WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN MISSOURI, 1993-94

Compiled by KATHERINE L. JENKINS-BARTLE *and* FELICIA D. HEADRICK

U.S. GEOLOGICAL SURVEY

Open-File Report 94-538

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1995

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

GORDON P. EATON, Director

For additional information
write to:

District Chief
U.S. Geological Survey
1400 Independence Road
Mail Stop 200
Rolla, Missouri 65401

Copies of this report can be
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U.S. Geological Survey
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Message from the District Chief

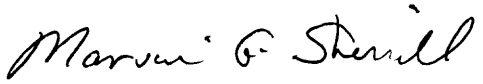
The U.S. Geological Survey, Water Resources Division, continues its long history of cooperation with State, local, and Federal agencies in providing water information for the citizens of Missouri and the Nation. The Missouri District maintains its close working relationship with these agencies in evaluating the critical water resources of the State. Investigations and data-collection activities relative to these water resources are described in this activities report.

Since our last activities report in 1992, several activities described in that report have been completed and reported; new studies have been initiated. The Ozark Plateaus National Water-Quality Assessment (NAWQA) Program has reached the point of maximum sampling intensity; the Mississippi Embayment NAWQA, which will include the "bootheel" area of Missouri is just getting started. The Management System Evaluation Area (MSEA) site near Centralia has been selected as one of only two national sites to go into a second, more detailed phase. The Ozark Stream Geomorphology project has produced a recent report on land-use changes and the effects on stream disturbances.

The hydrologic data-collection program has undergone some major changes since our 1992 report. Water-quality monitoring efforts, which at the time of our last report were minimal, have now been reestablished to their former size and strength. Perhaps the District's biggest challenge came with the summer flooding in 1993. Considerable data, much of which had never been available, was collected and was or will be reported on. In addition, several special projects were initiated, for example, levee-break hydrology and geomorphology, highway bridge-approach hydraulics, and floodplain sedimentation, to name a few.

Timeliness of our reports is a primary concern of the District and our cooperators. Special efforts are being made in this area such as better planning, more definitive proposals, and a closer working relationship between authors and the publications unit. Additionally, a total quality management team has been established to address the report process and to make recommendations to District management.

The Missouri District is dedicated to providing our cooperators quality work (data or reports) in a timely manner. We hope this activities report is a step in that direction.



Marvin G. Sherrill

ORIGIN AND MISSION OF THE U.S. GEOLOGICAL SURVEY

The U.S. Geological Survey was established by an act of Congress on March 3,1879, to provide a permanent Federal agency to conduct the systematic and scientific "classification of the public lands, and examination of the geological structure, mineral resources, and products of national domain." An integral part of that original mission includes publishing and disseminating the earth-science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and fact-finding role of the U.S. Geological Survey has grown and been modified to meet the changing needs of the Nation it serves. As part of that evolution, the U.S. Geological Survey has become the Federal Government's largest earth-science research agency, the Nation's largest civilian mapmaking agency, the primary source of data on the Nation's surface- and ground-water resources, and the employer of the largest number of professional earth scientists. Today's programs serve a diversity of needs and users. Programs include:

- Conducting detailed assessments of the energy and mineral potential of the Nation's land and offshore areas.
- Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.
- Conducting research on the geologic structure of the Nation.
- Studying the geologic features, structure, processes, and history of the other planets of our solar system.
- Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.
- Developing and producing digital cartographic data bases and products.
- Collecting data on a routine basis to determine the quantity, quality, and use of surface and ground water.
- Conducting water-resources appraisals to describe the consequences of alternative plans for developing land and water resources.
- Conducting research in hydraulics and hydrology, and coordinating all Federal water-data acquisition.
- Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural resources planning and management.
- Providing earth-science information through an extensive publications program and a network of public access points.

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the U.S. Geological Survey remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation--providing Earth Science in the public service.

MISSION AND PROGRAM OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States.

This is accomplished, in large part, through cooperation with other Federal and non-Federal agencies by:

- Collecting, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.
- Conducting analytical and interpretive water-resources appraisals describing the occurrence, availability, and physical, chemical, and biological characteristics of surface and ground water.
- Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.
- Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground water.
- Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to international agencies on behalf of the Department of State.

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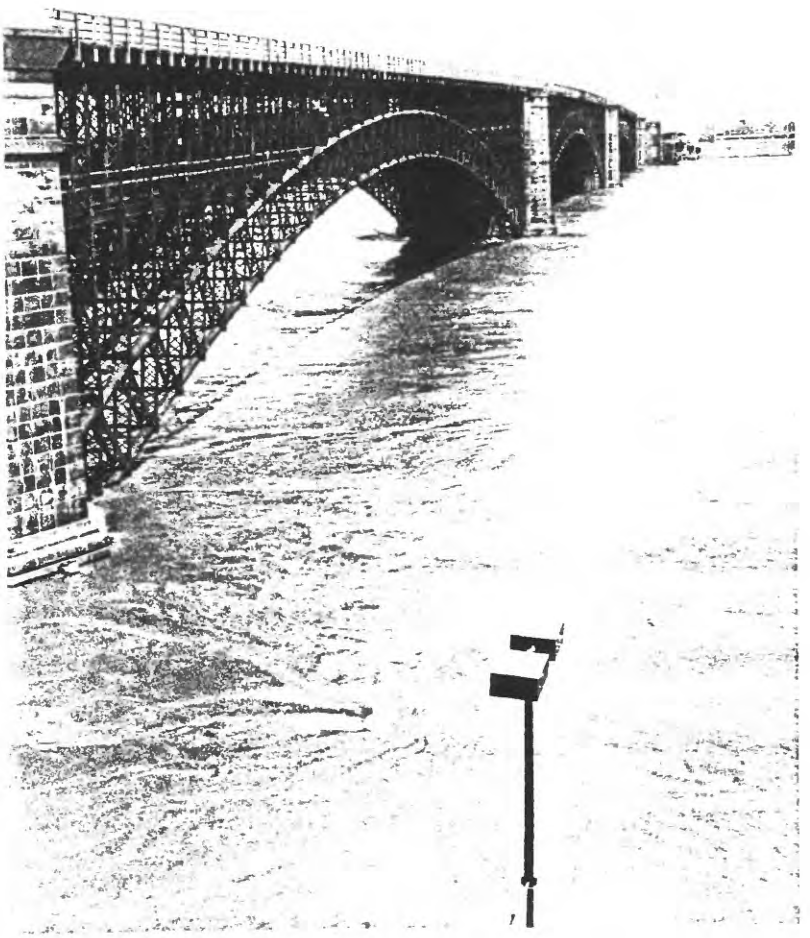


WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN MISSOURI, 1993-94

Compiled by Katherine L. Jenkins-Bartle *and* Felicia D. Headrick

ABSTRACT

Water-resources activities of the U.S. Geological Survey in Missouri consist of collecting hydrologic data and making interpretive studies. Hydrologic studies in Missouri are made through three basic types of projects: hydrologic data-collection programs, local or areal hydrologic investigations, and statewide or regional studies. These projects are funded through cooperative joint-funding agreements with State and local agencies, transfer of funds from other Federal agencies, and direct Federal funds. The data and the results of the investigations are published or released by either the U.S. Geological Survey or by cooperating agencies. This report describes the hydrologic data-collection programs, local or areal hydrologic investigations, and statewide or regional studies in Missouri for 1993-94 and provides a list of selected water-resources references for Missouri.

MISSOURI DISTRICT

A District Office of the U.S. Geological Survey was established in Rolla, Missouri, during 1921, when a cooperative program was begun with the Missouri Bureau of Geology and Mines (now the Missouri Department of Natural Resources, Division of Geology and Land Survey). The Missouri District, with field offices in Rolla and Olivette, and a subdistrict office in Independence (fig. 1), investigates the occurrence, quantity, quality, distribution, and movement of surface and ground water in Missouri.

Hydrologic data-collection programs and interpretive studies in Missouri are conducted by two operating sections and four support units (fig. 2). The two operating sections are responsible for the implementation and execution of District projects assigned to project chiefs.

Operating Sections

The Hydrologic Surveillance and Surface-Water Analysis Section designs, constructs, operates, and maintains all hydrologic-data networks in the State. The Section manages the collection and analysis of the hydrologic data for the State network, prepares water-resources data for the annual water-data report, provides quality control of results for field and office methods, and conducts hydraulic, flood frequency, and bridge scour studies. The Hydrologic Investigations and Analysis Section plans, executes, and reports on water-resources projects, such as ground-water hydraulics and mathematical modeling of aquifer systems, effects of agricultural chemicals

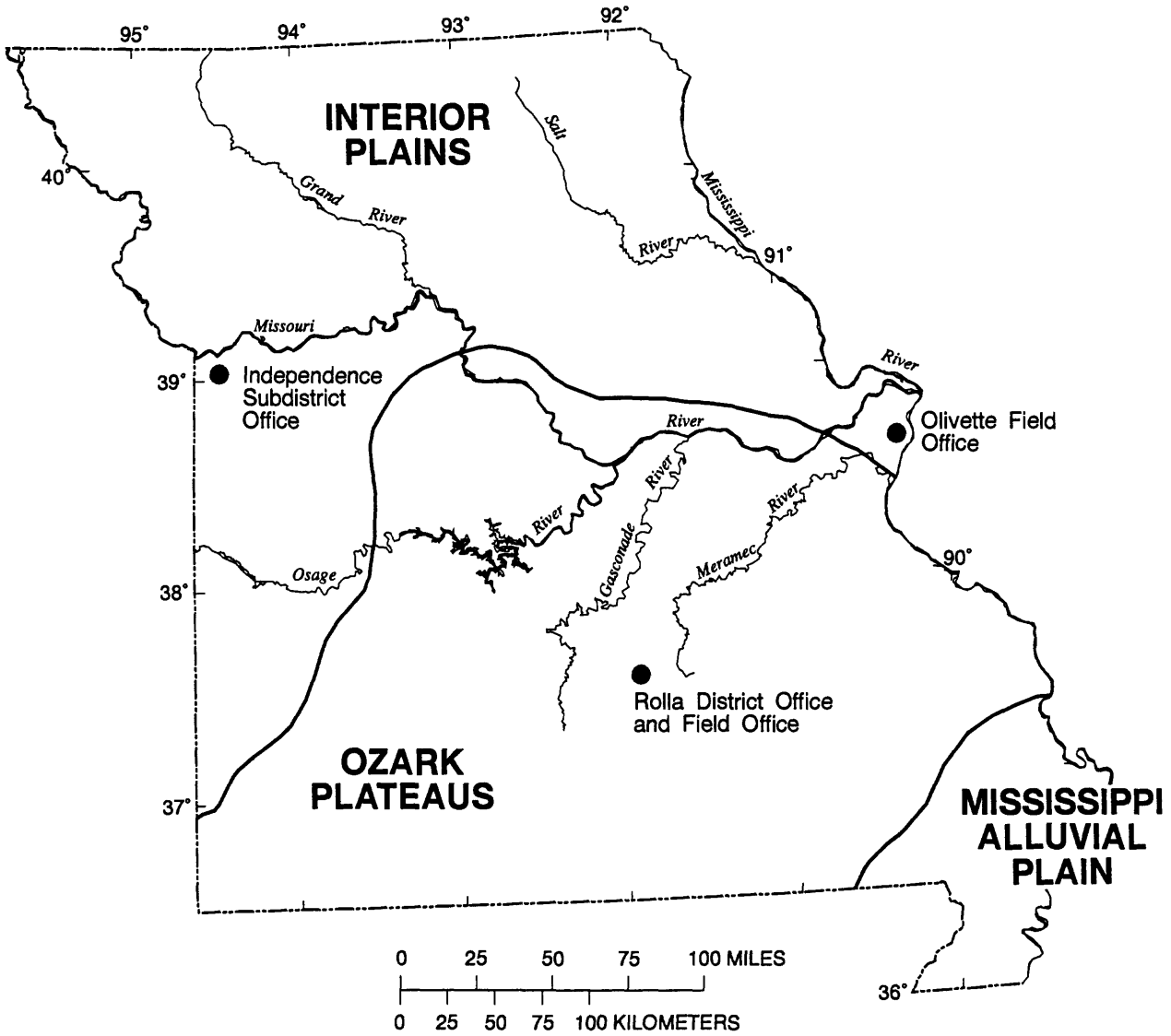


Figure 1. Location of offices of the U.S. Geological Survey in Missouri.

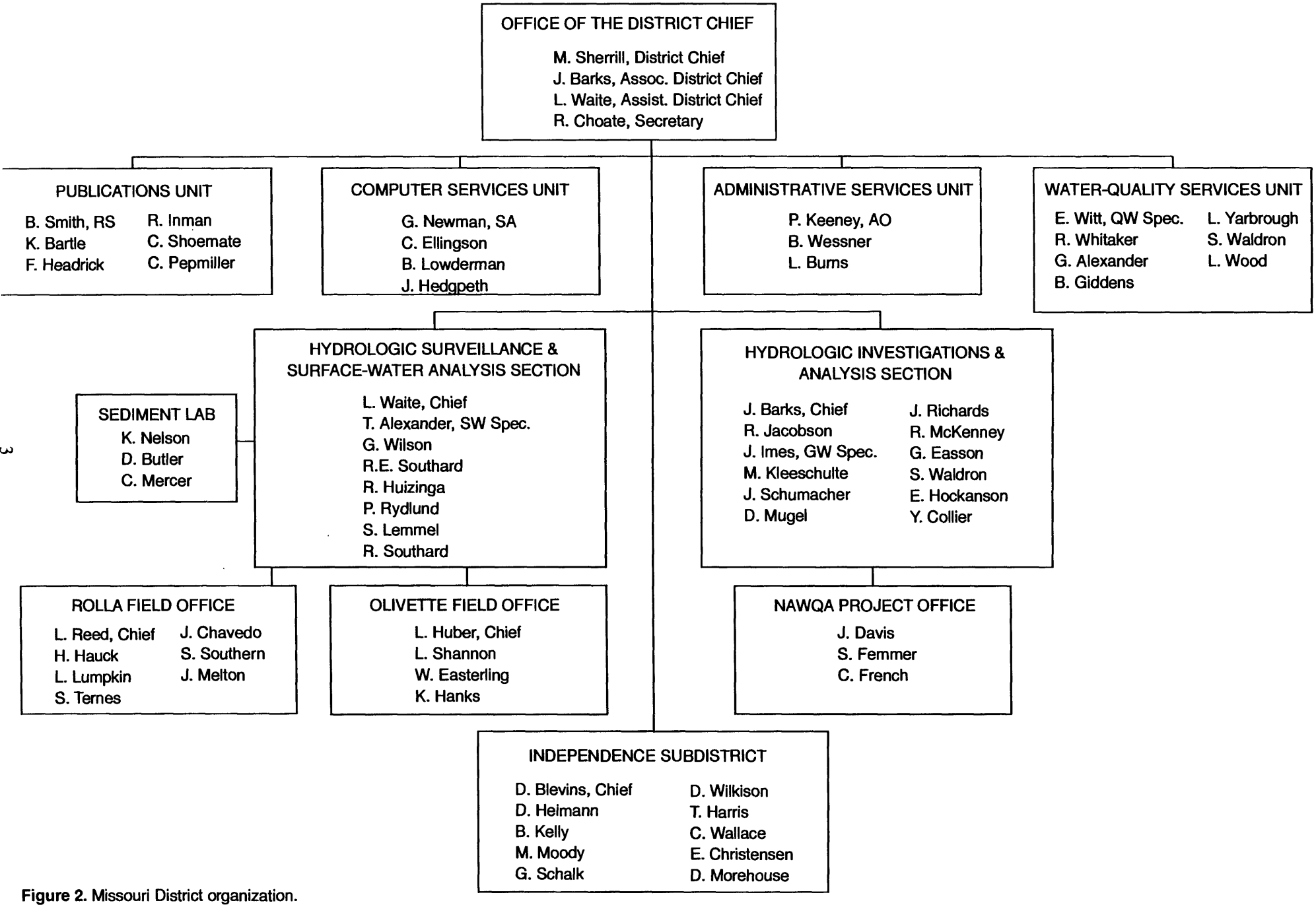


Figure 2. Missouri District organization.

on water quality, hydrology of urban areas, analysis of the effects and assessment of hazardous wastes and historical and ongoing mineral mining on the hydrologic system, and stream geomorphology.

Support Units

The Publications Unit maintains records of technical and hydrologic-data reports; reviews project annotated outlines; and edits, types, assembles, verifies, and prepares manuscripts and illustrations for publication. The Unit advises and updates District personnel on current report-writing procedures.

The Computer Services Unit manages and maintains the District's computer system, and coordinates processing, storage, and retrieval of data for the District and National Computer files. The Unit helps design, implement, and maintain the computer program software necessary for District operation.

The Administrative Services Unit provides administrative support for the District, including programming, budgeting, accounting, management of personnel, property inventory, travel records, vehicle management, and related services.

The Water-Quality Services Unit operates the ambient water-quality network and prepares water-quality data for annual reports. The Unit provides quality assurance for field and office methods and maintains the quality assurance data base.

COOPERATION AND PROGRAM FUNDING

The Missouri District and agencies of the State of Missouri have had cooperative agreements for the systematic collection of streamflow records since 1921. About 90 percent of the hydrologic data collected by the U.S. Geological Survey in Missouri is in cooperation with local, State, or other Federal agencies. Collection of surface-water data was begun at a few selected sites during 1903; collection of ground-water data in cooperation with the Missouri Department of Natural Resources, Division of Geology and Land Survey, was begun during 1963; and collection of water-quality data was begun during 1962 in cooperation with the Missouri Water Pollution Control Program (now a part of the Missouri Department of Natural Resources, Division of Environmental Quality). Surface-water data primarily are collected cooperatively with other Federal agencies, whereas the ground-water and water-quality data primarily are collected in cooperation with state agencies. These types of data are needed for the continuing determination and evaluation of the quantity, quality, and use of Missouri's water resources. Interpretive studies are designed and completed in cooperation with local, State, and other Federal agencies and as part of U.S. Geological Survey programs.

Moneys for program operation of the U.S. Geological Survey in Missouri come from joint-funding agreements with local and State agencies, transfer of funds from other Federal agencies, and direct Federal funds. Distribution of funding for program operation during fiscal year 1994 is shown in figure 3.

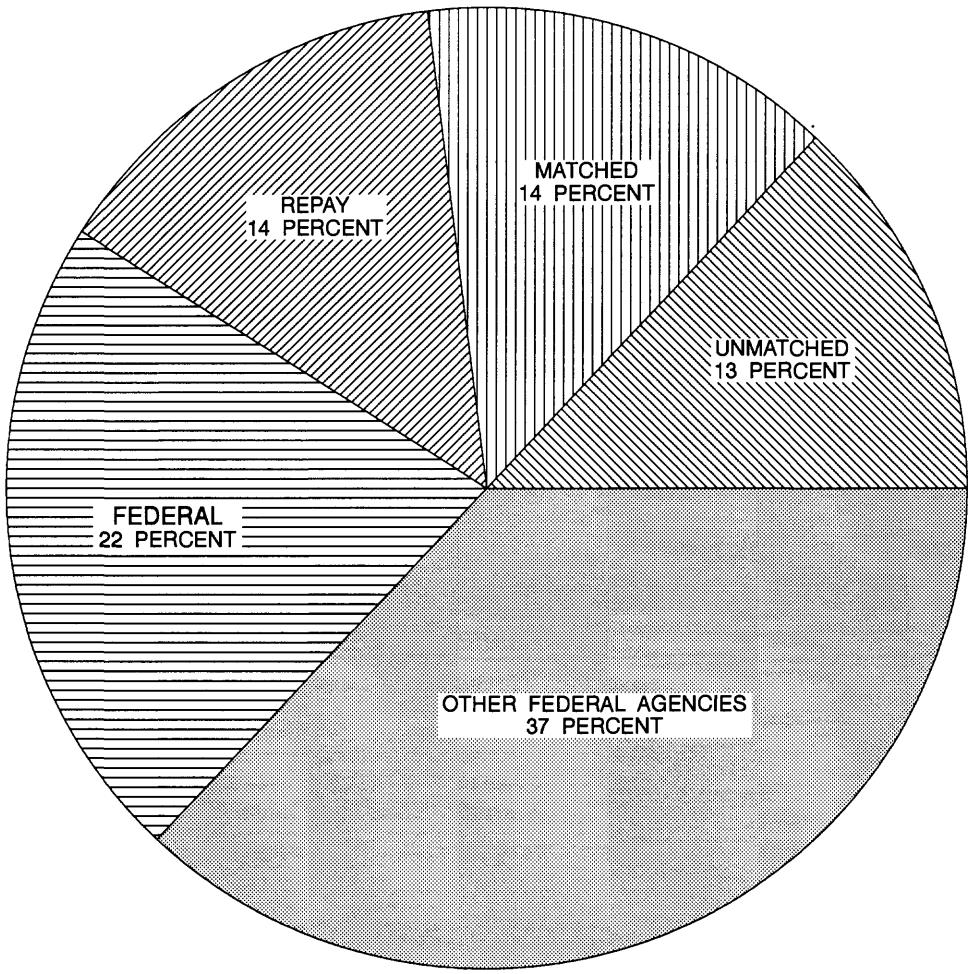


Figure 3. Distribution of funding for water-resources programs of the U.S. Geological Survey in Missouri, fiscal year 1994.

