SUMMARY OF WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--FISCAL YEAR 1991

Compiled by Patricia A. Griffith

U.S. GEOLOGICAL SURVEY

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Denver, Colorado

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U.S. DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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SUMMARY OF WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--FISCAL YEAR 1991

INTRODUCTION

Water-resources activities of the U.S. Geological Survey in Colorado consist of collecting water-resources data and doing interpretive hydrologic investigations. The water-resources data and the results of the investigations are published or released by either the U.S. Geological Survey or by cooperating agencies. Water-resources investigations in Colorado for the 1991 fiscal year (October 1, 1990, to September 30, 1991) are described in this report.

The U.S. Geological Survey's investigations of the water resources of Colorado are under the direction of C.A. (Jerry) Pascale, District Chief. The Colorado District office is located on the second floor of Building 53, Denver Federal Center, Denver, Colorado. The Colorado District has two Subdistrict offices, the Western Slope Subdistrict office in Grand Junction and the Pueblo Subdistrict office in Pueblo, and three field headquarters--Lakewood (located in Building 82 on the Federal Center), Meeker, and Durango. Requests for information should be addressed as follows:

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MISSION OF THE U.S. GEOLOGICAL SURVEY

The U.S. Geological Survey was established by an act of Congress on March 3, 1879, to answer the need for a permanent government agency at the Federal level to conduct, on a continuing, systematic, and scientific basis, investigations of the "geological structure, mineral resources, and products of the national domain." Although a number of laws and executive orders have expanded and modified the scope of the Survey's responsibilities during its 112-year history, the Survey has remained principally a scientific and technical investigation agency as contrasted with a developmental or regulatory one. Today the Survey is mandated to assess onshore and offshore energy and mineral resources; to provide information for society to mitigate the impact of floods, earthquakes, landslides, volcanoes, and droughts; to monitor the Nation's ground- and surface-water supplies; to study the impact of man on the Nation's water resources; and to provide mapped information on the Nation's landscape and land use. The Survey is the principal source of scientific and technical expertise in the earth sciences within the Department of the Interior and the Federal Government. The Survey's activities span a wide range of earth-science research and services in the fields of geology, hydrology, and cartography and represent the continuing pursuit of the long-standing scientific missions of the Survey.[1]

[1]Source: Adapted (and updated December 1984) from U.S. Geological Survey Yearbook for Fiscal Year 1983.

MISSION OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division, which supports the mission of the Geological Survey and the U.S. Department of the Interior, is to develop and disseminate scientific knowledge and understanding of the Nation's water resources. The activities carried out by the Water Resources Division fall into three broad categories: (1) resource assessment; (2) research; and (3) coordinating the activities and cataloging the products of numerous other entities involved in water research, data acquisition, or information transfer.

Resource Assessment. Resource assessment consists of:

- Collecting data on the quantity, quality, and use of surface water (rivers, streams, lakes, reservoirs, estuaries, and glaciers); the quantity, quality, and use of ground water (including water in the unsaturated zone); and the quality of precipitation.

- Storing and disseminating these data.

- Interpreting these data and publishing the results of these interpretations. This involves the inference of hydrologic causes, effects, and probabilities; and the extension, over space and time, of information contained directly in the data.

- Developing and applying new methods of hydrologic data collection, analysis, and interpretation.

- Conducting areally focused interpretive investigations and appraisals at national, regional, State, or local scales. These include characterizations of ground and surface waters, and of precipitation chemistry, evaluation of natural hydrologic hazards, and studies of other water-related topics. Frequently these investigations involve the development, testing, and application of mathematical models capable of predicting the hydrologic consequences of management actions, development plans, or natural phenomena. These investigations are carried out through specific Federal programs or in cooperation with State and local governments or other Federal agencies. Results are published in technical journals or in State, local, USGS, or other Federal agency publications.

- Reporting to the Nation, on a regular basis, on the overall status of the water resource, and on hydrologic events and water-resource issues.

Research. The Division conducts research in a wide variety of scientific disciplines--geochemistry, ecology, geomorphology and sediment transport, water chemistry, ground-water hydrology, and surface-water hydrology--particularly as these disciplines relate to the quantity, flow, and quality of surface water and ground water and to other aspects of the hydrologic cycle. The research is intended to:

- Improve the overall understanding of the pathways, rates of movement, chemical processes, and biological processes in the hydrologic cycle.

- Improve the overall understanding of the hydraulic, chemical, and biological factors, both natural and anthropogenic, which affect the resource.

- Provide new strategies of data collection, analysis, and interpretation, in the light of new knowledge and evolving scientific capabilities.

- Improve methods of predicting the response of hydrologic systems to stresses, whether hydraulic or chemical, and whether of natural or human origin.

Coordinating the Activities and Cataloging the Products of Other Entities Involved in Water Research, Data Acquisition, or Information Transfer. This function has four major components:

- The coordination of water-data acquisition activities of Federal agencies (as mandated by OMB Circular A-67).

- The acquisition of water-use data and development of State and national water-use data bases in cooperation with State governments.

- The operation of Water Information Exchanges and Centers which provide all interested parties with indexing and access to many sources of water data and information.

- The administration of extramural water-resources research, technology, development, academic training, and information-transfer programs mandated by the Water Resources Research Act of 1984 (Public Law 98-242). The Act mandates research oriented to the environmental values associated with the resource. The research promoted by the Act involves many disciplines and activities other than those required in the assessment, research, and coordinating functions of the Water Resources Division.[2]

COOPERATING AGENCIES

In Colorado, some of the water-resources data-collection activities and interpretive hydrologic investigations are done in cooperation with Federal, State, and local agencies. Those agencies cooperating with the U.S. Geological Survey during fiscal year 1991 are as follows:

[2]Source: Mission statement by the Chief Hydrologist, September 28, 1984.

Arkansas River Compact Administration
Bent County Board of County Commissioners
Boulder County Public Works Department
Centennial Water and Sanitation District
Cherokee Water and Sanitation District
City and County of Denver, Board of Water Commissioners
City of Arvada
City of Aspen
City of Aurora
City of Boulder
City of Colorado Springs,
  Department of Public Works
  Department of Utilities, Wastewater Division
City of Englewood
City of Fort Collins, Water and Wastewater Department
City of Glendale
City of Glenwood Springs
City of Golden
City of Lakewood
City of Lamar
City of Las Animas
City of Longmont
City of Loveland
City of Northglenn
City of Pueblo, Department of Public Works
City of Rocky Ford
City of Steamboat Springs, Public Works Department
City of Thornton
City of Westminster
Colorado Department of Health
Colorado Department of Highways
Colorado Department of Natural Resources
  Division of Water Resources, Office of the State Engineer
  Division of Wildlife
  Mined Land Reclamation Division
  Oil and Gas Conservation Commission
Colorado River Water Conservation District
Colorado Water Conservation Board
Delta County Board of County Commissioners
Denver Regional Council of Governments
Eagle County Board of County Commissioners
East Grand County Water Quality Board
Evergreen Metropolitan District
Fountain Valley Authority
Fremont Sanitation District
Garfield County, Building, Sanitation, and Planning Department
Jefferson County Board of County Commissioners
LaPlata County Board of County Commissioners
Lower Fountain Water Quality Management Association
Metro Wastewater Reclamation District
Moffat County
Northern Colorado Water Conservancy District
Pueblo Board of Water Works

Pueblo County Board of County Commissioners
Pueblo West Metropolitan District
Rio Blanco County Board of County Commissioners
Rio Grande Water Conservation District
St. Charles Mesa Water District
Southeastern Colorado Water Conservancy District
Southern Ute Tribal Council
Southwestern Colorado Water Conservancy District
Town of Breckenridge
TRANS Mountain Hydro Corp, Federal Energy Regulatory Commission Licensee
Trinchera Water Conservancy District
Uncompahgre Valley Water Users Association
Upper Arkansas Area Council of Governments
Upper Arkansas Water Conservancy District
Upper Eagle Regional Water Authority
Upper Yampa Water Conservancy District
Urban Drainage and Flood Control District
U.S. Department of Defense
    Department of the Air Force
        Air Force Academy
        Human Systems Division
    Department of the Army
        Aberdeen Proving Ground
        Corps of Engineers
            Albuquerque District
            Omaha District
            Sacramento District
        Fort Carson
        Pueblo Depot Activity
        Program Manager, Rocky Mountain Arsenal
U.S. Department of Energy
U.S. Department of the Interior
    Bureau of Land Management
    Bureau of Reclamation
    Fish and Wildlife Service
    Office of the Secretary
U.S. Environmental Protection Agency
Ute Mountain Ute Indian Tribe
Vail Valley Consolidated Water District
Yellow Jacket Water Conservancy District

COLLECTION OF WATER-RESOURCES DATA

Hydrologic-data stations are maintained at selected locations throughout Colorado and constitute a water-resources-data network for obtaining records on streamflow stage and discharge, lake elevation and storage, the quality of surface and ground water, ground-water levels, well and spring discharge, and meteorological data (table 1). Every year some new stations are added and other stations are terminated; thus, the U.S. Geological Survey has a current and a historical file of hydrologic data. Most water-resources data are stored in the U.S. Geological Survey's NWIS (National Water Information System) data base and are available on request to water planners and others involved in making decisions affecting Colorado's water resources. These data can be retrieved in machine-readable form or in the form of computer-printed tables, statistical summaries, and computer plots. Local assistance in the acquisition of services or products from NWIS can be obtained by contacting the District Chief, Denver, Colo.

Table 1.--*Water-resources data-collection stations in operation during fiscal year 1991, by station classification*

[The number and type of stations located in each county are shown on plate 1 (in pocket)]

STATION CLASSIFICATION	NUMBER OF STATIONS
Surface Water:	
Streamflow:	
Continuous (daily) record	321
Seasonal (daily) record	5
Peakflow, crest-stage record	39
Real-time stage and discharge	53
Lakes and reservoirs:	
Stage and contents	26
Real-time stage and contents	4
Water quality:	
Periodic chemical quality	151
Daily quality monitoring	47
Ground water:	
Periodic water levels	1,450
Daily water levels	14
Chemical quality	30
Meteorological:	
Precipitation quantity or air temperature or both	25
Periodic precipitation quality	1

Surface-Water Data

Surface-water stage (water level), discharge (streamflow), and water-quality data are collected for general hydrologic purposes, such as assessment of water resources, areal analysis, determination of long-term trends, research and special studies, or for management and operational purposes. Data-collection platforms (DCP's), used for the transmission of satellite-telemetered data, have been installed at 53 sites throughout the State. Satellite-telemetry acquisition of the information is essential to many agencies for operating reservoirs, predicting river stage and flood conditions, and optimizing the use of water resources. DCP information is transmitted to the GOES (Geostationary Operational Environmental Satellite) and received at the U.S. Geological Survey DRGS (Direct Readout Ground Station) located in Denver, where it is processed and made available to other agencies.

Continuous water-quality monitoring for water temperature, pH, dissolved oxygen, specific conductance, or turbidity is being done at 47 sites. Instruments measure the parameters of interest periodically during the day, enabling the information to be summarized for the day, such as the daily maximum, minimum, and mean values.

Periodic water-quality data (major ions, nutrients, trace elements, pesticides, or radiochemicals) are obtained at 151 of the surface-water stations listed in table 1. Seven of these stations are part of a U.S. Geological Survey nationwide network known as NASQAN (National Stream Quality Accounting Network) and two of these stations are part of the nationwide Hydrologic Benchmark Network that provides data used in the evaluation of trends in stream quality. Information from water-quality stations is used to monitor the quality of surface water in Colorado. The frequency of sample collection can vary from daily for some of the physical data to annually for pesticide or radiochemical data.

A variety of water-quality data is collected at miscellaneous sites that are part of interpretive hydrologic studies. This information also is available from the files of the U.S. Geological Survey.

Ground-Water Data

Water levels in wells are key characteristics for monitoring ground-water trends; however, they must be integrated with other observations and ground-water investigations to have the most relevance and usefulness. A network of 1,450 observation wells is maintained in eastern Colorado and the San Luis basin for monitoring fluctuations in water levels. Other wells, known as "project wells," are used for specific (generally short-term) investigations; although these wells are not part of the observation-well networks, data obtained from them also are available.

Water-quality data are not collected routinely from wells. However, a variety of water-quality data was collected at 30 wells during 1990 for interpretive hydrologic investigations. These data are available from the files of the U.S. Geological Survey.

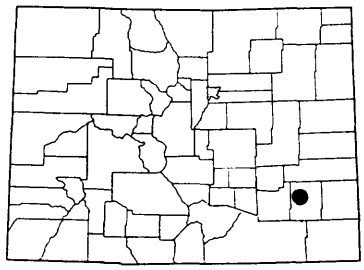
The Pueblo Subdistrict has had an ongoing program of collection of water-quality data from eight wells located in the Widefield aquifer, southwest Colorado Springs, and from one well located in the upper Black Squirrel Creek basin. Onsite measurements of water-quality properties and sampling for nutrient analyses are done at the wells on a quarterly basis, and the data are published annually in the Colorado Water Resources Data Report.

Meteorological Data

Precipitation quantity or air temperature or both are collected at 25 stations in Colorado, and the data are published. One station, located in Bent County, is part of the nationwide NTN (National Trends Network) program to monitor long-term precipitation-quality changes. Information from the precipitation stations is available to users on request.

INTERPRETIVE HYDROLOGIC INVESTIGATIONS

Thirty-eight interpretive hydrologic investigations are being done during fiscal year 1991 in cooperation with 42 Federal, State, and local agencies. Hydrologic investigations are being done that will provide information needed to answer hydrologic questions specific to the State's four major river basins (Missouri, Arkansas, Rio Grande, and Colorado), as well as questions addressing nationwide, multistate, and statewide hydrologic problems. A summary of each investigation, including problem, objectives, approach, progress, and plans for fiscal year 1991 follows.



