WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN KANSAS--FISCAL YEARS 1992 AND 1993, AND PLANS FOR FISCAL YEAR 1994

Compiled by K.A. Powell

U.S. GEOLOGICAL SURVEY
Open-File Report 94-89

Lawrence, Kansas
1994

U.S. DEPARTMENT OF THE INTERIOR

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FOREWORD

WATER RESOURCES DIVISION OF THE U.S. GEOLOGICAL SURVEY

Who We Are and What We Do

1. We are 5,000 scientists, engineers, technicians, and support people in about 200 offices throughout the Nation.

2. We are widely recognized as the largest and finest water-science/water-information organization anywhere.

3. We develop and disseminate policy relevant, policy neutral water data and information to support and enhance the well being of the people of the United States.

4. We have a total budget of about $400 million in fiscal year (FY) 1994, including about $210 milllion from about 1,000 Federal, State, and local agencies.

5. We operate the Nation's streamflow measuring network, a nationwide network of observation wells, and three nationwide water-quality networks.

6. We have about 650 mission-oriented and process-oriented scientific projects in FY 1994.

7. We carry out the National Water-Quality Assessment Program.

8. We have a powerful program-support infrastructaure, most notably a nationwide distributed computing and related telecommunication system and a world-class analytical water-quality laboratory.

9. We have a long and proud heritage (since 1888) and an organizational culture that nurtures a high-quality work force dedicated to public service and characterized by high morale.

Philip Cohen, Chief Hydrologist
January 17, 1994

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	*By*	*To obtain*
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
ounce, fluid (fl. oz)	0.338	liter
pound per acre (lb/acre)	1.121	kilogram per hectare
degree Fahrenheit (°F)	(1)	degree Celsius (°C)

Office of U.S. Geological Survey in Lawrence, Kansas

WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN KANSAS-- FISCAL YEARS 1992 AND 1993, AND PLANS FOR FISCAL YEAR 1994

Compiled by K.A. Powell

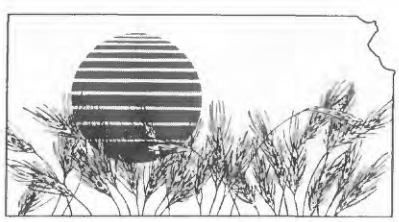
ABSTRACT

The principal mission of the U.S. Geological Survey, Water Resources Division, in Kansas is to investigate the occurrence, quantity, quality, distribution, and movement of surface and ground water throughout the State. Primary activities include the systematic collection, analysis, and interpretation of hydrologic data, evaluation of water demands, and water-resources research. Three types of studies are conducted: (1) data-collection activities, (2) statewide or regional hydrologic investigations, and (3) hydrologic research. These studies are funded through joint-funding agreements with State and local agencies, transfer of funds from other Federal agencies, and direct Federal funds.

Thirty-five water-related studies were ongoing during fiscal years 1992-94 in Kansas. This report describes for each study, the problem that initiated the study, the objectives of the study, the approach designed to achieve the objectives, and significant milestones that resulted during fiscal years 1992 and 1993. Also included is a description of planned activities for fiscal year 1994 for each study. Information on more than 1,800 data-collection sites in Kansas is presented in maps and tables. A list of 59 reports and abstracts published or released by the U.S. Geological Survey, its cooperators, or technical and scientific organizations during calendar years 1992 and 1993 is provided.

INTRODUCTION

The Organic Act of March 3, 1879, established the U.S. Geological Survey as a separate Bureau of the U.S. Department of the Interior. The Survey's principal mission became (1) the classification and survey of public lands, (2) the examination of the geologic structure and the mineral resources of the national domain, and (3) the determination of the water resources of the United States. Seven years later, in 1886, the first water-resources investigation by the U.S. Geological Survey in Kansas was completed by A.C. Peale. A joint-funding agreement with the Kansas State Board of Irrigation and Surveys established the first streamflow-gaging stations in western Kansas during 1895. The gaging program was extended to eastern Kansas in 1899.



From these early beginnings, the U.S. Geological Survey has expanded its work in Kansas to meet the growing demand for scientific data by Federal, State, and local agencies for use in the management of one of the State's most precious resources--water. The Kansas District, with headquarters in Lawrence and field offices in Lawrence, Garden City, and Wichita (fig. 1), investigates the occurrence, quantity, quality, distribution, and movement of surface and ground water. The District's activities include the

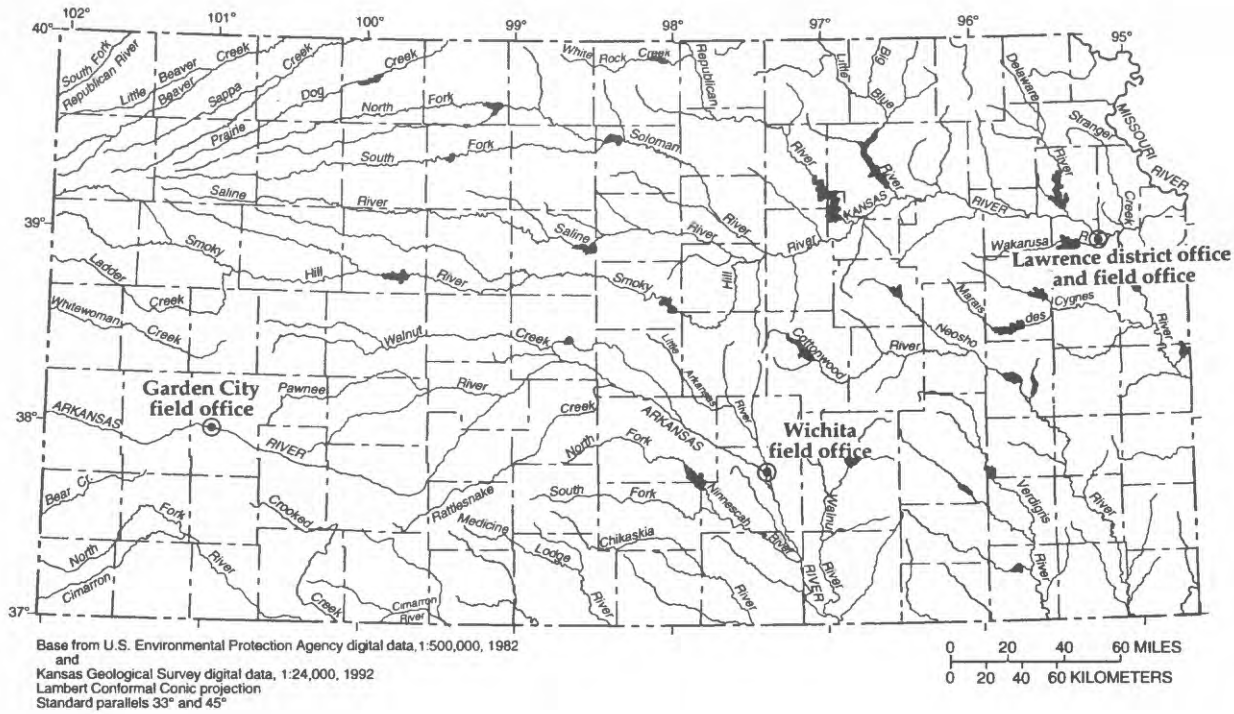


Figure 1. Location of offices of the U.S. Geological Survey in Kansas.

systematic collection, analysis, and interpretation of data; the investigation of water demand for public supply, industrial, domestic, and agricultural purposes; and the research and development of new techniques to improve the scientific basis of data collection and investigative principles.

Hydrologic data collection, data analyses, and investigative studies are conducted at project offices in Lawrence, Garden City, and Wichita. Hydrologic data management, the District's organic geochemistry research laboratory, computer applications, and the scientific publications section are located at the District office in Lawrence. The percentages of Survey personnel in the Kansas District by job category for fiscal years 1993-94 are shown in figure 2. The fiscal year (FY) for Federal-government operations extends from October 1 of each year to September 30 of the following year. In publications of the U.S. Geological Survey, this time period also is known as a water year.

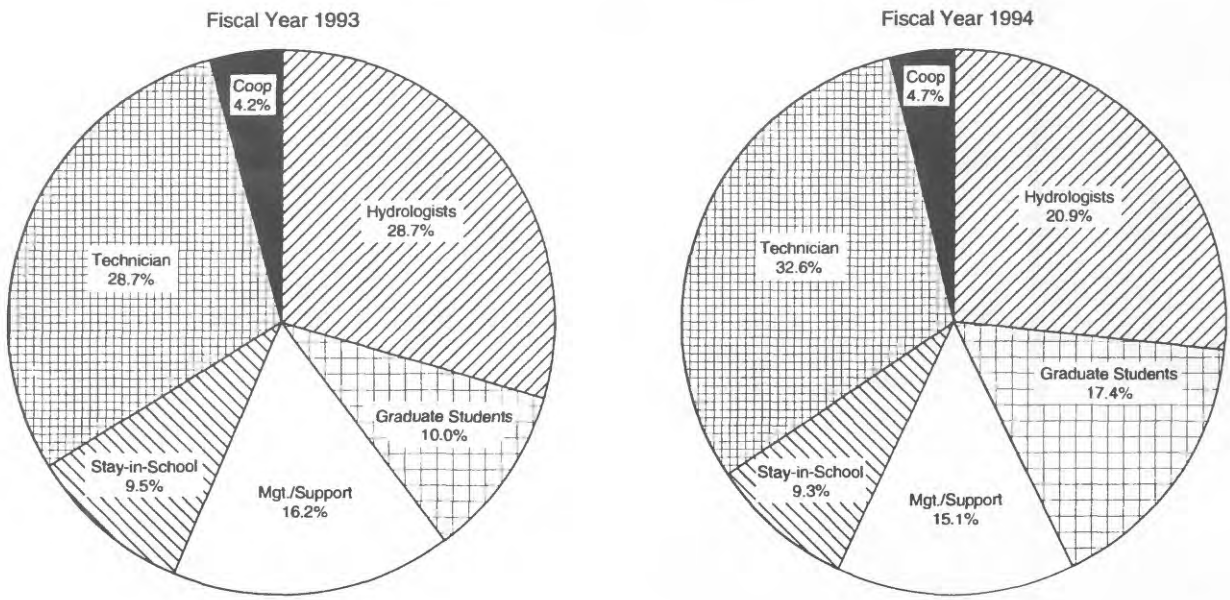


Figure 2. Percentage of Survey personnel in Kansas District by job category, fiscal years 1993-94.

PROGRAM FUNDING AND COOPERATION

Funding for program operation of the U.S. Geological Survey in Kansas comes from joint-funding agreements with State and local agencies, transfer of funds from other Federal agencies, and direct Federal appropriations to the U.S. Geological Survey. Distribution of funding for program operation in fiscal years 1993-94 is illustrated in figure 3. Those agencies having joint-funding agreements with the U.S. Geological Survey in Kansas during fiscal years 1993-94 were:

Federal

Department of Air Force
Department of Army
Fort Leavenworth
Fort Riley
U.S. Army Corps of Engineers, Kansas City District
U.S. Army Corps of Engineers, Tulsa District
U.S. Army National Guard
U.S. Bureau of Indian Affairs
U.S. Bureau of Reclamation
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service

State and local agencies

Arkansas River Compact Administration
Brazos River Authority
City of Cameron
City of Emporia
City of Hays
City of Olathe
City of Topeka
City of Wichita
Franklin County
Equus Beds Groundwater Management District #2
Harvey County
Harvey County Conservation District
Hillsdale Lake Region Resources Conservation and Development Council
Iowa Tribe of Kansas and Nebraska
Johnson County
Kansas Biological Survey
Kansas City--Wyandotte County
Kansas Department of Health and Environment
Kansas Department of Transportation
Kansas Geological Survey
Kansas State Board of Agriculture, Division of Water Resources
Kansas State Conservation Commission
Kansas State University
Kansas University
Kansas Water Office
Kickapoo Tribe of Kansas
Linn County
Prairie Band of Potawatomie
Reno County
Sac and Fox Tribe of Missouri
Sedgwick County
University of Kansas Center for Research, Incorporated

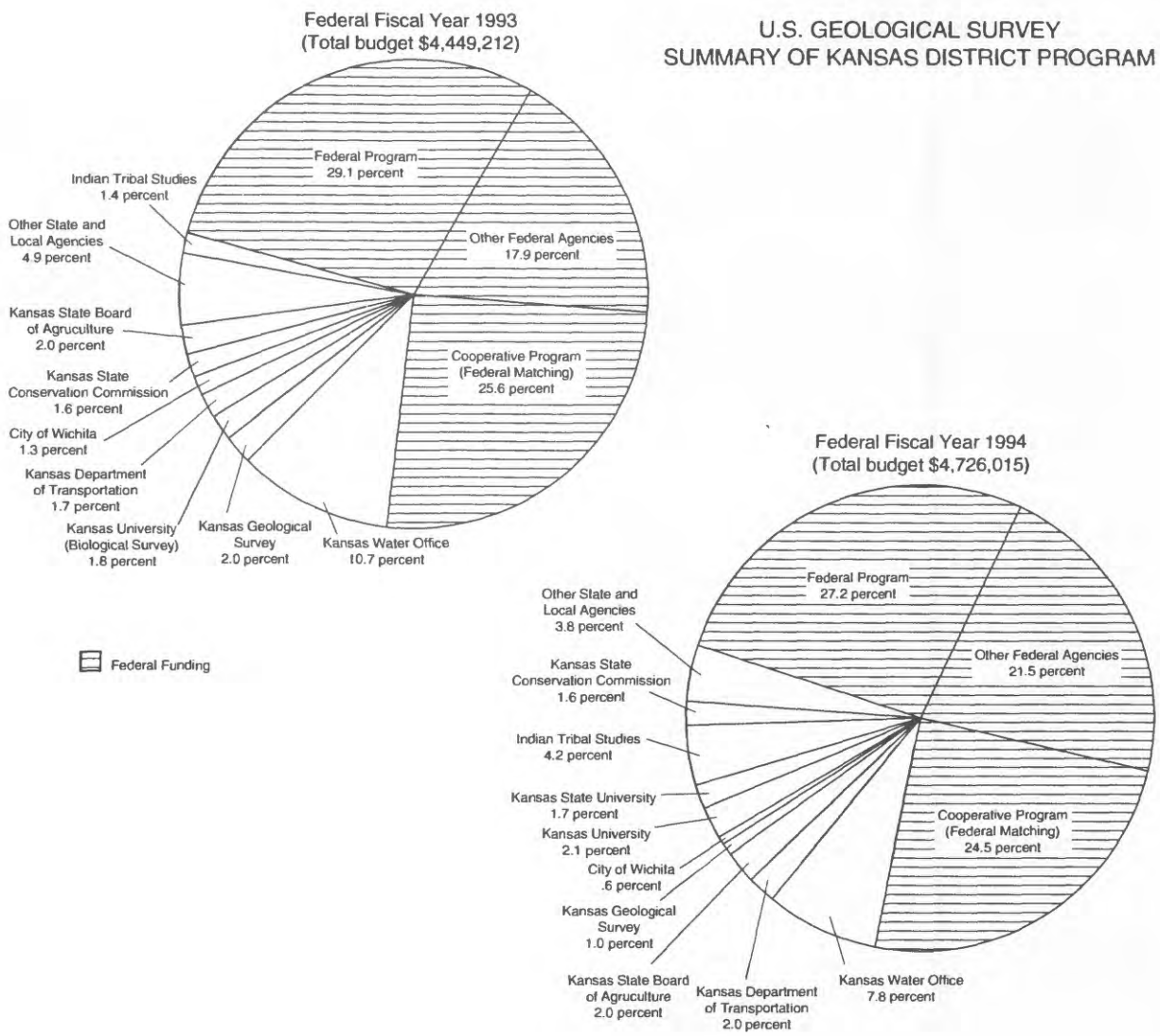


Figure 3. Distribution of funding for the water-resources program of the U.S. Geological Survey in Kansas, fiscal years 1993-94.

PUBLICATIONS

Water-resources data and the results of hydrologic investigations in Kansas are published or released either by the U.S. Geological Survey, by cooperating agencies, or by journals of technical and scientific organizations. Requests for such information and for publications resulting from past or present investigations of the U.S. Geological Survey in Kansas should be addressed to one of the following:

District Chief
U.S. Geological Survey
Water Resources Division
4821 Quail Crest Place
Lawrence, Kansas 66049-3839
Telephone: (913) 842-9909

Office Chief
U.S. Geological Survey
Water Resources Division
206 Fulton Terrace
Garden City, Kansas 67846
Telephone: (316) 275-4123

Office Chief
U.S. Geological Survey
Water Resources Division
425 South Main
Wichita, KS 67202

U.S. Geological Survey
Earth-Science Information Center
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

During calendar years 1992 and 1993, personnel of the U.S. Geological Survey in Kansas authored or coauthored 59 water-related reports and abstracts. This total included 37 interpretive reports, 9 data reports, and 13 abstracts. A complete listing of these reports and abstracts begins on page 80.

The U.S. Geological Survey also conducts an extensive mapping program in Kansas from its regional office in Rolla, Missouri. Standard topographic quadrangle maps published in the 7 1/2- and 15-minute series provide coverage for the entire State. Land-use, land-cover, and topographic maps and associated digital map data also are available at a scale of 1:250,000. County-wide metric topographic maps (1:50,000 and 1:100,000 scale) and 7 1/2-minute slope maps are available only for selected areas. To obtain an index or to purchase these maps, contact:

Kansas Geological Survey
Publications Sales
1930 Constant Avenue - Campus West
Lawrence, Kansas 66046
Telephone (913) 864-3965

For additional information on the U.S. Geological Survey's mapping program in Kansas, contact:

Mid-Continent National Cartographic
Information Center
U.S. Geological Survey
1400 Independence Road
Rolla, Missouri 65401
Telephone (314) 341-0851

Studies in Kansas to investigate the frequency and extent of flooding have resulted in delineation of the 100-year flood boundary on selected topographic quadrangle maps (fig. 4). These maps are available from the Kansas district office in Lawrence.

EDUCATIONAL OUTREACH

The President of the United States has called for every sector of America to make a concerted effort to improve pre-college education. The U.S. Department of the Interior supports the President's goal of raising the standards of education and making quality education accessible to all Americans. The U.S. Geological Survey is participating in this effort by providing leadership to support the development of Earth-science literacy in elementary and secondary schools.

Elementary and Secondary Education

Colleges and Universities

The U.S. Geological Survey in Kansas and departments and agencies throughout the Federal government have supported student employment under the Stay-In-School Program for many years. This program has as its major objective the employment of students, giving them a chance to work in Federal agencies so that they can resume or continue their educations without the interruptions caused by financial pressures. The Stay-In-School Program is designed to benefit students who are in high school or who are continuing their educations immediately after high school. During fiscal years 1993-94, a total of eight stay-in-school students were employed by the Kansas District as well as 11 graduate students paid with project funds.

Education Materials

The U.S. Geological Survey continues to develop educational materials for students in kindergarten through senior high school. Materials include lectures, lesson plans, slides, posters, and student activities. Educational materials are available from several outlets. Help in choosing the most appropriate outlet may be obtained from the District office in Lawrence (telephone: 913-842-9909).

The Earth Science Information Center of the U.S. Geological Survey is a mail-order outlet that distributes the following kinds of book products: (1) books in the formal series, such as U.S. Geological Survey Bulletins, Professional Papers, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulars, special books, and catalogs; (2) popular publications of general interest, such as leaflets, pamphlets, posters, and booklets; (3) single copies of "Earthquake and Volcanoes," and "Preliminary Determination of Epicenters"; and (4) miscellaneous reports including some that are no longer available from Superintendent of Documents. The Center also is a mail-order facility for

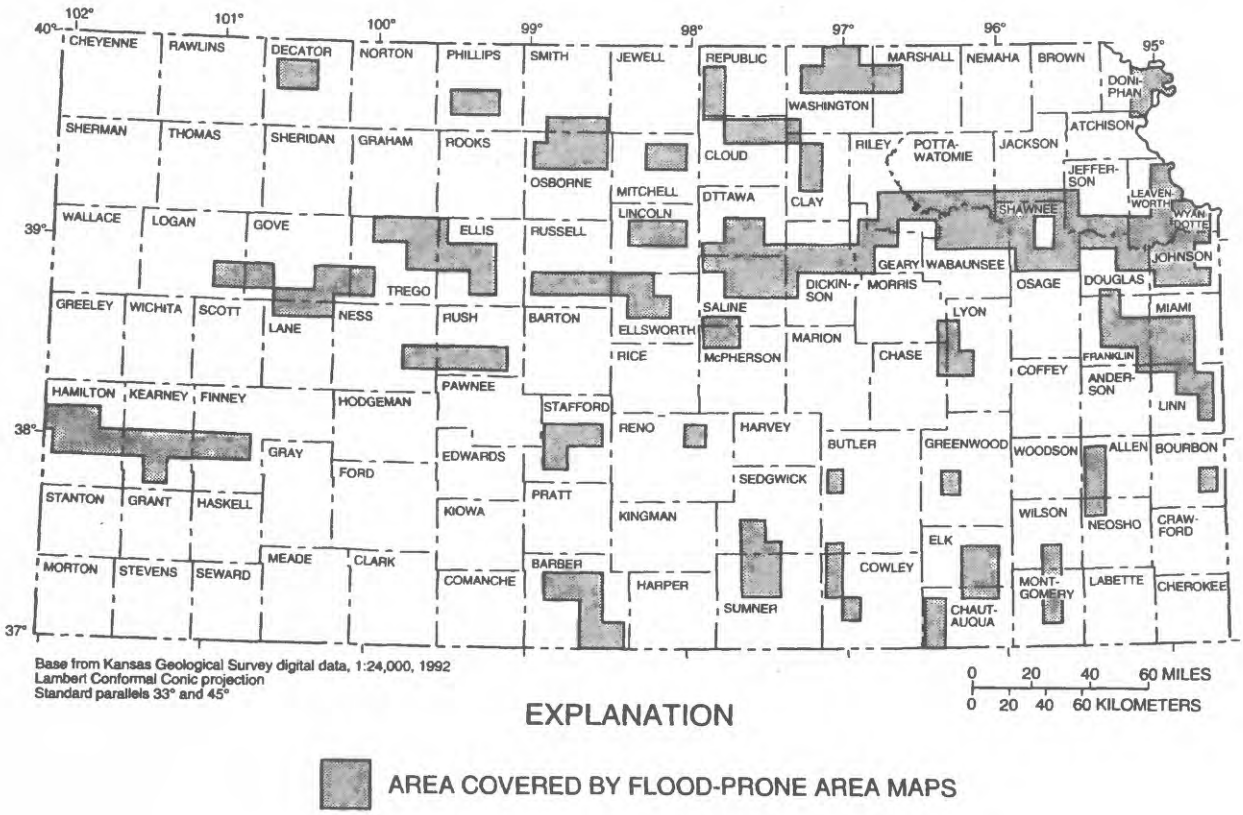


Figure 4. Availability of flood-prone area maps.

microfiche and paper copies of most U.S. Geological Survey Open-File Reports as well as the primary distribution center for new Water-Resources Investigations Reports.

U.S. Geological Survey
Earth-Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

The Visual Information Services Group provides Earth-science movies and videos on a free-loan, short-term (2- to 3-day) basis to educational institutions, professional and scientific societies, civic and industrial groups, and other such establishments.

Visual Information Services Group
U.S. Geological Survey
790 National Center
Reston, VA 22092
(703) 648-4376

Exhibits illustrating recent work in cartography, geography, geology, water resources, and other aspects of U.S. Geological Survey research

can be requested from the USGS Exhibits Committee for display at professional meetings and technical conferences.

Chairman, USGS Exhibits Committee
U.S. Geological Survey
790 National Center
Reston, VA 22092
(703) 648-4357

Packets of teaching aids, which differ according to subject, grade level, and geographic location, are available from the Geologic Inquiries Group and the National Cartographic Information Center. These packets include lists of reference materials, various maps and map indices, and a selection of general interest publications. Requests for teachers packets should be sent on school letterhead and should indicate the grade level and subject of interest. The Geologic Inquiries Group compiles two packets: (1) "Selected Packet of Geologic Teaching Aids," for elementary- and secondary-school teachers of general science courses, and (2) "Teachers Packet of Geologic Materials," for secondary-school and college teachers of Earth-science courses.

Geologic Inquiries Group
U.S. Geological Survey
907 National Center
Reston, VA 22092
(703) 648-4383

The National Cartographic Information Center compiles specialized packets emphasizing mapping. Requests for packets should include specific details about the needs and (or) interests of a particular class.

National Cartographic Information Center
U.S. Geological Survey
507 National Center
Room 1-C-107
12201 Sunrise Valley Drive
Reston, VA 22092
(703) 648-5963

Several Kansas District employees taught a course on ARC/INFO during fiscal years 1992 and 1993 at Haskell Indian Nations University as part of a cooperative agreement between the U.S. Geological Survey and the college. A series of demonstrations also were given at Haskell Indian Nations University during fiscal year 1992. During fiscal year 1993, Kansas District employees taught three sessions of an environmental class and also participated in a career fair at Haskell Indian Nations University.

Two Kansas District employees taught courses on climatology and geochemistry at the University of Kansas during fiscal years 1992 and 1993.

DATA-COLLECTION PROGRAMS

Throughout its long history of service, one mission of the U.S. Geological Survey, Water Resources Division, has been the comprehensive and systematic collection of hydrologic data and the timely release of such data for public use. To help provide this service, a network of hydrologic-data stations is maintained throughout Kansas to obtain records of (1) stage, discharge, chemical quality, and sediment yield of streams; (2) stage and content of lakes and reservoirs; (3) precipitation; and (4) ground-water levels.

Systematically and routinely, the U.S. Geological Survey gathers data from more than 1,800 hydrologic sites in Kansas. The backbone of the system is a network of 161 automated streamflow-gaging stations. Measurements made at most automated data-collection stations are punched on paper tapes that are retrieved during visits to each site at intervals of 6 weeks or more. However, real-time data are available from 117 of these stations via satellite transmission.

A major objective of the U.S. Geological Survey in Kansas is to decrease the amount of time between the collection and dissemination of hydrologic data. Of the 161 automated streamflow-gaging stations in Kansas, 22 are linked via telephone lines for immediate retrieval of current stream stages. Even more detailed, real-time data are available from 117 hydrologic stations via satellite transmission to computer-receiving stations. Those hydrologic stations equipped with satellite-transmission facilities are shown in figure 5.

Hydrologic data collected in Kansas as part of the water-resources-data network are published annually in a comprehensive report entitled "Water Resources Data for Kansas, Water Year 19--." Each water-data report carries an identification number consisting of the two-letter state abbreviation, the last two digits of the water year, and the volume number. For example, the report for the 1992 water year is identified as "U.S. Geological Survey Water-Data Report KS-92-1." Reports for each water year are released the following calendar year. Water-data reports are available from the U.S. Geological Survey office in Lawrence, Kansas, or from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Hydrologic data also are stored in both current and historical computer files in the U.S. Geological Survey's National Water-Data Storage and Retrieval System (WATSTORE). The data are available for water planning and management in machine-readable form, computer-printed tables or graphs, statistical analyses, and digital plots. Local assistance in the acquisition of computer services is available from the Kansas District office in Lawrence.

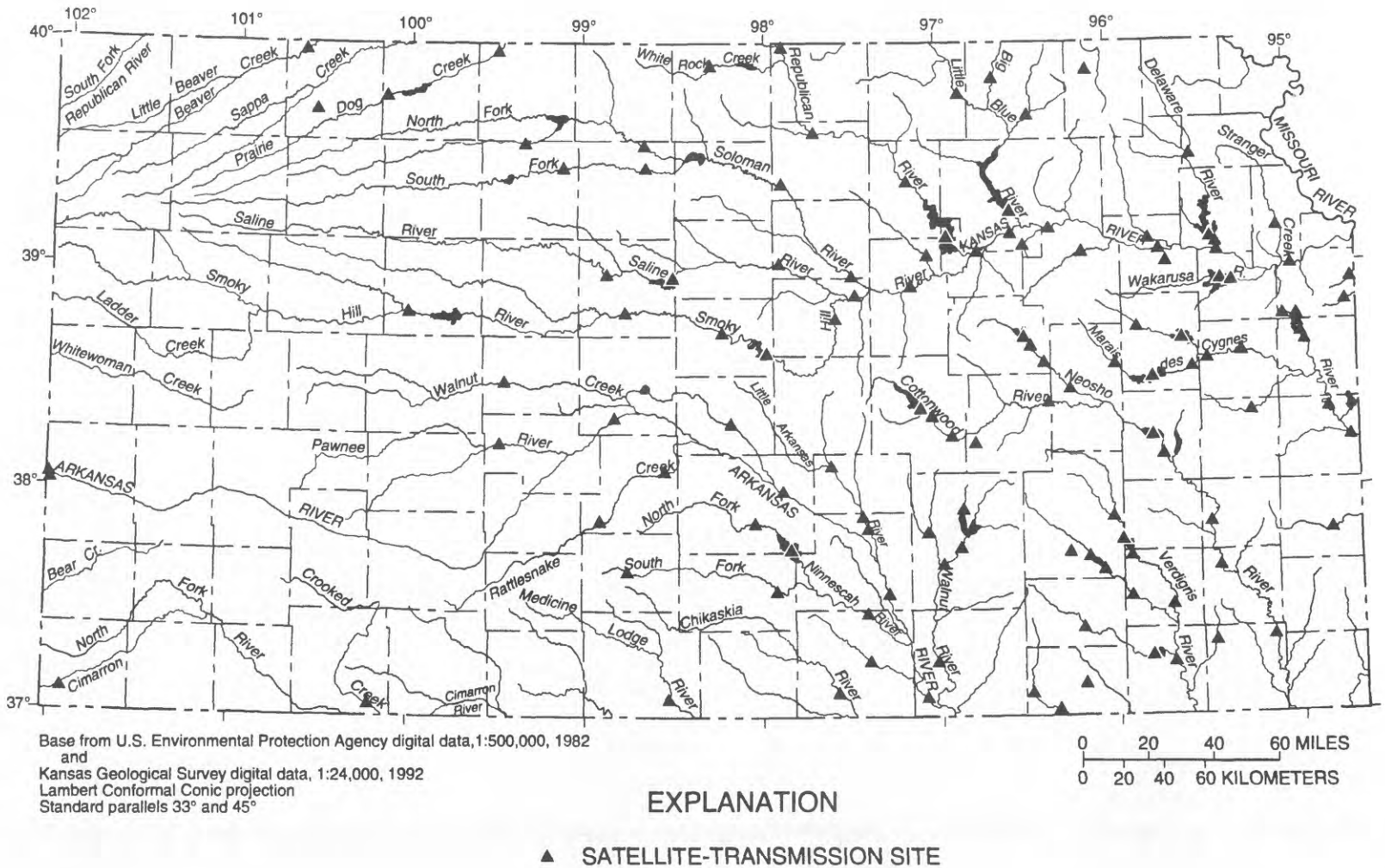


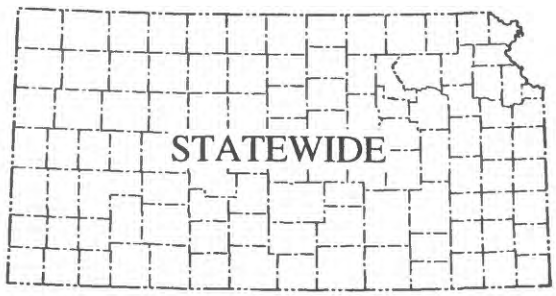
Figure 5. Location of satellite-transmission sites for 1993 water year.

