Water-Resources Activities of the U.S. Geological Survey in Wyoming, October 1991 through September 1993

Compiled by U.S. GEOLOGICAL SURVEY

U.S. GEOLOGICAL SURVEY OPEN-FILE REPORT 93-413

Cheyenne, Wyoming
1993

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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City of Gillette
Fremont County Weed and Pest Control District
Laramie County
Midvale Irrigation District
National Park Service
Northern Arapahoe Tribe
Office of the Secretary of the Interior
Sheridan Area Water Supply-Joint Powers Board
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Wyoming Department of Agriculture
Wyoming Department of Environmental Quality
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Wyoming Highway Department
Wyoming State Engineer
Wyoming Water Development Commission
Wyoming Water Resources Center

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Box 25286 Federal Center
Denver, Colorado 80225

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CONVERSION FACTORS

Multiply	By	To obtain
foot	0.3048	meter
cubic foot per second	0.02832	cubic meter per second
gallon per minute	0.06308	liter per second
mile	1.609	kilometer
square mile	2.590	square kilometer
acre-foot per year	1,233	cubic meter per year

Water-Resources Activities of the U.S. Geological Survey in Wyoming, October 1991 through September 1993

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Abstract

This report describes the water-resources activities of the U.S. Geological Survey (USGS), Wyoming District. The activities are classified as data-collection programs and water-resources-appraisal projects. Much of the work is done in cooperation with other agencies. During fiscal years 1992 and 1993, cooperators included nine local agencies, two Native American tribes, seven State agencies, and nine Federal agencies. This report is a biennial progress report to the cooperating agencies and the general public.

During fiscal year 1992, the Wyoming District operated 166 streamflow stations, 1 reservoir station, 93 surface-water-quality stations, 34 fluvial-sediment stations, 85 ground-water-level observation wells, and 100 ground-water-quality sites, of which 25 were sampled during fiscal year 1992.

Descriptions, location maps, and status statements are given for the 4 long-term data-collection projects and for 16 water-resources-appraisal projects that were active (funded) during fiscal year 1992 or 1993. Also included are lists of 14 projects that were completed between May 1991 and June 1993; and 2 projects for which funding ended prior to 1993 and that are completed except for the final report(s). The final section is a bibliographic listing of reports by USGS authors about the water resources of Wyoming.

INTRODUCTION

The U.S. Geological Survey (USGS) is the Federal agency responsible for appraising the quantity, quality, and movement of the Nation's surface-water and ground-water resources. The Water Resources Division Districts of the USGS maintain long-term networks of hydrologic-data stations and conduct interpretive studies in every State, the Commonwealth of Puerto Rico, and the American Trust Territories. Many of the water-resources activities are carried out in cooperation with local, State, and other Federal agencies to describe local and regional hydrologic systems and processes, or to evaluate and solve hydrologic problems. The cooperating agencies commonly use the results in water-resources management. The information products of the investigations, however—hydrologic data and interpretive reports—are available to any one, on request.

This report describes the water-resources activities of the Wyoming District during fiscal years 1992 and 1993 (October 1, 1991 through September 30, 1993). It is a biennial progress report to officials of cooperating agencies and to the public. Cooperating agencies during 1992-93 are listed in the front of the report (back of title page) and are identified with each activity described in the text. The activities are classified into two groups: (1) data-collection projects, and (2) water-resources-appraisal projects.

The data-collection projects include (1) collecting records of streamflow and reservoir storage, (2) sampling and chemical analysis of water from streams and ground-water wells, (3) sampling and analysis of sediment in surface water, and (4) measuring water levels in wells. This report contains maps showing the location of data-collection sites during water year 1992. (A water year is the same as a fiscal year—October 1 through September 30.) Hydrologic data also are collected as part of many water-resources-appraisal projects; location of these short-term sites are not shown on the maps in this report.

The water-resources-appraisal projects described are those being conducted during fiscal years 1992 and (or) 1993. Projects completed prior to fiscal year 1993, but for which final reports were still in preparation as of release of this report, are listed separately. An extensive listing of reports of results from previous activities is provided at the back of this report. A brochure summarizing the activities of the Wyoming District is provided at the back of this report.

ORIGIN OF THE U.S. GEOLOGICAL SURVEY

The USGS was established by an act of Congress on March 3, 1879, providing 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 USGS has expanded and been modified to meet the changing needs of the Nation it serves. As part of that evolution, the USGS has become the Federal Government's largest earth-science research agency, the Nation's largest civilian map-making 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 area.
- 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, 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-resource appraisals in order to describe the consequences of alternative plans for developing land and water resources.
- Conducting research in hydraulics and hydrology, and coordinating most Federal water-data acquisition.
- Using remotely sensed data to develop new research techniques in cartography, geology, and hydrology for natural-resources planning and management.
- Providing earth-science information through an extensive publications program.

Along with its continuing commitment to meet the expanding and changing earth-science needs of the Nation, the USGS remains dedicated to its original mission: to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation--providing earth science to the public.

MISSION OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division is to provide the hydrologic information and technical evaluation needed for the optimum use 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-resource appraisals describing the occurrence, availability, and the physical, chemical, and biological characteristics of surface and ground water.
- Conducting basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific knowledge for investigations and measurement techniques.
- 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 State, local, and other Federal agencies, to licensees of the Federal Power Commission, and to international agencies on behalf of the U.S. Department of State.

ORIGIN OF THE WYOMING DISTRICT

The Water Resources Division of the USGS, of which the Wyoming District is a part, has its roots in the Irrigation Survey of 1888-90. The Sundry Civil Appropriation Act of 1888 established an Irrigation Survey as a part of the USGS "for the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation * * *."[1] In 1888, the Washington, D.C. office of the USGS paid the installation costs for the first streamflow-gaging station in Wyoming—Laramie River at Woods Landing. The station was constructed and operated by the Territorial Engineer, Elwood Mead. Between 1895 and 1901, the USGS paid operating expenses for additional stations operated by the Wyoming State Engineer. A.J. Parshall became the first resident hydrographer for the USGS in Wyoming in 1901.

These early activities were forerunners of the Federal-State Cooperative Water-Resources Program, first funded by Congress in 1905, and given formal recognition by Congress in 1927. The Cooperative Program is a partnership between the USGS and State and local agencies for water-resources investigations.

Surface-water investigations in cooperation with the State Engineer have continued without interruption since 1915. Early Federal cooperators included the Reclamation Service (about 1902), the Indian Service (1908), and the Forest Service (1910). A flood-investigations program was started in 1959 in cooperation with the Wyoming Highway Department; this successful program was completed in 1988.

Surface-water activities in Wyoming were directed from Washington until 1903, when the Colorado District was established under M.C. Hinderlider. Between 1903 and 1961, Wyoming was part of the Colorado District, with local offices at various times in Kemmerer, Sheridan, and Casper. The Wyoming District, Surface Water Branch, was established in 1961, with L.A. Wiard as District Engineer.

[1]U.S. Statutes at Large, 1887-89, The Sundry Civil Appropriations Act of 1888: Washington, v. 25, chap. 1069, p. 526.

The earliest known ground-water studies by the USGS in Wyoming were done between 1901 and 1917 by G.I. Adams in Goshen Hole area; N.H. Darton and others in the Great Plains, Bighorn Mountains, Laramie Range, and Black Hills; and O.E. Meinzer in Lodgepole Valley. Investigations in cooperation with State agencies have been carried out since 1940, when the Wyoming Planning and Water Conservation Board sponsored a study of the Egbert-Pine Bluffs area by T.W. Robinson. Cooperation on hydrologic studies with the State Engineer has continued since 1945.

Ground-water work in Wyoming was directed from Washington until 1945, when Wyoming became a part of the Colorado District under S.W. Lohman. The local geologist in charge was A.M. Morgan. In 1951 the Wyoming District, Ground Water Branch, was established with H.M. Babcock as District Geologist.

Surface-water quality work in Wyoming began with the establishment of an office and sediment laboratory in Worland in March 1946, with T.F. Hanly in charge. The program was directed by P.C. Benedict, Regional Engineer, in Lincoln, Nebraska. During 1948, chemical-quality and sediment stations were in operation in the North Platte River basin under the Missouri River basin program of the U.S. Department of the Interior.

In February 1956, the office in Worland was designated as a District Office, Quality of Water Branch, with T.F. Hanly as District Engineer. The first sediment station in the State cooperative program was established on Rock Creek near Atlantic City with the Wyoming Natural Resources Board in 1957. A cooperative chemical-quality program with the State Engineer was started in 1959 to evaluate the effects of the Kendrick Project on the North Platte River. Since 1965, the Wyoming Department of Agriculture has been the principal State cooperator for chemical quality, and the State Engineer for sediment data.

The Branch Districts in Wyoming were combined into a single Water Resources Division District in February 1967, with L.A. Wiard as District Chief. Subsequent District Chiefs include: R.L. Cushman (1968), S.W. West (1973), W.W. Dudley, Jr. (1979), R.M. Bloyd (1983), and J.E. Kircher (1987). The present District Chief, B.D. Lewis, was appointed in 1992.

DISTRICT OPERATIONS

The water-resources activities of the Wyoming District Office are carried out by two operating sections. The Hydrologic Surveillance and Data Management Section designs, constructs, operates, and

maintains the District's hydrologic-data stations and manages the collection, analysis, publication, and storage of hydrologic data. The Hydrologic Investigations Section plans and executes water-resources investigations Statewide, including mathematical modeling of ground-water systems, application of open-channel hydraulics to surface-water problems, water-resources appraisals, hazardous-waste investigations, and evaluation of the hydrologic effects of human activities such as irrigation of croplands or surface mining of coal. The operating sections are supported by the Administrative Services Section, Computer Support Unit, and Publications Support Unit.

The District Office is in Cheyenne, with Field Offices in Casper and Riverton (inside front cover and fig. 1). Personnel of the Field Offices perform most of the hydrologic-data collection; the Casper office is responsible for eastern Wyoming, and the Riverton office is responsible for western Wyoming. District managers and subject-matter specialists are listed below:

District Chief	Barney D. Lewis
Assistant District Chief and Chief Hydrologic Surveillance and Data Management Section	Stanley A. Druse
Chief, Hydrologic Investigations Section	(vacant)
Chief, Casper Field Office	William R. Glass
Chief, Riverton Field Office	Myron L. Smalley
Chief, Environmental Studies Unit	Hugh W. Lowham
Chief, Hydrologic Studies Unit	Randolph B. See
Administrative Officer	Doris J. Adair
Reports Specialist	William B. Borchert
Computer Specialist	Charles A. Eshelman
Surface-Water Specialist	James G. Rankl
Quality-of-Water Specialist	George F. Ritz
Ground-Water Specialist	(vacant)

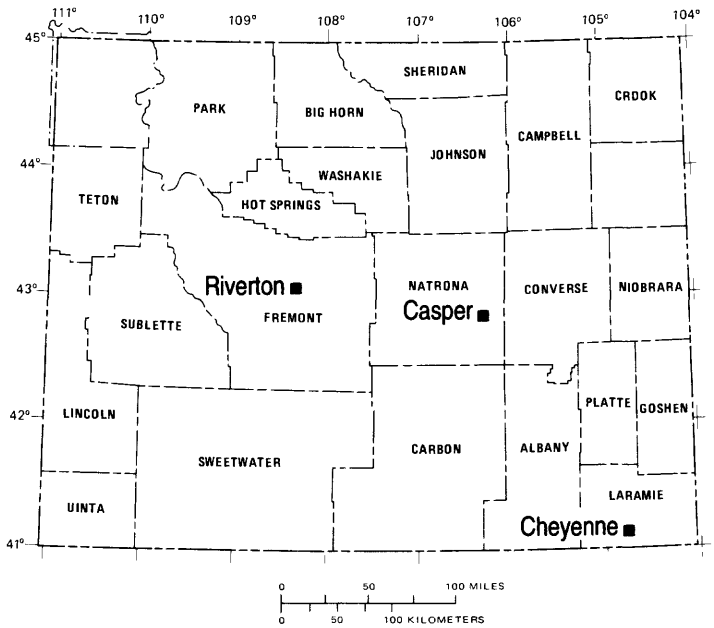


Figure 1.--Location of U.S. Geological Survey, Water Resources Division offices in Wyoming.

SOURCES OF FUNDING

Funds for carrying out the water-resources investigations of the U.S. Geological Survey (USGS) in Wyoming are provided by many agencies. The agencies are classified by three major categories: (1) State and local agencies that provide funds or services, or both, generally matched on a 50-50 (percent) basis by USGS funds (cooperative program); (2) other Federal agencies that transfer funds to the USGS (OFA program); and (3) USGS funds received by direct appropriation for activities that are national in scope (Federal program). The distribution of these funds in Wyoming by major category for fiscal years 1992 and 1993 is shown in figure 2. During fiscal year 1992, about 15 percent of the funds were used for collection of hydrologic data and about 85 percent for interpretive hydrologic studies, while in 1993 the distribution is 17 percent hydrologic data and 83 percent hydrologic studies.

