SUMMARY OF WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--FISCAL YEAR 1986

Compiled by Julie M. Stewart

U.S. Geological Survey

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CONTENTS

CONTENTS

PLATE

TABLE

SUMMARY OF WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--FISCAL YEAR 1986

INTRODUCTION

Water-resources activities of the U.S. Geological Survey in Colorado consist of collecting water-resources data and conducting 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. This report describes the water-resources investigations in Colorado for the 1985 and 1986 fiscal years (October 1, 1984, to September 30, 1986).

The U.S. Geological Survey's investigations of the water resources of Colorado are under the direction of Richard O. Hawkinson, Acting District Chief. The Colorado District office is in Building 53, Denver Federal Center, Lakewood, Colorado. The Colorado District has four subdistrict offices, in Grand Junction, Lakewood, Meeker, and Pueblo. 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 107-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]

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, and use of ground water (including water in the unsaturated zone); and the quality of precipitation.
- Storing and disseminating these data.

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

- 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 conducted in cooperation with Federal, State, and local agencies. Those agencies cooperating with the U.S. Geological Survey during fiscal year 1985 and 1986 are:

Arkansas River Compact Administration
Boulder County Public Works Department
Central Yuma Ground-Water Management 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 Colorado Springs, Department of Public Utilities
City of Colorado Springs, Office of the City Manager
City of Englewood, Bi-City Wastewater-Treatment Plant
City of Fruita
City of Glendale
City of Glenwood Springs
City of Longmont
City of Steamboat Springs
Colorado Department of Health
Colorado Department of Natural Resources
  Division of Mined Lands Reclamation
  Division of Water Resources, Office of the State Engineer
Colorado Geological Survey
Colorado River Water Conservation District
Custer County Commissioners
Delta County Board of County Commissioners
Denver Regional Council of Governments
Douglas County
Eagle County Board of Commissioners
El Paso County Water Users Association

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

Evergreen Metropolitan District
Fountain Valley Authority
Frenchman Ground-Water Management District
Garfield County
Grand County Board of Commissioners
Larimer-Weld Regional Council of Governments
Marks Butte Ground Water Management District
Metropolitan Denver Sewage Disposal District No. 1
Mineral County
Moffat County
North Kiowa-Bijou Ground Water Management District
Northern Colorado Water Conservancy District
Pitkin County Board of County Commissioners
Pueblo Board of Water Works
Pueblo Civil Defense Agency
Pueblo West Metropolitan Water District
Purgatoire River Water Conservancy District
Rio Blanco County
Rio Grande Water Conservation District
Round Mountain Water and Sanitation District
St. Charles Mesa Water Association
Sand Hills Ground-Water Management District
Southeastern Colorado Water Conservancy District
Southwestern Water Conservation District
Town of Breckenridge
Town of Castle Rock
Trinchera Water Conservancy District
Uncompahgre Valley Water Users Association
Upper Arkansas River Water Conservancy District
Upper Yampa Water Conservancy District
Urban Drainage and Flood Control District
U.S. Air Force Academy
U.S. Department of the Army
    Corps of Engineers
    Fort Carson
U.S. Department of Energy
U.S. Department of the Interior
    Bureau of Land Management
    Bureau of Reclamation
    National Park Service
    Office of Surface Mining
U.S. Environmental Protection Agency
U.S. Federal Emergency Management Agency
U.S. Federal Highway Administration
U.S. National Weather Service
Water Users No. 1
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 stream discharge and stage, reservoir and lake storage, ground-water levels, well and spring discharge, and the quality of surface and ground water. Every year, some new stations are added and other stations are terminated; thus, the U.S. Geological Survey has both a current and a historical file of hydrologic data. Most water-resources data are stored in the U.S. Geological Survey's WATSTORE (National Water Data Storage and Retrieval 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 digital plots. Local assistance in the acquisition of services or products from WATSTORE can be obtained by contacting the Colorado District office, Lakewood, Colorado.

Surface-Water Data

Surface-water discharge (streamflow), stage (water level), 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) maintained by either the Colorado State Engineer's Office or the U.S. Geological Survey and used for the transmission of satellite-telemetered river-stage information have been installed at 66 U.S. Geological Survey stations in Colorado. 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. Discharge and stage data currently are being obtained at the number of stations given below.

Station Classification	Number of Stations
Streamflow continuous-record stations--	325
Streamflow partial-record stations-----	40
Lake and reservoir stations----------	23
Total stations----------	388

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

Water-quality data (common ions, nutrients, and(or) trace metals) are obtained at 106 of the surface-water stations listed in table 1. Eight of these stations are part of a U.S. Geological Survey nationwide network known as NASQAN (National Stream Quality Accounting Network), and two are part of the nationwide Benchmark network, that provides data used in the evaluation of trends in stream quality.