PROJECT TITLE:
Surface-water data program

PROJECT NUMBER:
KS-001

COOPERATING AGENCY:
Multi-agency

PROJECT CHIEF:
C. O. Geiger



KS001

Problem--Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management in such water-related fields as water supply, hydroelectric power, flood control, irrigation, flood-plain management, and water-resources development. To provide this information, an appropriate and comprehensive data base is necessary.

Objective--Collect surface-water data sufficient to satisfy needs for current uses, such as (1) assessment of water resources, (2) operation of reservoirs or industrial supplies, (3) forecasting, (4) pollution control and disposal of wastes, (5) discharge data to accompany water-quality measurements, (6) compact and legal requirements, and (7) research or special studies.

Collect data necessary for analytical studies to define, for any location, the statistical properties of, and trends in, the occurrence of water in streams, lakes, and reservoirs for use in planning and design.

Approach--A network of gaging stations (figs. 6, 7, and 8; and tables 1, 2, and 3 at the end of this report) is maintained to provide surface-water data for management and operation, for determination of long-term trends, and for research and special studies. Data are collected on stage and discharge of streams or canals, on stage, surface area, and content of lakes and reservoirs, and on precipitation. The network of stations is reviewed periodically to ensure the collection of meaningful and worthwhile data.

Significant milestones--All network data were collected on schedule, and during the 1992 and 1993 water years, 136 complete-record streamflow-gaging stations (table 1), 28 partial-record stations (table 2), and 16 precipitation stations (table 3) provided surface-water data throughout the State. Data on stage, surface area, and content of 24 lakes and reservoirs (table 1) also were collected. Annual water year records were prepared and published.

Plans for fiscal year 1994--Continue operation of network. Data will be collected at 140 continuous-record streamflow-gaging stations, 20 reservoirs, 7 continuous-stage streamflow-gaging stations, 28 high-flow partial-record streamflow-gaging stations, 2 low-flow partial-record streamflow-gaging stations, 13 continuous-recording precipitation gages, and 1 rating forecast streamflow-gaging station.

Reports

Geiger, C.O., Lacock, D.L., Schneider, D.R., Carlson, M.D., and Dague, B.J., 1993, Water resources data, Kansas, water year 1992: U.S. Geological Survey Water-Data Report KS-92-1, 500 p.

Geiger, C.O., Lacock, D.L., Schneider, D.R., Carlson, M.D., and Pabst, B.J., 1992, Water resources data, Kansas, water year 1991: U.S. Geological Survey Water-Data Report KS-91-1, 358 p.

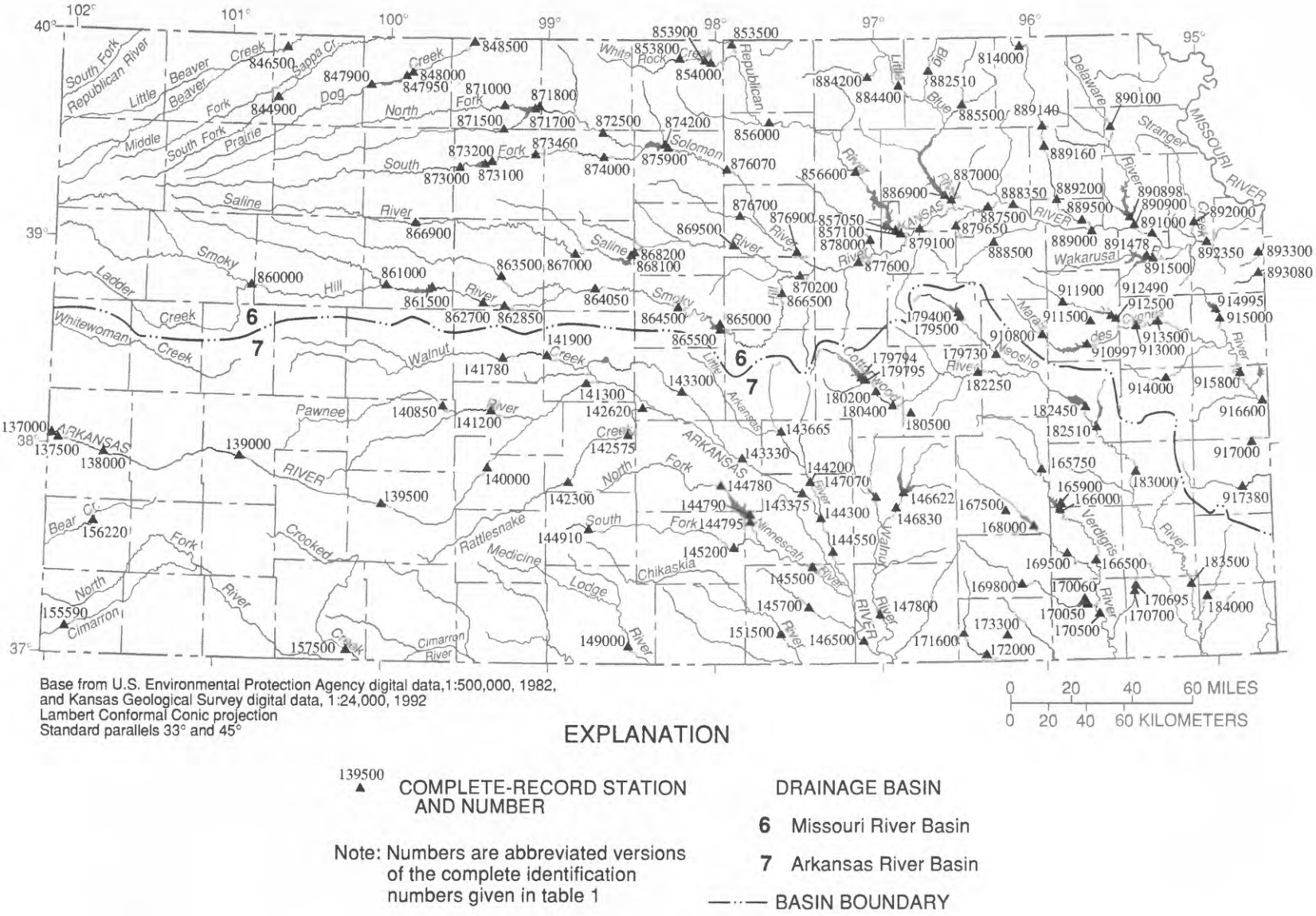


Figure 6. Location of complete-record streamflow-gaging stations, 1993 water year.

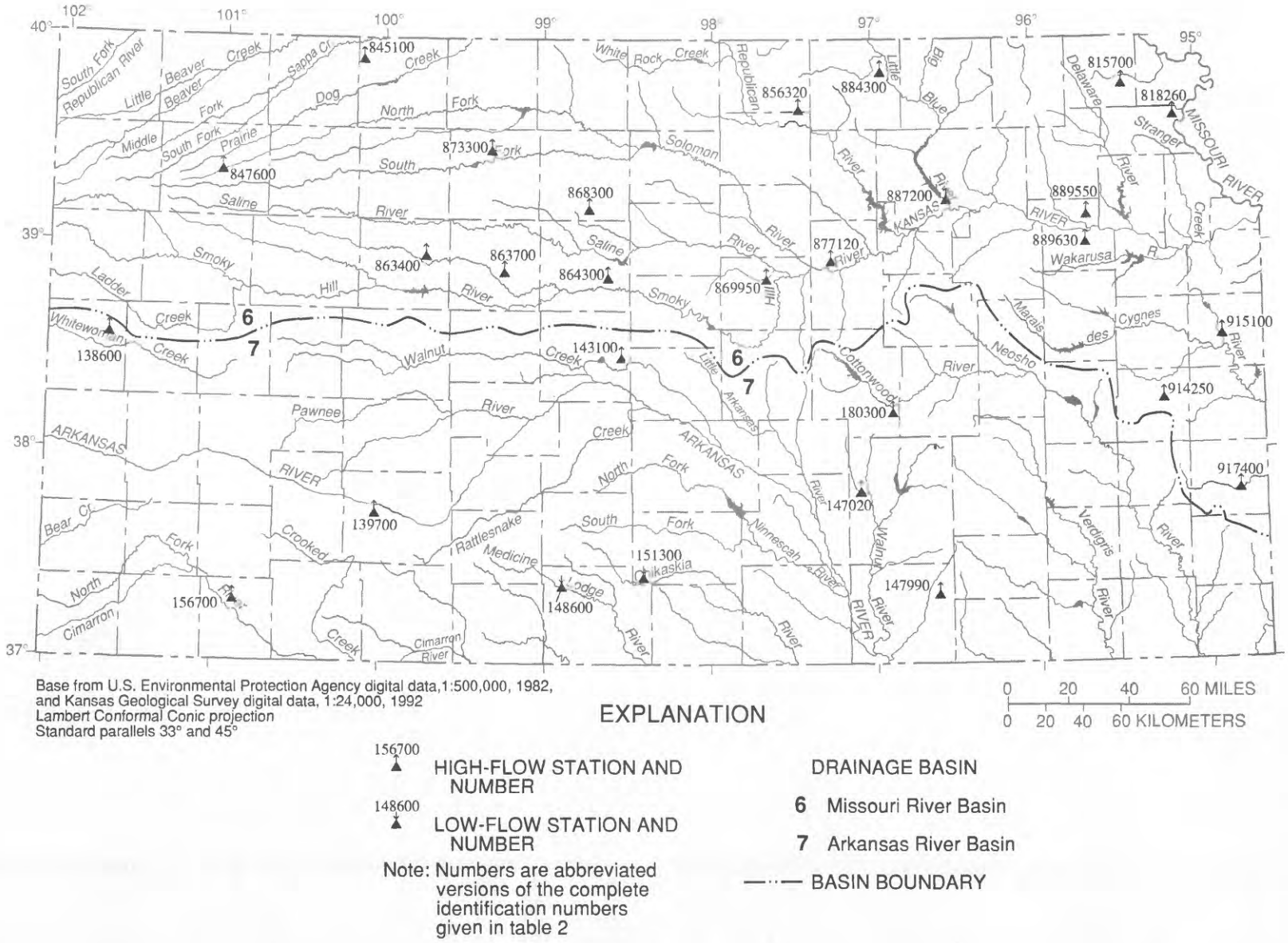


Figure 7. Location of partial-record streamflow-gaging stations, 1993 water year.

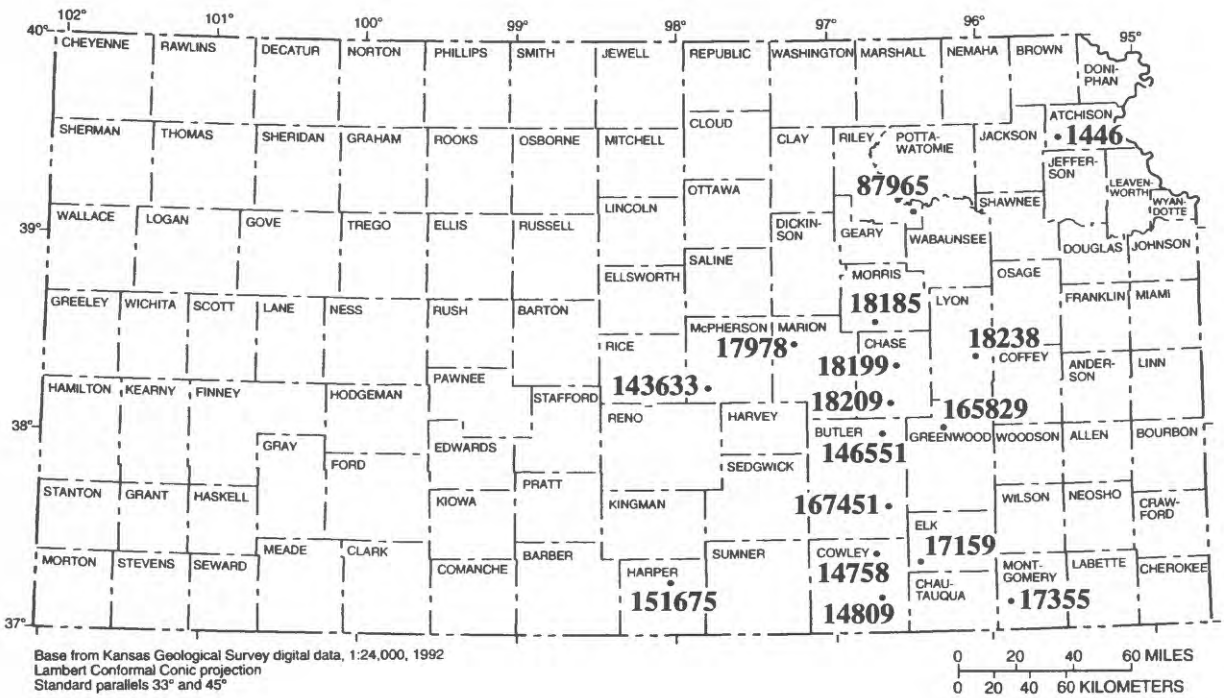
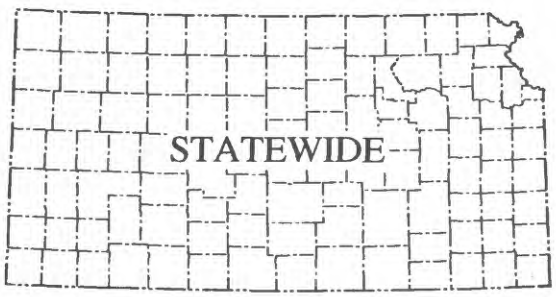


Figure 8. Location of recording precipitation stations, 1993 water year.



KS002

PROJECT TITLE:
Ground-water data program

PROJECT NUMBER:
KS-002

COOPERATING AGENCY:
Multi-agency

PROJECT CHIEF:
C. O. Geiger

Problem--Long-term water-level records are needed to: (1) evaluate the effects of climatic variations on the recharge to and discharge from ground-water systems in Kansas, (2) provide a data base from which to measure the effects of development, (3) assist in the prediction of future supplies, and (4) provide data for management of the resource.

Objective--Collect ground-water-level data sufficient to provide a minimum long-term data base so that the general response of the hydrologic system to natural climatic variations and induced stresses is known and so that potential problems can be defined early enough to allow proper planning and management.

Provide a data base against which the short-term records acquired in areal studies can be analyzed. This analysis must (1) provide an assessment of the ground-water resources, (2) allow projections of future conditions, (3) detect and define pollution and supply problems, and (4) provide the data base necessary for management of the resource.

Approach--A network of observation wells (fig. 9 and table 4 at the end of this report) is measured to provide a data base for monitoring the general response of ground-water systems to natural climatic variations and to stresses of pumpage. A long-term record of water-level measurements, in conjunction with a description of the hydrologic system, provides data for proper planning and management, and for scientific investigations.

Significant milestones--Ground-water levels were measured by the U.S. Geological Survey and State and local agencies in approximately 1,560 observation wells during the 1992 and 1993 water years.

Plans for fiscal year 1994--Continue to operate the network. Water levels will be measured in approximately 1,560 wells.

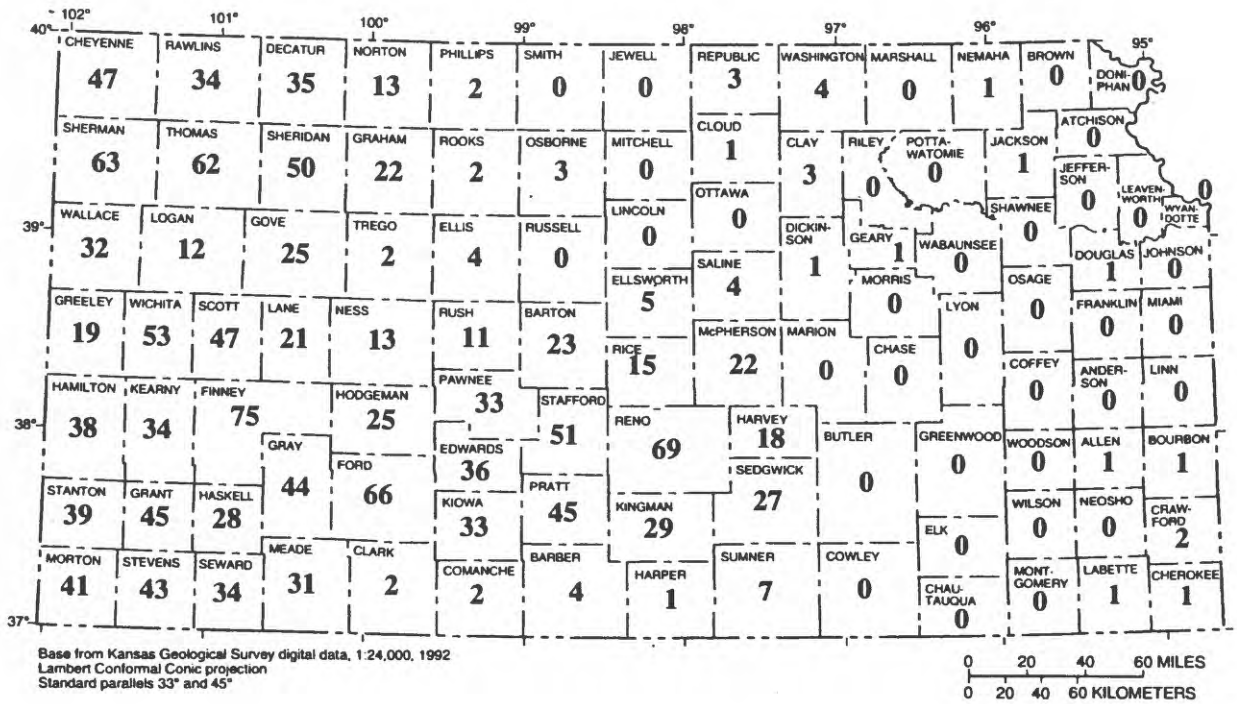
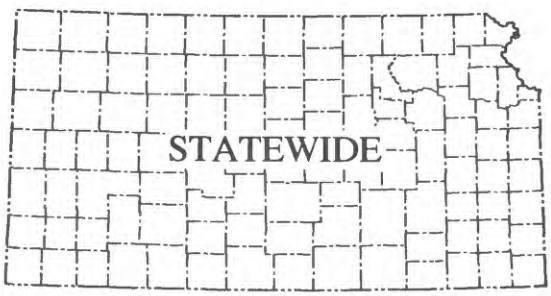


Figure 9. Number of ground-water-level observation wells per county, 1993 water year.



KS003

PROJECT TITLE:
Water-quality data program

PROJECT NUMBER:
KS-003

COOPERATING AGENCY:
Multi-agency

PROJECT CHIEF:
C. O. Geiger

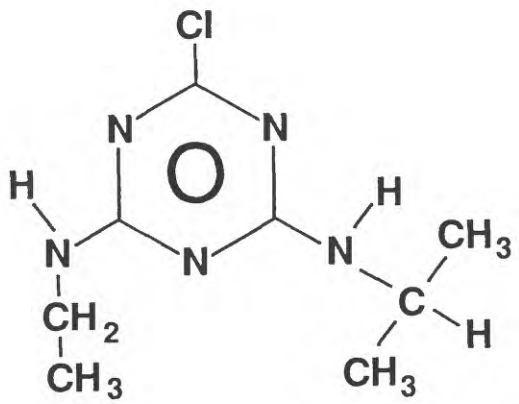
Problem--Water-resources planning and water-quality assessment require a national data base of relatively standardized information. For intelligent planning and realistic assessment of the water resource, the chemical and physical quality of the rivers, streams, lakes, and reservoirs, as well as major ground-water systems, must be defined and monitored.

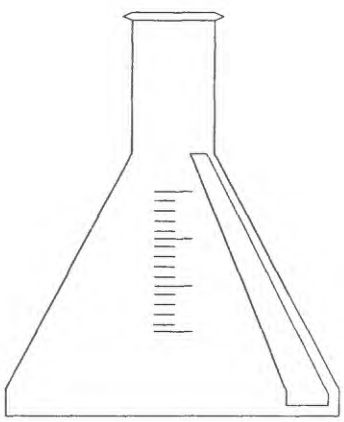
Objective--The primary objective is to establish and maintain a network that will: (1) provide statewide data for a national data base of water-quality information for State, local, or Federal planning and action programs; (2) depict areal variability of streamflow- and water-quality conditions statewide on a year-by-year basis; and (3) detect and assess long-term changes in streamflow and water quality.

Approach--Surface-water-quality stations (fig. 10 and table 5 at the end of this report) are maintained to monitor long-term and short-term trends related to changes in streamflow, reservoir operation, and local or regional pollution. In addition, a network for collection of surface-water-quality data, identified as the National Stream-Quality Accounting Network (NASQAN), is designed by the U.S. Geological Survey to meet many of the informational demands of agencies or groups involved in national or regional water-quality planning and management. Water samples are collected at a few regular surface-water stations, as a Federal interagency activity, for monitoring the concentration and distribution of pesticides in streams where potential contamination could result from continued or future application of the commonly used insecticides and herbicides.

Significant milestones--During the 1992 and 1993 fiscal years, water-quality data were collected at five complete-record streamflow-gaging stations and two partial-record stations on a regular scheduled basis. The five complete-record streamflow-gaging stations were in the National Stream-Quality Accounting Network, one partial-record station was in the Hydrologic Benchmark Network, and one was a Missouri River Basin partial-record station.

Plans for fiscal year 1994--During the 1994 fiscal year, water-quality data will be collected at 140 continuous-record streamflow-gaging stations. Four of these stations are in the National Stream-Quality Accounting Network (NASQAN), one station is in the Missouri River Basin (MRB) Network, and one station is in the Hydrologic Benchmark Network.





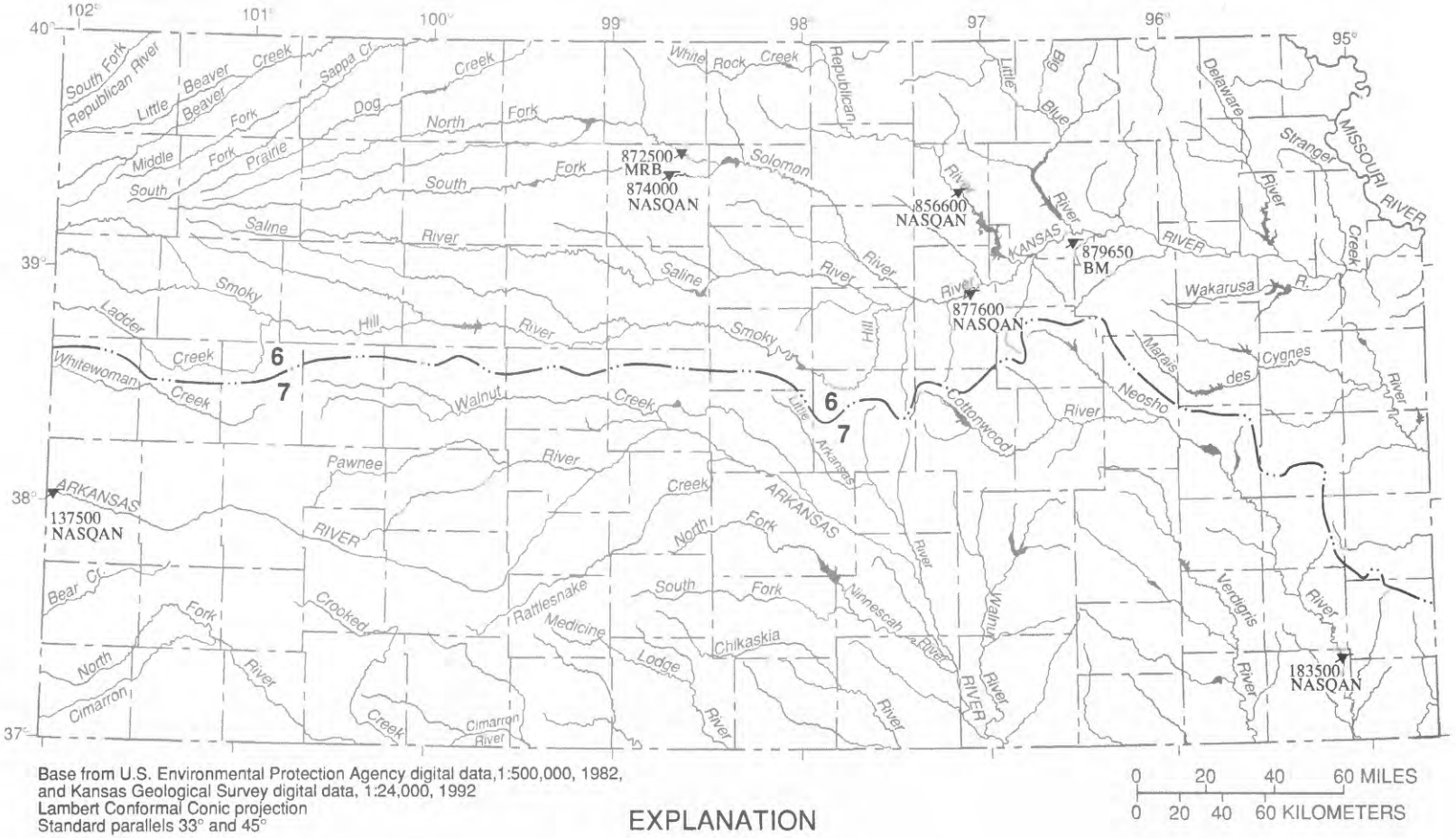


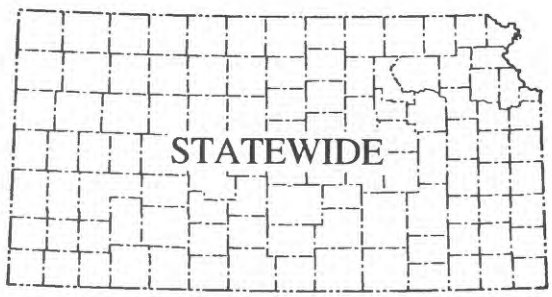
Figure 10. Location of surface-water-quality gaging stations, 1993 water year.

PROJECT TITLE:
Sediment-data program

PROJECT NUMBER:
KS-004

COOPERATING AGENCY:
Multi-agency

PROJECT CHIEF:
C.O. Geiger



KS004

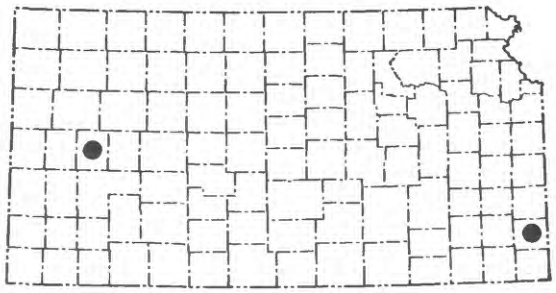
Problem--Sediment concentrations and discharges in rivers and streams must be defined and monitored in order to make a comprehensive water-quality assessment of the Nation's water resources.

Objective--The primary objective of this project is to provide statewide data for a national data base of standardized sediment information for use in local, State, and Federal planning and action programs.

Approach--A network of sediment stations (as shown in figure 10 and listed in table 5 at the end of this report) has been established to provide spatial and temporal averages and trends in concentration, discharge, and particle size of sediment being transported by rivers and streams.

Significant milestones--During fiscal year 1992, network data were collected on schedule, and annual water-year records were prepared and published. During the 1993 fiscal year, water samples were collected at 17 sites for analysis and determination of suspended-sediment discharge.

Plans for fiscal year 1994--During the 1994 fiscal year, water samples will be collected at 16 stations for analysis and determination of suspended-sediment discharge.



KS005

PROJECT TITLE:
National Atmospheric Deposition Program

PROJECT NUMBER:
KS-005

COOPERATING AGENCY:
Federal

PROJECT CHIEF:
C.O. Geiger

Problem--In recent decades human activities have greatly increased both the abundance of substances dispersed in the atmosphere and their effect on the biosphere of the Earth. These changes have resulted mainly from increases in (1) combustion of fossil fuels in power production, space heating, and transportation; (2) emissions of dust, aerosols, and gases from industrial and land-management activities; (3) use of fertilizers and other chemicals in intensive agriculture and forestry; and (4) decomposition and combustion of industrial, urban, and agricultural wastes.

Objectives--Primary objectives of this program are to: (1) establish a National Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and injurious substances in precipitation and dry particulate matter and (2) determine the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to total atmospheric deposition.

Approach--Sites in Kansas, located on the index map above, are equipped with identical collectors of wet and dry deposition, a recording rain gage, and specific-conductance and pH meters. Samples of precipitation are collected at each site on a weekly basis. During the first phase of network operations, analyses are made for specific conductance, pH, acidity or alkalinity, calcium, magnesium, potassium, sulfate, chloride, nitrate, ammonia, and phosphate. Later, certain additional analyses are added, including boron, bromide, cadmium, copper, fluoride, iodide, iron, lead, manganese, mercury, molybdenum, nickel, vanadium, and zinc. Pesticides and radioactive materials also are analyzed. To ensure that the data are of sufficient quality to provide maximum credibility for a wide variety of fundamental research and mission-oriented purposes, a Quality Assurance Committee oversees the operations.

Significant milestones--All network data were collected on schedule, and annual water year records were prepared and published during fiscal year 1992. During the 1993 water year, data were collected at two sites (see index map) as part of the

National Trends Network and National Atmospheric Deposition Program (NTN and NADP).

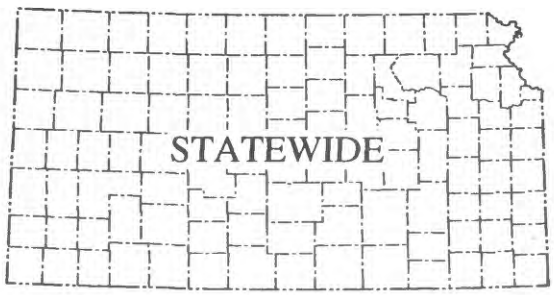
Plans for fiscal year 1994--During the 1994 fiscal year, data will continue to be obtained from these sites.

PROJECT TITLE:
Water use

PROJECT NUMBER:
KS-007

COOPERATING AGENCY:
Division of Water Resources,
Kansas State Board of Agriculture

PROJECT CHIEF:
N.C. Myers



Problem--Uses of Kansas water and competition among types of uses are increasing each year. State water-rights agencies need detailed information about water use to effectively manage the resource. As part of the National Water-Use Program in Kansas, a State-operated and maintained water-use and water-rights data base was developed. To facilitate the progress of the water-use program in Kansas and to ensure that the resulting State data base addresses the needs of the National Water-Use Program, it is important for the U.S. Geological Survey to participate in the State water-use program.

