	Algae	Physical and chemical properties (B1)	Continuous streamflow monitoring	Continuous water temperature monitoring (B1)	Continuous specific conductance (B1)	Habitat surveys
17	05270380	Sauk River at Richmond, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
18	05270500	Sauk River near St. Cloud, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
19	05270700	Mississippi River at St. Cloud, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	--	x	--	--	--	x
20	05275000	Elk River near Big Lake, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
21	05276005	North Fork Crow River above Paynesville, Minn.	X	--	X	X	X	x	--	X	x	x	x	x	x	x	x	X	X	X	X	X	X	X	x
22	05278400	North Fork Crow River near Rockford, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
23	05278590	South Fork Crow River at Biscay, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
24	05278930	Buffalo Creek near Glencoe, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
25	05280000	Crow River at Rockford, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
26	05280400	Crow River below State Highway 101 at Dayton, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
27	05283500	Mississippi River at Anoka, Minn.	x	--	x	x	x	x	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	x
28	05286000	Rum River near St. Francis, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
29	05286290	Cedar Creek near Coopers Corner, Minn.	X	--	X	X	X	x	--	X	x	x	x	x	x	x	x	x	x	x	X	X	X	X	x
30	05286798	Ford Brook at Green Valley Road in Ramsey, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
31	05287000	Rum River at Anoka, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
32	05287890	Elm Creek near Champlin, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	x
33	05288500	Mississippi River near Anoka, Minn.	X	--	X	X	X	x	--	X	x	x	x	x	x	x	x	x	x	x	X	X	X	X	x
34	05288475	Coon Creek at 131st Street in Coon Rapids, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	--	x	x	x	--	--	--	x

Table A2. Types of samples collected and analyzed at all stream sites--Continued

[X, sampled or analyzed routinely; x, sampled or analyzed once or occasionally; --, not sampled or analyzed; PCB, polychlorinated biphenyl; BNA, base-neutral-acid extractable; SVOC, semivolatile organic compound; codes in parentheses of column headings refer to tables describing methods in Appendix B]

			Water								Streambed sediment					Fish Tissue		Biological Communties			Field Measurements				
Map identifier	Site identifier	Site name	Chlorophyll *a* (B2)	Fecal coliform bacteria	Major ions and inorganic constituents (B3)	Nutrients (B4)	Organic carbon (B5)	Pesticides (B7-B10)	Volatile organic compounds (B6)	Suspended sediment (B11)	Trace elements and other constituents (B12)	Organic carbon (B13)	Organochlorine and PCB compounds (B14)	BNA extractable and SVOCs (B15)	Streambed sediment size (B11)	Trace elements (B16)	Organochlorine and PCB compounds (B17)	Fish	Invertebrates	Algae	Physical and chemical properties (B1)	Continuous streamflow monitoring	Continuous water temperature monitoring (B1)	Continuous specific conductance (B1)	Habitat surveys
35	05288487	Sand Creek at Xeon Street in Coon Rapids, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
36	05288598	Rice Creek at Central Ave. in Fridley, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
37	05288695	Shingle Creek at Zane Ave. at Brooklyn Park, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
38	05288700	Shingle Creek at Brooklyn Center, Minn.	--	--	x	x	x	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
39	450401-093183401	Parking Lot Outflow at Public Library at Brooklyn Center, Minn.	--	--	--	--	x	--	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40	05288705	Shingle Creek at Queen Ave in Minneapolis, Minn.	X	x	X	X	X	X	X	X	x	x	x	x	x	x	x	X	X	X	X	X	X	X	x
41	05288710	Shingle Creek at 46th Street in Minneapolis, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
42	05288730	Mississippi River at 28th Ave. in Minneapolis, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
43	05288839	Bassett Creek at Dresden Lane in Golden Valley, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
44	05289600	Minnehaha Creek at Nicollet Ave. in Minneapolis, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
45	05303900	Shakopee Creek near Louriston, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	--	x	x	x	--	--	--	x
46	05304795	Dry Weather Creek near Watson, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
47	05312000	Spring Creek near Spring Creek, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
48	05314500	Hawk Creek near Maynard, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
49	05314510	Chetomba Creek near Renville, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
50	05316985	Sleepy Eye Creek near Springfield, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
51	05317170	Little Cottonwood River near Searles, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
52	05317800	West Branch Blue Earth River above Elmore, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x

Table A2. Types of samples collected and analyzed at all stream sites--Continued

[X, sampled or analyzed routinely; x, sampled or analyzed once or occasionally; --, not sampled or analyzed; PCB, polychlorinated biphenyl; BNA, base-neutral-acid extractable; SVOC, semivolatile organic compound; codes in parentheses of column headings refer to tables describing methods in Appendix B]

			Water								Streambed sediment					Fish Tissue		Biological Communties			Field Measurements				
Map identifier	Site identifier	Site name	Chlorophyll *a* (B2)	Fecal coliform bacteria	Major ions and inorganic constituents (B3)	Nutrients (B4)	Organic carbon (B5)	Pesticides (B7-B10)	Volatile organic compounds (B6)	Suspended sediment (B11)	Trace elements and other constituents (B12)	Organic carbon (B13)	Organochlorine and PCB compounds (B14)	BNA extractable and SVOCs (B15)	Streambed sediment size (B11)	Trace elements (B16)	Organochlorine and PCB compounds (B17)	Fish	Invertebrates	Algae	Physical and chemical properties (B1)	Continuous streamflow monitoring	Continuous water temperature monitoring (B1)	Continuous specific conductance (B1)	Habitat surveys
53	05317828	Coon Creek at U.S. Hwy. 169 near Blue Earth, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
54	05318050	East Branch Blue Earth River below Bricelyn, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	--	x	x	x	--	--	--	x
55	05318138	South Creek near Huntley, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
56	05318178	Center Creek at Huntley, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
57	05318240	Elm Creek near Northrop, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
58	05318630	Watonwan River near St. James, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
59	05318800	St. James Creek near La Salle, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	--	x	x	x	--	--	--	x
60	05319050	South Fork Watonwan River near St. James, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
61	05319360	Perch Creek below Vernon Center, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
62	05320080	Le Sueur River near Wilton, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
63	05320230	Cobb River near Mapleton, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
64	05320270	Little Cobb River near Beauford, Minn.	X	--	X	X	X	X	--	X	x	x	x	x	x	x	x	X	X	X	X	X	X	X	x
65	05320450	Maple River near Sterling Center, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	--	x	x	x	--	--	--	x
66	05326150	Rush River near New Rome, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
67	05326250	South Branch Rush River near Rush River, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
68	05326700	High Island Creek near Arlington, Minn.	x	--	--	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
69	05330000	Minnesota River near Jordan, Minn.	X	--	X	X	X	X	x	X	x	x	x	x	x	x	x	X	X	X	X	X	X	X	x
70	05330702	Minnesota River tributary at Beech St. in Chaska, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x

Table A2. Types of samples collected and analyzed at all stream sites--Continued

[X, sampled or analyzed routinely; x, sampled or analyzed once or occasionally; --, not sampled or analyzed; PCB, polychlorinated biphenyl; BNA, base-neutral-acid extractable; SVOC, semivolatile organic compound; codes in parentheses of column headings refer to tables describing methods in Appendix B]

			Water								Streambed sediment					Fish Tissue		Biological Communties			Field Measurements				
Map identifier	Site identifier	Site name	Chlorophyll *a* (B2)	Fecal coliform bacteria	Major ions and inorganic constituents (B3)	Nutrients (B4)	Organic carbon (B5)	Pesticides (B7-B10)	Volatile organic compounds (B6)	Suspended sediment (B11)	Trace elements and other constituents (B12)	Organic carbon (B13)	Organochlorine and PCB compounds (B14)	BNA extractable and SVOCs (B15)	Streambed sediment size (B11)	Trace elements (B16)	Organochlorine and PCB compounds (B17)	Fish	Invertebrates	Algae	Physical and chemical properties (B1)	Continuous streamflow monitoring	Continuous water temperature monitoring (B1)	Continuous specific conductance (B1)	Habitat surveys
71	05330750	Riley Creek at Eden Prairie, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
72	05330801	Purgatory Creek at Pioneer Tr. in Eden Prairie, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
73	05330902	Nine Mile Creek near James Circle at Bloomington, Minn.	X	x	X	X	X	X	X	X	x	x	x	x	x	x	x	X	X	X	X	X	X	X	x
74	05331045	Battle Creek at Meadow Lane in Woodbury, Minn.	--	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
75	05331050	Battle Creek below McKnight Road in St. Paul, Minn.	x	x	x	x	x	x	--	x	--	--	--	--	--	--	--	x	x	x	x	--	--	--	x
76	05331570	Mississippi River at Nininger, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
77	05331580	Mississippi River below Lock & Dam #2 at Hastings, Minn.	X	--	X	X	X	X	x	X	--	--	--	--	--	--	--	X	X	X	X	X	X	X	x
78	05331775	St. Croix River near Woodland Corner, Wis.	--	--	x	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
79	05331833	Namekagon River at Leonards, Wis.	X	--	X	X	X	x	--	X	x	x	x	x	x	x	x	X	X	X	X	X	X	X	x
80	05331873	Namekagon River above Spring Lake Creek near Hayward, Wis.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
81	05333400	Namekagon River near Woodland Corner, Wis.	--	--	x	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
82	05333500	St. Croix River near Danbury, Wis.	X	--	X	X	X	x	--	X	x	x	x	x	x	x	x	X	X	X	X	X	X	X	x
83	053350006	Yellow River near Danbury, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
84	05335170	Crooked Creek near Hinckley, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
85	05335326	Clam River near Siren, Wis.	--	--	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
86	05335500	Clam River near Webster, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
87	05336180	Kettle River near Kettle River, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--

Table A2. Types of samples collected and analyzed at all stream sites--Continued

[X, sampled or analyzed routinely; x, sampled or analyzed once or occasionally; --, not sampled or analyzed; PCB, polychlorinated biphenyl; BNA, base-neutral-acid extractable; SVOC, semivolatile organic compound; codes in parentheses of column headings refer to tables describing methods in Appendix B]

			Water								Streambed sediment					Fish Tissue		Biological Communities			Field Measurements				
Map identifier	Site identifier	Site name	Chlorophyll *a* (B2)	Fecal coliform bacteria	Major ions and inorganic constituents (B3)	Nutrients (B4)	Organic carbon (B5)	Pesticides (B7-B10)	Volatile organic compounds (B6)	Suspended sediment (B11)	Trace elements and other constituents (B12)	Organic carbon (B13)	Organochlorine and PCB compounds (B14)	BNA extractable and SVOCs (B15)	Streambed sediment size (B11)	Trace elements (B16)	Organochlorine and PCB compounds (B17)	Fish	Invertebrates	Algae	Physical and chemical properties (B1)	Continuous streamflow monitoring	Continuous water temperature monitoring (B1)	Continuous specific conductance (B1)	Habitat surveys
88	05336700	Kettle River below Sandstone, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
89	460041-092502001	Kettle River near Hinckley, Minn	--	--	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
90	05338500	Snake River near Pine City, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
91	05338975	Wood River at State Highway 70 near Grantsburg, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
92	05339770	St. Croix River near Sunrise, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
93	453049-092512101	Sunrise River at Sunrise, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
94	05340370	Trade River near Trade River, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
95	05340500	St. Croix River at St. Croix Falls, Wis.	X	--	X	X	X	X	--	X	--	--	--	--	--	--	--	X	X	X	X	X	X	X	x
96	053405524	St. Croix River tributary near Osceola, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
97	05341125	Apple River near Range, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
98	05341500	Apple River near Somerset, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
99	05341540	Browns Creek at Stillwater, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
100	05341552	St. Croix River at Hudson, Wis.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
101	05341740	Willow River at Burkhardt, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
102	05342000	Kinnickinnic River near River Falls, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
103	05344490	St. Croix River at Prescott, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
104	05345000	Vermillion River near Empire, Minn.	--	--	--	x	--	--	--	x	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--

Table A2. Types of samples collected and analyzed at all stream sites--Continued

[X, sampled or analyzed routinely; x, sampled or analyzed once or occasionally; --, not sampled or analyzed; PCB, polychlorinated biphenyl; BNA, base-neutral-acid extractable; SVOC, semivolatile organic compound; codes in parentheses of column headings refer to tables describing methods in Appendix B]

			Water								Streambed sediment					Fish Tissue		Biological Communities			Field Measurements				
Map identifier	Site identifier	Site name	Chlorophyll *a* (B2)	Fecal coliform bacteria	Major ions and inorganic constituents (B3)	Nutrients (B4)	Organic carbon (B5)	Pesticides (B7-B10)	Volatile organic compounds (B6)	Suspended sediment (B11)	Trace elements and other constituents (B12)	Organic carbon (B13)	Organochlorine and PCB compounds (B14)	BNA extractable and SVOCs (B15)	Streambed sediment size (B11)	Trace elements (B16)	Organochlorine and PCB compounds (B17)	Fish	Invertebrates	Algae	Physical and chemical properties (B1)	Continuous streamflow monitoring	Continuous water temperature monitoring (B1)	Continuous specific conductance (B1)	Habitat surveys
105	05353800	Straight River near Faribault, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	x	--	--	--	--
106	05355090	Cannon River at Lake Byllesby near Cannon Falls, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
107	05355200	Cannon River at Welch, Minn.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
108	05355250	Mississippi River at Red Wing, Minn.	X	--	X	X	X	x	x	X	--	--	--	--	--	--	--	X	X	X	X	X	X	X	x
109	05355330	Rush River near Maiden Rock, Wis.	--	--	--	x	--	--	--	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
110	443334-092205201	Mississippi River in Lake Pepin near Frontenac, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	--	--	--	--	--	x	--	--	--	--
111	442912-092174201	Mississippi River in Lake Pepin near Central Point, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	x	x	--	--	--	x	--	--	--	--
112	442633-092130801	Mississippi River in Lake Pepin near Lake City, Minn.	--	--	--	--	--	--	--	--	x	x	x	x	x	--	--	--	--	--	x	--	--	--	--