Table 1.--*Water-resources data-collection stations in operation during fiscal year 1985, by county*

[DCP, data-collection platform; --, no data]

County	Number and type of surface-water stations						Number and type of ground-water stations		
	Partial record	Continuous record	DCP record	Lake and reservoir record	Water-quality record	Sediment record	Recording-level record	Periodic-level record	Water-quality record
Adams	4	1	1	--	--	--	--	2	--
Alamosa	--	--	--	--	--	--	30	42	--
Arapahoe	--	2	--	1	1	--	--	--	--
Archuleta	--	6	1	--	1	1	--	--	--
Baca	--	--	--	--	--	--	--	1	--
Bent	--	4	4	1	--	--	1	51	--
Boulder	1	3	--	--	--	--	--	--	--
Chaffee	--	4	2	--	--	--	--	16	--
Cheyenne	--	--	--	--	--	--	--	43	--
Clear Creek	--	--	--	--	--	--	--	--	--
Conejos	--	3	--	1	--	--	--	14	--
Costilla	--	--	--	--	--	--	4	30	--
Crowley	--	--	--	--	--	--	1	11	--
Custer	--	2	--	--	--	--	--	--	--
Delta	--	11	1	--	1	1	--	--	--
Denver	2	1	--	--	--	--	--	--	--
Dolores	--	2	1	--	--	--	--	--	--
Douglas	--	4	--	2	--	--	--	--	--
Eagle	2	26	--	--	4	3	--	--	--
Elbert	--	--	--	--	--	--	--	--	--
El Paso	3	22	--	--	11	8	3	200	14
Fremont	--	6	2	--	1	1	--	13	--
Garfield	1	11	2	--	3	--	--	--	--
Gilpin	--	--	--	--	--	--	--	--	--
Grand	--	30	1	4	7	1	--	--	--
Gunnison	--	8	4	1	--	--	--	--	--
Hinsdale	--	3	--	--	--	--	--	--	--
Huerfano	--	--	--	--	--	--	--	5	--
Jackson	--	1	--	--	--	--	--	--	--
Jefferson	13	4	7	--	2	2	--	--	--
Kiowa	--	--	--	--	--	--	--	17	--
Kit Carson	--	--	--	--	--	--	--	199	--
Lake	--	4	3	1	3	1	--	7	--
La Plata	2	5	1	1	3	1	--	2	2
Larimer	2	5	--	2	12	--	--	3	--
Las Animas	--	14	3	1	10	7	--	10	--
Lincoln	--	--	--	--	--	--	--	20	--
Logan	--	--	--	--	--	--	--	14	--

Table 1.--*Water-resources data-collection stations in operation during fiscal year 1985, by county*--Continued

County	Number and type of surface-water stations						Number and type of ground-water stations		
	Partial record	Continuous record	DCP record	Lake and reservoir record	Water-quality record	Sediment record	Recording-level record	Periodic-level record	Water-quality record
Mesa	--	11	2	--	4	4	--	2	--
Mineral	--	5	--	--	3	3	--	--	--
Moffat	2	13	3	--	4	3	--	1	--
Montezuma	--	8	--	--	3	--	--	1	--
Montrose	--	--	--	--	--	--	--	--	--
Morgan	--	1	--	--	1	--	--	--	--
Otero	--	6	5	--	--	--	2	42	--
Ouray	--	3	1	--	--	--	--	--	--
Park	--	4	3	--	--	--	--	--	--
Phillips	--	--	--	--	--	--	--	52	--
Pitkin	--	9	2	1	--	--	--	--	--
Prowers	--	4	4	--	1	--	2	83	--
Pueblo	3	8	4	2	1	--	2	57	--
Rio Blanco	--	18	5	2	15	9	--	--	--
Rio Grande	--	2	--	--	--	--	1	28	--
Routt	4	16	2	--	7	9	--	--	--
Saguache	--	6	--	--	--	--	27	56	--
San Juan	--	--	--	--	--	--	--	--	--
San Miguel	--	1	1	--	--	--	--	--	--
Sedgwick	--	--	--	--	1	--	--	14	--
Summit	--	16	--	2	1	--	--	--	--
Teller	--	--	--	--	--	--	--	--	--
Washington	--	--	--	--	--	--	--	104	--
Weld	--	2	--	--	2	--	--	--	--
Yuma	--	1	--	1				233	--
Total	40	325	66	23	106	54	73	1,373	14

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. In addition to the water-quality data collected at the aforementioned stations, a variety of information is collected at miscellaneous sites as a part of interpretive hydrologic studies. This information also is available from the U.S. Geological Survey files.

Ground-Water Data

Water levels in wells are measured to help determine ground-water trends; however, they must be integrated with other observations and investigations to have the most relevance and usefulness. A network of 57 observation wells (pl. 1) is maintained in Colorado by the U.S. Geological Survey. In addition, a network of about 880 observation wells is maintained in eastern Colorado, in cooperation with various water-conservancy districts and water-management districts. Six wells were measured in western Colorado during 1985. 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 in the statewide networks. However, a variety of water-quality data were collected at 66 wells during 1985 for interpretive hydrologic investigations. These data are available from the files of the U.S. Geological Survey.

Precipitation Data

Precipitation quality and quantity are collected at six precipitation stations in Colorado. One station, located in Bent County, is part of the nationwide NTN (National Trends Network) program to monitor long-term precipitation-quality changes. Precipitation quantity is measured and satellite-telemetered to the U.S. Geological Survey DRGS from 14 surface-water stations. Information from the precipitation stations is available to users on request.

Water Conditions

Streamflow in all the major river basins of Colorado was above normal throughout the entire 1985 water year. This streamflow is attributed to above-normal precipitation throughout the State in 1984 and 1985. Examples of above-normal mean discharges that occurred in the 1984 and 1985 water years are shown below.