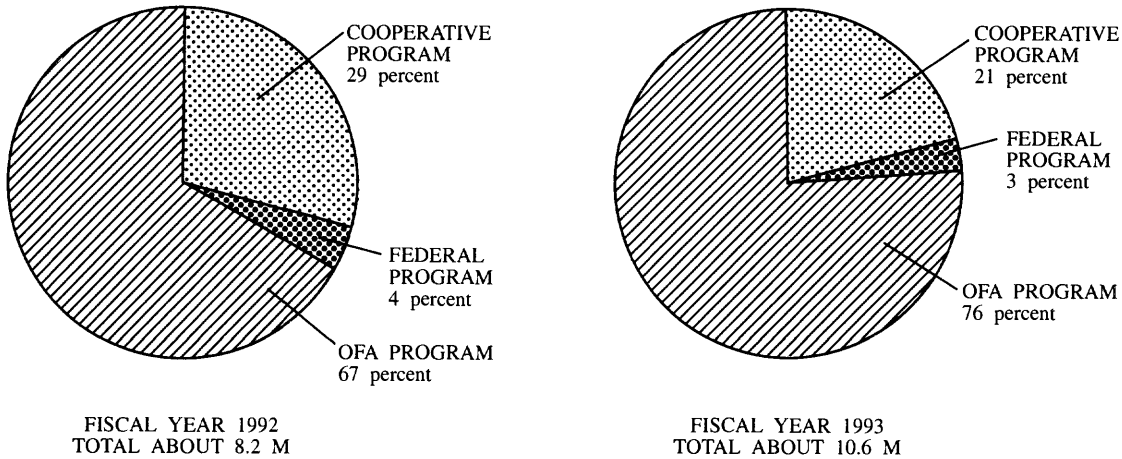


Figure 2.--Sources of funding.

SUMMARY OF HYDROLOGIC CONDITIONS DURING WATER YEAR 1992

Hydrologic conditions during water year 1992 in Wyoming was dominated by less-than-average streamflow throughout most of the State. Less-than-normal precipitation was prevalent in western Wyoming with near normal precipitation elsewhere. Although above average precipitation prevailed during water year 1991, water year 1992 was another year of drought conditions that have persisted since 1988. Most of the State continued to be affected by drought, ranging from moderate to extreme, as reported in the 1992 issues of the ***Weekly Weather and Crop Bulletin*** prepared and published by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture Joint Agricultural Weather Facility. The August 22, 1992 issue indicated most of the State was affected by extreme drought as determined by the long-term Palmer drought severity index (which predicts prolonged, months/years, of abnormal dryness or wetness). The major exception was the Bighorn Mountain area in north-central Wyoming which improved to no drought effect. Drought conditions caused several Wyoming counties to be declared federal disaster areas during the year. Counties so designed included Crook and two contiguous counties—Campbell and Weston; Platte and five contiguous counties—Albany, Converse, Goshen, Laramie, and Niobrara; and Sublette and four contiguous counties—Fremont, Sweetwater, Lincoln, and Teton.

Precipitation

Precipitation during water year 1992 was less than normal (1951-80 average) for the western part of the State, greater-than-normal in the north-central, and near normal elsewhere. Precipitation and departures from normal for the major divisions (drainage basins) are published by NOAA. The Snake River basin, and Green and Bear River basins in western Wyoming received 78 and 86 percent of normal precipitation. The [Lower] North Platte River basin in southeastern Wyoming was also less than normal at 95 percent. Precipitation was greater than normal in north-central Wyoming, where the Bighorn River basins received 128 percent of normal, the Wind River 119 percent, and the Powder River/Little Missouri/Tongue River area, 102 percent. The [Upper] North Platte River basin in south-central Wyoming received 106 percent of normal precipitation.

Precipitation in the mountains, in the form of snow, provides most of Wyoming's annual water supply. Precipitation and snowpack in Wyoming's mountains is reported by the U.S. Soil Conservation Service in ***Basin Outlook Reports.*** Graphs in the June 1, 1992 issue indicated that greater-than-normal precipitation occurred throughout most of the mountainous areas of the State in November and May. However, most of the remaining months were near or appreciably less than normal. At the end of May 1992, the percent of normal precipitation—for mountainous areas in selected basins—were as follows:

Wind River basin—75 percent

Bighorn River basin—95 percent

Upper North Platte River basin—83 percent

Lower North Platte/Sweetwater/and Laramie basins—75 percent
Upper Green River basin—57 percent

The June 1, 1992 issue noted: "Water users throughout the State face a grim water season this summer. Forecasts indicated that streamflow will be below to much below average for the spring and summer runoff period. Accumulated snowpack started melting four to six weeks early this year, so most high elevation snow is gone."

Streamflow

Monthly and annual discharge in most streams reflected the ongoing drought conditions prevalent in most of the State. The exceptions were those streams in the Bighorn Mountains, where streamflow at several gaging stations exceeded the long-term average discharge. The average discharge for water year 1992 at selected index stations was in the lower quartile of annual average discharges for the periods of record. The average discharge during water year 1992 for North Platte River at Wyoming-Nebraska State line was the lowest for the period of record. Gordon W. Fassett, Wyoming State Engineer, noted in a December 1992 written communication that the total volume of water stored in the North Platte Reservoir system was the lowest for that time of year since 1966. Also, system storage had declined from more than 2 million acre-feet at the end of 1986 Water Year to 722,900 acre-feet at the end of the Water Year 1992.

Floods

Flooding, particularly that from snowmelt, was moderate throughout the State during water year 1992. The moderate maximum discharges generally reflected the continuing drought and the earlier-than-normal snowmelt. Maximum discharges at most streamflow-gaging stations in Wyoming had a recurrence interval of 2 years or less. Summer thunderstorms caused locally severe flooding in several streams throughout the State. Most noteworthy of the reports of flooding was that of June 15 in the Crazy Woman Creek, North Fork Powder River, and Clear Creek drainage basins, south and east of Buffalo, Wyoming. Streams in these basins were reported to be out of their banks. The streamflow-gaging station, 06311400 North Fork Powder River below Pass Creek, near Mayoworth had a peak of 1,090 cubic feet per second which has a recurrence interval of about 20 years. Stan Krenz, National Weather Service, Sheridan (oral commun.) reported 4.75 inches of precipitation for a location 20 miles south of Buffalo. He noted that unconfirmed reports indicated total precipitation as high as 6 inches.

Chemical Quality of Surface Water

Specific conductance of water samples from streams during water year 1992 was not significantly different from that of the previous 10 years, based on the data from seven water-quality stations. Specific conductance was chosen as an indicator of dissolved-solids concentration in water, because the conductance varies directly with the concentration and species of ions in the water. These seven stations were selected to represent the major river basins of Wyoming.

The mean values of specific conductance at each station for water year 1992 was compared to the mean value for the previous 10 water years at that station, 1982-91, using the Wilcoxon-Mann-Whitney rank sum test. The mean values of specific conductance at these stations for water year 1992 were not significantly different statistically than the mean values for the previous 10-year period.

Ground-Water Levels

Ground-water levels were measured in a statewide network of 85 observation wells; most wells are in areas of extensive ground-water withdrawal—mainly in southeastern Wyoming. In Niobrara, Goshen, and eastern Laramie Counties, most withdrawals from the High Plains aquifer are for irrigation. In Platte County, withdrawals from alluvium also are mainly for irrigation. In central Laramie County, water is withdrawn from the High Plains aquifer, mainly for domestic use.

Water levels were measured and continuously recorded in 65 wells equipped with float-driven digital water-level recorders and at 2 artesian wells equipped with pressure-sensing transducers and electronic data recorders. Water levels in the remaining wells in the network were measured manually by use of a steel tape. The changes in water levels in wells between water year 1991 and water year 1992 were determined from the maximum water levels (referred to only as water levels in the following discussion) measured during each water year.

Water levels in most observation wells throughout the State declined between water years 1991 and 1992. Hot Springs and Sweetwater Counties were the only counties where water levels rose in most of the ob-

servation wells. The changes between water years 1991 and 1992 in 18 wells in Laramie County ranged from about a 3.8-foot rise to about a 5.5-foot decline; the median change for all observation wells in Laramie County was 0.4-foot decline. Water-level changes in 10 wells in Platte County ranged from about a 0.4-foot rise to a 6.0-foot decline; the median was a 0.3-foot decline. Changes in 6 wells in Niobrara County ranged from about a 0.8-foot rise to a 1.2-foot decline; the median was a 0.1-foot decline. Changes in 10 wells in Goshen County ranged from about a 0.2-foot rise to a 2.5-foot decline; the median was a 0.6-foot decline. Water-level declines also were predominant in observation wells in Campbell and Crook Counties, where changes ranged from about a 2.0-foot rise to a 4.5-foot decline; the median was a 3.7 foot decline.

Hydrographs of water levels and selected statistical data are published in separate water-level reports. The most recent report, ***Open-File Report 92-111*** (see Selected Publications at back of this report), is available for inspection at the U.S. Geological Survey in Cheyenne.

Drought conditions persisted throughout most of Wyoming during water year 1990, with only extreme eastern and extreme northwestern Wyoming having near normal conditions. The ***Weekly Weather and Crop Bulletin***, prepared and published by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture Joint Agricultural Weather Facility, reported little change from 1989 in the area affected by severe and extreme drought during the summer months. The July 7 report showed the area of extreme drought included all of Wyoming except extreme eastern and extreme northwestern Wyoming, and this condition prevailed through their September report. Water year 1990 was the third consecutive year of drought throughout most of Wyoming.

Ground-Water Quality

The quality of ground water ordinarily changes slowly; therefore, for most general purposes, groundwater quality is monitored by one annual sampling or by sampling selected sites at infrequent intervals during the year. All wells sampled are pumped long enough to assure that the water collected is a representative sample of the aquifer.

During 1988-92, approximately 100 water wells were part of the ground-water- quality monitoring program. Twenty-five of the wells were sampled each year. No substantial changes in ground-water quality have been detected during the 4-year period.

DATA-COLLECTION SITES

Hydrologic-data stations are maintained at selected locations throughout Wyoming for obtaining records of streamflow stage and discharge, reservoir elevation and storage, the quality of surface water and ground water, ground-water levels, and well and spring discharge. The location of stations for which hydrologic data were published in the report, ***Water-Resources Data for Wyoming—water year 1992***, are shown in figures 3-5. A summary of stations operated by the Wyoming District during water year 1992 is listed in table 1.

Table 1.--Hydrologic-data stations operated by the Wyoming District, U.S. Geological Survey, during water year 1992

[Data stations in Wyoming, but operated by Districts in adjacent States, are not included]

Station type	Number of stations
Surface water:	
Streamflow:	
Continuous (daily) record	116
Seasonal (daily) record	45
Peak-flow, crest-stage record	5
Lakes and reservoirs:	
Stage and contents	[a]1
Water quality:	
Periodic chemical quality	87
Daily quality monitoring	6
Suspended sediment	34
Ground water:	
Periodic water levels	18
Daily water levels	
Chemical quality	[b]100
Meteorological:	
Precipitation quantity, air temperature, or both	7

[a]Records of daily or month-end contents provided by U.S. Bureau of Reclamation for 13 reservoirs in Wyoming were published in USGS Water-Data Report WY-92-1 (see listings at back of this report).

[b]Twenty-five wells sampled each year; resampled every 4 years.

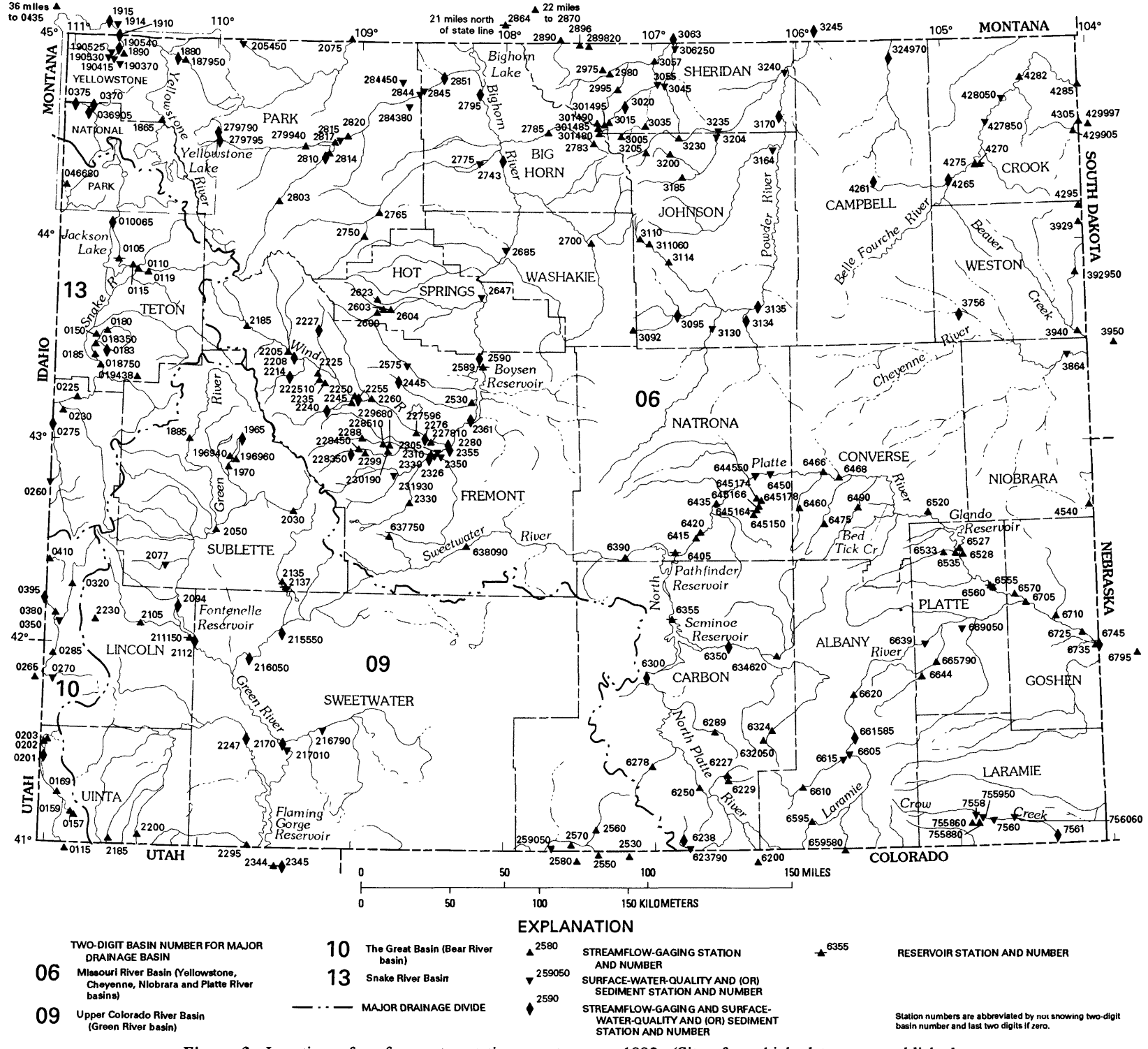


Figure 3.--Location of surface-water stations, water year 1992. (Sites for which data were published in U.S. Geological Survey Water-Data Report WY-92-1. See listings at back of this report.)