PROJECT TITLE: National Trends Network for Monitoring Atmospheric Deposition

PROJECT NUMBER: CO-83-005

STUDY LOCATION: Bent County Board of County Commissioners, Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Ronnie D. Steger, Subdistrict Office, Pueblo

PROJECT DURATION: October 1983 to September 1991

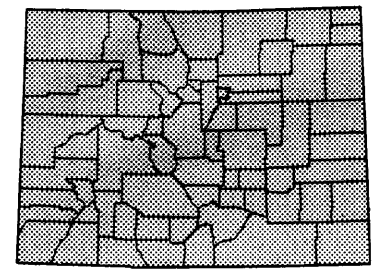
PROBLEM: Great variability exists nationwide in precipitation quality and quantity and their potential environmental impacts.

OBJECTIVES: To monitor precipitation volume and chemistry as part of the National Trends Network (NTN) program. To relate precipitation chemistry and volume to concurrent discharge and stream chemistry.

APPROACH: Maintain and operate a monitoring station that is part of a nationwide network established to provide concentrations, loads, and time trends of chemical constituents in precipitation and stream water.

PROGRESS: Data collection continued on a weekly basis at one rain gage, with sampling as required.

PLANS FOR FY 91: Weekly visitation of the site and sampling as required will be continued.



PROJECT TITLE: Statewide Water-Use Inventory

PROJECT NUMBER: CO-78-007

STUDY LOCATION: Statewide

COOPERATING AGENCIES: City and County of Denver, Board of Water Commissioners; Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer; Colorado River Water Conservation District

PROJECT CHIEF AND OFFICE: David W. Litke, District Office, Denver

PROJECT DURATION: October 1977 to September 1991

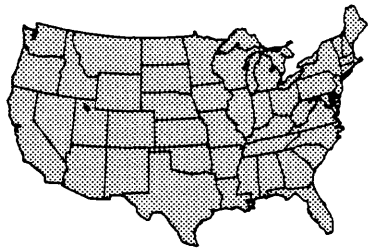
PROBLEM: Water-use data in Colorado are not complete and detailed enough for planning purposes and implementation of a State water plan. Sources of water supplies, water use, and the volume of water consumed or available for multiple use require documentation so that State and local managers and planners may be better informed to make decisions for development of the State's water resources.

OBJECTIVES: Maintain a computerized water-use data base that can be accessed by a variety of users. Develop methods for more complete and accurate estimation of water use.

APPROACH: Obtain water-use data by contacting users, accessing pre-existing data bases, and developing estimation techniques when necessary.

PROGRESS: U.S. Geological Survey Water-Resources Investigations Report 89-4107 "Estimating pumping time and ground-water withdrawals using energy-consumption data" was published. The section, "Colorado--Water Supply and Use" (in the 1987 National Water Summary) was published. Final draft of the report "Analysis of residential use of water in the Denver metropolitan area, Colorado, 1980-87" was completed and now is in review. Cooperative work with the U.S. Bureau of Reclamation continued on development of an irrigated acreage and water-use data base for the Upper Colorado River Basin.

PLANS FOR FY 91: Data will be collected for the national effort--1990 estimated use of water in the United States.



PROJECT TITLE: Evaluation of the Hydrologic Benchmark Network

PROJECT NUMBER: CO-80-131

STUDY LOCATION: Nationwide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: John T. Turk, District Office, Denver

PROJECT DURATION: November 1979 to September 1993

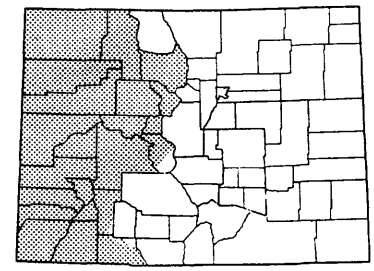
PROBLEM: The purpose of the Hydrologic Benchmark Network (HBM) is to detect trends in the chemistry and hydrology of pristine, headwater hydrologic systems unaffected by local, anthropogenic disturbances. However, because many of these sites contain roads, dwellings, mines, logged areas, or other disturbances, they may not be truly pristine. Whether these apparent disturbances significantly affect stream chemistry is not known.

OBJECTIVES: This study will determine whether the past and present HBM sites are appropriate to meet the goals of the HBM program. The study also will determine what types of new sites are needed to improve the program.

APPROACH: Each past or present HBM site is to be visited by a review team. The watershed subbasins will be sampled for major ion chemistry to determine whether the watershed chemistry is heterogeneous. Disturbances will be documented, and sampling downstream from disturbances will be used to determine their importance. Information from land managers on watershed history and management will be cataloged. A publication will be prepared documenting the status of past and present sites.

PROGRESS: Background information on watershed characteristics has been assembled for most sites. Sampling of watersheds has begun.

PLANS FOR FY 91: Background information will be assembled for the remaining sites. Sampling will continue.



PROJECT TITLE: Regional Aquifer System Analysis of the Upper Colorado River Basin in Colorado

PROJECT NUMBER: CO-81-158

STUDY LOCATION: The Upper Colorado River Basin in western Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Emanuel Weiss, District Office, Denver

PROJECT DURATION: July 1981 to September 1991

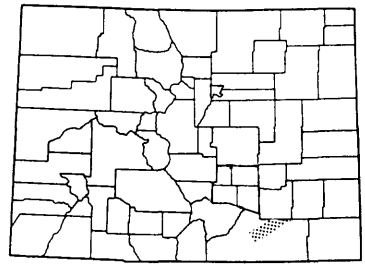
PROBLEM: Water demands are increasing in the Upper Colorado River Basin. Ground-water reservoirs may contain large water supplies, but not all water supplies have been investigated. Effective water management cannot proceed until quantity and quality of available water supplies have been appraised.

OBJECTIVES: Locate major aquifer systems, estimate the volume of ground water in storage, determine the quality of available ground water, and estimate the hydrologic impacts of major withdrawals and injection.

APPROACH: Compile hydrologic and geochemical data from existing well logs and onsite inventory of wells and springs. Prepare and use simulation models to estimate the effects of withdrawals from, and injection into, various aquifer systems.

PROGRESS: All project reports were in the review process by the end of March 1991. Consequently, this project essentially will be completed by the end of March 1991, except for answering review questions about reports that are in the review process.

PLANS FOR FY 91: To answer review questions as they originate about reports in the review process, to obtain Director's approval, and to publish the reports.



PROJECT TITLE: Assessment of Water Resources and Related Effects Resulting from Military Training in the Pinon Canyon Area, Colorado

PROJECT NUMBER: CO-83-172

STUDY LOCATION: Southeastern Colorado, including tributaries of the Purgatoire and Apishapa Rivers in Las Animas County

COOPERATING AGENCY: U.S. Department of the Army, Fort Carson

PROJECT CHIEF AND OFFICE: Paul von Guerard, Subdistrict Office, Pueblo

PROJECT DURATION: October 1982 to September 1991

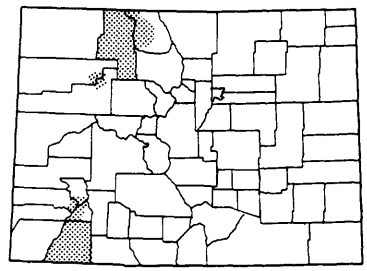
PROBLEM: Beginning in 1985, a 400-square-mile area was acquired in the Pinon Canyon area by the U.S. Army and was used for military training. Conversion of land use from grazing may alter streamflow and water quality. These changes could not be quantified in the environmental impact statement for the acquisition, but they are a concern to downstream water users in Colorado and Kansas. The Authorizing Act for the acquisition directs the Army to establish a system of hydrologic monitoring to collect baseline data and record changes in the quantity and quality of water flowing from the land acquired.

OBJECTIVES: Assess the quantity and quality of surface- and ground-water resources in the area. Determine the effect of military training on the water resources of the area.

APPROACH: Monitor surface-water flow and specific conductance at 10 streamflow-gaging stations and collect sediment samples by using automatic samplers at 7 stations. Collect water-quality samples of base flow and storm runoff at all stations. Determine current (1983-84) reservoir capacity in 49 small reservoirs; probe 29 of these reservoirs to determine historical sediment content and resurvey all reservoirs following military training. Inventory existing wells, measure water levels in 10 wells, and collect samples of water from 50 wells. Intensely instrument one drainage basin on the site and use information to calibrate rainfall-runoff model.

PROGRESS: Streamflow, water quality, and suspended-sediment data collection continued at a network of 10 streamflow-gaging stations in and around the U.S. Army Pinon Canyon Maneuver site. Precipitation volume and intensity were measured during May through September at 19 sites in the Taylor and Lockwood Arroyo drainage basins to provide data for a rainfall-runoff model. Saturated hydraulic conductivity was determined for three soil types for disturbed and undisturbed land-use conditions. The final interpretive report, which describes the effects of military maneuvers on the hydrology at the maneuver site, was revised and transmitted to the Director for review and approval.

PLANS FOR FY 91: Data-collection activities will continue during 1991 at a slightly decreased intensity. Following Director's approval of the final interpretive report, the report will be published and distributed.



PROJECT TITLE: Effects of Energy-Production Emissions on Colorado Lakes

PROJECT NUMBER: CO-80-165

STUDY LOCATION: Rio Blanco, Garfield, Mesa, Delta, LaPlata, and Routt Counties

COOPERATING AGENCIES: Colorado Department of Health
Delta County Board of County Commissioners

PROJECT CHIEF AND OFFICE: John T. Turk, District Office, Denver

PROJECT DURATION: November 1979 to September 1991

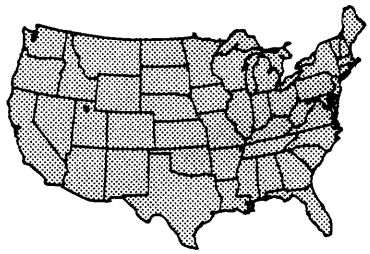
PROBLEM: Current and proposed production of energy in Colorado and surrounding States will release acidic gases and other constituents that can affect the chemistry of precipitation and of poorly buffered lakes and streams. The water resources of the Flat Tops, Mt. Zirkel, and Weminuche Wilderness Areas in western Colorado are located downwind from areas of possible oil-shale development and coal-burning powerplants. The unreactive bedrock of the area, combined with the orographic effect on precipitation, may cause the area to be particularly susceptible to adverse effects of energy production. Data on precipitation and lake quality do not exist to define predevelopment conditions or relative sensitivity of waters to input of additional chemical constituents.

OBJECTIVE: Delineate the areas in Colorado most susceptible to the effect of acid rain. Determine which lakes, within susceptible areas, have the least buffering capacity and the smallest nutrient-loading rate. Select lakes, representative of other lakes within the susceptible areas, for more detailed study. Determine baseline chemical quality of precipitation.

APPROACH: Select areas most susceptible to acidification based on the following: downwind location from acidic-gas sources, unreactive bedrock geology, and large snowpack accumulation. Measure relative buffering capacity of the lakes by alkalinity-titration curves. Install and operate precipitation gages and weather stations to collect samples for analysis of wet- and dry-deposition quality and data on wind direction and speed.

PROGRESS: The chemistry of atmospheric deposition and lakes has been monitored and used to demonstrate the rapid response of high-elevation lakes to changes in the chemistry of atmospheric deposition.

PLANS FOR FY 91: Monitoring of lakes and wetfall will continue. Stable sulfur isotopes have been added to routine monitoring of major ions.



PROJECT TITLE: An Update of Fluvial-Sediment Discharge to the Oceans from the United States

PROJECT NUMBER: CO-84-184

STUDY LOCATION: Nationwide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Randolph S. Parker, District Office, Denver

PROJECT DURATION: April 1984 to September 1991

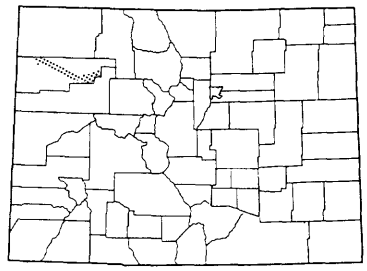
PROBLEM: Knowledge of the quantity of sediment transported by the various rivers of the United States is essential for the following: (1) Designing reservoirs to allow sufficient space to store sediment expected to accumulate in reservoirs; (2) predicting the fate of contaminants, such as pesticides, radionuclides, and toxic metals that can be adsorbed to the sediment particles; and (3) indicating regional and continental rates of erosion. A summary of transported sediment will be useful to the hydrologic community.

OBJECTIVE: Calculate sediment outflow to the oceans from the major sediment-producing rivers of the United States. In addition, give examples of changes in sediment yields from man's activities upstream and examples of extreme events and their effect on sediment production.

APPROACH: Calculate sediment yields of major river basins in the United States from data contained in WATSTORE. Record examples from the literature of the effects of man's modifications and of extreme events.

PROGRESS: Maps of average sediment loads of the major rivers of the United States are being converted to a geographic information system (ARC/INFO). This system will provide an easy method of reducing and publishing the maps. In addition, the system will provide access to the data for other purposes. Project is complete except for report.

PLANS FOR FY 91: The geographic information system will be used to devise final maps for publication.



PROJECT TITLE: Sediment Transport and Water Quality at Reservoir Sites in Western Colorado

PROJECT NUMBER: CO-84-187

STUDY LOCATION: Proposed reservoir sites, western Colorado

COOPERATING AGENCIES: Colorado River Water Conservation District and Yellow Jacket Water Conservancy District

PROJECT CHIEF AND OFFICE: Robert L. Tobin, Field Headquarters, Meeker

PROJECT DURATION: March 1984 to September 1991

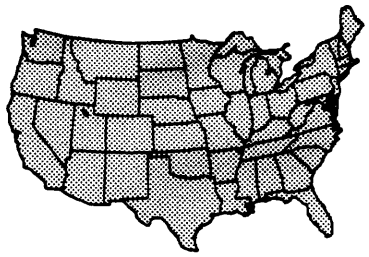
PROBLEM: Sediment transported by rivers flowing into reservoirs are deposited throughout the length of the impoundment. Deposits may occur in the upper reaches of the reservoir. As water depths increase and flow velocity decreases, bedload or coarser material is deposited first; subsequently, sand-sized material is deposited. Ultimately, finer silt and clay fractions in suspension are deposited, usually farther within the reservoir. To estimate total load and sedimentation rate, the following information is required: (1) Water discharge; (2) suspended-sediment concentration and size distribution; and (3) bedload-transport rate and size distribution. In addition, data on stream water-quality characteristics are required to evaluate potential effects of impoundment.