Name of streamflow-gaging station	Percent of median discharge above normal		Median annual discharge (cubic feet per second)
	WY 1985	WY 1984	WY 1951-80
Animas River at Durango-------	172	152	695
Arkansas River at Parkdale----	143	166	764
Bear Creek at Morrison--------	176	221	37.5
Colorado River near Colorado-Utah State line----	205	258	5,211
Eagle River below Gypsum------	137	196	551
East River at Almont----------	138	170	315
Gunnison River near Grand Junction----------	231	275	1,186
Rio Grande near Del Norte-----	178	136	759
South Platte River at Denver--	320	373	218
White River near Meeker-------	158	176	592
Yampa River near Maybell------	154	205	1,474

INTERPRETIVE HYDROLOGIC INVESTIGATIONS

Forty-six interpretive hydrologic investigations are being conducted during fiscal year 1986 in cooperation with 73 Federal, State, and local agencies. Hydrologic investigations are being conducted 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 statewide, multistate, and nationwide hydrologic problems. A summary of each investigation, including problem, objectives, approach, progress, and plans follows.

PROJECT TITLE: National Trends Network for Monitoring Atmospheric Deposition

PROJECT NUMBER: CO-83-005

STUDY LOCATION: Bent County, 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 1986

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

OBJECTIVES: Develop a nationwide information base of precipitation quantity and quality data. Evaluate regional variations in precipitation quantity and quality related to regional land use, as well as the way in which these precipitation quantity and quality variations influence stream discharge and chemistry.

APPROACH: Operate one precipitation station at the Las Animas fish hatchery near Las Animas, Colorado, as part of the National Atmospheric Deposition Network. Obtain information on precipitation quantity, quality, pH, and specific conductance for storm events. Collect samples for chemical analyses and send to the Illinois State Water Survey Laboratory. Coordinate computations of chemical loading and evaluation of areal and temporal variations in precipitation quantity and quality.

PROGRESS: Precipitation site was visited each week throughout the year.

PLANS FOR FY 1986: Weekly operation of the site will be continued.

PROJECT TITLE: Flood Investigations

PROJECT NUMBER: CO-84-006

STUDY LOCATION: Yampa River above and below Steamboat Springs, Colorado, and Elk River below Glen Eden, Colorado.

COOPERATING AGENCY: Federal Emergency Management Agency

PROJECT CHIEF AND OFFICE: Larry L. Jones, District Office, Lakewood

PROJECT DURATION: April 1984 to September 1986

PROBLEM: The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provide for the operation of a flood-insurance program. The Federal Emergency Management Agency (FEMA) needs flood studies in selected areas to determine applicable flood-insurance premium rates.

OBJECTIVE: Conduct necessary hydrologic and hydraulic studies of areas assigned by FEMA and present the results in a report.

APPROACH: Conduct ground surveys and determine flood-discharge frequency relations, using local historical information, streamflow data, streamflow-gaging station records, or other applicable information. Determine water-surface profiles, using step-backwater models or other acceptable methods; furnish results in reports prepared to FEMA specifications.

PROGRESS: Onsite reconnaissance of study area was completed. Tentative location of cross sections was selected. Hydraulic problem areas were defined, and approach to onsite data collection in these areas was resolved. Study area was surveyed. Onsite work nearly was completed, including horizontal-vertical surveys of: (1) 42 full valley cross sections; (2) 12 lesser cross sections; (3) 10 miles of railroad bed or highway bed; and (4) 11 bridges and culverts. Over 250 photographs were taken; 50 onsite sketches were made of cross sections and bridges. Roughness values were selected for all cross sections.

PLANS FOR FY 86: Onsite data will be checked and plotted on work maps. Computer step-backwater programs will be run; 100-year flood profiles will be drawn. A brief flood report for each study subarea will be prepared. Maps, profiles, reports, and computational work sheets will be delivered to FEMA.

PROJECT TITLE: Statewide Water-Use Inventory

PROJECT NUMBER: CO-78-007

STUDY LOCATION: Statewide

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

PROJECT CHIEF AND OFFICE: David L. Litke, District Office, Lakewood

PROJECT DURATION: October 1977 to September 1987

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 requires documentation, so State and local managers and planners may be better informed to make decisions for development of the State's water resources.

OBJECTIVES: Develop an inventory procedure to obtain both current and future water-use data. Develop a computerized data base that can be accessed by a variety of users.

APPROACH: Obtain water-use data by contacting users in person or by mail. If they are already collecting water-use data, ask them to complete a questionnaire in which water-use data are tabulated; if they are not collecting water-use data, devise techniques for converting available data into water-use data, or suggest techniques for collecting water-use data.

PROGRESS: A computer data base was designed for storage and manipulation of water-use information by county and by hydrologic accounting units. Data for irrigation-water use were entered into the data base.

PLANS FOR FY 86: Data required for the 1985 National Water Use Report will be collected; these data will be summarized for Colorado in a report titled, "Water Use in Colorado, 1985."

PROJECT TITLE: Effects of Sludge Disposal on Ground-Water Quality

PROJECT NUMBER: CO-77-097

STUDY LOCATION: Arapahoe County

COOPERATING AGENCY: Metropolitan Denver Sewage Disposal District No. 1

PROJECT CHIEF AND OFFICE: Neville G. Gaggiani, Subdistrict Office, Lakewood

PROJECT DURATION: May 1977 to September 1988

PROBLEM: In 1983, nitrate-nitrogen concentrations in the hundreds of milligrams per liter were found in the alluvial aquifer within the Lowry sewage-sludge land-disposal site located in Arapahoe County, Colorado. Metropolitan Denver Sewage Disposal District No. 1 has been operating the site for more than 10 years. Although the high concentrations seem to be confined to the site, concern exists that the contamination could spread and affect ground-water quality adjacent to the site.