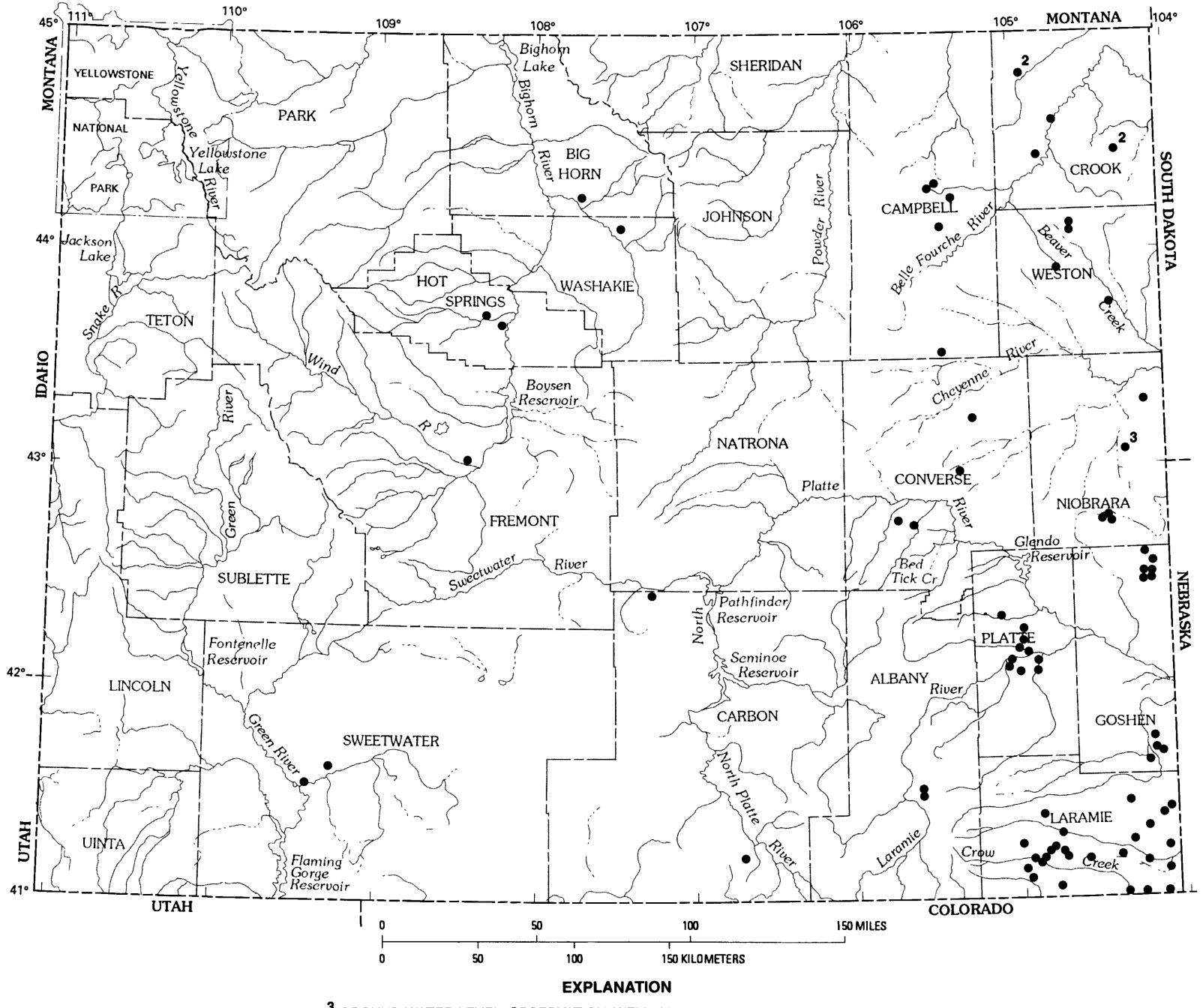


Figure 4.--Location of ground-water-level observation wells, water year 1992.

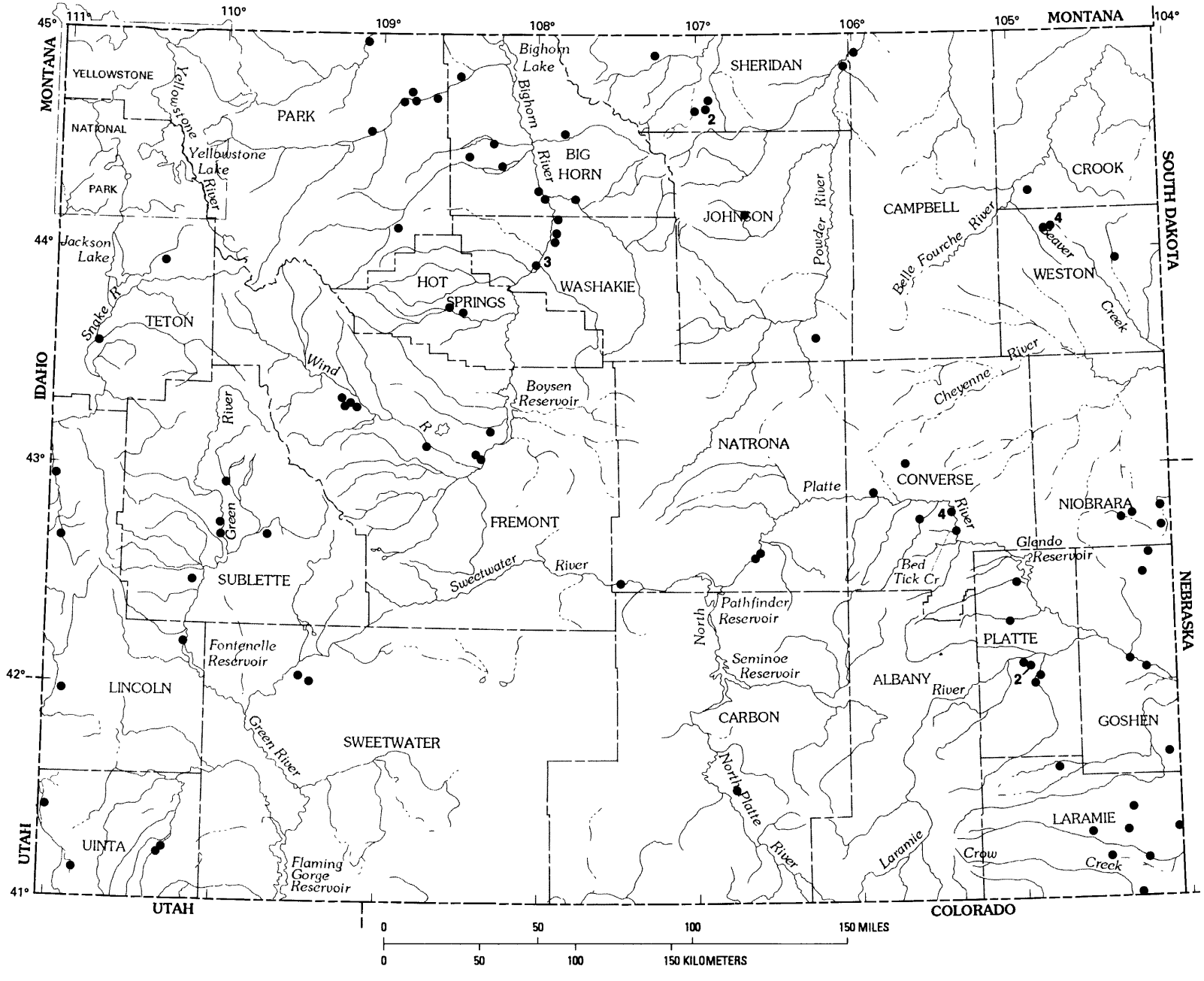


Figure 5.--Location of ground-water-quality sites, water year 1992.

Every year new stations are added and others are discontinued; thus, the USGS has Statewide coverage of both current and historical hydrologic data. A complete list of discontinued and active data-collection stations (excluding ground-water wells) is published in the annual report, ***Water-Resources Data for Wyoming.*** A separate index of surface-water stations through water year 1990 also is available from the any of the three USGS offices in Wyoming (see ***Open-File Report 91-497*** in Selected Publications at the back of this report).

Most water-resources data are stored in the USGS National Water Information System (NWIS) data base and are available on request. These data can be retrieved on machine-readable media or on paper printouts as tables, statistical summaries, or graphs. Assistance in acquiring services or products from NWIS can be obtained by contacting the District Office in Cheyenne.

DATA-COLLECTION PROJECTS

Surface-water stations (WY001)

FUNDING AGENCIES: Wyoming State Engineer, Wyoming Department of Environmental Quality, Wyoming Water Development Commission, Wyoming Game and Fish Department, Teton County, Uinta County, Sheridan Area Water Supply-Joint Powers Board, City of Evanston, City of Gillette, Shoshone Tribe, Northern Arapahoe Tribe, Midvale Irrigation District, U.S. Air Force, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Army, Corps of Engineers, U.S. Forest Service, and USGS

PROJECT LEADER: Stanley A. Druse

FIELD LOCATION: Statewide

PERIOD OF PROJECT: Ongoing

PROBLEM: Surface-water information is needed for surveillance, planning, design, hazard warning, operation, and management in related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVES: (1) Collect sufficient surface-water data to satisfy needs for current-purpose uses such as: assessment of water resources, operation of reservoirs and irrigation projects, prediction of stage or discharge, pollution controls and disposal of wastes, discharge data to accompany water-quality measurements, compact and legal requirements, and research or special studies; and (2) collection of data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams and lakes for use in planning and design.

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,*** and partial-record gaging will be used where it serves the required purpose instead of complete-record gaging.

STATUS: During water year 1992, there were 166 stations in the network—116 continuous-record stations and 50 seasonal or partial-record peak-flow stations. The level of activity moderated during 1992, with a net increase of 2 new continuous-record stations. The Wyoming State Engineer's Office operates 28 stations, most of which are operated seasonally. Computation and compilation of surface-water data for the water-year 1992 data report were completed on schedule, again allowing the Wyoming District to the Division's goal of having the report to the printer by April 1. Wyoming again participated in having the data report entered into the Headquarters-sponsored CD-ROM project. Work continues on the District's cableway-safety program, to install handrails on cableway platforms at a rate of about 10 per year and new main cables at a rate of two per year. Also, a dead-load tester was constructed, and testing of cableways has begun. In the District's program to eliminate mercury manometers, three stations were converted from manometers to stilling wells during 1992. An index of streamflow stations operated through 1990 was published in 1992.

PUBLICATIONS (See listings at back of this report):

U.S. Geological Survey Water-Data Reports WY-91-1 and WY-92-1.

U.S. Geological Survey Open-File Report 91-072. *Summary of data indicating gain or loss of streamflow across outcrops of Paleozoic formations in northeastern Wyoming, 1974-91,* by W.R. Glass and L.G. Sultz. 1992.

U.S. Geological Survey Open-File Report 91-497. *Index of surface-water discharge, water-quality, sediment, and biological records through September 30, 1990, for Wyoming,* by N.K. Ruby, R.J. Sagmeister, S.L. Green, and J.D. Walgren. 1991.

Ground-water stations (WY002)

FUNDING AGENCIES: Wyoming State Engineer, National Park Service, and USGS

PROJECT LEADER: Hugh I. Kennedy

FIELD LOCATION: Statewide

PERIOD OF PROJECT: Ongoing

PROBLEM: Long-term ground-water-level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems to provide a data base from which to measure the effects of development, assist in the prediction of future supplies, and provide data for management of the resource. Short-term water-level records also are needed for ground-water resources assessment, areal investigations, and water-use investigations.