WATER CONDITIONS

Sufficient water for present demands is available in many parts of Missouri during most years. Annual precipitation ranges from 34 inches in the northwest to 46 inches in the southeast, according to the National Oceanic and Atmospheric Administration (1990; fig. 4), but in some years precipitation has been as much as 15 inches less than normal.

Surface-water supplies generally are adequate for most uses (fig. 5). However, variation in availability occurs within and among the State's three major physiographic regions: the Interior Plains, the Ozark Plateaus, and the Mississippi Alluvial Plain (fig. 6). Some small communities in the Plains region, for example, can have water-supply shortages during droughts because many of the public-water supply districts serve large areas and cannot meet increased demands during extreme low-flow periods. Ozark streams generally have the best-sustained low flows because of the contribution of ground water from extensive solution cavities in the carbonate aquifers. Low flows in the Mississippi Alluvial Plain are second in magnitude to those of the Ozarks and are sustained by ground-water contributions from the extensive alluvial deposits.

More communities depend on ground water than on surface water, but larger quantities of surface water are withdrawn because most of Missouri's large cities have surface-water supplies. The southeastern two-thirds of the State is underlain by freshwater aquifers (Harris, 1979).

Large quantities of saline ground water are available in the northwestern one-third of Missouri (fig. 7). However, without desalination, this water is unsuitable for most purposes. In local areas of the State, the increased use of ground water for farmland irrigation has lowered ground-water levels.

Generally, water quality in Missouri streams and aquifers is adequate for most uses (Missouri Division of Geology and Land Survey, 1967). However, water-quality concerns in Missouri include hazardous waste-disposal sites; landfill sites; stream erosion that is among the largest in the United States; carbonate rocks in the Ozarks region that contain solution-enlarged cracks and crevices allowing contaminants, such as sewage-lagoon effluent, to directly enter the shallow ground-water system; and many obsolete sewage-treatment plants in the State that adversely affect the water quality of streams.

NATIONAL HYDROLOGIC-DATA NETWORKS AND PROGRAMS

A significant quantity of stream water-quality data is collected in Missouri as part of the National Stream Quality Accounting Network (NASQAN). The NASQAN is a data-collecting effort for obtaining consistent regional nationwide overviews of the quality of streams. The primary objectives of the network are to: (1) account for the quantity and quality of water moving within and from major river basins in the United States; (2) depict areal variability; (3) detect changes in stream quality; and (4) provide data for future assessments of changes in stream quality. Seven NASQAN stations are included in the Missouri District's hydrologic data-collection program.

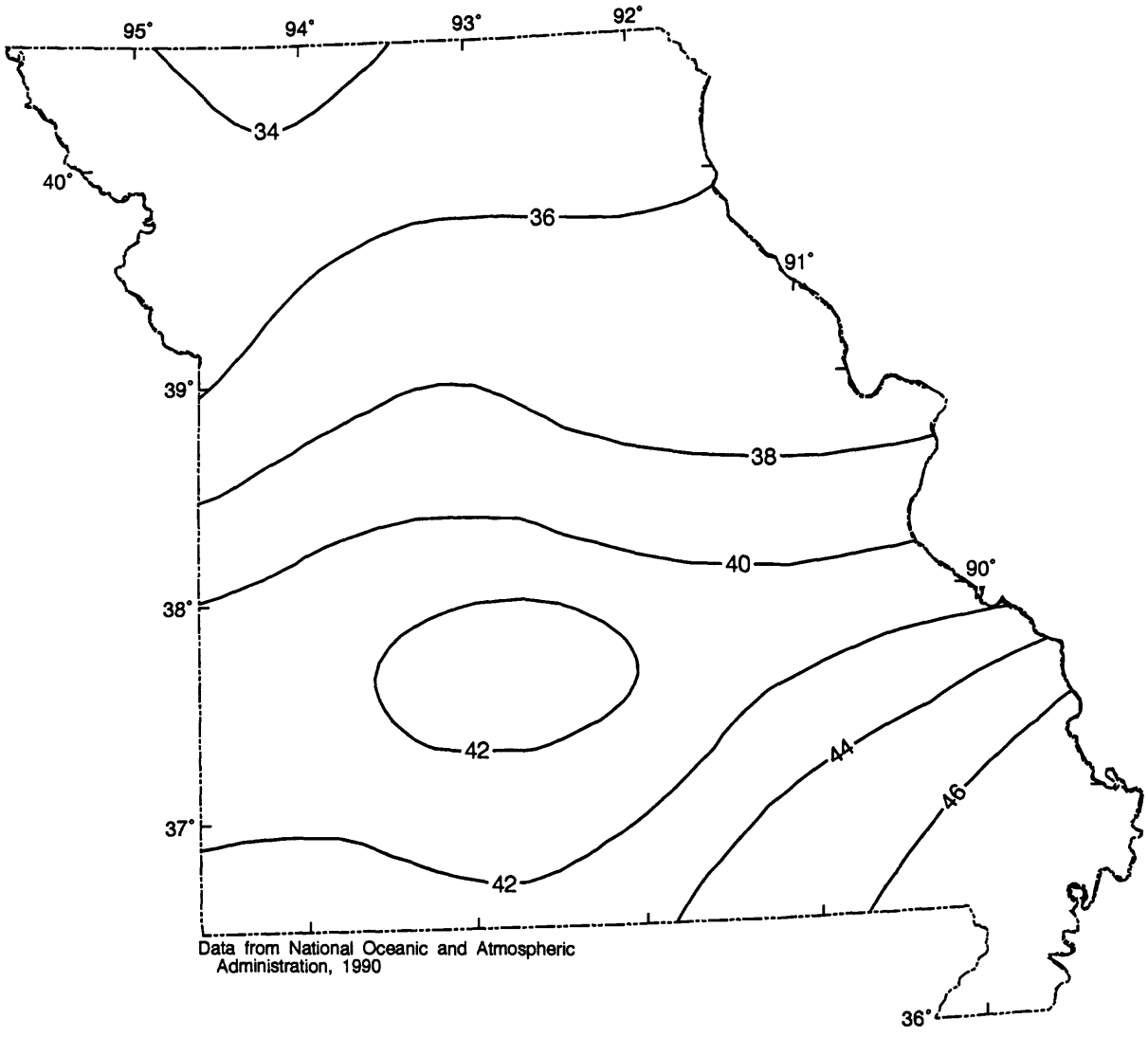


Figure 4. Mean annual precipitation.

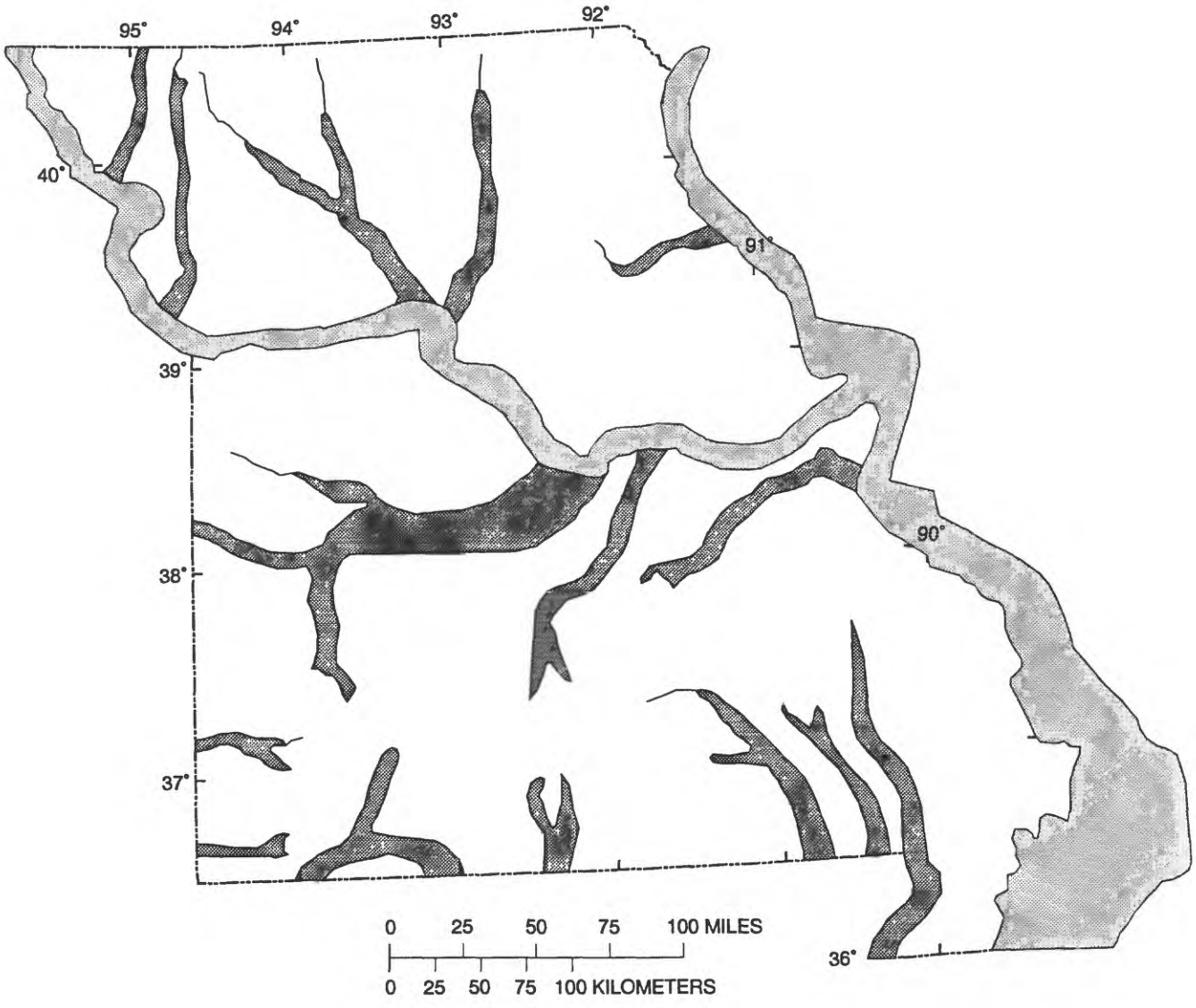


Figure 5. Average discharge of the principal rivers.

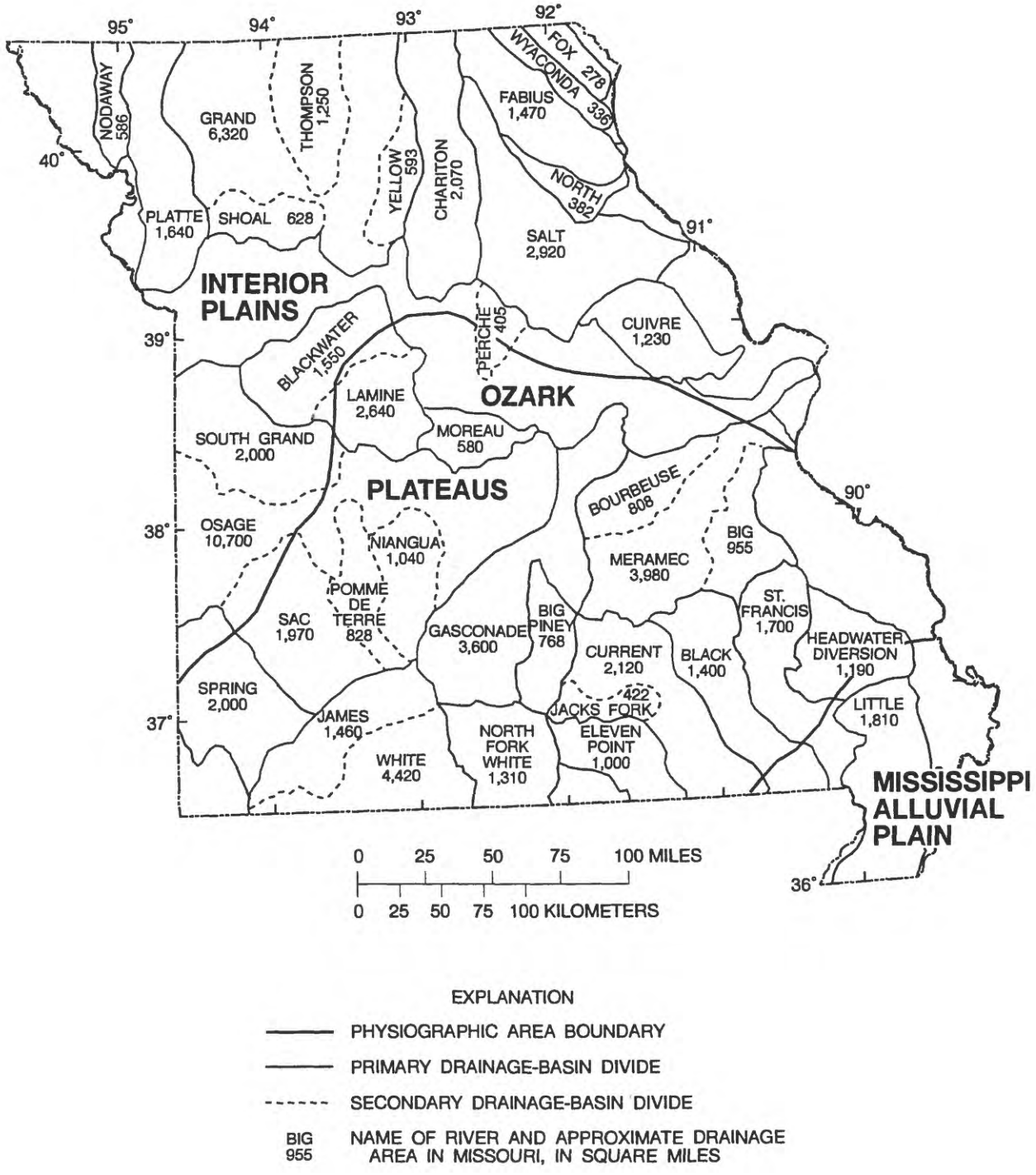


Figure 6. Physiographic divisions and major drainage basins.

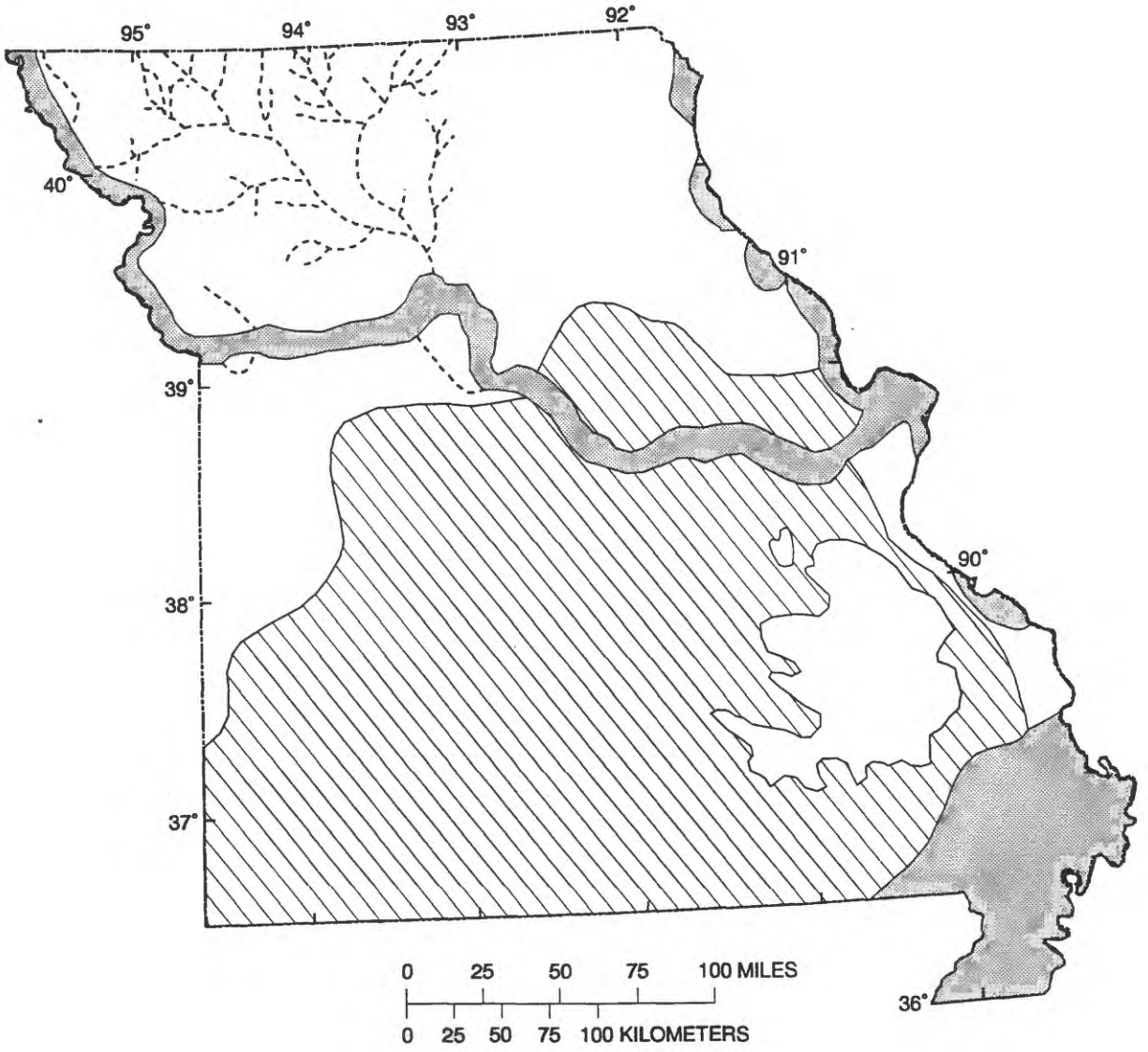


Figure 7. Availability of ground water.

The U.S. Geological Survey outlines flood-prone areas on topographic maps as part of a nationwide Federal program for managing flood losses. Studies of the frequency and extent of flooding in Missouri have resulted in delineation of the 100-year flood boundary on selected topographic quadrangle maps (fig. 8). These maps are available on request from the Missouri District Office in Rolla.

The National Water-Use Information Program of the U.S. Geological Survey is a Federal-State cooperative program designed to collect, store, and disseminate water-use information both nationally and locally. The program was begun during 1978 to develop a single source of uniform information on water use. The water-use information from this program complements long-term U.S. Geological Survey data on the availability and quality of the Nation's water resources. Information on the National Water-Use Information Program and its data bases can be obtained from the District Office in Rolla.

The National Water Quality Assessment (NAWQA) program is designed to assess historical, current, and future water-quality conditions in representative river basins and aquifers Nationwide. One of the primary objectives of the program is to describe relations between natural factors, human activities, and water-quality conditions and to define those factors that most affect water quality in different parts of the Nation. Results from the NAWQA program are released to the public through a variety of publications as elements of the studies are completed.

District Chief
U.S. Geological Survey
1400 Independence Road, Mail Stop 200
Rolla, Missouri 65401

As part of the U.S. Geological Survey's program of releasing water data to the public, a large-scale computerized system is used for the storage and retrieval of water data. Presently (1994), all primary U.S. Geological Survey water-resources data are maintained on the National Water Data Storage and Retrieval System (WATSTORE) at the central computer facilities in Reston, Virginia. These data also are stored and are available on District minicomputer files using the Distributed Information System (DIS). The DIS configuration provides easier dissemination and access of data that pertain to a given State. These data are available for water planning and management in machine-readable form, computer-printed tables or graphs, statistical tabulations, and digital plots. Information about the availability of specific types of data, the acquisition of data or products, and user charges can be obtained from the District Office in Rolla.

A Master Water Data Index (MWDI) was developed by the Office of Water Data Coordination (OWDC) and is managed by the National Water Data Exchange (NAWDEX) Program Office to assist users of water data to identify, locate, and acquire needed data. The U.S. Geological Survey, through OWDC, coordinates the water-data-acquisition activities of the U.S. Geological Survey and other Federal agencies. This information is made available to all users of water data by means of a national network of assistance centers. In Missouri, NAWDEX services can be obtained from the District Chief, Rolla, Missouri.