OBJECTIVES: Determine the location of, depth to, and areal extent of alluvial and bedrock aquifers beneath the sludge-disposal site and adjacent area. Determine the direction of ground-water flow and the quality of ground water.

APPROACH: Expand the present ground-water monitoring network within an approximate 28-square-mile area around the sludge-disposal site. Using network wells, obtain water-level measurements and samples for water-quality analysis. Construct potentiometric-surface maps of the alluvial and bedrock aquifers to aid in determining ground-water flow paths. Solute-transport potential will be evaluated, based on estimates of aquifer hydraulic properties.

PROGRESS: Ground-water levels were measured and water samples for chemical analysis were obtained from 28 observation wells at and near the Lowry sludge-spreading area in the winter, spring, and summer. Surface-runoff water was sampled in the spring and summer. Iron casing with lockable caps was added to 14 wells. Water levels in the observation wells were measured monthly.

PLANS FOR FY 86: Quarterly sampling of the observation wells and of the surface-water sites will be continued. Monthly water levels in the observation wells also will be measured.

PROJECT TITLE: Ground-Water Model of the Piceance Structural Basin

PROJECT NUMBER: CO-77-100

STUDY LOCATION: Rio Blanco and Garfield Counties

COOPERATING AGENCY: Rio Blanco County

PROJECT CHIEF AND OFFICE: R. Theodore Hurr, District Office, Lakewood

PROJECT DURATION: August 1977 to December 1986, except for FY 81

PROBLEM: Rich oil-shale deposits in the Piceance basin eventually may be developed. However, the draining of these deposits prior to development could cause widespread changes in the hydrologic regimen of the area. Extensive dewatering of the aquifers may reduce the flow of springs and streams. A hydrologic model has been developed to simulate the effects of mine dewatering on the regional ground-water system. However, a better understanding of the interconnections between aquifers themselves, as well as with the surface-water system, is necessary to provide a more reliable prediction of the consequences of oil-shale development.

OBJECTIVE: Improve the understanding of the ground-water flow system by determining the degree of hydraulic connection between the bedrock aquifers, the alluvial aquifer, and the streams. Improve the model framework, so that mine-drainage impacts can be simulated realistically.

APPROACH: Improve the understanding of the ground-water flow system by obtaining additional well-log and hydrologic testing data. Prepare improved potentiometric maps for the bedrock aquifers. In addition, appraise the vertical distribution of horizontal hydraulic conductivity using the relation between well yield and well depth. Sample bedrock aquifers at various sites for radionuclides to permit calculation of (1) Residence times; and (2) regional-aquifer characteristics. Appraise stream-aquifer relations, using gain-and-loss studies along Piceance and Yellow Creeks and stream discharge and water-quality measurements in Roan and Parachute Creeks. Improve the model by the addition of the valley-fill alluvial aquifer as another model layer and conversion of constant-head nodes to head-dependent discharge nodes.

PROGRESS: Data collection was completed. Modifications to the finite-difference model were completed to better simulate springs and surface-water flow as constant-head discharge nodes. A report on the model simulation was written and is in the review process. A report on the alluvial-aquifer system is in preparation.

PLANS FOR FY 86: The report on the alluvial aquifer system will be completed. No further work on this project is anticipated.

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

PROJECT NUMBER: CO-80-131

STUDY LOCATION: Rio Blanco, Garfield, Mesa, and Delta Counties in northwestern Colorado

COOPERATING AGENCY: Bureau of Land Management, Environmental Protection Agency, Mesa County, and Delta County

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

PROJECT DURATION: November 1979 to September 1986

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 Wilderness Area 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 orogenic 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.

OBJECTIVES: Delineate the areas in Colorado most susceptible to the influence of acid rain. Determine within susceptible areas the lakes with 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: Downwind location from acidic-gas sources, unreactive bedrock geology, and large snowpack accumulation. Measure relative buffering capacity of the lakes by alkalinity-titration curves, and approximate nutrient loading by hypolimnetic-nutrient concentrations, snowpack amount and nutrient concentrations, and stream-discharge rates and nutrient concentrations. 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: A report was prepared on the influence of natural pH variations on pH-trend detection; another report was prepared on lake-evaporation rates.

PLANS FOR FY 86: Report on transferability of results will be completed.

PROJECT TITLE: Upper Black Squirrel Creek Basin Digital Model

PROJECT NUMBER: CO-81-143

STUDY LOCATION: Black Squirrel Creek basin, El Paso County, Colorado

COOPERATING AGENCY: Cherokee Water and Sanitation District

PROJECT CHIEF AND OFFICE: Douglas L. Cain, Subdistrict Office, Pueblo

PROJECT DURATION: July 1983 through September 1987

PROBLEM: The upper Black Squirrel basin is designated by the State of Colorado as a ground-water basin and a major source of water for future supply. Large water-level declines have occurred in the basin since 1964. Recently, additional water-supply requirements have been created by the new Space Consolidation Center east of Colorado Springs. Existing and anticipated water-supply demands indicate that long-term water-use practices need to be evaluated.

OBJECTIVES: Define current water-level and water-quality conditions in the alluvial aquifer. Evaluate potential hydrologic impacts of various options for development and use of alluvial ground water.

APPROACH: Inventory wells in the basin; select several wells for installation of recorders. Measure water levels bimonthly at remaining network wells. Measure specific conductance; sample wells selectively for chemical analyses. Perform aquifer tests at selected wells to define variation in hydraulic properties. Use two-dimensional digital model to simulate long-term pumpage scenarios.