OBJECTIVES: (1) Collect sufficient water-level data to provide a data base so that the general hydrologic response to climatic variations and induced stresses is known and potential problems can be defined early enough to allow planning and management; and (2) provide a data base against which short-term records acquired in areal studies can be analyzed. This analysis must provide an assessment of the ground-water resource, allow prediction of future conditions, detect and define pollution and supply problems, and provide the data base necessary for ground-water management.

APPROACH: The most advantageous locations for long-term observations will be determined. This network will be refined as records become available and detailed areal studies of the ground-water system more closely define the aquifers, their properties, and the stresses to which they are subjected.

STATUS: During water year 1992, there were 85 observation wells in the network—67 continuous-record sites and 18 periodic-record sites. The Wyoming State Engineer's Office operates about two-thirds of the network wells. Computation and compilation of the data are maintained at a near-current status.

PUBLICATIONS (See listings at back of this report):

U.S. Geological Survey Water-Data Reports WY-91-1 and WY-92-1.

U.S. Geological Survey Open-File Report 92-111. *Ground-water levels in Wyoming, 1982 through September 1991*, by H I. Kennedy and S.L. Green. 1992.

Water-quality stations (WY003)

FUNDING AGENCIES: Wyoming Department of Agriculture, Wyoming State Engineer, Wyoming Department of Environmental Quality, Wyoming Water Development Commission, Wyoming Game and Fish Department, Fremont County Weed and Pest Control District, City of Gillette, Shoshone Tribe, Northern Arapahoe Tribe, National Park Service, U.S. Bureau of Reclamation, U.S. Forest Service, and USGS

PROJECT LEADER: George F. Ritz

FIELD LOCATION: Statewide

PERIOD OF PROJECT: Ongoing

PROBLEM: Water-resource planning and water-quality assessment require a nationwide base level of standardized information. For intelligent planning and realistic assessment of the water resource, the chemical and physical quality of surface and ground water must be defined and monitored.

OBJECTIVES: (1) Provide Statewide data to a national bank of water-quality data for broad Federal and State planning and action programs, (2) provide data for State and Federal management of interstate waters, and (3) provide data for interpretation in areal studies.

APPROACH: A network of water-quality stations will be operated at stream sites to provide data on average chemical concentrations, loads, and trends as required by planning and management agencies. Selected ground-water wells also will be sampled.

STATUS: During water year 1992, there were 93 surface-water stations in the network—6 daily-record sites, and 87 periodic-record sites. The ground-water monitoring program focused on the northeastern quadrant of the state; 25 wells of the 100-well network were sampled for herbicides, major dissolved constituents, and field measurements. Data were compiled, checked, and published in the Annual Data Report for 1992.

PUBLICATIONS (See listings at back of this report):

U.S. Geological Survey Water-Data Reports WY-91-1 and WY-92-1

U.S. Geological Survey Open-File Report 91-497. *Index of surface-water discharge, water-quality, sediment, and biological records through September 30, 1990, for Wyoming*, by N.K. Ruby, R.J. Sagmeister, S.L. Green and J.D. Walgren. 1991.

Sediment stations (WY004)

FUNDING AGENCIES: Wyoming Water Development Commission, Wyoming Department of Environmental Quality, City of Gillette, National Park Service, U.S. Bureau of Reclamation, U.S. Federal Highway Administration, U.S. Forest Service, and USGS

PROJECT LEADER: George F. Ritz

FIELD LOCATION: Statewide

PERIOD OF PROJECT: Ongoing

PROBLEM: Water-resource planning and water-quality assessment require a nationwide base level of relatively standardized information. Sediment concentrations and discharges in rivers and streams must be defined and monitored.

OBJECTIVE: (1) Provide a national bank of sediment data for use in broad Federal and State planning and action programs, (2) provide data for Federal and State management of interstate water, and (3) provide data for interpretation in areal studies.

APPROACH: A network of sediment stations will be established and operated to provide data on areal and temporal averages and trends of sediment concentration, sediment discharges, and particle-size distribution of sediment being transported by rivers and streams.

STATUS: During water year 1992 there were 34 sediment stations in the network—1 continuous-record station, and 33 stations were sampled at various intervals. Suspended-sediment concentration and sand-silt size break were analyzed in samples from the Colorado and Utah Districts. Analyses for Wyoming were checked and compiled for publication in the annual data report, which was ready for the printer by the Division goal of April 1. The District sediment lab personnel participated in Division training and new quality-assurance procedures. The lab received an excellent rating during a technical review in 1992.

PUBLICATIONS (See listings at back of this report):

U.S. Geological Survey Water-Data Reports WY-91-1 and WY-92-1

U.S. Geological Survey Open-File Report 91-497. *Index of surface-water discharge, water-quality, sediment, and biological records through September 30, 1990, for Wyoming*, by N.K. Ruby, R.J. Sagmeister, S.L. Green, and J.D. Walgren. 1991.

WATER-RESOURCES-APPRAISAL PROJECTS

Water-use data system and wetlands compilation for Wyoming (WY007)

FUNDING AGENCIES: Wyoming State Engineer and USGS

PROJECT LEADER: Kathy M. Ogle

FIELD LOCATION: Statewide

PERIOD OF PROJECT: Started January 1984; ongoing

PROBEM: The demand for water for a variety of competing uses in Wyoming is expected to continue to increase. Water planners and managers at all levels of government need detailed, accurate water-use information. In addition, a compilation of information about wetlands in Wyoming is needed both for national purposes and to provide State agencies with the uniform, detailed information they require.

OBJECTIVES: Establish a water-use data system for Wyoming that is consistent with the USGS national water-use data system and is responsive to the needs of State water planners and managers. The system will provide for the compilation, storage, retrieval, and dissemination of water-use and wetlands data.

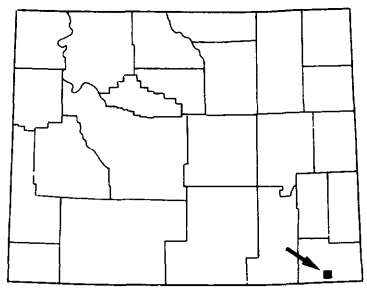
APPROACH: Data on file at the Wyoming State Engineer's office and other State and Federal agencies will be used as a base for the Wyoming water-use data system and to compile wetlands information. State agencies with water-related activities will be consulted on a continuing basis for suggestions and review of the program. Statewide water-use data will be compiled by type and geographic area every 5 years for the USGS Circular series, "Estimated Use of Water in the United States." Wetlands information will include area, distribution, and type of biota.

STATUS: Wyoming water-use data for 1990 were compiled and submitted for publication in the report listed below. The data were entered into a geographic information system (GIS) data base for later transfer into the Geological Survey National Aggregated Water-Use System. The compilation of wetlands information will begin in 1993 and will continue for 2 years.

PUBLICATION (See listings at back of this report):

U.S. Geological Survey Circular 1081. *Estimated use of water in the United States in 1990*, by W.B. Solley, C.F. Merk, and H.A. Perlman. 1993.

Site characterization and preparation of a remedial-action plan for the Installation Restoration Program at F.E. Warren Air Force Base, Wyoming (WY095)



FUNDING AGENCY: U.S. Air Force

PROJECT LEADER: L. Rodney Larson

FIELD LOCATION: Southeastern Wyoming

PERIOD OF PROJECT: December 1985 through December 1995

PROBLEM: At F.E. Warren Air Force Base, Wyoming, the U.S. Air Force has used, stored, and disposed of various hazardous materials, especially since about the 1940s, with installation and operations associated with intercontinental ballistic missiles. Studies since 1985 show that contamination of soil, ground water, or surface water has occurred at as many as 24 sites. The hazardous materials primarily are volatile organic compounds. As a result of the extent of contamination, and because of the threat it poses to nearby domestic wells, F.E. Warren Air Force Base was placed on the National Priorities List in February 1990.

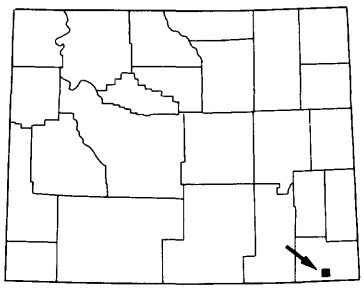
OBJECTIVE: Remedial investigations are being conducted to determine the nature and extent of contamination, to assess the impact of the contaminants on the environment, and to summarize this information in final reports so the U.S. Air Force may determine appropriate remedial action for each site. The characterization will include identification of contamination in the soil, water, and air. The hydrologic and geotechnical properties of the sites will be measured in order to provide data necessary to predict movement and fate of the contaminants and to evaluate potential cleanup methods.

APPROACH: The investigation is planned to determine the extent and movement of contaminants in the soil, water, and air. Detailed work plans that specify the methodology and approach are being developed for seven operable units, each of which include one or more spill sites grouped according to contaminant type. The field activities will include drilling and logging of observation wells and boreholes, sampling and measurement of soil and water chemical quality, and collection of geophysical, geotechnical, aquifer-test, water-level, and biological data. Modeling of the ground and surface waters will be done to assist in the development of potentiometric-surface and groundwater contaminant-plume maps. The characterization also will include streamflows, surface runoff, and biota. The data analyses concerning the characterization of the contamination will be summarized in final reports for each operable unit.

STATUS: During water year 1992, field investigations of contaminants in the soil and water began for Operable Unit 1 (seven sites), Operable Unit 4 (one site), and Operable Unit 5 (two sites). An administrative report was completed and approved for Operable Unit 1, which is an acid dry well site. Numerous other reports, including a Sampling and Analysis Plan, Work Plans for Operable Units 1, 4, and 5, Safety and Health Plans, and a Work Plan and final administrative report for a re-utilization facility were prepared and approved. All studies are developed through extensive discussion and review with the U.S. Air Force and the regulatory agencies, which include the U.S. Environmental Protection Agency and the Wyoming Department of Environmental Quality. All investigations and reports have been completed on or ahead of schedule. Current field investigations are being conducted at seven land-fill areas—part of Operable Unit 3. Reports for Operable Units 1 and 5 are in preparation. A digital model is being developed to assist with describing transport of trichloroethylene in shallow ground water.

Note.—All reports described above are administrative reports to the U.S. Air Force. They belong to the Air Force, and are not available to the public through the U.S. Geological Survey.

Urban Flood Hydrology for Cheyenne, Wyoming (WY100)



FUNDING AGENCIES: City of Cheyenne, Laramie County, and USGS

PROJECT LEADER: James G. Rankl

FIELD LOCATION: Southeastern Wyoming

PERIOD OF PROJECT: October 1986 through September 1994

PROBLEM: The City of Cheyenne, Wyoming, is susceptible to extreme flooding because of its location in the foothills of the Laramie Mountains. Streams in this area pose a significant flood hazard from intense thunderstorms, especially during the months of July and August. Although more than 80 years of precipitation data are available, the relation between precipitation and runoff has not been defined for rural areas around Cheyenne or for urban areas within the city limits.

OBJECTIVE: (1) Determine the relation between rainfall and runoff for both rural and urban areas, and (2) use the results of the rainfall and runoff relations in conjunction with the 80 years of precipitation data to develop predictions of peak and volume frequencies. The peak and volume frequencies will be used by the City of Cheyenne to design the proper size openings for hydraulic structures.

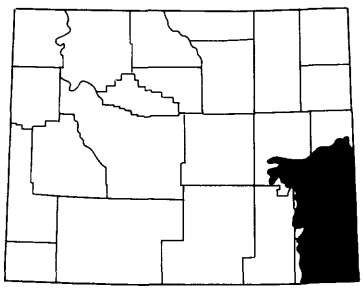
APPROACH: Three streamflow-gaging stations equipped with stage sensors and recording precipitation gages will be installed on channels of three small drainage basins entering the Cheyenne area. An additional site will be installed on Henderson Drain to sample a completely urbanized area. A streamflow-gaging station will be located about 15 miles west of Cheyenne for collecting hydrologic data. All sites will be equipped with a flood-alert system operated by the National Weather Service. Hydrologic data will be collected for 4 to 5 years.

STATUS: Recording and telemetry equipment were removed from the gaging station on Dry Creek tributary at Converse Avenue because Converse Avenue has been extended up the Dry Creek tributary channel. The gage will be moved to a new site upstream when construction is completed. Records for the streamflow gaging stations have been processed. The project is being revised and extended through water year 1993. Data from the study will be published in an open-file report

PUBLICATIONS (See listings at back of this report):

U.S. Geological Survey Water-Resources Investigations Report 93-4022. *Flood boundaries and water-surface profiles for the computed 50-, 100-, and 500-year floods, Childs Draw and tributary, near Cheyenne, Wyoming, August 1991,* by G.F. Ritz. *In Press.*

Description and analysis of water-level changes in the High Plains aquifer, Wyoming (WY107)



FUNDING AGENCIES: Wyoming State Engineer and USGS

PROJECT LEADER: Kirk A. Miller

FIELD LOCATION: Southeastern Wyoming

PERIOD OF PROJECT: April 1990 through September 1993

PROBLEM: In response to concerns over the status of conditions in the High Plains (Ogallala) aquifer, Congress has directed the USGS to monitor water levels in the aquifer and to report the results annually to them.

OBJECTIVE: The directive from Congress will be met by preparing an annual report with information concerning (1) changes in water levels or storage, (2) changes in water quality with time, (3) factors such as climatic and land-use conditions that affect the aquifer, and (4) results of an analysis of the relations between causative factors and changes in the aquifer.