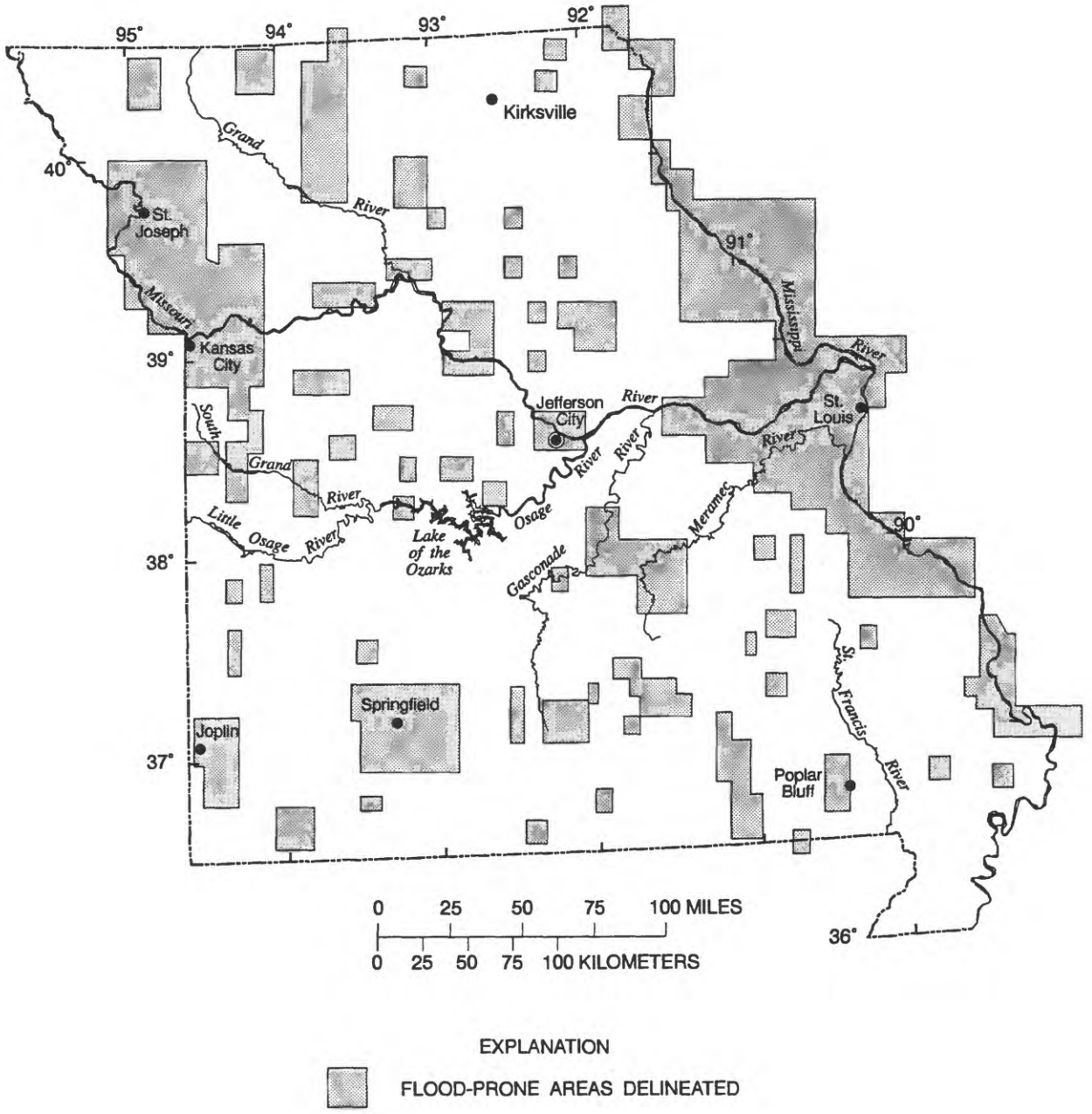


Figure 8. Flood-prone area maps completed in Missouri.

HYDROLOGIC DATA-COLLECTION PROGRAMS

Hydrologic data-collection stations are maintained by the U.S. Geological Survey throughout Missouri to obtain records of stream discharge or stage, lake and reservoir storage, spring discharge, ground-water levels, and the quality of surface and ground water. Major drainage basins in Missouri and approximate areas in square miles are shown in figure 6. Daily discharge and surface-water quality data-collection stations in operation during 1993-94 are listed in dowstream order in table 1, which also includes the cooperating agency and type of data collected. In addition to these stations, the Missouri District collects data from several hundred low-flow partial-record stations, peak-flow partial-record stations, and observation wells throughout the State.

Hydrologic data collected in Missouri as part of the data-collection network are published annually in a report entitled "Water Resources Data, Missouri, Water Year 19__" (the water year is from October 1 of each year to September 30 of the following year). These data represent most of the water-resources data collected in Missouri in cooperation with local, State, and other Federal agencies. Reports for each year are released the following year. Water-data reports are available for inspection at the U.S. Geological Survey in Rolla, Missouri, or may be purchased from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia 22161.

Table 1.—*Daily discharge, stage, and surface-water quality stations in operation during 1993-94*

Station number	Station name	Cooperation[1]	Type of data[1]
05490600	Des Moines River at St. Francisville	CE RI	C,M,S
05495000	Fox River at Wayland	CE RI	D
05496000	Wyaconda River above Canton	CE RI	D
05497000	North Fabius River at Monticello	CE RI	D
05498000	Middle Fabius River near Monticello	CE RI	D
05500000	South Fabius River near Taylor	CE RI	D
05501000	North River at Palmyra	CE RI	D
05502000	Bear Creek at Hannibal	FED, CE RI	D
05502300	North Fork Salt River at Hagers Grove	CE STL	D
05502500	North Fork Salt River near Shelbina	CE STL	D,S
05503800	Crooked Creek near Paris	CE STL	D
05504800	South Fork Salt River above Santa Fe	CE STL	D
05506100	Long Branch near Santa Fe	CE STL	D
05506500	Middle Fork Salt River at Paris	CE STL	D,S
05506800	Elk Fork Salt River near Madison	CE STL	D
05507600	Lick Creek at Perry	CE STL	D
05507795	Salt River below Cannon Dam	CE STL	St
05507800	Salt River near Center	CE STL	D
05508000	Salt River near New London	CE STL	D,S
05508805	Spencer Creek below Plum Creek near Frankford	CE STL	D
05509300	Salt River at Ashburn	CE STL	St
05514500	Cuivre River near Troy	CE STL, DEQ	C,D,M
05587450	Mississippi River at Grafton, Illinois	FED, CE STL	D
05587455	Mississippi River below Grafton, Illinois	NONE	C,M,S
05587750	Mississippi River at Hartford	CE STL	St
06817700	Nodaway River near Graham	CE KC	D
06818000	Missouri River at St. Joseph	CE KC, DEQ	C,D,M,S
06818900	Platte River at Ravenwood	FED	St
06820500	Platte River near Agency	CE KC	D
06821140	Smithville Reservoir near Smithville	CE KC	R
06821150	Little Platte River at Smithville	CE KC	D
06821190	Platte River at Sharps Station	CE KC	C,D,M
06893000	Missouri River at Kansas City	FED, CE KC	D,S
06893500	Blue River near Kansas City	CE KC	D
06893590	Blue River at 12th Street in Kansas City	CE KC	St

Table 1.—*Daily discharge, stage, and surface-water quality stations in operation during 1993-94*—Continued

Station number	Station name	Cooperation[1]	Type of data[1]
06893791	Longview Reservoir at Kansas City	CE KC	R
06893793	Little Blue River below Longview Dam at Kansas City	CE KC	D
06893880	Lake Jacomo near Blue Springs	CE KC	St
06893885	Blue Springs Reservoir near Blue Springs	CE KC	St
06893890	East Fork Little Blue River near Blue Springs	CE KC	D
06894000	Little Blue River near Lake City	CE KC	D
06895000	Crooked River near Richmond	FED	St
06895500	Missouri River at Waverly	CE KC	D
06896000	Wakenda River near Carrollton	FED	St
06897000	East Fork Big Creek near Bethany	FED	St
06897500	Grand River near Gallatin	CE KC	D
06899500	Thompson River at Trenton	CE KC	D
06899680	Grand River at Chillicothe	CE KC	St
06901100	Locust Creek at Reger	DC	St
06901500	Moreau River near Jefferson City	FED	St
06902000	Grand River near Sumner	FED, CE KC, DEQ	C,D,M
06904050	Chariton River at Livonia	CE KC	D
06904500	Chariton River at Novinger	CE KC	D
06905500	Chariton River near Prairie Hill	CE KC	D
06906000	Mussel Fork near Musselfork	CE KC	St
06906190	Long Branch Reservoir near Macon	CE KC	R
06906200	East Fork Little Chariton River near Macon	CE KC	D
06906300	East Fork Little Chariton River near Huntsville	CE KC, DEQ	C,D,M
06906500	Missouri River at Glasgow	CE KC, DEQ	C,D,M
06906800	Lamine River near Otterville	DC	D
06908000	Blackwater River at Blue Lick	CE KC	D
06909000	Missouri River at Boonville	CE KC	D
06909500	Moniteau Creek near Fayette	FED	St
06910450	Missouri River at Jefferson City	UE	St
06916664	Marais des Cygnes River at Rich Hill	CE KC	St
06916670	Miami Creek near Butler	CE KC	St
06917060	Little Osage River near Horton	CE KC	St
06918065	Marmaton River near Nevada	CE KC	St
06918070	Osage River above Schell City	CE KC	C,D,M,S
06918330	Clear Creek near Eldorado Springs	CE KC	St

Table 1.—*Daily discharge, stage, and surface-water quality stations in operation during 1993-94*—Continued

Station number	Station name	Cooperation[1]	Type of data[1]
06918335	Monegaw Creek at Monegaw Springs	CE KC	St
06918440	Sac River near Dadeville	CE KC	D
06918460	Turnback Creek above Greenfield	CE KC	D
06918740	Little Sac River near Morrisville	CE KC	D
06918990	Stockton Lake near Stockton	CE KC	R
06919000	Sac River near Stockton	CE KC	St
06919020	Sac River below Stockton	CE KC	D
06919500	Cedar Creek near Pleasant View	CE KC	D
06919900	Sac River near Caplinger Mills	CE KC	D
06920500	Osage River at Osceola	CE KC	St
06921070	Pomme de Terre River near Polk	CE KC	D
06921200	Lindley Creek near Polk	CE KC	D
06921325	Pomme de Terre Lake near Hermitage	CE KC	R
06921350	Pomme de Terre River near Hermitage	CE KC	D
06921760	South Grand River near Clinton	CE KC	D,S
06922075	Tributary to Middle Fork Tebo Creek near Leeton	DEQ	C
06922190	West Fork Tebo Creek near Lewis	CE KC	C,M
06922315	Dousinberry Creek near Wall Street	FED (NAWQA)	D
06922440	Harry S. Truman Reservoir at Warsaw	CE KC	R
06922450	Osage River below Truman Dam at Warsaw	CE KC	D
06922500	Osage River at Warsaw	CE KC	St
06922550	Osage River below Warsaw	CE KC	St
06922560	Lake of the Ozarks at Oar House Marina	CE KC	St
06922790	Lake of the Ozarks above Buffalo Cove	CE KC	St
06922900	Lake of the Ozarks at Rainy Creek	CE KC	St
06923250	Niangua River near Windyville	DEQ	D,C,M
06923500	Bennett Spring at Bennett Springs	DEQ	C,M
06925500	Lake of the Ozarks near Bagnell	UE	R
06926000	Osage River near Bagnell	UE	D
06926500	Osage River near St. Thomas	CE KC, UE	D
06926510	Osage River below St. Thomas	FED	C,M
06927000	Maries River at Westphalia	FED	St
06929315	Paddy Creek above Slabtown Spring	FED (NAWQA)	D
06930800	Gasconade River above Jerome	DEQ	C
06932000	Little Piney Creek at Newburg	FED	D

Table 1.—*Daily discharge, stage, and surface-water quality stations in operation during 1993-94*—Continued

Station number	Station name	Cooperation[1]	Type of data[1]
06933500	Gasconade River at Jerome	FED	D
06934000	Gasconade River near Rich Fountain	CE KC	D
06934500	Missouri River at Hermann	FED, CE KC, DEQ	C,D,M,S,T
06935965	Missouri River at St. Charles	CE STL	St
07010000	Mississippi River at St. Louis	FED, CE STL	D,S,T
07013000	Meramec River near Steelville	CE STL	D
07014500	Meramec River near Sullivan	CE STL	D
07015720	Bourbeuse River near Highgate	CE STL	D
07016500	Bourbeuse River at Union	CE STL	D
07017020	Meramec River at Pacific	CE STL	St
07017200	Big River at Irondale	FED, CE STL	D
07018100	Big River near Richwoods	FED, CE STL	D
07018500	Big River near Byrnesville	FED, CE STL	D
07019000	Meramec River near Eureka	FED, CE STL	C,D,M
07019280	Meramec River at Paulina Hills	DEQ	C,M
07019300	Meramec River at Arnold	CE STL	St
07020500	Mississippi River at Chester, Illinois	FED, CE STL	D,S
07020850	Mississippi River at Cape Girardeau	CE STL	St
07022000	Mississippi River at Thebes, Illinois	CE STL	C,D,M,S
07034000	St. Francis River near Roselle	CE STL	D
07035000	Little St. Francis River near Fredericktown	CE STL	D
07035800	St. Francis River near Mill Creek	CE STL	D
07036100	St. Francis River near Saco	CE STL	D,S
07037000	Big Creek at Des Arc	CE STL	D
07037500	St. Francis River near Patterson	CE STL	D
07039000	Wappapello Lake at Wappapello	CE STL	R
07039500	St. Francis River at Wappapello	CE STL	D
07050700	James River near Springfield	CU	D
07052500	James River at Galena	CE LR	D
07053200	Long Creek at Denver, Arkansas	CE LR	D
07053400	Table Rock Lake near Branson	CE LR	R
07054080	Beaver Creek near Bradleyville	CE LR	D
07053450	White River below Table Rock Dam near Branson	CE LR	C,T
07053500	White River near Branson	CE LR	D
07053600	Lake Taneycomo at College of the Ozarks	CE LR	C,St,T

Table 1.—*Daily discharge, stage, and surface-water quality stations in operation during 1993-94*—Continued

Station number	Station name	Cooperation[1]	Type of data[1]
07053700	Lake Taneycomo at Branson	DEQ	C,M
07053805	Bull Creek near Branson	CE LR	D
07053820	Lake Taneycomo at Powersite Dam	CE LR	St
07057500	North Fork River near Tecumseh	CE LR	D
07058000	Bryant Creek near Tecumseh	CE LR	D
07061500	Black River near Annapolis	CE LR	D
07061900	Logan Creek at Ellington	CE LR	D
07062000	Clearwater Lake near Piedmont	CE LR	R
07062500	Black River at Leeper	CE LR	D
07063000	Black River at Poplar Bluff	CE LR	D
07063500	Cane Creek at Harviell	CE LR	St
07064400	Montauk Springs at Montauk	NPS	C
07064440	Current River below Montauk State Park	NPS	C
07064530	Welch Spring near Akers	NPS	C
07064555	Pulltite Spring near Round Spring	NPS	C
07065000	Round Spring at Round Spring	NPS	C
07065490	Jacks Fork above Alley Spring	FED (NAWQA), DC	D
07065500	Alley Spring at Alley	NPS	C
07066000	Jacks Fork at Eminence	DGLS	D
07066110	Jacks Fork above Two Rivers	NPS	C
07066510	Current River above Powder Mill	NPS	C
07066550	Blue Spring near Eminence	NPS	C
07067000	Current River at Van Buren	CE LR	D
07067500	Big Spring near Van Buren	FED, NPS	C,D
07067800	Current River below Hawes Campground	NPS	C
07068000	Current River at Doniphan	CE LR	D
07071000	Greer Spring at Greer	USFS	D
07071500	Eleven Point River near Bardley	CE LR	D
07186000	Spring River near Waco	CE TU	D
07186470	Center Creek near Carl Junction	FED (NAWQA)	D
07187000	Shoal Creek above Joplin	CE TU	D
07189000	Elk River at Tiff City	CE TU	D

[1]Explanation of abbreviations:

Cooperation

CU	City Utilities of Springfield
FED	Federal
DC	Missouri Department of Conservation
DEQ	Missouri Division of Environmental Quality
DGLS	Missouri Division of Geology and Land Survey
NPS	National Park Service
NAWQA	National Water Quality Assessment
UE	Union Electric Company of Missouri
CE KC	U.S. Army Corps of Engineers, Kansas City
CE LR	U.S. Army Corps of Engineers, Little Rock
CE RI	U.S. Army Corps of Engineers, Rock Island
CE STL	U.S. Army Corps of Engineers, St. Louis
CE TU	U.S. Army Corps of Engineers, Tulsa
USFS	U.S. Forest Service

Type of Data

C	Chemical
D	Discharge--continuous record of stage and discharge
M	Microbiological
R	Reservoir content or elevation
S	Sediment
St	Stage only
T	Temperature

Collection of Surface-Water Data (MO 00-001)

In cooperation with

City Utilities of Springfield
Missouri Department of Conservation
Missouri Department of Natural Resources,
  Division of Environmental Quality
  Division of Geology and Land Survey
National Park Service
Union Electric Company of Missouri
U.S. Army Corps of Engineers

Loyd A. Waite, Project Chief

NEED FOR STUDY

Surface-water information is needed for surveillance, planning, design, hazard warning, and operation and management in water-related fields, such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, contamination abatement, flood-plain management, waste disposal, and water-resources development.

OBJECTIVES

(1) Collect surface-water data sufficient to satisfy needs for current-purpose uses, such as assessment of water resources; operation of reservoirs or industries; forecasting, disposal of wastes, both common and nuclear; contamination controls; discharge data to accompany water-quality measurements; compact and legal requirements; and research or special studies. (2) Collect data necessary for analytical studies and define the trends and statistical properties of streamflow.

APPROACH

Standard methods of data collection will be used as described in the series *Techniques of Water-Resources Investigations of the U.S. Geological Survey.*

Collection of Surface-Water Data (MO 00-001)--Continued

ACTIVITIES DURING 1993

The 1992 annual water-data report was completed and submitted to the U.S. Government Printing Office in March 1993; printed copies were distributed to cooperators and other Federal agencies.

PLANNED ACTIVITIES DURING 1994

Data collection will continue, and a date of April 1994 is anticipated for completion of the 1993 water-data report.

REPORTS

Reed, H.L., Perkins, T.J., and Gray, G.L., Jr., 1993, Water resources data, Missouri, water year 1992: U.S. Geological Survey Water-Data Report MO-92-1, 236 p. (published annually).

_____ 1994, Water resources data, Missouri, water year 1993: U.S. Geological Survey Water-Data Report MO-93-1, 274 p. (published annually).

Collection of Ground-Water Data (MO 00-002)

In cooperation with

City Utilities of Springfield

Jeffrey L. Imes, Project Chief

NEED FOR STUDY

Ground-water information is needed to evaluate the effects of climatic variations on recharge to and discharge from the aquifer systems, to provide a data base for measuring the effects of development, to assist in the prediction of future supplies, and to provide data for management of the resources.

OBJECTIVES

(1) Collect sufficient data to provide a long-term data base so that the general response of the hydrologic system to natural climatic variations and induced stresses is known to allow for proper planning and management of potential concerns in the State. (2) Provide a data base from which the short-term records acquired in areal studies can be analyzed.

APPROACH

Evaluation of regional geology allows a broad, general definition of aquifer systems and their boundary conditions. Within this framework, data will be collected to help define stresses on the systems and the hydrologic properties of the aquifers. The data-collection network will be refined as records accumulate and detailed areal studies of the ground-water system more closely define the aquifers, their properties, and the stresses to which they are subjected.

ACTIVITIES DURING 1993

Ground-water level data were collected and processed quarterly for about 12 wells in the Springfield, Missouri, area. The data were published in "Water Resources Data, Missouri" (published annually).

PLANNED ACTIVITIES DURING 1994

Data collection will continue on a quarterly basis in the Springfield area.

Collection of Ground-Water Data (MO 00-002)--Continued

REPORTS

Reed, H.L., Perkins, T.J., and Gray, G.L., Jr., 1993, Water resources data, Missouri, water year 1992: U.S. Geological Survey Water-Data Report MO-92-1, 236 p. (published annually).

_____ 1994, Water resources data, Missouri, water year 1993: U.S. Geological Survey Water-Data Report MO-93-1, 274 p. (published annually).

Collection of Quality-Water Data (MO 00-003)

In cooperation with

Missouri Department of Natural Resources
  Division of Environmental Quality
  Division of Parks, and
  Land Reclamation Commission
National Park Service
U.S. Army Corps of Engineers
U.S. Forest Service

Emitt C. Witt, III, Project Chief

NEED FOR STUDY

Water-resources planning and water-quality assessment require a statewide and nationwide base of relatively standardized information. For planning and assessment of water resources, the chemical and physical quality of the rivers and streams needs to be defined and monitored.

OBJECTIVES

(1) Collect sufficient data to provide a long-term data base so that the general water quality of the hydrologic system is known to allow for proper planning and management of potential concerns in the State. (2) Collect data necessary for analytical studies and define the trends and statistical properties of water-quality conditions.

APPROACH

A network of quality-water stations will be operated to measure chemical conditions, loads, and time trends as required by planning and management agencies.

ACTIVITIES DURING 1993

The Missouri District water-quality network included 9 NASQAN stations, 22 State-supported Ambient Water Quality Monitoring stations, 22 subproject monitoring sites, and 11 National Park Service sampling sites. Samples are collected at varying frequencies from weekly to bi-annually. Sample analysis includes major ions, nutrients, trace elements, and herbicides. Standard field measurements include specific conductance, pH, temperature, dissolved oxygen,

indictor bacteria, and alkalinity. Dissolved oxygen and temperature are monitored continuously from June to November at two sites for the U.S. Army Corps of Engineers. The data were published in "Water-Resources Data, Missouri" (published annually).

PLANNED ACTIVITIES DURING 1994

The Missouri District water-quality network will include 7 NASQAN stations, 37 State-supported Ambient Water Quality Monitoring stations, 22 subproject monitoring sites, 2 sites supported by the Missouri Division of Parks, and 12 National Park Service sampling sites. Sampling frequency will vary from weekly to bi-annually. Sample analysis will include major ions, nutrients, trace elements, and pesticides. Standard field measurements will include specific conductance, pH, temperature, dissolved oxygen, indicator bacteria, and alkalinity. Temperature and dissolved oxygen will be monitored continuously from June to November at two U.S. Army Corps of Engineers sites.