Table A3. Site characteristics for streambed sediment and tissue sampling sites

[mi^2, square mile; Minn., Minnesota; Wis., Wisconsin]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
6	05211000	Mississippi River at Grand Rapids, Minn.	47°13’56”	093°31’48”	Itasca	Till plain-Moraine	Calcareous	0.4	8.8	60	16	14	0.8	3320
14	05263500	Mississippi River below Little Falls, Minn.	45°56’22”	094°23’20”	Morrison	Till plain-Moraine	Calcareous	0.6	24	49	8.7	16	0.9	11300
17	05270380	Sauk River at Richmond, Minn.	45°26’56”	094°31’30”	Stearns	Till plain-Moraine	Calcareous	0.9	84	8.1	4.2	3.0	0.1	818
21	05276005	North Fork Crow River above Paynesville, Minn.	45°22’38”	094°47’00”	Kandiyohi	Outwash-Alluvium	Calcareous	0.3	90	2.1	1.7	5.6	0.1	232
26	05280400	Crow River below State Highway 101 at Dayton, Minn.	45°13’20”	093°31’12”	Hennepin	Till plain-Moraine	Calcareous	1.4	87	3.8	4.9	2.8	0.2	2770
29	05286290	Cedar Creek near Coopers Corner, Minn.	45°23’31”	093°12’44”	Anoka	Outwash-Alluvium	Calcareous	0.1	69	7.8	0	23	0	27.3
31	05287000	Rum River at Anoka, Minn.	45°12’41”	093°23’11”	Anoka	Till plain-Moraine	Calcareous	0.7	49	21	15	14	0.6	1560
33	05288500	Mississippi River near Anoka, Minn.	45°07’36”	093°17’48”	Hennepin	Outwash-Alluvium	Calcareous	1.1	45	34	7.6	12	0.7	19200
37	05288695	Shingle Creek at Zane Ave. at Brooklyn Park, Minn.	45°05’32”	093°21’22”	Hennepin	Outwash-Alluvium	Calcareous	57	30	1.3	5.9	1	5.1	19.2
40	05288705	Shingle Creek at Queen Ave. in Minneapolis, Minn.	45°03’00”	093°18’36”	Hennepin	Outwash-Alluvium	Calcareous	71	20	0.9	4.0	0.7	3.5	28.2
41	05288710	Shingle Creek at 46th Street in Minneapolis, Minn.	45°02’17”	093°17’30”	Hennepin	Outwash-Alluvium	Calcareous	79	14	0.6	3.9	0.5	2.4	40.8
42	05288730	Mississippi River at 28th Ave. in Minneapolis, Minn.	45°01’12”	093°16’31”	Hennepin	Till plain-Moraine	Calcareous	1.7	44	33	7.6	12	0.7	19600
64	05320270	Little Cobb River near Beauford, Minn.	43°59’48”	093°54’30”	Blue Earth	Till plain-Moraine	Calcareous	0.2	94	0.5	0.6	4.0	0	130
69	05330000	Minnesota River near Jordan, Minn.	44°41’35”	093°38’30”	Carver	Till plain-Moraine	Calcareous	0.9	94	1.7	2.2	1.1	0.2	16200
73	05330902	Nine Mile Creek near James Circle at Bloomington, Minn.	44°48’26”	093°18’05”	Hennepin	Till plain-Moraine	Calcareous	87	5.7	2.2	3.7	1.7	0	44.6

Table A3. Site characteristics for streambed sediment and tissue sampling sites--Continued

[mi^2, square mile; Minn., Minnesota; Wis., Wisconsin]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
76	05331570	Mississippi River at Nininger, Minn.	44°46’22”	092°54’07”	Dakota	Till plain-Moraine	Calcareous	2.5	66	19	5.2	7.1	0.4	37000
79	05331833	Namekagon River at Leonards, Wis.	46°10’18”	091°19’50”	Bayfield	Outwash-Alluvium	Siliceous	0.7	1.8	78	6.3	12	1.0	128
80	05331873	Namekagon River above Spring Lake Creek near Hayward, Wis.	45°59’22”	091°30’33”	Sawyer	Outwash-Alluvium	Siliceous	1.4	5.5	78	4.7	9.6	0.7	208
82	05333500	St. Croix River near Danbury, Wis.	46°04’28”	092°14’50”	Burnett	Outwash-Alluvium	Siliceous	0.3	4.9	79	4.0	12	0.3	1510
87	05336180	Kettle River near Kettle River, Minn.	46°29’03”	092°53’19”	Carlton	Till plain-Moraine	Siliceous	0.0	23.4	43.4	0.7	32.5	0.0	157.2
92	05339770	St. Croix River near Sunrise, Minn.	45°34’14”	092°52’30”	Chisago	Outwash-Alluvium	Siliceous	0.4	24	59	2.8	15	0.2	5510
100	05341552	St. Croix River at Hudson, Wis.	44°58’57”	092°46’07”	St. Croix	Till plain-Moraine	Siliceous	0.7	34	49	3.2	13	0.2	7340
104	05345000	Vermillion River near Empire, Minn.	44°40’00”	093°03’17”	Dakota	Outwash-Alluvium	Calcareous	16	76	3.9	1.7	0.5	1.2	129
106	05355090	Cannon River at Lake Byllesby near Cannon Falls, Minn.	44°30’35”	092°57’00”	Goodhue	Till plain-Moraine	Calcareous	3.1	89	2.6	3.1	2.3	0.2	1150
110	443334-092205201	Mississippi River in Lake Pepin near Frontenac, Minn.	44°33’34”	092°20’52”	Goodhue	Till plain-Moraine	Calcareous	2.3	62	22	4.8	7.7	0.4	47300
111	442912-092174201	Mississippi River in Lake Pepin near Central Point, Minn.	44°29’12”	092°17’42”	Goodhue	Till plain-Moraine	Calcareous	2.3	62	22	4.8	7.7	0.4	47300
112	442633-092130801	Mississippi River in Lake Pepin near Lake City, Minn.	44°26’33”	092°13’08”	Wabasha	Till plain-Moraine	Calcareous	2.3	62	22	4.8	7.7	0.4	47300

[1]Percentages associated with each site may not total 100 percent because of rounding

Table A4. Site characteristics for streams sampled during the snowmelt synoptic study

[mi^2, square mile; Minn., Minnesota; Wis., Wisconsin]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
15	05267000	Mississippi River near Royalton, Minn.	45°51’40”	094°21’30”	Morrison	Outwash-Alluvium	Calcareous	0.6	25	49	8.6	16	0.9	11600
16	05268000	Platte River at Royalton, Minn.	45°50’43”	094°17’40”	Morrison	Outwash-Alluvium	Calcareous	0.4	64	23	1.9	10	0.1	424
18	05270500	Sauk River near St. Cloud, Minn.	45°33’35”	094°14’00”	Stearns	Outwash-Alluvium	Calcareous	1.1	83	8.4	4.3	2.7	0.1	1030
20	05275000	Elk River near Big Lake, Minn.	45°20’02”	093°40’00”	Sherburne	Outwash-Alluvium	Calcareous	0.8	75	10	1.3	13	0	549
21	05276005	North Fork Crow River above Paynesville, Minn.	45°22’38”	094°47’00”	Kandiyohi	Outwash-Alluvium	Calcareous	0.3	90	2.1	1.7	5.6	0.1	232
22	05278400	North Fork Crow River near Rockford, Minn.	45°05’44”	093°47’18”	Wright	Till plain-Moraine	Calcareous	1.2	83	6.3	6.0	3.5	0.1	1350
23	05278590	South Fork Crow River at Biscay, Minn.	44°50’11”	094°17’16”	McLeod	Till plain-Moraine	Calcareous	2.3	89	0.6	6.0	2.2	0.1	477
24	05278930	Buffalo Creek near Glencoe, Minn.	44°45’50”	094°05’27”	McLeod	Till plain-Moraine	Calcareous	0.7	96	0	1.7	0.9	0.1	373
25	05280000	Crow River at Rockford, Minn.	45°05’12”	093°44’02”	Wright	Till plain-Moraine	Calcareous	1.4	87	3.7	4.8	2.7	0.1	2640
28	05286000	Rum River near St. Francis, Minn.	45°19’40”	093°22’20”	Anoka	Outwash-Alluvium	Calcareous	0.5	47	22	16	14	0.5	1380
33	05288500	Mississippi River near Anoka, Minn.	45°07’36”	093°17’48”	Hennepin	Outwash-Alluvium	Calcareous	1.1	45	34	7.6	12	0.7	19200
40	05288705	Shingle Creek at Queen Ave in Minneapolis, Minn.	45°03’00”	093°18’36”	Hennepin	Outwash-Alluvium	Calcareous	71	20	0.9	4.0	0.7	3.5	28.2
64	05320270	Little Cobb River near Beauford, Minn.	43°59’48”	093°54’30”	Blue Earth	Till plain-Moraine	Calcareous	0.2	94	0.5	0.6	4.0	0	130
69	05330000	Minnesota River near Jordan, Minn.	44°41’35”	093°38’30”	Scott	Till plain-Moraine	Calcareous	0.9	94	1.7	2.2	1.1	0.2	16200

Table A4. Site characteristics for streams sampled during the snowmelt synoptic study--Continued

[mi^2, square mile; Minn., Minnesota; Wis., Wisconsin]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
73	05330902	Nine Mile Creek near James Circle at Bloomington, Minn.	44°48’26”	093°18’05”	Hennepin	Till plain-Moraine	Calcareous	87	5.7	2.2	3.7	1.7	0	44.6
77	05331580	Mississippi River below Lock & Dam #2 at Hastings, Minn.	44°44’48”	092°51’08”	Dakota	Till plain-Moraine	Calcareous	2.5	66	18	5.2	7.1	0.4	37000
78	05331775	St. Croix River near Woodland Corner, Wis.	46°07’00”	092°07’53”	Burnett	Outwash-Alluvium	Siliceous	0.2	1.0	86	3.4	9.6	0.2	433
79	05331833	Namekagon River at Leonards, Wis.	46°10’18”	091°19’50”	Bayfield	Outwash-Alluvium	Siliceous	0.7	1.8	78	6.3	12	1.0	128
81	05333400	Namekagon River near Woodland Corner, Wis.	46°05’02”	092°06’47”	Burnett	Outwash-Alluvium	Siliceous	0.4	6.0	76	4.4	13	0.3	1020
82	05333500	St. Croix River near Danbury, Wis.	46°04’28”	092°14’50”	Burnett	Outwash-Alluvium	Siliceous	0.3	4.9	79	4.0	12	0.3	1510
83	053350006	Yellow River near Danbury, Wis.	45°58’59”	092°23’05”	Burnett	Outwash-Alluvium	Siliceous	0.8	23	56	9.0	11	0.6	312
84	05335170	Crooked Creek near Hinckley, Minn.	46°00’42”	092°31’45”	Pine	Outwash-Alluvium	Siliceous	0	18	69	1.4	12	0	94.4
86	05335500	Clam River near Webster, Wis.	45°52’52”	092°29’16”	Burnett	Outwash-Alluvium	Siliceous	0.3	32	55	3.1	9.9	0	358
88	05336700	Kettle River below Sandstone, Minn.	46°06’20”	092°51’50”	Pine	Outwash-Alluvium	Siliceous	0.5	27	53	1.7	18	0.1	868
90	05338500	Snake River near Pine City, Minn.	45°50’30”	092°56’00”	Pine	Till plain-Moraine	Calcareous	0.4	40	42	1.2	16	0	975
91	05338975	Wood River at State Highway 70 near Grantsburg, Wis.	45°46’22”	092°42’29”	Burnett	Outwash-Alluvium	Siliceous	0.6	44	27	5.0	24	0	160
93	453049-092512101	Sunrise River at Sunrise, Minn.	45°30’49”	092°51’21”	Chisago	Outwash-Alluvium	Calcareous	2.9	58	8.3	5.3	26	0.1	170
94	05340370	Trade River near Trade River, Wis.	45°35’58”	092°46’02”	Polk	Outwash-Alluvium	Siliceous	0.5	47	38	2.6	12	0	133
95	05340500	St. Croix River at St. Croix Falls, Wis.	45°24’25”	092°38’49”	Polk	Till plain-Moraine	Siliceous	0.4	26	56	2.8	14	0.2	6149

Table A4. Site characteristics for streams sampled during the snowmelt synoptic study--Continued