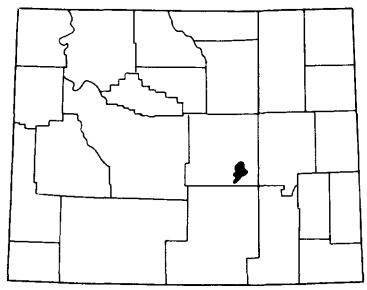
APPROACH: This project is part of a coordinated effort to describe water-level trends in the High Plains aquifer in parts of Kansas, Nebraska, New Mexico, South Dakota, Texas, and Wyoming. Water-level data are collected and new observation wells installed where necessary. Data collected by State agencies are compiled and reviewed; all data are published in annual reports.

STATUS: Water-level data from wells in the High Plains aquifer are being collected and compiled. Data indicative of local water-level conditions are noted and made available to project leaders in the Nebraska District Office, which has responsibility for preparing the regional report on the High Plains aquifer.

PUBLICATIONS (See listings at back of this report):

Article in U.S. Geological Survey Water-Resources Investigations Report 91-4165 (p. 50-52). *Widespread water-level declines occur during 1989-90 in the High Plains Aquifer in Wyoming,* by K.A. Miller. 1992.

Detailed study and assessment of irrigation drainage in the Kendrick Reclamation Project area, Wyoming (WY111)



FUNDING AGENCY: U.S. Bureau of Reclamation

PROJECT LEADER: Randolph B. See

FIELD LOCATION: Central Wyoming

PERIOD OF PROJECT: October 1987 through September 1994

PROBLEM: Soil, representative plants, water, bottom sediment and biota samples collected on or near the Kendrick Reclamation Project have elevated concentrations of selenium. Surface and ground-water transport of selenium, influenced by irrigation practices, are resulting in adverse impacts to migratory birds.

OBJECTIVES: The objectives of Phase IV of the National Irrigation Water Quality Program at the Kendrick Reclamation Project are to: (1) protect and restore or replace migratory bird habitat identified as adversely affected by irrigation drainage-induced selenium impacts; (2) identify and minimize potential public health risks associated with irrigation drainage; (3) address existing and future uses of water in the development of remedial alternatives; and (4) address social and economic implications in the development of remedial alternatives.

STATUS: All field work and reports for previous phases of the program have been completed. U.S. Geological Survey personnel serve as members of an interagency task group to develop remedial planning alternatives and continue to assist the Bureau of Reclamation in developing options for remediation. A surface-water monitoring program is in operation, to extend the data record for selenium concentrations in water.

PUBLICATIONS (See listings at back of this report):

U.S. Geological Survey Water-Resources Investigations Report 91-4131. *Detailed study of selenium in soil, representative plants, bottom sediment, and biota in the Kendrick Reclamation Project area, Wyoming, 1988-90,* by R.B. See, D.L. Naftz,

D.A. Peterson, J.G. Crock, J.A. Erdman, and R.C. Severson—U.S. Geological Survey, and Pedro Ramirez, Jr. and J.A. Armstrong—U.S. Fish and Wildlife Service. 1992.

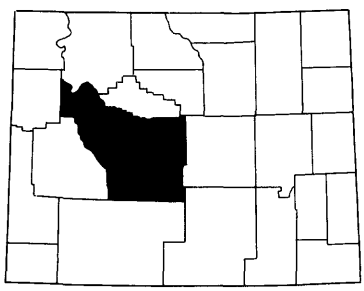
U.S. Geological Survey Open-File Report 91-533. *Physical, chemical, and biological data for detailed study of irrigation drainage in the Kendrick Reclamation Project area, Wyoming, 1988-90,* by R.B. See, Pedro Ramirez, Jr., and D.A. Peterson. 1992.

Published scientific journal articles:

See and others (1992).

Naftz and others (1993).

Water resources of Fremont County, Wyoming (WY124)



FUNDING AGENCIES: Wyoming State Engineer and USGS

PROJECT LEADER: Maria Plafcan

FIELD LOCATION: Central Wyoming

PERIOD OF PROJECT: March 1990 through September 1993

PROBLEM: Ground water of poor chemical quality has long been a problem for residents in Fremont County. Demand for water suitable for domestic and municipal supply has increased as previous supplies have become unsatisfactory because of yield or water quality. Water quality and the potential yield of aquifers currently not used need to be investigated to aid county planners.

OBJECTIVES: (1) To describe the geohydrologic conditions in the county; (2) to determine the general occurrence and chemical quality of ground water; and (3) to describe the availability of ground water and areas of potential contamination.

APPROACH: Representative wells and springs will be inventoried and specific conductance of ground water and base flow will be measured. Samples of ground water will be collected and analyzed for dissolved constituents. Some ground-water samples will be analyzed to determine if specific contaminants are in the water. Low-flow gains and losses along selected reaches of the Wind River and tributaries will be measured at specific geologic formations to estimate recharge and discharge. Observation wells will be suggested for potential long-term monitoring.

STATUS: Field work was completed during 1992. Water-quality samples were collected from wells and springs. All samples were analyzed for major ions. The project report is nearly completed.

Preparation of U.S. Department of the Interior environmental impact statement on operation of Glen Canyon Dam, Arizona (WY125)

FUNDING AGENCY: U.S. Bureau of Reclamation

PROJECT LEADER: James F. Wilson, Jr.

FIELD LOCATION: Administrative

PERIOD OF PROJECT: February 1991 through June 1994

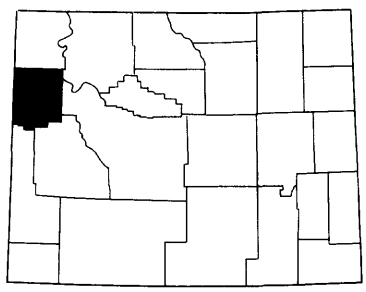
PROBLEM: The Secretary of the Interior has directed that an Environmental Impact Statement (EIS) be prepared on the effects of operation of Glen Canyon Dam on the aquatic and riparian resources of the Colorado River downstream in Glen Canyon and Grand Canyon National Park. Sediment transported and deposited in the river is the foundation for biological and recreational resources. The dam traps about 80 percent of the annual sediment load that formerly entered the canyon; there is concern about the long-term net loss of sediment. Patterns of water releases from the dam for power generation exacerbate the problem. The USGS is doing hydrologic and hydraulic research in Grand Canyon, in part to provide information for the EIS. (Note—The Colorado River basin above Glen Canyon Dam includes the Green River basin of Wyoming.)

OBJECTIVE: To serve as the USGS representative on the interagency EIS Team, led by the U.S. Bureau of Reclamation, including preparation of sections of the EIS having to do with river hydraulics and sediment transport and deposition.

APPROACH: Principal activities will include: (1) familiarization with past and ongoing sediment-related research in Grand Canyon and adjacent areas; (2) liaison between the EIS team and the scientists of the Water Resources Division National Research Program and Arizona District, and Geologic Division; (3) participation in all EIS team functions, including public meetings; (4) preparation of the fluvial-sediment sections of the draft and final EIS.

STATUS: Hydrographs for the six Colorado River gaging stations in Grand Canyon were analyzed to evaluate downstream changes in minimum stage and discharge of the translatory waves released daily from the dam. The results were used in comparing potential heights and widths of sandbars in wide and narrow reaches of the river, for alternative dam-release patterns. Field work included assisting with the USGS time-of-travel measurements between the dam and Lower Granite Gorge using dye tracers (1991), and participation in a National Park Service cultural-resources river trip to examine erosion of fluvial terraces (1992). The sediment sections of the draft EIS chapters on the affected environment and environmental consequences were completed and were reviewed by scientists of the Glen Canyon Environment Studies and by representatives of the EIS Cooperating Agencies. The draft EIS is scheduled for release for public comment in the fall of 1993.

Water resources of Teton County, Wyoming (WY126)



FUNDING AGENCIES: Wyoming State Engineer and USGS

PROJECT LEADER: Bernard T. Nolan

FIELD LOCATION: Northwestern Wyoming

PERIOD OF PROJECT: March 1991 through September 1994

PROBLEM: Collection and interpretation of ground- and surface-water data are necessary to characterize the water resources of Teton County. Land-use planners lack detailed information about the water resources of the county. Increased development in the Snake River basin has increased the potential for changes in water quantity and quality. Lack of understanding of land-use effects on water resources could result in unnecessary depletion or degradation of water both in developed and in pristine areas.

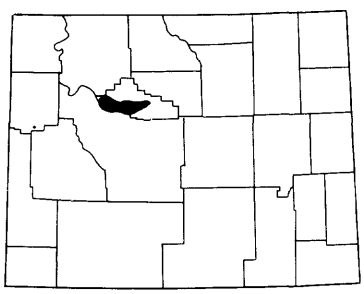
OBJECTIVES: (1) To determine the current condition of water resources in the county; (2) to identify land uses capable of affecting water quantity and quality in developed areas; (3) to evaluate the availability of ground and surface water and the spatial distribution of water-quality constituents; and (4) to determine future ground- and surface-water monitoring requirements.

APPROACH: (1) Determine prior conditions by reviewing information in USGS data bases (year 1 of study); (2) identify major land uses and potential effects on water quantity and quality (year 1); (3) characterize current conditions by conducting a representative, county-wide survey (years 1-3); and

(4) determine the statistical distribution of the data with histograms and fractile analysis (years 2-3).

STATUS: During 1992, the inventory of wells and springs was completed; 81 ground-water sites were identified. Ground-water samples were analyzed for major ions, nutrients, and trace elements. The ground-water-sampling phase of the study has been completed. The large number of inventoried sites will ensure that assessments of ground-water quality and quantity are statistically sound. The surface-water component of the study will be addressed in fiscal year 1993. Streamflows in major streams and tributaries will be measured to determine gains (or losses) attributable to ground-water discharge to the Snake River (or leakage to ground water). The information will be used to determine hydraulic characteristics of the aquifer and to estimate the magnitude of ground-water recharge to the alluvial aquifer. The project report is on schedule.

Evaluation of changes in and potential causes of differences in chemical quality of streamflow, Owl Creek basin, Wyoming (WY127)



FUNDING AGENCIES: Shoshone Tribe, Northern Arapahoe Tribe, and USGS

PROJECT LEADER: Kathy Muller Ogle

FIELD LOCATION: North-central Wyoming

PERIOD OF PROJECT: April 1991 through September 1994

PROBLEM: A recent investigation, "Quality of surface water and ground water in the Owl Creek basin, Wind River Indian Reservation, Wyoming" (WY114), concluded that the quality of the major streams in the basin degraded significantly from the upper end to the lower end (USGS ***Water-Resources Investigations Report 91-4108***, listed below). The watershed reflected three distinct segments, each with a significantly different dissolved-solids concentration, water type, and ratio of dissolved-solids concentration to specific conductance. The chemical quality of streamflow in the middle and lower segments of Owl Creek limits its use. Possible causes of the water-quality changes include irrigation return flows, surficial geology, and ground-water inflow from various aquifers. Reservation managers need detailed information about the extent and magnitude of the mineralized streamflow and how the hydrologic system in Owl Creek basin affects water quality of streamflow.

OBJECTIVES: The general objective is to provide water-resources data that can be used in managing the Wind River Indian Reservation's natural resources. Specific objectives are: (1) To define the reaches where the chemical quality of streamflow in the Owl Creek basin changes, and (2) to determine whether irrigation return flows, surficial geology, or inflow from bedrock aquifers are affecting the chemical quality of streamflow.

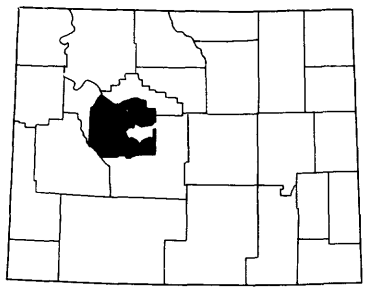
APPROACH: All data on streamflow and chemical quality of surface and ground water in the basin will be compiled and entered into data bases. Streamflow water quality will be sampled during low flow in selected reaches for specific conductance. Previously developed ratios of dissolved-solids concentration to specific conductance, and dissolved-solids concentrations for the three basin segments will be used to identify reaches where changes in streamflow chemical quality occur. A relational analysis will be performed between streamflow chemical quality and the three previously identified factors (irrigation return flows, surficial geology, or inflow from bedrock aquifers). Streamflow (low flow), pH, specific conductance, temperature, and radon will be measured at selected sites. Water-quality samples will be analyzed for major ions, selected trace metals (arsenic, lithium, and bromide), and selected isotopes (tritium, sulfur, oxygen, and deuterium).

STATUS: Data collection was complete during 1992. Analysis of the data is continuing, and the project report has been started.

RELATED PUBLICATION (See listings at back of this report):

U.S. Geological Survey Water-Resources Investigations Report 91-4108. *Surface- and ground-water quality in the Owl Creek basin, north-central Wyoming*, by K.M. Ogle. 1992.