Objective--The primary objective of the project is to maintain an automated State water-use and water-rights data base. The data base serves the dual functions of a management tool for administering water rights within the State and of acting as a repository for water-use data to meet State and National needs.

Approach--The data base was developed by the Kansas Department of Administration, Division of Information Systems and Computing. Data capture, preparation, and input are handled by the Division of Water Resources, Kansas State Board of Agriculture. U.S. Geological Survey personnel work with the Division of Water Resources to provide for data exchange between the completed State data base and the National Water-Use Data System.

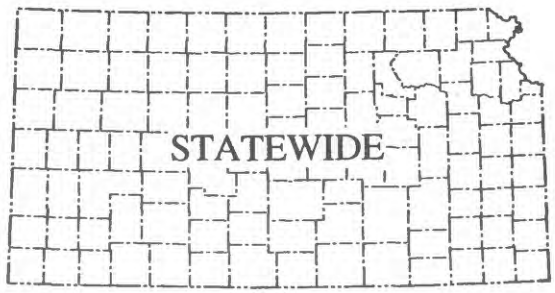
Significant milestones--Information on water withdrawals during 1990-92 was obtained from the Division of Water Resources and used to build the U.S. Geological Survey data base used for the Water Information Management and Analysis System (WIMAS) geographic-information-system (GIS) application. This approach to storing water-use data allows spatial analysis of information for management decisions and hydrologic studies. The GIS data base also facilitated compilation of data for the National report, "Estimated Use of Water in the United States in 1990." For that report, site-specific, water-use data from multiple sources were aggregated by county and hydrologic cataloging unit. A series of

observation wells were installed near the Manhattan, Kansas, well field.

Plans for fiscal year 1994--Continue cooperative work with the State in water-use data collection and evaluation.

Reports

Juracek, K.E., and Kenny, J.F., 1993, Management and analysis of water-use data using a geographic information system, *in* Harlin, J.M., and Lanfear, K.J., eds., Geographic information systems and water resources: Proceedings, American Water Resources Association, Mobile, Ala., p. 483-490, 627-628.



KS009

PROJECT TITLE:
Floods in the United States, 1990-93

PROJECT NUMBER:
KS-009

COOPERATING AGENCY:
Federal

PROJECT CHIEF:
P.R. Jordan

Problem--The American public needs a source of information from which they can learn the basic characteristics of the floods that occurred during 1990-93 in the United States.

Objective--Produce a report summarizing the significant floods that occurred in the United States during 1990-93.

Approach--Assemble the articles received from U.S. Geological Survey offices. Search available sources of information on other floods and encourage offices to prepare additional articles as may be needed. Review and edit all articles and make improvements as appropriate. Prepare introductory text, tables, and illustrations. Guide the report through the publication process.

Significant milestones--Reviewed articles and information and communicated with authors and U.S. Geological Survey offices.

Plans for fiscal year 1994--Complete the reviews, revisions, and editing; prepare report for Director's approval.

Flood release of 40,000 cubic feet per second from Tuttle Creek Lake, July 23, 1993.

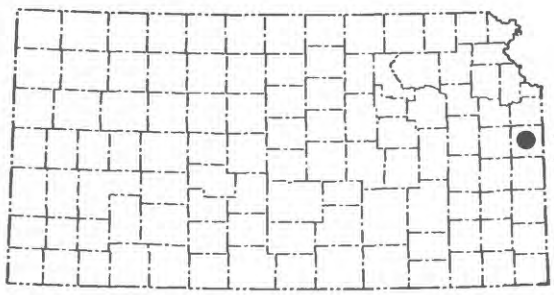
Channel erosion downstream from Tuttle Creek Dam caused by flood releases in July 1993.

(Photographs taken by Paul Maginness, Kansas State University, Manhattan)

HYDROLOGIC INVESTIGATIONS

Hydrologic investigations provide water-resources information that is valuable for a variety of uses by Federal, State, and local agencies, by the general public, and by universities and the consulting community. These investigations may include regional, State, county, and site-specific studies, as well as applied research. Some of the anticipated uses of the results of these investigations include: (1) general resources information and definition of hydrologic systems; (2) water supply (planning and development); (3) protection and conservation of resources; (4) pollution detection, control, abatement, and enforcement; (5) bridge, culvert, and highway design; (6) public safety (flood warnings and flood-plain delineation); (7) salinity control and abatement; (8) hazardous-waste disposal; (9) land management; and (10) fish and wildlife resources management. These investigations help to assess the State's water resources in terms of quantity, quality, and use of water, and to develop the knowledge and hydrologic understanding necessary to predict the consequences of alternative plans and policies for water development and use.

Automated weather station.



PROJECT TITLE:
Hillsdale Lake water-quality protection

PROJECT NUMBER:
KS-00101

COOPERATING AGENCY:
Hillsdale Lake Region Resource Conservation and Development Council (Hillsdale RC&D)

PROJECT CHIEF:
C.O. Geiger

Problem--Hillsdale Lake has significant nutrient concentrations in the lake water causing an accelerated rate of eutrophication. Atrazine and alachlor have been detected in the lake water at concentrations exceeding State health guidelines. Large nitrate and phosphorus concentrations have degraded the stream conditions.

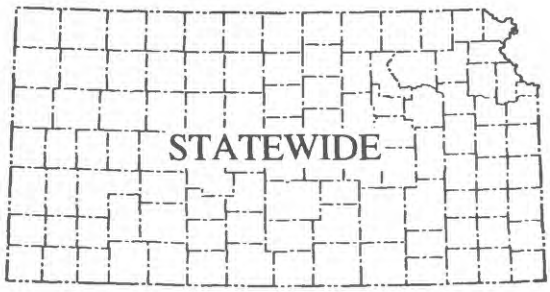
In response to the water-quality problems, the Kansas Department of Health and Environment has developed criteria for the phosphorus loadings from point and nonpoint sources. Study of the water quality and quantity of Hillsdale Lake was initiated through the U.S. Environmental Protection Agency, the Kansas Department of Health and Environment, the U.S. Army Corps of Engineers, the U.S. Agricultural Stabilization and Conservation Service, the Johnson County Department of Health, the U.S. Geological Survey (USGS), and the Hillsdale RC&D.

Objectives--The objectives of the overall study are to determine the sources of nutrients and pesticides to the lake, chemical loadings of constituents to the lake, and source reduction. The secondary objective for the study is to determine the stage/discharge relation at five sites in the watershed and determine the continuous discharge at three sites on the major tributaries to the lake, including Big Bull Creek, Little Bull Creek, and Rock Creek.

Approach--The stage/discharge relation at five sites in the watershed was determined using standard USGS stream-gaging techniques. Three of the five sites, located on the largest streams in the watershed, have continuous stage-recording equipment and automated samplers. The automated samplers are maintained by the Johnson County Health Department. The discharge data are used by the Hillsdale RC&D to compute constituent loadings to and from the lake.

Significant milestones--All equipment was installed and is operating.

Plans for fiscal year 1994--Continue operation of five data-collection sites.



KS010

PROJECT TITLE:
Flood hydrology and hydraulics for transportation applications

PROJECT NUMBER:
KS-010

COOPERATING AGENCY:
Kansas Department of Transportation

PROJECT CHIEF:
R.W. Clement

Problem--There is continuing need for adequately defined flood-frequency characteristics and evaluation of the scour potential for existing and future bridge sites on Kansas streams. Streamflow records, including records of annual peak discharges, have been collected on Kansas streams since 1895. The current peak-discharge gaging network includes continuous-record and partial-record (crest-stage gage) stations that are operated by the U.S. Geological Survey in cooperation with State and other Federal agencies. Included is a subnetwork of 30 crest-stage gaging stations operated in cooperation with the Kansas Department of Transportation. There is a significant lack of data concerning bridge-scour potential on streams in Kansas.

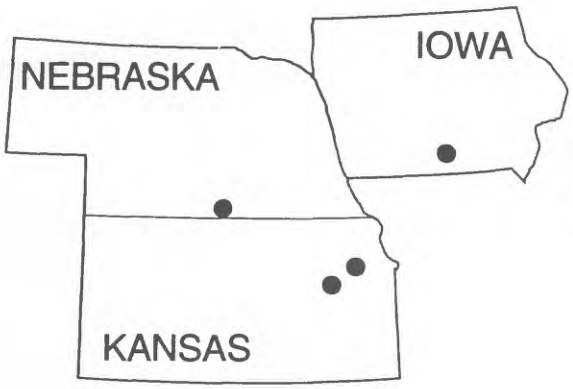
Objectives--The objectives of this program are to: (1) monitor flood-frequency characteristics on gaged streams in Kansas and (2) investigate and define the flow and scour characteristics at selected bridge sites.

Approach--Flood-frequency characteristics have been defined for gaged streams in Kansas. A network of 30 crest-stage-gaging stations is operated to collect peak-discharge data on small, unregulated streams. Data collected from the peak-flow-station network, including crest-stage and continuous-record streamflow-gaging stations, are used to define flood magnitude and frequency at specific streamflow-gaging stations. The depth of scour at selected bridge sites is measured and correlated with the flow characteristics of the site to define the effects of bridge geometry on the amount of scour.

Significant milestones--During fiscal year 1993, the analysis of magnitude and frequency of peak discharges at streamflow-gaging stations on Kansas' streams was completed. Planning and developing the bridge-scour study continued.

Plans for fiscal year 1994--During fiscal year 1994, the report on results of the analysis of magnitude and frequency of annual peak

discharges at streamflow-gaging stations in Kansas will be completed. A reconnaissance of bridge sites for study of scour at existing highway drainage structures is planned. Operation of partial-record gaging station network (crest-stage gages) on small watersheds will continue.



KS00303

PROJECT TITLE:
Water-quality appraisal of inflow, outflow, and impounded water of selected U.S. Army Corps of Engineers reservoirs in Iowa, Kansas, and Nebraska

PROJECT NUMBER:
KS-00303

COOPERATING AGENCY:
U.S. Army Corps of Engineers

PROJECT CHIEF:
A.C. Ziegler

Problem--Increased concentrations of herbicides, nutrients, dissolved solids, certain trace metals, and phytoplankton can degrade reservoir water quality. Increased concentrations of these constituents may affect and cause less diversity in macroinvertebrate populations at inflows to reservoirs. The U.S. Army Corps of Engineers, Kansas City District, manages Harlan County Reservoir, Nebraska, Clinton and Pomona Reservoirs, Kansas, and Rathbun Reservoir, Iowa. These four reservoirs are used for flood control, water supply, and recreational activities. Degradation of water quality in these reservoirs can (1) cause water to be unsuitable for irrigation, (2) pose potential public-health problems in processed drinking water, (3) inhibit growth, reproduction, and diversity of aquatic organisms, and (4) reduce recreational desirability of these reservoirs.

The need exists to continue to monitor the water quality of these reservoirs to define existing or potential water-quality problems. Results of this study will define water-quality impacts in the reservoirs and aid the Corps of Engineers in managing water resources in these reservoirs to the maximum benefit.

Objectives--This study will define existing or potential water-quality conditions during May through August 1993. Objectives of the study are to: (1) define temporal variations and stratification patterns of specific conductance, pH, water temperature, turbidity, dissolved oxygen, chemical oxygen demand, alkalinity, major ions, nutrients, selected metals, total organic carbon, selected herbicides, fecal coliform bacteria, and chlorophyll-*a*; (2) define downstream effects of impoundment on the major contributing stream by summarizing water-quality characteristics immediately upstream and downstream of the reservoirs; and (3) define macroinvertebrate diversity immediately upstream of the reservoirs in the major inflows.

Approach--Water-quality sampling will be conducted at the onset of stratification during the spring and at maximum stratification during the late summer. Data-collection sites will be established on the major inflow and outflow streams of each reservoir and at least three sites in each reservoir. Lake-sampling depths will vary depending on the lake depth, but all lakes will be sampled 0.3 ft below the lake surface and 3 ft above the lake bottom with a nonmetallic Kemmerer[1] sampler. In-situ constituents will be collected in the middle of the stream at mid-depth. Benthic macroinvertebrates will be sampled at the inflow stations only.

Analytical methods used will be either U.S. Environmental Protection Agency (USEPA) methods or those of the U.S. Geological Survey (USGS). Sample collection and preservation will be done according to methods used by the USGS. Alkalinity, bicarbonate, and carbonate concentrations will be determined at the time of sample collection. Fecal-coliform counts will be determined by membrane filtration and filtered within 6 hours of sample collection. Nutrient samples will be collected in 125-milliliter bottles, preserved with 0.5 milliliter of mercuric chloride (to eliminate biological activity), and chilled at 4 °C until analysis. A detailed description of any analytical and sampling procedure will be written. All data will be entered into the USGS WATSTORE data base, and that data will be transferred to the USEPA STORET data base. Data will be retrieved on a monthly basis.

Significant milestones--A progress report was submitted to the U.S. Army Corps of Engineers in June 1993. A final report presenting all data and procedures for the study was delivered to the U.S. Army Corps of Engineers in April 1994.

Plans for fiscal year 1994--U.S. Army Corps of Engineers will continue monitoring each location without assistance of USGS.

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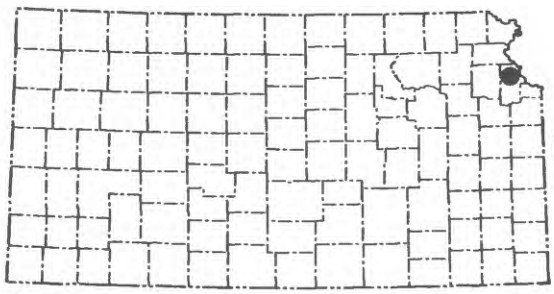
[1] The use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey



KS00304

PROJECT TITLE:
Determination of stormwater runoff quality at Fort Leavenworth, Kansas

PROJECT NUMBER:
KS-00304

COOPERATING AGENCY:
Fort Leavenworth

PROJECT CHIEF:
A.C. Ziegler

Problem--Municipal storm-sewer systems have been installed at Ft. Leavenworth to provide drainage for developed areas. Concentrations of many pollutants in discharges from municipal storm sewers are often small relative to many industrial and municipal wastewater discharges. However, in a widespread area supporting a large population, such as Ft. Leavenworth, the pollutant loads associated with discharges from the separate storm sewers can have significant effects on water quality. Of greatest concern are discharges from storm-sewer systems (1) with illicit connections of sanitary, commercial, or industrial discharges or (2) draining areas with construction-site runoff.

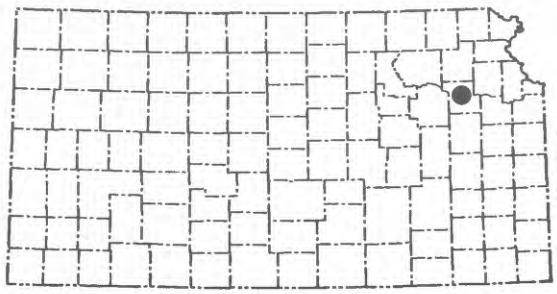
Objectives--The purposes of this investigation are to evaluate stormwater quality in selected storm sewers draining Ft. Leavenworth, Kansas, and to relate stormwater-quality characteristics to land use. The specific objectives of this study are to: (1) characterize the quantity and quality of discharge from storm-sewer outfalls during periods of dry weather, (2) characterize the quantity and the physical, chemical, and bacteriological quality of stormwater in streams and channels draining seven areas of specific land use at Ft. Leavenworth (the characterization will include estimation of annual and seasonal constituent loading from cumulative discharges, and of mean concentration of constituents in discharges from six representative storms), (3) determine if the previously developed equations for predicting constituent loads and mean concentrations in urban stormwater can be used to accurately predict loads and concentrations for urban watersheds in the Ft. Leavenworth area, (4) if the equations do not apply, refine the existing equations to provide more accurate estimation of the constituent loads from Ft. Leavenworth to the Missouri River and its tributaries, (5) compute estimates of annual and seasonal constituent loads and mean concentrations for each storm-sewer outfall identified by Ft. Leavenworth as required for Part II of the U.S. Environmental Protection Agency stormwater permit application, and (6) using the estimates computed for objective 5, identify potential or existing water-quality effects on receiving

waters, as required by Part II of the U.S. Environmental Protection Agency stormwater permit application.

Approach--The overall approach to this study will be done in two phases, similar to the U.S. Environmental Protection Agency's approach to permitting stormwater discharges. Phase 1 of the investigation includes a compilation of existing land-use and hydrologic data and dry-weather screening of all major storm-sewer outfalls. Phase 2 of the investigation includes collection and analysis of site data, verification of regression equations, calibration of regression equations, calibration of regression models for additional constituents, estimation of loads and concentrations for each outfall, and assessment of potential or existing water-quality effects on receiving water.

Significant milestones--Instrumentation was purchased.

Plans for fiscal year 1994--Instrumentation will be installed at three stream sites. Two storm occurrences at each of the three sites will be sampled. Stage-discharge relations will be developed at the three stream sites. Preliminary loads will be calculated.



PROJECT TITLE:
Appraisal of the effects of the City of Topeka on the water quality of receiving streams

PROJECT NUMBER:
KS-00306

COOPERATING AGENCY:
City of Topeka

PROJECT CHIEF:
A.C. Ziegler

Problem--Increased concentrations of dissolved solids, nutrients, trace metals, and pesticides can degrade the water quality of streams receiving discharge from cities. Degradation of water quality in the receiving streams can cause water to be unsuitable for irrigation; pose potential public health problems in processed drinking water; inhibit growth, reproduction, and diversity of aquatic organisms; and reduce recreational desirability of the streams. The U.S. Geological Survey will define water quality at selected sites on the Kansas River, Soldier Creek, and Shunganunga Creek as requested by the City of Topeka. Data will be collected for the City's NPDES (National Pollution Discharge Elimination System) permit application and will assist in evaluating the effects of urban discharges on the water quality of receiving streams.

Objective--The objective of this study is to define the water quality in the Kansas River, Soldier Creek, and Shunganunga Creek. The appraisal will be based on the results of analyses of water-quality samples from two sites on the Kansas River, one site on Soldier Creek, two sites on Shunganunga Creek, and one site on the South Branch of Shunganunga Creek. One stream gage will be installed at the downstream site on Shunganunga Creek to assist with the calculation of chemical loads to the Kansas River.

Approach--The objective of this study will be accomplished by defining the water quality and measuring discharge at the sites. Water-quality characteristics of the sites will be defined by sampling monthly at each site, except the Soldier Creek site, which will be sampled quarterly. One of the sampling times each year will be during a storm occurrence. Water samples will be collected by cross-sectional, depth-integrated sampling.

Significant milestones--Stream-gage equipment was purchased.

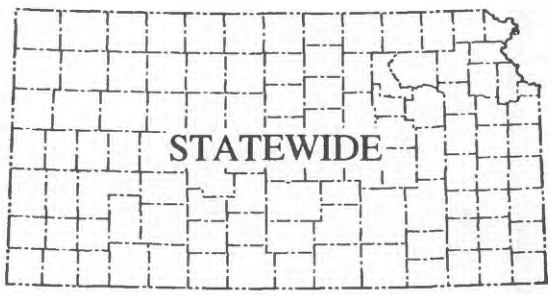
Plans for fiscal year 1994--One stream gage was installed. Samples will be collected 15 times from seven sites.

PROJECT TITLE:
Central Midwest regional aquifer-system analysis, Kansas

PROJECT NUMBER:
KS-111

COOPERATING AGENCY:
Federal

PROJECT CHIEF:
C.V. Hansen



KS111

Problem--The hydrology of the freshwater, brackish-water, and saline-water aquifer systems in rocks of Cambrian through Early Cretaceous age is not well defined. Because of the increased demand for water from the overlying High Plains aquifer in western Kansas, deeper aquifers are being looked upon as a potential source of additional water supply. In addition, increased pumpage in eastern Kansas has caused saline-water encroachment into deeper aquifers. Added to these problems are those resulting from injection of industrial wastes and oil-field brine into these rocks.

Objectives--The objectives of this study are to: (1) describe the hydrology of the freshwater, brackish-water, and saline-water aquifer systems in rocks of Cambrian through Early Cretaceous age; (2) create a regional data base for the rock systems and describe present and potential problems associated with current and future water use; and (3) evaluate the aquifer system's response to future stresses.

Approach--A search of the available literature was made to determine the extent of geologic interpretations and available data. Data were compiled to establish a data base of regional significance that included detailed lithologic descriptions for selected wells, water-quality information, hydraulic characteristics of the rock systems, and information on water use, waste disposal, and brine injection. Appropriate maps were prepared for steady-state digital-model construction to test the conceptual flow system and to define additional data needs to calibrate a digital model capable of simulating the flow system.

Significant milestones--Funds were received in fiscal year 1992 to complete preparation of reports covering the multi-state Central Midwest regional aquifer-system analysis area. Nine chapters of a U.S. Geological Survey Hydrologic Investigations Atlas and three chapters of a U.S. Geological Survey Professional Paper have been approved for release and three reports have been submitted for approval. Study is complete, and report preparation for publication continues.

Reports

Combs, L.J., Hansen, C.V., and Wolf, R.J., 1993, Geohydrologic systems in Kansas--Geohydrology of the lower aquifer unit in the Western Interior Plains aquifer system: U.S. Geological Survey Hydrologic Investigations Atlas HA-722-I, 3 sheets, scale 1:1,500,000.

Hansen, C.V., Underwood, E.J., Wolf, R.J., and Spinazola, J.M., 1992, Geohydrologic systems in Kansas--Physical framework of the upper aquifer unit in the Western Interior Plains aquifer system: U.S. Geological Survey Hydrologic Investigations Atlas HA-722-D, 2 sheets, scales 1:1,000,000 and 1:3,000,000.

Hansen, C.V., Wolf, R.J., and Spinazola, J.M., 1992, Geohydrologic systems in Kansas--Physical framework of the confining unit in the Western Interior Plains aquifer system: U.S. Geological Survey Hydrologic Investigations Atlas HA-722-E, 2 sheets, scales 1:1,000,000 and 1:3,000,000.

Helgesen, J.O., Leonard, R.B., and Wolf, R.J., 1993, Hydrology of the Great Plains aquifer system in Nebraska, Colorado, Kansas, and adjacent areas: U.S. Geological Survey Professional Paper 1414-E, 80 p., 10 plates.

Jorgensen, D.G., Helgesen, J.O., and Imes, J.L., 1993, Regional aquifers in Kansas, Nebraska, and parts of Arkansas, Colorado, Missouri, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming--Geohydrologic framework: U.S. Geological Survey Professional Paper 1414-B, 72 p.

Kenny, J.F., Hansen, C.V., and Wolf, R.J., 1993, Geohydrologic systems in Kansas--Geohydrology of the upper aquifer unit in the Western Interior Plains aquifer system: U.S. Geological Survey Hydrologic Investigations Atlas HA-722-H, 2 sheets, scale 1:500,000.

McGovern, H.E., and Wolf, R.J., 1993, Geohydrologic systems in Kansas--Geohydrology of the Great Plains aquifer system: U.S. Geological Survey Hydrologic Investigations Atlas HA-722-G, 2 sheets, scales 1:1,000,000, 1:2,000,000, and 1:3,000,000.

Spinazola, J.M., Wolf, R.J., and McGovern, H.E., 1992, Geohydrologic systems in Kansas--Physical framework of the Great Plains aquifer system: U.S. Geological Survey Hydrologic Investigations Atlas HA-722-B, scales 1:1,000,000 and 1:2,000,000, 2 sheets.

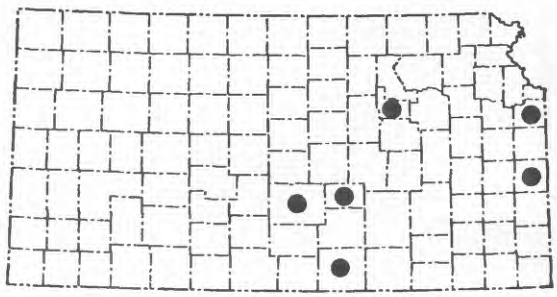
Wolf, R.J., McGovern, H.E., and Spinazola, J.M., 1992, Geohydrologic systems in Kansas--Physical framework of the Western Interior Plains confining system: U.S. Geological Survey Hydrologic Investigations Atlas HA-722-C, scales 1:1,000,000 and 1:3,000,000, 2 sheets.

PROJECT TITLE:
Geohydrologic evaluation of hazardous-waste sites in selected areas of Kansas

PROJECT NUMBER:
KS-138

COOPERATING AGENCY:
Multi-agency

PROJECT CHIEF:
A.C. Ziegler



KS138

Problem--Hazardous-waste sites can pose significant risks to public health and the quality of the environment. At least 201 potential hazardous-waste sites have been identified in Kansas [Kansas Department of Health and Environment (KDHE), written commun., 1983]. The State has performed an initial assessment of 81 sites. There is a need to document which of the remaining sites have contaminated ground and surface water in Kansas and identify those sites which warrant intensive geohydrologic investigation.

Objectives--(1) Compile site history, hydrogeologic, and chemical quality information to document possible ground- and surface-water contamination at approximately 30 selected hazardous-waste sites in Kansas. (2) Identify principal chemical contaminants that may be associated with specific types of hazardous-waste sites (private, county, municipal, industrial, and so forth) in specific regions of the State. (3) Determine principal geochemical and hydrogeologic factors that affect the mobility of major chemical contaminants from hazardous-waste sites in selected regions of the State.

Approach--Detailed information will be obtained for each site, including types of waste stored, mode of storage, time of storage, and geology. Surface geophysical methods will be used to detect possible contaminant plumes. Monitoring wells will be installed to obtain water samples, water levels, and geophysical logs. Water samples will be analyzed for major cations and anions, nitrate and ammonia nitrogen, trace metals, and total organic carbon. Gas chromatography/mass spectrometry (GC/MS) scans also will be made. Data analysis will include identification of principal contaminants associated with each waste-site category and identification of which combination of geochemical and hydrogeological factors control the major contaminants.

Significant milestones--Hazardous-waste site studies continued through respective phases (site investigations, report, ongoing monitoring). Two hazardous-waste site reports were sent for headquarters approval. Field work completed for three

county-wide compilations of hydrogeologic and chemical-quality information. A total of nine site investigations, four county-wide compilations, and seven reports are complete. Two sites have ongoing monitoring.

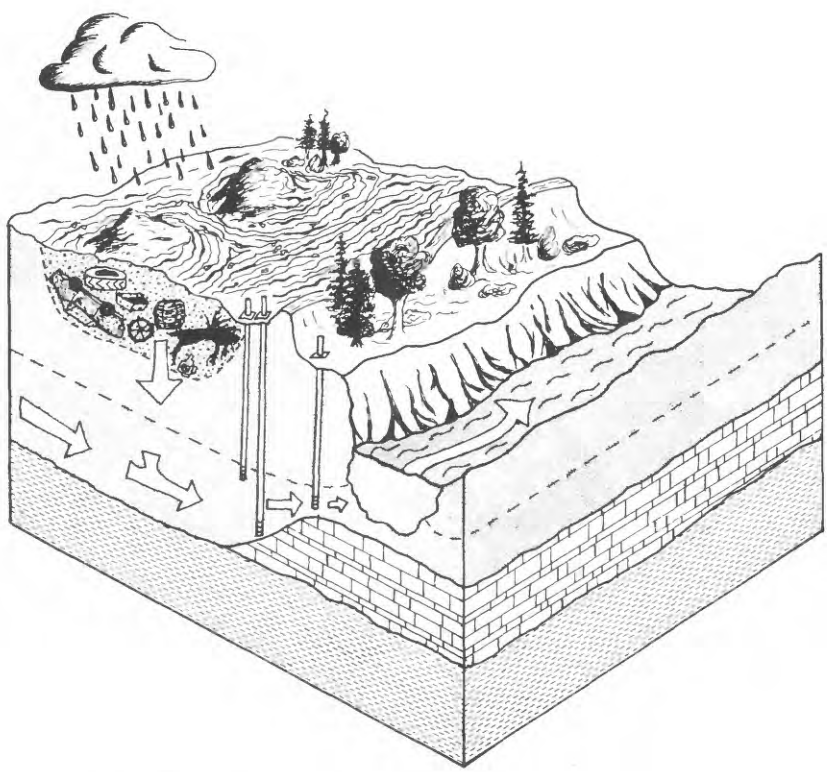
Plans for fiscal year 1994--Continue respective phases at all landfill sites.

Reports

Heck, B.A., Myers, N.C., and Hargadine, D.A., 1992, Hydrogeology and ground-water-quality conditions at the Reno County Landfill, south-central Kansas, 1990-91: U.S. Geological Survey Water-Resources Investigations Report 92-4169, 56 p.

Helgesen, J.O., Heck, B.A., and Hargadine, D.A., 1993, Hydrogeology and ground-water-quality conditions at the Harvey County Landfill, south-central Kansas, 1990: U.S. Geological Survey Water-Resources Investigations Report 93-4036, 44 p.

Myers, N.C., Heck, B.A., and Hargadine, D.A., 1993, Hydrogeology and ground-water-quality conditions at the Sumner County Landfill, south-central Kansas, 1989-90: U.S. Geological Survey Water-Resources Investigations Report 92-4177, 52 p.



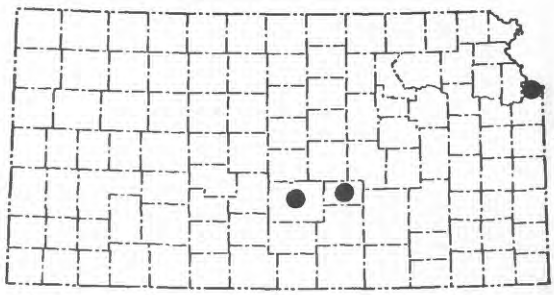
Hydrologic cycle.

PROJECT TITLE:
Local Environmental Planning Program (LEPP) of Harvey, Reno, and Wyandotte Counties

PROJECT NUMBER:
KS-13805

COOPERATING AGENCY:
Multi-agency

PROJECT CHIEF:
C.V. Hansen



Problem--Harvey, Reno, and Wyandotte Counties are participating in the LEPP, a program established by the Kansas Department of Health and Environmental (KDHE) to prevent and correct sources of contamination. Many areas in each county have agricultural and suburban land uses with water-supply wells in a shallow aquifer vulnerable to contaminants, particularly from septic systems and agricultural chemicals.

Objectives--The objectives of the study are to: (1) compile data to assist Harvey, Reno, and Wyandotte Counties in the identification of common problems associated with private drinking-water supplies, and the subsequent development of program objectives and workplans for the correction or prevention of these problems; and (2) identify the location of industrial, irrigation, and public-supply wells to facilitate the development of program objectives and workplans to protect ground-water quality in each county.