[mi^2, square mile; Minn., Minnesota; Wis., Wisconsin]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
96	053405524	St. Croix River tributary near Osceola, Wis.	45°20’52”	092°40’55”	Polk	Till plain-Moraine	Siliceous	4.4	65	29	0.4	0	0.7	10
97	05341125	Apple River near Range, Wis.	45°23’45”	092°21’50”	Polk	Outwash-Alluvium	Siliceous	0	44	40	5.5	10	0	167
98	05341500	Apple River near Somerset, Wis.	45°09’27”	092°42’59”	St. Croix	Till plain-Moraine	Siliceous	0.5	63	24	5.1	7.1	0.1	551
99	05341540	Browns Creek at Stillwater, Minn.	45°04’35”	092°48’21”	Washington	Till plain-Moraine	Calcareous	6.7	80	5.8	4.3	2.9	0.5	34.1
101	05341740	Willow River at Burkhardt, Wis.	45°01’30”	092°39’23”	St. Croix	Outwash-Alluvium	Siliceous	1.1	89	7.8	0.6	1.1	0	254
102	05342000	Kinnickinnic River near River Falls, Wis.	44°49’50”	092°44’00”	Pierce	Driftless	Calcareous	3.6	92	4.6	0.2	0	0	173
103	05344490	St. Croix River at Prescott, Wis.	44°44’57”	092°48’16”	Pierce	Till plain-Moraine	Siliceous	0.9	36.7	46.8	3.2	12.2	0.2	7691.5
104	05345000	Vermillion River near Empire, Minn.	44°40’00”	093°03’17”	Dakota	Outwash-Alluvium	Calcareous	16	76	3.9	1.7	0.5	1.2	129
105	05353800	Straight River near Faribault, Minn.	44°15’29”	093°13’51”	Rice	Till plain-Moraine	Calcareous	3.5	92	1.5	0.8	2.1	0.2	436
107	05355200	Cannon River at Welch, Minn.	44°33’50”	092°43’55”	Goodhue	Till plain-Moraine	Calcareous	2.8	88	4.0	2.7	2.0	0.2	1340
108	05355250	Mississippi River at Red Wing, Minn.	44°36’36”	092°36’36”	Goodhue	Till plain-Moraine	Calcareous	2.3	62	22	4.8	7.8	0.4	46800
109	05355330	Rush River near Maiden Rock, Wis.	44°34’15”	092°19’44”	Pierce	Driftless	Calcareous	0.5	88	11	0.1	0	0	225

[1]Percentages associated with each site may not total 100 percent because of rounding.

Table A5. Site characteristics for streams sampled during the agricultural synoptic study

[mi^2, square mile; Minn., Minnesota; Hwy., Highway]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
45	05303900	Shakopee Creek near Louriston, Minn.	45°08’16”	095°28’12”	Chippewa	Till plain-Moraine	Calcareous	0.2	87	3.8	8.0	0.7	0	149
46	05304795	Dry Weather Creek near Watson, Minn.	45°02’33”	095°45’33”	Chippewa	Till plain-Moraine	Calcareous	0.1	98	0.3	0.0	1.4	0	105
47	05312000	Spring Creek near Spring Creek, Minn.	44°42’38”	095°47’16”	Yellow-Medicine	Till plain-Moraine	Calcareous	0.1	99	0	0.2	0.5	0.1	112
48	05314500	Hawk Creek near Maynard, Minn.	44°52’11”	095°28’59”	Renville	Till plain-Moraine	Calcareous	1.6	94	0.4	3.1	0.6	0.1	317
49	05314510	Chetomba Creek near Renville, Minn.	44°50’24”	095°14’20”	Renville	Till plain-Moraine	Calcareous	0.6	99	0	0.2	0.1	0.1	120
50	05316985	Sleepy Eye Creek near Springfield, Minn.	44°16’33”	094°54’22”	Brown	Till plain-Moraine	Calcareous	0.2	99	0	0.1	0.1	0	250
51	05317170	Little Cottonwood River near Searles, Minn.	44°14’19”	094°26’05”	Brown	Till plain-Moraine	Calcareous	0.3	98	0.2	0.3	0.7	0.1	162
52	05317800	West Branch Blue Earth River above Elmore, Minn.	43°30’56”	094°07’41”	Faribault	Till plain-Moraine	Calcareous	0.3	98	0	0.5	0.7	0	150
53	05317828	Coon Creek at U.S. Hwy. 169 near Blue Earth, Minn.	43°36’38”	094°05’14”	Faribault	Till plain-Moraine	Calcareous	0.2	99	0.7	0	0	0	99.1
54	05318050	East Branch Blue Earth River below Bricelyn, Minn.	43°35’09”	093°50’52”	Faribault	Till plain-Moraine	Calcareous	1.2	95	0.5	1.1	2.4	0.1	186
55	05318138	South Creek near Huntley, Minn.	43°41’39”	094°14’52”	Martin	Till plain-Moraine	Calcareous	0.5	94	0.1	3.4	2.1	0.2	104
56	05318178	Center Creek at Huntley, Minn.	43°43’28”	094°13’20”	Faribault	Till plain-Moraine	Calcareous	6.1	88	0.1	4.2	0.9	0.7	111
57	05318240	Elm Creek near Northrop, Minn.	43°46’01”	094°22’57”	Martin	Till plain-Moraine	Calcareous	0.3	96	0.4	1.9	0.8	0.1	232
58	05318630	Watonwan River near St. James, Minn.	44°03’03”	094°39’56”	Watonwan	Till plain-Moraine	Calcareous	1.0	97	1.1	1.0	0	0	99.9

Table A5. Site characteristics for streams sampled during the agricultural synoptic study--Continued

[mi^2, square mile; Minn., Minnesota; Hwy., Highway]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
59	05318800	St. James Creek near La Salle, Minn.	44°03’04”	094°33’27”	Watonwan	Till plain-Moraine	Calcareous	3.8	93	0	2.4	0.9	0.2	60
60	05319050	South Fork Watonwan River near St. James, Minn.	43°58’45”	094°30’49”	Watonwan	Till plain-Moraine	Calcareous	0.5	97	0.7	1.4	0.2	0	192
61	05319360	Perch Creek below Vernon Center, Minn.	43°59’46”	094°16’38”	Blue Earth	Till plain-Moraine	Calcareous	0.7	98	0.4	0.3	1.1	0	150
62	05320080	Le Sueur River near Wilton, Minn.	44°01’38”	093°32’47”	Waseca	Till plain-Moraine	Calcareous	0.5	96	2.2	0.1	1.0	0.2	181
63	05320230	Cobb River near Mapleton, Minn.	43°53’56”	093°52’14”	Blue Earth	Till plain-Moraine	Calcareous	0.4	93	1.4	2.9	2.0	0	112
64	05320270	Little Cobb River near Beauford, Minn.	43°59’48”	093°54’30”	Blue Earth	Till plain-Moraine	Calcareous	0.2	94	0.5	0.6	4.0	0	130
65	05320450	Maple River near Sterling Center, Minn.	43°56’06”	094°04’15”	Blue Earth	Till plain-Moraine	Calcareous	0.9	95	0.8	1.9	1.2	1.7	317
66	05326150	Rush River near New Rome, Minn.	44°30’54”	094°02’59”	Sibley	Till plain-Moraine	Calcareous	0.7	97	0.2	1.1	0.5	1.4	190
67	05326250	South Branch Rush River near Rush River, Minn.	44°29’08”	094°02’10”	Sibley	Till plain-Moraine	Calcareous	0.3	99	0.2	0.7	0.1	0	180
68	05326700	High Island Creek near Arlington, Minn.	44°37’22”	094°05’29”	Sibley	Till plain-Moraine	Calcareous	0.3	96	0.4	2.3	1.4	0	163

[1]Percentages associated with each site may not total 100 percent because of rounding.

Table A6. Site characteristics for streams sampled during the urban synoptic study

[mi^2, square mile; Minn., Minnesota]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
30	05286798	Ford Brook at Green Valley Road in Ramsey, Minn.	45°17’28”	093°25’22”	Hennepin	Outwash-Alluvium	Calcareous	0.1	80	1.7	4.3	13	1.0	28.8
32	05287890	Elm Creek near Champlin, Minn.	45°09’48”	093°26’11”	Hennepin	Till plain-Moraine	Calcareous	8.7	84	1.6	2.1	2.8	0.2	85.8
34	05288475	Coon Creek at 131st Street in Coon Rapids, Minn.	45°12’30”	093°20’02”	Anoka	Outwash-Alluvium	Calcareous	5.9	51	6.4	4.6	31	0.6	79.8
35	05288487	Sand Creek at Xeon Street in Coon Rapids, Minn.	45°11’02”	093°17’48”	Anoka	Outwash-Alluvium	Calcareous	48	40	2.1	0	10	0	15.4
36	05288598	Rice Creek at Central Ave. in Fridley, Minn.	45°05’37”	093°14’40”	Anoka	Outwash-Alluvium	Calcareous	29	48	2.2	6.2	15	0.2	152
40	05288705	Shingle Creek at Queen Ave in Minneapolis, Minn.	45°03’00”	093°18’36”	Hennepin	Outwash-Alluvium	Calcareous	71	20	0.9	4.0	0.7	3.5	28.2
43	05288839	Bassett Creek at Dresden Lane in Golden Valley, Minn.	45°00’14”	093°19’51”	Hennepin	Till plain-Moraine	Calcareous	82	11	0.3	5.4	0.5	1.1	32.9
44	05289600	Minnehaha Creek at Nicollet Ave. in Minneapolis, Minn.	44°54’27”	093°16’41”	Hennepin	Till plain-Moraine	Calcareous	37	38	3.6	18	3.5	0.1	149
70	05330702	Minnesota River tributary at Beech St. in Chaska, Minn.	44°47’21”	093°35’38”	Carver	Till plain-Moraine	Calcareous	30	62	3.4	4.3	0	0	11.9
71	05330750	Riley Creek at Eden Prairie, Minn.	44°48’23”	093°28’49”	Hennepin	Till plain-Moraine	Calcareous	8.0	78	5.7	8	0	0	9.90
72	05330801	Purgatory Creek at Pioneer Tr. in Eden Prairie, Minn.	44°49’39”	093°25’20”	Hennepin	Till plain-Moraine	Calcareous	83	12	0.2	4.0	0	0	27.0
73	05330902	Nine Mile Creek near James Circle at Bloomington, Minn.	44°48’26”	093°18’05”	Hennepin	Till plain-Moraine	Calcareous	87	5.7	2.2	3.7	1.7	0	44.6
75	05331050	Battle Creek below McKnight Road in St. Paul, Minn.	44°56’40”	093°00’35”	Ramsey	Till plain-Moraine	Siliceous	83	13	1.1	2.8	0	0	10.2

[1]Percentages associated with each site may not total 100 percent because of rounding.

Table A7. Site characteristics for streams sampled during the Mississippi River mainstem synoptic study

[mi^2, square mile; Hwy, Highway; Minn., Minnesota]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
1	05200020	Mississippi River at Hwy 200 near Lake Itasca, Minn.	47°15’12”	095°13’35”	Clearwater	Outwash-Alluvium	Calcareous	0.1	0	87	10	2.4	0	31.6
2	05200510	Mississippi River near Bemidji, Minn.	47°29’00”	094°43’40”	Beltrami	Outwash-Alluvium	Calcareous	1.1	17	67	5.9	8.8	0.2	664
3	05200940	Mississippi River near Pennington, Minn.	47°26’39”	094°25’31”	Beltrami	Outwash-Alluvium	Calcareous	0.8	14	65	11	9.1	0.6	1130
4	05201550	Mississippi River at Hwy 2 near Ball Club, Minn.	47°19’30”	093°57’35”	Cass	Till plain-Moraine	Calcareous	0.6	10	62	14	11	0.8	1540
5	05210000	Mississippi River at Days High Landing near Deer River, Minn.	47°15’10”	093°48’00”	Cass	Till plain-Moraine	Calcareous	0.4	8.7	61	17	12	0.8	2880
6	05211000	Mississippi River at Grand Rapids, Minn.	47°13’56”	093°31’48”	Itasca	Till plain-Moraine	Calcareous	0.4	8.8	60	16	14	0.8	3320
7	05213500	Mississippi River near Blackberry, Minn.	47°10’24”	093°24’47”	Itasca	Till plain-Moraine	Calcareous	0.5	8.3	61	15	14	1.0	3860
8	05217600	Mississippi River at Jacobson, Minn.	47°00’05”	093°16’06”	Aitkin	Till plain-Moraine	Calcareous	0.5	8.2	60	14	15	2.1	4270
9	05220600	Mississippi River at Palisade, Minn.	46°34’04”	093°28’03”	Aitkin	Till plain-Moraine	Calcareous	0.5	8.8	58	13	18	1.9	4840
10	05221060	Mississippi River at Hwy 169 near Hassman, Minn.	46°39’04”	093°36’45”	Aitkin	Till plain-Moraine	Calcareous	0.4	8.6	57	12	21	1.7	5384
11	05227500	Mississippi River at Aitkin, Minn.	46°32’26”	093°42’26”	Aitkin	Till plain-Moraine	Calcareous	0.4	9.6	56	11	21	1.6	5880
12	05242300	Mississippi River at Brainerd, Minn.	46°22’40”	094°10’59”	Crow Wing	Till plain-Moraine	Calcareous	0.4	10	57	11	20	1.4	7090
13	05261000	Mississippi River near Fort Ripley, Minn.	46°10’50”	094°21’56”	Crow Wing	Till plain-Moraine	Calcareous	0.5	23	50	9.0	17	1.0	10900
15	05267000	Mississippi River near Royalton, Minn.	45°51’40”	094°21’30”	Morrison	Till plain-Moraine	Calcareous	0.6	25	49	8.6	16	0.9	11600
19	05270700	Mississippi River at St. Cloud, Minn.	45°32’50”	094°08’44”	Stearns	Till plain-Moraine	Calcareous	0.7	33	44	7.8	14	0.8	13600
27	05283500	Mississippi River at Anoka, Minn.	45°11’30”	093°23’40”	Anoka	Till plain-Moraine	Calcareous	1.0	44	35	7.1	12	0.7	17500

Table A7. Site characteristics for streams sampled during the Mississippi River mainstem synoptic study--Continued

[mi^2, square mile; Hwy, Highway; Minn., Minnesota]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Dominant surficial geology	Dominant glacial deposit composition	Land use (percent[1])						Drainage area (mi^2)
								Urban	Agriculture	Forest	Water	Wetland	Other	
33	05288500	Mississippi River near Anoka, Minn.	45°07’36”	093°17’48”	Hennepin	Till plain-Moraine	Calcareous	1.1	44	34	7.6	12	0.7	19200
77	05331580	Mississippi River below Lock & Dam #2 at Hastings, Minn.	44°44’48”	092°51’08”	Dakota	Till plain-Moraine	Calcareous	2.5	66	18	5.2	7.1	0.4	37000
108	05355250	Mississippi River at Red Wing, Minn.	44°36’36”	092°36’36”	Goodhue	Till plain-Moraine	Calcareous	2.3	62	22	4.8	7.8	0.4	46800

[1]Percentages associated with each site may not total 100 percent because of rounding.