Estimates of monthly streamflow characteristics for ungaged sites, Wind River Indian Reservation, Wyoming (WY128)



FUNDING AGENCIES: Shoshone Tribe, Northern Arapahoe Tribe, and USGS

PROJECT LEADER: James G. Rankl

FIELD LOCATION: Central Wyoming

PERIOD OF PROJECT: October 1990 through September 1994

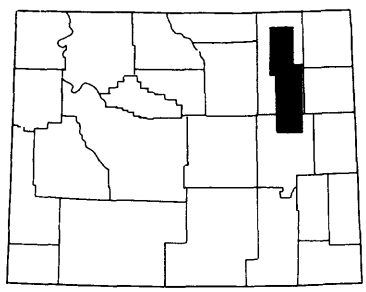
PROBLEM: Following a 12-year legal action, the U.S. Supreme Court in 1989 awarded 500,000 acre-feet per year of surface water on the Wind River and its tributaries to the Arapahoe and Shoshone Indian Tribes. Planning and management of these waters make accurate data important. However, only a few of the stream sites where data are needed have streamflow-gaging stations. Management of surface-water allocations requires knowledge about: (1) The quantity of runoff that originates on the Reservation, and (2) the magnitudes of monthly and mean-annual flows in streams entering and leaving the Reservation.

OBJECTIVES: A refined technique for estimating mean monthly and annual streamflows will be developed, and streamflows at selected sites will be estimated, to assist the Wind River Environmental Quality Council in the development of a streamflow-management model.

APPROACH: About 20 ungaged sites will be selected for estimation of mean monthly and annual discharge, with about 10 gaged sites used for control. Monthly measurements will be made for 1 year. Three methods will be investigated: (1) monthly mean discharge will be related to instantaneous discharge at nearby gaged sites, using regression; (2) a set of mean monthly discharge estimates will be made from regression equations relating mean monthly discharge to physical and climatic variables; and (3) a set of mean monthly discharge estimates will be made from regression equations using channel width. The final estimate will be a weighted average of results for methods that are statistically significant.

STATUS: During 1991 and 1992, monthly streamflow measurements were made for October through November and March through May. Basin characteristics have been digitized, computed, and checked, for all stations to be considered for the regression analyses. Channel-geometry measurements have been made on 24 streams. All of the monthly streamflow data, both recorded and estimated, have been entered into a statistics program. The regression models for estimating monthly streamflow characteristics using basin characteristics and using channel geometry have been completed. The project report is nearly complete.

The role of natural organic solutes on the mobility of selenium in abandoned coal mine spoil-ground-water systems (WY132)



FUNDING AGENCY: Wyoming Water Resources Center, and USGS

PROJECT LEADER: Randolph B. See

FIELD LOCATION: Northeastern Wyoming

PERIOD OF PROJECT: October 1991 through September 1994

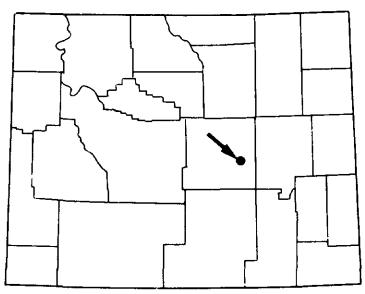
PROBLEM: Natural organic solutes may increase the mobility of selenium (Se) in high-carbon environments. Coal deposits, wetlands, and certain irrigated soils contain significant levels of organics. Coal mines provide a unique opportunity to investigate the effect of organic solutes on the adsorption of several oxidized forms of selenium.

OBJECTIVES: (1) Perform a detailed characterization of carbon material and associated ground water, using mineralogical and chemical analyses; (2) identify solid phases and associated Se species that precipitate in water in contact with carbon material, and to determine the kinetics of process reactions; (3) determine the extent to which organics and Se species competitively adsorb onto carbon material and a pure mineral; and (4) evaluate the effect of redox potential on the oxidation state of Se species in ground water affected by carbon material.

APPROACH: Sites will be selected from sites where ground waters contain dissolved-selenium concentrations greater than 100 micrograms per liter. Chemical and mineralogical analyses will be completed on spoil core and ground-water samples. Laboratory experiments will characterize adsorption/desorption and precipitation/dissolution reactions. Dissolved organic carbon fractionation analysis will be used to characterize hydrophobic and hydrophilic solutes in water samples.

STATUS: Geochemical characterization of spoil samples and dissolved organic carbon fractionation of water samples will be completed during 1993. Adsorption/desorption and precipitation/dissolution experiments will be conducted in redox-controlled chambers to evaluate geochemical processes controlling solubility of selenium. The project report will be completed in 1994.

Characterization of water quality, water quantity, and sediment in Goose Egg Spring, Natrona County, Wyoming (WY133)



FUNDING AGENCY: Wyoming Game and Fish Department and USGS

PROJECT LEADER: George F. Ritz

FIELD LOCATION: Central Wyoming

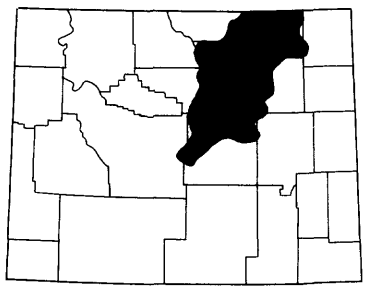
PERIOD OF PROJECT: May 1992 through September 1992 (completed)

PROBLEM: Recent blasting from a limestone quarry may have increased sediment deposition within Goose Egg Spring. The spring is the source of water for the Speas Fish Hatchery. Increased sedimentation could damage pumping equipment while changes in water quality could impair fish production.

OBJECTIVES: To determine discharge, chemical and radiological quality of spring water, and sediment deposition.

STATUS: A surface-water gage was installed on the lower pool of Goose Egg Spring. Because of the unstable stage-discharge relation at this gage, a second gage was installed in the upper pool in June 1992. Water samples collected in May and July 1992 were analyzed for common ions, nutrients, and trace metals. A tritium sample was collected in July 1992. Sample cores from the bed of the upper pool were collected from eight locations, and soil scrapings were obtained from locations around the upper pool of Goose Egg Spring. Mineralogical descriptions, particle-size analysis and x-ray diffraction analysis have been performed on selected core and soil samples. Stratigraphy of core samples has been determined. Data collection and analysis are complete, and the project report is in technical review.

Methodology for the geomorphic classification and design of drainage basins and stream channels in the Powder River coal fields of Wyoming (WY134)



FUNDING AGENCY: Wyoming Water Resources Center and USGS

PROJECT LEADER: Richard L. Daddow

FIELD LOCATION: Northeastern Wyoming

PERIOD OF PROJECT: July 1992 through September 1994

PROBLEM: Historic surface and underground mining activities in Wyoming often have caused changes to the natural landscape. In some cases, these activities have resulted in detrimental impacts, such as accelerated erosion and increased sediment yields, on the drainage basins and stream channels. Most active surface coal mines in Wyoming are located in the Powder River structural basin, where it is projected that as much as 253 square miles of land surface could be disturbed by mining. The reconstruction of drainage basins and stream channels is critical to their long-term hydrologic function and stability; however, the science of drainage-basin and stream-channel design currently is in a developmental stage.

OBJECTIVES: The study will address elements of research topics concerning land-form reconstruction, and erosion and sedimentation control. Specific objectives are to: (1) Summarize procedures being used for reconstruction and reclamation of drainage basins and stream channels in the Powder River coal field in Wyoming, especially the type and extent that the geomorphic approach is used for reconstruction;
(2) develop a classification system for drainage basins and stream channels in the Powder River coal fields in Wyoming based on the physical characteristics of selected groups of small drainage basins; and
(3) determine the geomorphic characteristics of different classes or types of drainage basins and stream channels, thereby developing geomorphic methodology and criteria for the reconstruction of drainage basins and stream channels.

APPROACH: A literature search and review will be made of existing methods and previous studies involving reconstruction and reclamation of drainage basins and stream channels. The geomorphic approach will be emphasized. Selected small drainage basins will be delineated on 7.5-minute topographic maps or from aerial photos, natural drainage basin characteristics will be measured for each delineated basin, and cluster analysis will be used to identify groups of drainage basins with similar characteristics. Geomorphic characteristics of natural drainage basins and stream channels will be analyzed and summarized for each class of drainage basins. Based on this analysis, graphs and other relations will be developed to provide the basic methodology for the reconstruction of drainage basins and stream channels.

STATUS: During 1992, selected coal mines in the Powder River Basin were visited to interview environmental specialists about drainage-basin and channel reclamation. Additional information will be collected during 1993. Selected Federal and State regulatory and management agencies were contacted about drainage-basin and channel reclamation. Detailed search and inventory of resource data in existing mine-permit applications have been compiled. The study area was narrowed to the eastern Powder River basin. The project report will be completed in 1994.

Synthesis and interpretation of data from National Irrigation Water Quality Program investigations of areas receiving irrigation drainage (WY135)

FUNDING AGENCY: Office of the Secretary of the Interior

PROJECT LEADER: Ralph L. Seiler

FIELD LOCATION: Administrative

PERIOD OF PROJECT: October 1992 through September 1994

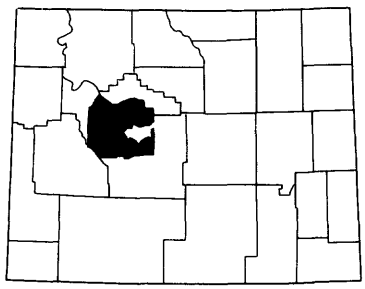
PROBLEM: Selenium is an essential nutrient for animals; however, excessive concentrations can be toxic to plants and animals. Irrigation can accelerate the natural leaching of selenium and other elements in the soil. Evaporation of irrigation drainage in closed basins can concentrate trace elements and other agricultural pollutants, producing levels toxic to aquatic biota. Under the National Irrigation Water Quality Program (NIWQP), twenty-five reconnaissance and seven detailed investigations were conducted in the western United States at sites receiving irrigation drainage. Most data have yet to be interpreted. Data synthesis and interpretation are required to determine the relative importance of human and environmental factors affecting selenium transport and accumulation in irrigated areas.

OBJECTIVES: The overall objective is to determine the degree to which irrigation accelerates the natural leaching of potentially toxic constituents in seleniferous soils. Specific objectives are (1) to synthesize all data from the reconnaissance and detailed investigations in a usable format; (2) to make site-to-site comparisons of chemical constituents in soil, bottom sediment, surface water, ground water, plants, and aquatic biota; (3) to determine the relative importance of human and environmental factors controlling selenium transport and accumulation; and (4) to identify predictable patterns of contamination.

APPROACH: The technical approach involves (1) compilation of a relational database; (2) calculation of summary statistics for constituents common to all sites; (3) use of geochemical and statistical computer programs to determine the significance of climatic, geochemical, hydrologic, and human factors; and (4) use of geographic information systems (GIS) to identify areas and patterns of selenium accumulation and to explore linkages among factors.

STATUS: Data from 25 reconnaissance and 7 detailed investigations Nationwide are being compiled in a relational database. Chemical constituents common to all study sites are being analyzed for statistical properties to assess the potential need for data transformation. Summary statistics will be calculated to allow site-to-site comparison of chemicals in soil, bottom sediment, surface and ground water, and aquatic biota. Several reports of results are planned.

Reconnaissance investigation of selenium and other constituents in water, bottom sediments, and biota affected by irrigation drainage on the Wind River Indian Reservation, Wyoming (WY136)



FUNDING AGENCIES: Shoshone Tribe, Northern Arapahoe Tribe, and USGS

PROJECT LEADER: Dennis N. Grasso

FIELD LOCATION: Central Wyoming

PERIOD OF PROJECT: October 1992 through September 1994

PROBLEM: Increasing concern about the quality of irrigation drainage and its potential effects on human health, fish, and wildlife has led to increased study of irrigation drainage throughout the western United States. Selenium—one constituent of concern in irrigation drainages—affects the reproductive success of fish and waterfowl in wetlands through the process of bio-accumulation. The Geological Survey of Wyoming has classified soils covering about two-thirds of the Wind River Indian Reservation (WRIR) as potentially seleniferous. The underlying geologic formations (predominantly the Wind River Formation and Cody Shale) and the soils that form on those formations support vegetation that may concentrate selenium to levels potentially toxic to grazing animals. Currently, two federally listed endangered species: bald eagles and peregrine falcons—as well as herons and other migratory birds—use the wetlands of the WRIR. A reconnaissance-level study of the adjacent Riverton Reclamation Project, conducted as part of the National Irrigation Water Quality Program (NIWQP), has shown that selenium concentrations in the irrigation drainage may be cause for concern (USGS ***Water-Resources Investigations Report 90-4187***, listed below).

OBJECTIVES: The objective of this preliminary investigation is to determine whether irrigation drainage has the potential to cause harmful effects on human health, fish, wildlife, or other water users in the WRIR. Additional research on irrigation drainage in the WRIR may be funded under the NIWQP if the results of this investigation indicate hazards related to irrigation drainage.

APPROACH: The U.S. Geological Survey (USGS) will sample and analyze the water and bottom sediments, and the U.S. Fish and Wildlife Service (USFWS) will sample and analyze the biota. Methodology for the study will follow the protocols established for Phase II (Reconnaissance) studies of the NIWQP. Sampling sites for water and bottom sediment have been selected at four discrete sub-areas of the Wind River Federal Irrigation Project. The Little Wind-Ray Lake and Coolidge Canal area, the Upper Wind Unit-Crowheart area, the Johnstown Unit, and the Left Hand Unit will be sampled at selected upstream (inflow) sites and at selected ponds, wetlands, drains, and canals that may receive irrigation drainage. Water and bottom sediment samples will be collected during April or May to determine if there is a "first-flush" leaching of accumulated salts in the soil zone, as reported for the Kendrick Reclamation Project area in Natrona County (USGS Water-Resources Investigations Report 91-4131, listed below). Water samples will be analyzed for temperature, pH and specific conductance in the field and for major ions, trace elements, and pesticides in the lab. Aquatic habitats recommended as collection sites include: Goose Pond, Mill Creek Basin, and the Little Wind River. Goose Pond and Mill Creek Basin are closed basins.