To achieve these objectives, data bases will be created for Harvey, Reno, and Wyandotte Counties. These data bases will include information on location and use of water and, if available, information about ownership, construction, permit number, and existence of water-quality analyses or water-level measurements.

Approach--U.S. Geological Survey (USGS) activities consists of the following: (1) compile readily available information about existing wells in Harvey, Reno, and Wyandotte Counties; (2) collected well information will be entered into each county's data base; (3) selected well-drilling contractors will be contacted and, if permission granted, their files will be searched for information about private wells (this information will be used to facilitate the well inventory and data verification in rural parts of each county); (4) inventory selected privately owned wells in the rural parts of each county; (5) enter information collected from well-drilling contractors and private wells into each county's data base; (6) develop a geographic-information system using information from each county's data base; (7) prepare a map showing the locations of wells, types of information available, use of water, water levels,

and water-quality information; and (8) prepare plans for a complete ground-water-quality assessment for each county based on an evaluation of available data. The assessment plans would include sampling network of wells and plans for data analysis to describe current water quality and define problem areas in each county.

Significant milestones--Project complete. Three reports have been published.

Reports

Hansen, C.V., 1993a, Description of geographic-information-system files containing water-resource-related data compiled and collected for Wyandotte County, northeastern Kansas: U.S. Geological Survey Open-File Report 93-92, 46 p.

__1993b, Description of water-resource-related data compiled for Harvey County, south-central Kansas: U.S. Geological Survey Open-File Report 93-116, 29 p.

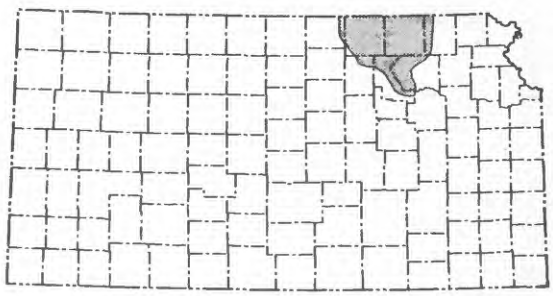
__1993c, Description of water-resource-related data compiled for Reno County, south-central Kansas: U.S. Geological Survey Open-File Report 93-99, 27 p.

PROJECT TITLE:
Occurrence of agricultural pesticides in the Tuttle Creek Lake-stream system, Kansas

PROJECT NUMBER:
KS-150

COOPERATING AGENCY:
Kansas Department of Health and Environment

PROJECT CHIEF:
H.E. Bevans



KS150

Problem--Pesticides have been detected in Kansas lakes and streams that are current or future sources of public-water supplies. Atrazine, the most extensively used agricultural pesticide in Kansas, has been reported to occur in concentrations as large as 27 micrograms per liter in Tuttle Creek Lake. Although the long-term effects of atrazine and other pesticides on human health have not been fully determined, these pesticides pose a potential threat to the quality of water in lakes that provide public-water supplies. Additionally, the presence of pesticides in lake water may affect phytoplankton productivity.

Objective--This investigation of the occurrence of agricultural pesticides in the Tuttle Creek Lake-stream system is directed towards: (1) documenting the occurrence of pesticides in the lake-stream system, (2) describing the transport of pesticides through the lake-stream system, and (3) determining the effects of atrazine on photosynthesis and carbon uptake of lake phytoplankton.

Approach--Samples of water-sediment mixture were collected during a 1-year period from Tuttle Creek Lake, lake tributaries, and the lake outflow. Concentrations of total pesticides, total organic carbon, and suspended sediment were determined for all samples. Dissolved concentrations of pesticides and organic carbon also were determined for the Big Blue River, the principal lake tributary. Experiments were conducted using Tuttle Creek Lake samples and samples from a control lake, where pesticides were not detected, to determine the effects of atrazine on lake phytoplankton. Interpretations of these data were used to meet study objectives.

Significant milestones--The study is complete, and the report has been published.

Reports

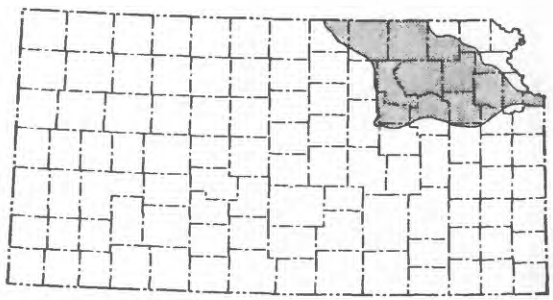
Bevans, H.E., Fromm, C.H., and Watkins, S.A., 1993, The occurrence and transport of agricultural pesticides in the Tuttle Creek Lake-stream system, Kansas and Nebraska: U.S. Geological Survey Open-File Report 93-87 (pending publication as a Water-Supply Paper), 44 p.

PROJECT TITLE:
National Water-Quality Assessment of the lower Kansas River Basin, Kansas and Nebraska

PROJECT NUMBER:
KS-152

COOPERATING AGENCY:
Federal

PROJECT CHIEF:
J.K. Stamer



KS152

Problem--Protecting and increasing the supply of good quality water in the United States is a national priority. The Nation's Midwest is a very productive agricultural grain belt. The lower Kansas River Basin drainage is typical of this midwestern agricultural region that includes irrigated and nonirrigated land. The basin also is representative of water use, namely, for irrigation, municipal, and industrial purposes. An assessment of the water quality and quantity of the lower Kansas River Basin, which includes the Big Blue River Basin in Nebraska and Kansas, is important.

Objectives--(1) To define the existing water quality of the lower Kansas River Basin, its major tributaries, and selected reservoirs. (2) To determine trends in water quality of the lower Kansas River Basin, its major tributaries, and selected reservoirs. (3) To define cause- and effect-relations for a selected subbasin or river reach. (4) To identify water-quality problems or potential problems.

Approach--The approach will be divided into three elements: (1) Fixed-station studies to assess average annual constituent transport and water-quality trends; (2) synoptic studies to determine the quantity and quality of ground-water and irrigation-return flows, to determine trace organic residues in the streambed sediments during low flow, and to calculate constituent transport at the fixed stations during high flow; and (3) intensive subbasin or river-reach studies to define cause-effect relations, pending time and resource constraints.

Significant milestones--Study is complete. Three reports were published during 1992-93. Additional reports are pending Director's approval.

Reports

Fallon, J.D., and McChesney, J.A., 1993, Surface-water-quality assessment of the lower Kansas River Basin, Kansas and Nebraska--Project data, November 1986 through April 1990: U.S. Geological Survey Open-File Report 93-51, 594 p.

Stamer, J.K., 1992, Distribution of atrazine in surface water, lower Kansas River Basin, Kansas and Nebraska: Proceedings of North Central Weed Science Society, v. 47, p. 148.

Stamer, J.K., and Zelt, R.B., 1992, Distribution of atrazine and similar nitrogen-containing herbicides, lower Kansas River Basin: U.S. Geological Survey Director's Yearbook 1991, p. 76-79.

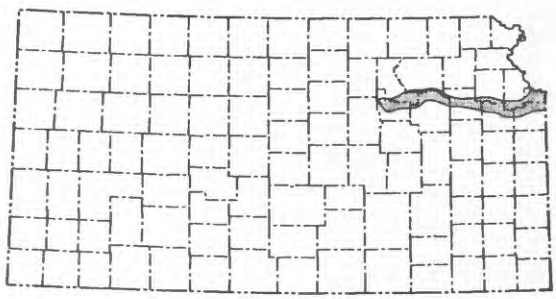
Major streams, surface-water impoundments, cities, and other geographic features in and near lower Kansas River basin, Kansas and Nebraska.

PROJECT TITLE:
Ground-water and surface-water relationships in the Kansas River alluvium

PROJECT NUMBER:
KS-153

COOPERATING AGENCY:
U.S. Bureau of Reclamation

PROJECT CHIEF:
R.J. Wolf



KS153

Problem--The State of Kansas is developing a water-management plan for the Kansas River as part of the purchase of storage in Federal reservoirs. The effect of pumpage from the alluvium on releases from the reservoir in time of drought needs to be determined. The area studied is the valley alluvium along the main stem of the Kansas River.

Objectives--(1) Provide information needed to anticipate the effects of pumpage on reservoir releases, (2) determine the effects of pumping on streamflows during low-flow periods, and (3) determine transit losses and traveltimes of reservoir releases.

Approach--Documentation of ground-water levels and streamflows will be used to determine the interaction between the river and alluvial aquifer. Various analytical and digital-modeling techniques will be used to quantify the effects of pumpage on the river during low-flow periods. Synoptic studies of stream discharge along the river are planned to determine the transit losses and travel times during reservoir releases at low flow.

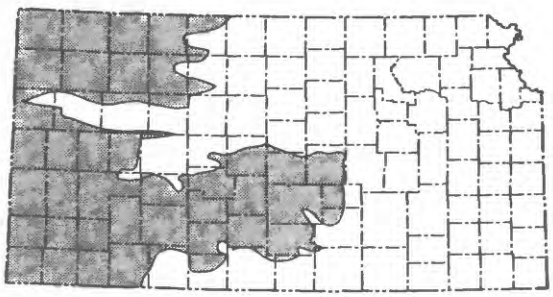
Significant milestones--Study is complete, and report has been published.

Reports

Wolf, R.J., and Helgesen, J.O., 1993, Ground- and surface-water interaction between the Kansas River and associated alluvial aquifer, northeastern Kansas: U.S. Geological Survey Water-Resources Investigations Report 92-4137, 49 p.

PROJECT TITLE:
High-Plains monitoring, Kansas

PROJECT NUMBER:
KS-160



KS160

COOPERATING AGENCY:
City of Wichita, Kansas Geological Survey, and Kansas State Board of Agriculture

PROJECT CHIEF:
J.B. Gillespie

Problem--In response to concern about ground-water-level declines in the High Plains aquifer system, Congress has directed the U.S. Geological Survey (USGS) to expand its capability of monitoring ground-water levels in the aquifer and to make the information available in annual reports.

Objectives--To develop the capability of more adequately monitoring water levels in the High Plains aquifer system in Kansas and to provide the regional staff with water-level data and other information necessary for their preparation of the Congressionally mandated annual report about ground-water conditions in the High Plains aquifer system.

Approach--(1) Review data from U.S. Geological Survey and local agency observation-well networks to determine if data obtained is adequate for defining areal and temporal water-level changes. (2) Work with local agencies to expand the U.S. Geological Survey's capability of monitoring water-level changes in the High Plains aquifer system. (3) Evaluate, analyze, and interpret water-level data so that the information can be readily available to the public.

Significant milestones--Water-level data were collected from approximately 1,560 observation wells that are in the statewide network. Water-level data were received from Groundwater Management Districts 2 and 5. Computer tapes were received from Kansas State Board of Agriculture, Division of Water Resources for 1992 water use.

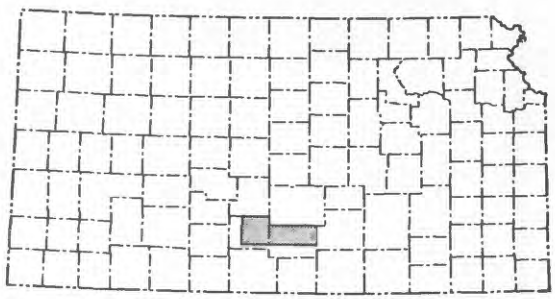
Plans for fiscal year 1994--Water-level data will be measured and collected during fiscal year 1994. Water-level data for 1993 will be compiled from the Kansas State Board of Agriculture, Division of Water Resources.

PROJECT TITLE: Saline ground-water discharge to the South Fork Ninnescah River in Pratt and Kingman Counties, south-central Kansas

PROJECT NUMBER: KS-162

COOPERATING AGENCY: City of Wichita, Sedgwick County, and Kansas Water Office

PROJECT CHIEF: J.B. Gillespie



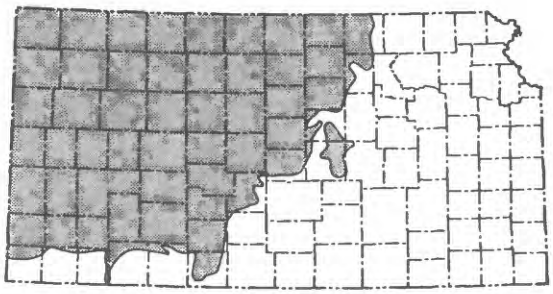
KS162

Problem--The Wichita metropolitan area has some concern about future water supplies. One potential source of supply is the South Fork Ninnescah River. However, between Pratt and Kingman Counties, saline ground water is discharged to the river. The chloride concentrations downstream in the river are greater than 250 mg/L (milligrams per liter) 70 percent of the time and commonly exceed 50 mg/L. The source of saltwater is the rocks of Permian age that underlie about 50-250 ft of the alluvium in the area.

Objectives--(1) Determine the location and extent of saline ground-water discharge to the river, (2) identify the source and approximate flow rates of the saline water, (3) define the characteristics of movement and mixing of the freshwater and saltwater, and (4) provide a comparative evaluation of selected measures that might be taken to abate the salinity problem.

Approach--Conduct literature and data-base searches. Low flows will be measured and water-quality samples collected to determine the reach in which saline ground water is discharging to the river. Existing wells will be used, and additional wells will be drilled in the area of saline ground-water discharge. Aquifer tests will be conducted to determine aquifer properties, and ground-water samples will be analyzed to determine the distribution and location of the saltwater. Water-quality modeling or analytical techniques will be used to estimate saline-water discharge and effects of various pumping alternatives that could potentially intercept saline water before it enters the river.

Significant milestones--Study complete. Report is approved and being prepared for publication.



KS164

PROJECT TITLE:
Water-resources potential of the Dakota aquifer in Kansas

PROJECT NUMBER:
KS-164

COOPERATING AGENCY:
Kansas Geological Survey

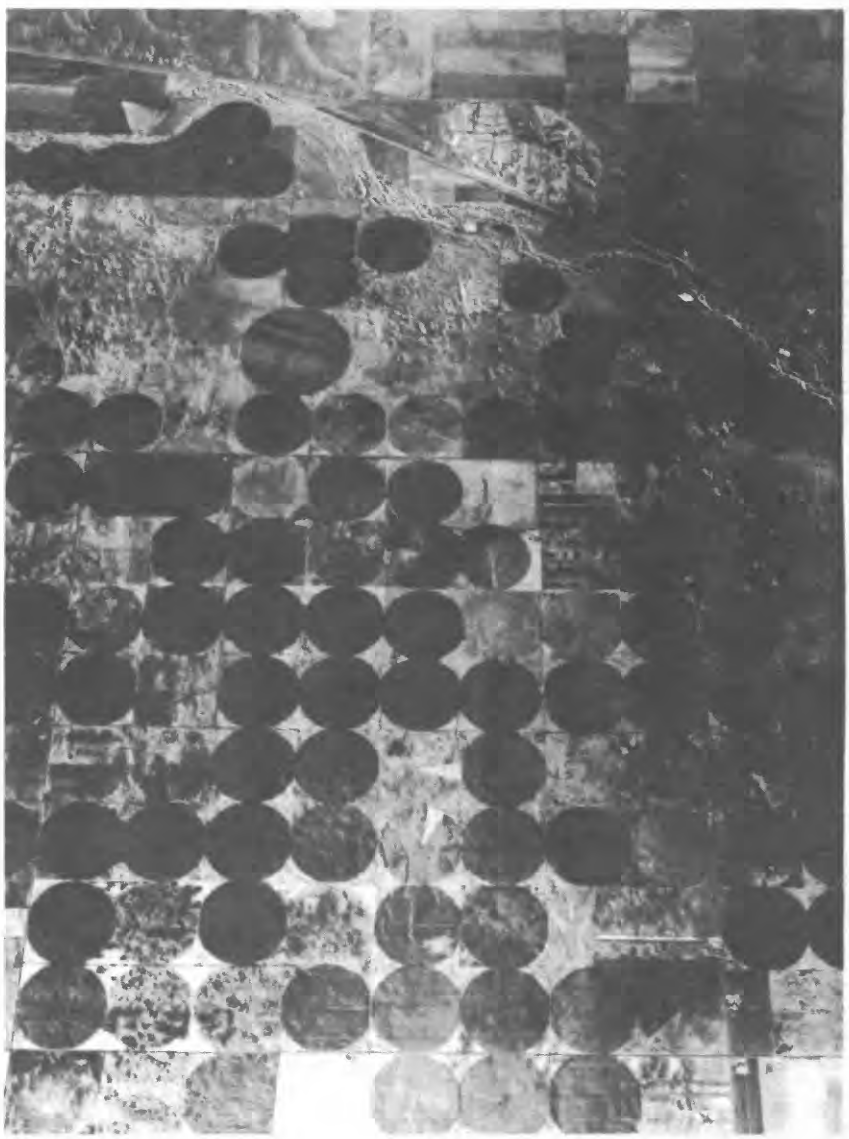
PROJECT CHIEF:
R.J. Wolf

Problem--The Dakota aquifer is the second most extensive aquifer in Kansas after the High Plains aquifer. In the near future, severe depletion of the High Plains aquifer due to overdevelopment may cause a critical water shortage in parts of western Kansas. The Dakota aquifer will be the next available source of water for this region and is already providing water for parts of southwestern and central Kansas. At present, insufficient information concerning the quantity and quality of Dakota water limits the ability of State water planners to evaluate this aquifer as a future major source of water. Water managers and planners need a dependable, sound technical basis for future water-management and planning efforts.

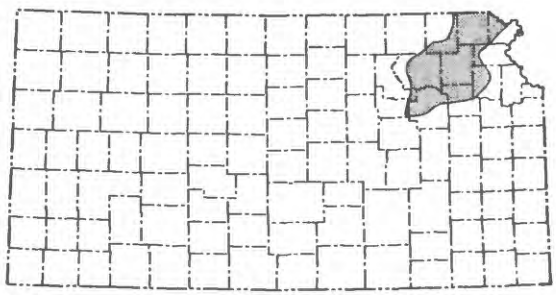
Objective--This study was developed to assemble and summarize all current information pertaining to the Dakota aquifer in Kansas. Collective analysis of all information will provide preliminary interpretations and a planning base for long-term investigation of the Dakota aquifer, which is an important need as identified by all agencies that are responsible for Kansas' water resources.

Approach--All data will be assembled and compiled into consistent formats in a data-base management system with geographic information system (GIS) capabilities. Sources of data will include the U.S. Geological Survey's (USGS) Regional Aquifer System Analysis (RASA) data base and files; State-agency data; and public and private petroleum-data sources. Synthesis of all data and previous interpretive information will provide descriptions (using maps, sections, tabulations, statistical analyses) of current statewide knowledge of the aquifer. Application of a GIS will provide coverages for the geometry, depth, and hydraulic properties of the aquifer. This will facilitate development of "baseline" interpretations of the system and will help identify needs to guide future work. Data are expected to be sufficient in southwestern Kansas to enable formulation of a preliminary three-dimensional flow model of that part of the system.

Significant milestones--Southeast Colorado water levels were measured during the winter 1992. Twenty radioisotope samples collected by the Kansas Geological Survey were sent for analysis. Drilling of Stanton County aquifer-test site wells was completed. Documented formulation of conceptual model, prepared necessary data, and used ARC/INFO as a preprocessor to begin steady-state model of the Dakota system in southwest Kansas, including area in southeast Colorado. Ten to fifteen radioscope samples collected by the Kansas Geological Survey will be sent to the National Water-Quality Laboratory in Denver, Colorado, for analysis. U.S. Geological Survey participation in the study has been completed. Several interim progress reports are available from the Kansas Geological Survey in Lawrence.



Center-pivot irrigation systems, southeast of Garden City (Photograph courtesy of the Kansas Applied Remote Sensing Program, Lawrence, Kansas).



KS167

PROJECT TITLE:
Water-resource interests of the Kickapoo, Potawatomi, Iowa, and Sac and Fox Indian Tribes in Kansas

PROJECT NUMBER:
KS-167

COOPERATING AGENCY:
Multi-Agency

PROJECT CHIEF:
T.J. Trombley

Problem--Water-related data for the Kickapoo, Potawatomi, Iowa, and Sac and Fox Indian Tribes in Kansas are needed for water-rights management. A hydrologic evaluation of these lands would include descriptions of surface- and ground-water resources at the time the reservations were established; summaries of existing data or quantity, quality, and the use of the water; and collection of additional data as needed to supplement existing data. This information will be useful to the Tribal Councils, the U.S. Bureau of Indian Affairs, and other Federal and State agencies involved in water-jurisdiction issues.

Objectives--(1) To compile and evaluate existing information on the extent of water resources of tribal areas in Kansas. (2) To acquire additional data as needed to describe the predevelopment water resources in these areas and to define current water uses and availability.

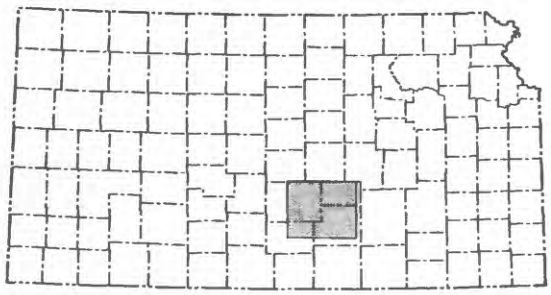
Approach--Available water data in the tribal areas will be compiled. Current and historical data on streamflows, well measurements, and water quality will be evaluated for consistency of coverage and data needs. Additional data will be collected by Kansas District personnel to supplement data on surface water, ground water, water quality, and water use.

Significant milestones--The data report is approved. Surface-water analyses are completed. Bedrock-elevation data from the Kansas Geological Survey have been partially entered into ARC/INFO.

Plans for fiscal year 1994--Staff will be working with Haskell Indian Nations University to enter results of a tree-stand assessment into ARC/INFO, finish putting bedrock-elevation data into ARC/INFO, and complete the evaluation of surface- and ground-water resources in the study area.

Reports

Trombley, T.J., and Kenny, J.F., 1992, Water resources on and near Indian lands in northeastern Kansas and southeastern Nebraska--Study description: U.S. Geological Survey Open-File Report 91-468, 19 p.



KS169

PROJECT TITLE:
Influence of the Arkansas River on the *Equus* Beds aquifer adjacent to the Arkansas River between Hutchinson and Wichita in south-central Kansas

PROJECT NUMBER:
KS-169

COOPERATING AGENCY:
Kansas Water Office

PROJECT CHIEF:
Nathan C. Myers

Problem--There is potential for the poor water quality of the Arkansas River to contaminate the water in adjacent alluvial aquifers. In the Arkansas River water near Hutchinson, dissolved-solids and chloride concentrations ranged from 447 to 1,810 mg/L (milligrams per liter) and 360 to 900 mg/L, respectively. Ground-water withdrawals from the *Equus* Beds supply water to private, municipal, and industrial users. The effects of these withdrawals, which are increasing yearly, on the river's flow is currently unknown; however, it is known that water quality in the *Equus* Beds aquifer is deteriorating in certain locations. Mineralized water from the Arkansas River, or from natural salt deposits, or from oil-field activity could be the cause of deterioration.

Objectives--(1) Define the flow system between the Arkansas River and the aquifer in the reach from Hutchinson to Wichita. (2) Determine the water-quality profile between the Arkansas River and the aquifer in the reach from Hutchinson to Wichita.

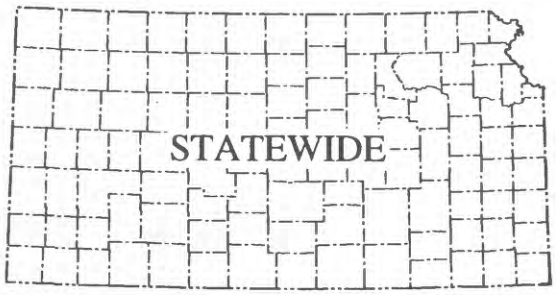
Approach--(1) Review literature on chemical analysis and flow models. (2) Collect and analyze streamflow, river-water quality, water-level, ground-water quality, transmissivity, and pumpage data. (3) Apply flow model and particle-tracking model to evaluate the lateral- and vertical-flow system and to define the extent of Arkansas River chloride in the aquifer. (4) If the modeling proves successful, the model could be used to project the effects of system stresses on ground-water quality.

Significant milestones--Study is complete.

Plans for fiscal year 1994--Report will be sent for Director's approval in fiscal year 1994.

Reports

Myers, N.C., 1993, Chloride distribution in the alluvial aquifer adjacent to the Arkansas River between Hutchinson and Wichita, south-central Kansas, *in* Abstracts of Papers Presented at 124th Annual Meeting, Hutchinson, Kans., March 26-27, 1992: Kansas Academy of Science, v. 11, p. 33.



KS172

PROJECT TITLE:
Administrative Information System (AIS) software development and implementation

PROJECT NUMBER:
KS-172

COOPERATING AGENCY:
Federal

PROJECT CHIEF:
S.J. Brady

Problem--The PRIME minicomputers, on which reside the U.S. Geological Survey, Water Resources Division's administrative systems, such as AFIMS, CDP, and MIS, are to be phased out between 1991 and 1993. Administrative systems will have to be moved to the new platform, which consists of a widely distributed network of Data General Aviion Unix workstations. The proprietary software, INFO, used by the administrative systems will not be available on the new workstations. The relational data-base management system INGRES will be available on the Aviion.

Over the last several years, automated systems have been developed in the U.S. Geological Survey (USGS) to assist Water Resources Division (WRD) personnel in accomplishing their mission. Included among these division and bureau systems are the Administrative Financial Management System (AFIMS), Career Documentation Profile (CDP), Management Information System (MIS), Payroll and Personnel System (PAY/PERS), and the recently implemented Federal Financial System (FFS). There are useful data and features within each of these systems. However, the evolution of these basically autonomous systems has created a situation of duplicate data entry, disjointedness, and in some cases, cumbersome operation. The need exists to integrate and enhance these systems in order to meet the increasing requirements for useful and timely administrative information for USGS personnel at all levels.

Objective--The goal of the AIS effort is to develop and implement a highly flexible administrative information data-management and processing system, one that can be easily changed and expanded in a rapidly changing technological and political environment. The AIS, when completed, will replace the current Administrative Financial Management System, the CDP, the MIS, the district Report Tracking System (RTS), and the WRD Memorandum System, which reside on a distributed network of PRiME minicomputers. The new system will be distributed across a national network of 32-bit microprocessors utilizing local-area network (LAN) and wide-area network (WAN) technology. The AIS

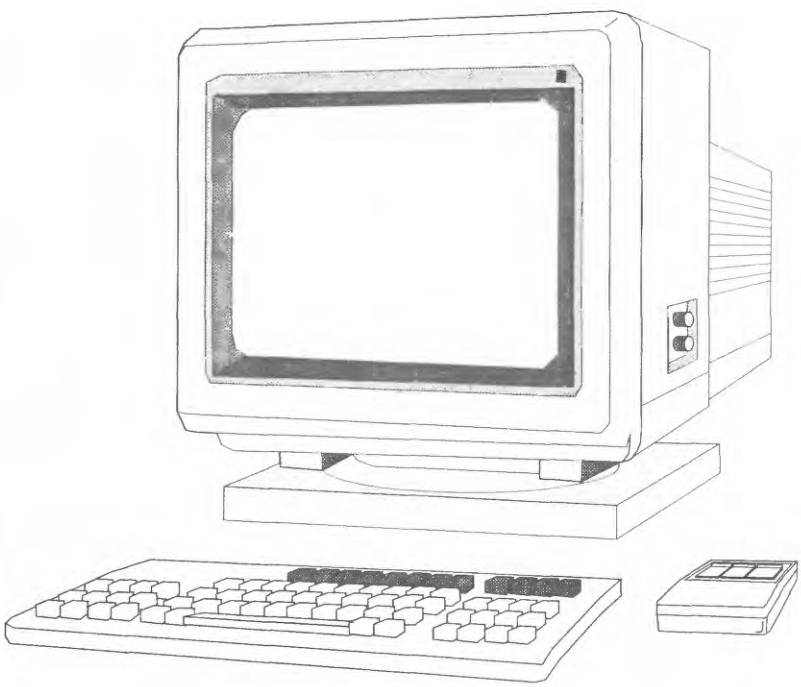
also will interface with other systems within the WRD, such as the NWIS-II, with systems maintained by other USGS divisions such as the Federal Financial System, the Personnel Action System (PAS), and the Property/Vehicle System, with any other Bureau administrative system that may be identified by the User Work Groups, and other Federal Agency (OFA) systems such as the Bureau of Reclamation (BOR) PAY/PERS system.

Approach--On February 28, 1990, members of the Assistant Chief Hydrologist for Operations (ACH/O) staff met to discuss the migration of Water Resources Division (WRD) administrative systems to the DIS-II environment. The items addressed at this meeting were (1) the Branch of Administrative Management Systems (BAMS) Strategic Information Systems Planning for FY90 through FY94, (2) the formation of a "strike team," later renamed "Planning Team" who would take the BAMS Strategic Plan and ensure that all administrative areas of concern to the Division were properly addressed, (3) the formation of a Steering Committee for Administrative issues, (4) the impact of the National Water Information Systems II (NWIS-II) on administrative functions and the need to coordinate all development efforts with NWIS-II to ensure proper integration of the scientific and business data bases, (5) the importance of having the Strategic Planning Group (SPG) look at the Division's overall information needs and not just those of NWIS-II, (6) the need for a Program Manager, and (7) the creation of administrative User Work Groups with the charge of describing their administrative requirements. These requirements form the basis of the design and development of the new Administrative Information System (AIS).

Significant milestones--In fiscal year 1992, a complete FUNDING module was ready for beta testing by April 1992. The FUNDING prototype was presented at the National Computer Technical Meeting in Norfolk, Virginia, in May 1992. The first release of the AIS was ready for beta testing in June-July 1992. The first release was to include all functionality identified as "High" by the User Work Groups in the System Requirements Specification document. The first release of the AIS was ready December 1992 and included most of the Financial Management functionality.

In fiscal year 1993, the first AIS release was announced December 31, 1992. The first release included the Financial Management aspects of AIS. The system provided functionality to be able to handle the Division's funding and expenditure day-to-day activities. Parts of the Project Management module were released that were required for accounting purposes. Additional functionality was added throughout the fiscal year for labor cost, automatic reconciliation, and MIS updates. The Close-Out module was prepared and released in September 1993.

Plans for fiscal year 1994--In fiscal year 1994, plans include testing and releasing to WRD the Budged part of AIS. Testing was done in November 1993 at the National Water-Quality Laboratory in Denver, Colorado. Participating in the testing were members of the Financial Management User Work Group on budgeting and the AIS Development Team. Early in fiscal year 1994, development of the Project Management Module will begin. Testing will begin in May, and release to WRD is expected in June.