Table A8. Site characteristics for miscellaneous stream sampling

[Minn., Minnesota; Wis., Wisconsin]

Map identifier	Site identifier	Site name	Latitude	Longitude	County	Comments
38	05288700	Shingle Creek at Brooklyn Center, Minn.	45°04’45”	093°18’55”	Hennepin	Sampled twice in conjunction with urban flow-path study
39	450401093183401	Parking Lot Outflow at Public Library at Brooklyn Center, Minn.	45°04’01”	093°18’34”	Hennepin	Sampled once as part of VOC mass balance study
74	05331045	Battle Creek at Meadow Lane in Woodbury, Minn.	44°56’34”	092°58’35”	Washington	Sample once as follow up to urban synoptic study
85	05335326	Clam River near Siren, Wis.	45°42’43”	092°19’46”	Burnett	Sampled once for calcium for the National Park Service
89	460041092502001	Kettle River near Hinckley, Minn	46°00’41”	092°50’20”	Pine	Sampled once for calcium for the National Park Service

Table A9. Site characteristics for wells sampled during the Prairie du Chien-Jordan aquifer subunit surveys in Minnesota

[Local identifier indicates whether wells are located in the unconfined or confined portion of the aquifer—for example, PDCJ-U01 is a well in the unconfined portion and PDCJ-C01 is a well in the confined portion]

Site identifier	Local identifier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bottom of casing (feet)	Water level (feet below land surface)	Date measured
442612093110201	PDCJ-U01	162682	Washington	442612	0931102	950	07/29/77	340	259	17.37	08/13/96
443328093184701	PDCJ-U02	212377	Scott	443328	0931847	1140	08/26/73	235	207	179	08/26/73
443808093012801	PDCJ-U03	198261	Dakota	443808	0930128	875	09/08/83	220	195	18.4	09/03/96
444331093080801	PDCJ-U04	136548	Dakota	444331	0930808	941	05/01/78	200	170	48.44	04/28/84
450810092583501	PDCJ-U05	182149	Washington	450810	0925835	938	04/28/84	118	85	14.36	09/06/96
445117093042701	PDCJ-U06	427141	Dakota	445117	0930427	968	11/22/86	335	295	218.05	09/05/96
443934092565601	PDCJ-U07	412478	Dakota	443934	0925656	905	07/06/85	270	250	70	07/06/85
443119093050101	PDCJ-U08	443920	Dakota	443119	0930501	905	06/22/88	137	105	13.4	08/08/96
443042092570401	PDCJ-U09	145903	Dakota	443042	0925704	862	10/07/77	320	279	40	10/07/77
444211092544601	PDCJ-U10	457211	Dakota	444211	0925446	820	06/28/89	320	284	120	06/28/89
445245092545501	PDCJ-U11	427865	Washington	445245	0925455	920	11/11/86	143	139	103	11/11/86
451602092515601	PDCJ-U12	138286	Washington	451602	0925156	943	09/26/77	87	86	24.89	09/06/96
450603092500201	PDCJ-U13	162901	Washington	450603	0925002	904	08/31/79	110	108	40	08/31/79
445919092500101	PDCJ-U14	199550	Washington	445919	0925001	930	01/04/84	143	126	90.34	09/06/96
444214092490401	PDCJ-U15	185962	Dakota	444214	0924904	842	06/07/82	245	220	110	06/07/82
443112092513901	PDCJ-U16	162685	Goodhue	443112	0925139	883	10/09/78	339	301	68.23	08/29/96
441450093265701	PDCJ-C01	451200	Rice	441450	0932657	1090	11/23/88	290	271	82.47	09/05/96
443505093255201	PDCJ-C02	427107	Scott	443505	0932552	974	08/29/86	124	119	37	08/29/86
444059093260901	PDCJ-C03	127106	Scott	444059	0932609	975	12/18/76	231	231	110	12/18/76
445018093290901	PDCJ-C04	118808	Hennepin	445018	0932909	910	09/25/75	265	247	144.9	09/10/96
450516093281001	PDCJ-C05	104843	Hennepin	450516	0932810	915	08/09/76	157	152	17.79	08/27/96
444854093242501	PDCJ-C06	413372	Hennepin	444854	0932425	845	08/16/85	342	323	106.95	09/10/96
444202093225901	PDCJ-C07	207461	Scott	444202	0932259	950	11/11/1900	130	112	61	11/11/1900
443232093230901	PDCJ-C08	436444	Rice	443232	0932309	1091	10/07/87	260	192	90.3	09/05/96
441944093194601	PDCJ-C09	416242	Rice	441944	0931946	1055	10/15/85	200	175	65	10/15/85
442816093125901	PDCJ-C10	509102	Rice	442816	0931259	989	09/18/89	355	355	39.8	08/27/96

Table A9. Site characteristics for wells sampled during the Prairie du Chien-Jordan aquifer subunit surveys in Minnesota--Continued

[Local identifier indicates whether wells are located in the unconfined or confined portion of the aquifer—for example, PDCJ-U01 is a well in the unconfined portion and PDCJ-C01 is a well in the confined portion]

Site identifier	Local identifier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bottom of casing (feet)	Water level (feet below land surface)	Date measured
443641093110701	PDCJ-C11	119678	Dakota	443641	0931107	932	06/01/77	110	90	13.38	09/06/96
445108093054801	PDCJ-C12	127189	Dakota	445108	0930548	933	06/06/80	271	259	146.19	09/05/96
450758093061501	PDCJ-C13	170633	Anoka	450758	0930615	902	11/12/80	125	105	30.78	08/26/96
450825092524801	PDCJ-C14	195648	Washington	450825	0925248	995	08/23/83	130	120	45	08/23/83
450520092543401	PDCJ-C15	413597	Washington	450520	0925434	1001	10/25/87	175	162	59.17	09/06/96
445321092590101	PDCJ-C16	415681	Washington	445321	0925901	982	08/16/85	284	270	239	08/16/86
443645092525501	PDCJ-C17	443901	Dakota	443645	0925255	1022	09/17/88	400	360	160	09/17/88
442733092532401	PDCJ-C18	100029	Goodhue	442733	0925324	1138	08/24/76	335	290	235	08/24/76
442140092521101	PDCJ-C19	140992	Goodhue	442140	0925211	1180	05/22/78	380	340	214.2	08/27/96

Table A10. Site characteristics for wells sampled during the Prairie du Chien-Jordan aquifer subunit surveys in Wisconsin

[Local identifier indicates whether wells are located in the unconfined or confined portion of the aquifer—for example, PDCT-U01 is a well in the unconfined portion and PDCT-C01 is a well in the confined portion; NA, not available]

Site identifier	Local identifier	WI unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bottom of casing (feet)	Water level (feet below land surface)	Date measured
445010092422201	PDCT-U01	NA	Pierce	445010	0924222	920	07/25/86	230	40	180	07/25/86
450635092302201	PDCT-U02	FK 344	St. Croix	450635	0923022	1000	07/06/93	77	57	37.09	09/09/96
451242092433201	PDCT-U03	DD 945	Polk	451242	0924332	1000	09/06/90	278	248	211	09/06/90
452102092212201	PDCT-U04	HQ 473	Polk	452102	0922122	1100	08/21/95	120	103	20.09	08/06/96
445933092222301	PDCT-U05	AR 809	St. Croix	445933	0922223	1160	05/22/90	104	84	65	05/02/90
443703092261301	PDCT-U06	NA	Pierce	443703	0922613	740	02/17/81	140	120	84.8	08/12/96
443502092212301	PDCT-U07	HB 354	Pierce	443502	0922123	710	10/25/95	66	56	15.62	08/05/96
451027092142901	PDCT-U08	AJ 266	St. Croix	451027	0921429	1160	09/26/88	180	121	75.46	08/08/96
452709092141101	PDCT-U09	HS 369	Polk	452709	0921411	1190	11/02/94	94	90	31.07	09/09/96
454942092310701	PDCT-C01	HO 173	Pierce	444942	0923107	1020	10/28/94	190	68	130.23	09/09/96
455630092323801	PDCT-C02	IC 379	St. Croix	445630	0923238	1020	06/05/95	175	168	86.34	09/09/96
451351092345901	PDCT-C03	NA	Polk	451351	0923459	940	12/19/86	105	84	41.2	09/09/96
451104092212501	PDCT-C04	EO 124	St. Croix	451104	0922125	1070	08/21/92	105	100	24.28	08/05/96
450444092275001	PDCT-C05	NA	St. Croix	450444	0922750	1085	03/10/80	115	80	83.51	08/19/96
444452092251401	PDCT-C06	FS 067	Pierce	444452	0922514	1020	07/20/94	210	189	98.35	08/07/96

Table A11. Site characteristics for wells sampled during the urban land-use study, Anoka and Hennepin Counties, Minnesota

Site indentifier	Local indenti-fier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bot-tom of casing (feet)	Water level (feet below land sur-face)	Date measured
451315093202501	CR-A	560381	Anoka	451314	0932025	881.52	06/10/96	20.8	15.8	15.28	06/17/96
451222093185001	CR-B	560396	Anoka	451222	0931851	895.67	05/20/96	24.5	19.5	17.76	06/20/96
451150093162601	CR-C	560397	Anoka	451152	0931626	896.71	06/10/96	13.5	8.5	5.01	06/17/96
451100093181401	CR-D	560399	Anoka	451102	0931822	856.88	05/15/96	18	13	6.17	06/18/96
451009093181701	CR-E	560398	Anoka	451004	0931815	861.98	05/16/96	19	14	13.15	06/20/96
451013093185101	CR-F	560400	Anoka	451012	0931852	860.02	05/15/96	23	18	6.44	06/18/96
451104093212801	CR-G	560401	Anoka	451102	0932130	854.66	05/17/96	14	9	6.6	06/19/96
451236093202001	CR-H	560405	Anoka	451238	0932021	877.4	05/17/96	20	15	12.86	06/19/96
451116093183101	CR-I	560406	Anoka	451117	0931829	867.9	05/16/96	13	8	5.42	06/24/96
450704093210401	HN-A	560407	Hennepin	450704	0932105	868.1	05/21/96	24.3	19.3	13.23	06/25/96
450702093185101	HN-B	560408	Hennepin	450706	0931857	858.37	05/21/96	24	19	9.5	06/24/96
450624093220501	HN-C	560409	Hennepin	450619	0932204	875.23	05/21/96	29	24	15.99	06/25/96
450557093201801	HN-D	560410	Hennepin	450556	0932022	866.61	06/07/96	22.5	17.5	16.8	06/25/96
450516093195901	HN-E	560411	Hennepin	450515	0932005	863.27	06/03/96	23	18	14.13	06/26/96
450611093183101	HN-F	560412	Hennepin	450612	0931830	867.89	05/22/96	13.5	8.5	6.84	06/26/96
450518093172501	HN-G	560413	Hennepin	450518	0931725	850.44	05/22/96	33.5	28.5	23.14	06/26/96
450524093223201	HN-H	560414	Hennepin	450523	0932229	876.18	05/23/96	18	13	9.85	07/10/96
450448093205301	HN-I	560415	Hennepin	450450	0932049	866.22	05/24/96	18	13	10.54	06/27/96
450542093182301	HN-J	560416	Hennepin	450530	0931819	849.61	06/04/96	15	10	8.64	06/27/96
450430093220801	HN-K	560417	Hennepin	450428	0932206	881.79	06/03/96	22.5	17.5	16.49	07/02/96
450333093201701	HN-L	560418	Hennepin	450333	0932016	857.91	05/24/96	9	4	4.99	07/02/96
450456093193201	HN-M	560419	Hennepin	450500	0931931	849.06	06/06/96	9	4	4.3	07/02/96
450326093175201	HN-N	560420	Hennepin	450325	0931752	848.67	06/06/96	18	13	11.24	07/03/96
450305093172501	HN-O	560421	Hennepin	450305	0931724	849.81	06/05/96	28	23	10.75	07/09/96
450328093232001	HN-P	560422	Hennepin	450329	0932141	872.77	06/05/96	18	13	10.92	07/03/96
450226093203901	HN-Q	560423	Hennepin	450225	0932035	875.25	06/04/96	29	24	21.73	07/08/96
450327093193501	HN-R	560424	Hennepin	450328	0931936	851	06/06/96	10	5	2.39	07/08/96