OBJECTIVE: Measure suspended-sediment loads and bedload in streams where reservoirs are proposed. Estimate the effects of sediment deposition on reservoir capacity and evaluate stream water-quality characteristics and potential effects of impoundment.

APPROACH: (1) Using standard techniques, collect suspended-sediment, bed-material, and bedload samples; (2) develop suspended-sediment, bedload, and total sediment-discharge relations, based on the collected data and on estimates from empirical techniques such as regression models; (3) compute annual sediment discharges at potential reservoir locations, using the sediment ratings and streamflow data; (4) estimate trap efficiency in reservoirs; and (5) collect and compile water-quality data.

PROGRESS: Streamflow, sediment, and water-quality data for six sites on the White River were compiled and analyzed for water years 1975-88. Annual loads of suspended sediment and dissolved solids were determined from regression estimates of daily loads, and concentrations of major constituents were regressed on values of specific conductance. Technical reviews of the report were addressed, and the report has been submitted for Region and Headquarters review and approval.

PLANS FOR FY 91: Address additional reviews of the project report and process the report for publication; continue to collect data for trend analyses.



PROJECT TITLE: Federal Series Reports Preparation Center

PROJECT NUMBER: CO-85-199

STUDY LOCATION: Colorado District Office

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Edward J. Swibas, District Office, Denver

PROJECT DURATION: February 1985 to September 1991

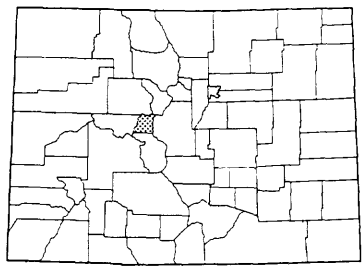
PROBLEM: After submittal to the Geologic Division, the average time needed to prepare a formal series report for publication is about 18 months. Geologic Division's staff is not sufficient to prepare all illustrations for the large number of Water Resources Division (WRD) reports submitted within the timeframe mandated by the Director.

OBJECTIVES: Provide support to the Branch of Scientific Publications at Headquarters (WRD) for the preparation of illustrations for Federal Series Reports. Decrease the backlog of approved Federal Series Reports not yet published. Provide WRD with a facility within the Division that provides quality preparation of illustrations, has working knowledge of the sciences, and a high level of expertise in visual communication. Employ the most efficient illustration-preparation techniques to decrease the time required to publish WRD Federal Series Reports.

APPROACH: Draft illustrations are sent to the Colorado Federal Series Reports Preparation Center (FSR-Colorado) to be prepared for printing. The FSR-Colorado designs and prepares final illustrations.

PROGRESS: During FY 90, 84 page-size illustrations and 33 plates were completed. All reports that were planned to be completed have been submitted to Headquarters. All chapters of Professional Paper 1370 have been printed.

PLANS FOR FY 91: Plans are to complete all reports, currently in production in the Unit, by the end of FY 91. These reports are Professional Papers 1404-I and 1416-B and Water-Supply Papers 2295C and 2357B.



PROJECT TITLE: Mechanisms of Stream Recovery from Metal Contamination

PROJECT NUMBER: CO-86-217

STUDY LOCATION: Arkansas River near Leadville, Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Briant A. Kimball, District Office, Salt Lake City, Utah

PROJECT DURATION: February 1986 to September 1993

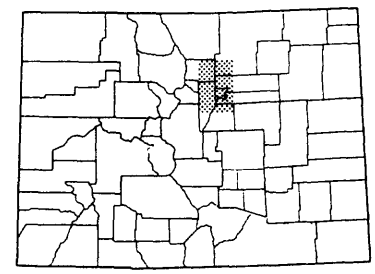
PROBLEM: Past mining of ore deposits in the Leadville, Colo., area has yielded economic quantities of gold, silver, copper, lead, zinc, iron, and bismuth. Water flowing through abandoned tailings and from adits in the Leadville area contributes large quantities of cadmium, copper, iron, lead, manganese, nickel, and zinc to the Arkansas River. Reactive solute-transport processes occurring within the channel are not well quantified. An interdisciplinary study of controls on trace-element concentrations in streams of the Leadville area will allow a better understanding of the transport and removal mechanisms controlling trace-element concentrations in streams.

OBJECTIVES: Characterize the within-stream chemical processes that control the transport and distribution of trace elements in streams of the Leadville area. Characterize the chemistry of sediment and sediment coatings that are active in controlling the dissolved concentrations of trace elements. Quantify the time and length scales for chemical and hydrologic processes that affect the trace elements. Determine the chemical equilibrium and kinetic controls on trace-element concentrations and quantify these controls in a reactive solute-transport model that is based on instream experimental data from Saint Kevin Gulch.

APPROACH: Define the transition from natural conditions to areas affected by acid-mine drainage, using chemical mass balance to study reactions. Determine concentration, mineralogy, and particle-size distribution of suspended sediment, including colloids. Use instream transport experiments to quantify time and length scales of chemical reactions.

PROGRESS: Most of the sampling for all parts of the study is completed. Work on the development of a solute-transport model that treats conservative and reactive solutes now is in progress. In August 1990, two detailed experiments were done in Saint Kevin Gulch. The first experiment traced the diel variations of iron into the subsurface stream zone to evaluate the net effects of subsurface streamflow on the overall processes of solute transport. The second experiment followed nutrient dynamics during the injection of a phosphorus-32 tracer. During the same week, work was begun to investigate hillslope effects on subsurface streamflow. The State of Colorado and the U.S. Environmental Protection Agency have used the water-quality data base developed as part of this project for their planning efforts on the Upper Arkansas River.

PLANS FOR FY 91: The emphasis in 1991 will be on model development, data analysis, and interpretation. This emphasis includes all aspects of the research, from intensive spatial and temporal data collected in Saint Kevin Gulch to chemical mass balance of acid inflows to the Arkansas River and to sediment pore water 200 kilometers downstream in Pueblo Reservoir. A major effort will be the cooperative work with the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado. During the year, this work should produce an operational code for running the solute-transport simulations using data from instream experiments in Saint Kevin Gulch. The code will be used to simulate the conservative tracers from each instream experiment. The next step will be incorporation of geochemical reactions for the reactive solutes, which will extend beyond 1991. The study of wetlands at the mouth of Saint Kevin Gulch and the analysis of the phosphorus-32 experiment also should be completed during 1991.



PROJECT TITLE: Application of a Geographic Information System to Determine the Vulnerability of Ground-Water Resources in the Greater Denver Area

PROJECT NUMBER: CO-87-224

STUDY LOCATION: Central Colorado

COOPERATING AGENCY: Colorado Department of Health

PROJECT CHIEF AND OFFICE: Glenn A. Hearne, District Office, Denver

PROJECT DURATION: June 1987 to September 1991

PROBLEM: Ground water in shallow aquifers is vulnerable to contamination from sources on the land surface. The vulnerability is difficult to evaluate because of the lack of readily accessible data in a usable format. To map vulnerability for regional areas, methods are needed to access the available data and to process large amounts of data using computerized techniques.

OBJECTIVE: Develop a map (or maps) of the study area showing the vulnerability of ground water in the uppermost aquifer to contamination from sources on the land surface. Methods used will be documented to aid in transferring techniques to priority areas in Colorado and other States.

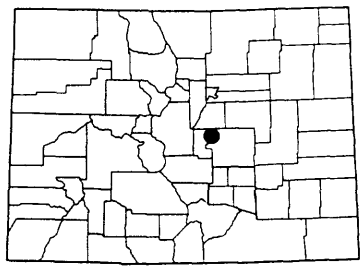
APPROACH: For the study area, data sources will be identified for the characteristics needed to compare ground-water vulnerability in the uppermost aquifer. The characteristics considered will include at least the following:

Depth to ground water, recharge rate, aquifer media type, soil type, topography, effect of the vadose zone, hydraulic conductivity, hydrogeologic setting, secondary permeability, and hydraulic connection with deeper aquifers.

The ARC/INFO geographic information system will be used to calculate and map the relative vulnerability of ground water using selected attribute data that have been integrated into ARC/INFO.

PROGRESS: Separate ARC/INFO covers of geology, depth to water, irrigated area, and soil associations have been generated. The three major hydrogeographic settings (mountain slopes, mountain flanks, and bedded sedimentary rocks) have been identified and a cover generated. Elevation data were acquired as 1:24,000 digital elevation models (DEMs), where available, and as 1:250,000 DEMs for other areas. Slope maps have been generated from these DEMs. Separate covers of geology, depth to water, soil associations, and slope of land surface were intersected to produce a vulnerability map. The results have been presented in a draft report that has been submitted for review and approval as a U.S. Geological Survey publication.

PLANS FOR FY 91: The final report is planned to include a map (25 in. wide by 38 in. high plus a border for explanation) in multiple colors and about 200 pages of text, published as a U.S. Geological Survey Water-Resources Investigations report. The environmental covers will be published by the Colorado Department of Health with references to the Water-Resources Investigations report and suggested applications.



PROJECT TITLE: U.S. Air Force Academy Installation Restoration Program Study

PROJECT NUMBER: CO-88-226

STUDY LOCATION: U.S. Department of the Air Force, Air Force Academy

Colorado Springs, Colorado

COOPERATING AGENCY: U.S. Air Force

PROJECT CHIEF AND OFFICE: David K. Mueller, District Office, Denver

PROJECT DURATION: October 1987 to September 1993

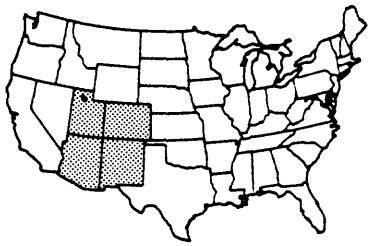
PROBLEM: After the reauthorization and amendments to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) by Superfund Amendment Reauthorization Act (SARA), all federally owned installations and property must be in compliance with all Federal and State environmental laws and regulations. As a consequence, the U.S. Air Force started the Installation Restoration Program (IRP) to identify sites on Air Force installations that are not in compliance with the existing environmental laws and to remediate the sites if a threat exists to human health or the environment.

OBJECTIVE: The objectives of the IRP, and this investigation, are to assess past potential hazardous-waste disposal or spill sites on the U.S. Air Force Academy and to develop remedial actions consistent with the National Contingency Plan (NCP) for those sites that pose a threat to human health and welfare or the environment.

APPROACH: Eleven sites on the Academy were identified as potential risks to human health. Monitoring wells were installed, and surface-water, ground-water, sediment, and soil samples were collected and analyzed. Analysis of these data indicated that 5 of the 11 sites had contamination at levels that could be harmful to human health. Additional monitoring wells were installed at these five sites, and additional samples were collected to better characterize the types of contaminants and the extent and movement of the contamination. Human health risk assessments will be done following U.S. Environmental Protection Agency (EPA) guidelines to determine if a human health risk exists at the point of nearest human contact. Two additional sites also have been identified as potential risks to human health, and these sites will be investigated in a manner similar to that used for the first 11 sites.

PROGRESS: The Phase I report, with the purpose of summarizing the data collected to determine which sites potentially posed a human health risk, was completed and approved by the U.S. Geological Survey and the U.S. Air Force. The statement of work and agreement for Phase II were completed, and the field work (installing additional monitoring wells and environmental sample collection) was completed to meet the Phase II objectives. The human health risk assessment was begun for the five Phase II sites using Phase I and Phase II data.

PLANS FOR FY 91: The human health risk assessments for three Phase II sites will be completed, as will the Phase II report summarizing the data collected, data analysis, and the risk assessment. Similar work is expected to begin on two additional sites. A more detailed hydrologic investigation will begin to obtain information so that contaminant movement can be better defined. No Further Action Decision Documents will be completed for those sites at which the risk assessment indicates that there are no adverse health effects for humans because of the contamination at the site.



PROJECT TITLE: National Ground-Water Atlas

PROJECT NUMBER: CO-88-229

STUDY LOCATION: Nationwide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Stanley G. Robson, District Office, Denver

PROJECT DURATION: October 1987 to September 1991

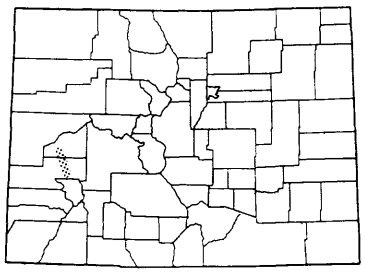
PROBLEM: A unified summary of ground-water conditions in the Nation is needed. The U.S. Geological Survey Regional Aquifer System Analysis (RASA) program provides regional summaries of ground-water information, but the results of this program have not been compiled to produce a national picture. A National Ground-Water Atlas will summarize in one publication the most important ground-water information that has been collected and published over many years by the U.S. Geological Survey. It also will serve as a ready source to answer ground-water inquiries from the public, other Federal agencies, and the congressional staffs.

OBJECTIVE: (1) To provide a summary of the Nation's ground-water resources for readers that include the lay public, consultants, planners, colleges and universities, congressional staffs, and other governmental agencies; and (2) to synthesize ground-water information that now exists at many scales into a single document that can be used to respond to requests for information from the above groups and others.