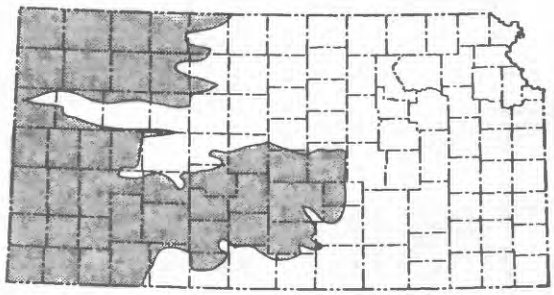


PROJECT TITLE:
Application of GIS for information retrieval and technical evaluation of agricultural water use and availability in the Kansas High Plains

PROJECT NUMBER:
KS-175

COOPERATING AGENCY:
Kansas State Board of Agriculture, Division of Water Resources

PROJECT CHIEF:
Kyle Juracek



KS175

Problem--To develop the framework for and selected components of a geographic-information-based (GIS) system that addresses water use and availability for irrigated agriculture in the Kansas High Plains. Such a system is needed to provide decision support for water-allocation planning within the State.

Objectives--(1) Create GIS data sets from existing data bases; (2) enhance or modify existing data bases to meet analytical requirements; (3) develop or utilize existing interfaces between GIS data sets and computational and display software; and (4) develop or utilize existing computational, graphical, and spatial analytical software to perform various analyses concerning the use and availability of water for irrigated agriculture in the Kansas High Plains.

Approach--Existing software and available data bases will be utilized where appropriate. Customized analysis and display capabilities will be developed. Emphasis will be given to the development of the system framework and selected analytical capabilities. In selected areas, enhancements or additions will be made to some data sets to provide for more complete analysis.

Significant milestones--New capabilities include the ability to query available water-appropriations and water-use information in Kansas by source of water, type of use, and user-defined area (Ford County, fig. 11), basin, user-defined polygon, user-defined circle, and point of diversion. Two reports are in headquarters review.

Plans for fiscal year 1994--Immediate plans include completion of reports and seeking additional funding for continuation of the project.

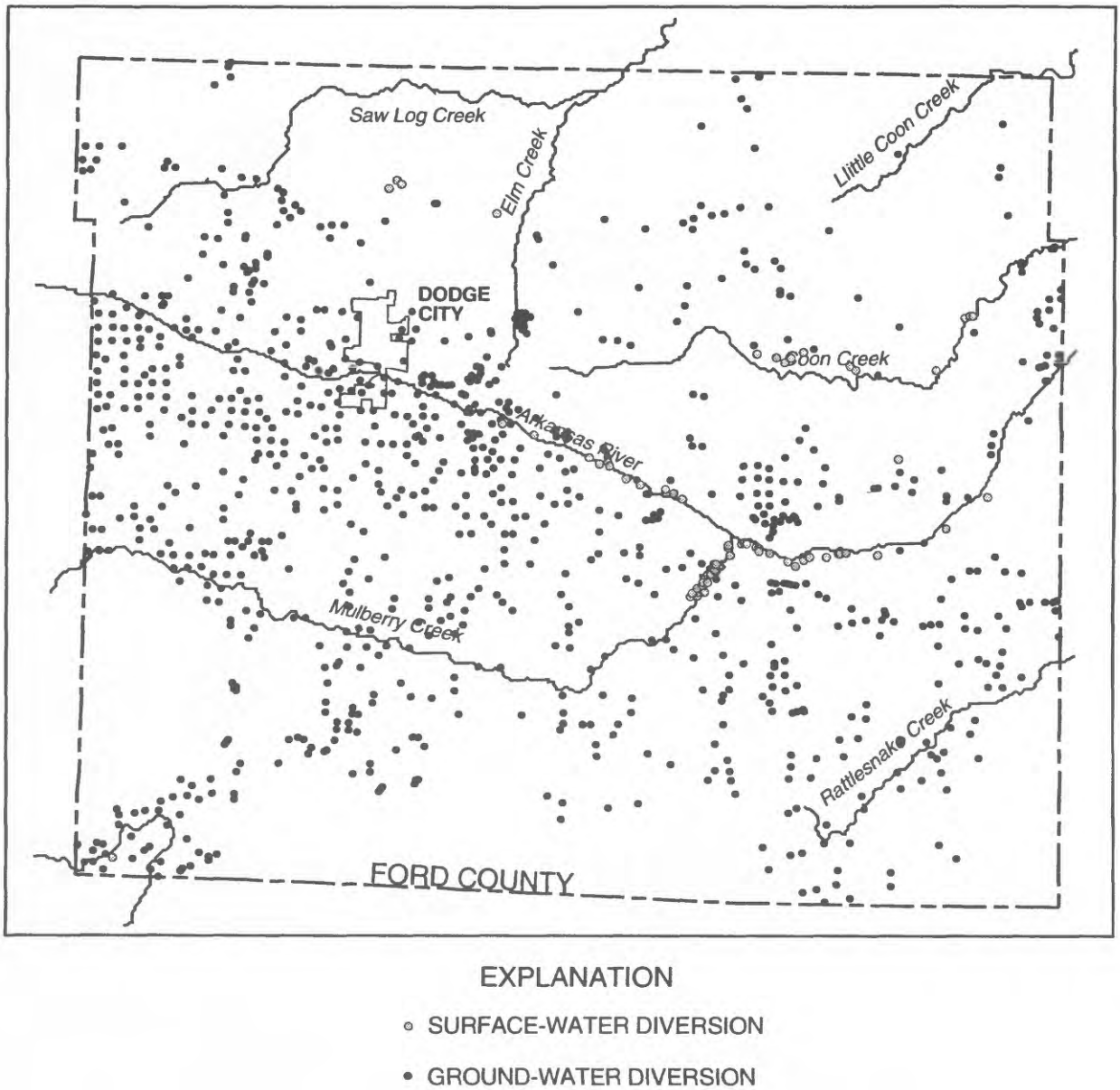


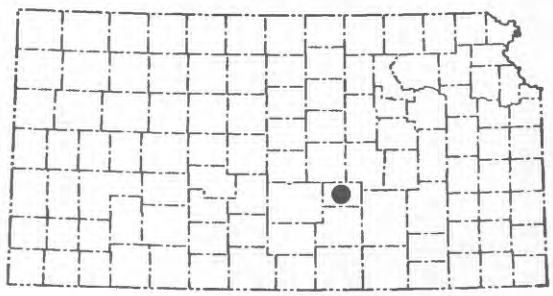
Figure 11. Example of results of a county query for water-diversion information for Ford County, Kansas.

PROJECT TITLE:
Nitrates and triazine herbicides in the unsaturated zone: An investigation of the potential vulnerability of the *Equus* Beds aquifer in Harvey County, Kansas

PROJECT NUMBER:
KS-176

COOPERATING AGENCY:
Harvey County Conservation District

PROJECT CHIEF:
Kyle Juracek



KS176

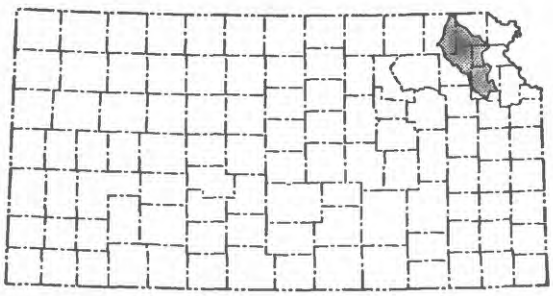
Problem--To determine the potential vulnerability of the *Equus* Beds aquifer to contamination by nitrates and triazine herbicides throughout western Harvey County, Kansas.

Objectives--(1) To measure the concentrations of triazine herbicides in the unsaturated zone at sites where triazine herbicides are used in corn and grain sorghum production; (2) determine the relations among detections of triazine herbicides in the unsaturated zone and various cultural and natural factors, including rate of chemical application, method of chemical application, and the amount of water applied to the land surface (by precipitation and irrigation); (3) develop a tool for estimating the potential for contamination of the unsaturated zone in specific areas due to combinations of cultural and natural factors; and (4) provide knowledge that will assist farmers in selecting management practices that will reduce the potential for contamination of the unsaturated zone by triazine herbicides.

Approach--Within the study area, 60 sites (30 dryland and 30 irrigated) will be established. Soil cores will be collected at each site and analyzed for triazine herbicides. Precipitation data will be collected via a 30-gage network distributed across the study area. Information on irrigation and triazine herbicide use will be collected from the farmers. The resultant data will be analyzed statistically (analysis of variance and regression).

Significant milestones--Soil cores for March 1992, October 1992, and March 1993 have been collected and analyzed for triazine herbicides (atrazine). All data (herbicide usage, method of herbicide application, soils, precipitation, irrigation, measured herbicide concentrations) have been compiled for statistical analysis.

Plans for fiscal year 1994--Complete study objectives.



KS177

PROJECT TITLE:
Assessment and monitoring of atrazine in the Delaware River Basin, northeast Kansas

PROJECT NUMBER:
KS-177

COOPERATING AGENCY:
Kansas State Conservation Commission

PROJECT CHIEF:
L.M. Pope

Problem--Atrazine is the most frequently used herbicide in corn and sorghum production in Kansas. Also, it is the most frequently detected pesticide in surface water within the State. The widespread use, relatively large solubility, and potential for atrazine to move in overland runoff pose a threat to public surface-water supplies. This threat is most pronounced in northeast Kansas where soils, topographic relief, and usage may contribute to atrazine movement.

On the basis of existing atrazine data, which indicated a potential violation of the U.S. Environmental Protection Agency's 3.0-µg/L (micrograms per liter) Maximum Contaminant Level in drinking-water supplies, the Kansas State Board of Agriculture established a Pesticide Management Area (PMA) in the Delaware River Basin. Recommendations of the PMA advocated the establishment of a monitoring network to document atrazine concentrations during the effective period of the PMA. In response, the U.S. Geological Survey and the Kansas State Conservation Commission began a cooperative study to assess the occurrence and extent of atrazine within the basin.

The purpose of this study is to provide the information necessary to assess the present and evaluate future changes in the distribution and magnitude of atrazine concentrations spatially, temporally, and in relation to hydrologic conditions. Specifically, the study coordinates the collection of atrazine data from a network of 10 automatic sampling and streamflow-gaging stations located on the main stem and principal tributaries of the Delaware River.

Objectives--Specific objectives of this study are to: (1) compare recent atrazine information determined from the analysis of existing data to newly collected data, (2) reduce the uncertainty of atrazine information by intensifying spatial and temporal sampling, (3) generate a data base from which to calculate mean

annual concentrations and transport of atrazine, and (4) improve the understanding of the relations between the occurrence of atrazine in surface water to suspect causal factors.

Approach--This investigation is viewed as a multi-year effort. The first year would be an assessment of the basin to define the extent of the atrazine problem and identify areas that may require more intensive study. This assessment will include four distinct components that relate to a quantitative description of conditions and characteristics of the Delaware River Basin. First, an analysis of existing hydrologic and atrazine data will be performed. Second, this analysis will provide the basis for developing the strategy for obtaining specific additional hydrologic data that will be used to improve definition of the spatial and temporal distributions of atrazine and similar nitrogen-containing herbicides. Third, ancillary information will be obtained and compiled into a geographic information system (GIS) that can be used as a descriptive and analytical tool to relate the distribution and magnitude of atrazine concentrations and loads to human and natural factors. Fourth, long-term monitoring of selected subbasins will help to define trends in atrazine occurrences and evaluate the effectiveness of changes in land-management practices.

Ten streamflow and sample-collection sites were established at locations on the main stem Delaware River and on major tributaries to the Delaware River. These sites were instrumented with flow-monitoring and automatic sample-collection equipment. An additional site was established at the outlet of Perry Lake, which is located at the downstream end of the basin. This site is sampled manually.

During periods of base flow, surface-water sites will be sampled at biweekly intervals. Automatically collected samples will define atrazine concentrations over the range of expected flows during the year. This sampling schedule is needed to describe the variability in flow rates and atrazine concentrations and loading rates that are anticipated as a result of seasonal precipitation, agricultural practices, and flow controls. Stream-discharge ratings will be developed for each site.

Most samples for determination of atrazine concentrations will be analyzed by enzyme-linked immunosorbent-assay (immunoassay) techniques with sufficient quality-assurance samples analyzed by gas chromatography/mass spectrometry (GC/MS) to document the precision and reliability of the immunoassay procedures. In addition to the quality-assurance aspects, GC/MS analyses will provide concentrations for other nitrogen-containing herbicides and degradation products of atrazine.

Significant milestones--From July 1992 through September 1993, more than 2,600 samples were collected and analyzed by immunoassay techniques to determine triazine concentrations. About 120 of these samples were split and also analyzed by GC/MS methodology for atrazine concentrations. Results from

these duplicate analysis will be used to define the relation between triazine and atrazine concentrations.

Preliminary analysis of data indicate significant regional differences in occurrence of triazines in surface water. For the period August 1992 through July 1993, mean concentrations ranged from 0.88 µg/L in Elk Creek to 3.39 µg/L in Coal Creek. Triazine concentrations in discharge from Perry Lake averaged 2.04 µg/L for this same period.

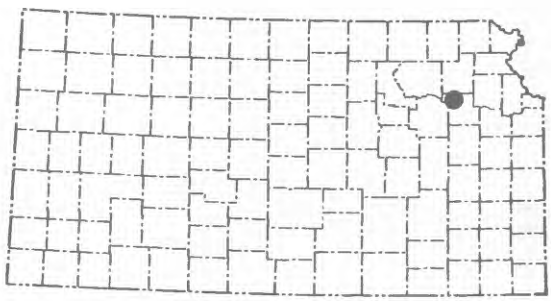
Plans for fiscal year 1994--Plans for fiscal year 1994 are to continue automatic and manual sampling. Samples will be analyzed using immunoassay and GC/MS procedures. Mean-daily discharge and atrazine concentrations for all fixed-station sites will be computed. Conduct three synoptic sample collections at 75-100 sites during base flow in November, March, and June. Make periodic discharge measurements to define shifting channel and extreme flow conditions.

PROJECT TITLE:
Evaluating field-scale pesticide movement in surface and ground water

PROJECT NUMBER:
KS-178

COOPERATING AGENCY:
Kansas State Board of Agriculture

PROJECT CHIEF:
L.M. Pope



KS178

Problem--Nonpoint-source contamination of surface and ground water from agricultural land in the midwestern United States has emerged as a National issue. In the lower Kansas River Basin, surface water frequently has contained concentrations of soluble herbicides, such as atrazine, in excess of the Maximum Contaminant Level established by the U.S. Environmental Protection Agency. Data collected at sites that drain land principally in row crop indicate that atrazine concentrations in water resulting from surface runoff often exceed 10 µg/L (micrograms per liter) during the 2 months following application. Additionally, concentrations of atrazine in base flow, predominantly ground-water discharge, are largest in areas of greatest application.

The purpose of this study is to determine the potential to mitigate or aggravate the transport of pesticides into surface and ground water by commonly used agricultural and land-management practices. Unless research can find a scientific solution for the safe and effective application of pesticides, such as atrazine, it could be banned from agricultural use. The economic effect of an atrazine ban on growers would be significant because the best alternative costs almost twice as much.

Objectives--The objectives of this study are to: (1) measure pesticide and specific metabolites and suspend-sediment concentrations in surface runoff between a clean-tilled, nonterraced cornfield, and a terraced cornfield, both of which are planted on the contour; (2) compare the amount of atrazine in surface runoff to the amount that has been applied on both the terraced and nonterraced fields; and (3) evaluate the difference in infiltration volume and soil-water quality between the terraced and nonterraced fields.

Approach--Surface-water flows from each field are measured with commercially available Marshall-type flumes. Approach hydraulic head is measured by pneumatic-bubble orifices continuously monitored by a multichannel data-acquisition system and recorded on solid-state storage modules. Samples of surface-water

runoff are collected automatically throughout the duration of storms by refrigerated samplers with a 24-discrete-sample capacity. Discrete samples from each storm will be composited in a one storm-occurrence sample. For the first few storms after the pesticide application, discrete samples also will be analyzed. The U.S. Geological Survey research laboratory in Lawrence, Kans., will analyze the samples for concentrations of dissolved and suspended atrazine and alachlor, two dealkylated degradation products of atrazine, and a principal degradation product of alachlor. To determine soil-water quality, a cluster of suction lysimeters were installed just upfield of each terrace and in the nonterraced field. Each cluster contains three lysimeters set at 2, 4, and 6 ft below the land surface.

Significant milestones--In fiscal year 1992, runoff data were collected from the terraced and nonterraced fields under contour tillage. An evaluation was made comparing pesticide losses from each field. In fiscal year 1993, a third field was established to examine the effect of ridge-till cultivation in mitigating pesticide losses.

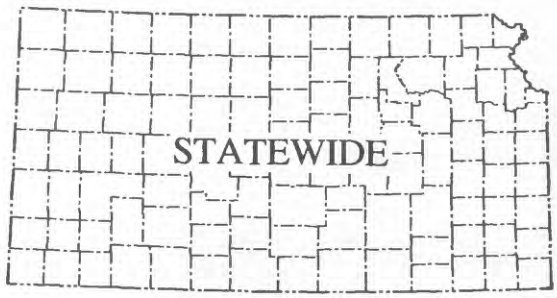
Plans for fiscal year 1994--Evaluate data collected from the 1992 growing season and determine agricultural practices that were implemented in 1993. Corn will be planted on-the-contour using the ridge-till cultivation method. In the event that additional funding becomes available, the nonterraced field may be redesigned to incorporate a grass waterway. Runoff data will be collected to evaluate these agricultural practices.

PROJECT TITLE:
Development of GIS data bases for major aquifers in Kansas

PROJECT NUMBER:
KS-179

COOPERATING AGENCY:
Kansas Water Office

PROJECT CHIEF:
Kyle Juracek



KS179

Problem--To develop a series of geographic-information-system (GIS) digital maps for the following major aquifers in Kansas: the High Plains, the Glacial Drift, the Ozark, the Dakota, and the alluvial aquifers.

Objectives--To develop GIS digital maps of: (1) the aquifer boundaries (all five aquifers); (2) the altitude of the land surface (all except the alluvial); (3) the altitude of the top of the aquifer (all except the alluvial); (4) the altitude of the bottom of the aquifer (all except the alluvial).

Approach--Available information (for example, maps, reports, digital data files) will be used to create the digital maps at the largest scale possible (typically, 1;250,000 or 1:500,000).

Significant milestones--The digital maps for the High Plains aquifer have been prepared and currently are being reviewed by State agencies. Work has begun on the Ozark aquifer.

Plans for fiscal year 1994--Complete all study objectives.

KS156

PROJECT TITLE:
Organic geochemistry of natural and polluted water--Nonpoint-source contamination

PROJECT NUMBER:
KS-156

COOPERATING AGENCY:
Multi-agency

PROJECT CHIEF:
E.M. Thurman

Problem--A recent feature article in Environmental Science and Technology on nonpoint-source (NPS) contamination quotes U.S. Environmental Protection Agency (EPA) sources that "NPS pollution is a principal source of water-quality problems...and that agricultural activities are a major cause." The Midcontinent, especially Kansas, Nebraska, and Iowa, use many herbicides to control weeds that affect corn, sorghum, and soybean production. The result is that large quantities of herbicides (2-5 lb/acre) are used annually in these states. Numerous reports show the contamination of rivers, reservoirs, and ground water by herbicides. To assess the effect of NPS pollution on surface and ground water and to develop management strategies, the compounds that cause NPS pollution need to be determined and linked to both geochemical and hydrologic processes.

Objectives--(1) To investigate the amount, distribution, geochemistry, and transport of NPS pollutants (herbicides, degradation products, adjuvants, and fertilizers) at field scales in the Midcontinent where problems are most acute. Tie research with modeling efforts of other agencies such as GLEAMS and PRZM. (2) To identify "fingerprint" compounds that indicate agricultural and urban sources of NPS pollution and to link this research with hydrologic information and management models of NPS pollution, such as small-scale (regional) data bases, which then could be used to abate NPS pollution.

Approach--The approach consists of three parts: (1) methods development for herbicide analysis, (2) survey of herbicides in natural waters and, (3) geochemical process studies on herbicide transport and fate. Methods development consists of developing analysis methods for herbicides and metabolites by GC/MS, HPLC, and immunoassay and linking these methods together. The survey consists of measuring herbicides and metabolites in ground water, surface water, lakes, and so forth. The geochemical process

consists of studies on herbicide transport in soil, in the unsaturated zone, in ground water, and on surfaces.

Significant milestones--An analytical chemistry laboratory for gas chromatography/mass spectrometry (GC/MS) analysis has been established, and several methods developed. Sixteen reports or abstracts have been published.

Plans for fiscal year 1994--Develop methods by HPLC for ionic metabolites of alachlor and metolachlor.

Reports

Aga, D.S., and Thurman, E.M., 1993, Coupling solid-phase extraction and enzyme-linked immunosorbent assay for ultratrace determination of herbicide in pristine water: Analytical Chemistry, v. 65, p. 2894-2898.

Aga, D.S., Thurman, E.M., and Pomes, M.L., 1993, Measurement of concentrations of alachlor and its ethanesulfonic acid metabolite in water by solid-phase extraction and enzyme-linked immunosorbent assay, *in* Morganwalp, D.W., and Aronson, D.A., compilers, U.S. Geological Survey Toxic Substances Hydrology Program--Abstracts of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Open-File Report 93-454, p. 80.

Cromwell, A.E., and Thurman, E.M., 1993, Atrazine transport and degradation in a pristine watershed--The fate of atrazine deposited by precipitation, *in* Morganwalp, D.W., and Aronson, D.A., compilers, U.S. Geological Survey Toxic Substances Hydrology Program--Abstracts of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Open-File Report 93-454, p. 82.

Fallon, J.D., and Thurman, E.M., 1993, Determining the relative age, transport, and three-dimensional distribution of atrazine in a reservoir using immunoassay, *in* Morganwalp, D.W., and Aronson, D.A., compilers, U.S. Geological Survey Toxic Substances Hydrology Program--Abstracts of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Open-File Report 93-454, p. 72.

Kolpin, D.W., Burkhart, M.R., and Thurman, E.M., 1993, Hydrogeologic, water-quality, and land-use data for the reconnaissance of herbicides and nitrate in near-surface aquifers of the midcontinental United States, 1991: U.S. Geological Survey Open-File Report 93-114, 61 p.

Meyer, M.T., Mills, M.S., and Thurman, E.M., 1993, Automated solid-phase extraction of herbicides from water for gas chromatographic-mass spectrometric analysis: Journal of Chromatography, v. 629, p. 55-59.

Reports--Continued

Meyer, M.T., and Thurman, E.M., 1993, The degradation and transport of cyanazine metabolites in surface water of the midwestern United States, *in* Morganwalp, D.W., and Aronson, D.A., compilers, U.S. Geological Survey Toxic Substances Hydrology Program--Abstracts of the Technical meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Open-File Report 93-454, p. 87.

Mills, M.S., and Thurman, E.M., 1992, Mixed-mode isolation of triazine metabolites in soil and aquifer sediments using automated solid-phase extraction: Analytical Chemistry, v. 64, p. 1985-1990.

Mills, M.S. Thurman, E.M., and Pedersen, M.J., 1993, Application of mixed-mode, solid-phase extraction in environmental and clinical chemistry-combining hydrogen-bonding, cation-exchange and Van der Waals interactions: Journal of Chromatography, v. 629, p. 11-21.

Plummer, L.N., Michel, R.L., Thurman, E.M., and Glynn, P.D., 1993, Environmental tracers for age dating young ground water, *in* Alley, W.M., ed., Regional ground-water quality: New York, Van Nostrand Reinhold, p. 255-294.

Pomes, M.L., Holub, D.F., Aga, D.S., and Thurman, E.M., 1993, Isocratic separation of alachlor ethanesulfonic acid, alachlor oxoacetic acid, and hydroxyatrazine by reversed-phase liquid chromatography, *in* Morganwalp, D.W., and Aronson, D.A., compilers, U.S. Geological Survey Toxic Substances Hydrology Program--Abstracts of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Open-File Report 93-454, p. 81.

Scribner, E.A., Thurman, E.M., and Goolsby, D.A., 1993, Reconnaissance data for selected herbicides and two metabolites in surface water of the midwestern United States--Chemical analysis by immunoassay and gas chromatography/mass spectrometry, *in* Morganwalp, D.W., and Aronson, D.A., compilers, U.S. Geological Survey Toxic Substances Hydrology Program--Abstracts of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Open-File Report 93-454, p. 84.

Scribner, E.A., Thurman, E.M., Goolsby, D.A., Meyer, M.T., Mills, M.S., and Pomes, M.L., 1993, Reconnaissance data for selected herbicides, two atrazine metabolites, and nitrate in surface water of the midwestern United States, 1989-90: U.S. Geological Survey Open-File Report 93-457, 77 p.

Squillace, P.J., and Thurman, E.M., 1992, Herbicide transport in rivers--Importance of hydrology and geochemistry in nonpoint-source contamination: Environmental Science and Technology, v. 26, no. 3, p. 538-545.

Reports--Continued

Thurman, E.M., Goolsby, D.A., Meyer, M.T., 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.

Thurman, E.M., Mills, M.S., and Meyer, M.T., 1993, Chemistry, degradation, and transport of triazine herbicide metabolites in surface water, *in* Morganwalp, D.W., and Aronson, D.A., compilers, U.S. Geological Survey Toxic Substances Hydrology Program--Abstracts of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Open-File Report 93-454, p. 68.

KS168

PROJECT TITLE:
Origin and chemistry of natural surfactants in streams

PROJECT NUMBER:
KS-168

COOPERATING AGENCY:
University of Kansas Center for Research Incorporated

PROJECT CHIEF:
E.M. Thurman

Problem--The problem is to understand the chemical nature of natural foams on streams and rivers and to demonstrate with chemical analysis that manufactured detergents are significantly different in chemical structure than natural foams.

Objectives--(1) Develop simple sampling scheme for natural foam in streams; (2) characterize the natural foams from a mountain stream and an algae pond with chemical analysis; and (3) show that natural foam is chemically different than manufactured foam.

Approach--(1) Sample foam from two sources--mountain stream and algae pond. (2) Separate foam with Ron Miles apparatus. (3) Collapse foam and chemically analyze for percentage of carbon, carbohydrate content, and humic content.

Significant milestones--Degradation studies were completed for the surfactants of natural origin with various herbicide metabolites. Both alachlor and atrazine were degraded in the presence and absence of natural surfactants. The definition and characterization of the natural surfactants also are underway. One report has been completed.

Reports

Shamet, K.A., 1992, Surfactants in a natural aquatic foam--Characterization and role in enhanced degradation of herbicides: Lawrence, University of Kansas, Department of Civil Engineering, masters thesis, 83 p.

PROJECT TITLE:
Distinguishing atrazine occurrence in ground water--Point source versus nonpoint source

PROJECT NUMBER:
KS-173

COOPERATING AGENCY:
Brazos River Authority, City of Cameron, University of Kansas Center for Research, Incorporated

PROJECT CHIEF:
E.M. Thurman

Problem--In order to correct problems caused by herbicide contamination of ground water, it is important to be able to distinguish point-source from nonpoint-source contamination. Point-source contamination is the incorrect usage of herbicide, such as a spill, whereas nonpoint source is the correct application of herbicide to a field. Being able to distinguish these two sources will allow regulations about herbicides to be formed that are reasonable both for the farmer and the chemical manufacturer.

Objectives--The objectives of the study are to distinguish whether ground-water contamination by herbicides has occurred because of correct applications of herbicides (nonpoint source) or incorrect application or spillage or disposal of herbicide (point source).

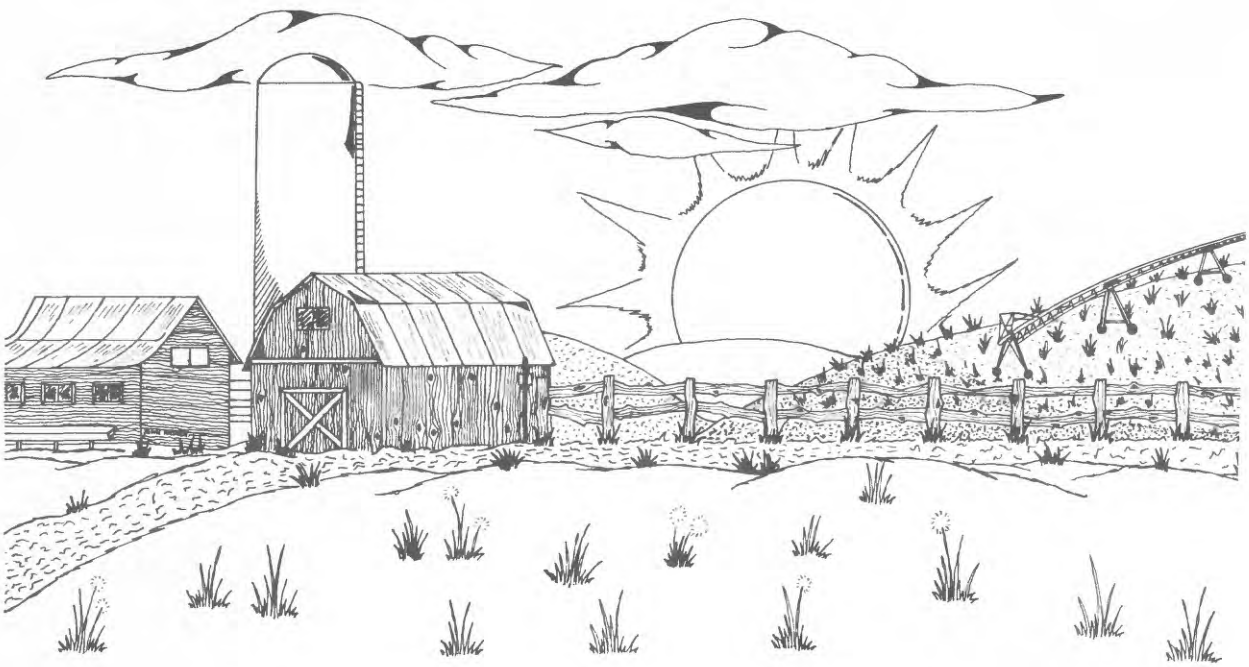
Approach--The approach consists of measuring the parent herbicide (atrazine) and a major degradation product deethylatrazine in ground water that has been contaminated both by point sources (spills) and nonpoint sources (field-dissipation studies) and determining if the ratio of deethylatrazine to atrazine, called the DAR, is different. The hypothesis is that the DAR will be small for point-source contamination and large for nonpoint-source contamination. This hypothesis will be tested at 5-10 field locations.

Significant milestones--The results from the Topeka, Kansas, field site show that a large DAR, greater than 0.5, is associated with nonpoint-source contamination of ground water by atrazine. Alachlor and its metabolite ESA have been added to the list of tracer compounds.

Plans for fiscal year 1994--Examine several field sites that have point-source contamination and determine the DAR values for each to see if DAR's will be small for point-source contamination sites.

Reports

Squillace, P.J., Thurman, E.M., and Furlong, E.T., 1993, Ground water as nonpoint source of atrazine and deethylatrazine in a river during base-flow conditions: Water Resources Research, v. 29, no. 6, p. 1719-1729.