Table A11. Site characteristics for wells sampled during the urban land-use study, Anoka and Hennepin Counties, Minnesota--Continued

Site indentifier	Local indenti-fier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bot-tom of casing (feet)	Water level (feet below land sur-face)	Date measured
450236093175801	HN-S	560425	Hennepin	450236	0931759	844.11	06/11/96	17	12	9.85	07/08/96
450122093193801	HN-T	560426	Hennepin	450118	0931936	857.71	06/11/96	19	14	11.7	06/13/96
450126093180901	HN-U	571162	Hennepin	450125	0931805	910.81	06/07/96	28.5	24	17.49	07/09/96

Table A12. Site characteristics for wells sampled during the agricultural land-use study, Sherburne and Wright Counties, Minnesota

[NA, not available]

Site identifier	Local identifier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bottom of casing (feet)	Water level (feet below land surface)	Date measured
452408093553001	ALUS-01	582131	Sherburne	452408	0935530	975	09/16/97	31.5	26.5	27.9	05/13/98
452428093591601	ALUS-02	582132	Sherburne	452428	0935916	960	09/17/97	20.5	15.5	14.7	05/13/98
452545093571002	ALUS-03	371006	Sherburne	452545	0935710	985	10/21/76	36.2	34.2	22	05/15/98
452610093553001	ALUS-04	582133	Sherburne	452610	0935530	975	09/18/97	11.5	6.5	6.4	05/11/98
452720093552202	ALUS-05	NA	Sherburne	452720	0935522	970	10/11/83	25	23	12.4	05/11/98
452711093565501	ALUS-06	582134	Sherburne	452711	0935655	975	09/18/97	14.5	9.5	9.4	05/11/98
452609093553001	ALUS-07	582135	Sherburne	452632	0935518	975	09/18/97	15.5	10.5	10.6	05/12/98
452543093544801	ALUS-08	482926	Sherburne	452543	0935448	980	04/21/92	57	53	NA	NA
452408093552901	ALUS-09	NA	Sherburne	452443	0935408	975	NA	28	NA	NA	NA
452324093541601	ALUS-10	517548	Sherburne	452324	0935416	971	04/01/93	34	24	26.3	05/21/98
452229093525801	ALUS-11	NA	Sherburne	452229	0935258	963	08/26/81	60	40	35	05/21/98
451953093484901	ALUS-12	582149	Sherburne	451953	0934849	950	09/11/97	43	38	37.7	05/18/98
452030093511403	ALUS-13	612777	Sherburne	452030	0935114	929	07/10/98	22.5	17.5	18.9	08/11/98
452111093523401	ALUS-14	582051	Sherburne	452111	0935234	950	09/17/97	34	24	32.0	05/19/98
452210093523701	ALUS-15	493038	Sherburne	452210	0935237	960	09/06/91	37	27	36.5	05/21/98
452335093504301	ALUS-16	NA	Sherburne	452400	0935107	955	1978	23	NA	NA	NA
452335093504501	ALUS-17	582136	Sherburne	452335	0935045	960	09/15/97	18	13	14.1	05/14/98
452215093481001	ALUS-18	582137	Sherburne	452215	0934810	955	09/16/97	26	21	20.7	05/14/98
452040093463101	ALUS-19	582138	Sherburne	452040	0934631	940	09/12/97	24.2	19.2	20	05/19/98
451957093483201	ALUS-20	582139	Sherburne	451957	0934832	940	09/12/97	49	44	37.4	05/18/98
451924093474601	ALUS-21	582140	Sherburne	451924	0934746	945	09/11/97	35	30	29.7	08/18/98
451811093445601	ALUS-22	582141	Sherburne	451811	0934456	930	09/10/97	19	14	13.8	05/19/98
451755093433901	ALUS-23	582142	Wright	451755	0934339	920	09/10/97	25	15	12.5	05/27/98
451835093400401	ALUS-24	582143	Sherburne	451835	0934004	920	09/08/97	11.8	6.8	6.8	05/27/98
451822093413201	ALUS-25	582144	Sherburne	451822	0934108	920	09/08/97	30	25	25.2	05/27/98
451915093463901	ALUS-26	475151	Sherburne	451915	0934639	944	05/16/91	28.2	18.2	18.2	05/26/98

Table A12. Site characteristics for wells sampled during the agricultural land-use study, Sherburne and Wright Counties, Minnesota--Continued

[NA, not available]

Site identifier	Local identifier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bottom of casing (feet)	Water level (feet below land surface)	Date measured
451921093445101	ALUS-27	582145	Sherburne	451921	0934451	930	09/10/97	8	3	3.3	05/26/98
452007093413001	ALUS-28	582146	Sherburne	452007	0934130	930	09/09/97	16	11	11.7	05/20/98
451730093423001	ALUS-29	582147	Sherburne	452010	0934230	930	09/09/97	15	10	10.8	05/20/98
452036093423701	ALUS-30	582148	Sherburne	452036	0934237	930	09/09/97	9	4	4.9	05/20/98

Table A13. Site characteristics for wells sampled during the forested land-use study, Beltrami, Cass, and Clearwater Counties, Minnesota

[NA, not available]

Site identifier	Local identifier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bottom of casing (feet)	Water level (feet below land surface)	Date measured
471546094331700	FLUS-01	NA	Cass	471546	0943317	1310	NA	17	15	7.8	06/23/98
472201094320401	FLUS-02	612751	Cass	472201	0943204	1320	06/22/98	19	14	10.4	06/22/98
472300094231800	FLUS-03	243228	Cass	472300	0942318	1325	09/09/86	25.5	18.5	15.5	06/18/98
472533094284500	FLUS-04	243242	Beltrami	472533	0942845	1312	08/06/86	13	11	3.9	06/18/98
472537094261700	FLUS-05	243241	Beltrami	472537	0942617	1317	08/06/86	13	11.3	10.3	06/23/98
472553094384500	FLUS-06	243304	Beltrami	472553	0943845	1313	08/06/86	14	11	5	06/17/98
472724095055200	FLUS-07	243315	Beltrami	472724	0950552	1375	06/11/86	26.5	23	6.3	06/16/98
472813095160200	FLUS-08	243219	Clearwater	472813	0951602	1525	08/26/86	36	33	29.3	06/15/98
473140095041201	FLUS-09	243296	Beltrami	473140	0950412	1410	07/31/86	16.5	11.5	7.5	06/22/98
473150095210500	FLUS-10	243201	Clearwater	473150	0952105	1470	08/15/86	29	26	0.7	06/15/98
473236094505400	FLUS-11	243347	Beltrami	473236	0945054	1400	07/28/86	21.5	18.4	8.7	06/16/98
473306094480000	FLUS-12	243334	Beltrami	473306	0944800	1370	05/08/86	15	13	5.1	06/16/98
473410095073000	FLUS-13	243297	Beltrami	473410	0950730	1400	07/30/86	14	12	4.9	06/17/98
472200094394001	FLUS-14	243225	Cass	472200	0943940	1344	09/08/86	29	26	23.2	06/17/98
473418095051701	FLUS-15	NA	Beltrami	473418	0950517	1397	NA	21.4	NA	6.7	06/17/98

Table A14. Site characteristics for wells sampled during the flow-path study, Hennepin County, Minnesota

Site identifier	Local identifier	MN unique well number	County	Latitude	Longitude	Altitude of land surface (feet)	Date of construction	Well depth (feet)	Depth to bottom of casing (feet)	Water level (feet below land surface)	Date measured
450430093220801	HN-K	560417	Hennepin	450428	0932206	881.79	06/03/96	22.5	17.5	17.32	07/15/97
450424093210501	UFP-1 PORT A	582101	Hennepin	450424	0932105	870.08	06/16/97	9.5	9	dry	07/15/97
450424093210502	UFP-1 PORT B	582101	Hennepin	450424	0932105	870.08	06/16/97	11.5	11	8.32	07/15/97
450424093210504	UFP-1 PORT C	582101	Hennepin	450424	0932105	870.08	06/16/97	17.5	17	8.90	07/14/97
450424093210505	UFP-1 PORT D	582101	Hennepin	450424	0932105	870.08	06/16/97	21.5	21	8.90	07/14/97
450425093195301	UFP-2 PORT A	582123	Hennepin	450425	0931953	862.14	05/18/97	10.5	10	dry	07/10/97
450425093195302	UFP-2 PORT B	582123	Hennepin	450425	0931953	862.14	05/18/97	13.5	13	11.93	07/10/97
450425093195303	UFP-2 PORT C	582123	Hennepin	450425	0931953	862.14	05/18/97	19.5	19	11.96	07/10/97
450425093195304	UFP-2 PORT D	582123	Hennepin	450425	0931953	862.14	05/18/97	27.5	27	11.96	07/10/97
450423093194301	UFP-3 PORT A	582124	Hennepin	450423	0931943	858.68	05/20/97	11.5	11	8.80	07/09/97
450423093194303	UFP-3 PORT B	582124	Hennepin	450423	0931943	858.68	05/20/97	21.5	21	8.95	07/09/97
450423093194304	UFP-3 PORT C	582124	Hennepin	450423	0931943	858.68	05/20/97	29.5	29	9.00	07/09/97
450423093194305	UFP-3 PORT D	582124	Hennepin	450423	0931943	858.68	05/20/97	37.5	37	9.01	07/09/97
450415093184800	UFP-4 PORT A	582125	Hennepin	450415	0931848	847.05	05/22/97	4	3.5	dry	07/07/97
450415093184801	UFP-4 PORT B	582125	Hennepin	450415	0931848	847.05	05/22/97	7.5	7	5.37	07/07/97
450415093184802	UFP-4 PORT C	582125	Hennepin	450415	0931848	847.05	05/22/97	10.5	10	5.37	07/07/97
450415093184803	UFP-4 PORT D	582125	Hennepin	450415	0931848	847.05	05/22/97	14.5	14	5.38	07/07/97
450414093184301	UFP-5 PORT A	582122	Hennepin	450414	0931843	842.08	05/21/97	5.5	5	-0.27	07/24/97
450414093184303	UFP-5 PORT B	582122	Hennepin	450414	0931843	842.08	05/21/97	27.5	27	-0.19	07/08/97
450414093184304	UFP-5 PORT C	582122	Hennepin	450414	0931843	842.08	05/21/97	31.5	31	0.37	07/08/97
450414093184305	UFP-5 PORT D	582122	Hennepin	450414	0931843	842.08	05/21/97	33.5	33	0.37	07/08/97
450406093170201	UFP-6 PORT A	571163	Hennepin	450406	0931702	821.98	05/20/97	6.5	6	dry	07/09/97
450406093170202	UFP-6 PORT B	571163	Hennepin	450406	0931702	821.98	05/20/97	9.5	9	dry	07/09/97
450406093170204	UFP-6 PORT C	571163	Hennepin	450406	0931702	821.98	05/20/97	15.5	15	10.60	07/09/97
450406093170205	UFP-6 PORT D	571163	Hennepin	450406	0931702	821.98	05/20/97	21.5	21	11.50	07/09/97

Appendix B - Analytical Groupings of Water-Quality Characteristics

[Unless otherwise noted, all analyses performed by USGS National Water-Quality Laboratory, Arvada, Colo.; Parameter code is a 5-digit number used in the U.S. Geological Survey computerized data system WATSTORE, to uniquely identify a specific constituent]

Table B1. Field measurements of physical and chemical properties of water

[$CaCO_3$, calcium carbonate; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25° Celsius; °C, degrees Celsius; NTU, nephelometric turbidity units]

Constituent name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Alkalinity as $CaCO_3$	39086	Filtered incremental titration	1.0	mg/L
[1]Alkalinity as $CaCO_3$	00419	Unfiltered incremental titration	1.0	mg/L
Bicarbonate as HCO_3	00453	Calculated from 39086		mg/L
Carbonate as CO_3	00452	Calculated from 39086		mg/L
Dissolved oxygen	00300	Cathode/electrometric, membrane electrode	0.1	mg/L
Oxygen saturation	00301	Calculated	.1	percent
pH	00400	Electrometric, glass electrode	.1	
Specific conductance	00095	Electrometric, Wheatstone bridge	1.0	µS/cm
Temperature	00010	Electrometric, thermistor		°C
Turbidity	00076	Nephelometric method		NTU

[1]Ground water only

Table B2. Analytical grouping of chlorophyll *a* in biological samples

[N.A., not applicable. All reporting units are in micrograms per liter]

Constituent name	Parameter code	Analytical method	Method reporting limit
Chlorophyll *a*[1]	70953	High-pressure liquid chromatography	0.1
Chlorophyll *a*[2]		Fluorimetry	N.A.