REPORTS

Reed, H.L., Perkins, T.J., and Gray, G.L., Jr., 1993, Water resources data, Missouri, water year 1992: U.S. Geological Survey Water-Data Report MO-92-1, 236 p. (published annually).

_____ 1994, Water resources data, Missouri, water year 1993: U.S. Geological Survey Water-Data Report MO-93-1, 274 p. (published annually).

Collection of Sediment Data (MO 00-004)

In cooperation with

U.S. Army Corps of Engineers

Rodney E. Southard, Project Chief

NEED FOR STUDY

Water-resources planning and water-quality assessment require a nationwide base level of relatively standardized information. Sediment concentrations and discharges in Missouri's rivers and streams need to be defined and monitored.

OBJECTIVE

Provide sediment data for use in comprehensive State and Federal planning and action programs, including State and Federal management of interstate and international waters.

APPROACH

A network of sediment stations will be established and operated to provide spatial and temporal averages and trends of sediment concentration, sediment discharge, and particle size of sediment transported by rivers and streams.

ACTIVITIES DURING 1993

The operation of nine daily suspended-sediment data sites and seven partial record suspended-sediment sites continued, and the data were published in "Water-Resources Data, Missouri" (published annually). Historical suspended-sediment data for the Missouri River at Hermann were entered into the data base. The sediment computation program SEDCALC was evaluated on two Missouri sediment stations.

PLANNED ACTIVITIES DURING 1994

Data collection at the nine suspended-sediment data sites and seven partial record suspended-sediment sites will continue.

Collection of Sediment Data (MO 00-004)--Continued

REPORTS

Reed, H.L., Perkins, T.J., and Gray, G.L., Jr., 1993, Water resources data, Missouri, water year 1992: U.S. Geological Survey Water-Data Report MO-92-1, 236 p. (published annually).

_____ 1994, Water resources data, Missouri, water year 1993: U.S. Geological Survey Water-Data Report MO-93-1, 274 p. (published annually).

Water-Use Data-Collection and Reporting Program (MO 00-007)

In cooperation with

Missouri Department of Natural Resources,
Division of Geology and Land Survey

Richard J. Huizinga, Project Chief

NEED FOR STUDY

As population increases and industry expands to meet the needs of that population, demand for and use of water will increase. This places a two-fold stress on the water supply. The increased demand may exceed the supply, and increased use accelerates the potential for degradation of the water quality.

OBJECTIVES

(1) Systematically collect data for the estimation of the withdrawal and return of water for all types of water uses. (2) Provide a comprehensive data base from which many types of analyses can be made. (3) Provide a greater knowledge of the general hydrologic effects of increased withdrawals from the water system. (4) Provide data to the national water-use data base to assist in the national water-resources management.

APPROACH

Water-use data will be collected by category on a statewide basis. Existing data will be compiled from State files, stored in the U.S. Geological Survey Prime computer system, and entered into the U.S. Geological Survey aggregated data base. Data-collection methods and sampling strategies will be devised to acquire additional data. Statistical summaries will be included in the annual water-data report.

ACTIVITIES DURING 1993

Water-use data were collected for public supply, commercial, domestic, industrial, fossil fuel, nuclear, mining, livestock, animal specialities, irrigation, hydroelectric, sewage treatment, and reservoir evaporation as needed for various projects.

Water-Use Data-Collection and Reporting Program (MO 00-007)--Continued

PLANNED ACTIVITIES DURING 1994

Data-collection activities will continue, and the data will be entered into the WUDS computer program.

REPORTS

Reed, H.L., Perkins, T.J., and Gray, G.L., Jr., 1993, Water resources data, Missouri, water year 1992: U.S.Geological Survey Water-Data Report MO-92-1, 236 p. (published annually).

_____ 1994, Water resources data, Missouri, water year 1993: U.S. Geological Survey Water-Data Report MO-93-1, 274 p. (published annually).

HYDROLOGIC INVESTIGATIONS

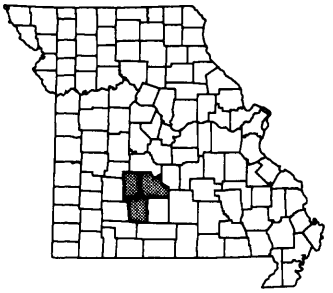
Hydrologic investigations include multidiscipline appraisal studies and hydrologic and hydraulic investigations. These investigations include ground-water hydraulics and mathematical modeling of aquifer systems, environmental problems, effects of manmade structures on hydraulics, magnitude and frequency of floods and droughts, urban hydrology, analyses of the effect of hazardous wastes and historical and ongoing mineral mining on the hydrologic system, and stream geomorphology.

Hydrologic information collected during these investigations is published in interpretive and basic-data reports. These reports are available for inspection at the U.S. Geological Survey District Office in Rolla, Missouri, or may be purchased from the sources shown in a later section of this report, "Sources of Water Resources Division Publications and Information."

Niangua River Watershed Nonpoint Source Water-Quality Monitoring (MO 00-00307)

In cooperation with

Agricultural Stabilization and Conservation Service
Missouri Department of Health
Missouri Department of Natural Resources
Missouri Farm Bureau
University of Missouri at Columbia
Natural Resources Conservation Service



Emitt C. Witt, III, Project Chief

NEED FOR STUDY

The Niangua River Basin contains intensive dairy and beef operations, with emphasis on forage production, either for hay or pasture. It includes about 236,000 acres in parts of Dallas, Laclede, and Webster Counties. Ground and surface water has become contaminated with nutrients and bacteria because of absent or ineffective animal-waste-management practices. This project was established to monitor improvement in surface-water quality as a result of planned improvements in animal-waste management.

OBJECTIVE

To assess changes in water quality as a result of habitat improvements resulting from the implementation of the Natural Resources Conservation Service Upper Niangua Hydrologic Unit project.

APPROACH

The project is using a single basin with upstream/downstream and before/after comparisons. No comparable "reference" basin is available. However, smaller basins, or subbasins, within the main basin have been paired. This will allow examination of water-quality response at several levels of spatial scale in relation to land-use changes. Site selection was made to allow several upstream/downstream comparisons, as well as multiple before/after comparisons.

During the 1991 water year, water samples were collected weekly at two continuous surface-water gaging stations and once from 20 stream and spring sites to determine pre-implementation water-quality characteristics. Beginning during the 1992 water year and continuing through 1995, samples will be collected monthly at two gages and quarterly at the 20 stream and spring sites. Samples are collected and composited using depth-integrating samplers at equal width increments across the cross section of the stream. Field analyses include specific conductance, pH, temperature, dissolved oxygen, fecal coliform bacteria, and fecal streptococci bacteria using

methods approved by the U.S. Geological Survey. Samples are being analyzed for total and dissolved nutrients including nitrite, nitrite plus nitrate, ammonia, ammonia plus organic, phosphorus, and orthophosphate at a U.S. Geological Survey laboratory.

ACTIVITIES DURING 1993

Water-quality samples were collected quarterly at 20 stream and spring sites, monthly at 2 continuous record stations, and during 2 events of rainfall runoff at 2 sites in the main channel. Samples also will be collected at two subbasins within the Niangua River Basin weekly from February through July.

PLANNED ACTIVITIES DURING 1994

Water-quality samples will be collected quarterly at 20 stream and spring sites, monthly at 2 continuous record stations, and during 2 events of rainfall runoff at 2 sites in the main channel. Samples also will be collected at 2 subbasins within the Niangua River Basin weekly from February through July.

Extent and Magnitude of Contamination of the Water Resources in the Vicinity of the Weldon Spring Radioactive Waste-Disposal Sites, St. Charles County, Missouri (MO 87-071)

In cooperation with

U.S. Department of Energy

Michael J. Kleeschulte, Project Chief

NEED FOR STUDY

Chemical analyses indicate that water in the shallow bedrock aquifer contains large concentrations of calcium, lithium, magnesium, nitrate, sodium, strontium, sulfate, and uranium in the vicinity of four low-level radioactive waste-disposal pits near Weldon Spring, Missouri. A spring 1.5 miles north of the site also has increased lithium, nitrate, and uranium concentrations, but monitoring wells between the pits and spring do not indicate a contamination plume. Monitoring of discharge and water quality at this spring is necessary.

OBJECTIVE

To continually monitor the discharge and specific conductance of water from Burgermeister spring to observe seasonal changes.

ACTIVITIES DURING 1993

A U.S. Geological Survey Open-File Report was published. An interpretive report defining the areas of surface- and ground-water contamination and the results of a three-dimensional finite difference ground-water flow model was published. A report defining the background water quality in the Missouri River and the Missouri River alluvium near Weldon Spring was published.

PLANNED ACTIVITIES DURING 1994

A U.S. Geological Survey Open-File Report will be finished, approved, and published. The report will include hydrologic data collected as a result of this project on and in the vicinity of the Weldon Spring chemical plant between 1989 and 1993. Basic data collection, including operation of stream-gaging and minimonitor equipment at Burgermeister spring, will continue.

Extent and Magnitude of Contamination of the Water Resources in the Vicinity of the Weldon Spring Radioactive Waste-Disposal Sites, St. Charles County, Missouri (MO 87-071)--Continued

REPORTS

Kleeschulte, M.J., 1991, Geohydrology of bedrock aquifers and public supply and domestic water use, 1962-85, in St. Charles County, Missouri, in Proceedings of the Geosciences Workshop: U.S. Department of Energy, Oak Ridge Operations Office, p. 41-74.

_____ 1993, Water-quality data for the Missouri River and Missouri River alluvium near Weldon Spring, St. Charles County, Missouri--1991-92: U.S. Geological Survey Open-File Report 93-109, 48 p.

Kleeschulte, M.J., and Cross, P.W., 1990, Hydrologic data for the Weldon Spring chemical plant site and vicinity property, St. Charles County, Missouri--1986-89: U.S. Geological Survey Open-File Report 90-552, 117 p.

Kleeschulte M.J., and Emmett, L.F., 1986, Compilation and preliminary interpretation of hydrologic data for the Weldon Spring radioactive waste-disposal sites, St. Charles County, Missouri--A progress report: U.S. Geological Survey Water-Resources Investigations Report 85-4272, 71 p.

_____ 1987, Hydrology and water quality at the Weldon Spring radioactive waste-disposal sites, St. Charles County, Missouri: U.S. Geological Survey Water-Resources Investigations Report 87-4169, 65 p.

Kleeschulte, M.J., Emmett, L.F., and Barks, J.H., 1986, Hydrologic data for the Weldon Spring radioactive waste-disposal sites, St. Charles County, Missouri--1984-1986: U.S. Geological Survey Open-File Report 86-488, 61 p.

Kleeschulte, M.J., and Imes, J.L., 1994, Geohydrology, water quality, and simulation of ground-water flow at the Weldon Spring chemical plant and vicinity, St. Charles County, Missouri, 1987-90: U.S. Geological Survey Open-File Report 93-648, 106 p.

Investigation of Bridge-Scour Processes Occurring at Selected Sites on Missouri Streams (MO 88-076)

In cooperation with

Missouri Highway and Transportation Commission

Lawrence D. Becker, Project Chief

NEED FOR STUDY

Adequate definition of potential scour at bridge piers is essential to proper design, construction, and maintenance of hydraulic structures. Reasonably accurate estimates of scour depth are needed for safe, cost-effective bridge design. Although many scour estimating equations have been developed based on laboratory work, site-specific data have not been collected to verify the accuracy of these equations and techniques and their applicability to Missouri streams.

OBJECTIVES

To investigate bridge-pier scour processes at selected sites on Missouri streams, collect data relative to bridge-pier scour during floods, evaluate existing scour prediction techniques and equations, and possibly develop depth-of-scour estimation techniques applicable to Missouri in whole or part.

APPROACH

The scope of study is statewide, but will be limited to regions where pier scour can be expected to be a significant consideration in bridge design. Approximately 12 sites will be selected for data collection relative to extent of scour, sediment and bed material, and flow velocities and directions during and following flood events. Collected data will be used in verification or development of methods to predict scour effects at ungaged or site-specific locations.

ACTIVITIES DURING 1993

Scour data were collected at 10 sites and for 24 floods. Seven local-scour equations will be evaluated as to their usefulness to estimate the measured scour at the sites studied.

Investigation of Bridge-Scour Processes Occurring at Selected Sites on Missouri Streams (MO 88-076)--Continued

PLANNED ACTIVITIES DURING 1994

A U.S. Geological Survey Water-Resources Investigations Report will be written and approved.

REPORT

Becker, L.D., 1994, Investigtion of bridge scour at selected sites on Missouri streams: U.S. Geological Survey Water-Resources Investigations Report 94-4200, 40 p.

Comprehensive Assessment of the Potential Hydrologic and Biological Impact of Lead and Zinc Mining in the Mark Twain National Forest of Southern Missouri (MO 89-079)

In cooperation with

Bureau of Land Management
Missouri Department of Conservation
U.S. Forest Service

Michael J. Kleeschulte, Project Chief

NEED FOR STUDY

The Bureau of Land Management has issued two preference right lease applications for lead and zinc in the Mark Twain National Forest. Lead and zinc mining could potentially affect the water resources in the area by degrading water quality or decreasing the ground-water flow, or both. Declining water levels could cause domestic wells to go dry and contribute to land subsidence in the karst terrane. Changes in water quality and quantity could adversely affect flora and fauna, including some threatened and endangered species, as well as the large tourist industry.

OBJECTIVES

The overall objective is to provide a technical basis for estimating the probable environmental effects of lead and zinc mining in the hydrologically and biologically sensitive Mark Twain National Forest.

APPROACH

The study has been divided into three phases that generally coincide with mine development. Phase 1 will include an extensive literature search, installation of monitoring equipment on wells, inventory of existing wells, sampling of ground and surface water and bed material for chemical analyses, water-level measurements, and monitoring stream discharge. If mineralization warrants further exploration and mine development, phase 2 will include continued collection and analyses of water and sediment, preparation of a geologic map, core analyses, aquifer testing, and construction of a ground-water flow model. Phase 3 will include comparison of data collected from earlier phases and data from monitoring in this phase to determine if resources are being affected by mining.

Comprehensive Assessment of the Potential Hydrologic and Biological Impact of Lead and Zinc Mining in the Mark Twain National Forest of Southern Missouri (MO 89-079)--Continued

ACTIVITIES DURING 1993

Continuous recorders were operated on three wells, one precipitation gage, and one spring flow gage. Mass water-level measurements were made in the spring and fall. Water samples were collected from a network of stream, spring, and ground-water sites in the fall and analyzed for major inorganic constituents, nutrients, and trace elements. Bed-material samples were collected at stream and spring sites and analyzed for trace elements.

PLANNED ACTIVITIES DURING 1994

Data collection will cease and the hydrologic data collected as a result of this project will be compiled and published as a U.S. Geological Survey Open-File Report and a U.S. Geological Survey Water-Resources Investigations Report.

REPORT

Kleeschulte, M.J., and Sutley, S.J., 1995, Hydrologic data for the Fristoe Unit of the Mark Twain National Forest, south-central Missouri, 1988-93: U.S. Geological Survey Open-File Report 95-106, 106 p.

Mudflow Research Using a Rotating Flume (MO 90-080)

Robert R. Holmes, Jr., Project Chief

NEED FOR STUDY

Mudflows are complex and the rheology (science of deformation and flow of matter) is not understood. Predictive mathematical models for mudflows are not available due to the incomplete understanding of the rheology. Currently (1994), open-channel streamflow models are being used to predict mudflow inundation with suspect results.

OBJECTIVES

To develop understanding of the rheology of different non-Newtonian flows and the effect of various flow characteristics (sediment concentration, grain-size distribution, clay content, and clay type) on the rheology.

APPROACH

The study will involve using a rotating flume to simulate flows with various physical properties of sediment concentration and grain-size distribution. Measurements of shear stress and strain rate will be taken on various flows.

ACTIVITIES DURING 1993

One master's thesis was completed in addition to a U.S. Geological Survey Water-Resources Investigations Report.

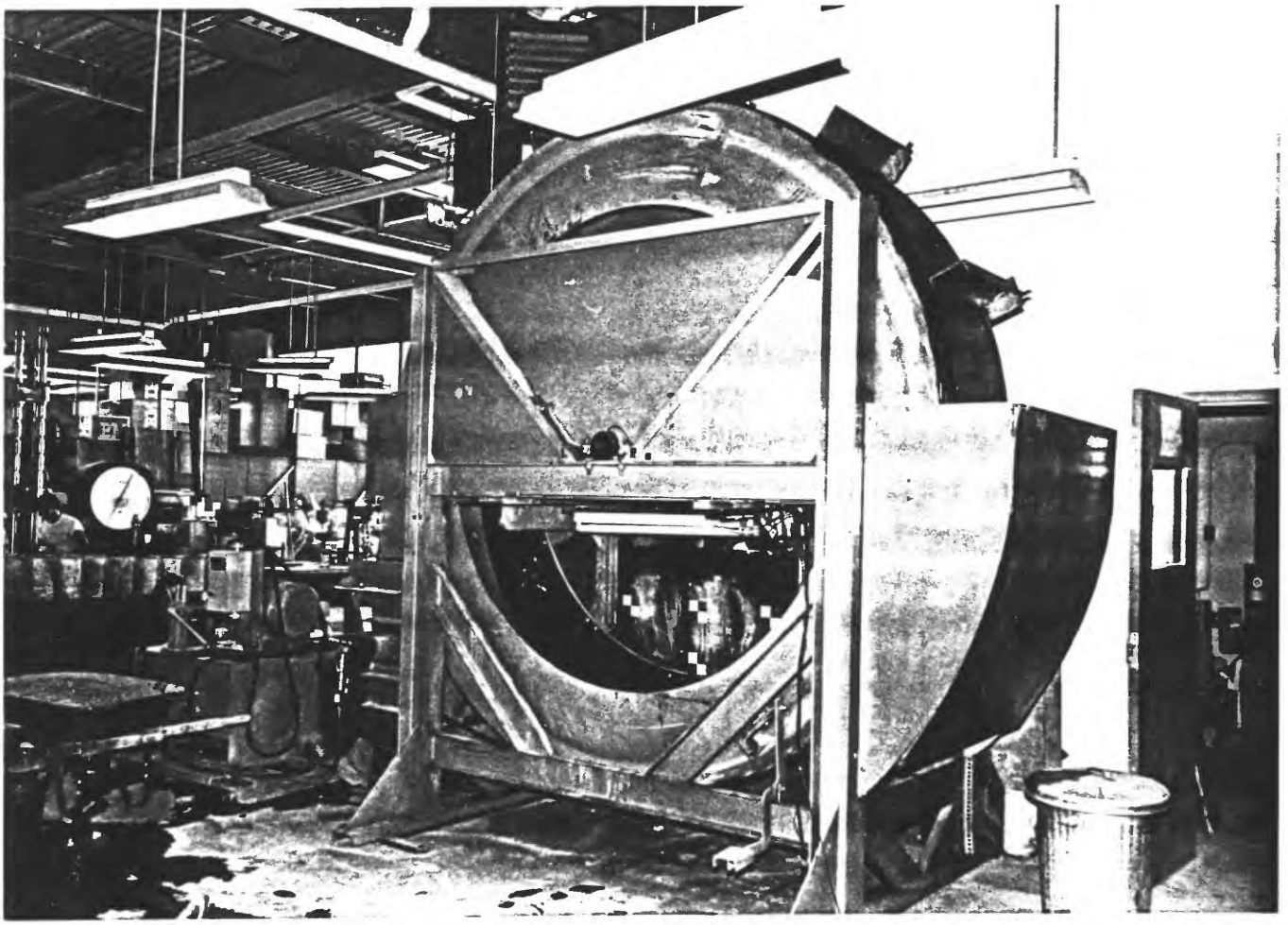
PLANNED ACTIVITIES DURING 1994

A journal article for the American Society of Civil Engineers will be published.

REPORTS

Holmes, R.R., Jr., Huizinga, R.J., Brown, S.M., and Jobson, H.E., 1993, Laboratory procedures and data reduction techniques to determine rheologic properties of mass flows: U.S. Geological Survey Water-Resources Investigations Report 93-4123, 17 p.

Holmes, R.R., Jr., Westphal, J.A., and Jobson, H.E., 1990, Mudflow rheology in a vertically rotating flume, in French, R.H., ed., Proceedings of the International Symposium Hydraulics/Hydrology of Arid Lands: San Diego, Calif., July 30-August 2, 1990, p. 212-217.

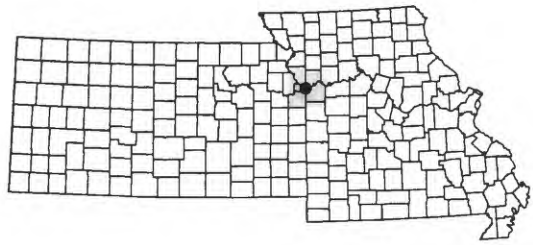


Ground-Water Flow and Quality in the Missouri River Alluvium near Kansas City, Missouri and Kansas (MO 90-081)

In cooperation with

Mid-America Regional Council

Brian P. Kelly, Project Chief



NEED FOR STUDY

The Missouri River alluvium is the only aquifer near Kansas City that can produce more than 20 gallons of water per minute. The aquifer is used for public supply, industry, and irrigation. The aquifer is threatened by urban and rural activities.