APPROACH: (1) Synthesis and merging of existing interpretations, starting with those of the RASA program; (2) separation of the Country into 13 multi-State segments and assignment of each segment to an experienced hydrologist charged with assembling all materials necessary to present hydrologic conditions for all important aquifers in that segment; and (3) obtaining limited new maps and other products from districts as needed. Segment 2 will be completed by this project. Segment 2 includes Arizona, Colorado, New Mexico, and Utah.

PROGRESS: The final report for this project describes the ground-water resources of the principal aquifers in Arizona, Colorado, New Mexico, and Utah. The draft of the report and a set of color illustrations have been prepared and are undergoing review prior to approval for publication.

PLANS FOR FY 91: The draft report will be revised in response to colleague-review comments.



PROJECT TITLE: U.S. Department of the Interior Detailed Investigation of Irrigation Drainage in the Lower Gunnison River Basin, Uncompahgre River Basin, and in the Grand Valley, west-central Colorado

PROJECT NUMBER: CO-88-231

STUDY LOCATION: West-central Colorado

COOPERATING AGENCY: U.S. Department of the Interior, Office of the Secretary

PROJECT CHIEF AND OFFICE: David L. Butler, Subdistrict Office, Grand Junction

PROJECT DURATION: March 1991 to September 1993

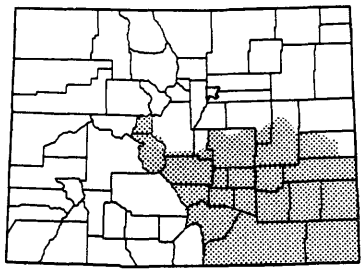
PROBLEM: The U.S. Department of the Interior (DOI) initiated more than 20 studies in the Western United States to identify irrigation-induced water-quality problems that may be caused by irrigation projects constructed or managed by DOI. One such study was the Uncompahgre Project, which included parts of the lower Gunnison River, the Uncompahgre River, and Sweitzer Lake. Results of that study indicate that irrigation from the Uncompahgre Project area may be contributing dissolved solids, sulfate, nitrate, selenium, boron, and uranium to the Gunnison and Uncompahgre Rivers. The U.S. Fish and Wildlife Service reported significant concentrations of selenium in biota from Sweitzer Lake and the Escalante State Wildlife Area. Based on the results of the reconnaissance study, the Irrigation Drainage Task Group decided that further study of the Uncompahgre Project area was needed to provide basic technical information for future planning and management. The Grand Valley area was added to the detailed study becuase of known or suspected impacts to water quality of the Colorado River.

OBJECTIVE: There are two general objectives for detailed irrigation-drainage studies: (1) Determine the geographical extent and severity of existing and potential irrigation-induced water-quality problems, and (2) provide the scientific understanding needed for development of reasonable alternatives to mitigate or resolve identified problems.

APPROACH: A synoptic water-quality sampling of the Grand Valley and Uncompahgre Project area is scheduled for FY 91. The Grand Valley will be sampled in late March to collect data at low-flow conditions. A limited number of sites were sampled for the reconnaissance study of the Gunnison and Uncompahgre Rivers. A much more expanded sampling program will be developed for that area. Other specific work elements of the detailed study have not been finalized at this time. Geohydrological and geochemical investigations will likely be part of the detailed study work plan.

PROGRESS: A meeting was held February 19-21, 1991, in Grand Junction to initiate the Gunnison-Grand Valley detailed study. Members of the inter-bureau study team met with the DOI Task Group and regional coordinators. Development of the work plan was discussed. Planning for the Grand Valley sampling scheduled for March was completed.

PLANS FOR FY 91: The work plan will be developed in two stages. A brief plan of study and budget for work to be done in FY 91 is due April 30, 1991, to the manager of the National Irrigation Water Quality Program. The work plan for the entire detailed study is due August 31, 1991. The extent of field work for FY 91 is not fully known at this time. Sampling of drains and ground water in the Grand Valley is scheduled for late March, before irrigation diversions begin. Synoptic sampling of the Uncompahgre Project area probably will be done this summer. Other work elements, such as ground-water investigations, geochemical studies, or soil sampling, have not yet been developed.



PROJECT TITLE: Evaluation of Water Quality in the Arkansas River Basin of Colorado

PROJECT NUMBER: CO-88-232

STUDY LOCATION: Arkansas River basin, southeastern Colorado

COOPERATING AGENCIES: City of Aurora; City of Colorado Springs, Department of Utilities; City of Lamar; City of Las Animas; City of Pueblo, Department of Public Works; City of Rocky Ford; Fremont Sanitation District; Pueblo Board of Water Works; Pueblo County; Pueblo West Metropolitan District; St. Charles Mesa Water District; Southeastern Colorado Water Conservancy District; Upper Arkansas Area Council of Governments; Upper Arkansas Water Conservancy District; U.S. Bureau of Reclamation

PROJECT CHIEF AND OFFICE: Patrick Edelmann, Subdistrict Office, Pueblo

PROJECT DURATION: March 1990 to September 1995

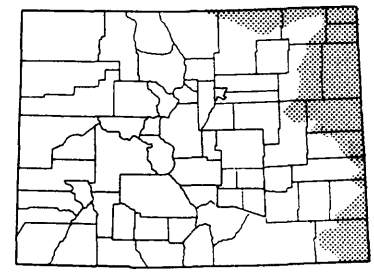
PROBLEM: Available water-quality data indicate that the use of water in parts of the basin is impaired as the result of poor water quality. Current water-quality networks lack a consistent, basinwide set of water-quality data that are needed for making sound decisions for present and future planning and management of the basin's water resources, including the effects of water uses, land uses, tributary inflows, wastewater discharge, climate, and geology on water quality. Improved information is needed to establish appropriate water-quality standards and to evaluate trends in water quality.

OBJECTIVE: The objectives of this study include: (1) Evaluating downstream and seasonal variations in water quality that occur throughout the basin, (2) assessing variations in water quality that occur during different flow periods, and (3) assessing effects on water quality that may occur as the result of water uses, land uses, tributary inflows, point- and nonpoint-source discharges, and natural climatic and geologic conditions affecting water quality of the Arkansas River.

APPROACH: The water quality of the Arkansas River will be evaluated using existing and newly collected data. The water-quality monitoring network consists of collecting water-quality data for an initial period of 3 years at 20 main-stem sites, 32 tributary sites, and 9 transmountain diversions. Water samples will be collected at critical flows and hydrologic conditions during each year. These data will provide the necessary information to meet the study objectives. Data will be evaluated graphically and statistically as data are collected and analyzed.

PROGRESS: Data collection was initiated in April 1990. Extensive water-quality data were collected during the spring and summer at critical flows and selected hydrologic conditions at 20 main-stem sites, 32 tributary sites, and 9 transmountain diversions. A network of observers was established to make periodic stage readings and collect periodic samples for measurement of specific conductance at numerous tributary and main-stem sites. Data compilation, review, and analyses were begun.

PLANS FOR FY 91: Data-collection efforts will continue. Traveltime investigations are planned to provide additional information on transit times at three different flow regimes. All data collected during 1990 will be reviewed, updated, and published in the Colorado Water Resources Data Report. Data compilation, review, and analyses will continue as additional data are collected.



PROJECT TITLE: High Plains Water-Level Network

PROJECT NUMBER: CO-88-233

STUDY LOCATION: High Plains of eastern Colorado

COOPERATING AGENCY: Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer

PROJECT CHIEF AND OFFICE: Edward R. Banta, District Office, Denver

PROJECT DURATION: August 1988 to September 1992

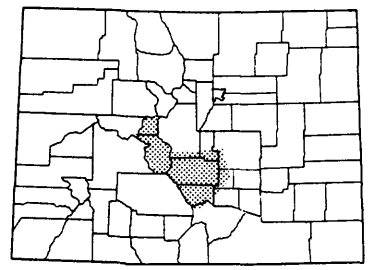
PROBLEM: The High Plains aquifer is the principal source of water for much of eastern Colorado. Historical pumpage has caused substantial water-level declines in some areas. Since the end of Phase I of the High Plains Regional Aquifer System Analysis (RASA) study in 1983, the number of water-level measurements has declined considerably, no interpretation of the data has been made, and no information about the seasonal variation has been collected.

OBJECTIVE: To enhance the water-level network of the High Plains, to identify the seasonal variation of water levels, and to determine areas of water-level change.

APPROACH: Personnel from the Office of the State Engineer and local conservancy districts will measure about 700 wells in the High Plains annually. U.S. Geological Survey personnel will enter the data into the USGS Ground-Water Site Inventory (GWSI) system and screen the data for consistency and possible errors. Some wells will be remeasured and additional wells will be measured by the U.S. Geological Survey. Continuous recorders will be operated to monitor the seasonal variation in water levels. Trends in water levels will be evaluated, and areas of substantial water-level change will be mapped.

PROGRESS: In 1990, the State and local conservancy districts made water-level measurements in about 700 wells. The U.S. Geological Survey made water-level measurements in 18 wells. All measurements were checked against previous water levels measured in the same wells. No wells required remeasurement. Water levels, new-owner data, and remarks pertaining to the measured wells and a large number of wells that had been destroyed or were otherwise unmeasurable were entered into the GWSI system. The Office of the Colorado State Engineer published two data reports containing tabulated water-level measurements for the High Plains area. Five continuous water-level recorders collected data throughout the year.

PLANS FOR FY 91: Repeat water-level measurements in the same wells where measurements were made in FY 90. Measurements will be made by the State, local conservancy districts, and U.S. Geological Survey personnel, as in 1990. Remeasure water levels where data quality is suspect. Continue operation of five continuous water-level recorders. Enter data into the GWSI system. Provide the State with data for analysis and publication.



PROJECT TITLE: Probability Analysis of Daily Floodflows into Pueblo Reservoir during April and May

PROJECT NUMBER: CO-89-234

STUDY LOCATION: Arkansas River basin upstream from Pueblo Reservoir

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF AND OFFICE: Gerhard Kuhn, District Office, Denver

PROJECT DURATION: October 1988 to June 1992

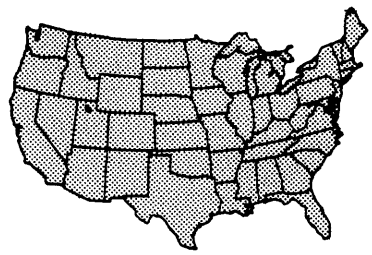
PROBLEM: Pueblo Reservoir, located 10 miles west of Pueblo, Colo., is one of the principal features of the Fryingpan-Arkansas Project, a water-development project of the U.S. Bureau of Reclamation. Part of the storage space in Pueblo Reservoir consists of a 66,000 acre-foot joint-use pool that can be used to regulate imported and native waters for municipal, industrial, and irrigation uses during the period November 15 through April 14. During the original design of Pueblo Dam, the U.S. Army Corps of Engineers designated April 15 as the date each year by when the joint-use pool must be vacated for additional flood-control storage. The possibility of using water stored in the joint-use pool for even a brief time beyond April 15, typically the beginning of the growing season, is very important to the economic interests of water users and to the wise management of water resources. In addition, the long-term yield of the joint-use pool would be increased if the April 15 date were extended during some years when hydrologic and climatic conditions were favorable.

OBJECTIVES: The objectives of the study are to (1) Assess the probability of floodflows into Pueblo Reservoir during April and May on the basis of historic streamflow data, and (2) develop a method for evaluation of the risks of allowing extended storage in the joint-use pool in Pueblo Reservoir based on real-time data during April and May of each year.

APPROACH: The approach will consist of several steps: (1) Evaluate the Precipitation-Runoff Modeling System, the National Weather Service River Forecast System (NWSRFS) model, or other appropriate models for applicability to the study and select the most appropriate model; (2) develop a data base of historic streamflow and climatologic data; (3) calibrate and verify the hydrologic model with independent data sets; and (4) couple the calibrated model with the extended streamflow prediction procedure to provide probabilistic estimates of future flood volumes and peak discharges on the Arkansas River at Pueblo Reservoir.

PROGRESS: The calibration component of the NWSRFS model was modified by personnel of the National Weather Service (NWS) to operate on the Prime computer. Mean area temperature (MAT) and mean areal precipitation (MAP) time-series data were developed for the Arkansas River upstream from Wellsville. Reservoir contents and transmountain-imports data also were compiled for the basin upstream from Wellsville. The model and the input data files were loaded onto the Colorado District's computer. Calibration of the model has begun and is being done simultaneously in the Pueblo Subdistrict Office and in the Tulsa, Oklahoma, and Silver Springs, Maryland, offices of the NWS.

PLANS FOR FY 91: Calibration of the model will continue. After several subbasins have been calibrated, the model variables will be analyzed to develop consistent regional variables. MAT and MAP time-series data will be developed for the basin downstream from Wellsville followed by calibration of that area. The extended streamflow prediction procedure will be used in conjunction with the calibrated model to analyze risk associated with April 15 to May 15 storage in the joint-use pool.



PROJECT TITLE: National Water Summary Report Preparation Center

PROJECT NUMBER: CO-89-235

STUDY LOCATION: Nationwide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: John S. Williams, District Office, Denver

PROJECT DURATION: October 1988 to September 1991

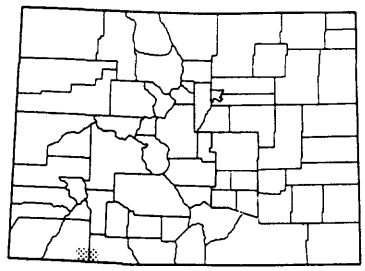
PROBLEM: Continued growth in the scope, complexity, and size of the National Water Summary (NWS) reports have made editorial and technical support and State-report management outside of Headquarters necessary in order to produce quality reports in a timely manner.

OBJECTIVES: Review, revise, and quality assure NWS State reports and coordinate the manuscript-preparation process. In cooperation with Headquarters Branch of National Water Summary (BNWS) personnel, assist in the design and layout of the NWS "front part," prepare specifications for front-part illustrations, and carry out their production. Participate in the conceptualization and design of future NWS reports.