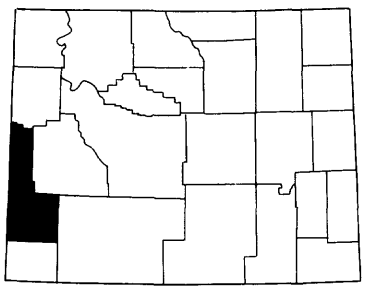
STATUS: Surface water and bottom sediment will be sampled by the USGS during April and May 1993. Results will be published in the Wyoming Water-Data Report for water year 1993. Biota will be sampled by the USFWS during May and June 1993.

RELATED PUBLICATIONS (See listings at back of this report):

U.S. Geological Survey Water-Resources Investigations Report 90-4187. *Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Riverton Reclamation Project, Wyoming, 1988-89,* by D.A. Peterson, T.F. Harms, Pedro Ramirez, Jr., G.A. Allen, and A.H. Christenson. 1991.

U.S. Geological Survey Water-Resources Investigations Report 91-4131. *Detailed study of selenium in soil, representative plants, bottom sediment, and biota in the Kendrick Reclamation Project area, Wyoming, 1988-90,* by R.B. See, D.L. Naftz, D.A. Peterson, J.G. Crock, J.A. Erdman, and R.C. Severson—U.S. Geological Survey, and Pedro Ramirez, Jr. and J.A. Armstrong—U.S. Fish and Wildlife Service. 1992.

Water resources of Lincoln County, Wyoming (WY137)



FUNDING AGENCY: Wyoming State Engineer and USGS

PROJECT LEADER: Cheryl A. Eddy-Miller

FIELD LOCATION: Western Wyoming

PERIOD OF PROJECT: July 1993 through September 1996

PROBLEM: Ground water of variable chemical quality has long been a problem of residents in the county. Demand for water suitable for domestic and municipal supply has increased as previous supplies have become unsatisfactory because of yield or water quality. Water quality and the potential yield of aquifers currently not used need to be investigated to aid county planners.

OBJECTIVES: To describe the geohydrologic conditions in the county; to determine the general occurrence and chemical quality of ground water, and to describe areas of potential contamination and the availability of ground water.

APPROACH: Representative wells and springs will be inventoried and specific conductance of ground water and base flow will be measured. Samples of ground water will be collected and analyzed for dissolved constituents. Some ground-water samples will be analyzed to determine if specific contaminants are in the water. Low-flow gains and losses along selected reaches of the Wind-Big Horn River and tributaries will be measured at specific geologic formations to estimate recharge and discharge. Observation wells will be established and monitored for water-level changes.

STATUS: Field work is scheduled to begin during the summer of 1993.

PROJECTS COMPLETED EXCEPT FOR REPORT(S)

The following projects have been completed except for approval of the final report(s). Funding for these projects ended prior to October 1, 1992.

Project number	Project title	Status
WY081	Water resources of Park County	Project report completed. Technical review completed. Report submitted for Director's approval to publish.
WY115	Hydrologic appraisal of the Wind River Indian Reservation	Project report completed. Technical review started. Data report published.

PROJECTS COMPLETED SINCE MAY 1991

Project number	Project title	Project report(s)[1]
WY070	Upper Colorado River Basin Regional Aquifer-System Analysis—Wyoming	PP 1411-B WRIR 92-4164
WY076	Fluvial system in energy-mineral area of Wyoming	WRIR 91-4153
WY091	Geohydrology of the High Plains aquifer, Cheyenne, Wyoming	WRIR 92-4047
WY103	Water resources of Big Horn County, Wyoming	WRIR 93-4021
WY105	Streamflow and channel characteristics of the Bear River at Evanston, Wyoming	WRIR 93-4032
WY114	Quality of surface water and ground water in the Owl Creek basin, Wind River Indian Reservation, Wyoming	WRIR 91-4108
WY116	Water quality of the Powder River, Wyoming and Montana	WRIR 91-4199
WY118	Effects of in-situ oil-shale retorting on water quality near Rock Springs, Wyoming	Administrative Report[2]
WY119	Water resources of Hot Springs County, Wyoming	WRIR 93-4141
WY120	Determination of long-term atmospheric deposition quality and climatic changes in the Western United States using continuous ice cores, Wind River Range, Wyoming	Journal articles: Naftz and others (1991); Naftz and Smith (in press); Naftz and others (in press)
WY121	Quantification of seepage and sedimentation in selected irrigation canals on the Wind River Indian Reservation, Wyoming	OFR 93-142
WY122	Hydrologic characteristics in fractured-rock aquifer, Rock Springs, Wyoming	Article in WRIR 91-4034
WY129	Summary and evaluation of well and geologic data for pre-Tertiary aquifers on the Wind River Indian Reservation, Wyoming	Journal article: Lindner-Lunsford and Bruce (in press)
WY133	Characterization of water quality, water quantity, and sediment in Goose Egg Spring, Natrona County, Wyoming	Report in technical review

[1]See listings that follow for U.S. Geological Survey Professional Papers (PP), Water-Resources Investigations Reports (WRIR) and Open-File Reports (OFR). Journal articles are listed under "Scientific Journals."

[2]Administrative Reports are not available to the public through the U.S. Geological Survey. This report belongs to the U.S. Department of Energy.

WATER-RESOURCES INFORMATION

A monthly summary of the national water situation is presented in a newsletter, "National Water Conditions," available free upon request to the Hydrologic Information Unit, U.S. Geological Survey, 419 National Center, Reston, VA 22092. Requests for miscellaneous water information and information about programs in other states may be referred to Water Resources Division, U.S. Geological Survey, 440 National Center, Reston, VA 22092. Streamflow, groundwater, and water-quality data are available in several series of publications.

Hydrologic Data Prior to 1971

Records of streamflow, ground-water levels, and quality of water were published for many years as Geological Survey Water-Supply Papers, as explained below. The Water-Supply Papers are not listed in this report; information about them can be obtained from the Cheyenne office of the Geological Survey.

Records of daily flows of streams prior to 1971 were published in the Water-Supply Paper series, ***Surface-Water Supply of the United States,*** which was released in numbered parts as determined by natural drainage basins. Data for Wyoming are published in Parts 6, 9, 10, and 13. Until 1961, this was an annual series; monthly and yearly summaries of these data were compiled in two reports: ***Compilation of Records of Surface Waters of the United States through September 1950,*** and ***Compilation of Records of Surface Waters of the United States, October 1950 to September 1960.*** A 5-year compilation was published for the period, 1965-70.

Ground-water levels and artesian pressures in observation wells prior to 1975 were reported by geographic areas in a 5-year Water-Supply Paper series. Data for Wyoming are in ***Ground-Water Levels in the United States, Northwestern States.***

Surface-water-quality data prior to 1971 were published annually in the Water-Supply Paper series ***Quality of Surface Waters of the United States,*** which also was released in numbered parts as determined by natural drainage basins. Data for Wyoming are in Parts 6, 9, 10, and 13.

Hydrologic Data After 1970

Beginning with the 1971 water year, the Water-Supply Paper series described above was replaced by a new publication series, ***U.S. Geological Survey Water-Data Reports.*** For Water Years 1971-74 surface-water

records and water-quality records were published in separate volumes. Beginning with 1975 this series combines under one cover: streamflow data, water-quality data for surface and ground water, and ground-water-level data for each State. For Wyoming, the title is ***Water Resources Data - Wyoming—Water Year (date).*** Since 1975 the reports are numbered: ***U.S. Geological Survey Water-Data Report WY-(year)-1 or 2***; reports for 1971-74 are unnumbered. These reports are listed in the next section of this report.

Flood Information

Methods for estimating the magnitude and frequency of floods for streams in Wyoming are given in ***Water-Resources Investigations Report 88-4045***; methods for estimating flood volumes and hydrographs on small plains streams are described in ***Water-Supply Paper 2056*** (see listings that follow). The U.S. Geological Survey also has outlined flood-prone areas on topographic maps as part of a nationwide Federal program for managing flood losses. In Wyoming, 225 flood-prone area maps have been completed. These maps, available at no charge from the District Office in Cheyenne, show areas estimated to be inundated by a 100-year flood. Official flood-insurance maps are available from the Federal Emergency Management Agency (toll-free phone number 1-800-638-6620).

SELECTED PUBLICATIONS

General Information

The U.S. Geological Survey announces all its publications in a monthly report, "New Publications of the Geological Survey." Subscription to this monthly listing is available free upon request to the Mailing List Unit, U.S. Geological Survey, 582 National Center, Reston, VA 22092. All publications are for sale unless specifically stated otherwise; prepayment is required. Checks or money orders should be payable to: "Department of the Interior—USGS." Prices, which are subject to change, are not included here. Information on price and availability should be obtained from listed sales offices before placing an order.

Additional information about Geological Survey products and sources where they may be obtained is given in ***A Guide to Obtaining USGS Information, U.S. Geological Survey Circular 900,*** available without cost from Branch of Distribution, U.S. Geological Survey, Federal Center, Box 25286, Denver, CO 80225.

The Geological Survey National Center maintains a library with an extensive earth-sciences collection. Local libraries may obtain books, periodicals, and maps through interlibrary loan by writing to U.S. Geological Survey Library, 950 National Center, Reston, VA 22092, telephone (703) 860-6671.

Publications pertaining to water resources in Wyoming are listed below. The list includes all reports published during the last 15 years and selected older reports. Most of these reports are available for inspection at the Geological Survey offices in Cheyenne, Casper, and Riverton and also at large public and university libraries. The sources for obtaining copies of the reports are given for each report series. Because many of the older reports are out of print, loan copies are available from the District Office in Cheyenne.

Bulletins (*B*) and Professional Papers (*P*)

Bulletins and Professional Papers are sold by U.S. Geological Survey, Branch of Distribution, Box 25286, Federal Center, Denver, CO 80225.

B 1959. Chloride flux and surface water discharge out of Yellowstone National Park, 1982-1989, by D.R. Norton and Irving Friedman. 1991.

P 501-D. Variation of permeability in the Tensleep Sandstone in the Bighorn basin, Wyoming, as interpreted from core analyses and geophysical logs, by J.D. Bredehoeft, *in* Geological Survey Research 1964, Chap. D, by U.S. Geological Survey, p. D166-D170. 1964.

P 550-D. The White River Formation as an aquifer in southeastern Wyoming and adjacent parts of Nebraska and Colorado, by M.E. Lowry, in Geological Survey Research 1966, Chap. D, by U.S. Geological Survey, p. D217-D222. 1966.

P 622-A. The hydraulics of overland flow on hillslopes, by W.W. Emmett. 1970.

P 700-D. Synthesizing hydrographs for small semiarid drainage basins, by G.S. Craig, Jr., *in* Geological Survey Research 1970, Chap. D, by U.S. Geological Survey, p. D238-D243. 1970.

P 1117. Scour and fill in a stream channel, East Fork River, western Wyoming, by E.D. Andrews. 1979.

P 1130. Hydrologic and human aspects of the 1976-77 drought, by H.F. Matthai. 1979.

P 1139. A field calibration of the sediment-trapping characteristics of the Helley-Smith bedload sampler, by W.W. Emmett. 1980

P 1164. Effects of coal mine subsidence in the Sheridan, Wyoming area, by C.R. Dunrud and F.W. Osterwald. 1980.

P 1242. Perennial-streamflow characteristics related to channel geometry and sediment in the Missouri River basin, by W.R. Osterkamp and E.R. Hedman. 1982.

P 1244. Floods of May 1978 in southeastern Montana and northeastern Wyoming, by Charles Parrett, D.D

P 1273-A. Stratigraphy and sedimentary facies of the Madison Limestone and associated rocks in parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming, by J.A. Peterson. 1984.

P 1273-B. Correlation of Paleostructure and sediment deposition in the Madison Limestone and associated rocks in parts of Montana, North Dakota, South Dakota, Wyoming, and Nebraska, by D.L. Brown, R.K. Blankennagel, L.M. MacCary, and J.A. Peterson. 1984.

P 1273-C. Relationship of porosity and permeability to petrology of the Madison Limestone in rock cores from three test wells in Montana and Wyoming, by P.A. Thayer. 1983.

P 1273-D. Apparent water resistivity, porosity, and water temperature of the Madison Limestone and underlying rocks in parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming, by L.M. MacCary. 1984.

P 1273-E. Potentially favorable areas for large-yield wells in the Red River Formation and Madison Limestone in parts of Montana, North Dakota, South Dakota, and Wyoming, by L.M. MacCary, E.M. Cushing, and D.L. Brown. 1983.

P 1273-F. Geochemical evolution of water in the Madison aquifer in parts of Montana, South Dakota, and Wyoming, by J.F. Busby, L.N. Plummer, R.W. Lee, and B.B. Hanshaw. 1991.

P 1273-G. Geohydrology of the Madison and associated aquifers in parts of Montana, North Dakota, South Dakota, and Wyoming, by J.S. Downey. 1984.