[1]Analyzed according to Britton and Greeson (1989)
[2]Analyzed according to Arar and Collins (1992)

Table B3. Analytical grouping of major ions and inorganic constituents in water

[Samples analyzed according to Fishman and Friedman (1989) or Fishman (1993); $CaCO_3$, calcium carbonate; mg/L, milligrams per liter; ICP, inductively coupled plasma spectrophotometry; IC, ion-exchange chromatography; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter; AA, atomic absorption spectrophotometry; ROE, residue on evaporation; °C, degrees Celsius]

Constituent name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Alkalinity, as $CaCO_3$, laboratory	90410	Fixed-endpoint electrometric titration	1.0	mg/L
Bromide, dissolved	71870	Colorimetry	0.01	mg/L
Calcium, dissolved	00915	ICP	.02	mg/L
Chloride, dissolved	00940	IC	.1	mg/L
Fluoride, dissolved	00950	Ion-selective electrode	.1	mg/L
Iron, dissolved	01046	ICP	10.0	µg/L
Magnesium, dissolved	00925	ICP	.004	mg/L
Manganese, dissolved	01056	ICP	4.0	µg/L
pH, laboratory	00403	Electrometric	.1	units
Potassium, dissolved	00935	AA	.1	mg/L
ROE dissolved @ 180°C	70300	Gravimetric analysis	10.0	mg/L
Silica, dissolved	00955	ICP	.1	mg/L
Sodium, dissolved	00930	ICP	.1	mg/L
Specific conductance, laboratory	90095	Electrometric, Wheatstone bridge	1.0	µS/cm
Sulfate, dissolved	00945	IC	.1	mg/L

Table B4. Analytical grouping of nutrients in water

[Samples analyzed according to Fishman (1993); N, nitrogen; NH_4, ammonia; NO_3, nitrate; NO_2, nitrite; P, phosphorus; Ortho-P, orthophosphate; all reporting units are in milligrams per liter]

Nutrient name	Parameter code	Analytical method	Method reporting limit
Nitrogen, Ammonia, as N, dissolved	00608	Colorimetry	0.02
Nitrogen, NH_4 +Organic, as N, dissolved	00623	Colorimetry	.1
Nitrogen, NH_4 +Organic, as N, total [1]	00625	Colorimetry	.1
Nitrogen, Nitrite, as N, dissolved	00613	Colorimetry	.01
Nitrogen, NO_3 +NO_2, as N, dissolved	00631	Colorimetry	.05
Phosphorus, as P, dissolved	00666	Colorimetry	.01
Phosphorus, as P, total [1]	00665	Colorimetry	.01
Phosphorus, Ortho-P, as P, dissolved	00671	Colorimetry	.01

[1]Surface water only.

Table B5. Analytical grouping of organic carbon in water

[Samples analyzed according to Brenton and Arnett (1993) and Wershaw and others (1987); mg/L, milligrams per liter]

Name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Dissolved organic carbon	00681	Infrared spectrometry	0.1	mg/L
Suspended organic carbon[1]	00689	Infrared spectrometry	.1	mg/L

[1]Surface water only.

Table B6. Analytical grouping of volatile organic compounds in water

[Samples analyzed according to Connor and others (1998); GC/MS, gas chromatography/mass spectrometry; all reporting units are in micrograms per liter]

Compound name	Parameter Code	Analytical method	Method reporting limit
acetone	81552	GC/MS	4.900
2-propenenitrile	34215	GC/MS	1.230
benzene	34030	GC/MS	.032
bromobenzene	81555	GC/MS	.036
bromochloromethane	77297	GC/MS	.044
bromodichloromethane	32101	GC/MS	.048
Tribromomethane	32104	GC/MS	.104
bromomethane	34413	GC/MS	.148
2-butanone	81595	GC/MS	1.650
n-butylbenzene	77342	GC/MS	.186
(1-methylpropyl)benzene	77350	GC/MS	.048
(1-dimethylethyl)benzene	77353	GC/MS	.096
Methyl-*tert*-butylether	78032	GC/MS	.112
carbon disulfide	77041	GC/MS	.080
chlorobenzene	34301	GC/MS	.028
chloroethane	34311	GC/MS	.120
Trichloromethane	32106	GC/MS	.052
chloromethane	34418	GC/MS	.254
3-chloro-1-propene	78109	GC/MS	.196
1-chloro-2-methylbenzene	77275	GC/MS	.042
1-chloro-4-methylbenzene	77277	GC/MS	.056
dibromochloromethane	32105	GC/MS	.182
1,2-dibromo-3-chloropropane	82625	GC/MS	.214
1,2-dibromoethane	77651	GC/MS	.036
dibromomethane	30217	GC/MS	.050
1,2-dichlorobenzene	34536	GC/MS	.048
1,3-dichlorobenzene	34566	GC/MS	.054
1,4-dichlorobenzene	34571	GC/MS	.050
trans-1,4-dichloro-2-butene	73547	GC/MS	.692
dichlorodifluoromethane	34668	GC/MS	.096
1,1-dichloroethane	34496	GC/MS	.066
1,2-dichloroethane	32103	GC/MS	.134
1,1-dichloroethylene	34501	GC/MS	.044
cis-1,2-dichloroethylene	77093	GC/MS	.038
trans-1,2-dichloroethylene	34546	GC/MS	.032

Table B6. Analytical grouping of volatile organic compounds in water--Continued

[Samples analyzed according to Connor and others (1998); GC/MS, gas chromatography/mass spectrometry; all reporting units are in micrograms per liter]

Compound name	Parameter Code	Analytical method	Method reporting limit
dichloromethane	34423	GC/MS	.382
1,2-dichloropropane	34541	GC/MS	.068
1,3-dichloropropane	77173	GC/MS	.116
2,2-dichloropropane	77170	GC/MS	.078
1,1-dichloropropene	77168	GC/MS	.026
trans-1,3-dichloropropene	34699	GC/MS	.134
cis-1,3-dichloropropene	34704	GC/MS	.092
diethylether	81576	GC/MS	.170
diisopropylether	81577	GC/MS	.098
ethylbenzene	34371	GC/MS	.030
ethylmethacrylate	73570	GC/MS	.278
ethyl-*tert*-butylether	50004	GC/MS	.054
2-ethyltoluene	77220	GC/MS	.100
hexachlorobutadiene	39702	GC/MS	.142
1,1,1,2,2,2-hexachloroethane	34396	GC/MS	.362
2-hexanone	77103	GC/MS	.746
(1-Methylethyl)benzene	77223	GC/MS	.032
4-isopropyl-1-methylbenzene	77356	GC/MS	.110
methylacrylate	49991	GC/MS	.612
methylacrylonitrile	81593	GC/MS	.570
Iodomethane	77424	GC/MS	.076
methylmethacrylate	81597	GC/MS	.350
4-methyl-2-pentanone	78133	GC/MS	.374
naphthalene	34696	GC/MS	.250
tert-amylmethylether	50005	GC/MS	.112
n-propylbenzene	77224	GC/MS	.042
Ethenylbenzene	77128	GC/MS	.042
1,1,1,2-tetrachloroethane	77562	GC/MS	.044
1,1,2,2-tetrachloroethane	34516	GC/MS	.132
tetrachloroethylene	34475	GC/MS	.038
tetrachloromethane	32102	GC/MS	.088
tetrahydrofuran	81607	GC/MS	1.150
1,2,3,4-tetramethylbenzene	49999	GC/MS	.230
1,2,3,5-tetramethylbenzene	50000	GC/MS	.240
Methylbenzene	34010	GC/MS	.038
1,2,3-trichlorobenzene	77613	GC/MS	.266

Table B6. Analytical grouping of volatile organic compounds in water--Continued

[Samples analyzed according to Connor and others (1998); GC/MS, gas chromatography/mass spectrometry; all reporting units are in micrograms per liter]

Compound name	Parameter Code	Analytical method	Method reporting limit
1,2,4-trichlorobenzene	34551	GC/MS	.188
1,1,1-trichloroethane	34506	GC/MS	.032
1,1,2-trichloroethane	34511	GC/MS	.064
trichloroethylene	39180	GC/MS	.038
trichlorofluoromethane	34488	GC/MS	.032
1,2,3-trichloropropane	77443	GC/MS	.070
1,1,2-trichloro-1,2,2-trifluoroethane	77652	GC/MS	.092
1,2,3-trimethylbenzene	77221	GC/MS	.124
1,2,4-trimethylbenzene	77222	GC/MS	.056
1,3,5-trimethylbenzene	77226	GC/MS	.044
Bromomethane	50002	GC/MS	.100
Chloroethene	39175	GC/MS	.112
1,3 & 1,4-dimethylbenzene	85795	GC/MS	.064
1,2-dimethylbenzene	77135	GC/MS	.064

Table B7. Analytical grouping of pesticides in filtered water analyzed by gas chromatography/mass spectrometry

[Samples analyzed according to Zaugg and others (1995); GC/MS, gas chromatography/mass spectrometry. All reporting units are in micrograms per liter]

Compound name (common name)	Parameter code	Analytical method	Method reporting limit
Acetochlor	49260	GC/MS	0.002
Alachlor (Lasso)	46342	GC/MS	.002
Atrazine (AAtrex)	39632	GC/MS	.001
Benfluralin (Benefin, Balan, Bonalin)	82673	GC/MS	.002
Butylate (Genate Plus, Sutan+)	04028	GC/MS	.002
Carbaryl (Sevin)[1]	82680	GC/MS	.003
Carbofuran (Furadan)	82674	GC/MS	.003
Chlorpyrifos (Dursban)	38933	GC/MS	.004
Cyanazine (Bladex)	04041	GC/MS	.004
Deethylatrazine[2]	04040	GC/MS	.002
DCPA (Dacthal)	82682	GC/MS	.002
p,p-DDE	34653	GC/MS	.006
Diazinon (Knox-Out)	39572	GC/MS	.002
Dieldrin (Panoram D-31)	39381	GC/MS	.001
2,6-Diethylanaline	82660	GC/MS	.003
Disulfoton (Di-Syston)	82677	GC/MS	.017
EPTC (Eptam)	82668	GC/MS	.002
Ethalfluralin (Sonalin)	82663	GC/MS	.004
Ethoprop (Mocap, Ethoprophos)	82672	GC/MS	.003
Fonofos	04095	GC/MS	.003
α-HCH	34253	GC/MS	.002
γ-HCH (Lindane)	39341	GC/MS	.004
Linuron (Lorox, Linex)	82666	GC/MS	.002
Malathion (Cythion)	39532	GC/MS	.005
Methyl-azinphos (Guthion)	82686	GC/MS	.001
Methyl-parathion (Penncap-M)	82667	GC/MS	.006
Metolachlor (Dual)	39415	GC/MS	.002
Metribuzin (Lexone, Sencor)	82630	GC/MS	.004
Molinate (Ordram)	82671	GC/MS	.004
Napropamide (Devrinol)	82684	GC/MS	.003
Parathion (Parathion)	39542	GC/MS	.004
Pebulate (Tillam)	82669	GC/MS	.004
Pendimethalin (Prowl)	82683	GC/MS	.004
cis-Permethrin (Ambush)	82687	GC/MS	.005
Phorate (Thimet)	82664	GC/MS	.002

Table B7. Analytical grouping of pesticides in filtered water analyzed by gas chromatography/mass spectrometry--Continued

[Samples analyzed according to Zaugg and others (1995); GC/MS, gas chromatography/mass spectrometry. All reporting units are in micrograms per liter]

Compound name (common name)	Parameter code	Analytical method	Method reporting limit
Prometon (Pramitol)	82676	GC/MS	.018
Pronamide (Kerb, Propyzamid)	04037	GC/MS	.003
Propachlor (Ramrod)	04024	GC/MS	.007
Propanil (Stampede)	82679	GC/MS	.004
Propargite (Omite, alkyl sulfite)	82685	GC/MS	.013
Simazine (Aquazine, Princep)	04035	GC/MS	.005
Tebuthiuron (Spike)	82670	GC/MS	.010
Terbacil (Sinbar)	82665	GC/MS	.007
Terbufos (Counter)	82675	GC/MS	.013
Thiobencarb (Bolero)	82681	GC/MS	.002
Triallate (Avadex BW, FarGo)	82678	GC/MS	.001
Trifluralin (Treflan)	82661	GC/MS	.002

[1]Compound also analyzed by high pressure liquid chromatography

[2]Analysis for this compound produced poor results. Values reported are estimates

Table B8. Analytical grouping of pesticides in filtered water analyzed by high-performance liquid chromatography

[Samples analyzed according to Werner and others (1996); HPLC, high performance liquid chromatography. All reporting units are in micrograms per liter]