APPROACH: Colorado District Graphics Unit personnel assist BNWS Headquarters personnel in the design of the NWS front-part illustrations. The principal Colorado NWS project illustrator prepares the specifications for front-part illustrations and upon their approval by Headquarters prepares the front-part mockups and final figures using traditional and digital techniques. State-report manuscripts are submitted to the Colorado NWS Report Preparation Center for review, revision, preparation for Director approval and, subsequently, for final revision and transmission to the USGS Cartographic and Publication Project (CAPP) in Madison, Wisconsin. The Colorado Report Preparation Center coordinates and tracks the entire manuscript-preparation process prior to transmission of the manuscripts to the CAPP.

PROGRESS: The Colorado Graphics Unit produced many of the State-report illustrations and most of the front-part illustrations for the 1987 NWS report using primarily traditional methods. The principal illustrator and the Colorado Graphics Unit Chief subsequently developed techniques whereby future front-end illustrations can be produced digitally, thus, greatly decreasing total production time and expense. All nonphotographic front-end illustrations for the 1988-89 NWS report will be produced in this manner. Specifications for the illustrations have been approved by Headquarters. State-report manuscript-preparation personnel, in conjunction with the senior State-report editor in Helena, Montana, completed the review and revision of most of the 1988-89 State reports. Colorado NWS project members assisted in the design, review, and preparation of the 1990-91 NWS State-report prototypes.

PLANS FOR FY 91: Most front-end illustrations for the 1988-89 NWS report will be completed. Review and revision of the 1988-89 and 1990-91 NWS State reports will be completed, and the reports will be transmitted to the CAPP. Planning and design of the 1992-93 NWS report will begin.



PROJECT TITLE: U.S. Department of the Interior Irrigation-Drainage Reconnaissance of the Pine River Area, Southern Ute Indian Reservation, Southwestern Colorado

PROJECT NUMBER: CO-89-236

STUDY LOCATION: Ignacio, Colorado

COOPERATING AGENCY: U.S. Department of the Interior, Office of the Secretary

PROJECT CHIEF AND OFFICE: David L. Butler, Subdistrict Office, Grand Junction

PROJECT DURATION: October 1988 to September 1991

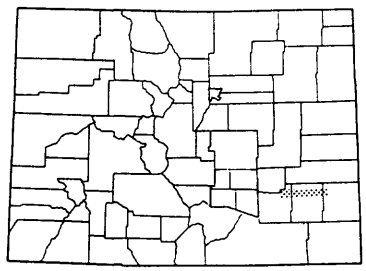
PROBLEM: Large concentrations of selenium have been reported in the ground water on parts of the Southern Ute Indian Reservation in southwestern Colorado. These areas also receive irrigation water from the U.S. Bureau of Reclamation's Pine River project. A documented case of human selenium poisoning caused by drinking well water occurred in 1962. Reports of occasional poisoning of horses and livestock are reported on the Reservation. Application of irrigation water to land containing large quantities of selenium could transport selenium into the ground-water system and to streams receiving drainage water. The Pine River area was selected for a reconnaissance-level investigation by an interbureau task group from the Department of the Interior (DOI) to identify water-quality problems that may be caused by irrigation drainage from projects constructed or managed by the Department of the Interior.

OBJECTIVE: The objective is to determine if water from the Pine River project is contributing selenium, other trace elements, and pesticides to water, bottom sediment, and biota in watersheds draining the project area on the Southern Ute Indian Reservation.

APPROACH: Collect water-quality samples for major ion and selected trace-element analysis from 17 stream sites and 5 wells. Streams will be sampled after, prior to, and during the irrigation season. Wells will be sampled during winter and summer. Outflow sites will be sampled during summer for herbicides. Selected outflow sites and Navajo Reservoir will be sampled for bottom sediments, trace elements, and pesticides. Biota sampling for birds, fish, invertebrates, and aquatic plants will be done during three surveys. Biota sampling and analysis will be done by the U.S. Fish and Wildlife Service

PROGRESS: The first draft of the report is complete. The introductory section and all interpretive sections except the biota section are written. Data interpretation of the biota data (U.S. Fish and Wildlife Service) was not begun until late in the year because of a delay in laboratory analysis of the biota samples. Project is complete except for report.

PLANS FOR FY 91: Complete the first draft of the report and publish the final report.



PROJECT TITLE: Conjunctive Water Use and Canal-Seepage Losses in an Extensive Irrigation System, Southeastern Colorado

PROJECT NUMBER: CO-89-238

STUDY LOCATION: Southeastern Colorado, Arkansas River between La Junta and Lamar, Colorado

COOPERATING AGENCY: Bent County Board of County Commissioners

PROJECT CHIEF AND OFFICE: Russell G. Dash, Subdistrict Office, Pueblo

PROJECT DURATION: August 1988 to October 1992

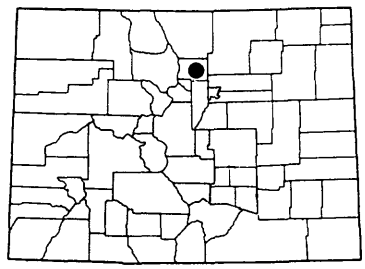
PROBLEM: Land overlying the alluvium of the Arkansas River in southeastern Colorado has been extensively irrigated for more than a century. Rapid changes in the sources and patterns of water use occurred following the completion of the Fryingpan-Arkansas Project by the U.S. Bureau of Reclamation during the 1970's. In addition to providing transmountain water to supplement native surface water, substantial upstream reservoir storage was added that provided a new dimension to irrigation along the Arkansas River. Estimates of water use from hydrologic studies done by the U.S. Geological Survey during the 1960's and early 1970's no longer may be valid. Quantification of present-day water use for lands under irrigation by the Fort Lyon Canal, the largest canal system in southeastern Colorado, would enable better present-day and future management of water resources in the area.

OBJECTIVE: Estimate the quantity of surface-water use, ground-water use, canal-seepage losses, and areal crop consumptive use for an extensive irrigation system in southeastern Colorado.

APPROACH: Surface-water use will be estimated from analysis of diversion records for the canal and storage reservoirs that comprise the irrigation system. Ground-water use will be estimated from analysis of power-delivery records and power-consumption coefficients determined at irrigation wells distributed throughout the irrigation system. Canal-seepage losses will be estimated by analysis of instantaneous discharge measurements and flow volumes at gaging stations along the canal during nonirrigation periods. Areal crop consumptive use will be estimated for the irrigation system using the Blaney-Criddle technique.

PROGRESS: Hydrologic data collection continued on schedule at surface-water stations and ground-water sites during the year. Surface-water records collected at four canal gaging stations during the 1988 and 1989 water years were published in the Colorado 1989 annual data report. Power coefficients to estimate pumpage were determined at about 50 percent of the ground-water sites developed in the shallow alluvial aquifer under Fort Lyon Canal irrigated land. Formats for data presentations and analyses were selected to estimate irrigation water use. A data base was assembled with irrigated-acreage and crop-type data for calculation of consumptive use.

PLANS FOR FY 91: Planned data collected at the surface- and ground-water networks will be completed by December 1990. Additional surface-water measurements and another gain-loss investigation will be made under the proper flow conditions. These data will improve the understanding of canal transport characteristics. Data collected during the 1989 and 1990 irrigation seasons will be collated as they become available and prepared for statistical and graphical analysis. Results will be interpreted and the report will be prepared and submitted for review.



PROJECT TITLE: Alluvial-Aquifer Surface-Water Interactions in Riparian Ecosystems

PROJECT NUMBER: CO-89-242

STUDY LOCATION: Cottonwood Grove Open Space, along Boulder Creek near Boulder, Colorado

COOPERATING AGENCY: City of Boulder, Colorado

PROJECT CHIEF AND OFFICE: Robert A. Kimbrough, District Office, Denver

PROJECT DURATION: August 1989 to September 1992

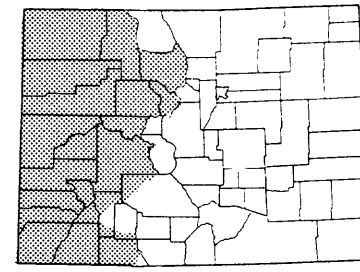
PROBLEM: Riparian vegetation, primarily cottonwoods, are not reproducing along Boulder Creek near the City of Boulder, Colorado. Flows in Boulder Creek have been altered from historic levels; thus, surface-water recharge to adjacent alluvial aquifers may have changed. Before the effect of human-induced changes on riparian vegetation can be determined, the baseline hydrologic conditions need to be understood.

OBJECTIVE: Establish the relation between the alluvial aquifer and surface water for a relatively undisturbed riparian study area. Describe alluvial-aquifer fluctuations in areas of riparian vegetation.

APPROACH: Transects of wells have been completed in the alluvial aquifer underlying selected riparian vegetation groups. A streamflow-gaging station has been established to monitor flow in Boulder Creek. Alluvial-aquifer hydrographs will be constructed using water-level measurements. Models will be used to evaluate ground-water surface-water relations.

PROGRESS: Physical properties of the aquifer have been evaluated using a modular finite-difference ground-water flow model. Water table maps have been constructed from well measurements. A continuous record of streamflow has been computed from data collected at the streaflow gage.

PLANS FOR FY 91: Monitoring of wells and streamflow will continue. Continuous recorders will be placed on certain wells to determine the extent of recharge to the aquifer during high flows.



PROJECT TITLE: Hydrogeologic Characteristics of Bedrock Aquifers in Western Colorado

PROJECT NUMBER: CO-90-243

STUDY LOCATION: Colorado west of the Continental Divide

COOPERATING AGENCY: Colorado Water Conservation Board

PROJECT CHIEF AND OFFICE: Edward R. Banta, District Office, Denver

PROJECT DURATION: FY 1990 through FY 1992

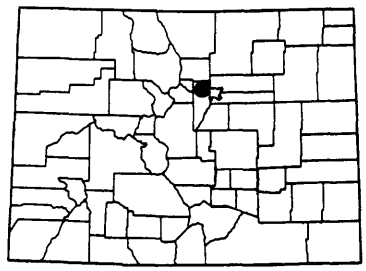
PROBLEM: The ground-water resources west of the Continental Divide in Colorado have been underutilized because of the general abundance of surface water and lack of knowledge of the aquifer systems. Great potential exists for development of the resource, however, and Federal and State agencies are faced with many concerns relative to assessing, administering, and managing those ground-water resources. Developers, administrators, and managers have had to deal with highly disorganized and scattered sources of basic data for wells and published and unpublished interpretive information. An organized method for identifying sources of data and information concerning the ground-water resources of western Colorado is lacking.

OBJECTIVE: The project will be directed toward identifying, referencing, and indexing existing basic-data files, basic-data reports, interpretive reports, and maps that may be useful in understanding the geohydrology of the aquifers of western Colorado. To fulfill this goal, this project will result in a report and a computerized bibliography system designed to direct readers or users who need information in an efficient way.

APPROACH: Two principal components of this project are planned. The first component is the preparation of a report that will be an indexed bibliography of about 1,000 to 2,000 publications related to the geohydrology of western Colorado. The second component of the project is the preparation of a computerized bibliography system. The computerized system will be an automated, expandable version of the bibliography report. References will be entered into the system with a basic level of detail to allow for generalized retrieval of references, and a subset of these will be described in greater detail to allow retrievals using more specific search strategies. Retrievals of reference information from the computerized system will be done using a commercially available data-base management system and FORTRAN programs.

PROGRESS: Structuring the framework of the basic computerized bibliography system has been done. About 900 references have been identified and entered into the basic system. FORTRAN programs to output the references in a format approximating U.S. Geological Survey style have been written.

PLANS FOR FY 91: Continue to identify references to be entered into the basic system and select a subset to be described in greater detail. Structure data-base files to accommodate the two levels of detail and allow for efficient retrieval strategies. Collect and enter all reference information into the system.



PROJECT TITLE: The Relation of Nutrients and Algae in Standley Lake with Taste and Odor Problems in Drinking-Water Withdrawals

PROJECT NUMBER: CO-90-244

STUDY LOCATION: Standley Lake, about 10 miles northwest of Denver

COOPERATING AGENCIES: The cities of Arvada, Golden, Northglenn, Thornton, and Westminster, and Jefferson County.

PROJECT CHIEF AND OFFICE: David K. Mueller, District Office, Denver

PROJECT DURATION: June 1989 to September 1991

PROBLEM: Standley Lake provides water for the cities of Northglenn, Thornton, and Westminster. In the past, periodic taste and odor problems have developed in water supplied from the lake. Based on previous studies, the cities determined that the taste and odor problems were related to phytoplankton growing in the lake, and that this growth could be controlled by regulating the phosphorus concentration in the lake. They petitioned the Colorado Water Quality Control Commission to set a phosphorus standard for the lake. This action was opposed by managers of the cities of Arvada and Golden and by Jefferson County, who potentially would be required to meet phosphorus control regulations under the standard. The Commission deferred a decision until the parties could develop the information necessary to determine an appropriate standard. The parties requested that the U.S. Geological Survey do a study, because the Agency has no advocacy position in the phosphorus-standard dispute.

OBJECTIVES: (1) Determine the condition of Standley Lake regarding nutrient dynamics, types and densities of phytoplankton and zooplankton, and processes that may affect nutrient availability, algal growth, or the occurrence of taste and odor problems; (2) quantify the nutrient loading to Standley Lake from inflow sources; (3) determine whether internal cycling from bottom sediment in Standley Lake may be a significant source of nutrients to the lake; (4) determine whether the availability of phosphorus limits algal growth in Standley Lake; and (5) determine the compounds responsible for taste and odor problems in water delivered from Standley Lake and the potential sources of these compounds.