PROGRESS: Aquifer tests were completed on three wells tapping the alluvial aquifer. Effects of increased pumpage on the alluvial aquifer were evaluated, using a two-dimensional flow model. A first draft of the report describing the geohydrology of the alluvial aquifer and the results of the modelling was completed; the report was sent to colleague review at the end of September 1985.

PLANS FOR FY 86: The two-dimensional flow-model report will be published. Additional geohydrologic data will be collected to simulate flow between the alluvial aquifer and the bedrock aquifers, and to determine the impact of development of the bedrock aquifers on the alluvial aquifer.

PROJECT TITLE: Hydrology of the Closed Basin Project Area, San Luis Valley, Colorado

PROJECT NUMBER: CO-81-146

STUDY LOCATION: Upper San Luis Valley in Saguache, Rio Grande, and Alamosa Counties

COOPERATING AGENCY: U.S. Bureau of Reclamation

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

PROJECT DURATION: October 1980 to September 1986

PROBLEM: The Closed Basin project area is an internally drained part of the Closed Basin, that is separated from the Rio Grande drainage in the Upper San Luis Valley. Significant quantities of water, now lost to evapotranspiration, could be salvaged and used for agriculture, and(or) used to partially fulfill Colorado's obligations to the Rio Grande Compact.

OBJECTIVES: Describe and evaluate quantitatively the hydrology of the project area. Construct and interrogate digital models to evaluate the effect of alternative locations of wells and pumping patterns on ground water in the unconfined aquifer and confined zone.

APPROACH: Compile and evaluate existing data on wells, pumpage, vegetation, and ground-water and surface-water inflow to quantify the hydrologic budget. Drill test holes to define hydraulic gradients, geology, hydrogeology, and water quality. Build and interrogate a two-dimensional finite-difference model to estimate well spacing and pumping patterns that would keep drawdown in the unconfined aquifer less than 2 feet at the project-area boundary.

PROGRESS: Monitoring of ground-water levels was continued. An interpretive report describing a ground-water model simulating the response to pumpage of the unconfined aquifer was revised.

PLANS FOR FY 86: A hydrologic-data report for the Closed Basin will be completed. Cyclic patterns of water-level fluctuations will be analyzed. Monitoring of water levels will be continued. As ground-water-use data and water-level data become available, the ground-water model will be verified and revised.

PROJECT TITLE: Stream-Water Resource Impacts of Energy Development within the White River Basin, Colorado and Utah

PROJECT NUMBER: CO-81-152

STUDY LOCATION: The White River basin in northwestern Colorado and Utah

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

PROJECT CHIEF AND OFFICE: Sherman R. Ellis, District Office, Lakewood

PROJECT DURATION: December 1980 to September 1986

PROBLEM: Various energy developments now are taking place or being planned across the States of Colorado and Utah. Decisions affecting the policy of the energy development need to consider all environmental impacts. The White River basin, located in northwestern Colorado and eastern Utah, has several forms of planned energy development, including oil shale, coal, and natural gas. With this large anticipated energy development in the basin and associated population increases, a need exists to study current streamflow-quantity and -quality conditions and to assess probable impacts of future changes.

OBJECTIVES: Describe hydrology of the study area in terms of water-resources availability and quality, prior to substantial energy development. Evaluate potential environmental impacts of the energy-resource development plans.

APPROACH: Describe the current stream-water quality, aquatic biology, stream reaeration, traveltime, stream mean velocity, and existing alluvial ground-water conditions, including aquifer extent and hydraulic properties in the White River basin. Model the potential impacts of oil-shale development on salt loads in Piceance and Yellow Creeks and the White River. Evaluate the potential changes in streamflow regime that would result from construction of reservoirs, canals, tunnels, and pumping plants.

PROGRESS: All reports were completed except for oil-shale summary report. Colorado part of summary is complete and in review.

PLANS FOR FY 86: Review and approval of summary report will be completed, and report will be prepared for publication.

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: O. James Taylor, District Office, Lakewood

PROJECT DURATION: July 1981 to September 1986

PROBLEM: Water demands are increasing in the Upper Colorado River Basin. Ground-water reservoirs may contain large supplies, but they have not 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: Two guidebook articles and one journal article were published. One major hydrologic atlas was approved. Three Water-Resources Investigations reports and one journal article were completed. Major progress was made in the analysis of hydrologic characteristics of Paleozoic rocks, base-flow analysis, simulation of regional aquifer systems, and regional geochemistry.

PLANS FOR FY 86: Geohydrologic simulation and base-flow analysis for Paleozoic rocks will be completed. Most of the geochemical analysis for water in Paleozoic, Mesozoic, and Tertiary rocks will be completed. Twelve technical reports will be prepared.

PROJECT TITLE: Comprehensive Hydrologic Quantity and Quality Model of the Arkansas River basin, Colorado

PROJECT NUMBER: CO-82-159

STUDY LOCATION: The Arkansas River basin of southeastern Colorado

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District and the U.S. Bureau of Land Management

PROJECT CHIEF AND OFFICE: Alan Burns, District Office, Lakewood

PROJECT DURATION: October 1981 to September 1986

PROBLEM: Major changes in water use and resultant water quality in the Arkansas River basin are having impacts on all water users. The current over-appropriation of surface-water supplies has led to a complex water-supply system of transmountain diversions, reservoir storage, and development of the alluvial aquifer. Currently no consistent, comprehensive means exist to assess the possible water-quantity and -quality effects of the many possible changes in the competing water uses.