PROJECT TITLE:
Progression of climate patterns across North America, which affects water availability and its relation to systematic global energy inputs

PROJECT NUMBER:
KS-174

COOPERATING AGENCY:
University of Kansas Center for Research, Incorporated

PROJECT CHIEF:
C.A. Perry

KS174

Problem--Water availability at any one location in North America is quite variable and dependent upon many factors. Shortages or excesses of water in regional water budgets can create problems in public drinking-water supplies, both quantity and quality, and in water supplies for irrigation, hydroelectric-power production, and in damage from floods. Hydrologic processes tend to lessen short-term climatic variability but can retain long-term trends or fluctuations in water availability in a regional sense. Estimates of water availability are needed in time frames that exceed established weather-prediction capabilities. Analysis of hydroclimatic information may provide a means to obtain these estimates.

Objective--The principal objective of this research is to test the hypothesis that a periodic progression of climatic patterns across North America exists, evidenced by regional deviations in streamflow, ground-water levels, and other climatic data. The progression of patterns would include an analysis of teleconnections between different regions throughout North America. A consequent objective would be to determine if a relation exists between the climatic patterns and global-energy input. The global-energy input would be a function of solar-constant fluctuations and their effect on sea-surface temperatures.

Approach--Hydroclimatic data will be examined for approximately 16 selected areas located throughout the United States. Special emphasis will be placed on the northwest one-fourth of the country. These data will include information from the U.S. Geological Survey's Hydro-Climatic Data Network (HCDN), temperature, precipitation, and geopotential atmospheric heights for North America. The available data will be collated for the

selected areas and analyzed for trends and periodic fluctuations using Fourier analysis and neutral networking. Trends and periodicity-phase shifting for each selected area will be examined for teleconnections to the other regions and with solar-constant variations to demonstrate a possible mechanism for climatic change.

Significant milestones--Research completed. All reports have been published.

Reports

Perry, C.A., 1992a, A correlation between precipitation in the western United States and solar-irradiance variations: Proceedings of the American Water Resources Association Conference, "Managing Water Resources during Climate Change," Reno, Nevada, November 1-5, 1992, p. 721-729.

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PROJECT TITLE:
Multi-residue immunoassay for water-quality surveys

PROJECT NUMBER:
KS-183

COOPERATING AGENCY:
Federal

PROJECT CHIEF:
E.M. Thurman

KS183

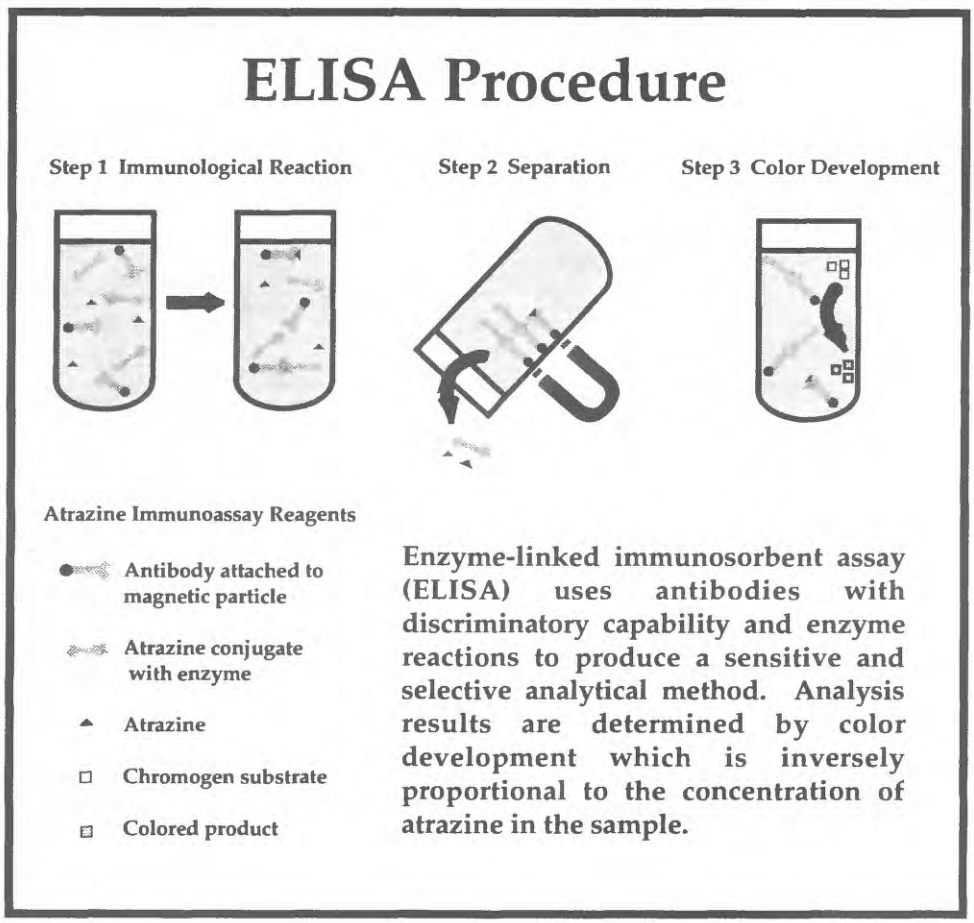
Problem--All of the commercially available immunoassays for environmental applications are in the form of enzyme-linked immunsorbent assay (ELISA), which has the capability to analyze only one compound at a time. This limits applicability of the immunoassay for multiple-residue analysis because one has to repeat the analysis several times to determine all the analytes of interest. Another drawback of ELISA is that the enzyme activity can be affected significantly by slight variations in the reaction conditions and by interferences from a complex sample matrix that sometimes impedes its utility for onsite analysis. This problem may be circumvented by using fluorescent labels, instead of enzyme labels for detection. Fluorescent labels, such as rare-earth chelates, should enable one to detect multiple analytes by a highly sensitive time-resolved fluorimetric immunoassay. The tracer has an indefinite shelf-life, and quantification of fluorescent labels rivals enzyme detection for rapidity and precision. The use of chelated rare-earth fluorophores, such as europium (Eu+3) and teribium (Tb+3), should help improve the sensitivity of the immunoassay by reducing the effects of background signals, which were a problem in earlier fluorimetric immunoassays. Once a multiple-analyte immunoassay is developed, many other applications of immunoassay can be found in environmental monitoring and ground-water modeling.

Objective--The objective of this research is to develop a multiple-analyte immunoassay for environmentally important compounds using fluorescent rare-earth chelates as labels in a time-resolved fluorimetric immunoassay.

Approach--The fulfillment of the objectives of this investigation involves three parts. First, coating of the antibodies for each particular analyte in magnetic particles, second is the selection of the most efficient fluorescent chelates for the assay, and thirdly, is the optimization of the time-resolved fluorimetric immunoassay. The experiment will start with a double-analyte system as a model using atrazine and deethylatrazine as the model compounds, after which the procedure can be extended to other analytes such as alachlor, alachlor ethane sulfonic acid metabolite, metolachlor, cyanazine, and other environmentally important compounds.

Significant milestones--Research was funded in late fiscal year 1993.

Plans for fiscal year 1994--Develop a multiple-analyte immunoassay for atrazine and deethylatrazine as described in the approach.



PROJECT TITLE:
Watershed processes and modeling

PROJECT NUMBER:
KS-184

COOPERATING AGENCY:
Federal

PROJECT CHIEF:
David Wolock

KS184

Problem--An important goal for both the National Water-Quality Assessment (NAWQA) and Water, Energy, and Biogeochemical Budgets (WEBB) programs is to better understand the factors that affect ground-water and surface-water quality. The NAWQA program hopes to accomplish this goal through water-quality sampling at many sites across the country, and the WEBB program is conducting process-oriented research and very detailed sampling in just a few watersheds.

One factor thought to have an important effect on water quality is the flow path of water through a watershed from the time it "arrives" in the watershed as precipitation to the time it "leaves" as streamflow. The flow path affects the length of time that water resides in a watershed and the biogeochemical reactions that modify its quality as it moves through or over a watershed. Given the importance of flow paths on water quality, it would be helpful to the NAWQA and WEBB programs to know how water moves through and over watersheds. Unfortunately, the quantities of water associated with flow paths and the ways that flow paths interact with other factors, such as land use, to affect water quality are difficult, if not impossible, to measure directly. It is possible, however, to quantify watershed characteristics, such as climate, topography, land use, vegetation, and soil properties, and then to relate these characteristics to flow paths and water quality using a watershed simulation model.

Objective--The objective of the proposed research is to determine the factors that affect the flow paths of precipitation over and through watersheds and to determine how flow paths affect streamflow water quality. The objective will be accomplished by: (1) developing a physically based watershed model that can be applied appropriately at NAWQA indicator sites and WEBB sites, and (2) using the model to generate and test hypotheses about how watershed characteristics affect flow paths and water quality.

Approach--An enhanced version of the watershed model TOPMODEL will be developed. TOPMODEL has two important characteristics that make it suitable as a tool to identify and understand watershed characteristics related to flow paths and water quality. The first characteristic is that the model is

physically based; that is, it is derived from first principles. This is an important characteristic because the objective is to understand the factors that affect water quality by generating and testing hypotheses about the physical processes that affect water quality.

The second characteristic that makes TOPMODEL suitable is that the watershed physical characteristics needed to determine the model parameters (and hence to make predictions) are derived from readily available information. If a model indicates that certain watershed characteristics have theoretically important effects on flow paths and water quality but those characteristics cannot be computed from readily available data, then the model-generated hypotheses cannot be tested.

The approach to using a watershed model to identify and understand the watershed characteristics that affect flow paths and water quality consists of two steps. In the first step, a sensitivity analysis of the model is performed to determine the theoretical effects of watershed characteristics on flow paths and water quality. Depending on the water-quality constituent, different factors probably will be identified. The sensitivity analysis can be thought of as a process in which hypotheses about how watershed characteristics affect flow paths and water quality are generated. In the second step, the characteristics predicted to be particularly important by the model are measured for the watersheds contributing flow to the water-quality sampling sites, and the observed relations of these characteristics to water quality are examined. The second step is the hypothesis-testing phase of the research based on field measurements.

Significant milestones--Two reports were published in fiscal year 1993.

Plans for fiscal year 1994--Model development continues. Plans are to expand the number of study sites.

Reports

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HYDROLOGIC-DATA STATIONS IN KANSAS, 1993 WATER YEAR

Explanation of Table Symbols

Surface-Water Stations

Station Type, Complete-Record Gaging Stations

B	-	Benchmark.
C	-	Current purpose station.
F	-	Flood forecast (also used by National Weather Service).
H	-	A hydrologic station to meet objectives of defining regional streamflow characteristics.
I	-	Interstate compact.
L	-	Long-term trend station to meet objectives of measuring principal unregulated streams.
P	-	Principal-stream station to meet objectives of measuring principal unregulated streams.
R	-	A station required for systems analysis of a regulated stream to meet objectives of defining regulated flow.

Type of Gage, Complete-Record Gaging Station

A	-	Precipitation gage	R	-	Graphic recorder
B	-	Bubble gage	S	-	Satellite-access telemetering equipment
C	-	Cableway	T	-	Telephone-access telemetering equipment
D	-	Digital recorder (stage)	W	-	Artificial control
Dp	-	Digital recorder (precipitation)			

Sampling Type, Water-Quality Stations

CHEM	Chemical analysis: cations, anions, nutrients
METAL	Trace metals analysis
BIOL	Biological analysis: phytoplankton, periphyton
TOC	Total organic carbon determination
SED	Suspended sediment: concentration, discharge, particle size
BED	Bed material: particle size
COLI	Coliform count: total fecal, fecal streptococcal
FIELD	Field measurements: discharge, water temperature, alkalinity, specific conductance, pH, dissolved oxygen

Cooperator or Supporting Program

CBR	Collection of basic records (Federal)
COMP	Arkansas River Compact Administration
DWR	Kansas State Board of Agriculture, Division of Water Resources
HAYS	City of Hays
KC-CE	Kansas City District, U.S. Army Corps of Engineers
KDHE	Kansas Department of Health and Environment
KDOT	Kansas Department of Transportation
KWO	Kansas Water Office
T-CE	Tulsa District, U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
WICHITA	City of Wichita

Ground-Water Wells

Well numbers

Well numbers in these listings indicate the location of wells according to a modified version of a system of land subdivisions by the U.S. Bureau of Land Management (fig. 12). An example of a typical well number is 21S 34W 16AADA 02 in Finney County. The first two digits indicate the township, which in Kansas are nearly all south (S) of the 40th Parallel base line. The second two digits indicate the range east (E) or west (W) of the sixth Principal Meridian. The third two digits indicate the section in which the well is located. The first letter following the section number denotes the quarter section or 160-acre tract; the second, the quarter-quarter section or 40-acre tract; the third, the quarter-quarter-quarter section or 10-acre tract; and the fourth, when used, the quarter-quarter-quarter-quarter section or 2 1/2-acre tract. The quarter sections, quarter-quarter sections, and so forth, are designated A, B, C, or D in a counterclockwise direction, beginning with A in the northeast quadrant. Wells located within the smallest subdivision indicated are numbered serially, as indicated by the last two digits (02) of the well number.

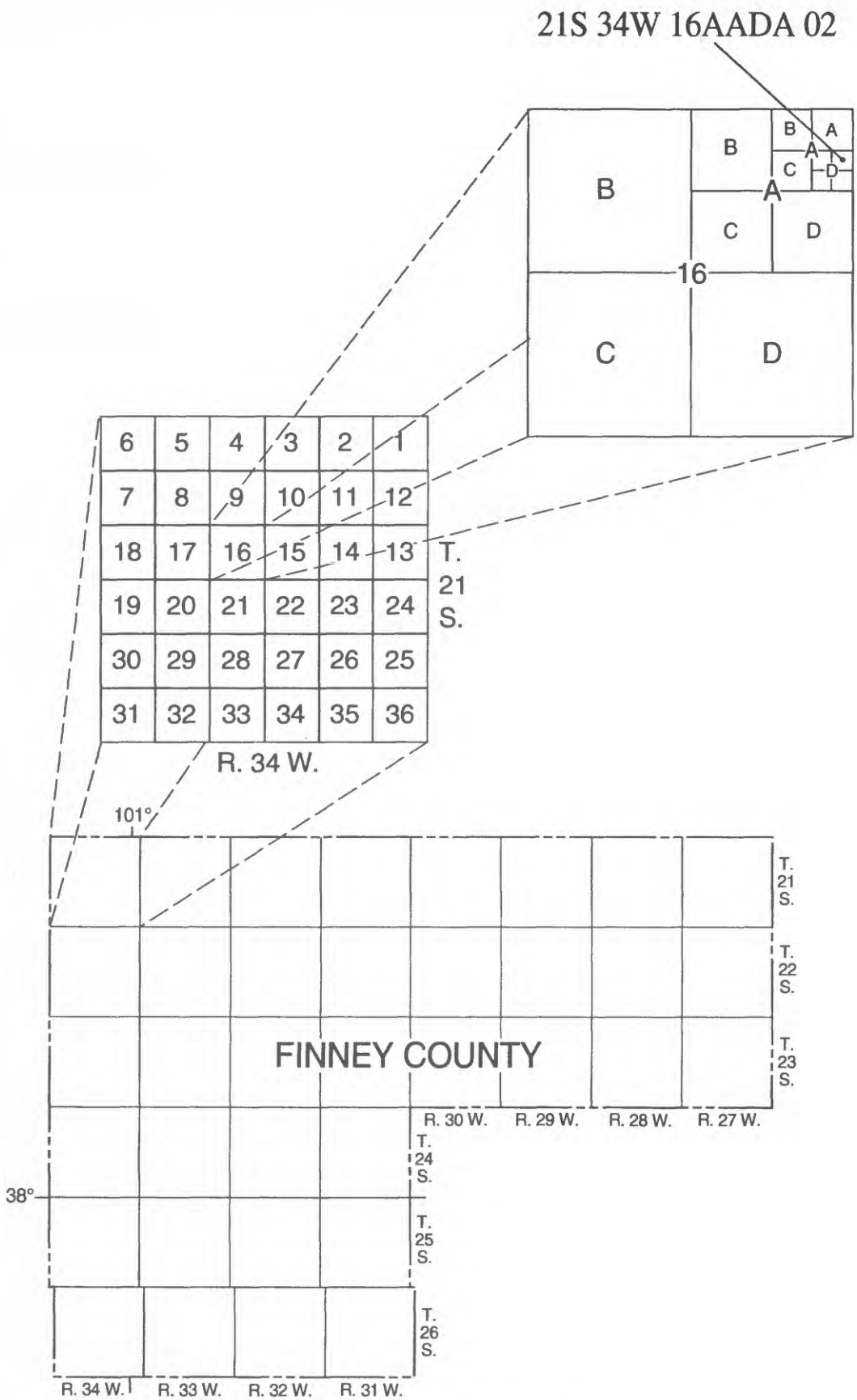

Figure 12. Well-numbering system.

Table 1. *Complete-record streamflow-gaging stations, 1993 water year*

Ident. no. (fig. 6)	Station name	Station purpose	Location Sec.	T.	R.	Type of gage	Coop. or support
		Missouri River Basin					
06-							
8140	Turkey Cr. nr Seneca	C,F,L,P	20	1S	12E	ABDRS	KWO
8449	S. Fk. Sappa Cr. nr Achilles	H,L	29	4S	30W	ABDRS	KWO
8465	Beaver Cr. at Cedar Bluffs	C,I,L,P	10	1S	29W	BDRT	CBR
8479	Prairie Dog Cr. ab Keith Sebelius Lake	C,L,P	23	3S	25W	BCDRW	KWO/ KC-CE
84795	Keith Sebelius Lake nr Norton		8	3S	23W	BR	KWO
8480	Prairie Dog Cr. at Norton	C,R	9	3S	23W	BDRW	KWO
8485	Prairie Dog Cr. nr Woodruff	C,I,L,R	9	1S	19W	ABDRS	CBR/ KC-CE
8535	Republican R. nr Hardy, Nebr.	C,I,R	6	1S	5W	BDRT	CBR
8538	White Rock Cr. nr Burr Oak	C,L,P	7	2S	8W	ABDRS	KC-CE
8539	Lovewell Res. nr Lovewell		6	2S	6W	BR	KWO
8540	White Rock Cr. at Lovewell	C,R	17	2S	6W	BDRW	KWO
8560	Republican R. at Concordia	C,R	28	5S	3W	ABDRST	KC-CE
8566	Republican R. at Clay Center	C,R	17	8S	3E	ABDRS	KC-CE
85705	Milford Lake nr Junction City		20	11S	5E	RS	KC-CE
8571	Republican R. bl Milford Dam	C,R	--	--	--	BCDRT	KC-CE
8600	Smoky Hill R. at Elkader	C,L,P	34	14S	32W	BDR	KWO
8610	Smoky Hill R. nr Arnold	C,P	29	14S	24W	ABDRS	KWO/ KC-CE
8615	Cedar Bluff Res. nr Ellis		36	14S	22W	BR	KWO
8627	Smoky Hill R. nr Schoenchen	C,F,R	25	15S	19W	BDR	KWO
86285	Smoky Hill R. bl Schoenchen	C,R	27	15S	18W	BDR	HAYS
8635	Big Cr. nr Hays	C,F,L	30	14S	17W	BDRT	KWO
86405	Smoky Hill R. nr Bunker Hill	C,R	33	14S	13W	ABDRS	KC-CE
8645	Smoky Hill R. at Ellsworth	C,R	20	15S	8W	ABDRS	KC-CE
8650	Kanopolis Lake nr Kanopolis		3	17S	6W	ABRS	KC-CE
8655	Smoky Hill R. nr Langley	C,R	35	16S	6W	BDRT	KC-CE
8665	Smoky Hill R. nr Mentor	C,R	29	14S	2W	ABDRS	KC-CE
8669	Saline R. nr WaKeeney	H,P	10	11S	23W	BDR	KWO
8670	Saline R. nr Russell	C,F,L	34	12S	14W	ABDRS	KWO/ KC-CE

Table 1. *Complete-record streamflow-gaging stations, 1993 water year*--Continued

Ident. no. (fig. 6)	Station name	Station purpose	Location Sec.	T.	R.	Type of gage	Coop. or support
	Missouri River Basin--Continued						
06-							
8681	Wilson Lake nr Wilson		36	12S	11W	ARS	KC-CE
8682	Saline R. at Wilson Dam	C,R	25	12S	11W	BDRT	KC-CE
8695	Saline R. at Tescott	C,F,R	16	12S	5W	ABDRS	KWO/ KC-CE
8702	Smoky Hill R. at New Cambria	C,R	1	14S	2W	BDRS	CBR/ KC-CE
8710	N. Fk. Solomon R. at Glade	C,P	25	4S	18W	BDR	KWO/KC-CE
8715	Bow Cr. nr Stockton	C,F,L	1	6S	18W	BDR	KWO
8717	Kirwin Res. at Kirwin		33	4S	16W	BR	KWO
8718	N. Fk. Solomon R. at Kirwin	C,R	33	4S	16W	DR	KWO
8725	N. Fk. Solomon R. at Portis	C,R	5	6S	12W	BDRS	KC-CE
8730	S. Fk. Solomon R. ab Webster Res.	C,P	8	8S	20W	BDR	KWO/KC-CE
8731	Webster Res. nr Stockton		27	7S	19W	BR	KWO
8732	S. Fk. Solomon R. bl Webster Res.	C,R	26	7S	19W	BCDR	KWO
87346	S. Fk. Solomon R. at Woodston	C,R	16	7S	16W	BDR	CBR
8740	S. Fk. Solomon R. at Osborne	C,F,R	20	7S	12W	ABDRS	KWO/KC-CE
8742	Waconda Lake at Glen Elder		27	6S	9W	BR	USBR
8759	Solomon R. nr Glen Elder	C,F,R	2	7S	9W	BCDRW	KWO
876070	Solomon R. nr Simpson	C,R	7	8S	5W	BDRS	KC-CE
8767	Salt Cr. nr Ada	C,F	36	10S	5W	BDRT	KWO
8769	Solomon R. at Niles	C,R	31	12S	1W	ABDRS	KC-CE
8776	Smoky Hill R. at Enterprise	C,R	20	13S	3E	ABDRS	KC-CE
8780	Chapman Cr. nr Chapman	F,L	1	12S	3E	ABDRS	KWO
8791	Kansas R. at Ft. Riley	C,R	33	11S	6E	BDRST	KC-CE
87965	Kings Cr. nr Manhattan	B	18	11S	8E	BCDRDp	CBR
88251	Big Blue R. at Marysville	C,P	32	25S	7E	ABDRS	KC-CE
8842	Mill Cr. at Washington	F,H	1	3S	3E	BDRT	KWO
8844	Little Blue R. nr Barnes	C,P	22	3S	5E	ABDRS	KC-CE
8855	Black Vermillion R. nr Frankfort	C,P	20	4S	9E	BDRS	KC-CE

Table 1. *Complete-record streamflow-gaging stations, 1993 water year*--Continued

Ident. no. (fig. 6)	Station name	Station purpose	Location Sec.	T.	R.	Type of gage	Coop. or support
	Missouri River Basin--Continued						
06-							
8869	Tuttle Creek Lake nr Manhattan		24	9S	7E	ABRS	KC-CE
8870	Big Blue R. nr Manhattan	C,R	30	9S	8E	BDRT	KC-CE
8875	Kansas R. at Wamego	C,R	9	10S	10E	ABDRS	KC-CE
88835	Kansas R. nr Belvue	C	13	10S	11E	BDRT	DWR
8885	Mill Cr. nr Paxico	C,F,L	27	11S	11E	ABDRS	KWO
8890	Kansas R. at Topeka	C,R	28	11S	16E	ABDRS	KC-CE
88914	Soldier Cr. nr Soldier	C,H	4	6S	13E	BDR	KWO
88916	Soldier Cr. nr Circleville	C,H	10	7S	13E	BDR	KWO
8892	Soldier Cr. nr Delia	C,H	8	10S	14E	BDR	KWO
8895	Soldier Cr. nr Topeka	C,P	14	11S	15E	ABDRS	KC-CE
8901	Delaware R. nr Muscotah	C,L	16	6S	17E	ABDRS	KC-CE
890898	Perry Lake nr Perry		9	11S	18E	ARS	KC-CE
8909	Delaware R. bl Perry Dam	C,R	9	11S	18E	CR	KC-CE
8910	Kansas R. at Lecompton	C,R	35	11S	18E	BDRS	KC-CE
891478	Clinton Lake nr Lawrence		8	13S	19E	ABRS	KC-CE
8915	Wakarusa R. nr Lawrence	C,R	23	13S	19E	ABDRS	KC-CE
8920	Stranger Cr. nr Tonganoxie	C,L	7	11S	22E	ABDRS	KC-CE
89235	Kansas R. at DeSoto	C,F,R	28	12S	22E	ABDRS	KWO/ KC-CE
89308	Blue R. nr Stanley	C,H	19	14S	25E	ABDRS	KWO/KC-CE
8933	Indian Cr. at Overland Park	C,H	6	13S	25E	ABDRS	KWO
9108	Marais des Cygnes R. nr Reading	C,P	15	17S	13E	BDRS	KC-CE
910997	Melvern Lake nr Melvern		1	18S	15E	ARS	KC-CE
9115	Salt Cr. nr Lyndon	C,F,L	34	16S	16E	BDRT	KWO
9119	Dragoon Cr. nr Burlingame	C,H	27	15S	14E	ABDRS	KC-CE
91249	Pomona Lake nr Quenemo		19	16S	17E	ARS	KC-CE
9125	Hundred and Ten Mile Cr. nr Quenemo	C,R	20	16S	17E	BCDRT	KC-CE
9130	Marais des Cygnes R. nr Pomona	C,R	7	17S	18E	BDRST	KC-CE

Table 1. *Complete-record streamflow-gaging stations, 1993 water year*--Continued

Ident. no. (fig. 6)	Station name	Station purpose	Location Sec.	T.	R.	Type of gage	Coop. or support
	Missouri River Basin--Continued						
06-							
9135	Marais des Cygnes R. nr Ottawa	C,R	36	16S	19E	ABDRST	KC-CE
9140	Pottawatomie Cr. nr Garnett	C,F,L	6	20S	20E	BDRT	KWO
914995	Hillsdale Lake nr Hillsdale		17	16S	23E	ABRS	KC-CE
9150	Big Bull Cr. nr Hillsdale	C,R	20	16S	23E	BCDRT	KC-CE
9158	Marais des Cygnes R. at La Cygne	C,R	32	19S	24E	ABDRS	KWO
9166	Marais des Cygnes R. nr Kansas-Missouri State Line	C,F,R	16	21S	25E	ABDRS	KWO/ KC-CE
9170	Little Osage R. at Fulton	C,F,L	25	23S	24E	BDRT	KWO
91738	Marmaton R. nr Marmaton	C,F,L	4	26S	24E	BCDRS	KWO/KC-CE
	Arkansas River Basin						
07-							
1370	Frontier Ditch nr Coolidge	C,I	21	23S	43W	BDRSW	CBR/ COMP
1375	Arkansas R. nr Coolidge	C,I,R	26	23S	43W	BDRS	CBR/ COMP
1380	Arkansas R. at Syracuse	C,F,R	18	24S	40W	BDRT	KWO
1390	Arkansas R. at Garden City	C,F,R	19	24S	32W	BDRT	KWO
1395	Arkansas R. at Dodge City	C,R	35	26S	25W	BDRT	T-CE/CBR
1400	Arkansas R. nr Kinsley	C,R	26	24S	19W	BDRT	KWO
14085	Pawnee R. nr Burdett	H,L,P	21	21S	21W	BDR	KWO
1412	Pawnee R. nr Larned	C,F,L,P	30	21S	18W	ABDRS	KWO
1413	Arkansas R. at Great Bend	C,R	33	19S	13W	ABDRS	T-CE
14178	Walnut Cr. nr Rush Center	C,H,P	24	18S	19W	BDR	KWO
1419	Walnut Cr. at Albert	C,L,P	29	18S	15W	BDR	KWO
1423	Rattlesnake Cr. nr Macksville	H,P	16	25S	14W	BDR	KWO
142575	Rattlesnake Cr. nr Zenith	H,P	26	22S	11W	ABDRS	KWO
14262	Rattlesnake Cr. nr Raymond	H,P	15	21S	10W	BDRT	KWO
1433	Cow Creek nr Lyons	C,F,L,R	15	20S	8W	ABDRS	KWO/ T-CE

Table 1. *Complete-record streamflow-gaging stations, 1993 water year*--Continued

Ident. no. (fig. 6)	Station name	Station purpose	Location Sec.	T.	R.	Type of gage	Coop. or support
	Arkansas River Basin--Continued						
07-							
14333	Arkansas R. nr Hutchinson	C,F,R	21	24S	4W	ABDRS	KWO/ T-CE
143375	Arkansas R. nr Maize	C	23	26S	1W	BDR	USBR
143665	Little Ark. R. at Alta Mills	H,P	30	22S	2W	BDRS	KWO
1442	Little Ark. R. at Valley Center (floodway)		34	25S	1W	BR	KWO
1442	Little Ark. R. at Valley Center (main stem)	C,L	36	25S	1W	ABDRS	KWO
1443	Arkansas R. at Wichita (floodway)		11	27S	1W	BR	KWO
1443	Arkansas R. at Wichita (main stem)	C,F,P	5	28S	1E	BDR	KWO
14455	Arkansas R. at Derby	C,P	12	29S	1E	ABDRS	T-CE
14478	N. Fk. Ninnescah R. ab Cheney Reservoir	C,P	25	25S	6W	ABDRS	WICHITA
14479	Cheney Reservoir nr Cheney		6	27S	4W	ABRS	WICHITA/ T-CE
144795	N. Fk. Ninnescah R. at Cheney Dam	C,R	6	27S	4W	BDRW	WICHITA
14491	S. Fk. Ninnescah R. nr Pratt	H,P	2	28S	13W	ABDRS	KWO/ T-CE
1452	S. Fk. Ninnescah R. nr Murdock	C,F,L	34	28S	5W	ABDRS	KWO/ T-CE
1455	Ninnescah R. nr Peck	C,R	10	30S	1W	ABDRS	T-CE
1457	Slate Cr. at Wellington	H,P	23	32S	1W	ABDRS	KWO/ T-CE
1465	Arkansas R. at Arkansas City	C,L,P	35	34S	3E	ABDRS	T-CE
146622	El Dorado Lake nr El Dorado		30	25S	6E	ARS	T-CE
14683	Walnut R. at Hwy. 54 east of El Dorado	C,R	1	26S	5E	ABDRS	T-CE
14707	Whitewater R. at Towanda	C,F,P	8	26S	4E	ABDRS	KWO/ T-CE
1478	Walnut R. at Winfield	C,L	33	32S	4E	ABDRS	T-CE

Table 1. *Complete-record streamflow-gaging stations, 1993 water year*--Continued