APPROACH: Samples will be collected from two sites at Standley Lake. Profiles of temperature, pH, specific conductance, and dissolved oxygen will be measured at each site every time a sample is collected. Transparency will be measured using a Secchi disk. Integrated samples will be collected through the photic zone, defined as twice the Secchi-disk depth. Grab samples also will be collected from near the bottom. All samples will be analyzed for nutrients. Samples collected from the photic zone will be analyzed for chlorophyll *a* and phytoplankton. Zooplankton samples will be collected at each site using a vertical tow from near the bottom to the surface. Samples of periphyton will be collected during the months of August through October from natural and artificial substrates at sites near the dam and the major inflows. Samples will be collected from three inflow sites and one outflow site. Sampling will concentrate on periods of maximum nutrient loading--including runoff and storm events. Samples will be analyzed for nutrients, total organic carbon, and suspended solids. Monthly nutrient loadings will be computed.

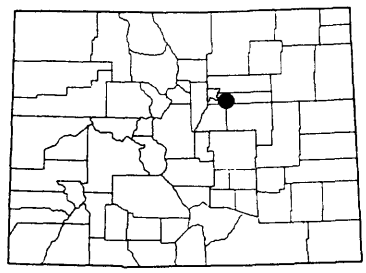
Potential flux from the sediment will be determined by computing the gradients of constituents in pore water. Sediment cores will be collected at several lake sites. Sections of the core will be removed at 1-centimeter intervals, and the pore water will be extracted by centrifuging. A sample of the overlying lake water, as close as possible to the bottom also will be collected. Each sample will be analyzed for concentrations of nutrients and trace elements. The sediment itself will be characterized by analysis of dredge samples collected at 10 locations in the lake, including the core-sampling sites.

In-situ microcosms and mesocosms will be used to test the algal response to phosphorus and nitrogen additions in the lake. The microcosms will consist of 10-liter sealed containers suspended in the lake at one-half the Secchi-disk depth. The mesocosms will be constructed of 1-meter-diameter polyethylene tubing, closed at the bottom, and long enough to extend through the photic zone. Treatments will include a control, a phosphorus addition, a nitrogen addition, and a combined phosphorus and nitrogen addition. Microcosms will be incubated for 4 days following nutrient addition and sampled at the end of this period. Mesocosms will be incubated for 7 days. Samples will be analyzed for concentrations of nutrients, chlorophyll *a*, and phytoplankton.

Samples from the lake, the inflow, and the outflow will be analyzed for organic compounds known to cause taste and odor problems. Algae will be cultured from samples, and then actinomycetes bacteria will be cultured from the algae. All cultures will be analyzed for taste and odor-producing compounds.

PROGRESS: All samples were collected during June 1989 through October 1990. Pore-water extractions were made from two sites in August and October 1989, from five sites in May 1990, and from three sites in August 1990. Monthly nutrient fluxes were estimated for water-year 1990 and compared to loading from inflow sources. Nutrient-limitation tests were made four times in 1989 and twice in 1990. The mesocosm test was completely successful only once but provided a comparison to determine the adequacy of the microcosm results. Samples for taste and odor constituents and culturing were collected once in 1989 and twice in 1990, but no taste and odor problems occurred during the study.

PLANS FOR FY 91: All data will be tabulated and data analyses completed. Two reports will be written, one presenting the data and the other presenting the interpretation. The reports will be given to the cooperating agencies during the spring. Results of the study will be presented to the Colorado Water Quality Control Commission in September.



PROJECT TITLE: The Effects of Leachate from Sewage-Sludge-Disposal Areas on Ground-Water Quality

PROJECT NUMBER: CO-90-245

STUDY LOCATION: Parts of Senac Creek and Coal Creek basins, Arapahoe County, Colorado

COOPERATING AGENCY: Metro Wastewater Reclamation District

PROJECT CHIEF AND OFFICE: Neville Gaggiani, District Office, Denver

PROJECT DURATION: October 1989 through September 1994

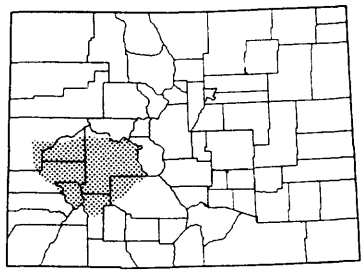
PROBLEM: From 1969 to 1986, the Metro Wastewater Reclamation District, (formerly, the Metropolitan Denver Sewage Disposal District) disposed of about 233,000 dry tons of sewage sludge by burial or incorporation into soil at a 1,280-acre site about 15 miles southeast of Denver, Colorado. Movement of leachate from the sewage sludge in the soil could degrade the alluvial ground water and surface-water runoff. Also, a new reservoir upstream from the study area could recharge the ground water, move the contaminants, and alter streamflow patterns.

OBJECTIVES: To determine the (1) movement of nitrite plus nitrate in the alluvial ground water outside of the disposal site, (2) long-term distribution and trends of water quality within the disposal site, (3) general distribution of organic compounds in soil and ground water within the disposal site, and (4) hydrologic effects of Aurora Reservoir on the alluvial and bedrock aquifers.

APPROACH: Ground water will be sampled three times per year from 15 wells at the boundary and outside of the disposal site and once per year from 15 wells inside the disposal site. Maps will be used to show changes in nitrate concentrations with time and estimate the rate of nitrate movement in the alluvial aquifer. Surface-water levels will be recorded and surface water will be sampled at the gage on Senac Creek. Ground-water and soil samples for organic analyses will be obtained from 12 wells and 7 soil sites. Ground-water levels in the alluvial and bedrock aquifers will be monitored.

PROGRESS: Water levels in the observation wells were measured monthly and indicated that levels generally rise in the spring and decline in the summer and fall. Water-level recorders were operated on the alluvial and bedrock wells downstream from the new reservoir. Water-quality samples were collected from the observation wells. Nitrate concentrations larger than 10 milligrams per liter were measured in the alluvial ground water. During the year, surface-water samples were collected at Senac Creek for chemical analysis. Selected ground-water and soil samples were analyzed for semivolatile organic compounds. Samples for organic analysis were sent to the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo., and to the Metro Wastewater Reclamation District laboratory.

PLANS FOR FY 91: Water samples for inorganic analyses will be collected from the observation wells. Water levels will be measured monthly at the observation wells, and water-level recorders will record hourly water levels in the alluvial and bedrock wells downstream from the new reservoir.



PROJECT TITLE: Assessment of Effects of Potential Climate Change on the Hydrology of the Gunnison River Basin

PROJECT NUMBER: CO-90-246

STUDY LOCATION: Gunnison River basin, Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Randolph S. Parker, District Office, Denver

PROJECT DURATION: October 1990 through September 1994

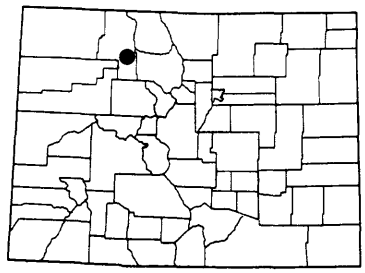
PROBLEM: Changes in climate that result from increasing concentrations of atmospheric carbon dioxide and other trace gases may alter various hydrologic processes in the drainage basins of the Rocky Mountains. Changes in these processes will affect snowpack accumulation and melt, evapotranspiration, streamflow, and recharge to subsurface storage. The Gunnison River drainage basin is a large contributor of water in the Colorado River system and has similar attributes to many basins in the Rocky Mountain region. An effort is needed to improve the understanding of the sensitivity of the Rocky Mountain region's water resources to the potential effects of climate change.

OBJECTIVES: The general objectives of this study are: (1) Identify the sensitivity of the water resource of the Gunnison River basin, including the hydrologic response to reasonable scenarios of climate variation and (2) develop techniques useful in assessing the water resource with changes in climate.

APPROACH: The study has been divided into the following work categories: (1) Developing climate scenarios, (2) using streamflow modeling (watershed and routing/accounting models), (3) assessing water use and water rights, (4) identifying the effect of changes in streamflow to other processes such as sediment transport, and (5) utilizing geographic information systems (GIS) and remote sensing.

PROGRESS: To date, no research has been done within the study. A work plan has been developed and committees established to develop communication among researchers doing parallel work in the Rocky Mountain region.

PLANS FOR FY 91: Climatic and streamflow data will be compiled, and quality control of the data base being assembled will be done that includes identification of length of records, missing records, and periods of non-stationarity. Analysis of climatic record will include the examination of spatial properties of the air temperature and precipitation data. Analysis of monthly streamflows will help identify subbasins to be modeled using watershed models.



PROJECT TITLE: Water-Quality and Sediment Characteristics of the Upper Yampa River and Stagecoach Reservoir, Northwestern Colorado

PROJECT NUMBER: CO-90-247

STUDY LOCATION: Stagecoach Reservoir on the Yampa River approximately 18 miles south of Steamboat Springs, Colorado

COOPERATING AGENCY: Upper Yampa Water Conservancy District

PROJECT CHIEF AND OFFICE: Robert L. Tobin, Field Headquarters, Meeker

PROJECT DURATION: October 1989 through September 1993

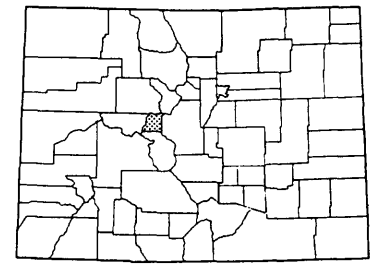
PROBLEM: Water-quality and sediment characteristics of streamflow discharged from Stagecoach Reservoir may be substantially different from streamflow that entered the reservoir. To measure, assess, and manage the potential changes, a comprehensive monitoring plan was developed. The plan lists required data collections to determine the physical, chemical, and biological characteristics of water contained within the reservoir and at streamflow sites upstream and downstream from the reservoir. The implementation of the monitoring program for the Stagecoach Reservoir Project will provide information necessary for the effective management of fish habitats. It also can be used to fulfill the requirements of the Corps of Engineers for granting of a 404 Permit.

OBJECTIVES: (1) To evaluate, report, and interpret data on the physical, chemical, and biological processes in Stagecoach Reservoir; (2) to collate and analyze data to assess potential changes in water quality from streamflow sites upstream and downstream from the reservoir; and (3) to estimate sediment loads in the Yampa River upstream and downstream from Stagecoach Reservoir and provide estimates of sediment retention and volume displacement in the reservoir.

APPROACH: Two or three sampling sites will be established for Stagecoach Reservoir to define the lateral distribution of physical, chemical, and biological constituents. Vertical changes in water-quality characteristics will be determined monthly from Secchi-disk and continuous profile measurements with depth of temperature, specific conductance, pH, and dissolved oxygen at all sites from April through October. Samples for laboratory analyses of biochemical oxygen demand and concentrations of dissolved and total nutrients, major ions, trace constituents, bacteria, and phytoplankton will be analyzed from water samples collected from the near surface and near-bottom depths at the dam and inflow sites. Data from streamflow-gaging stations upstream and downstream from the reservoir will be reviewed for changes in water-quality and sediment characteristics. Suspended-sediment data and water-discharge measurements will be compiled for gaging stations upstream and downstream from the reservoir. The information will be used to estimate sediment loads in the Yampa River upstream and downstream from the reservoir. The information from the load computations and the suspended-solids distribution in the reservoir will be used to measure sediment-retention rates in Stagecoach Reservoir. An interpretive report that describes the physical, chemical, and biological processes in the reservoir will be written. The report also will contain results of sediment-load calculations for streamflow to and from the reservoir and desiment-retention rates for the reservoir.

PROGRESS: Water-quality and sediment samples were collected from a range of discharge at streamflow sites upstream and downstream from the reservoir. Depth-related onsite measurements and water-quality and biological samples were collected monthly at two sites in Stagecoach Reservoir from April to September. Algae blooms of mostly *Aphanizomenon flos-aguae* were common at near-surface depths, and anaerobic conditions existed below 30 feet during summer.

PLANS FOR FY 91: Continue onsite measurements and collect samples for laboratory analyses. Compile and analyze data and modify sample collections, as needed.



PROJECT TITLE: Upper Arkansas River Metal Loads

PROJECT NUMBER: CO-90-248

STUDY LOCATION: Lake County, Colorado

COOPERATING AGENCY: Multiple agencies

PROJECT CHIEF AND OFFICE: Katherine Walton-Day, District Office, Denver

PROJECT DURATION: June 1990 through September 1993

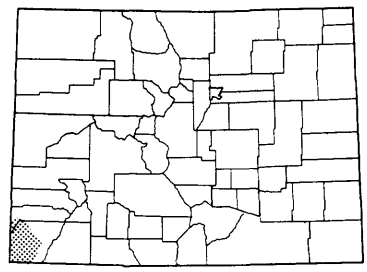
PROBLEM: Metal-rich water is discharged from abandoned mines in the Leadville, Colorado, area. These mines are point sources of metal loading to the headwaters of the Arkansas River. Nonpoint sources of metals from diffuse inflows draining alluvial accumulations of tailings and slag material might contribute metals to the Arkansas River. Remedial action in the mined areas might eliminate point-source contamination, but nonpoint sources may contribute metals to the Arkansas River indefinitely, and this nonpoint source has not been quantified. Solute loads often are calculated by regressing instantaneous solute load against daily values of streamflow. Application of this approach to the calculation of metal loads presents major difficulties due to the temporal variability of metal concentrations and the reactive transport of metals. Determination of metal loads requires a method that incorporates this variability and reactivity of metals, yet no method has been developed that incorporates these factors to determine metal loads.

OBJECTIVE: Develop a method for accurate determination of metal loads in the upper Arkansas River.

APPROACH: Development of the method to accurately determine metal loads will incorporate data from a network of streamflow gages where continuous record of streamflow, pH, conductivity, and temperature will be obtained. Water samples will be collected weekly and more frequently during runoff events by Leadville-based observers at the streamflow gages. Samples will be analyzed for concentrations of major ions and selected trace metals. Multiple-regression analysis will be used to relate instantaneous metals loads to variables such as streamflow, pH, and specific conductance.