OBJECTIVE

(1) Develop a regional geographic information system (GIS) for the hydrogeology of the Missouri River alluvium that incorporates existing data and can be updated as more data are collected. (2) Determine ground-water levels in the Missouri River alluvium in different seasons and stages of the Missouri River. This determination would help delineate the zones of contribution around municipal well fields in the Kansas City area. (3) Identify areas of the alluvial aquifer most susceptible to contamination from the land surface. (4) Establish a water-quality and water-level monitoring network.

APPROACH

All existing hydrogeologic data for the Missouri River alluvium will be entered into a GIS data base. Wells will be drilled where data are lacking. Water-level measurements will be used to map zones of contribution to well fields. Water samples will be collected to characterize present conditions. A map depicting susceptibility to surface contamination also will be prepared. Data collected will be incorporated into a regional ground-water flow model. Particle tracking analyses will be used to help identify areas that contribute ground water to public water-supply wells.

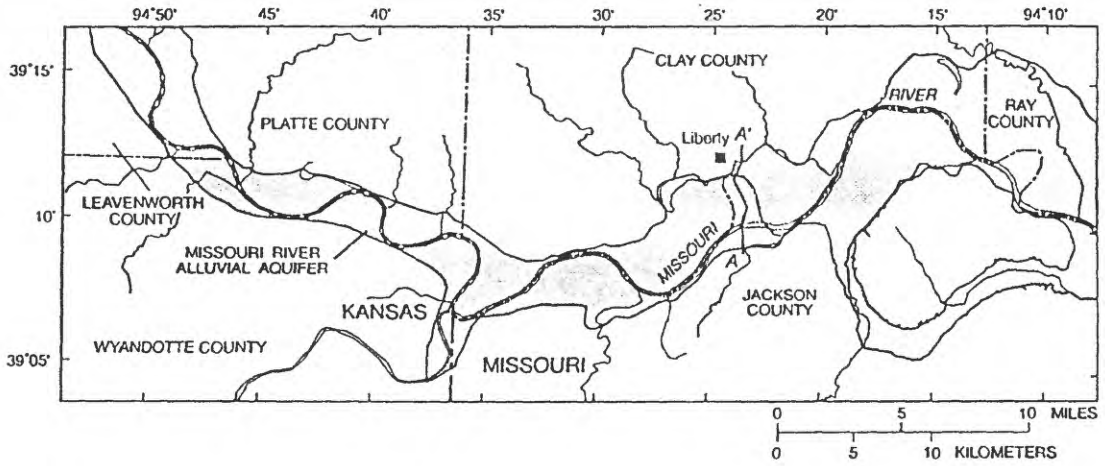
ACTIVITIES DURING 1993

All pertinent data available from the U.S. Geological Survey, as well as a significant quantity of data from other sources, has been compiled and entered into the regional GIS. A U.S. Geological Survey Open-File Report has been written.

Ground-Water Flow and Quality in the Missouri River Alluvium near Kansas City, Missouri and Kansas (MO 90-081)--Continued

PLANNED ACTIVITIES DURING 1994

Ground-water flow modeling and particle tracking analysis will be conducted for different river stages and pumping conditions to aid in defining the areas that contribute ground water to public water-supply wells in the Missouri River alluvial aquifer. A U.S. Geological Survey Water-Resources Investigations Report will be started.



Hydrochemical Investigations of the St. Francois County Landfill, St. Francois County, Missouri (MO 91-084)

In cooperation with

St. Francois County Environmental Corporation

John G. Schumacher, Project Chief

NEED FOR STUDY

The St. Francois County Landfill is located in an abandoned lead and zinc mine tailings pile. The 550-acre tailings pile is located within a meander bend of the Big River. Numerous unplugged exploratory boreholes are present beneath the landfill and tailings pile. These boreholes extend into underlying abandoned flooded mine cavities that are used as a local drinking-water supply for several communities. There are sparse data on direction of ground-water flow at the site, quality of ground water, or possible mobilization of trace elements within the mine tailings by landfill leachate. The tailings pile was placed on the U.S. Environmental Protection Agency's National Priority List as a Superfund site in October 1992.

OBJECTIVES

(1) Determine the direction of regional ground-water flow in the vicinity of the site. (2) Assess the extent and magnitude of contamination from landfill leachate within the mine tailings, shallow bedrock, and mine cavity system. (3) Determine the relation between the original land surface and abandoned boreholes to the migration of contaminants from the landfill. (4) Determine if landfill leachate is mobilizing substantial quantities of trace elements from the mine tailings.

APPROACH

A potentiometric map will be prepared for the area using water-level data collected during a well inventory. The ground-water/surface-water relations will be determined by conducting a seepage run along the Big River and various tributaries in the vicinity of the landfill. A ground-water monitoring network will be installed to collect water-quality data for the tailings, shallow bedrock, and mine cavities near the site. Exploration maps and auger drilling were used to delineate the original topography beneath the landfill and tailings pile.

Hydrochemical Investigations of the St. Francois County Landfill, St. Francois County, Missouri (MO 91-084)--Continued

ACTIVITIES DURING 1993

A ground-water monitoring network consisting of 13 monitoring wells and piezometers was installed at the landfill site. Quarterly water level-measurements and water-quality samples were collected from each monitoring well and piezometer. Several synoptic samples were collected from several seeps at the site, the Big River adjacent to the site, and several public water-supply wells in the area. The water-quality samples were analyzed for total and dissolved major and trace inorganic constituents, total organic carbon, volatile organic compounds, and pesticides. Several samples also were collected for the determination of tritium.

PLANNED ACTIVITIES DURING 1994

A U.S. Geological Survey Water-Resources Investigations Report will be written.

Use of Nitrogen and Oxygen Isotopes to Measure Nitrogen-Cycle Processes in Claypan Soils and Glacial-Drift Aquifers (MO 91-085)

Dale W. Blevins, Project Chief

NEED FOR STUDY

Nitrate concentrations in ground water under claypan soils in northern Missouri frequently are greater than the Missouri drinking water supply criteria of 10 milligrams per liter. However, the source, including the contribution of nitrogen fertilizers, of the nitrate is not known. Previous studies have not used nitrogen-15 to determine the contribution of nitrogen fertilizers to nitrate concentrations in ground water and field runoff.

OBJECTIVE

(1) Determine the contribution of nitrogen fertilizers to concentrations of nitrate in ground water and runoff from clay-rich soils and aquifers using nitrogen isotopes. (2) Identify hydrogeochemical factors that have significant roles in the speciation and transport of nitrogen in a claypan soil and underlying glacial deposits. (3) Refine and develop field methods for concentrating nitrate in water samples for nitrogen isotopic analysis.

APPROACH

A 0.1-acre plot was planted in continuous corn and instrumented with lysimeters, monitoring wells, neutron probe access tubes, and a runoff sampler. Existing isotopic signatures and fertilizer spiked with nitrogen-15 and bromide will be used to trace nitrogen fertilizer in the soil, ground water, and surface water. Soil gas samples are expected to reveal the extent of nitrification and denitrification. New methods for separation and preconcentration of nitrate on anion exchange resins are expected to substantially reduce the cost of high-precision nitrogen-15 analyses and make them an affordable tool in nitrogen studies.

ACTIVITIES DURING 1993

Field data collection was completed during a 28-month period and data analysis was begun. Preliminary results indicate 27.3 percent of the labeled fertilizer was removed in 2 corn harvests, more than 18 percent was leached to ground water, and less than 4 percent was lost to runoff. Denitrification was not a significant sink for nitrogen fertilizer, but emissions of nitrogen gases through plant surfaces appears to be substantial.

Use of Nitrogen and Oxygen Isotopes to Measure Nitrogen-Cycle Processes in Claypan Soils and Glacial-Drift Aquifers (MO 91-085)--Continued

PLANNED ACTIVITIES DURING 1994

Compilation and analysis of data will be completed and published in a series of reports.

REPORTS

Alberts, E.E., Prato, T., Kitchen, N.K., and Blevins, D.W., 1993, Research and education to improve surface and ground-water quality of a claypan soil, in Proceedings of Agricultural Research to Protect Water Quality, Minneapolis, Minn., 1993, Soil Conservation Society, p. 21-38.

Blevins, D.W., 1991, Planned studies of movement of nitrogen species and herbicides on claypan soils at the Management Systems Evaluation Area in Missouri, in Mallard, G.E., and Aronson, D.A., (eds.) Proceedings of the Technical Meeting of the U.S. Geological Survey Toxic Substance Hydrology Program: Monterey, Calif., March 11-15, 1991, U.S. Geological Survey Water-Resources Investigations Report 91-4034, p. 240-242.

Blevins, D.W., Wilkison, D.H., Silva, S.R., and Kelly, B.P., 1995, Use of 15N to trace movement of nitrogen fertilizer at a field plot, in Morganwalp, D.W., and Aronson, D.A., (eds.), Proceedings of the technical meeting of the U.S. Geological Survey Toxic Substances Hydrology Program: Monterey, Calif., March 11-15, 1991, U.S. Geological Survey Water-Resources Investigations Report 94-4015.

Kelly, B.P., and Blevins, D.W., 1993a, Hydrologic budget and nitrogen distribution for an agricultural test plot in claypan soil and glacial till near Centralia, Missouri--May 1991 to May 1992, in Proceedings of Agricultural Research to Protect Water Quality; Minneapolis, Minn., 1993, Soil Conservation Society, p. 545-547.

_____ 1993b, Hydrologic budget and nitrogen distribution for an agricultural study plot in claypan soil and glacial till near Centralia, Missouri--May 1991 to May 1992, in Proceedings of the 3rd Annual Water Quality Conference: Columbia, Mo., Feb. 4-5, 1993, Missouri Agricultural Experiment Station, p. 100-105.

Wilkison, D.H., Blevins, D.W., Kelly, B.P., and Wallace, W.C., 1995, Hydrology and water quality in claypan soil and glacial till at the Missouri Management Systems Evaluation Area near Centralia, Missouri--May 1991 to September 1993: U.S. Geological Survey Open-File Report 94-705, 64 p.

Water-Quality Characteristics of Lake Jacomo, Prairie Lee Lake, and Harrisonville Lake in Jackson and Cass Counties, Missouri (MO 91-086)

In cooperation with

Cass County Soil and Water Conservation District
City of Independence
Jackson County Parks and Recreation Department

David C. Heimann, Project Chief

NEED FOR STUDY

Lake Jacomo, Prairie Lee Lake, and Harrisonville City Lake are located in a rapidly growing urban area near the Kansas City metropolitan area. Development of the lake drainage areas has caused sediment and nutrient loading of the lakes. Harrisonville City Lake also receives drainage from agricultural areas. The existing water quality needs to be characterized to develop water-quality protection and remediation plans for the lakes.

OBJECTIVE

(1) Characterize the water quality and microbiology of Lake Jacomo, Prairie Lee Lake, and Harrisonville City Lake. (2) Identify source areas for selected constituents detected in Lake Jacomo, Prairie Lee Lake, and Harrisonville City Lake.

APPROACH

Lake samples will be collected about 3 feet below the lake surface and about 3 feet above the bottom at three locations on all lakes. Samples will be analyzed for specific conductance, pH, bacteria, alkalinity, suspended solids, nutrients, algae, chlorophyll *a*, and suspended sediment. Temperature and dissolved oxygen profiles will be obtained at each site. Samples will be collected every other week from May through September and monthly from October through April. A bottom sediment sample will be collected at each site and analyzed for nutrients, trace elements, pesticides, and total organic carbon. Composite storm runoff samples will be collected at three sites and analyzed for sediment, nutrients, and volatile suspended solids.

Water-Quality Characteristics of Lake Jacomo, Prairie Lee Lake, and Harrisonville Lake in Jackson and Cass Counties, Missouri (MO 91-086)--Continued

ACTIVITIES DURING 1993

Harrisonville City Lake was monitored through March 1993, and collected data were analyzed for Prairie Lee Lake, Lake Jacomo, and Harrisonville City Lake. Atrazine and agricultural herbicides were detected at Harrisonville City Lake.

PLANNED ACTIVITIES DURING 1994

A U.S. Geological Survey Water-Resources Investigations Report will be written.

Determination of Stormwater Runoff Quality in Independence, Missouri (MO 92-087)

In cooperation with

City of Independence

Gregg K. Schalk, Project Chief

NEED FOR STUDY

Stormwater quality of streams, the stormwater systems, and the relation of stormwater quality to different land uses in Independence are unknown.

OBJECTIVES

(1) Characterize the quantity and quality of discharge from storm-sewer outfalls during dry weather. (2) Characterize the quantity and physical, chemical, and bacteriological quality of stormwater in streams and channels draining from land with specific land-use categories.

APPROACH

Land-use data will be compiled and storm-sewer outfalls will be located during characterization of dry weather water quality. Existing hydrologic data and precipitation data will be compiled. Based on existing data and results of the dry weather reconnaissance, five gaging sites will be selected and instrumentation will be installed. Water samples will be manually collected three times at each gage and analyzed for constituents on the U.S. Environmental Protection Agency's primary pollutant list. Based on results from the first three storms, selected constituents will be analyzed from an additional storm.

ACTIVITIES DURING 1993

Samples were collected from July 1992 to February 1993 for three storms at five storm-runoff sites draining single-family, multi-family, commercial, and light-industrial lands uses to characterize stormwater runoff. Fecal coliform ranged from 500 to 290,000 colonies per 100 milliliters and fecal streptococci ranged from 1,900 to 500,000 colonies per 100 milliliters in 35 first-flush samples. The chemical oxygen demand ranged from 36 to 1,600 milligrams per liter. Biological oxygen demand ranged from 15 to more than 650 milligrams per liter. Dissolved solids ranged from 75 milligrams per liter to 14,700 milligrams per liter. Suspended solids ranged from 38 to 1,200 milligrams per liter. The following trace elements were detected: arsenic, cadmium,

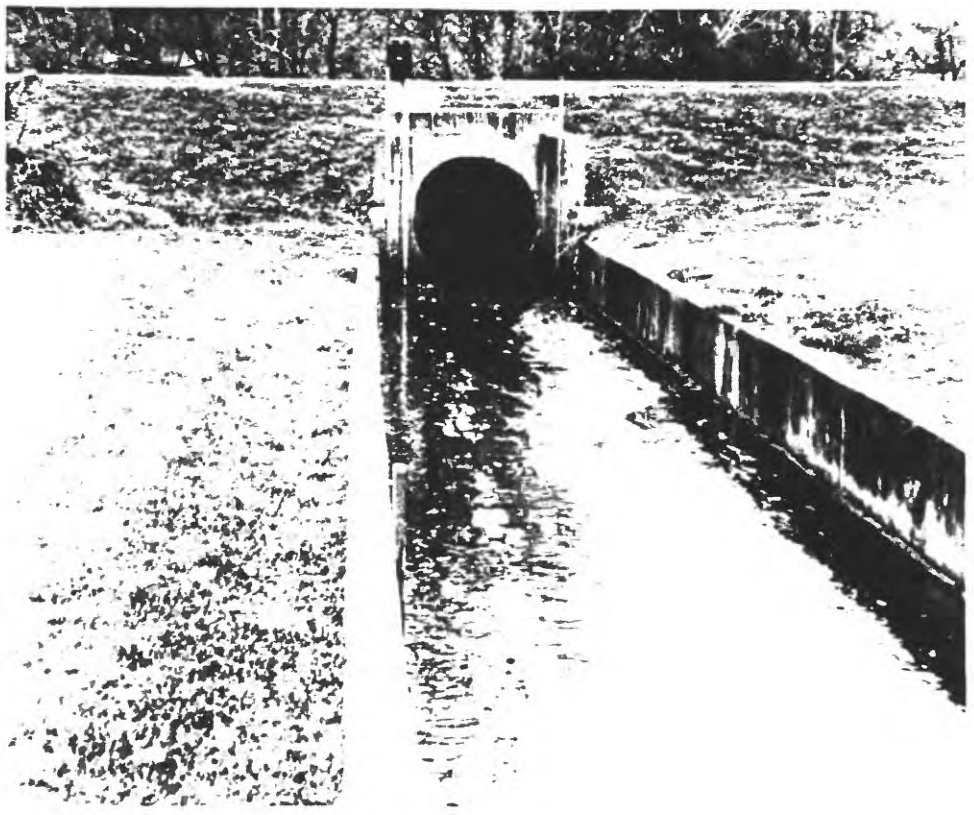
chromium, copper, lead, mercury, nickel, and zinc. Antimony, beryllium, selenium, and thallium were not detected; silver was detected once. Pesticides detected include chlordane, DDD, DDT, diazinon, dieldrin, lindane, and aroclor 1254. Thirteen of the 63 volatile organic compounds analyzed were detected 27 times. Acidic organic compounds were not detected. Basic and neutral organic compounds detected included di-2-ethylhexyl phthalate, fluoranthene, phenanthrene, and pyrene. Runoff loads were calculated for each constituent detected. Five additional storms were sampled from April to September 1993 and analyzed for selected constituents.

PLANNED ACTIVITIES DURING 1994

A U.S. Geological Survey Open-File Report has been approved.

REPORT

Schalk, G.K., 1994, Quantity and quality of base flow and stormwater runoff in Independence, Missouri--October 1991 to February 1993: U.S. Geological Survey Open-File Report 93-495, 69 p.



The Role of Preferential Flow in the Transport of Agricultural Chemicals in Claypan Soils (MO 92-088)

Brian P. Kelly, Project Chief

NEED FOR STUDY

Claypan soils cover about 16,000 square miles of the central United States. Claypan soils have low intrinsic permeabilities, yet macropores form in claypan soils from shrinkage cracks and biologic activity. Once formed, these macropores may transmit recharge and agricultural chemicals to the underlying aquifers. Knowledge of the effects and processes of water flow and chemical transport in claypan soils is crucial to understanding the larger concerns of water contamination from agricultural sources because of the large areal extent of these soils.

OBJECTIVES

(1) Determine the rate of water flow through macropores in a claypan soil compared to the transport of nitrate, nitrogen-15 in nitrate, and bromide. (2) Determine the rate of water flow, and the transport of nitrate, nitrogen-15 in nitrate, and bromide through macropores compared to flow and transport through the soil matrix.

APPROACH

A 0.1-acre plot will be used as the study area. Conventional methods of corn production and herbicide application will be used on and around the plot. Tracers such as nitrogen-15 (in nitrate) and bromide will be applied with the fertilizer. Water samples from rainfall, surface runoff, the unsaturated zone, interflow, and ground water will be analyzed to follow nitrate tracers and water from the ground surface through the unsaturated zone and into the ground water beneath the study plot.

PLANNED ACTIVITIES DURING 1994

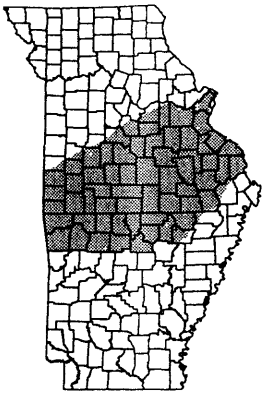
Rainfall, surface runoff, interflow, and ground water will continue to be sampled for Nitrogen-15 and bromide. Water, nitrogen, and bromide budgets will continue to be developed as new data are collected. Analysis of soil staining experiments will be completed.

Land-Use and Climatic Effects on the Stream Geomorphology and Physical Aquatic Habitat in the Ozark Highlands (MO 92-089)

In cooperation with

Missouri Department of Conservation
National Biological Survey
National Park Service

Robert B. Jacobson, Project Chief



NEED FOR STUDY

Ozarks stream channels are characterized by extensive, unvegetated gravel bars, rapidly shifting channels, and extensive eroding cut banks. It is not known if these conditions are natural or unnatural, whether they are getting better or worse, and what their effects have been on stream ecology. Management of aquatic ecosystem resources in the Ozarks requires a predictive understanding of how streams and physical habitat attained their present condition and how they will respond to future land use and climate changes.

OBJECTIVES

(1) Determine how stream channels in the Ozarks achieved their present state of instability. (2) Assess the effect of channel disturbance on physical habitat. (3) Develop a predictive understanding of how future regional and global changes are likely to affect physical habitat of streams in the Ozarks using the record of past responses to disturbance. (4) Synthesize results of this study with results of channel disturbance studies in different geographic areas to develop a general model of processes and controls on channel disturbance and aquatic ecosystem disturbance.

APPROACH

The study will integrate stratigraphic, pedogenic, dendrochronologic, photogrammetric, historical, and channel monitoring data collected for this project with existing hydrologic and climatic data. A variety of physical hydraulic models will be used to model changes in aquatic habitat. Data and results will be synthesized with coordinated studies by other researchers involved in the National Park Service Global Change Research Program, including researchers in aquatic ecosystems, dendroclimatology, and regional-scale modeling.

ACTIVITIES DURING 1993

All 97 channel cross sections in the channel-monitoring data base were resurveyed during 1993. Particle-size and habitat variables were collected at six reaches used for monitoring and modeling components. Digital photographic methods were used to complete compilation of

channel-change maps for a 7-mile reach of Little Piney Creek for 1938-89. Stratigraphic drilling was completed at three sites on the Buffalo River in Arkansas, and samples were submitted for isotopic dating and particle-size analyses. Vegetation density and community age data were collected on gravel bars on the Jacks Fork to determine flood history and estimate effectiveness of vegetation on flow resistance.