Ident. no. (fig. 6)	Station name	Station purpose	Location Sec.	T.	R.	Type of gage	Coop. or support
	Arkansas River Basin--Continued						
07-							
1490	Medicine Lodge R. nr Kiowa	L,P	36	34S	11W	ABDRS	KWO
1515	Chikaskia R. nr Corbin	F,P	36	33S	3W	ABDRS	KWO
15559	Cimarron R. nr Elkhart	H	4	34S	42W	ABDRS	KWO
15622	Bear Cr. nr Johnson	H	12	28S	41W	BDR	KWO
1575	Crooked Cr. nr Nye	F,L	1	35S	27W	BDR	KWO
16575	Verdigris R. nr Virgil	C,P	19	24S	13E	ABDRS	T-CE
1659	Toronto Lake nr Toronto		36	26S	13E	ARTS	T-CE
1660	Verdigris R. nr Coyville	C,R	8	27S	14E	ABDRS	T-CE
1665	Verdigris R. nr Altoona	C,R	29	29S	16E	ABDRS	T-CE
1675	Otter Cr. at Climax	H,L	8	27S	11E	ABDRS	KWO
1680	Fall River Lake nr Fall River		3	28S	12E	ABRS	T-CE
1695	Fall R. at Fredonia	C,R	24	29S	14E	ABDRS	T-CE
1698	Elk R. at Elk Falls	C,H	3	31S	11E	ABDRS	KWO/T-CE
17005	Elk City Lake nr Independence		9	32S	15E	ABRS	T-CE
17006	Elk R. bl Elk City Lake	C,R	9	32S	15E	BDR	T-CE
1705	Verdigris R. at Independence	C,R	32	32S	16E	ABDRS	T-CE
170695	Big Hill Lake nr Cherryvale		7	32S	18E	ABRS	T-CE
1707	Big Hill Cr. nr Cherryvale	C,H	7	32S	18E	ABDRS	T-CE
1716	Caney R. nr Cedar Vale	C	11	34S	8E	ABDRS	T-CE
1720	Caney R. nr Elgin	C,L	16	35S	10E	ABDRS	KWO/T-CE
1733	Middle Caney Cr. at Sedan	C	3	34S	11E	ABDRS	T-CE
1794	Council Grove Lake nr Council Grove		10	16S	8E	ABRS	T-CE
1795	Neosho R. at Council Grove	C,R	14	16S	8E	ABDRS	T-CE
17973	Neosho R. nr Americus	C,R	24	18S	10E	ABDRS	T-CE
179794	Marion Lake nr Marion		27	19S	3E	ABRS	T-CE
179795	Cottonwood R. bl Marion Lake	C,R	27	19S	3E	ABCDRS	T-CE
1802	Cottonwood R. at Marion	C,R	31	19S	4E	ABDRS	T-CE
1804	Cottonwood R. nr Florence	C,R	10	21S	5E	ABDRS	T-CE
1805	Cedar Cr. nr Cedar Point	C,L	25	21S	5E	BDRS	KWO
18225	Cottonwood R. nr Plymouth	C,R	13	19S	9E	ABDRS	T-CE

Table 1. *Complete-record streamflow-gaging stations, 1993 water year*--Continued

Ident. no. (fig. 6)	Station name	Station purpose	Location Sec.	T.	R.	Type of gage	Coop. or support
	Arkansas River Basin--Continued						
07-							
18245	John Redmond Res. nr Burlington		9	21S	15E	ABRS	T-CE
18251	Neosho R. at Burlington	C,R	26	21S	15E	ABDRS	T-CE
1830	Neosho R. nr Iola	C,L,R	9	25S	18E	ABCDRS	T-CE
1835	Neosho R. nr Parsons	C,F,L,R	33	31S	21E	ABDRSW	KWO/T-CE
1840	Lightning Cr. nr McCune	H,L,P	7	32S	22E	BDR	KWO

Table 2. *Partial-record streamflow-gaging stations, 1993 water year*

Ident. no. (fig. 7)	Station name	Location Sec.	T.	R.	Coop. or support
	High Flow				
	Missouri River Basin				
06-					
8157	Buttermilk Cr. nr Willis	30	3S	18E	KDOT
81826	White Clay Cr. at Atchison	1	6S	20E	KC-CE
8451	Long Branch Draw nr Norcatur	6	2S	25W	KDOT
8476	Prairie Dog Cr. trib. at Colby	6	8S	33W	KDOT
85632	Elk Cr. at Clyde	26	5S	1W	KC-CE
8634	Big Cr. trib. nr Ogallah	11	13S	22W	KDOT
8637	Big Cr. trib. nr Hays	7	14S	17W	KDOT
8643	Smoky Hill R. trib. at Dorrance	12	14S	12W	KDOT
8683	Coon Cr. trib. nr Luray	19	10S	12W	KDOT
86995	Mulberry Cr. nr Salina	9	14S	3W	KC-CE
8733	Ash Cr. trib. nr Stockton	18	7S	18W	KDOT
87712	Mud Cr. at Abilene	17	13S	2E	KC-CE
8843	Mill Cr. trib. nr Washington	5	3S	4E	KDOT
8872	Cedar Cr. nr Manhattan	19	9S	8E	KDOT
88955	Indian Cr. nr Topeka	5	11S	16E	KC-CE
88963	Shunganunga Cr. at Topeka	6	12S	16E	KC-CE
91425	S. Fk. Pottawatomie Cr. trib. nr Garnett	7	21S	20E	KDOT
9151	Big Bull Cr. at Paola	17	17S	23E	KC-CE
9174	Marmaton R. trib. nr Fort Scott	9	26S	24E	KDOT

Table 2. *Partial-record streamflow-gaging stations, 1993 water year*--Continued

Ident. no. (fig. 7)	Station name	Location Sec.	T.	R.	Coop. or support
	High Flow--Continued				
	Arkansas River Basin				
07-					
1386	White Woman Cr. trib. nr Selkirk	34	17S	39W	KDOT
1397	Arkansas R. trib. nr Dodge City	11	27S	25W	KDOT
1431	Little Cheyenne Cr. trib. nr Claflin	28	18S	11W	KDOT
14702	Whitewater R. trib. nr Towanda	26	25S	3E	KDOT
14799	Cedar Cr. trib. nr Cambridge	26	31S	7E	KDOT
1567	Cimarron R. trib. nr Satanta	17	32S	33W	KDOT
1662	Sandy Cr. nr Yates Center	26	25S	14E	KDOT
	Low Flow				
	Arkansas River Basin				
07-					
1486	Medicine Lodge R. at Sun City	2	31S	15W	KWO
1513	Chikaskia R. at Spivey	14	30S	8W	KWO

Table 3. *Precipitation-record gaging stations, 1993 water year*

Ident. no. (fig. 8)	Station name	Location Sec.	T.	R.	Type of Gage	Coop. or support
	Missouri River Basin					
06-						
87965	Kings Cr. nr Manhattan	18	11S	8E	D	CBR
	Arkansas River Basin					
07-						
143633	at Inman	16	21S	4W	S	T-CE
1446	at Arlington	10	25S	8W	S	T-CE
146551	at Cassoday	27	23S	7E	S	T-CE
14758	at Atlanta	16	30S	6E	S	T-CE
14809	at Dexter	13	33S	6E	S	T-CE
151675	at Harper	11	32S	7W	S	T-CE
165829	at Thrall	28	24S	10E	S	T-CE
167451	at Beaumont	33	27S	8E	S	T-CE
17159	at Grenola	17	31S	9E	S	T-CE
17355	at Havana	13	34S	13E	S	T-CE
17978	at Durham	4	18S	2E	S	T-CE
18185	nr Diamond Springs	15	17S	6E	S	T-CE
18199	at Cottonwood Falls	29	19S	8E	S	T-CE
18209	nr Matfield Green	30	21S	8E	S	T-CE
18238	at Neosho Rapids	29	19S	13E	S	T-CE

Table 4. *Ground-water-level observation wells, 1993 water year*

County	Well number
Allen	24S 18E 28CDD 01
Barber	30S 11W 11CCA 01
	30S 11W 17AAC 01
	30S 11W 33ADA 01
	32S 12W 04DBC 01
Barton	18S 14W 27CDD 01
	18S 15W 28CCC 03
	19S 11W 19BDD 01
	19S 11W 26BDA 01
	19S 12W 06ADA 01
	19S 12W 28DBC 01
	19S 13W 08BAD 01
	19S 13W 33DDB 01
	19S 14W 06BBB 02
	19S 14W 23BBD 01
	19S 14W 29DDB 01
	19S 14W 30CDD01
	19S 14W 36BBC 01
	20S 11W 06CCC 01
	20S 11W 26AAC 01
	20S 12W 03DAC 01
	20S 12W 06AAC 01
	20S 12W 23CCA 01
	20S 13W 17DDC 01
	20S 13W 24DCB 01
	20S 14W 22DCB 01
	20S 15W 24DBD 01
	20S 15W 33ADD 01
Bourbon	25S 24E 36ADB 01
Cherokee	34S 24E 36BBA 01
Cheyenne	01S 38W 02CDC 01
	01S 38W 08DCC 01
	01S 38W 30BDC 01
	01S 39W 25CBC 01
	02S 37W 33DCC 01
	02S 39W 27BBB 01
	02S 40W 28DBA 01
	02S 40W 32BCB 01
	02S 41W 27BBD 01
	02S 41W 33DBC 01
Cheyenne (continued)	03S 37W 19BBC 01
	03S 37W 21DDD 01
	03S 37W 36ADB 01
	03S 38W 04BCC 01
	03S 38W 21BCB 01
	03S 38W 25BBB 01
	03S 39W 04CCC 01
	03S 39W 20DAC 01
	03S 39W 24DDD 01
	03S 39W 32BDB 01
	03S 40W 09BAA 02
	03S 40W 35AAC 01
	03S 41W 33ABB 01
	03S 42W 04AAA 01
	03S 42W 26CCD 01
	04S 37W 17AAC 01
	04S 37W 25DCA 01
	04S 38W 04BAC 01
	04S 38W 20CCC 01
	04S 38W 21ADC 01
	04S 40W 22BCB 01
	04S 41W 16DAA 01
	04S 41W 23AAA 01
	04S 41W 25BCB 01
	04S 41W 31ACA 01
	04S 42W 02BCC 01
	04S 42W 16CCD 01
	05S 37W 15DBB 01
	05S 38W 13BAD 01
	05S 38W 22ACB 01
	05S 39W 06DAA 01
	05S 39W 11CBC 01
	05S 39W 18CCC 01
	05S 39W 25CDA 01
	05S 40W 14BCD 01
	05S 41W 20DAA 01
	05S 42W 14DCC 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Clark	30S 23W 06AAA 01	Decatur	05S 26W 33DCC 01
	33S 22W 30CBC 01	(continued)	05S 27W 21CCA 01
			05S 28W 07BBC 01
Clay	06S 01E 02BCD 01		05S 28W 10BBB 01
	06S 02E 29DAC 01		05S 28W 14ADD 01
	08S 02E 02CCA 01		
			05S 28W 17DAC 01
Cloud	05S 02W 01BAC 01		05S 29W 11BAA 01
			05S 29W 22CBB 01
Comanche	31S 18W 19ACB 01		05S 30W 15CCB 01
	32S 18W 03DAC 01		05S 30W 35BCB 01
Crawford	29S 23E 24DBA 01	Dickinson	13S 01E 26DDC 01
	29S 24E 11ADD 01		
		Douglas	12S 20E 17CCB 01
Decatur	01S 26W 18DDB 01		
	01S 29W 03DDB 01	Edwards	23S 19W 22CCC 01
	01S 29W 19BDD 01		24S 16W 12CBC 01
	01S 30W 34DDD 01		24S 16W 12CCC 01
	02S 26W 11BBA 01		24S 17W 20ADC 01
			24S 17W 24DDD 01
	02S 28W 13ABA 01		
	02S 30W 23ADD 01		24S 18W 13DAC 01
	03S 26W 30CBB 02		24S 18W 17ABD 01
	03S 27W 32ABA 01		24S 18W 28DAC 01
	03S 28W 06DCB 01		24S 18W 36DDC 01
			24S 19W 34ADD 01
	03S 28W 32BCA 01		
	03S 29W 12BBA 01		25S 16W 02BBB 01
	03S 29W 17DCB 01		25S 16W 27AAC 01
	03S 29W 31DCC 01		25S 16W 31DCC 01
	03S 30W 03CBA 01		25S 17W 01DAB 01
			25S 17W 17AAC 01
	03S 30W 26BBB 01		
	04S 26W 08DDD 01		25S 17W 31BBD 01
	04S 26W 19DCA 01		25S 18W 09AAA 01
	04S 27W 17DAC 01		25S 18W 20AAB 01
	04S 27W 33BBB 01		25S 18W 33CDC 01
			25S 19W 08BDD 01
	04S 28W 15AAA 01		
	04S 28W 30DDD 01		25S 19W 26DDB 01
	04S 30W 07BBB 01		25S 19W 31CAB 01
	05S 26W 05ADD 01		25S 20W 03BCD 01
	05S 26W 26DDA 01		25S 20W 34CCC 01
			26S 16W 10CCC 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Edwards (continued)	26S 16W 31CCA 01	Finney (continued)	23S 27W 22DAB 01
	26S 16W 34ABC 01		23S 28W 22DCD 01
	26S 17W 14BAA 01		23S 28W 34DDC 01
	26S 17W 33DDB 01		23S 29W 30BBB 01
	26S 18W 15DCB 01		23S 29W 34CDD 01
	26S 18W 31CCC 01		23S 30W 04ACC 01
	26S 19W 12ABB 02		23S 30W 19CCB 01
	26S 19W 16BCB 01		23S 31W 03DCD 01
	26S 19W 31AAC 01		23S 31W 17ABA 01
	26S 19W 34BBD 01		23S 31W 35CCC 01
	26S 20W 20BBC 01		23S 32W 11ADC 01
			23S 32W 31CBD 01
Ellis	13S 18W 29CCC 01		23S 33W 17BBB 01
	14S 18W 12AAD 01		23S 33W 26ABB 01
	15S 18W 25CCD 01		23S 33W 28CDC 01
	15S 19W 25CAB 01		
			23S 34W 17CCC 01
Ellsworth	17S 09W 20BCD 01		23S 34W 21DDC 01
	17S 09W 21BCC 01		24S 31W 27CCB 01
	17S 09W 28CBB 02		24S 32W 03DAC 01
	17S 09W 31AAB 01		24S 32W 35DD 01
	17S 09W 31ADC 01		
			24S 33W 09CCD 01
Finney	21S 31W 26CCC 01		24S 33W 09CCD 02
	21S 32W 08ABD 01		24S 33W 09CCD 03
	21S 32W 20CBD 01		24S 33W 18BDB 02
	21S 32W 26DAA 01		24S 33W 19DBB 02
	21S 33W 29BBC 01		
			24S 33W 22BCC 01
	21S 34W 14DBB 01		24S 33W 22DCA 01
	21S 34W 16AADA02		24S 33W 28DAA 01
	22S 27W 14ADC 01		24S 33W 34CAC 01
	22S 31W 08CCC 01		24S 34W 01BCBB01
	22S 31W 16ADD 01		
			25S 31W 21CAB 01
	22S 32W 08ACB 01		25S 31W 35DBA 01
	22S 32W 21CDC 01		25S 32W 22DBC 01
	22S 33W 22BAA 01		25S 32W 31DDC 01
	22S 33W 36BCCC 01		25S 32W 35ADB 01
	22S 34W 08BCB 01		
			25S 33W 03BCC 01
	22S 34W 10AAA 01		25S 33W 05ABD 01
	22S 34W 18CDD 01		25S 33W 09ABD 01
	21S 31W 26CCC 01		
	22S 32W 08ACB 01		
	22S 34W 26CCC 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Finney (continued)	25S 33W 15DAC 01	Ford (continued)	26S 26W 18CCB 01
	25S 33W 16DCC 01		26S 26W 32DCC 01
	25S 33W 17DBD 01		26S 26W 36DCC 01
	25S 33W 33CDA 01		27S 21W 10DBB 01
	25S 33W 35DBD 01		27S 22W 09DAB 01
	25S 34W 06AAA 01		27S 23W 24BCB 01
	25S 34W 10ABB 01		27S 23W 28AAA 01
	25S 34W 34DBD 01		27S 23W 36CCC 01
	26S 31W 01DDA 01		27S 24W 03BBD 01
	26S 31W 06BBBB01		27S 24W 03CDD 01
	26S 31W 31CDC 01		27S 24W 04BBC 01
	26S 31W 36CAB 01		27S 24W 09AAD 01
	26S 32W 22ABB 01		27S 24W 16BDB 01
	26S 33W 17DBD 01		27S 24W 26DAA 01
	26S 33W 26ABB 01		27S 25W 09ACA 01
	26S 34W 05ADC 01		27S 25W 25BBB 01
	26S 34W 21BBD 01		28S 21W 10DDD 01
			28S 21W 23DBC 01
Ford	25S 22W 20AAA 01		28S 21W 25ABB 01
	25S 22W 27CCD 01		28S 22W 05ADD 01
	25S 23W 11CCC 01		
	25S 23W 12BBB 01		28S 22W 12CAC 01
	25S 23W 14ADD 01		28S 22W 32BAB 01
			28S 23W 18BAB 01
	25S 25W 32CDD 01		28S 23W 24ABB 01
	25S 25W 32DAD 01		28S 24W 08DCC 01
	25S 26W 25CDD 01		
	25S 26W 30ABC 01		28S 24W 22CDA 01
	26S 21W 17DBC 01		28S 24W 35CAB 01
			28S 25W 06ABB 01
	26S 21W 23ADA 01		28S 25W 19BBB 01
	26S 21W 25CCC 01		28S 26W 06AAB 01
	26S 22W 21DCD 01		
	26S 23W 02ABB 01		28S 26W 10BAA 01
	26S 23W 10DAD 01		28S 26W 13CAA 01
			29S 21W 05BBB 01
	26S 24W 29DDD 01		29S 21W 20CAD 01
	26S 24W 31DDA 01		29S 22W 17DAD 01
	26S 24W 32CBA 01		
	26S 24W 33CDA 01		29S 22W 36ACA 01
	26S 25W 16DCC 01		29S 23W 12BAC 01
			29S 24W 01ABA 01
			29S 24W 13BCA 01
			29S 24W 18BAA 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Ford	29S 25W 03ADA 01	Graham	07S 22W 10BBC 01
(continued)	29S 25W 10BBBC01	(continued)	07S 22W 19BBB 01
	29S 26W 01CDD 01		07S 24W 02BBB 01
	29S 26W 20BDD 01		07S 24W 08CBA 01
	29S 26W 29ABB 01		07S 25W 24BBB 01
	29S 26W 36BBB 01		07S 25W 33DDD 01
			08S 21W 17ABB 01
Geary	11S 06E 27CBB 01		08S 22W 18CDC 01
			08S 24W 23ACC 01
Gove	11S 26W 04CDC 01		08S 25W 24BAB 01
	11S 26W 19AAA 01		
	11S 27W 04CDC 01		09S 22W 19BBB 01
	11S 27W 13ABB 01		09S 23W 26BAA 01
	11S 27W 36BCC 01		09S 24W 22BAA 01
			09S 25W 14DDD 01
	11S 28W 08AAA 01		
	11S 28W 17DDC 01	Grant	27S 35W 17ADD 01
	11S 28W 26ABA 01		27S 35W 25BDC 01
	11S 29W 04DAD 01		27S 36W 18DCB 01
	11S 29W 33BBA 01		27S 36W 21DCC 01
			27S 36W 25CC 01
	11S 30W 27ABB 01		
	11S 30W 28CBA 01		27S 37W 04ABB 01
	11S 30W 36CBB 01		27S 37W 11ABA 01
	11S 31W 12AAB 01		27S 37W 16AAD 01
	11S 31W 27ADC 01		27S 37W 21BDD 01
			27S 38W 12ADC 01
	11S 31W 35BDC 01		
	12S 26W 12BCC 01		27S 38W 15BBB 01
	12S 27W 10CCB 01		27S 38W 22CBB 01
	12S 27W 12ABB 01		27S 38W 23CBB 01
	12S 28W 07DDD 01		28S 35W 03DBB 01
			28S 35W 05BCC 01
	12S 28W 12DDD 01		
	12S 29W 36CCC 01		28S 35W 15CBB 01
	13S 26W 20CBC 01		28S 35W 36ABC 01
	13S 27W 16CA 02		28S 36W 18ABC 01
	13S 28W 14AC 01		28S 36W 21CDD 01
			28S 37W 02BBB 04
Graham	06S 21W 19CDC 01		
	06S 22W 19CCC 01		28S 37W 10BCD 02
	06S 23W 13BBB 01		28S 38W 12BCB 01
	06S 23W 17CCA 01		28S 38W 17AAA 01
	06S 24W 14AAA 01		28S 38W 33BDB 01
			29S 35W 07CBD 01
	06S 24W 28BAB 01		
	06S 25W 12CCC 01		29S 35W 24BAA 01
	06S 25W 28CBC 01		29S 35W 28ACC 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Grant (continued)	29S 36W 19BCB 01	Gray (continued)	26S 30W 01ABC 01
	29S 36W 33ADB 01		26S 30W 24DDD 01
	29S 37W 03CDB 01		27S 27W 01BAA 01
	29S 37W 08CBA 01		27S 27W 07ADC 01
	29S 37W 29BBA 01		27S 27W 10CDB 01
	29S 38W 20CDC 01		27S 27W 25CCD 01
	29S 38W 35CCD 01		27S 28W 05AAA 01
	30S 35W 02DBC 01		27S 28W 30CCA 01
	30S 35W 19BCD 01		27S 29W 27CAA 01
	30S 36W 01BBB 01		27S 30W 08BBB 01
	30S 36W 04ABB 01		27S 30W 23BBA 01
	30S 36W 32BBC 01		27S 30W 34CCC 01
	30S 37W 02BAA 02		28S 27W 03BBB 01
	30S 37W 03DBA 01		28S 28W 07CDD 01
	30S 37W 20CBC 01		28S 28W 20ADD 02
	30S 38W 13CCC 01		28S 29W 16ACC 01
	30S 38W 15DBC 01		28S 30W 10DDD 01
	30S 38W 30ACA 01		28S 30W 17BBA 01
			28S 30W 24BAB 01
Gray	24S 27W 08CCC 01		29S 27W 30BCC 01
	24S 27W 14ABB 01		
	24S 27W 29BCC 01		29S 28W 28CDC 01
	24S 27W 31CDD 01		29S 29W 10ABB 01
	24S 28W 28BBA 01		29S 29W 27BCB 01
			29S 30W 22BBC 01
	24S 28W 31DD 01		29S 30W 35ACD 01
	24S 29W 16DCA 01		
	24S 29W 18CCB 01	Greeley	16S 39W 02BDC 01
	24S 30W 15CCC 01		16S 39W 22DCB 01
	24S 30W 33ADD 01		16S 40W 15ACC 01
			16S 40W 17CBC 01
	25S 27W 33ABB 01		16S 40W 26ADA 01
	25S 29W 07BCB 01		
	25S 29W 14ABB 01		16S 41W 20BAD 01
	25S 29W 27CCB 01		16S 42W 22BCB 01
	25S 30W 20BCB 01		16S 42W 25AAA 01
			17S 39W 02BAA 01
	26S 27W 13BBC 01		17S 39W 22ABB 01
	26S 27W 27CDD 01		
	26S 28W 06DDB 01		17S 39W 34CCB 01
	26S 29W 35CCC 01		17S 40W 15CCB 01
			17S 40W 17BBA 01
			17S 40W 31BBA 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number
Greeley (continued)	17S 42W 27CBB 01
	18S 39W 07BBD 01
	18S 39W 19CDA 01
	18S 39W 23CCB 01
	18S 39W 24AAC 01
Hamilton	21S 39W 07CBA 01
	22S 39W 03BBB 01
	23S 39W 15ADD 01
	23S 40W 29DDB 01
	23S 42W 19CBB 01
	23S 42W 26DCA 01
	23S 42W 27DDB 01
	23S 42W 34CBB 01
	23S 43W 21ABA 01
	23S 43W 23BCB 01
	23S 43W 25CBD 02
	23S 43W 26BCC 01
	24S 39W 19CBC 01
	24S 39W 22CCB 01
	24S 39W 35BAC 01
	24S 39W 35CBA 01
	24S 40W 07CBB 01
	24S 40W 17BBB 01
	24S 40W 23AAB 01
	24S 40W 31BBB 01
	24S 41W 01DAD 01
	24S 42W 04AAD 01
	24S 42W 28DDD 01
	24S 43W 14CBB 01
	25S 39W 02CAD 01
	25S 39W 23BDD 01
	25S 40W 01CA 01
	25S 40W 26BBB 01
	25S 43W 03ABB 01
	25S 43W 25CCD 01
	26S 41W 20BCD 01
	26S 41W 32DDB 01
	26S 41W 36CCC 01
	26S 42W 10BB 02
Hamilton (continued)	26S 42W 17CBB 01
	26S 42W 22DCC 01
	26S 43W 10DBB 01
	26S 43W 25DCC 01
Harper	32S 06W 01DDD 01
Harvey	22S 02W 05CBD 01
	22S 02W 29BBA 01
	22S 03W 02DCD 01
	22S 03W 28BAD 01
	22S 03W 35AAA 01
	23S 01W 19AAC 01
	23S 01W 28AAD 01
	23S 02W 22CCD 01
	23S 02W 34DCC 01
	23S 03W 06DDD 01
	23S 03W 14AAC 01
	23S 03W 32DCC 02
	24S 01W 05AAB 01
	24S 01W 19BCC 01
	24S 01W 22BCC 01
	24S 02W 16BAA 01
	24S 02W 28DDD 01
	24S 03W 14BBB 01
Haskell	27S 31W 24CDC 01
	27S 31W 31BCC 01
	27S 32W 03CBB 01
	27S 32W 06CBB 01
	27S 32W 19CCD 01
	27S 33W 29DAA 01
	27S 34W 16DDD 01
	27S 34W 28DAA 02
	28S 31W 35CCB 01
	28S 32W 18BBB 01
	28S 32W 24BCC 01
	28S 33W 20DDD 01
	28S 34W 15DAB 01
	29S 31W 09CB 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Haskell (continued)	29S 31W 34BCA 01	Jackson	06S 15E 27BAB 01
	29S 32W 04AAA 01		
	29S 32W 19CCC 01	Kearny	22S 35W 23CDD 01
	29S 32W 26CBB 02		22S 36W 28DCC 01
	29S 33W 01AAB 01		22S 37W 34BBC 01
			23S 35W 05ACC 01
	29S 33W 28BCB 01		23S 35W 12CCC 01
	29S 33W 34DDD 01		
	30S 31W 24BBC 01		23S 35W 16BBC 01
	30S 31W 26ABB 01		23S 35W 25BBB 02
	30S 32W 11BBB 01		23S 36W 04CBB 01
			23S 36W 32BBB 01
	30S 32W 22BBB 01		23S 36W 35BBB 01
	30S 32W 31BAB 01		
	30S 34W 05BBB 01		23S 37W 04ABC 01
	30S 34W 30ADD 02		23S 37W 19CCC 01
			23S 37W 28CCB 01
Hodgeman	21S 22W 12BCB 01		24S 35W 09CCC 01
	22S 22W 13CCC 01		24S 35W 13CCC 02
	22S 24W 14BBC 01		
	22S 24W 15BDA 01		24S 35W 24BCB 01
	22S 24W 16ADB 02		24S 36W 23CBB 02
			25S 35W 02BAA 01
	22S 24W 24DDD 01		25S 35W 04BDD 01
	22S 24W 25DDC 01		25S 35W 17AAA 01
	22S 24W 26DDA 01		
	22S 24W 35DAC 01		25S 35W 26BAB 01
	23S 22W 07DAA 01		25S 36W 14B 01
			25S 36W 28BBD 01
	23S 23W 04AAD 01		25S 36W 35CCA 01
	23S 23W 04DCA 01		25S 37W 15ABA 02
	23S 23W 12ABD 01		
	23S 24W 11DAA 01		25S 37W 25BAD 02
	23S 26W 07CCC 01		25S 38W 02BDA 01
			25S 38W 08CAA 01
	23S 26W 20CCC 01		25S 38W 20ACC 01
	23S 26W 26AAD 01		25S 38W 26ACC 01
	23S 26W 31CDD 01		
	24S 21W 20CBB 01		26S 35W 06ACC 01
	24S 23W 03CCC 01		26S 35W 29BBD 01
			26S 36W 22CCA 01
	24S 23W 06AAB 01		26S 37W 06ACB 01
	24S 24W 02CCC 01		
	24S 24W 20CCC 01		
	24S 25W 22BAB 01		
	24S 26W 35CBC 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Kingman	27S 05W 24CDC 01	Kiowa	27S 20W 26ABD 01
	27S 05W 33ABB 02	(continued)	28S 17W 01CAB 01
	27S 06W 12CCD 01		28S 16W 12BCA 01
	27S 06W 16CCB 01		28S 17W 15DDB 01
	27S 07W 03ADC 01		28S 18W 05CDB 01
	27S 07W 23BCC 01		28S 18W 09BAC 01
	27S 08W 14DDC 01		28S 18W 19CCB 01
	27S 08W 17DAB 01		28S 18W 25CAC 01
	27S 08W 25DAD 01		28S 19W 10AAC 01
	27S 08W 28DAA 01		28S 19W 30CBC 01
	27S 08W 35CBC 01		28S 19W 33CBD 01
	27S 09W 15ABA 01		28S 20W 12BBD 01
	27S 09W 29AAA 01		20S 20W 30ACA 01
	27S 10W 03DDD 01		29S 16W 02ADB 01
	27S 10W 17DDD 01		29S 17W 04ABC 01
	27S 10W 24DAD 01		29S 17W 12DAA 01
	28S 07W 29CDD 01		29S 18W 02ACC 01
	28S 07W 35CCD 01		29S 18W 07BBD 01
	28S 08W 21BBB 01		29S 19W 22BAA 01
	28S 08W 26ABC 01		29S 20W 11CDD 01
	28S 09W 01BCC 01	Labette	31S 21E 15CCC 02
	28S 09W 21AAA 01		
	28S 09W 29CCC 01	Lane	16S 29W 26CCD 01
	28S 09W 34AAB 01		16S 29W 33BAB 01
	28S 10W 16BCB 01		16S 30W 24DCC 01
			16S 30W 29CDD 01
	29S 10W 19DDB 01		16S 30W 34DAB 01
	30S 10W 05BBD 01		
	30S 10W 13AAC 01		17S 27W 20CCC 01
	30S 10W 28DAC 01		17S 27W 26CCC 01
			17S 28W 07BBB 01
Kiowa	27S 16W 10BAC 01		17S 28W 15BBC 01
	27S 16W 19BBD 01		17S 28W 26ABB 01
	27S 16W 28CDD 01		
	27S 17W 21ADC 01		17S 28W 34CBB 01
	27S 18W 13AAA 01		17S 29W 10BAC 01
			17S 29W 36BAA 01
	27S 18W 18DDC 01		17S 30W 13CBB 01
	27S 18W 22ADC 01		17S 30W 20BBB 01
	27S 18W 36AAC 01		
			18S 27W 13CCC 01
	27S 20W 32ABD 01		18S 28W 18ACC 01
	30S 10W 28DAC 01		18S 29W 04DDA 01
	28S 16W 12BCA 01		
	28S 16W 17AAC 01		
	27S 19W 28CBD 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Logan	18S 30W 02AAA 01	Meade	30S 26W 04CBB 01
	18S 30W 04BAB 01		30S 26W 13ABB 01
	18S 30W 23AAA 01		30S 26W 32DDD 01
	11S 32W 04ACD 01		30S 27W 20ABA 01
	11S 32W 19AAB 01		30S 27W 23ABB 01
	11S 32W 31CCD 01		30S 27W 27BBB 01
	11S 32W 36ABA 01		30S 27W 32DDD 01
	11S 33W 14DCC 01		30S 28W 17ABB 01
	11S 34W 13AAB 01		30S 28W 33AAA 01
	11S 34W 16CDB 01		30S 29W 23CAD 01
	11S 36W 06ADD 02		30S 29W 28BBB 01
	11S 37W 01DCD 01		30S 30W 06CCC 01
	13S 36W 20CCB 01		30S 30W 28ABB 01
	15S 37W 29AAA 01		31S 26W 30BBB 01
			31S 27W 20AAA 02
McPherson	17S 04W 25DDD 01		
	17S 05W 07CBB 01		31S 28W 02CCC 01
	17S 05W 22BAA 01		31S 28W 10BCB 01
	18S 03W 30CCC 01		31S 28W 26ABB 01
	18S 04W 21CCC 01		31S 29W 02DBB 01
			31S 29W 25AAA 02
	19S 01W 32DAC 01		
	19S 03W 16BCB 01		31S 29W 30AAA 01
	19S 03W 31BBA 01		31S 30W 16BBC 01
	19S 04W 15AAC 01		32S 28W 04ADD 01
	20S 01W 22BBB 01		32S 29W 05CC 01
			32S 29W 27AAB 02
	20S 01W 29DDD 01		
	20S 03W 22DAA 01		32S 30W 09CCC 01
	20S 03W 30BBA 01		33S 28W 29BCB 01
	20S 04W 15BDD 01		33S 29W 36AAB 01
	20S 04W 27DAC 01		34S 28W 05BDA 01
			34S 30W 22CBC 01
	21S 02W 12BBB 01		
	21S 02W 28CBA 01		35S 30W 10CDA 01
	21S 02W 36ACA 01		
	21S 03W 06CBD 01		
	21S 03W 22BBB 01		
	21S 03W 33BBC 01		
	21S 04W 26CDC 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Morton	31S 39W 18CCC 01	Nemaha	05S 11E 10ADB 01
	31S 39W 33BCC 01		
	31S 40W 29ABB 01	Ness	16S 24W 15ABB 01
	31S 41W 07CDD 01		16S 26W 24DDA 01
	31S 41W 31CBB 01		18S 21W 25AAB 01
			18S 21W 31CAA 01
	31S 42W 29AAB 01		18S 24W 36ADB 01
	31S 43W 03CB 01		
	31S 43W 14DDC 01		18S 25W 33BBC 01
	32S 40W 07BDC 01		18S 26W 06BAB 02
	32S 40W 21ADB 01		19S 23W 01CCB 01
			19S 23W 08CBB 01
	32S 41W 15CDC 01		20S 22W 20CCC 01
	32S 41W 35DCC 01		
	32S 42W 14CCC 01		20S 22W 35BCC 01
	32S 42W 21BCC 01		20S 23W 32CDA 01
	32S 42W 26CDD 01		20S 26W 07BDC 01
	32S 43W 08CBD 01	Norton	01S 21W 17AAA 01
	32S 43W 28BBC 01		01S 23W 15AAA 01
	33S 39W 04DBB 01		01S 24W 13BCB 01
	33S 39W 16ABB 01		01S 25W 25BBB 01
	33S 40W 27CCC 01		02S 21W 33CCC 01
	33S 41W 03AAD 01		02S 23W 22AAA 01
	33S 41W03ADA 01		02S 25W 14AAA 01
	33S 41W 33DDD 01		04S 23W 03DDD 01
	33S 42W 05DCC 01		04S 23W 26CCC 01
	33S 42W 21BCB 01		04S 25W 13CCC 01
	33S 43W 08BDA 01		05S 21W 10AAA 01
	33S 43W 09DBA 01		05S 22W 18CCD 01
	33S 42W 21BCB 01		05S 24W 14BDC 01
	34S 39W 06CCA 01		
	34S 40W 16ABB 01	Osborne	06S 12W 23CDC 01
			07S 12W 28ABA 01
	34S 41W 26DCD 01		07S 15W 10CCC 01
	34S 41W 28CBA 01		
	34S 42W 05BDC 01	Pawnee	21S 15W 11CBB 01
	34S 42W 22CDB 01		21S 15W 17CCC 01
	34S 43W 07BDD 01		21S 15W 31BAD 01
			21S 16W 14ADC 01
	35S 39W 06CDD 01		21S 18W 32DAA 01
	35S 40W 03BBB 02		
	35S 41W 16CCD 01		21S 19W 27CCC 01
	35S 42W 02DBB 01		
	35S 43W 04AAC 01		
	35S 43W 13BDB 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Pawnee (continued)	21S 19W 30BCC 01	Pratt (continued)	26S 14W 17DCB 01
	21S 20W 29BBB 01		26S 15W 01AAB 01
	22S 15W 03AAA 01		26S 15W 17BBC 01
	22S 15W 03AAA 02		27S 11W 12CBC 01
	22S 15W 09CCA 01		27S 11W 31DAA 01
	22S 15W 13DCA 01		27S 12W 12DAA 01
	22S 15W 33DDD 01		27S 12W 33CBA 01
	22S 16W 03CBC 02		27S 13W 13DDC 01
	22S 16W 06BBA 01		27S 14W 03DAC 01
	22S 16W 23AAA 01		27S 14W 12DDD 01
	22S 16W 32CDD 01		27S 14W 21CAB 01
	22S 17W 05BBC 02		27S 15W 02ABC 01
	22S 17W 18AAD 01		27S 15W 05CDB 01
	22S 17W 24CBC 01		27S 15W 32CCA 01
	22S 17W 27BAB 01		27S 15W 36ADD 01
	22S 19W 07AAA 01		28S 11W 12ACC 01
	22S 19W 10BBA 01		28S 11W 20CAC 01
	23S 15W 12DDB 01		28S 12W 21BAD 01
	23S 15W 21DCC 01		28S 12W 34CCC 01
	23S 16W 11CDC 01		28S 13W 02DDC 01
	23S 16W 35CCD 02		28S 13W 17AAA 01
	23S 17W 07DBB 01		28S 13W 26DCB 01
	23S 17W 10CDB 01		28S 14W 14CCC 01
	23S 17W 25AAC 01		28S 15W 23CCD 01
	23S 17W 33CCA 01		29S 11W 06AAA 01
	23S 18W 28DAD 01		29S 11W 09ADD 01
	23S 18W 36DAC 01		29S 11W 29AAD 01
			29S 12W 20CCD 01
Phillips	04S 18W 23CDC 01		29S 13W 12ABB 01
	04S 19W 35DDD 01		29S 13W 31CAA 01
Pratt	26S 11W 01DDB 01		29S 14W 12ABB 01
	26S 11W 27AAC 01		29S 14W 17DBD 01
	26S 11W 29BCB 01		29S 15W 02CCA 01
	26S 12W 02ABA 01		29S 15W 18ADA 01
	26S 12W 17CCA 01		29S 15W 25AAB 02
	26S 12W 34CDC 01		
	26S 12W 34CDC 02		
	26S 13W 16DAA 01		
	26S 13W 19BBD 01		
	26S 13W 34BCB 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Rawlins	01S 33W 29CCC 01	Reno	22S 07W 17DCB 01
	02S 31W 03CAD 01	(continued)	22S 08W 09DBB 01
	02S 32W 20DCD 01		22S 08W 23DAD 01
	02S 33W 26DCC 01		22S 08W 33CCD 01
	02S 35W 13ABB 01		22S 09W 03BBD 01
	02S 35W 34CAA 01		22S 09W 17BAB 01
	02S 36W 13DDD 01		22S 09W 25BBA 01
	02S 36W 36BAA 01		22S 10W 02DCC 01
	03S 31W 07CBD 01		22S 10W 08BBB 01
	03S 33W 03DCC 01		22S 10W 30DAA 01
	03S 33W 08CDC 01		23S 04W 03BAB 02
	03S 34W 03ABB 01		23S 04W 16BBB 01
	03S 34W 26BAC 01		23S 04W 30BAA 01
	03S 35W 24CBB 01		23S 05W 05DDC 01
	03S 36W 14CBB 01		23S 06W 15BAC 01
	03S 36W 17CCC 01		23S 06W 31DCB 01
	03S 36W 21DBC 01		23S 07W 01ABA 01
	04S 31W 16ABD 01		23S 07W 05ABA 01
	04S 33W 10ABC 01		23S 07W 09DDD 01
	04S 33W 18DDA 01		23S 07W 13DDD 01
	04S 33W 28DCA 01		23S 08W 18AAD 01
	04S 34W 33CBC 01		23S 09W 05CBD 01
	04S 35W 06DCD 01		23S 09W 21DDB 01
	04S 35W 29DDD 01		23S 09W 35CCC 01
	04S 36W 23CBB 01		23S 10W 01AAA 03
	04S 36W 23DCA 01		23S 10W 25CAC 01
	05S 31W 10DDA 01		23S 10W 29DCA 01
	05S 31W 20CCA 01		24S 04W 05CDB 01
	05S 32W 14CDD 01		24S 04W 14DAC 01
	05S 33W 29BDA 01		24S 04W 25BBD 01
	05S 34W 01BBB 01		24S 04W 31DAB 02
	05S 34W 28ADC 01		24S 05W 10CCA 01
	05S 35W 30CBC 01		24S 06W 03AAB 01
	05S 36W 21BCD 01		24S 06W 23CBA 01
			24S 07W 08ADA 02
Reno	22S 04W 12CDA 01		24S 07W 28AAA 01
	22S 04W 32BBC 01		24S 08W 04AB 01
	22S 05W 17BCC 01		24S 08W 18BAC 01
	22S 06W 18BCB 01		24S 08W 34DAC 01
	22S 06W 28CCB 01		24S 09W 19DDB 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Reno (continued)	24S 10W 06DBB 01	Rooks	07S 17W 24BBC 01
	24S 10W 17DDC 01		07S 19W 23CDB 01
	24S 10W 31CBC 01		
	25S 04W 02ABB 01	Rush	18S 16W 18DAB 01
	25S 07W 07BBD 01		18S 16W 23DCC 01
			18S 16W 23DCC 02
	25S 07W 36CCC 01		18S 17W 14CCC 01
	25S 08W 19ADB 01		18S 17W 22AAD 01
	25S 09W 01DCD 01		
	25S 09W 17BBC 01		18S 17W 23BCC 01
	25S 09W 30DDA 01		18S 17W 30CAB 01
			18S 18W 27AAC 01
	25S 10W 14BBB 01		18S 19W 20ADD 01
	25S 10W 19ABD 01		18S 20W 14CCC 01
	26S 06W 13BAB 01		
	26S 06W 34BBC 01		18S 20W 19AAD 01
	26S 07W 12DCC 01		
		Saline	13S 01W 23BCB 02
	26S 07W 21DDC 01		13S 02W 33DDC 01
	26S 08W 06DCC 01		16S 02W 18CCC 01
	26S 08W 30DAA 01		16S 03W 33DCD 01
	26S 09W 10DDB 01		
	26S 09W 18AAA 01	Scott	16S 31W 17DDD 01
			16S 31W 31BCB 01
	26S 09W 31DCC 01		16S 32W 16BCA 01
	26S 09W 34DBD 01		16S 33W 19CBB 01
	26S 10W 18CDC 01		16S 33W 33BAA 01
	26S 10W 32BBD 01		
			16S 34W 09CCB 01
Republic	01S 03W 01CCA 01		16S 34W 29CBB 01
	01S 03W 09CBD 01		17S 31W 04DCC 01
	01S 04W 15AAA 01		17S 31W 19CDA 01
			17S 31W 35CCB 01
Rice	18S 09W 04BCC 01		
	18S 10W 24BBB 01		17S 32W 16BBB 01
	20S 08W 22AAA 01		17S 32W 27BBB 01
	20S 09W 12DDA 01		17S 32W 31BCB 01
	20S 09W 28ACD 01		17S 33W 07BBA 01
			17S 33W 14ACB 01
	20S 10W 27BBB 01		
	20S 10W 36ACD 01		17S 34W 06BCB 01
	21S 07W 04AAC 01		17S 34W 16ACB 01
	21S 07W 26CBD 01		17S 34W 25DBB 01
	21S 08W 09CBD 01		18S 31W 24BCB 01
			18S 31W 27ABA 01
	21S 08W 25ABB 01		
	21S 08W 32DBB 01		
	21S 09W 02DDA 01		
	21S 09W 15AAC 02		
	21S 10W 16CDC 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Scott (continued)	18S 32W 14BBB 01	Sedgwick (continued)	26S 02W 10DAA 01
	18S 32W 17ABA 02		26S 02W 14DDD 01
	18S 33W 03CCB 01		26S 02W 15DBB 01
	18S 33W 05CCC 01		26S 02W 23CCC 01
	18S 33W 11ABB 01		26S 02W 29AAA 01
	18S 33W 15DDD 01		26S 03W 02AAC 01
	18S 33W 25BBB 01		28S 01W 11BCB 01
	18S 33W 34ADB 01		28S 01W 15ACA 02
	18S 34W 05CBB 01		28S 01W 36BAB 01
	18S 34W 25BBD 01		29S 01E 11BCC 01
	18S 34W 34BBC 01		29S 01E 16DDD 01
	19S 32W 06CCB 01		29S 01E 35BBA 01
	19S 32W 32ACB 01		29S 01W 25AAA 01
	19S 33W 06DBB 01	Seward	31S 31W 08BCC 01
	19S 33W 12DDC 01		31S 32W 03DAD 01
	19S 33W 15DBD 01		31S 32W 31BBB 01
	19S 33W 29CBB 02		31S 33W 06CBD 01
	19S 34W 19DCCC01		31S 33W 20DBB 01
	20S 32W 16DAD 01		31S 34W 18BBB 01
	20S 32W 30BCD 01		32S 31W 02BBB 01
	20S 33W 02DBB 01		32S 31W 08BBB 01
	20S 33W 09BBB 01		32S 31W 26CAA 01
	20S 33W 17BAB 01		32S 32W 14BBB 01
	20S 33W 21ABA 01		32S 32W 19BAB 01
	20S 34W 15BAA 01		32S 33W 04BAA 01
	20S 34W 36CCD 01		32S 33W 32DBD 01
Sedgwick	25S 01W 07ABD 01		32S 34W 10DAA 01
	25S 01W 26DBD 01		32S 34W 32BBB 01
	25S 01W 28DBA 01		33S 31W 09AAB 01
	25S 02W 16DDB 01		33S 31W 28DDB 01
	25S 02W 23DBD 01		33S 32W 28CDD 02
	25S 03W 03DDD 01		33S 33W 12AAD 01
	25S 03W 15CCC 01		33S 33W 20BCC 01
	26S 01W 12BAD 01		33S 33W 25DCC 01
	26S 01W 19ABA 01		33S 34W 17DCC 01
	26S 01W 31CCC 02		34S 31W 30BBB 01
	26S 01W 31CCD 01		34S 32W 29BAA 01
	26S 02W 02DDD 02		34S 32W 35ADA 01
	26S 02W 07AAA 02		34S 33W 07CCB 01
	26S 02W 08AAB 01		34S 34W 16DAA 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Seward (continued)	34S 34W 26BCA 01	Sheridan (continued)	08S 27W 35CBB 01
	35S 31W 10AAC 01		08S 28W 11DAA 01
	35S 31W 18BBA 01		08S 29W 01DCB 01
	35S 32W 06CBB 01		08S 30W 11CBC 01
	35S 33W 16BCA 01		08S 30W 13DAA 01
	35S 34W 03CBC 01		08S 30W 30ABC 01
	35S 34W 10BBB 01		09S 26W 22BBB 01
			09S 27W 12CCC 01
Sheridan	06S 26W 26CBB 01		09S 27W 19DDD 01
	06S 27W 05CBB 01		09S 27W 27DAA 01
	06S 27W 08DCA 01		
	06S 27W 19ADC 01		09S 28W 04BCC 01
	06S 29W 10DBC 01		09S 29W 03AAA 01
			09S 29W 17BAB 01
	06S 29W 24ABB 01		09S 29W 26BAA 01
	06S 29W 33CDA 01		09S 30W 03AAB 02
	06S 30W 13BAA 01		
	06S 30W 14CCD 01		09S 30W 35BBB 01
	07S 26W 06AAB 01		10S 26W 08BAA 01
			10S 26W 12AAD 01
	07S 26W 12BAC 01		10S 27W 20CBC 01
	07S 26W 19BBC 01		10S 27W 22DBA 01
	07S 26W 28CAB 01		
	07S 27W 09BCB 01		10S 28W 05DDB 01
	07S 27W 22DAC 01		10S 28W 29DAA 01
			10S 29W 02DDD 01
	07S 28W 08BDC 01		10S 29W 20CAA 01
	07S 28W 21ABB 01		10S 30W 08DDD 01
	07S 28W 36ABA 01		
	07S 29W 05BBB 01		10S 30W 12ADA 01
	07S 29W 27CCC 01		
		Sherman	06S 37W 07BBA 01
	07S 29W 30ABA 01		06S 37W 16CDD 01
	07S 30W 08CBB 01		06S 37W 19ABB 01
	08S 26W 14DAA 01		06S 38W 09ABD 01
	08S 27W 11DCD 01		06S 39W 09DDD 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Sherman (continued)	06S 40W 10AAC 01	Sherman (continued)	09S 38W 13BCC 01
	06S 40W 13CBC 01		09S 39W 01DBA 01
	06S 40W 30DCC 01		09S 39W 02BAB 01
	06S 41W 19DBD 01		09S 39W 10CCB 01
	06S 41W 27DBD 01		09S 39W 19CCC 01
	06S 42W 02AAA 01		09S 40W 13CDC 01
	06S 42W 08CBB 01		09S 40W 29BBB 01
	06S 42W 22DCC 01		09S 41W 05DCC 01
	06S 42W 30ADA 01		09S 41W 14BBC 01
	07S 37W 04BBC 01		09S 41W 28AAA 01
	07S 37W 05CCB 01		09S 41W 34BAB 01
	07S 38W 28DAA 01		09S 42W 08AAA 01
	07S 39W 01DCD 01		09S 42W 14AAA 01
	07S 39W 09BBB 01		09S 42W 35ABB 01
	07S 39W 24BAA 01		10S 37W 23ABB 01
	07S 40W 06ADB 01		10S 40W 10ADC 01
	07S 40W 29BBA 01		10S 41W 15CAD 01
	07S 40W 35BBB 01		10S 42W 20ABB 01
	07S 40W 36BAB 01		10S 42W 21BBB 01
	07S 41W 07BCB 01		10S 42W 24BAB 01
	07S 41W 28DBB 01	Stafford	21S 11W 07BBB 01
	07S 42W 07DAA 01		21S 12W 10CDD 01
	07S 42W 17CCC 01		21S 13W 05CBD 01
	07S 42W 27AAB 01		21S 13W 27DDD 02
	08S 37W 03ADB 01		21S 14W 22AAC 01
	08S 37W 21CCC 01		21S 14W 32BAC 01
	08S 37W 32ABB 01		22S 11W 07BBB 01
	08S 38W 17CDD 01		22S 12W 05BBD 01
	08S 38W 24AAB 01		22S 12W 30BBD 01
	08S 39W 15CCC 01		22S 12W 36BBB 02
	08S 40W 12DBA 01		22S 13W 05CBC 01
	08S 40W 17CDB 01		22S 13W 12CAC 01
	08S 40W 25AAC 01		22S 13W 29DAD 01
	08S 41W 17CBA 01		22S 14W 14CCA 01
	08S 41W 25BBC 01		22S 14W 35DDB 01
	08S 42W 15DDB 01		23S 11W 02BBB 01
	08S 42W 31DCD 01		
	09S 37W 07DDB 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Stafford (continued)	23S 11W 22BCC 01	Stanton (continued)	27S 41W 07DCC 01
	23S 11W 36CCA 01		27S 41W 31CCB 02
	23S 12W 07DBD 01		27S 41W 35CCC 01
	23S 12W 22BCC 01		27S 42W 17CCC 01
	23S 12W 36BBC 01		27S 43W 02BBD 01
	23S 13W 08CCB 01		28S 39W 14BBC 01
	23S 13W 30CBB 01		28S 39W 16CCC 01
	23S 13W 35CCA 01		28S 39W 33ACC 01
	23S 14W 15ADD 01		28S 39W 36ABB 01
	23S 14W 30BBB 01		28S 40W 04CCC 01
	24S 11W 14CAB 01		28S 40W 12DDD 02
	24S 11W 17DDB 01		28S 40W 32CCB 01
	24S 12W 04CDB 01		28S 41W 02CCC 01
	24S 12W 17CAB 01		28S 41W 34BDD 01
	24S 12W 34ABC 01		28S 42W 06DBB 01
	24S 13W 16ACA 01		28S 42W 08CCC 01
	24S 13W 20CDD 01		28S 42W 20BCC 01
	24S 13W 36DDD 01		28S 42W 32BBB 01
	24S 14W 17AAC 01		29S 39W 21DBD 01
	24S 14W 31BBD 01		29S 39W 24DDA 01
	24S 15W 10BAB 01		29S 40W 28ABB 01
	24S 15W 32DBC 01		29S 41W 13ACC 01
	25S 11W 02ACB 01		29S 42W 08CDC 01
	25S 11W 23DDD 01		29S 42W 24CCC 01
	25S 12W 11AAA 01		29S 43W 33CDB 01
	25S 12W 16DCA 01		30S 39W 23BBB 01
	25S 12W 24DDB 01		30S 40W 12BBB 01
	25S 13W 16AAC 01		30S 40W 24CDC 01
	25S 13W 31DDA 01		30S 40W 33CCB 01
	25S 13W 36DCC 01		30S 41W 13CCC 02
	25S 14W 04AAD 01		30S 41W 23DDB 01
	25S 14W 21DDB 01		30S 42W 12ACC 01
	25S 14W 30CDB 01		30S 42W 16BDB 01
	25S 15W 11BCB 01		30S 43W 34BBB 01
	25S 15W 29BBD 01		30S 43W 36BB 01
Stanton	27S 39W 27BBA 01		
	27S 40W 07ABB 01		
	27S 40W 16CCC 01		
	27S 40W 25CBC 01		