PROGRESS: Three streamflow gages equipped with three-parameter minimonitors were installed in April and May 1990. Data collection at these gages is currently underway. The construction of the data-collection network and coordination of field efforts with cooperators, the Pueblo Subdistrict office, and the U.S. Environmental Protection Agency are in progress. Because of funding shortfalls, the objective of determining nonpoint-source metal contributions, based on synoptic sampling, has been deleted.

PLANS FOR FY 91: Operation of streamflow gages and mini-monitors will continue. Sampling at streamflow gages will be done weekly and at more frequent times to define snowmelt and storm events.



PROJECT TITLE: U.S. Department of the Interior Irrigation Drainage Reconnaissance Investigation of the Dolores Project, Southwestern Colorado

PROJECT NUMBER: CO-90-250

STUDY LOCATION: Southwestern Colorado, southeastern Utah

COOPERATING AGENCY: U.S. Department of the Interior, Office of the Secretary

PROJECT CHIEF AND OFFICE: David L. Butler, Subdistrict Office, Grand Junction

PROJECT DURATION: April 1990 through March 1992

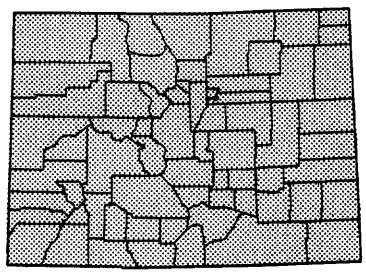
PROBLEM: The U.S. Department of the Interior (DOI) has done a series of studies that were initiated in 1986 to determine if irrigation from projects with Federal involvement have caused or have the potential to cause harmful effects on human health, fish and wildlife, or could adversely affect the suitability of water for beneficial uses. The Dolores Project, located in southwestern Colorado, was selected for a reconnaissance investigation in 1990 by the DOI Irrigation Drainage Program because the project may affect water quality of the San Juan River. There were indications that occasional increased concentrations of selenium and other trace elements have occurred in the San Juan River downstream from the project area. Long-term irrigation in the Montezuma Valley has adversely affected water quality in the McElmo Creek basin. Biological information collected by the Bureau of Reclamation and the U.S. Fish and Wildlife Service indicated that the Dolores Project may be transporting mercury from the Dolores River basin into the irrigated areas.

OBJECTIVES: Determine if water from the Dolores Project area is contributing selenium, other trace elements, and pesticides to water, bottom sediment, and biota in watersheds draining irrigated land. Effects from long-term irrigation in the Montezuma Valley and effects from new lands brought recently into irrigation will be addressed. A second objective is to gather background information that may be used to determine future effects of irrigation drainage from previously nonirrigated land.

APPROACH: The U.S. Geological Survey has responsibility for collection of water and bottom-sediment samples for the DOI studies. Water-quality data will be collected at 21 stream and canal sites, 1 well, and 3 reservoirs. The sampling program is designed to collect data in areas presently irrigated or that will be irrigated once all features of the Dolores Project are completed. Sites located outside the Dolores Project will be used as background sites. Samples will be collected three times in 1990: (1) Pre-irrigation season (March-April); (2) irrigation season (July); and (3) post-irrigation season (November). Samples will be analyzed for concentrations of major ions, dissolved solids, nitrate, and 14 trace elements, including arsenic, mercury and selenium. At 14 sites, water samples will be collected in July for analysis of concentrations of herbicides (2,4-D, picloram) and organophosphate insecticides. Bottom-sediment samples will be collected at 18 sites in November for analysis of concentrations of trace elements (Geologic Division laboratory) and for organochlorine pesticides and PCB's. Results for water and bottom-sediment samples will be reviewed in conjunction with the biological data collected by the U.S. Fish and Wildlife Service to determine problem areas or potential problem areas associated with irrigation drainage from the Dolores Project area.

PROGRESS: Water-quality sampling for the pre-irrigation season was completed in late March and April. The U.S. Fish and Wildlife Service collected biota samples. Analytical results (except uranium) for water samples are completed and have been reviewed for quality assurance. Samples collected last spring represented low-flow conditions; specific conductance at many sites exceeded 2,000 microsiemens per centimeter at 25 degrees Celsius, and sulfate exceeded 1,000 milligrams per liter. Selenium exceeded 10 micrograms per liter (µg/L) in three samples, including two samples collected in new irrigated areas. The most degraded water quality associated with irrigation drainage was sampled at Navajo Wash near Towaoc; selenium concentration was 38 µg/L in late March. Samples from McElmo Creek had 2 to 8 µg/L of selenium and 200 to 300 µg/L of boron. The second set of water-quality samples were collected during the irrigation season in July and included collection of herbicide samples at 14 sites.

PLANS FOR FY 91: Collect the post-irrigation season water-quality samples in November. Bottom-sediment samples are to be collected at 17 sites. Chemical results will be reviewed as the laboratory analyses become available. All introductory sections of the report will be written. Once all analytical data (water and bottom sediment) have been reviewed and verified, writing of the interpretive sections of the report will begin. Preparation of maps, illustrations, and tables for the report will be completed. The U.S. Fish and Wildlife Service will collect biota samples in November and will be responsible for interpretation of biota data for the project.



PROJECT TITLE: Evaluation of Potential Bridge Scour in Colorado

PROJECT NUMBER: CO-90-251

STUDY LOCATION: Statewide

COOPERATING AGENCY: Colorado Department of Highways

PROJECT CHIEF AND OFFICE: Jerry E. Vaill, Subdistrict Office, Grand Junction

PROJECT DURATION: July 1990 through September 1991

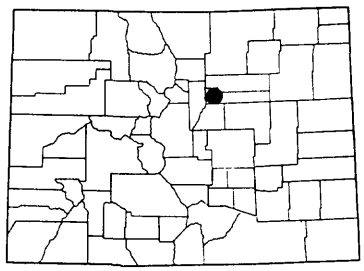
PROBLEM: The Federal Highway Administration has established a requirement that all State highway agencies evaluate bridges on the Federal Aid system for susceptibility of scour-related failures. In the State of Colorado, there are about 1,600 State-owned bridges that cross waterways. With such a large number of bridges that need to be evaluated as to their vulnerability to damage or failure from scour and the limited resources to repair or replace them, a need exists for a procedure to evaluate and identify bridges that are scour susceptible.

OBJECTIVES: Develop a procedure to evaluate the potential for scour at bridges in Colorado and identify those structures that are most susceptible to scour. Provide hydraulic information so that the Colorado Department of Highways (CDOH) may develop and implement scour countermeasures.

APPROACH: Perform field assessments of bridges from a list provided by CDOH as those ranked most susceptible to scour. Rank sites according to procedure developed by the U.S. Geological Survey and select sites considered most susceptible to scour for hydraulic evaluation. Install an INFO data-base management system for inclusion of scour data. Measure scour at a limited number of sites to use in scour-equation comparisons.

PROGRESS: Field assessments of 30 sites have been completed. Bridges have been ranked from a list of variables developed by the U.S. Geological Survey and compared to a ranking system provided by CDOH. Preliminary sites have been selected for hydraulic analysis. A data-base system from South Carolina has been installed and is being modified for use in Colorado. Hydraulic evaluations for two sites were completed in FY 90.

PLANS FOR FY 91: Complete field assessments for the remaining 170 sites on the CDOH list. Complete hydraulic evaluations for 48 sites to be selected from the 200 field assessments. Measure scour depths at a limited number of sites during significant runoff events. Input data into the INFO data base.



PROJECT TITLE: Surface-Water and Ground-Water Monitoring and Evaluation at the Rocky Mountain Arsenal

PROJECT NUMBER: CO-90-252

STUDY LOCATION: Rocky Mountain Arsenal and vicinity, Adams County, Colorado

COOPERATING AGENCY: U.S. Department of the Army, Program Manager, Rocky Mountain Arsenal

PROJECT CHIEF AND OFFICE: Robert F. Middelburg, District Office, Denver

PROJECT DURATION: August 1990 and continuing

PROBLEM: Because of increased activities, the Program Manager, Rocky Mountain Arsenal (PMRMA), U.S. Army Material Command, needs assistance in managing and evaluating the surface-water and ground-water elements of the Comprehensive Monitoring Program (CMP). The water-management program at Rocky Mountain Arsenal requires a comprehensive data-collection network for proper implementation and evaluation. In addition, the effects on water resources from offsite activities and planned development on Arsenal cleanup activities may require supplemental information and evaluation.

OBJECTIVES: The objectives of this project are to: (1) Provide guidance, review, and technical assistance for ground-water investigations designed to estimate the effect of offsite activities and onsite remedial actions on ground-water flow, ground-water-quality contaminant migration, and the relation between surface water and ground water to meet the needs of Feasibility Studies (FS); (2) evaluate the current surface-water and ground-water monitoring elements of the CMP and assist with the development of a long-term monitoring strategy to meet the needs of the RMA contamination cleanup; (3) develop and undertake hydrologic investigations associated with chemical transport in surface water and ground water at Rocky Mountain Arsenal; and (4) design, construct, equip, and operate gaging stations, as needed, to meet the objectives of the CMP.

APPROACH: For FY 90, 91 phases: This multiyear project will consist of multiple tasks designed to provide the PMRMA with hydrologic monitoring and assessment to evaluate and support water-management and contamination-cleanup efforts. Work began in FY 90 and consisted of initial planning, consultation, and coordination of U.S. Geological Survey (USGS) water-resources activities at RMA. Evaluation and consultation will begin in FY 91 and continue as long as deemed necessary by the PMRMA. The USGS will provide the PMRMA with the services of two scientists--one that has expertise in surface water and water quality and one that has expertise in ground-water modeling and data collection. The individuals will be assigned to the Colorado District, Denver, Colorado, but their project station will be at RMA. The scientists will be responsible for evaluating surface-water and ground-water monitoring at RMA and developing comprehensive surface-water and ground-water monitoring strategies. In addition, the scientists will provide consultation services to PMRMA staff, as needed, to include liaison and coordination of RMA activities with the Colorado District management. The USGS also will provide technical advisors and technician support to meet the objectives of this project.

PLANS FOR FY 91: Test ground-water model calibrations. Review wetlands activities being established at the Arsenal. Recommend and develop a hydrologic monitoring program of surface-water flows, lakes, and wetlands using satellite telemetry, where applicable. Develop proposals and work-plans for interpretive studies of the regional ground-water systems.

PROJECT TITLE: Methane Ground-Water Contamination in the Animas River Valley

PROJECT NUMBER: CO-91-253

STUDY LOCATION: Animas River Valley between Durango, Colorado, and Aztec, New Mexico

COOPERATING AGENCIES: Colorado Department of Natural Resources, Oil and Gas Conservation Commission; Southern Ute Tribal Council, La Plata County

PROJECT CHIEF AND OFFICE: Daniel T. Chafin, Field Headquarters, Durango

PROJECT DURATION: June 1990 to September 1992

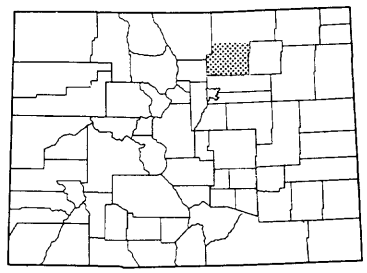
PROBLEM: Water from household wells in some areas of the Animas River Valley contains elevated concentrations of methane. The methane in shallow ground water may have originated from degradation of organic material near the land surface or it may have moved upward along natural pathways from deep underground reservoirs of natural gas. Commercial exploration and production of oil, natural gas, and coalbed gas also may have created pathways for upward movement of methane. The source of the methane and the mechanisms for methane movement to the ground water, and within the ground water, must be better understood before proper remedial and preventative procedures can be established.

OBJECTIVES: Map the occurrence of methane in shallow ground water. Assess the current chemical quality of potable ground water and evaluate the potential for contamination by communication with other deeper, formation waters. Attempt to differentiate between areas of increased gas concentrations that result from leaking oil and gas wells and areas of gas concentrations that result from upward movement through geologic units and fractures.

APPROACH: Sample household wells to determine concentrations of methane and other water-quality constituents at selected sites. Compare areas of elevated methane concentrations to mapped geologic features and the distribution of oil and gas wells to assess possible relations. Collect samples from selected household wells and gas wells for isotopic analyses of methane to determine sources of ground-water methane.

PROGRESS: Household wells were sampled for methane and other water-quality constituents.

PLANS FOR FY 91: Methane-isotope samples will be collected from household wells and gas wells. Water-well, gas-well, and geologic information will be compiled, and interpretation of data will begin.



PROJECT TITLE: Effects of Agricultural Practices on Surface- and Ground-Water Quality near Greeley, Colorado

PROJECT NUMBER: CO-90-254

STUDY LOCATION: Weld County, Colorado

COOPERATING AGENCIES: U.S. Environmental Protection Agency (1991), Central Colorado Water Conservancy District (1992 and 1993)

PROJECT CHIEF AND OFFICE: Gregory M. Clark, District Office, Denver

PROJECT DURATION: August 1990 to September 1993

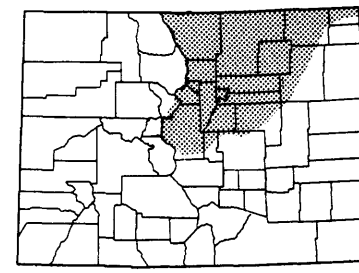
PROBLEM: Surface-water runoff and deep infiltration of water in agricultural areas are major sources of nonpoint pollution and contribute inorganic and organic contaminants to surface water and ground water throughout much of the United States. Studies indicate that past and present agricultural practices in large agricultural areas such as Weld County may affect water quality in the area. Use of low-input sustainable agricultural (LISA) practices has the potential to decrease effects on surface- and ground-water resources through decreased use of agricultural chemicals and more careful management of farming practices.