Compound name (common name)	Parameter code	Analytical method	Method reporting limit
Acifluorfen (Scepter, Blazer)	49315	HPLC	0.035
Aldicarb (Temik)	49312	HPLC	.016
Aldicarb Sulfone (Standak)	49313	HPLC	.016
Aldicarb Sulfoxide	49314	HPLC	.021
Bentazon (Basagran)	38711	HPLC	.014
Bromacil (Hyvar)	04029	HPLC	.035
Bromoxynil (Buctril)	49311	HPLC	.035
Carbaryl (Sevin)[1]	49310	HPLC	.080
Carbofuran[1] (Furadan)	49309	HPLC	.028
Carbofuran, 3-Hydroxy-	49308	HPLC	.014
Chloramben (Amiben)	49307	HPLC	.011
Chlorothalonil (Daconil)	49306	HPLC	.035
Clopyralid (Stinger, Lontrel))	49305	HPLC	.050
DCPA (Dacthal)[1]	49304	HPLC	.017
Dicamba, mono-acid- (Banvel)	38442	HPLC	.035
Dichlobenil (Casoron)	49303	HPLC	.020
Dichlorprop, mono-acid (Weedone)	49302	HPLC	.032
Dinoseb (DNBP, Premerge)	49301	HPLC	.035
Diuron (Karmex)	49300	HPLC	.020
DNOC (Elgotol)	49299	HPLC	.035
Fenuron	49297	HPLC	.013
Fluometuron (Cotoran)	38811	HPLC	.035
Linuron (Lorox, Linex)[1]	38478	HPLC	.018
MCPA, mono-acid- (Weedar, Chiptox))	38482	HPLC	.050
MCPB, mono-acid- (Thistrol)	38487	HPLC	.035
Methiocarb (Mesurol)	38501	HPLC	.026
Methomyl (Lannade)	49296	HPLC	.017
2,4-DB, mono-acid- (Butyrac)	38746	HPLC	.035
2,4-D, mono-acid- (Dacamine)	39732	HPLC	.035
2,4,5-T, mono-acid- (Weedar)	39742	HPLC	.035
Neburon	49294	HPLC	.015
Norflurazon (Zorial)	49293	HPLC	.024
Oryzalin (Surflan)	49292	HPLC	.019
Oxamyl (Vydate)	38866	HPLC	.018
Picloram, mono-acid- (Tordon)	49291	HPLC	.050
Propham (IPC, Chem-Hoe)	49236	HPLC	.035
Propoxur (Baygon)	38538	HPLC	.035
Silvex, mono-acid- (2,4,5-TP)	39762	HPLC	.035
Triclopyr, mono-acid- (Turflon)	49235	HPLC	.050

[1]Compound also analyzed by gas chromatography/mass spectrometry

Table B9. Analytical grouping of chlorophenoxy acid herbicides + Picloram and Dicamba, WWR in water

[Samples analyzed according to Wershaw and others (1987); GC-ECD, gas chromatography-electron capture detection; µg/L, micrograms per liter]

Name	Parameter code	Analytical method	Method reporting limit	Reporting unit
2,4-D	39730	GC-ECD	0.010	µg/L
Dicamba	82052	GC-ECD	.010	µg/L
Dichlorprop	82183	GC-ECD	.010	µg/L
Picloram	39720	GC-ECD	.010	µg/L
2-(2,4,5-trichlorophenoxy) propionic acid	39760	GC-ECD	.010	µg/L
2,4,5-T	39740	GC-ECD	.010	µg/L

Table B10. Analytical grouping of herbicides and herbicide metabolites in filtered water

[Samples analyzed according to Thurman and others (1992), Thurman and others (1996), and Kalkhoff and others (1998); HPLC, high performance liquid chromatography; GC/MS, gas chromatorgraphy/mass spectrometry; ESA, ethane sulfonic acid; OA, oxanilic acid; na, not available; µg/L, micrograms per liter]

Name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Acetochlor	49260	GC/MS	0.05	µg/L
Acetochlor ESA	61029	HPLC	.20	µg/L
Acetochlor OA	61030	HPLC	.20	µg/L
Alachlor	46342	GC/MS	.05	µg/L
Alachlor ESA	50009	HPLC	.20	µg/L
Alachlor OA	61031	HPLC	.20	µg/L
Ametryn	38401	GC/MS	.05	µg/L
Atrazine	39632	GC/MS	.12	µg/L
Cyanazine	04041	GC/MS	.13	µg/L
Cyanazine-amide	50010	GC/MS	.05	µg/L
Deethylatrazine	04040	GC/MS	.05	µg/L
Deisopropylatrazine	04038	GC/MS	.05	µg/L
Hydroxyatrazine	34761	HPLC	.20	µg/L
Metolachlor	39415	GC/MS	.05	µg/L
Metolachlor OA	61044	HPLC	.20	µg/L
Metolachlor ESA	61043	HPLC	.20	µg/L
Metribuzin	82630	GC/MS	.05	µg/L
Prometon	82676	GC/MS	.05	µg/L
Prometryn	04036	GC/MS	.05	µg/L
Propachlor	04024	GC/MS	.05	µg/L
Propazine	38535	GC/MS	.05	µg/L
Simazine	04035	GC/MS	.05	µg/L
Terbutryn	38888	GC/MS	.05	µg/L

Table B11. Analytical grouping of streambed- and suspended-sediment characteristics

[Samples analyzed according to Guy (1969); mm, millimeters; µm, microns; Analysis performed by USGS Iowa District Sediment Laboratory, Iowa City, Iowa. All reporting units are in percent except suspended sediment concentration, which is in milligrams per liter]

Parameter name	Parameter code	Analytical method	Estimated reporting limit
Particle size finer than 2.00 mm in streambed sediment	80169	Dry sieving	0.1
Particle size finer than 63 µm in streambed sediment	80164	Dry sieving	.1
Particle size finer than 4 µm in streambed sediment	80157	Pipet analysis or hydrometer	.01
Suspended sediment concentration	80154	Filtration	1.0
Particle size finer than 0.062 mm in suspended sediment	70331	Wet sieving	.1

Table B12. Analytical grouping of trace elements and other constituents in streambed sediments

[Samples analyzed according to Arbogast, (1990); ICP, inductively coupled plasma spectrophotometry; HG-AAS, hydride generation-atomic absorption spectrophotometry; µg/g, micrograms per gram; GF-AAS, graphite furnace-atomic absorption spectrophotometry; CV-AAS, cold-vapor-atomic absorption spectrophotometry;

Constituent name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Aluminum	34790	ICP	0.005	percent
Antimony	34795	HG-AAS	.1	µg/g
Arsenic	34800	HG-AAS	.1	µg/g
Barium	34805	ICP	1.0	µg/g
Beryllium	34810	ICP	1.0	µg/g
Bismuth	34816	ICP	10.0	µg/g
Cadmium	34825	GF-AAS	.1	µg/g
Calcium	34830	ICP	.005	percent
Carbon, inorganic	49269	Van Slyke	.01	percent
Carbon, organic	49266	Combustion	.01	percent
Carbon, total	49267	Combustion	.01	percent
Cerium	34835	ICP	4.0	µg/g
Chromium	34840	ICP	1.0	µg/g
Cobalt	34840	ICP	1.0	µg/g
Copper	34850	ICP	1.0	µg/g
Europium	34855	ICP	2.0	µg/g
Gallium	34860	ICP	4.0	µg/g
Gold	34870	ICP	8.0	µg/g
Holmium	34875	ICP	4.0	µg/g
Iron	34880	ICP	.005	percent
Lanthanum	34885	ICP	2.0	µg/g
Lead	34890	ICP	4.0	µg/g
Lithium	34895	ICP	2.0	µg/g
Magnesium	34900	ICP	.005	percent
Manganese	34905	ICP	4.0	µg/g
Mercury	34910	CV-AAS	.02	µg/g
Molybdenum	34915	ICP	2.0	µg/g
Neodymium	34920	ICP	4.0	µg/g
Nickel	34925	ICP	2.0	µg/g
Niobium	34930	ICP	4.0	µg/g
Phosphorus	34935	ICP	.005	percent
Potassium	34940	ICP	.05	percent
Scandium	34945	ICP	2.0	µg/g
Selenium	34950	HG-AAS	.1	µg/g

Table B12. Analytical grouping of trace elements and other constituents in streambed sediments--Continued

[Samples analyzed according to Arbogast, (1990); ICP, inductively coupled plasma spectrophotometry; HG-AAS, hydride generation-atomic absorption spectrophotometry; µg/g, micrograms per gram; GF-AAS, graphite furnace-atomic absorption spectrophotometry; CV-AAS, cold-vapor-atomic absorption spectrophotometry;

Constituent name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Silver	34955	GF-AAS	.1	µg/g
Sodium	34960	ICP	.005	percent
Strontium	34965	ICP	2.0	µg/g
Sulfur	34970	Combustion	.05	percent
Tantalum	34975	ICP	40.0	µg/g
Thorium	34980	Delayed neutron activation	1.0	µg/g
Tin	34985	ICP	5.0	µg/g
Titanium	49274	ICP	.005	percent
Uranium	35000	Delayed neutron activation	.05	µg/g
Vanadium	35005	ICP	2.0	µg/g
Ytterbium	35015	ICP	1.0	µg/g
Yttrium	35010	ICP	2.0	µg/g
Zinc	35020	ICP	4.0	µg/g

Table B13. Analytical grouping of carbon in streambed sediments less than 2 millimeters in diameter

[All reporting units are in grams per kilogram (dry weight)]

Constituent name	Parameter code	Analytical method	Method reporting limit
Carbon, carbonate	49270	Combustion	0.1
Carbon, organic	49271	Difference (between parameter 49272 and 49270)	.1
Carbon, total	49272	Combustion	.1

Table B14. Analytical grouping of organochlorine and polychlorinated biphenyl compounds in streambed sediments

[Samples analyzed according to Foreman and others (1995); GC-ECD, gas chromatography-electron capture detection; GC/MS, gas chromatography/mass spectrometry. All reporting units are in micrograms per kilogram]

Compound name (common name)	Parameter code	Analytical method	Method reporting limit
Aldrin	49319	GC-ECD	1.0
cis-Chlordane	49320	GC-ECD	1.0
trans-Chlordane	49321	GC-ECD	1.0
Chloroneb	49322	GC-ECD	5.0
DCPA (Dacthal)	49324	GC-ECD	5.0
o,p'-DDD	49325	GC-ECD	1.0
p,p'-DDD	49326	GC-ECD	1.0
o,p'-DDE	49327	GC-ECD	1.0
p,p'-DDE	49328	GC-ECD	1.0
o,p'-DDT	49329	GC-ECD	2.0
p,p'-DDT	49330	GC-ECD	2.0
Dieldrin (Panoram D-31)	49331	GC-ECD	1.0
Endosulfan I	49332	GC-ECD	1.0
Endrin	49335	GC-ECD	2.0
α-HCH	49338	GC-ECD	1.0
β-HCH	49339	GC-ECD	1.0
γ-HCH (Lindane)	49345	GC-ECD	1.0
Heptachlor	49341	GC-ECD	1.0
Heptachlor epoxide	49342	GC-ECD	1.0
Hexachlorobenzene	49343	GC-ECD	1.0
Isodrin	49344	GC-ECD	1.0
o,p'-Methoxychlor (Dual)	49347	GC-ECD	5.0
p,p'-Methoxychlor	49346	GC-ECD	5.0
Mirex	49348	GC/MS	1.0
cis-Nonachlor	49316	GC-ECD	1.0
trans-Nonachlor	49317	GC-ECD	1.0
Oxychlordane	49318	GC-ECD	1.0
Pentachloroanisole	49460	GC-ECD	1.0
cis-Permethrin (Ambush)	49349	GC-ECD	5.0
trans-Permethrin	49350	GC-ECD	5.0
Polychlorinated biphenyls, total	49459	GC-ECD	50.0
Toxaphene	49351	GC-ECD	200.0

Table B15. Analytical grouping of base-neutral-acid extractable, semivolatile organic compounds in streambed sediments

[Samples analyzed according to Furlong and others (1996); GC/MS, gas chromatography/mass spectrometry. All reporting units are in micrograms per kilogram (dry weight)]

Compound name	Parameter code	Analytical method	Method reporting limit
Acenaphthylene	49428	GC/MS	50.0
Acenaphthene	49429	GC/MS	50.0
Acridine	49430	GC/MS	50.0
C8-alkylphenol	49424	GC/MS	50.0
Anthracene	49434	GC/MS	50.0
Anthraquinone	49437	GC/MS	50.0
Azobenzene	49443	GC/MS	50.0
Benzo(*a*)anthracene	49436	GC/MS	50.0
Benzo(*b*)fluoranthene	49458	GC/MS	50.0
Benzo(*k*)fluoranthene	49397	GC/MS	50.0
Benzo(*g*,*h*,*i*)perylene	49408	GC/MS	50.0
Benzo(*a*)pyrene	49389	GC/MS	50.0
Benzo(*c*)quinoline	49468	GC/MS	50.0
2,2’-biquinoline	49391	GC/MS	50.0
4-bromophenylphenylether	49454	GC/MS	50.0
Butylbenzylphthalate	49427	GC/MS	50.0
9H-carbazole	49449	GC/MS	50.0
4-chloro-3-methylphenol	49422	GC/MS	50.0
2-chloronaphthalene	49407	GC/MS	50.0
2-chlorophenol	49467	GC/MS	50.0
4-chlorophenylphenylether	49455	GC/MS	50.0
Chrysene	49450	GC/MS	50.0
p-cresol	49451	GC/MS	50.0
Dibenzo(*a*,*h*)anthracene	49461	GC/MS	50.0
Dibenzothiophene	49452	GC/MS	50.0
1,2-dichlorobenzene	49439	GC/MS	50.0
1,3-dichlorobenzene	49441	GC/MS	50.0
1,4-dichlorobenzene	49442	GC/MS	50.0
2,4-dichlorophenol	49417	GC/MS	50.0
Diethylphthalate	49383	GC/MS	50.0
1,2-dimethylnaphthalene	49403	GC/MS	50.0
1,6-dimethylnaphthalene	49404	GC/MS	50.0
2,6-dimethylnaphthalene	49406	GC/MS	50.0
3,5-dimethylphenol	49421	GC/MS	50.0