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Stevens	31S 35W 15BAA 01	Stevens	35S 36W 15AAD 01
	31S 35W 26DCC 01	(continued)	35S 37W 16BCC 01
	31S 36W 02CDD 01		35S 39W 10CAD 01
	31S 36W 24BCB 01		
	31S 36W 27BCB 01	Sumner	30S 01E 09BBD 01
			30S 04W 21CBB 01
	31S 37W 09BCC 01		30S 04W 34BAA 01
	31S 37W 22BCC 01		31S 02E 09BBD 01
	31S 37W 30DDB 01		31S 02E 23BDB 01
	31S 38W 17CDA 01		
	31S 39W 23BBB 01		31S 04W 01DAC 01
			31S 04W 02BBB 01
	32S 35W 08DDD 01		
	32S 36W 21AAC 01	Thomas	06S 31W 03ADB 01
	32S 37W 10DCC 01		06S 31W 33CCD 01
	32S 37W 26BAC 01		06S 32W 12CBC 01
	32S 38W 11ADA 01		06S 32W 29CDC 01
			06S 33W 07BBB 01
	32S 38W 23BDD 01		
	32S 39W 02BBB 01		06S 33W 23DDD 01
	32S 39W 14DDD 01		06S 34W 01DDD 01
	33S 35W 23CBB 01		06S 34W 11CDD 01
	33S 36W 26DDD 01		06S 34W 17CBC 01
			06S 34W 22DCA 01
	33S 37W 17CCC 01		
	33S 37W 23CDB 01		06S 34W 31CDB 01
	33S 38W 06AAB 01		06S 35W 02CDD 01
	33S 38W 10ACC 01		06S 35W 26ACB 01
	33S 38W 20DDB 01		06S 36W 07BBB 01
			06S 36W 11ACC 01
	34S 35W 03DCC 01		
	34S 35W 07CBB 01		06S 36W 30DCB 01
	34S 35W 26ACC 01		06S 36W 34DDB 01
	34S 36W 10CAC 01		07S 31W 01DCA 01
	34S 36W 21DBD 01		07S 32W 07ACA 01
			07S 32W 13DBD 01
	34S 37W 08DAC 01		
	34S 37W 27ABC 02		07S 32W 33BCB 01
	34S 37W 29BBD 01		07S 33W 07BDA 01
	34S 37W 35AAD 01		07S 33W 35ADD 01
	34S 38W 02ADC 01		07S 34W 25AAA 01
			07S 34W 26DBD 01
	34S 38W 34CAA 01		
	34S 39W 02CCA 01		07S 35W 09CCC 01
	34S 39W 15CAD 01		07S 36W 17CCC 01
	35S 35W 15BCC 01		08S 31W 03CDD 01
	35S 36W 01AAA 01		08S 31W 20CDD 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Thomas (continued)	08S 32W 07BAA 01	Wallace	11S 38W 35CCC 02
	08S 32W 12DBC 01		11S 42W 08DDC 01
	08S 32W 27DAB 01		11S 42W 10AAD 01
	08S 33W 34BBC 01		13S 39W 33BBB 01
	08S 34W 01BAC 01		13S 42W 10BAC 01
	08S 34W 06CBC 01		13S 43W 36ABB 01
	08S 34W 23CBD 01		14S 38W 21DCC 01
	08S 34W 29CCC 01		14S 39W 28CAA 01
	08S 35W 04CCC 01		14S 40W 23ADD 01
	08S 36W 15CBB 01		14S 40W 29ABA 01
	08S 36W 18ABA 02		14S 41W 18DCB 01
	08S 36W 31BCD 01		14S 41W 22BBC 01
	09S 31W 10BBB 01		14S 42W 10BAA 01
	09S 31W 17CCC 01		14S 43W 25ABA 01
	09S 31W 36AAB 01		15S 38W 05CCB 01
	09S 32W 03AAA 01		15S 38W 14CCD 01
	09S 32W 27BCD 01		15S 38W 21CCC 01
	09S 33W 35AAD 01		15S 38W 36CBB 01
	09S 34W 11CCC 01		15S 39W 02BCA 01
	09S 34W 12ADA 01		15S 39W 06CBC 01
	09S 34W 17ABA 01		15S 39W 08ACC 01
	09S 35W 32DAA 01		15S 39W 26ACC 01
	10S 31W 26AAA 01		15S 40W 03BAB 01
	10S 31W 29AAB 01		15S 40W 09DCB 01
	10S 32W 11BAA 01		15S 40W 26CAB 01
	10S 32W 29DCB 01		15S 41W 02AAA 01
	10S 33W 06BBC 01		15S 41W 05ACB 01
	10S 33W 11BAB 01		15S 41W 27CBC 01
	10S 33W 19CBD 01		15S 41W 36DDB 02
	10S 34W 12BCD 01		15S 42W 02BBB 01
	10S 34W 29BBC 01		15S 42W 32BDA 01
	10S 35W 09ABB 01		15S 42W 36CDC 01
	10S 36W 16CCC 01		
		Washington	01S 05E 05ADA 01
Trego	12S 23W 20CCC 01		04S 02E 14CCC 01
	14S 25W 13BBA 01		05S 01E 20DAA 01
			05S 01E 31DDD 01

Table 4. *Ground-water-level observation wells, 1993 water year*--Continued

County	Well number	County	Well number
Wichita	16S 35W 06AAB 01	Wichita	18S 36W 15DBD 01
	16S 35W 13CCC 01	(continued)	18S 37W 01BBB 01
	16S 35W 20CCC 01		18S 37W 21BBB 01
	16S 36W 03DCC 01		18S 37W 25ABC 01
	16S 36W 07BCB 01		18S 38W 02BCC 01
	16S 36W 21CCC 01		18S 38W 08BBD 01
	16S 36W 30CBC 01		18S 38W 12BCC 01
	16S 36W 34CCC 02		18S 38W 20ACC 02
	16S 36W 36CBC 01		18S 38W 23BAB 01
	16S 37W 17BBB 01		18S 38W 31DBC 01
	16S 37W 30BAB 01		18S 38W 36DDD 01
	16S 38W 10ABB 01		19S 35W 01ABB 01
	16S 38W 26BBB 01		19S 35W 08BBB 01
	17S 35W 02ABC 01		19S 36W 15BAA 01
	17S 35W 15CDC 01		19S 37W 22AAB 01
	17S 35W 18DCC 01		19S 37W 28ABB 01
	17S 35W 27CCC 01		19S 38W 26CCB 01
	17S 35W 30CBB 01		19S 38W 31CBC 01
	17S 36W 10CBB 01		20S 35W 15BBB 01
	17S 36W 33BCB 01		20S 36W 24ACC 01
	17S 37W 08BAA 01		20S 37W 29DCC 01
	17S 37W 13CDD 01		20S 38W 17CBD 01
	17S 37W 28CBC 01		20S 38W 33BBA 01
	17S 38W 21BBB 01		
	17S 38W 24ACC 01		
	17S 38W 28CCC 01		
	18S 35W 08BBC 02		
	18S 35W 14DCD 01		
	18S 35W 31DDD 01		

Table 5. *Surface-water-quality gaging stations, 1993 water year*

Ident. no. (fig. 10)	Station name	Sampling type	Coop. or support
	Missouri River Basin		
06-			
8566	Republican R. at Clay Center	CHEM, BIOL, TOC, METAL, COLI, SED, FIELD	CBR
8725	N. Fk. Solomon R. at Portis	CHEM, FIELD	CBR
8740	S. Fk. Solomon R. at Osborne	CHEM, BIOL, TOC, METAL, COLI, SED, FIELD	CBR
8776	Smoky HIll R. at Enterprise	CHEM, BIOL, TOC, METAL, SED, BED, COLI, FIELD	CBR
87965	Kings Cr. nr Manhattan	CHEM, METAL, TOC, FIELD, SED	CBR
	Arkansas River Basin		
07-			
1375	Arkansas R. nr Coolidge	CHEM, BIOL, TOC, METAL, COLI, FIELD, SED	CR
1835	Neosho R. nr Parsons	CHEM, BIOL, TOC, METAL, SED, COLI, FIELD	CBR