PLANNED ACTIVITIES DURING 1994

All channel cross sections will be resurveyed at least once during 1994. Hydraulic data will be collected at high and low flows at one of the modeling reaches for calibration and verification of two-dimensional hydraulic models. Compilation of digital photogrammetric data will continue for the Jacks Fork. Photogrammetric data for Little Piney Creek will be analyzed and a report will be prepared on vegetative effects on channel migration and stability. Stratigraphic data will be compiled, analyzed, and prepared for publication. A report on land-use history and potential effects on stream stability will be submitted for Director's approval.

REPORTS

Jacobson, R.B., and Primm, A.T., 1994, Historical land-use changes and potential effects on stream disturbance in the Ozark Plateaus, Missouri: U.S. Geological Survey Open-File Report 94-333, 95 p.

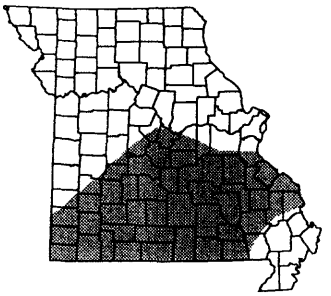
Jacobson, R.B., and Pugh, A.L., 1992, Effects of land use and climate shifts on channel instability, Ozark Plateaus, Missouri, U.S.A.: Proceedings of the workshop on the effects of global climate change on hydrology and water resources at the catchment scale, Japan-U.S. Committee on Hydrology, Water Resources and Global Climate Change, p. 423-444.

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

_____ 1993b, Geomorphic and hydraulic influences on the abundance and distribution of stream centrarchids in Ozark USA streams: Polskie Archiwum Hydrobiologii, v. 40, no. 1, p. 87-99.

National Water-Quality Assessment Program: Ozark Plateaus Study Unit--Missouri SubProject (MO 92-090)

David A. Freiwald, Project Chief
Jerri V. Davis, Missouri SubProject Chief



NEED FOR STUDY

The extensive karst features of the Ozark Plateaus create a complex hydrologic system that results in rapid interactions between ground and surface water. Poultry, cattle, and swine production, in addition to septic tanks and sewage-treatment plants, have affected the water quality with large concentrations of nitrate, ammonia, and bacteria. Serious degradation has occurred in the surface and ground water because of abandoned lead and zinc mines in the Tri-State District of Kansas, Missouri, and Oklahoma and the Old Lead Belt in Missouri. Recent lead mining in the New Lead Belt in southeastern Missouri has raised concerns about water quality in the area. Increased concentrations of radionuclides have been detected in numerous wells throughout the area, and highly saline ground water along the western boundary has caused some wells to be abandoned.

OBJECTIVES

(1) Describe the status and trends in the quality of the ground- and surface-water resources of the Ozark Plateaus study unit. (2) Provide an understanding of the natural and human factors that affect the quality of these resources. (3) Integrate study unit results with regional and national synthesis activities that will provide a base to assess specific water-quality issues of the Nation.

APPROACH

Compile and review available water-quality information for both surface- and ground-water resources in the first 2 years. Intensively sample and analyze the water resources of the study unit for a wide array of physical, chemical, and biological properties for about 3 years. Create computer data bases of water-quality and ancillary information to effectively interpret and report the results. Intermittently monitor the water quality of the study unit for about 5 years to establish trends using statistical and deterministic techniques.

ACTIVITIES DURING 1993

Nutrient and suspended-sediment retrospective data analysis was completed and the writing of a U.S. Geological Survey Water-Resources Investigations Report was begun. Water-quality sampling at 13 basic-fixed sites, which differ in drainage area, physiography, and land use, was started. The sites were sampled monthly for field parameters, indicator bacteria, nutrients, major constituents, and dissolved and suspended organic carbon and bi-monthly for trace elements.

National Water-Quality Assessment Program: Ozark Plateaus Study Unit--Missouri Sub-Project (MO 92-090)--Continued

Ecological surveys at the 13 basic-fixed sites, including Level I habitat assessment and fish, invertebrate, and algal community surveys, were conducted. The bed sediment and tissue contaminant survey at basic-fixed sites and selected synoptic sites was continued.

PLANNED ACTIVITIES DURING 1994

Water-quality sampling at 13 basic-fixed sites will continue, and intensive-fixed site sampling, which involves higher frequency sampling and includes dissolved pesticide analysis, at 2 of the basic-fixed sites will begin. The ecological survey will be repeated and Level II habitat assessment at basic-fixed sites will be done. Bed sediment and tissue contaminant survey will be completed. High-flux water-quality synoptic and low-flow water-quality and biological synoptic at 29 sites will be conducted. The 29 sites will be selected to verify the selection of the 13 basic-fixed sites and to determine study unit variability.

REPORT

Adamski, J.C., Peterson, J.C., Freiwald, D.A., and Davis, J.V., 1995, Environmental and hydrologic setting of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 94-4022, 69 p.

Femmer, S.R., and Joseph, R.L., 1994, NAWQA fact sheet--National water-quality assessment program--Ozark Plateaus surface-water quality study: U.S. Geological Survey Fact Sheet 94-015, 2 p.

Evaluation of Potential Bridge Scour in Missouri (MO 92-091)

In cooperation with

Missouri Highway and Transportation Department

Richard J. Huizinga, Project Chief

NEED FOR STUDY

The Federal Highway Administration requires all State highway agencies to evaluate the bridges on highways within the Federal Aid System for susceptibility to scour-related failure. There are about 4,700 bridges within the Federal Aid System requiring screening for scour susceptibility in Missouri.

OBJECTIVES

Evaluate the potential for scour at bridges and identify bridges that are observably scour critical (a bridge with abutment or pier foundations that are rated unstable).

APPROACH

Scour-susceptible bridges will be identified. Methodologies for quality assurance, calculation of stream-stability index, and field data collection also will be provided. Ten bridges will be selected from a list of observably scour-critical bridges, and a detailed analyses will be done for each one, including flood frequency relations. Step-backwater computations will be used to provide surface-water profiles and parameters necessary to calculate potential scour.

ACTIVITIES DURING 1993

A methodology for evaluating bridge scour in Missouri was developed. The Missouri Highway and Transportation Department used this methodology to inspect all of the bridges in the Federal Aid System.

PLANNED ACTIVITIES DURING 1994

A data base containing the inspections performed by the Missouri Highway and Transportation Department will be created to be used for reference by both the Missouri Highway and Transportation Department and U.S. Geological Survey personnel. A scour susceptibility rating will be developed that uses the information from the inspection stored in the data base. This rating will be used to rank the bridges according to their scour-critical nature.

REPORT

Huizinga, R.J., and Waite, L.A., 1994, Methodology for the assessment of scour at bridge sites in Missouri: U.S. Geological Survey Open-File Report 94-544, 23 p.

Peak-Flow Frequency for Rural Unregulated Streams in Missouri (MO 92-092)

In cooperation with

Missouri Highway and Transportation Department

Terry W. Alexander, Project Chief

NEED FOR STUDY

The Missouri Highway and Transportation Department has a need for updated flood frequency relations to assist them in future highway planning and design of bridges, road embankments, and culverts. For example, the 500-year flood frequency relation is needed for channel scour analyses at bridges.

OBJECTIVE

The existing 2-, 5-, 10-, 25-, 50-, and 100-year flood frequency relations will be updated for unregulated rural streams in Missouri. The 500-year flood frequency relation will be developed for use in bridge scour studies.

APPROACH

The basin characteristics and peak-flow files will be updated. The 2-, 5-, 10-, 25-, 50-, 100-, and 500-year discharges for individual stations will be computed and entered into the basin characteristics file. The generalized least squares regression approach will be used to develop the 2- to 500-year estimating equations for rural streams in Missouri.

PLANNED ACTIVITIES DURING 1994

Create a station-frequency data base from approximately 250 gaging station data analyzed during the 1993 water year. A preliminary statistical analysis (ordinary least squares) of these data will determine basin characteristics statistically significant for use in the regression equations for unregulated rural streams in Missouri. The final regression relations (5- to 500-year) will be developed using a generalized least squares approach.

Hydrologic Monitoring of the Columbia/Eagle Bluffs Wetland Complex (MO 92-093)

In cooperation with

City of Columbia
Missouri Department of Conservation

Joseph M. Richards, Project Chief

NEED FOR STUDY

Wetland areas are sensitive to chemical and physical changes in the hydrologic environment. An effective hydrologic monitoring network is needed to provide data that can be used to evaluate these changes and to analyze water-quality trends. Trend analysis will be an invaluable tool to identify changes before they become widespread or irreversible. The ability to evaluate changes is especially necessary because treated sewage effluent will be used as a major source of water for wetland management on the Eagle Bluffs Wildlife Area.

OBJECTIVE

Evaluate changes in surface- and ground-water flow and quality as the result of the construction of the effluent-wetland treatment system.

APPROACH

Two automatic data recorders installed on two existing wells will collect continuous water-level data. Thirty wells and two surface-water sites will be sampled for inorganic and organic constituents to characterize the pre-inundation water quality. After inundation, quarterly sampling of the monitoring network will be performed to provide data for water-quality trend analysis. All data will be synthesized into a Geographic Information System data base.

ACTIVITIES DURING 1993

Creation of a Geographic Information System data base integrating tabular and spatial data was started. A base map showing location of all wells with attributes was created and distributed to cooperators. Twenty monitoring wells were installed in the Eagle Bluffs Wildlife Area and upgradient of the area. Particle size and bulk mineralogy of the aquifer material at 14 well sites were determined. Automatic data recorders were installed on two existing wells in the wetland. The monitoring network, which includes 30 wells and 2 surface-water sites, was sampled quarterly until the flood of 1993. Because of the massive flooding of the wetland complex by the Missouri River, four flood sediment samples and four residual flood water samples were collected. Sediment deposition in the area ranged from thin (less than 1 inch) layers of fine silt and clay to thick (more than 5 feet) layers of sand.

Hydrologic Monitoring of the Columbia/Eagle Bluffs Wetland Complex (MO 92-093)--Continued

PLANNED ACTIVITIES DURING 1994

Inundation of the wetland has been postponed for a year to allow for cleanup and repairs to the levees and structures in the wetland complex. The monitoring network, which includes 30 wells and 2 surface-water sites, will be sampled quarterly to re-establish background conditions after flooding. A U.S. Geological Survey Report will be published presenting the data collected during August 1992 to the onset of flooding in July 1993.

Geohydrology of the Weldon Spring Ordnance Works (MO 93-094)

In cooperation with

U.S. Army Corps of Engineers,
Kansas City District

Douglas N. Mugel, Project Chief

NEED FOR STUDY

The former Weldon Spring ordnance works, which consists, in part, of the Weldon Spring chemical plant and the Weldon Spring training area, is the site of local nitroaromatic and radioactive contamination of soil and ground water. Separate studies have been performed by the U.S. Army at the Weldon Spring training area and the Weldon Spring ordnance works and by the U.S. Department of Energy at the Weldon Spring chemical plant, and hydrologic data have previously been collected by the U.S. Geological Survey throughout the Weldon Spring ordnance works, but lack of agreement in some stratigraphic terminology used by the U.S. Army and U.S. Department of Energy makes integration of data collected for different parts of the Weldon Spring ordnance works difficult. A comprehensive geohydrologic study is needed to develop a better understanding of ground water at the Weldon Spring ordnance works, bringing together data collected by the U.S. Army, U.S. Department of Energy, and the U.S. Geological Survey.

OBJECTIVES

To integrate geologic and hydrologic data collected throughout the Weldon Spring ordnance works and to use these data to describe the geohydrologic framework of the Weldon Spring ordnance works.

APPROACH

Data will be collected and verified for existing monitoring wells, and stratigraphic criteria and terminology will be adapted or developed as necessary to ensure consistency of data throughout the Weldon Spring ordnance works. A Geographic Information System data base will be created using these data and will be used to create geologic structure maps and cross sections and water-level maps that will describe the geohydrology of the Weldon Spring ordnance works.

ACTIVITIES DURING 1993

Documents prepared by the U.S. Army and U.S. Department of Energy describing geohydrologic conditions were reviewed. Drill core for some U.S. Army monitoring and U.S. Department of Energy monitoring wells were relogged and photographed for later reference, and some wells were geophysically logged (natural gamma). Work began on creating a Geographic Information System data base containing stratigraphic, well construction, and water-level data.

Geohydrology of the Weldon Spring Ordnance Works (MO 93-094)--Continued

PLANNED ACTIVITIES DURING 1994

The remainder of U.S. Army cores will be relogged and tabulated with U.S. Department of Energy core data that have been reviewed by U.S. Department of Energy for consistency with U.S. Army data. The Geographic Information System data base will be completed and verified. Geologic structure maps and cross sections and water-level maps will be prepared. Preparation of a U.S. Geological Water-Resources Investigations Report will begin.

Transport of Sediment and Contaminants in Stormwater Runoff at the Weldon Spring Ordnance Works, St. Charles County, Missouri (MO 93-095)

In cooperation with

U.S. Army Corps of Engineers,
Kansas City District

John G. Schumacher, Project Chief

NEED FOR STUDY

The Weldon Spring training area consists of 1,655 acres of land owned by the U.S. Army in south-central St. Charles County. The Weldon Spring training area is part of a larger (about 17,000 acres) site formerly owned by the U.S. Army known as the Weldon Spring ordnance works. The Weldon Spring ordnance works produced more than 700 million pounds of trinitrotoluene (TNT) and smaller quantities of dinitrotoluene (DNT) during its operation between 1941 and 1945. The plant consisted of 18 nearly identical TNT production plants (lines), 2 DNT production lines, and numerous other production support plants, such as nitric acid, sulfuric acid, and ammonia oxidation plants, and other facilities. At peak production the plant produced nearly 1 million pounds of TNT each day. Fifteen of the TNT lines, both DNT lines, and nearly all of the major production support facilities were within the boundary of the Weldon Spring training area site. The remaining three TNT lines were on a 217-acre tract immediately east of the Weldon Spring training area.

The U.S. Army Corps of Engineers has constructed a theoretical runoff and sediment-transport model for the Weldon Spring training area; however, no field data have been collected to verify this model. Because the U.S. Department of Defence will begin remediation of contaminated soils at the site (excavation of the most contaminated materials) monitoring will need to be done to ensure remedial activities do not adversely affect the quality of surface water leaving the site. This monitoring needs to begin before remediation to establish base-line values and should continue throughout the remediation phase. Monitoring during remediation is essential because land use, runoff, and sediment transport characteristics will constantly be changing. Additional monitoring for 1 or 2 years after remediation has been completed will assess the effectiveness of the remedial activities.

OBJECTIVES

The primary objective of this investigation is to determine changes in the transport of sediment, nitroaromatic compounds, arsenic, and lead in surface water from the Weldon Spring training area and burning ground 1 during remediation of the site. Secondary objectives will be to evaluate the current runoff-sediment transport model for the site and to determine if the nitroaromatic compounds are being transported in the dissolved or particulate phase and their environmental fate.

Transport of Sediment and Contaminants in Storm Water Runoff at the Weldon Spring Ordnance Works, St. Charles County, Missouri (MO 93-095)--Continued

APPROACH

A surface-water monitoring network consisting of two continuous recording gaging stations (Schote Creek at Highway D and 5200 tributary downstream from burning ground 1) and two additional ancillary sites will be installed immediately downstream from the training area and burning ground 1. A continual rainfall recording gage also will be installed at the site. The rainfall data from this recorder and rainfall from a nearby U.S. Department of Energy weather station will be used to verify the runoff and sediment-transport model for the northern part of the site.

A stage-discharge relation (rating) will be calculated for both gaging stations and ancillary sites. Daily mean discharge and peak discharge values will be calculated for the two continuous recording gage sites. This information will be published each year in the annual U.S. Geological Survey Water Resources Data for Missouri report. In addition to the continuous recorders, crest stage gages will be installed at each gaging station and ancillary site. These gages will record the maximum stage height and allow estimation of peak discharge if structures are over-topped or washed out.

Suspended sediment samples will be collected by automatic samplers during each runoff event at the two gaging stations. A total of about 200 to 300 samples will be collected from each of the 2 gaging stations and analyzed for suspended-sediment concentrations. A total of 30 water-quality samples are planned to be collected at each gaging station. Six samples will be collected from each of five runoff events; two spring events, two summer events, and one fall-winter event. Five of the samples will be collected at instantaneous points during each event and the sixth sample will be a composite comprised of numerous subsamples collected during the event. Physical properties and chemical constituents to be determined in the water-quality samples will include specific conductance and concentrations of suspended sediment, nitroaromatic compounds, arsenic, and lead. All concentrations will be in the total recoverable phase except for the composite sample where constituents will be determined in both the total recoverable and dissolved phases.

Discharge and water-quality data from the gaging stations will be used to compute total runoff volume, suspended-sediment loads, and loads of nitroaromatic compounds, arsenic, and lead. Total loads of nitroaromatic compounds, arsenic, and lead at the gaging stations will be estimated by evaluating the relation between sediment concentration and total recoverable and dissolved concentrations of nitroaromatic compounds, arsenic, and lead. Data from the ancillary sites will only be qualitative but will be useful to determine if a substantial contaminant transport by surface water exists. A comparison of total recoverable and dissolved analysis for nitroaromatics, arsenic, and lead will determine if contaminants are being transported in the dissolved or particulate phase.

Transport of Sediment and Contaminants in Storm Water Runoff at the Weldon Spring Ordnance Works, St. Charles County, Missouri (MO 93-095)--Continued

The existing sediment model for the Weldon Spring training area will be tested using data collected during this study. If the model seems inadequate to describe the sediment transport from the site, a new model may be selected and calibrated.

ACTIVITIES DURING 1993

A tipping bucket rainfall gage and field computer (equipped with a telephone modem) were installed near the center of the training area.

Two continuous recording stream gaging stations were installed. A broad-crested weir was installed at the gage site downstream from burning ground 1 to facilitate construction of a stage-discharge relation. Suspended-sediment samples were collected from every runoff event using an automatic sampler interfaced with the stage data logger. Manual samples were collected during three runoff events from both gage sites to substantiate values derived from the automatic samplers. A separate automatic sampler is used to collect water-quality samples. Stage record has been recorded at both sites since November 1993, and a preliminary stage-discharge rating has been constructed for each gage site. More than 100 suspended-sediment samples and 25 water-quality samples have been collected and analyzed for suspended concentrations, and concentrations of total and dissolved nitroaromatic compounds, arsenic, and lead.

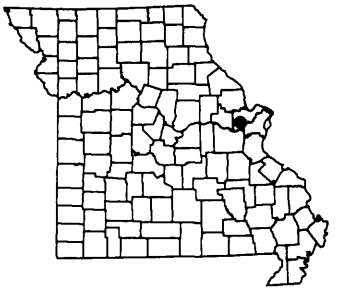
PLANNED ACTIVITIES DURING 1994

Two ancillary sites will be installed during the summer of 1994. Suspended-sediment and water-quality samples will be collected from these and the two gaging stations during summer runoff events. Stage-discharge and stage-suspended-sediment concentration relations will be constructed at both gaging stations.

Environmental Fate of Nitroaromatic Compounds in the Unsaturated Zone and Shallow Bedrock Aquifer at the Abandoned Weldon Spring Ordnance Works, St. Charles County, Missouri (MO 93-09501)

In cooperation with

U.S. Army Corps of Engineers,
Kansas City District



John G. Schumacher, Project Chief

NEED FOR STUDY

The Weldon Spring ordnance works consists of about 17,000 acres of land in south-central St. Charles County. The Weldon Spring ordnance works produced more than 700 million pounds of trinitrotoluene (TNT) and smaller quantities of dinitrotoluene (DNT) during its operation between 1941 and 1945. Most ordnance production took place within the 1,655-acre tract known as the Weldon Spring training area. The U.S. Army deeded all but this 1,655-acre tract to various State and local agencies. Fifteen of the TNT lines, two DNT lines, and nearly all of the major production support facilities were within the boundary of the Weldon Spring training area site. These lines were demolished in 1955 during the construction of a U.S. Department of Energy Uranium Feed Materials plant.

At least four major cleanup operations have been conducted at the site since 1944, leaving only foundations and a few of the more than 1,000 buildings on the Weldon Spring training area site. Despite these cleanup efforts, large concentrations of TNT and lead have been detected in soils from isolated areas around former production buildings. In addition, concentrations of TNT, lead, and nickel attributable to ordnance production have been detected in isolated areas along former TNT production lines and in areas of fill at the adjacent U.S. Department of Energy site. Although large quantities of TNT have been detected in surficial materials, concentrations generally decrease to less than a few milligrams per kilogram or less at depths greater than 5 feet below the surface.

Small concentrations of TNT ranging from less than 0.15 to 19 micrograms per liter, DNT concentrations ranging from less than 0.1 to 8.5 micrograms per liter, and smaller quantities of TNB and nitrotoluene have been detected in samples from 16 of the 34 monitoring wells at the site. Considerable uncertainty exists as to the source of the small concentrations of nitroaromatic compounds in the ground water. It is possible that small quantities of these compounds are migrating through the unsaturated zone from contaminated surficial soils; however, it is also possible that the nitroaromatic compounds are recalcitrant in the ground water and much of the ground-water contamination is relict and originates from disposal practices during the 1940's. Determining the source of nitroaromatic compounds in the ground water is required in developing remedial alternatives at the site. In addition, much of the knowledge on the environmental fate of nitroaromatic compounds is based on laboratory experiments and little or no field data are reported in the literature.