Table B15. Analytical grouping of base-neutral-acid extractable, semivolatile organic compounds in streambed sediments--Continued

[Samples analyzed according to Furlong and others (1996); GC/MS, gas chromatography/mass spectrometry. All reporting units are in micrograms per kilogram (dry weight)]

Compound name	Parameter code	Analytical method	Method reporting limit
Dimethylphthalate	49384	GC/MS	50.0
Di-*n*-butylphthalate	49381	GC/MS	50.0
4,6-dinitro-2-methylphenol	49419	GC/MS	50.0
2,4-dinitrophenol	49418	GC/MS	50.0
2,4-dinitrotoluene	49395	GC/MS	50.0
2,6-dinitrotoluene	49396	GC/MS	50.0
Di-*n*-octylphthalate	49382	GC/MS	50.0
bis(2-chloroethyl)ether	49456	GC/MS	50.0
bis(2-chloroisopropyl)ether	49457	GC/MS	50.0
2-ethylnaphthalene	49490	GC/MS	50.0
Fluoranthene	49466	GC/MS	50.0
9H-fluorene	49399	GC/MS	50.0
Hexachlorobutadiene	49448	GC/MS	50.0
Hexachlorocyclopentadiene	49489	GC/MS	50.0
Hexachloroethane	49453	GC/MS	50.0
Indeno(1,2,3-*c*,*d*)pyrene	49390	GC/MS	50.0
Isophorone	49400	GC/MS	50.0
Isoquinoline	49394	GC/MS	50.0
bis(2-chloroethoxy)methane	49401	GC/MS	50.0
2-methylanthracene	49435	GC/MS	50.0
4,5-methylenephenanthrene	49411	GC/MS	50.0
1-methyl-9H-fluorene	49398	GC/MS	50.0
1-methylphenanthrene	49410	GC/MS	50.0
1-methylpyrene	49388	GC/MS	50.0
Naphthalene	49402	GC/MS	50.0
Nitrobenzene	49444	GC/MS	50.0
2-nitrophenol	49420	GC/MS	50.0
4-nitrophenol	49423	GC/MS	50.0
n-Nitrosodiphenylamine	49433	GC/MS	50.0
n-Nitroso-di-*n*-propylamine	49431	GC/MS	50.0
Pentachloronitrobenzene	49446	GC/MS	50.0
Pentachlorophenol	49425	GC/MS	50.0
Phenanthrene	49409	GC/MS	50.0
Phenanthridine	49393	GC/MS	50.0
Phenol	49413	GC/MS	50.0

Table B15. Analytical grouping of base-neutral-acid extractable, semivolatile organic compounds in streambed sediments--Continued

[Samples analyzed according to Furlong and others (1996); GC/MS, gas chromatography/mass spectrometry. All reporting units are in micrograms per kilogram (dry weight)]

Compound name	Parameter code	Analytical method	Method reporting limit
Pyrene	49387	GC/MS	50.0
Quinoline	49392	GC/MS	50.0
2,3,5,6-tetramethylphenol	49414	GC/MS	50.0
1,2,4-trichlorobenzene	49438	GC/MS	50.0
2,4,6-trichlorophenol	49415	GC/MS	50.0
2,3,6-trimethylnaphthalene	49405	GC/MS	50.0
2,4,6-trimethylphenol	49416	GC/MS	50.0

Table B16. Analytical grouping of trace elements in aquatic-biological samples

[Samples analyzed according to Hoffman (1996); ICP-AES, inductively coupled plasma-atomic emission spectrometry; ICP-MS, inductively coupled plasma-mass spectrometry; CV-AAS, cold vapor-atomic absorption spectrophotometry; N.A., not applicable. All reporting units are in micrograms per gram (dry weight) except water content, which is in percent]

Constituent name	Parameter code	Analytical method	Method reporting limit
Aluminum	49237	ICP-AES	1.0
Antimony	49246	ICP-MS	0.1
Arsenic	49247	ICP-MS	.1
Barium	49238	ICP-AES	.1
Beryllium	49248	ICP-MS	.1
Boron	49239	ICP-AES	.2
Cadmium	49249	ICP-MS	.1
Chromium	49240	ICP-AES	.5
Cobalt	49250	ICP-MS	.1
Copper	49241	ICP-AES	.5
Iron	49242	ICP-AES	1.0
Lead	49251	ICP-MS	.1
Manganese	49243	ICP-AES	.1
Mercury	49258	CV-AAS	N.A.
Molybdenum	49252	ICP-MS	.1
Nickel	49253	ICP-MS	.1
Selenium	49254	ICP-MS	.1
Silver	49255	ICP-MS	.1
Strontium	49244	ICP-AES	.1
Uranium	49257	ICP-MS	.1
Vanadium	49465	ICP-MS	.1
Water content	49273	N.A.	N.A.
Zinc	49245	ICP-AES	.5

Table B17. Analytical grouping of organochlorine and polychlorinated biphenyl compounds in aquatic-biological samples

[Samples analyzed according to Leiker and others (1995); GC-ECD, gas chromatography-electron capture detection. All reporting units are in micrograms per kilogram except lipid content, which is in percent]

Compound name (common name)	Parameter code	Analytical method	Method reporting limit
Aldrin	49353	GC-ECD	5.0
cis-Chlordane	49380	GC-ECD	5.0
trans-Chlordane	49379	GC-ECD	5.0
DCPA (Dacthal)	49378	GC-ECD	5.0
o,p'-DDT	49377	GC-ECD	5.0
p,p'-DDT	49376	GC-ECD	5.0
p,p'-DDD	49375	GC-ECD	5.0
o,p'-DDD	49374	GC-ECD	5.0
o,p'-DDE	49373	GC-ECD	5.0
p,p'-DDE	49372	GC-ECD	5.0
Dieldrin (Cygon)	49371	GC-ECD	5.0
Endrin	49370	GC-ECD	5.0
Heptachlor	49369	GC-ECD	5.0
Heptachlor Epoxide	49368	GC-ECD	5.0
Hexachlorobenzene	49367	GC-ECD	5.0
α-HCH	49366	GC-ECD	5.0
β-HCH	49365	GC-ECD	5.0
δ-HCH	49364	GC-ECD	5.0
γ-HCH (Lindane)	49363	GC-ECD	5.0
Lipid content	49289	GC-ECD	0.5
o,p'-Methoxychlor (Dual)	49362	GC-ECD	5.0
p,p'-Methoxychlor	49361	GC-ECD	5.0
Mirex	49360	GC-ECD	5.0
cis-Nonachlor	49359	GC-ECD	5.0
trans-Nonachlor	49358	GC-ECD	5.0
Oxychlordane	49357	GC-ECD	5.0
Pentachloroanisole	49356	GC-ECD	5.0
Polychlorinated biphenyls, total	49354	GC-ECD	50.0
Toxaphene	49355	GC-ECD	200.0

Table B18. Analytical grouping of selected synthetic organic compounds in filtered water

[Samples analyzed by gas chromatogrpahy/mass spectrometry according to S. Zaugg, U.S. Geological Survey, personal commun., 1998. All reporting units are micrograms per liter. All analyses were performed at the U.S. Geological Survey National Water-Quality Laboratory in Arvada, Colorado.]

Name	Method reporting limit
Acenaphthene	0.04
Acenaphthylene	.03
Acetophenone	.10
Anthracene	.05
Atrazine	.03
Benzaldehyde	.10
Benzo(*a*)anthracene	.06
Benzo(*a*)pyrene	.05
Benzo(*b*)fluoranthene	.05
Benzo(*h*,*h*,*i*)perylene	.20
Benzo(*k*)fluoranthene	.05
Bis(2-ethylhexyl)adipate	1.50
Bis(2-ethylhexyl)phthalate	2.0
Bisphenol A	.09
2-butoxy-ethanol phosphate	.07
2-(2-butoxyethoxy)-ethanol	2.0
2-(2-butoxyethoxy)ethyl acetate	.06
Butylated hydroxy anisole (BHA)	.12
Buylated hydroxy toluene	.08
Caffeine	.08
Carbaryl	.06
Chlorpyrifos	.02
Cholesterol	1.50
Chrysene	.06
Cis-chlordane	.04
3B-coprostanol	.80
D-limonene	.05
Dacthal (DCPA)	.04
Diazinon	.03
1,2-dichlorobenzene	.03
1,3-dichlorobenzene	.03
1,4-dichlorobenzene	.03
Dibenzo(*a*,*h*)anthracene	.20
Dieldrin	.08

Table B18. Analytical grouping of selected synthetic organic compounds in filtered water--Continued

[Samples analyzed by gas chromatogrpahy/mass spectrometry according to S. Zaugg, U.S. Geological Survey, personal commun., 1998. All reporting units are micrograms per liter. All analyses were performed at the U.S. Geological Survey National Water-Quality Laboratory in Arvada, Colorado.]

Name	Method reporting limit
2,6-di-*tert*-butylphenol	.09
2-6-di-*tert*-para-benzoquinone	.07
17B-estradiol	.50
Fluoranthene	.03
Fluorene	.08
Indeno(1,2,3-*c*,*d*)pyrene	.20
Lindane	.05
1-methyl napthalene	.04
2-methyl napthalene	.04
Methyl parathion	.06
Metolachlor	.03
Napthalene	.03
Nonylphenol ethoxylates	1.0-1.1
Total nonylphenol	.50
p,*p*'-DDE	.04
Para-cresol	.03
Phenanthrene	.06
Phenol	.08
Phthalic anhydride	.15
Pyrene	.03
Simazine	.04
Tetrachloroethylene	.03
Trans-chlordane	.04
Tribromomethane	.04
Tributyl phosphate	.04
1,2,4-trimethylbenzene	.08
Triphenyl phosphate	.10
Tris(2-chloroethyl)phosphate	.04
Tris(dichloroisopropyl)phosphate	.10

Table B19. Analytical grouping of trace elements in filtered ground water

[Samples analyzed according to Fishman and Friedman (1989) or Faires (1993); ICP-MS, inductively coupled plasma-mass spectrometry; µg/L, micrograms per liter; HG-AAS, Hydride generation-atomic absorption spectrophotometry; µS/cm, microseimens per centimeter at 25° Celsius;

Name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Aluminum	01106	ICP-MS	1.0	µg/L
Antimony	01095	ICP-MS	1.0	µg/L
Arsenic	01000	HG-AAS	1.0	µg/L
Barium	01005	ICP-MS	1.0	µg/L
Beryllium	01010	ICP-MS	1.0	µg/L
Cadmium	01025	ICP-MS	1.0	µg/L
Chromium	01030	ICP-MS	1.0	µg/L
Cobalt	01035	ICP-MS	1.0	µg/L
Copper	01040	ICP-MS	1.0	µg/L
Lead	01049	ICP-MS	1.0	µg/L
Manganese	01056	ICP-MS	1.0	µg/L
Molybdenum	01060	ICP-MS	1.0	µg/L
Nickel	01065	ICP-MS	1.0	µg/L
pH	00403	Glass electrode	0.01	pH units
Selenium	01145	HG-AAS	1.0	µg/L
Silver	01075	ICP-MS	1.0	µg/L
Specific conductance	90095	Wheatstone bridge	1.0	µS/cm
Uranium	22703	ICP-MS	1.0	µg/L
Zinc	01090	ICP-MS	1.0	µg/L

Table B20. Analytical grouping of tritium in ground water

[Samples analyzed according to Östlund and Dorsey (1977); pCi/L, picocuries per liter; N/A, not applicable]

Name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Tritium	07000	Electrolytic enrichment and liquid scintillation	1.0	pCi/L
Tritium, 2 sigma precision estimate	75985	Electrolytic enrichment and liquid scintillation	N/A	pCi/L

Table B21. Analytical grouping of radon in ground water

[Samples analyzed according to American Society for Testing and Materials (1996); pCi/L, picocuries per liter; N/A, not applicable]

Name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Radon-222	82303	Liquid scinitillation counting	26	pCi/L
Radon-222, 2 sigma precision estimate	76002	Liquid scinitillation counting	N/A	pCi/L

Table B22. Analytical grouping of oxygen and nitrogen isotopes in ground water

[Samples analyzed according to Fishman and Friedman (1989), Miyaki and Wada (1967), Rittenberg (1947), and Vogel (1961); N/A, not applicable; g/mL, grams per milliliter]

Name	Parameter code	Analytical method	Method reporting limit	Reporting unit
Deuterium/protium	82082	Carbon dioxide quilibrilum technique	N/A	mil
Oxygen-18/oxygen-16	82085	Hydrogen equilibrium technique	N/A	mil
Nitrogen-15/nitrogen-14	82690	Mass spectrometry	N/A	g/mL