P 1277-A. Hydrologic and morphologic changes in channels of the Platte River basin in Colorado, Wyoming, and Nebraska; a historical perspective, by H.R. Eschner, R.F. Hadley, and K.D. Crowley. 1983.

P 1277-B. Effects of water development on surface-water hydrology, Platte River basin in Colorado, Wyoming, and Nebraska upstream from Duncan, Nebraska, by J.E. Kircher, and M.R. Karlinger. 1983.

P 1330. A seismic-stratigraphic investigation of the Madison and associated aquifers; application to groundwater exploration, Powder River basin, Montana-Wyoming, edited by A.H. Balch. 1988.

P 1338. Effects of organic wastes on water quality from the processing of oil shale from the Green River Formation, Colorado, Utah, and Wyoming, by J.A. Leenheer and T.I. Noyes. 1986.

P 1400-A. Summary of the High Plains Regional Aquifer-System Analysis in parts of Colorado, Kansas, Nebraska, New Mexico, South Dakota, Texas, Oklahoma, and Wyoming, by J.B. Weeks, E.D. Gutentag, F.J. Heimes, and R.R. Luckey. 1988.

P 1400-B. Geohydrology of the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, by E.D. Gutentag, F.J. Heimes, N.C. Krothe, R.R. Luckey, and J.B. Weeks. 1984.

P 1400-C. Mapping irrigated cropland from Landsat for determination of water-use from the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, by G.P. Thelin and F.J. Heimes. 1987.

P 1400-D. Digital simulation of ground-water flow in the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, by R.R. Luckey, E.D. Gutentag, F.J. Heimes, and J.B. Weeks. 1986.

P 1400-E. Effects of future ground-water pumpage on the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, by R.R. Luckey, E.D. Gutentag, F.J. Heimes, and J.B. Weeks. 1988.

P 1402-A. The regional aquifer system underlying the Northern Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming--summary, by J.S. Downey and G.A. Dinwiddie. 1988.

P 1402-B. Geologic framework of the ground-water system in Jurassic and Cretaceous rocks in the Northern Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming, by L.O. Anna. 1986.

P 1402-C. Geochemistry of ground water in two sandstone aquifer systems in the Northern Great Plains in parts of Montana and Wyoming, by Thomas Henderson. 1985.

P 1402-D. Freshwater heads and ground-water temperatures in aquifers of the Northern Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming, by D.H. Lobmeyer. 1985.

P 1402-E. Geohydrology of bedrock aquifers in the Northern Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming, by J.S. Downey. 1986.

P 1411-B. Geohydrology of Tertiary rocks in the Upper Colorado River basin in Colorado, Utah, and Wyoming, excluding the San Juan basin, by K.C. Glover, D.L. Naftz, and L.J. Martin. *In press.*

P 1411-C. Geohydrology of Mesozoic rocks in the Upper Colorado River basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, excluding the San Juan basin, by G.W. Freethey and G.E. Cordy. 1991.

P 1464. Summary of the U.S. Geological Survey and U.S. Bureau of Land Management national coal-hydrology program, 1974-84, edited by L.J. Britton, C.L. Anderson, D.A. Goolsby, and B.P. Van Haveren. 1989.

Journal of Research of the Geological Survey

The Journal of Research Series has been discontinued. Separate prints of the articles listed below are available from the District Chief, Cheyenne, Wyoming.

Iron in water near wastewater lagoons in Yellowstone National Park, Wyoming, by E.R. Cox, vol. 6, no. 3, p. 319-324. 1978.

Hydrologic characteristics of the Madison Limestone, the Minnelusa Formation, and equivalent rocks as determined by well-logging formation evaluation, Wyoming, Montana, South Dakota, and North Dakota, by W.J. Head and R.H. Merkel, vol. 5, no. 4, p. 473-485. 1977.

Water-Supply Papers (*W*)

Water-Supply Papers are sold by U.S. Geological Survey, Branch of Distribution, Box 25286, Federal Center, Denver, CO 80225.

W 1261. A postglacial chronology for some alluvial valleys in Wyoming, by L.B. Leopold and J.P. Miller. 1954.

W 1373. Sedimentation and chemical quality of surface waters in the Wind River basin, Wyoming, by B.R. Colby, C.H. Hembree, and F.H. Rainwater. 1956.

W 1375. Ground-water resources of the Riverton irrigation project area, Wyoming, by D.A. Morris, O.M. Hackett, K.E. Vanlier, and E.A. Moulder, *with a section on* Chemical quality of ground water, by W.H. Durum. 1959.

W 1377. Geology and ground-water resources of Goshen County, Wyoming, by J.R. Rapp, F.N. Visher, and R.T. Littleton, *with a section on* Chemical quality of ground water, by W.H. Durum. 1957.

W 1458. Geology and ground-water resources of the Rawlins area, Carbon County, Wyoming, by D.W. Berry. 1960.

W 1490. Geology and ground-water resources of Platte County, Wyoming, by D.A. Morris and H.M. Babcock, *with a section on* Chemical quality of ground water, by R.H. Langford. 1960.

W 1531. Hydrology of the upper Cheyenne River basin: Part A. Hydrology of stock-water reservoirs in upper Cheyenne River basin, by R.C. Culler; Part B. Sediment sources and drainage-basin characteristics in upper Cheyenne River basin, by R.F. Hadley and S.A. Schumm. 1961.

W 1532-A. Hydrologic effects of water spreading in Box Creek basin, Wyoming, by R.F. Hadley, I.S. McQueen, and others. 1961.

W 1535-E. Chemical degradation on opposite flanks of the Wind River Range, Wyoming, by C.H. Hembree and F.H. Rainwater. 1961.

W 1539-V. Availability of ground water in the Bear River Valley, Wyoming, by C.J. Robinove and D.W. Berry, *with a section on* Chemical quality of ground water, by J.G. Conner. 1963.

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Water-Data Reports

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Water resources data for Wyoming—water year 1971, part 1, surface-water records. 1972. (PB-289 523/AS)

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WY-82-1. Water resources data—Wyoming—water year 1982. 1983. (PB-84 114 669/AS)

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Hydrologic Unit Maps and Hydrologic Investigations Atlases are sold by U.S. Geological Survey, Map Distribution, Federal Center, Building 810, Box 25286, Denver, CO 80225.

Hydrologic unit map of Wyoming—1974, by U.S. Geological Survey. 1976.

HA-219. Ground-water reconnaissance of the Great Divide and Washakie basins and some adjacent areas, southwestern Wyoming, by G.E. Welder and L.J. McGreevy. 1966.

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HA-417. Quality of surface-water in the Bear River basin, Utah, Wyoming, and Idaho, by K.M. Waddell and Don Price. 1972.

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HA-477. Selected hydrologic data in the Upper Colorado River basin, by Don Price and K.M. Waddell. 1974.

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HA-658. Dissolved solids and sodium in water from the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, by N.C. Krothe, J.W. Oliver, and J.B. Weeks. 1982.

HA-687. Hydrogeologic framework of the Upper Colorado River basin--excluding the San Juan basin—Colorado, Utah, Wyoming, and Arizona, by O.J. Taylor, J.W. Hood, and E.A. Zimmerman. 1986.

HA-698. General hydrogeology of the aquifers of Mesozoic age, Upper Colorado River basin; excluding the San Juan Basin; Colorado, Utah, Wyoming, and Arizona, by G.W. Freethey, B.A. Kimball, D.E. Wilberg, and J.W. Hood. 1988.

HA-699. Flood of August 1, 1985, in Cheyenne, Wyoming, by S.A. Druse, M.E. Cooley, S.L. Green, and H.W. Lowham. 1986.

HA-702. Hydrogeology of aquifers of Paleozoic age, Upper Colorado River basin—excluding the San Juan Basin—in Colorado, Utah, Wyoming, and Arizona, by J.B. Lindner-Lunsford, B.A. Kimball, D.T. Chafin, and C.G. Bryant. 1989.

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Miscellaneous Investigations Maps are sold by U.S. Geological Survey, Map Distribution, Federal Center, Building 810, Box 25286, Denver, CO 80225.

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I-847-B. Map showing streamflow volumes in northeastern Wyoming and southeastern Montana, by D.G. Frickel and L.M. Shown. 1974.

I-847-C. Maps showing configuration and thickness, and potentiometric surface and water quality in the Madison Group, Powder River basin, Wyoming and Montana, by F.A. Swenson, W.R. Miller, W.G. Hodson, and F.N. Visher. 1976.

I-848-A. Land use map of the Gillette area, Wyoming, 1970, by L.M. Shown. 1973.

I-848-E. Maps showing occurrence of ground water in the Gillette area, Campbell County, Wyoming, by N.J. King. 1974.

I-848-F. Map showing some potential effects of surface mining of the Wyodak-Anderson coal, Gillette area, Campbell County, Wyoming, by R.F. Hadley and W.R. Keefer. 1975.

I-1159. Maps showing formation temperatures and configurations of the tops of the Minnelusa Formation and the Madison Limestone, Powder River basin, Wyoming, Montana, and adjacent areas, by W.J. Head, K.T. Kilty, and R.K. Knottek. 1979.

I-1308. Generalized fence diagram showing stratigraphy and potentiometric surface of the Tertiary formations in southeastern Wyoming and an adjacent part of Colorado, by M.E. Cooley and M.A. Crist. 1981.

I-1317. Thickness, percent sand, and configuration of shallow hydrogeologic units in the Powder River basin, Montana and Wyoming, by B.D. Lewis and W.R. Hotchkiss. 1981.

I-1687. Divisions of potential fracture permeability based on distribution of structures and linear features in sedimentary rocks, Northern Great Plains--Rocky Mountain region of Montana, North Dakota, South Dakota, Wyoming, and northern Nebraska, by M.E. Cooley. 1986.

Open-File Reports and Maps (*OF*)

Open-file reports, which may be in manuscript form, generally are not reproduced and distributed in quantity. These reports are available for inspection in the Cheyenne, Wyo., and Reston, Va., offices of the U.S. Geological Survey. Most numbered open-file reports may be purchased from U.S. Geological Survey, Open-File Reports—ESIC, Box 25425, Federal Center, Denver, CO 80225. Information on the availability of numbered and unnumbered reports may be obtained from the District Chief, Cheyenne, Wyoming; free copies of some reports, such as periodic compilations of ground-water levels, are available from the Cheyenne office.

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OF 76-22. Data for calibrating unsteady-flow sediment-transport models, East Fork River, Wyoming, 1975, by H.A. Mahoney, E.D. Andrews, W.W. Emmett, L.B. Leopold, R.H. Meade, R.M. Myrick, and C.F. Nordin, Jr. 1976.

OF 76-237. Floodflow characteristics at bridge site on Interstate 80, the Green River near Green River, Wyoming, by G.S. Craig, Jr. 1976.

OF 76-598. Ground-water levels in Wyoming, 1975, by W.C. Ballance and P.B. Freudenthal. 1976.

OF 77-164. Report on preliminary data for Madison Limestone test well no. 1, NE1/4SE1/4 sec.15, T. 57 N., R. 65 W., Crook County, Wyoming, by R.K. Blankennagel, W.R. Miller, D.L. Brown, and E.M. Cushing. 1977.

OF 77-275. Preliminary evaluation of waste-water movement in and near Grand Teton National Park, Wyoming, through October 1976, by E.R. Cox. 1977.

OF 77-676. Digital model of the Arikaree aquifer near Wheatland, southeastern Wyoming, by D.T. Hoxie. 1977.

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OF 79-1280. Results of transient simulations of a digital model of the Arikaree aquifer near Wheatland, southeastern Wyoming, by D.T. Hoxie. 1979.

OF 80-15. Projected effects of intermittent changes in withdrawal of water from the Arikaree aquifer near Wheatland, southeastern Wyoming, by D.T. Hoxie. 1980.

OF 80-748. Maps showing the dissolved solids concentration of waters in the Red River Formation and Mission Canyon Limestone in North Dakota, South Dakota, and parts of Wyoming and Montana, by Sheila Stenzel, Rebecca Buss, and John Busby. 1980.

OF 80-1101. Behavioral and catastrophic drift of invertebrates in two streams in northeastern Wyoming, by D.J. Wangsness and D.A. Peterson. 1980.

OF 80-1110. Effects of herbicide usage on water quality of selected streams in Wyoming, by D.L. Butler. 1980.

OF 80-1189. Field data describing the movement and storage of sediment in the East Fork River, Wyoming. Part I, River hydraulics and sediment transport, 1979, by W.W. Emmett, R.M. Myrick, and R.H. Meade. 1980.

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OF 81-201. Water-resources investigations of the U.S. Geological Survey in Wyoming, fiscal year 1980, by S.L. Green. 1981.

OF 81-410. Hydrologic data for the Cache Creek-Bear Thrust Environmental Impact Statement near Jackson, Wyoming, by G.S. Craig, Jr., B.H. Ringen, and E.R. Cox. 1981.

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OF 83-29. Pumpage data from irrigation wells in eastern Laramie County, Wyoming, and Kimball County, Nebraska, by C.F. Avery. 1983.

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OF 83-935. Linear features determined from Landsat imagery in Wyoming, map, scale 1:500,000, by M.E. Cooley. 1983 [1984].

OF 83-943. Ground-water data, Green River basin, Wyoming, by E.A. Zimmerman and K.R. Collier. 1985.

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