Environmental Fate of Nitroaromatic Compounds in the Unsaturated Zone and Shallow Bedrock Aquifer at the Abandoned Weldon Spring Ordnance Works, St. Charles County, Missouri (MO 93-09501)--Continued

Additional uncertainty exists regarding the environmental fate of nitroaromatic compounds at the site. The distribution of the various "target" nitroaromatic compounds [trinitrotoluene (TNT); 2,4-dinitrotoluene (2,4-DNT); 2,6-dinitrotoluene (2,6-DNT); trinitrobenzene (TNB); dinitrobenzene (DNB); nitrobenzene (NB); and nitrotoluene (NT)] in soil and ground water is extremely complex. Added to the uncertainty in the environmental fate is the lack of understanding the source of the various compounds in the ground water and uncertainties in analytical methods.

OBJECTIVES

The primary objectives are to determine if contaminated surficial soils are a potential threat to ground-water quality and to provide physical, chemical, and mineralogic data on the various overburden units at the site. The secondary objective is to develop an understanding of the environmental fate of nitroaromatic compounds at the site, especially in the unsaturated zone where little published information exists.

APPROACH

The original approach to the first objective was to collect water and soil samples from the unsaturated zone by installing lysimeters at various depths beneath contaminated surficial soils. Water and soil samples collected from this effort are to be analyzed for 2,4,6-trinitrotoluene, 1,3,5-trinitrobenzene, 2,4-DNT, 2,6-DNT, 2-nitrotoluene, 3-nitrotoluene, 4-nitrotoluene, and 1,3-dinitrobenzene. In addition, analytical methods were to be developed to determine concentrations of various potential microbial degradation products, such as 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, 2,4-diaminonitrotoluene, and 3,5-dinitroaniline. Most nitroaromatic compounds sorb only weakly to soil, and a comparison of analytical results of soil and lysimeter samples will indicate the potential for these compounds to migrate though the unsaturated glacial drift at the site. In addition, soil samples will be analyzed for various inorganic constituents and total organic carbon to provide preliminary information for incinerator design.

ACTIVITIES DURING 1993

Seventeen suction lysimeters and 7 monitoring wells were installed near several former production building at the site. Water-quality samples have been collected monthly from those lysimeters that contain sufficient water and quarterly from the seven U.S. Geological Survey monitoring wells and numerous monitoring wells installed previously across the site by the U.S. Army. Monitoring wells at the site and several springs in the vicinity were sampled for an expanded list of inorganic and organic constituents and tritium. Relations between the distribution of various nitroaromatic compounds with depth, season, and soil moisture content have been determined in the unsaturated zone. A one-dimensional natural gradient tracer test was conducted to estimate travel times through the unsaturated zone in one former production area. Laboratory sorption studies (using sterilized soils) and leaching experiments were performed using

Environmental Fate of Nitroaromatic Compounds in the Unsaturated Zone and Shallow Bedrock Aquifer at the Abandoned Weldon Spring Ordnance Works, St. Charles County, Missouri (MO 09501)--Continued

contaminated soils from the site to determine the partitioning coefficient between water and soil for TNT, 2,4-DNT and 2,6-DNT. A new analytical technique using high performance liquid chromatography and solid phase extraction was developed to determine concentrations of target nitroaromatic compounds and principle degradation products to 0.2 microgram per liter.

PLANNED ACTIVITIES DURING 1994

The lysimeters will continue to be sampled bi-monthly through the fall of 1994 and nearby monitoring wells will be sampled monthly. A second one-dimensional natural gradient tracer test using sodium bromide will be conducted in the unsaturated zone. Several additional monitoring wells and springs will be sampled for nitroaromatic compounds and tritium.

REPORTS

Schumacher, J.G., Lindley, C.E., and Anderson, F.S., 1992, Migration of nitroaromatic compounds in unsaturated soil at the abandoned Weldon Spring ordnance works, St. Charles County, Missouri: 16th Annual Army Environmental R&D Symposium, Williamsburg, Va., 1992, Proceedings.

Schumacher, J.G., Sutley, S.J., and Cathcart, J.D., 1993, Geochemical data for the Weldon Spring training area and vicinity property, St. Charles County, Missouri--1990-92, U.S. Geological Survey Open-File Report 93-153, 84 p.

Microbial Degradation of Trinitrotoluene and other Nitroaromatic Compounds at the Weldon Spring Training Area, St. Charles County, Missouri (MO 93-09502)

In cooperation with

U.S. Army Corps of Engineers,
Kansas City District

John G. Schumacher, Project Chief

NEED FOR STUDY

Data collected from lysimeters installed in the unsaturated zone beneath contaminated soils indicate substantial biologic transformation of trinitrotoluene (TNT), 2,4-dinitrotoluene (2,4-DNT), and 2,6-dinitrotuluene (2,6-DNT) into various metabolites. Laboratory experiments by the U.S. Geological Survey indicate complete mineralization of these compounds occurs in both the shallow soil zone and the residuum. In most cases degradation of the source compound was observed within 20 to 70 days. Detectable rates of mineralization also were observed in samples from the shallow bedrock aquifer. These experiments are especially important because the degradation was observed in natural samples, indicating this process is ongoing in the field.

A field tracer test using potassium bromide was conducted during the spring of 1993 in a line 11 settling tank. Three lysimeters were installed at depths of 2.5, 4.5, and 9.5 feet in this settling tank. Depth to ground water is only about 10 feet in this area. The glacial till in this area is about 2 feet thick, and the deeper lysimeters were installed in the residuum. The bromide peak reached all three lysimeters at about the same time (71 to 76 days), indicating that, once through the glacial till, migration within the residuum is rapid. The average rate of travel was between 0.03 and 0.12 foot per day. Concentrations of TNT decreased from a mean of 1,280 micrograms per liter in the shallow lysimeter to 12 micrograms per liter in the deepest lysimeter. Degradation products [2-amino- 4,6-dinitrotoluene (2-am) and 4-amino- 2,6-dinitrotoluene (4-am)] comprised about 20 percent of the nitroaromatic compounds in the shallow lysimeter and more than 70 percent in the deep lysimeter. The dramatic degradation of TNT observed in the lysimeters and the estimated travel time, about 75 days, compares favorably with the degradation of TNT within 20 to 70 days in the laboratory experiments. The field and laboratory data indicate substantial microbial degradation of TNT within the overburden at the Weldon Spring training area. Disappearance of 2,4-DNT and 2,6-DNT also was noted in the laboratory experiments; however, these compounds are not present in significant amounts in the unsaturated zone.

The fact that substantial degradation is occurring in soils at the site means that not only is biologic treatment of contaminated soils possible but that an in-situ technique may be feasible. A direct in-situ technique is land farming. In a general concept, this technique would require soils be tilled and possibly water or nutrients added to stimulate microbial activity. Because of the tendency for contamination to exist in isolated "hot spots" (containing thousands of milligrams

Microbial Degradation of Trinitrotoluene and other Nitroaromatic Compounds at the Weldon Spring Training Area, St. Charles County, Missouri (MO 93-09502)--Continued

per kilogram of TNT) surrounded by large areas of soils containing one to a few hundred milligrams per kilogram of TNT, land farming of the large areas combined with excavation and incineration of the small "hot spots" may be an effective remediation strategy.

OBJECTIVES

The primary objective of this project is to determine if land farming of TNT and DNT contaminated soils is a viable mechanism for soil remediation at the Weldon Spring site. A secondary objective is to evaluate the effect of tilling, soil moisture content, and the organic carbon content of the soils on the rate of microbial degradation of these compounds.

APPROACH

Several laboratory microcosm experiments will be conducted at the U.S. Geological Survey laboratory in Columbia, South Carolina, using contaminated soils from the site. These experiments will study the effects of the moisture content and concentrations of TNT on the rate of microbial degradation. Because soils collected from the site average about 30 percent water by weight, some soils will be air dried to achieve moisture contents of less than 30 percent and deionized water will be added to others. A separate series of experiments will focus on the effect of increasing concentrations of TNT on the degradation rate of TNT. The effect of organic carbon on the degradation rates will be examined by adding Cellobiose and Syringate. Cellobiose is a beta-linked polymer chain and will be used to simulate addition of cellulose type material. Syringate is an aromatic type compound that will be used to simulate the effect of adding a lignin-type substrate.

Results from the laboratory experiments will be used to design a field test plot. The test plot will be located near a former production building where soils are intensely contaminated with TNT. Core samples will be collected from the test plot and analyzed for grain-size, moisture content, total organic carbon content, soil pH, and concentrations of nitroaromatic compounds. Each plot will be segregated into several cells that will be treated differently. The number of cells will depend on the number of variables determined in the laboratory to influence TNT and DNT degradation rates. Currently (1994) at least three major factors are thought to affect the degradation rates: (1) moisture content; (2) nutrient concentrations; and (3) TNT content.

After background conditions have been determined in each cell, the upper 6 to 10 inches of soil will be thoroughly tilled using a small gas powered tiller. Various amendments may then be added to the various cells and the soil thoroughly mixed by tilling again. Soil core samples will again be collected to determine the degree of homogeneity of TNT concentrations. Cells will be instrumented with suction lysimeter to monitor the movement of nitroaromatic compounds out of the test area. A minimum of two monitoring wells also will be installed at the test plot.

Microbial Degradation of Trinitrotoluene and other Nitroaromatic Compounds at the Weldon Spring Training Area, St. Charles County, Missouri (MO 93-09502)--Continued

Moisture content will be monitored by analysis of grab samples. Initially, nitroaromatic samples will be collected bi-monthly for 6 months at random. Monthly samples will be collected thereafter.

ACTIVITIES DURING 1993

All laboratory studies have been completed and the field test plot is being designed. A location adjacent to a former wash house has been selected for the test plot. Two existing monitoring wells at this location will be incorporated into the test plot monitoring system. A paper discussing the results of the laboratory experiments has been submitted for publication.

PLANNED ACTIVITIES FOR 1994

The test plot will be installed during the summer of 1994. After the plot has been monitored for 1 year, a journal article will be prepared discussing preliminary results from the experiment.

REPORTS

Bradley, P.M., Chapelle, F.H., Landmeyer, J.E., and Schumacher, J.G., 1994, Microbial transformation of nitroaromatics in surface soils and aquifer materials, in American Society for Microbiology, v. 60, no. 6, p. 2,170-2,175.

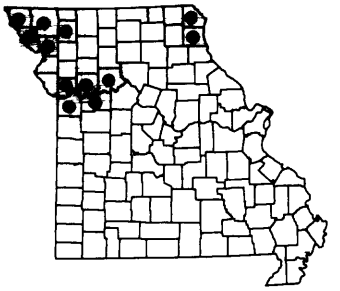
Chapelle, F.H., and Bradley, P.M., 1995, Microbial degradation of nitrotoluenes in surface soils and aquifer sediments, Weldon Spring, Missouri, in Proceedings of the U.S. Geological Survey Toxic Substances Hydrology Program--Proceedings of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4015.

Potential Contamination of Domestic Wells in Missouri by Agricultural Chemicals during the Flood of 1993 (MO 94-096)

In cooperation with

Missouri Department of Natural Resources,
Division of Environmental Quality

David C. Heimann, Project Chief



NEED FOR STUDY

During the spring and summer of 1993, record flooding inundated much of the upper Mississippi River Basin. Record flows were recorded on many streams in Missouri, including the Missouri River from the Iowa border to St. Louis, the Chariton River at Prairie Hill, the Grand River near Gallatin and at Sumner, the Platte River near Agency and at Sharp's Station, the Nodaway River near Graham, and the Thompson River at Trenton. Peak flows on the Mississippi River at St. Louis were only slightly less than the estimated record discharge. Many other tributaries in the basin had peak discharges that exceeded the 100-year recurrence interval. Large areas of agricultural lands were submerged when most levees failed because of the extent and duration of the flooding.

The flooding occurred soon after most crops were planted and agricultural chemicals were applied. The intense rains and flooding mobilized large amounts of agricultural chemicals into the Mississippi River and its tributaries. Concentrations of herbicides were similar to maximum concentrations measured during 1991 and 1992; however, the daily loads were much higher because of the volume of discharge. Atrazine loads transported to the Gulf of Mexico from April to August 1993 were 80 percent higher than during the same period in 1992 and 235 percent higher than in 1991. Contamination of alluvial aquifers could result from inundation of the land surface by flood waters. Because of the extensive amount of agricultural land subjected to flood waters and the reliance of many Missourians on ground water as their primary drinking-water source, the effect of the flood on agricultural chemical transport is a concern.

OBJECTIVES

The objective of this study is to determine the extent to which concentrations of agricultural chemicals in domestic wells measured before the 1993 flood have changed following the flood.

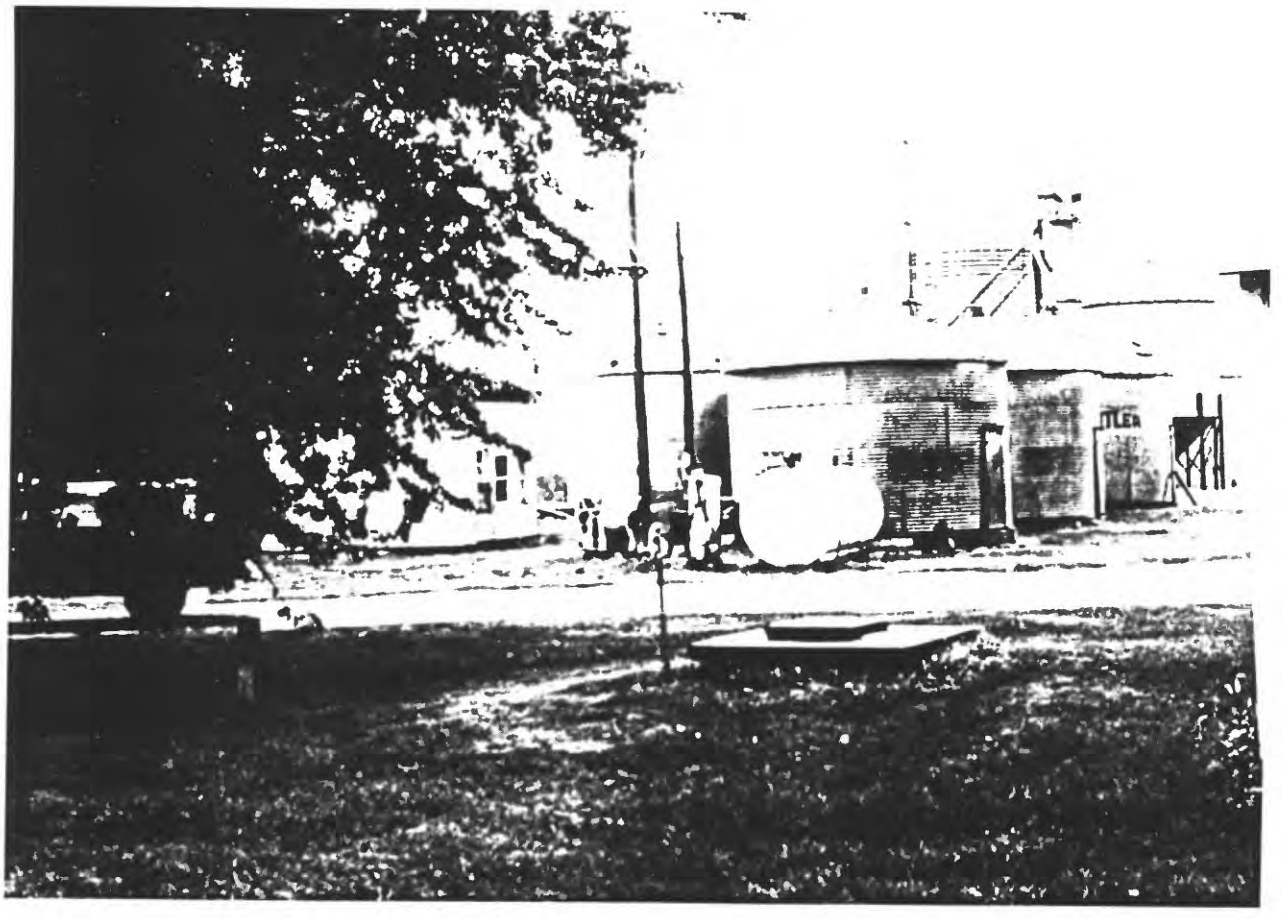
APPROACH

Eighty wells will be sampled three times between February 1994 and December 1994. These wells will be selected from a list of wells that were sampled between 1988 and 1992 as part of a reconnaissance of agricultural chemicals in ground water in Missouri. The wells will be sampled

before herbicides are reapplied in the spring (March 1994), after application (June-July 1994) and again in the fall (October 1994). This sampling schedule will allow for comparison of temporal trends in the occurrence of agricultural chemicals in the study area. These temporal trends may or may not be related to the flood event. The water will be analyzed for dissolved nitrite plus nitrate; alachlor, atrazine, and their metabolites; and other selected herbicides. Laboratory analyses of nitrite plus nitrate and the herbicides will be conducted by the U.S. Geological Survey. Samples will be screened for atrazine and alachlor using enzyme-linked immunosorbent assay. Those samples with detections and 10 percent of samples with non-detections will be sent to a U.S. Geological Survey laboratory.

PLANNED ACTIVITIES FOR 1994

Eighty wells will be located and sampled in late March 1994, before herbicides are applied, and again in late June or early July 1994. Results will be entered into the U.S. Geological Survey computer network, and statistical comparison of pre- and post-flood nitrate and herbicide concentrations in the sample wells will begin.



Physical Sedimentation and Erosion Processes Associated with Floodplain Inundation during the 1993 Flood on the Missouri River (MO 94-097)

Gregg K. Schalk, Project Chief

NEED FOR STUDY

The 1993 flood on the Missouri River resulted in numerous levee breaks and overbank flooding. Massive erosional and depositional facies are associated with these breaks. Large areas of Missouri River bottomland are now covered with 10 feet or more of sand.

OBJECTIVES

This study is designed to document and analyze the sedimentation and erosional effects of the 1993 flood levee breaks. The objectives are to (1) document and describe sedimentational erosional features; (2) analyze the cause and effect of the spatial distribution of deposited sediments and erosional scours; (3) analyze the effect on soil and land resources; and (4) develop a general model to simulate sedimentation and erosion from levee breaks.

APPROACH

At six sites, pre- and post-flood channel, levee, and associated riparian features will be mapped using the Geographic Information System. Using a total-station surveying instrument, levee break geometry, high-water marks, and depositional and erosional features will be mapped. At selected locations in each levee break site, pre- and post-flood samples will be collected for pesticide, nutrient, and grain-size analysis.

PLANNED ACTIVITIES DURING 1994

Six study sites will be selected from a reconnaissance of the Missouri River from St. Louis, Missouri to the Missouri/Iowa/Nebraska border. At each of the study sites the levee break, high-water marks, and depositional and erosional features will be mapped using a total station surveying instrument. Surveyed transects across the erosional features will be used to estimate eroded volumes. Surveyed transects and soil cores across the deposits will be used to describe thicknesses and nature of flood sediments. At each site particle-size distribution sediment samples will be collected. At two study sites soil-characterization data and herbicide samples will be collected. At one or more levee-break sites representative vertically faced erosional feature, split spoon samples will be core drilled adjacent to the erosional feature to investigate the extent to which sedimentology and stratigraphy of the pre-existing bottom-land sediments affected erosion of these features.

Agricultural Chemicals in Ground Water (MO 94-099)

In cooperation with

Missouri Department of Health,
Bureau of Environmental Epidemiology

Donald H. Wilkison, Project Chief

NEED FOR STUDY

Data are needed to determine the occurrence and distribution of pesticides and nitrate in domestic-water supplies from ground water in the agricultural areas of Missouri.

OBJECTIVES

(1) Collect data to provide information on concentrations of commonly used pesticides and nitrate in ground water from various aquifers in Missouri overlain by agricultural land. (2) Describe and interpret the possible causes of pesticide and nitrate occurrence in ground water.

APPROACH

Domestic-water supplies were sampled to measure the concentrations of pesticides and nitrate in water from different aquifers in areas in intense agricultural activity. Pertinent well, land-use, and agricultural chemical use information were collected to assist in interpretation of the chemical data.

A representative sampling of domestic wells in five areas of Missouri was completed. During 1986-87, wells in the Mississippi River alluvium in southeastern Missouri were sampled. During 1988-89, wells in the Missouri River alluvium in northwestern and west-central Missouri were sampled. In 1990 and 1991, wells in west-central Missouri were sampled. Wells in the glacial drift aquifer were sampled in northwestern Missouri in 1991. During 1992, wells in northeastern Missouri were sampled.

ACTIVITIES DURING 1993

Samples from 120 domestic-supply wells, 7 surface-water sites, and 3 springs were analyzed for concentrations of 9 common pesticides, nitrite plus nitrate, trace elements, and radionuclides and data from the west-central region sampled in 1990 and 1991 were compiled and published.

Samples from 130 domestic-supply wells in northwestern Missouri and 147 wells in northeastern Missouri were analyzed for concentrations of 12 common pesticides, nitrite plus nitrate, and trace elements and the data were compiled and published.