OBJECTIVE: Construct and document a model capable of assessing the basinwide quantity and quality impacts resulting from changes in water use. This model would be an interactive, planning-type, stream-network model to simulate the impact of the adjacent alluvial aquifer, simulate a water-quality mix, and include the legal-priority system of Colorado Water law.

APPROACH: Develop the model from existing stream-network and stream-aquifer models. Develop stream-aquifer response functions, precipitation-runoff relations, water-quality discharge relations, and irrigation application-recharge factors for entry into the model. Calibrate and demonstrate examples of the model's predictive capabilities in workshops and describe them in a report.

PROGRESS: Hydrograph and statistics report and water-operations report were approved. Water-quality relations report was prepared, reviewed in-house, and revised for colleague review. Snowmelt-runoff report was revised after colleague review; after return from Central Region, it will be revised further. Model development was completed, and calibration was begun. Numerous presentations were given to local, State, and Federal agencies.

PLANS FOR FY 86: Model-documentation report and model-calibration report will be prepared; these two reports will be revised; water-quality relations report will be revised. Model data base will be updated to 1985; bibliography of water-resources publications for Arkansas River basin in Colorado will be prepared; development of model for Fountain Creek (a tributary of the Arkansas River) will begin.

PROJECT TITLE: Effects of Projected Urbanization on Inflows to Cherry Creek Reservoir

PROJECT NUMBER: CO-82-164

STUDY LOCATION: Cherry Creek drainage above Cherry Creek Reservoir, Arapahoe and Douglas Counties, Colorado

COOPERATING AGENCY: Denver Regional Council of Governments

PROJECT CHIEF AND OFFICE: Martha H. Mustard, Subdistrict Office, Lakewood

PROJECT DURATION: April 1984 to September 1988

PROBLEM: Cherry Creek Reservoir is a U.S. Army Corps of Engineers flood-control reservoir used extensively for fishing, swimming, and boating, located on the current (1986) edge of the Denver metropolitan-urban area. Urbanization upstream of the reservoir will affect the quantity and quality of runoff entering the reservoir. Changes in chemical composition of runoff, as a result of watershed development, could cause violation of water-quality standards set by the Colorado Water Quality Control Commission and could affect the suitability of the reservoir for recreational activities.

OBJECTIVES: Monitor streamflow and collect samples under ambient and storm-runoff conditions for a 5-year period. Define ground-water levels and water quality in the alluvium upgradient of Cherry Creek Reservoir. Develop statistical relations between water-quality loadings and precipitation and basin characteristics.

APPROACH; Monitor the quantity and quality of surface-water inflow; in Cherry Creek and several principal tributaries. Precipitation data will be provided by rain gages located in the basin. Variation in water-quality conditions will be defined by a sampling program that includes quarterly ambient and storm-event samples. Monitor the shallow ground-water system; water-level measurements and water samples will be collected at approximately 10 wells to define seasonal variations in the alluvial ground-water system near the reservoirs. Use multiple-regression techniques in the analysis of runoff and water-quality characteristics to determine how these variables relate to rainfall and basin characteristics.

PROGRESS: Surface-water records were maintained at four stations. At least 12 water-quality samples were collected at each station. Lake profiles and water-quality samples were collected on Cherry Creek Lake. Rainfall records were maintained at nine sites. Ground-water samples were collected at four wells.

PLANS FOR FY 86: Data collection will be continued; data analysis will begin.

PROJECT TITLE: Assessment of Water Resources and Related Impacts 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: Department of the Army, Fort Carson

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

PROJECT DURATION: October 1982 to September 1988

PROBLEM: A 400-square-mile area will be acquired in the Pinon Canyon area by the U.S. Army and used for military training, beginning in 1985. 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 both surface- and ground-water resources in the area. Determine the impact of military training on the water resources of the area.

APPROACH: Monitor surface-water flow at 11 streamflow-gaging stations; 2 stations exist, and 9 stations were installed in FY 83. Monitor specific conductance continuously at all stations. Collect sediment samples by automatic samplers at seven stations. Collect water-quality samples of base flow and storm runoff. Determine current (1983-84) reservoir capacity in 49 small reservoirs; 29 of these reservoirs were probed to determine historical sediment contents; all reservoirs will be resurveyed following military training. Inventory existing wells; sample 50 wells. Measure water levels monthly in 10 wells.

PROGRESS: Hydrologic-data collection was continued at 11 streamflow-gaging stations and at 15 precipitation stations. Data collected included runoff from a few scattered thunderstorms during the summer. An additional three ponds were surveyed, and an additional eight ponds were probed. The off-site comparative basin was discontinued. The comparative-basin technique was abandoned in favor of a modeling approach to assess impacts from military training. Fourteen additional wells and one additional spring were inventoried in FY 85; monthly water levels were monitored in 11 wells, beginning in October 1984. Nine ground-water sites were sampled for water quality.

PLANS FOR FY 86: Data collection for surface water, water quality, precipitation, and ground water will be continued. Sediment ponds will be resurveyed when needed. Data files needed for the hydrologic model will be developed. A Water-Resources Investigations Report on the baseline-hydrologic conditions in Pinon Canyon will be prepared. Water levels will be monitored in 10 wells. Approximately 30 additional sites for ground-water quality will be sampled.