OBJECTIVES: Determine the current hydrology of surface water and ground water in the study area and document any changes in the chemical quality of the soil, subsoil, and surface and ground water near selected fields managed by sustainable and other agricultural practices.

APPROACH: The first phase will include instrumentation of selected fields and the collection of baseline hydrologic information over an area surrounding and including the selected fields. The second phase will include monitoring of the fields where current agricultural and sustainable practices have been incorporated. A statistical comparison then can be made to determine if agricultural practices have changed nonpoint-source effects on surface- and ground-water resources.

PROGRESS: Available data for the general study area have been gathered and compiled and include information concerning the geology, soil and crop types, surface- and ground-water relations, and water quality. The information is being presented to cooperating agencies prior to final field selection.

PLANS FOR FY 91: Specific fields will be selected and instrumented, and baseline hydrologic information will be collected.



PROJECT TITLE: Water-Quality Assessment of the South Platte Basin, Colorado, Wyoming, and Nebraska

PROJECT NUMBER: CO-91-255

STUDY LOCATION: Northeastern Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Kevin F. Dennehy, District Office, Denver

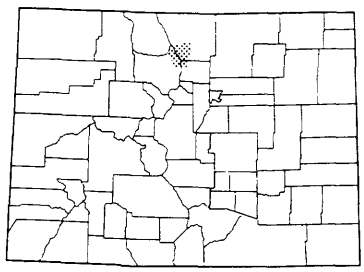
PROJECT DURATION: October 1990 to September 1996 (completion of initial intensive phase)

PROBLEM: Beginning in 1986, the Congress appropriated funds for the U.S. Geological Survey to test and refine concepts for a National Water-Quality Assessment (NAWQA) program. The long-term goals for a full-scale program are to provide a nationally consistent description of current water-quality resources, to define long-term trends in water quality, and to identify, describe, and explain, as possible, the major factors that affect observed conditions and trends in water quality. This information, obtained on a continuing basis, would be made available to water managers, policy makers, and the public to provide an improved scientific basis for evaluating the effectiveness of water-quality management programs and for predicting the likely effects of contemplated changes in land- and water-management practices. In fiscal year 1991, investigations of water-quality conditions will begin at 20 of the eventual 60 study units located across the Country. The South Platte basin will be one of the study units selected for this initial full-scale assessment.

OBJECTIVES: (1) To define existing water-quality conditions within the basin; (2) to determine magnitude and direction of temporal changes that have or could occur within the basin; (3) to identify current or potential water-quality problems; and (4) to develop understanding of the cause-effect relations and water-quality processes that are responsible for the present water-quality conditions within the basin.

APPROACH: This long-term investigation will be divided into various phases. The first phase of the project will concentrate on developing a work plan that will satisfy the objectives of this study and the national program. A liaison committee will be formed that is made up of various Federal, State, and local agencies that have an interest in the water-quality assessment of the South Platte basin. The committee will be informed of the U.S. Geological Survey program, coordination of potential field and interpretive work of respective agencies will be addressed, and water-quality issues of concern to each agency will be identified and discussed. The next phase of the study will be the compilation of available hydrologic information to include a wide array of physical, chemical, and biological properties and the interpretation and reporting of the results. The third phase will include the intensive data collection and interpretation part of the investigation that is to last for 3 years. Hydrologic, biologic, and water-quality information pertinent to fulfilling the study objectives will be collected through the use of fixed-station monitoring, synoptic surveys, and reach-intensive investigations. Ground-water quality will be examined by doing regional sampling for a wide array of water-quality constituents, targeted sampling in selected locations for specific groups of water-quality constituents, and by long-term sampling of selected wells. The final phase will be directed to completion of reports.

PLANS FOR FY 91: Project staffing will occur during this first year, and personnel will develop a conceptual model of the study basin. Liaison committee members will be selected and meetings held to discuss the overall project objectives and establish the priority issues that are of concern to the majority of the participants. A data base will begin to be assembled to contain all existing usable water-quality data. Factors and processes that have an effect on current water-quality conditions within the basin will be identified and incorporated into the work plan. The work plan for the full-scale water-quality assessment will be completed.



PROJECT TITLE: Processes Controlling Weathering

PROJECT NUMBER: CO-91-256

STUDY LOCATION: Rocky Mountain National Park

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: John T. Turk, District Office, Denver

PROJECT DURATION: October 1990 to September 1999

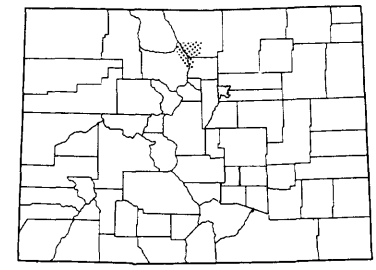
PROBLEM: Lack of understanding of weathering and biogeochemical budgets seriously affects our calculation of the CO_2 budget. The amount of atmospheric CO_2 converted to the HCO_3 we measure as transported from a watershed is twice the amount if feldspar weathering rather than carbonate weathering is the controlling process. The common assumption is that feldspar weathering is the controlling process because feldspars are the most common, weatherable mineral in the granitic bedrock of the Rocky Mountains; however, recent work indicates that carbonate weathering may be the controlling process. Also, the effect of climate change on chemical weathering depends on which of these is the controlling process.

OBJECTIVES: Determine the processes controlling weathering.

APPROACH: Use stable strontium isotopes as a tracer of the minerals being weathered. Confirmation of these results will be done with stable and radioactive carbon isotopes.

PROGRESS: New project.

PLANS FOR FY 91: Work will begin on sampling of bedrock and water.



PROJECT TITLE: Processes Controlling Energy Balance and Chemistry of Snowpacks

PROJECT NUMBER: CO-91-257

STUDY LOCATION: Rocky Mountain National Park

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Donald H. Campbell, District Office, Denver

PROJECT DURATION: October 1990 to September 1999

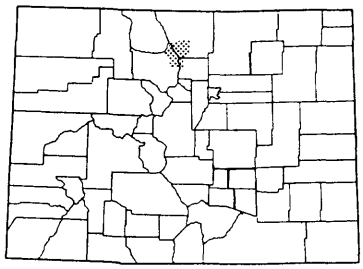
PROBLEM: Lack of understanding of the energy balance and chemistry of snowpacks affects our ability to predict runoff generation, the chemistry of runoff, and sediment transport and storage in response to climate change. Also, changing albedo on climate as a result of various snowmelt characteristics is affected.

OBJECTIVES: To determine in detail the metamorphosis of Rocky Mountain snowpacks, which are colder than most of the better studied snowpacks, and to model the interaction of energy, snowpack accumulation and melt, and runoff generation. This modeling will include the water and solutes that are transported through the watershed.

APPROACH: Use point energy and mass-balance model.

PROGRESS: New project.

PLANS FOR FY 91: Snowpack monitoring sites will be selected, instrumented, and sampled.



PROJECT TITLE: Processes Controlling or Controlled by the Flowpath and Flux of Water

PROJECT NUMBER: CO-91-258

STUDY LOCATION: Rocky Mountain National Park

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Norman E. Spahr, District Office, Denver

PROJECT DURATION: October 1990 through September 1991

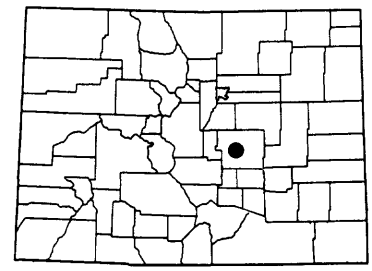
PROBLEM: Lack of understanding of the flowpath and flux of water within the watershed affects our ability to predict which geologic materials and biotic processes will have an opportunity to alter water flow and composition as it moves through the watershed. Under changing climatic conditions, processes that are important now, such as infiltration of unfrozen soil by snowmelt, may not occur. Also, such processes affect climate by affecting evapotranspiration and other feedbacks to climate.

OBJECTIVES: To determine in detail the flowpaths and relative amounts of water in various important landforms within the study watersheds and to model the interaction of common climatic variables with the routing of water along selected flowpaths.

APPROACH: Select instrument and flowpaths to sample water chemistry representing interaction with various components of the watershed.

PROGRESS: New project.

PLANS FOR FY 91: Study sites will be selected, instrumented, and sampled.



PROJECT TITLE: Hydrogeology, Recharge, and Discharge at Aquifer Boundaries and Water Quality of the Fountain Creek Alluvial Aquifer between Colorado Springs and Widefield in Southwestern El Paso County, Colorado

PROJECT NUMBER: CO-91-259

STUDY LOCATION: Colorado Springs, Colorado

COOPERATING AGENCY: City of Colorado Springs, Department of Utilities, Wastewater Division

PROJECT CHIEF AND OFFICE: Kenneth R. Watts, Subdistrict Office, Pueblo

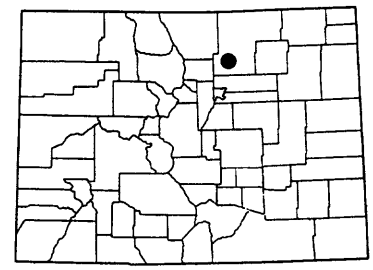
PROJECT DURATION: January 1991 to September 1994

PROBLEM: Concentrations of nitrate in the Fountain Creek alluvial aquifer, locally, are near the regulatory limit of 10 milligrams per liter. Because the alluvial aquifer is hydraulically connected with Fountain Creek, which receives effluent from the Colorado Springs Wastewater Treatment Plant, the quality of effluent from the treatment plant may adversely affect water quality in the alluvial aquifer. However, the potential effects on water quality in the aquifer cannot be predicted without additional knowledge of the hydraulic conditions at the aquifer boundaries and knowledge of the water quality of boundary recharge to the alluvial aquifer.

OBJECTIVE: The objectives are to: (1) Define the geometry and hydrologic boundaries of the aquifer; (2) identify reaches of Fountain Creek that are hydraulically connected to the aquifer; (3) quantify boundary flux, including flow between the stream and aquifer; (4) define selected chemical characteristics of boundary flux; and (5) define long-term trends in nitrogen concentrations in the alluvial aquifer.

APPROACH: Test drilling and seismic refraction will be used to refine the geometric configuration of the bedrock surface. Monitoring wells will be installed to measure potentiometric levels and for collection of water samples. Water levels will be measured monthly at about 30 wells and semi-annually at about 30 additional wells. Continuous recorders will be installed in about 10 wells adjacent to Fountain Creek. Gain-loss measurements will be used to estimate stream-aquifer flux. Samples for chemical analyses will be collected quarterly from about 28 wells. Water-quality data from eight wells that have been sampled quarterly since 1978 to 1981 will be analyzed to define long-term trends in nitrogen concentrations in the alluvial aquifer.

PLANS FOR FY 91: Reconnaissance and geophysical surveys will be completed during the second quarter, and test-drilling and monitor-well installation will be completed during the third quarter. Monthly water-level measurements and quarterly water-quality sampling will begin. Gain-loss investigations on an 8-mile reach of Fountain Creek will begin.



PROJECT TITLE: The Effects of Agricultural Application of Sewage Sludge on Farmland near Denver, Colorado

PROJECT NUMBER: CO-91-260

STUDY LOCATION: One square mile of farmland in the South Platte River basin in Weld County, Colorado

COOPERATING AGENCY: Metro Wastewater Reclamation District

PROJECT CHIEF AND OFFICE: Neville Gaggiani, District Office, Denver

PROJECT DURATION: October 1990 through September 1995

PROBLEM: Inorganic and organic fertilizers used during the past 20 years on farmland 2 miles east of Platteville probably have caused nitrate concentrations in the shallow ground water to increase above the recommended drinking-water limit of 10 milligrams per liter. About 5,140 dry tons of sewage sludge have been applied by Metro Wastewater Reclamation District (MWRD) on about 1 square mile of this farmland from late 1985 to 1988. There is a need to determine if the nitrogen from sewage-sludge-amended soil also is affecting the ground-water quality.

OBJECTIVES: (1) Determine if the nitrogen from the sewage-sludge-amended soil is moving downward through the unsaturated zone, (2) estimate the quantity of water moving through the unsaturated zone to the water table, (3) determine the lateral and vertical movement of nitrogen in the saturated zone, and (4) determine the changes in the aeolian/alluvial aquifer underlying the sewage-sludge application area and in the alluvial and bedrock aquifers near the sewage-sludge application area.

APPROACH: Nitrogen-15-enriched tracer will be applied to the soil of three test plots during the second, third, and fourth years of the study while treated sewage sludge is applied and plowed into the soil. The nitrogen-15-enriched tracer will move through the unsaturated zone in a similar manner as the nitrogen from the sewage sludge, but the tracer will be much easier to detect. A water budget will be calculated, and water movement through the unsaturated zone will be estimated using data from a rain gage, a gaging station on the irrigation canal, a power-use meter, the Blaney-Criddle method for estimating evapotranspiration, soil-moisture tubes, and ground-water-level recorders. Changes in distribution between sampling of multilevel ground-water sampling devices will indicate the direction of vertical and horizontal movement of nitrogen concentrations. Monthly water-level measurements from observation wells will be used to determine the direction of ground-water flow. Aquifer characteristics will be determined based on aquifer testing of wells and from laboratory analysis of cores. Water samples also will be obtained for chemical and bacteriological analyses four times each year from 14 existing and 3 new observation wells on the sludge-application site and from 1 irrigation and 3 domestic wells in the nearby farming area.

PLANS FOR FY 91: Observation wells, soil-moisture tubes, multilevel ground-water sampling devices, the gaging station, and ground-water recorders will be installed. Chemical and bacteriological samples will be obtained from the ground water. The best test plots for using the nitrogen-15 tracer will be delineated. Ground-water levels will be measured monthly.

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Water-Resources Data Reports

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