PLANNED ACTIVITIES DURING 1994

Begin data analysis for a U.S. Geological Survey Water-Resources Investigations Report on the occurrence of pesticides and nitrate in ground water in Missouri. Compile data to examine relations between well type, well depth and diameter, well construction, land-use patterns near the well, site geology and soil types and the occurrence of agricultural chemicals in ground water in Missouri.

REPORTS

Mesko, T.O., and Carlson, G.M., 1988, Occurrence of pesticides, nitrate, volatile organic compounds, and trace elements in ground water and streams, southeastern Missouri, 1986-87: U.S. Geological Survey Open-File Report 88-495, 73 p.

Wilkison, D.H., and Maley, R.D., 1994, Occurrence of herbicides, nitrite plus nitrate, and selected trace elements in ground water from northwestern and northeastern Missouri, July 1991 and 1992: U.S. Geological Survey Open-File Report 94-332, 64 p.

Ziegler, A.C., Wallace, W.C., Blevins, D.W., and Maley, R.D., 1993, Occurrence of pesticides, nitrite plus nitrate, arsenic, and iron in water from two reaches of the Missouri River alluvium, northwestern Missouri--July 1988 and June-July 1989: U.S. Geological Survey Open-File Report 93-101, 30 p.

Ziegler, A.C., Wilkison, D.H., and Maley, R.D., 1994, Occurrence of selected pesticides, nutrients, selected trace elements, and radionuclides in ground and surface water from west-central Missouri--July 1990-March 1991: U.S. Geological Survey Open-File Report 93-362, 71 p.

Ground-Water Flow and Surface-Water/Ground-Water Interaction at the Weldon Spring Quarry Disposal Site, St. Charles County, Missouri (MO 94-100)

In cooperation with

U.S. Department of Energy

Jeffrey L. Imes, Project Chief

NEED FOR STUDY

Ground-water recharge form the Weldon Spring quarry disposal site contains uranium, trinitrotoluene (TNT), and TNT degradation products. Ground-water information is needed to assess the probable directions of movement of contaminants from the quarry and support the development of a digital model of ground-water flow from the quarry into the adjacent Missouri River alluvial aquifer.

OBJECTIVES

(1) Determine the lateral and vertical movement of ground water from the Weldon Spring quarry to probable discharge sites on the Missouri River alluvium under different seasonal hydrologic conditions by monitoring ground-water levels in a piezometer network. (2) Assess surface-water/ground-water interaction near the quarry by monitoring the stage and discharge of surface-water bodies that are potential ground-water discharge areas.

APPROACH

Hydrologic characterization of the quarry area includes ground-water level monitoring in shallow water-table wells and deeper wells open to the Plattin Limestone. Monthly water-level measurements will be combined with surface-water stage measurements to produce potentiometric maps depicting ground-water flow directions. Several wells along a cross section from the quarry to the alluvium will be monitored continuously and water levels will be compared to daily precipitations.

PLANNED ACTIVITIES DURING 1994

The monitoring piezometer network will be drilled and instrumented. Staff gages will be installed on selected streams and sloughs that are probable discharge sites for ground water flowing from the quarry. A total of approximately 40 wells are to be drilled in bedrock around the quarry and in the alluvial plain.

Use of Conservative and Isotopic Tracers to Determine the Fate of Nitrogen Fertilizer in Claypan Soils under Continuous-Corn Management (MO 94-10100)

Dale W. Blevins, Project Chief

NEED FOR STUDY

The effects of a claypan layer on transport of water and chemicals within midwestern soils are not well established. The amount of horizontal flow and perching on top of the claypan is not known. Also the persistence of a single application of nitrate fertilizer in the soil zone and the time required for ground water to reach maximum concentrations of nitrate from a single application of nitrate fertilizer have not been determined. Measurement of these processes are needed to design best management practices for fertilization of claypan soils.

OBJECTIVES

Determine the persistence of a single application of nitrate fertilizer in a claypan soil and underlying ground water. Identify significant pathways of nitrogen transport as species other than nitrate. Determine rates and extent of vertical and horizontal (downslope) transport of nitrate and conservative tracers.

APPROACH

Movement of tracers on the existing tracer plot (established in MO 91-085) will continue to be monitored. Continued sampling of ground water, surface water, soil water, and soils will be used to quantify the persistence of isotopically labeled fertilizer and bromide in the unsaturated zone and the delay between application and arrival of maximum concentrations in shallow ground water under continuous corn management. The nitrogen and isotopically labeled nitrogen content of corn also will be monitored. Soil gas samples will be collected and analyzed for denitrified labeled nitrogen.

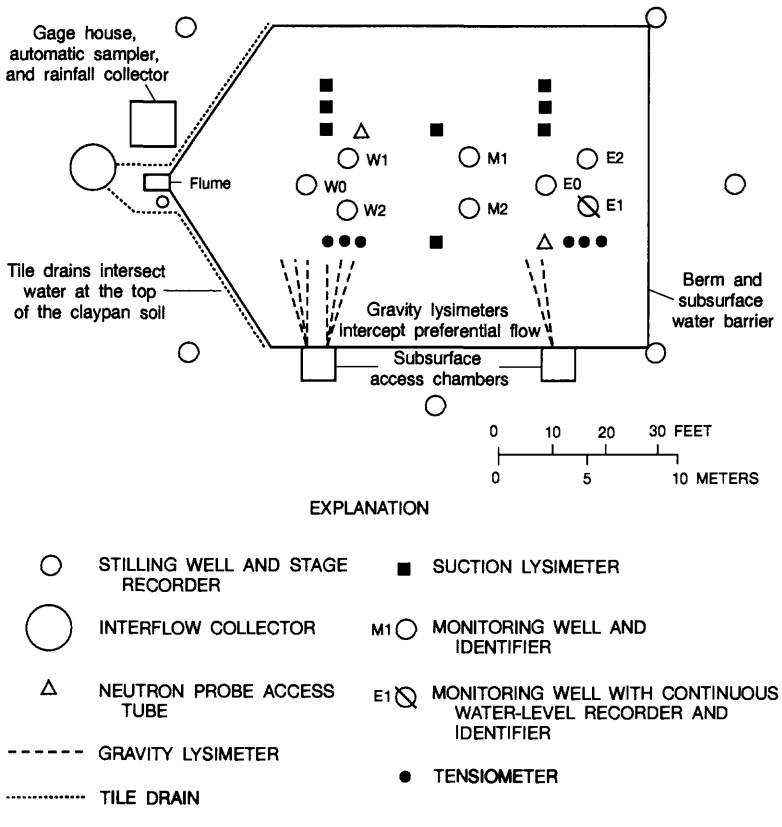
A new tracer plot will be instrumented with suction lysimeters and shallow topsoil piezometers. Chloride, bromide, and labeled nitrogen will be applied and monitored to determine the rate of tracer movement in the vertical and downslope directions.

Use of Conservative and Isotopic Tracers to Determine the Fate of Nitrogen Fertilizer in Claypan Soils under Continuous-Corn Management (MO 94-10100)--Continued

PLANNED ACTIVITIES DURING 1994

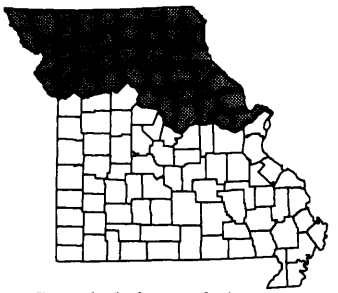
A new 0.1-acre tracer plot will be designed and instrumented. Labeled nitrogen fertilizer, bromide, and chloride will be applied to the new tracer plot in May 1994, and the movement of tracers throughout the growing season and dormant period will be monitored. Suction lysimeter samples, soil piezometer samples, and soil cores will be analyzed.

Field data collection will continue on the existing plot. Modeling and data compilation and analysis will be undertaken.



Physical and Chemical Characteristics of Sediments Deposited in the Missouri and Mississippi River Floodplains during the July through August 1993 Flood (MO 94-70101)

Gregg K. Schalk, Project Chief



NEED FOR STUDY

Large quantities of sediment were transported and deposited on the floodplains of the Missouri and Mississippi Rivers during the flood of 1993. The chemical quality of the silt and clay sediment that was deposited on the floodplains during inundation of the flood waters is unknown. The presence of contaminants associated with the sediments also is unknown.

OBJECTIVES

(1) To assess the regional variability of the quality of sediments deposited on the floodplains during the 1993 Missouri and upper Mississippi River floods. (2) To evaluate the presence of contaminants associated with sediments deposited in the floodplains.

APPROACH

Samples of silt and clay deposition will be collected at 12 sites at estimated intervals of 45 river miles along the 560-mile reach of the Missouri River from Nebraska City, Nebraska, to St. Louis, Missouri and at 13 sites at estimated intervals of 46 river miles along the 578-mile reach of the Mississippi River from Dubuque, Iowa, to Cairo, Illinois. Samples will be analyzed for particle-sized distribution; water content; nutrients; volatile solids; major, minor, and trace elements; total, organic, and inorganic carbon; pesticides; and semi-volatile inorganic compounds. Pre-flood sediment samples will be collected at the same locations and analyzed for particle-size distribution.

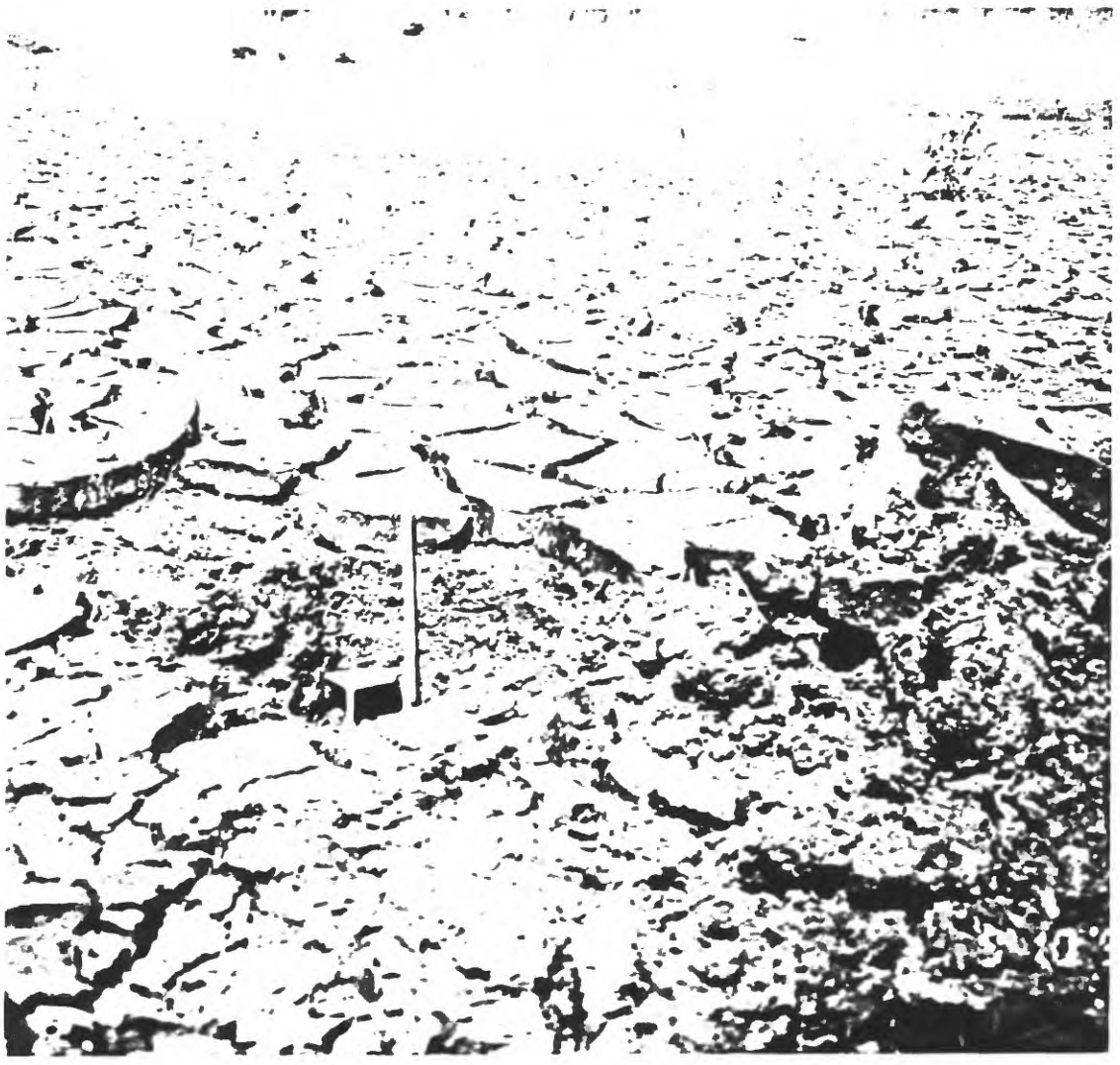
ACTIVITIES DURING 1993

Sampling and analysis of the 25 sites were completed. Selected pesticides and semivolatile organic compounds were analyzed using U.S. Environmental Protection Agency analytical methods for all 25 sites. No pesticides or semivolatile organic compounds were detected using these methods. Selected pesticides were analyzed for using U.S. Geological Survey estimating analytical methods at 15 sites. Pesticides detected included alachlor, atrazine, DDE, desethylatrazine, dieldrin, metolachlor, simazine, and trifluralin. Of these pesticides, only DDE and dieldrin were analyzed using U.S. Environmental Protection Agency methods at a higher detection limit than the U.S. Geological Survey methods. At 15 sites, 23 semi-volatile compounds were detected using U.S. Geological Survey methods. However, the detection limits using the U.S. Geological Survey methods were lower than those used in the U.S. Environmental Protection Agency methods. Sediment depositional features observed on the Missouri River floodplain during this study included sand dunes as deep as 9.8 to 13 feet near St. Charles, Missouri, and silt and clay deposits as deep as 5.5 inches near Hermann, Missouri.

Physical and Chemical Characteristics of Sediments Deposited in the Missouri and Mississippi River Floodplains during the July through August 1993 Flood (MO 94-70101)--Continued

PLANNED ACTIVITIES DURING 1994

Complete a U.S. Geological Survey Circular.



Flood of July-August 1993 in Jefferson City and St. Louis, Missouri, Vicinities (MO 94-70102)

Terry W. Alexander, Project Chief

NEED FOR STUDY

Because of the extensive flooding that occurred on the Missouri and Mississippi Rivers, data could be collected to improve the technical base on which floodplain management decisions can be made by other agencies.

OBJECTIVES

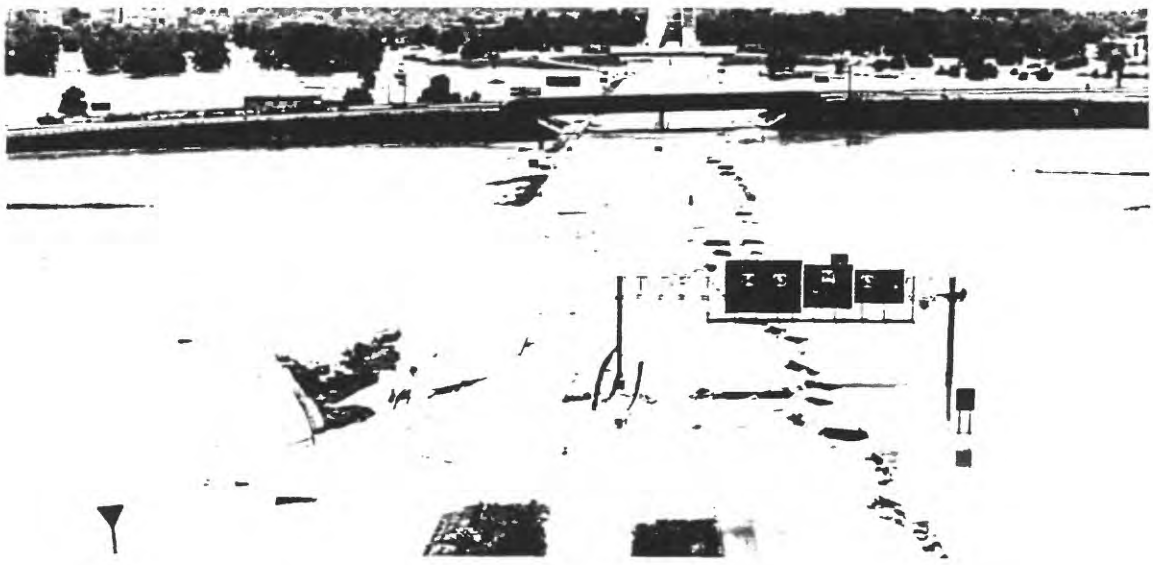
Document the effects of the 1993 flooding in Missouri in Jefferson City and St. Louis and vicinities.

APPROACH

Collect Missouri and Mississippi River flood-peak elevation data and delineate the areal extent of 1993 flooding in the vicinity of Jefferson City and St. Louis, Missouri, on 7 1/2 minute maps.

ACTIVITIES DURING 1994

High-water floodmarks were summarized at selected Missouri and Mississippi River locations. Geographic Information System technology was used to outline the 1993 flood boundaries in the two cities. Peak elevations, discharge data, and area inundated at Jefferson City and St. Louis will be published as U.S. Geological Survey Hydrologic Investigations Atlases.



Sediment Transport in the Lower Missouri and Central Mississippi Rivers During the 1993 Flood (MO 94-70103)

Robert R. Holmes, Jr., Project Chief

NEED FOR STUDY

Sediment transport in large rivers is complex and dynamic. Riverine sediment processes are major considerations in reservoir design, in river navigation engineering, and in transport of various chemical constituents that absorb to sediment particles. The Mississippi River system is the largest transporter of sediment in North America. Sediment transport is especially dynamic during major flood events. As such the U.S. Geological Survey operates sediment-data-collection stations at various locations in the Mississippi River Basin to assess sediment transport both during floods and during normal flows.

OBJECTIVES

The objective of this project is to document and describe the dynamic sediment transport processes for parts of the Missouri and Mississippi Rivers during the flood in July and August 1993.

APPROACH

Suspended and bed-material sediment data were collected during the 1993 flood. Suspended-sediment loads were computed from this data and bedloads were estimated using existing bedload equations or field hydraulic and geometric data collected during water-discharge measurements. Data from previous floods were used in conjunction with data from the 1993 flood.

ACTIVITIES DURING 1993

Sediment and hydraulic data were collected during the 1993 flood and laboratory analyses were made.

PLANNED ACTIVITIES DURING 1994

Sediment loads were computed and a U.S. Geological Survey Circular was written.

Geomorphic Effects of the Floods of 1993: The Levee-Break Complex at Miller City, Illinois (MO 94-70104)

Robert B. Jacobson, Project Chief

NEED FOR STUDY

The floods in July-August, September, and November 1993 on the Missouri and upper Mississippi Rivers created large scours and extensive sand deposits at sites where levees were breached. These geomorphic features are orders of magnitude larger than features formed in non-leveed areas. Areas affected by scour and deposition suffered irreparable damage to structures and highly productive agricultural land. Little is known of the dynamics and short- and long-term effects of these high-energy events.

OBJECTIVES

This study is intended to document a large levee-break complex created at Miller City, Illinois. Documentation includes discharge and velocity measurements during the levee-break event, compiling a map of sediment type and thickness, evaluating the volume of scoured sediment, and putting the 1993 features in a historical context.

APPROACH

Velocity and discharge measurements were collected in the river and levee break by acoustic doppler current profiles. After the water has receded, aerial photography will be acquired; the aerial photography will be used to construct detailed maps of sediment type and thickness using photogrammetric techniques. Ground survey of sediment thickness and erosional features will be used to estimate volumes of sediment eroded and deposited. The historical context for the 1993 features will be established by comparison to the Holocene history of channel changes in the area.

ACTIVITIES DURING 1993

Activities during 1993 included velocity and discharge measurements during the floods, reconnaissance of the subject area by helicopter and boat, and collection of anecdotal evidence from land owners.

PLANNED ACTIVITIES FOR 1994

In 1994 aerial photography will be acquired and used to map the area under pre- and post-flood conditions. The site will be surveyed in the field to establish thicknesses of sediment and depths of scour. Available maps of Holocene channel changes will be digitized for comparison with 1993 features. A U.S. Geological Survey Circular will be written and submitted for review.

SOURCES OF WATER RESOURCES DIVISION PUBLICATIONS AND INFORMATION

Selected references on water resources in Missouri are listed on the following pages, and many of these publications are available for inspection at:

U.S. Geological Survey
Water Resources Division
1400 Independence Road
Mail Stop 200
Rolla, Missouri 65401

and

Missouri Division of Geology and Land Survey
Fairgrounds Road
Rolla, Missouri 65401

Current releases are described in a monthly pamphlet, "New Publications of the Geological Survey," and may be obtained from:

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Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Earthquake Information Bulletins, and popular leaflets, pamphlets, and booklets may be purchased from Books and Open-File Reports Section, Denver, Colorado (address above); additional information is given in "Guide to Obtaining U.S. Geological Survey Information," U.S. Geological Survey Circular 900, which is available without cost from Books and Open-File Reports Section, Denver, Colorado.

Open-File and Water-Resources Investigations Reports for Missouri are available for inspection at the Missouri District Office, and may be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
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Denver Federal Center
Denver, Colorado 80225

To obtain information on maps, write:

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Mail Stop 231
Rolla, Missouri 65401

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U.S. Geological Survey
1028 General Services Administration Building
19th and F Streets, NW
Washington, D.C. 20244

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