PROJECT TITLE: Urban Studies Data Compilation and Analysis

PROJECT NUMBER: CO-83-176

STUDY LOCATION: Urban study areas nationwide

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

PROJECT CHIEF AND OFFICE: Nancy E. Driver, District Office, Lakewood

PROJECT DURATION: January 1983 to December 1987

PROBLEM: Many Districts have conducted urban studies in which storm-event discharge, water-quality, and rainfall data have been collected. In most cases the data are not easily obtainable by interested users outside individual project offices. In addition, these data have not been compiled and interpreted on a regional basis.

OBJECTIVES: Compile the data into one urban-studies data base; conduct regional analyses to determine the significant climatic and basin characteristics that account for the variations in quality of runoff from urban watersheds.

APPROACH: Locate potential data sets from Districts that have conducted urban studies. Select only data sets that have documented runoff events. Check all data for quality assurance, and load the data onto an urban-studies data-base magnetic tape. Compute annual and(or) storm loads for appropriate water-quality constituents. Determine which climatic and basin characteristics have significant impact on water quality, using statistical techniques, such as multiple regression, cluster analysis, and regional regression.

PROGRESS: The data report and magnetic tape are complete and published. A second data base, containing storm loads and storm characteristics from the U.S. Geological Survey is being compiled and quality-assured.

PLANS FOR FY 86: Interpretive reports using statistical methods, such as generalized least-squares analysis, multiple linear regression, and cluster analysis will identify the climatic and physical characteristics of urban watersheds that affect water quality. Regional variations in factors controlling constituents loads in storm runoff will be determined. Results will be used to develop methods to transfer this constituent-load information to ungaged areas to determine loads for individual storms or seasons.

PROJECT TITLE: Water-Quality Reconnaissance of Blunn Reservoir

PROJECT NUMBER: CO-83-177

STUDY LOCATION: Jefferson County, Colorado

COOPERATING AGENCY: City of Arvada

PROJECT CHIEF AND OFFICE: Linda J. Britton, District Office, Lakewood

PROJECT DURATION: June 1983 to September 1986

PROBLEM: Blunn Reservoir presently is being filled, but faces potential problems associated with a rural-urban environment. Specifically, the irrigation canal that will be the major source of water to the reservoir may contain excessive nutrient concentrations that could provide conditions for rapid algal growth. Because the reservoir is in the filling stage, an opportunity exists to monitor the present water quality, prior to its use as a drinking-water supply. In addition, a lack of data exists to describe the quality of inflows to the reservoir and to assess potential impacts on water stored in the reservoir.

OBJECTIVES: Provide an assessment of the chemical and biological quality of the reservoir. Provide an estimate of the water balance and loading of nutrients to the reservoir. Estimate the amount of algal growth that the reservoir is capable of supporting, as well as the substances that limit or stimulate growth. Evaluate the impact of various source waters to the reservoir. Estimate the primary productivity and trophic status of the reservoir.

APPROACH: Make thermal- and chemical-profile measurements biweekly; complete chemical and biological analyses of the water in spring, summer, and fall at several sites on the reservoir. Calculate water-balance to include inflow and outflow information, nutrient loading from nutrient concentrations, and estimates of storm loading. Complete algal growth-potential tests on source and reservoir waters. Use chemical and biological results to evaluate impacts on reservoir. Complete an estimate of primary productivity from oxygen-light-dark bottle sampling and trophic status from known indices.

PROGRESS: Vertical-profile measurements were conducted at three sites on the reservoir on a biweekly basis, and water samples of selected nutrient and biological analyses were collected. Inflows were sampled on the same schedule. The reservoir thermally stratified and became anaerobic below the thermocline. Reservoir transparency increased, compared to previous sampling years.

PLANS FOR FY 86: Sampling is complete. Data will be analyzed in regard to trophic status, algal control, and other limnological properties, for a final report that will be completed in Spring 1986.

PROJECT TITLE: Analysis of the Sediment Data Network in Colorado

PROJECT NUMBER: CO-84-179

STUDY LOCATION: Statewide

COOPERATING AGENCIES: Colorado River Water Conservation District, U.S. Bureau of Reclamation, and U.S. Geological Survey.

PROJECT CHIEF AND OFFICE: John G. Elliott, District Office, Lakewood

PROJECT DURATION: October 1983 to September 1986

PROBLEM: For many years, sediment data have been collected at surface-water sites throughout Colorado by many different agencies. Most of these data have been published either in interpretive reports or in hydrologic-data reports. To date, however, no coordinated effort to compile and analyze all sediment data available for Colorado streams has been assembled. With the increased potential for coal and oil-shale mining and associated development, as well as the future need for reservoirs and diversion structures, a need exists to compile and interpret available sediment data, so that it will be more usable to State and Federal water-planning and management agencies. This need can be met by compiling data into a single data base and by preparing a statewide sediment-yield map.

OBJECTIVES: Collate available sediment data; document location, source of data, and other pertinent technical information regarding the accuracy and usability of the data. Analyze available sediment data and prepare a statewide sediment-yield map. Evaluate areas impacted by land-use changes, such as mining or agricultural development, where sediment data are available. Determine if sediment yield can be related to land use, basin, and climatic characteristics.

APPROACH: Tabulate and illustrate all data (including U.S. Geological Survey data) for presentation in a report. Compute annual sediment loads from daily measurements at sediment stations. Make record extensions where they can be proven to be statistically sound. Regress mean annual sediment loads against land-use factors and basin and climatic characteristics to determine if variation in sediment loads can be explained by natural characteristics and man-induced development; the extent of this analysis will depend on the adequacy of the sediment-data base.

PROGRESS: All sediment-data sources in Colorado have been identified; most data have been summarized for the U.S. Geological Survey, the U.S. Forest Service, and other collecting agencies. Annual sediment-load estimates have been made, where data are reliable and adequate. Loads estimated by other investigators also have been tabulated.

PLANS FOR FY 86: Regional analysis of sediment yields in Colorado will be started and completed. Sediment loads were computed (estimated) in FY 85. Many basin characteristics for the same streams have been published. Trends in sedimentation yields with time, geomorphology, and land use will be searched.

PROJECT TITLE: Sources and Movement of Hazardous Wastes in a Heavily Used Stream-Aquifer System

PROJECT NUMBER: CO-84-180

STUDY LOCATION: El Paso County, Colorado

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

PROJECT CHIEF AND OFFICE: Douglas L. Cain, Subdistrict Office, Pueblo

PROJECT DURATION: April 1984 to September 1987

PROBLEM: Stream-aquifer systems are among the most important sources of ground-water supply for municipal and agricultural uses in the semiarid west. Concurrently, the streams that are part of these systems often are used heavily for disposal of municipal, industrial, and agricultural waste water, resulting in a high potential for ground-water contamination. Currently, little is known about the concentrations, distribution, sources, and movement of hazardous substances in stream-aquifer systems.

OBJECTIVES: Determine the occurrence and distribution of organic substances and trace metals in the Fountain Creek stream-aquifer system. Determine if the occurrence or concentrations are related to land use or quality of recharge water. Evaluate the concentrations, sources, and movement of specific organic chemicals or metals in a small area of the stream-aquifer system; assess the applicability of the study results to other locations.

APPROACH: Assemble and evaluate existing data on water quality, well location and construction, land use, and waste discharge. Review literature on sampling methods for organics. Collect reconnaissance water-quality data from about 15 wells under each land use. Evaluate reconnaissance data for relation between water quality and land use. Select constituents for intensive study in a small area. Collect samples in area selected, based on ground-water flow and recharge pattern, to determine temporal and spatial distribution, and source and movement of select constituents.

PROGRESS: Existing water-quality data were compiled and summarized; additional water-quality samples were collected at six surface-water sites. Geologic, hydrologic, land-use, and water-quality data were evaluated and analyzed; a draft-reconnaissance report was prepared for the alluvial aquifer along Fountain Creek between Colorado Springs and Pueblo, Colo. The draft report was condensed into a summary chapter for inclusion in the summary report of regional ground-water-quality appraisals.

PLANS FOR FY 86: Original draft report will be revised and published. Chapter for inclusion in summary report will be revised. Work plan for second phase of study will be prepared, and second phase of study will begin.

PROJECT TITLE: Dissolved Solids in the Colorado River Basin

PROJECT NUMBER: CO-84-181

STUDY LOCATION: Colorado River Basin

COOPERATING AGENCY: U.S. Bureau of Reclamation and U.S. Geological Survey

PROJECT CHIEF AND AGENCY: David K. Mueller, District Office, Lakewood

PROJECT DURATION: March 1984 to September 1986

PROBLEM: The salt load in the Colorado River causes millions of dollars in damage annually to agricultural, industrial, and municipal users. The U.S. Bureau of Reclamation is in process of implementing various salinity-control programs in the Upper Colorado River Basin to reduce salt loads to the river. Decreased salt loads from some upper basin areas have been indicated; however, definitive causes for the decreases are not readily apparent. Hence, a need exists to determine if a trend occurs in the salinity data from the monitoring stations, and, if so, to determine the source of the trend.

OBJECTIVES: Determine for the Upper Colorado River Basin: (1) General source areas of dissolved-solids concentration and water discharge; (2) concentration variation at each monitoring station; (3) time series of annual dissolved-solids load at each site; (4) long-term trends in dissolved-solids concentration at each of the stations; and (5) influence of man's activities on the salt load; then (6) develop a method to determine the natural salt load in the Upper Colorado River Basin.

APPROACH: Determine general source areas of dissolved-solids concentrations by percentage of dissolved-solids load at the mouth of the Upper Colorado River Basin. Based on historical record, identify the range of concentrations of dissolved solids for each monitoring station. Using state-of-the-art statistical techniques, determine and present the time series of annual dissolved-solids loads, and identify any long-term trends in dissolved-solids concentrations that may exist. Based on development information, determine the natural and historical salt load at each site in the Upper Colorado River Basin.

PROGRESS: All data were retrieved and compiled for 68 water-quality stations in the Upper Colorado River Basin. A draft of the first report is being prepared at this time. The interpretation and data retrieval necessary for the second and third reports are progressing simultaneously with the writing of the first report.

PLANS FOR FY 86: All interpretations will be completed, and three reports will be prepared.

PROJECT TITLE: Preliminary Assessment of Methods for Determination of Evaporation Components by Water Resources Council (WRC) Subregions

PROJECT NUMBER: CO-84-183

STUDY LOCATION: Nationwide

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

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

PROJECT DURATION: April 1984 to September 1986

PROBLEM: To estimate renewable water supply on a subregion basis for the National Water Summary, consumptive use must be known. Consumptive use includes industrial and agricultural consumption and net reservoir evaporation. Net reservoir evaporation is the water-surface evaporation, excluding the natural evapotranspiration that would occur had the reservoir not been constructed. Therefore, for the National Water Summary, estimates of natural evapotranspiration and gross evaporation will be needed on a Water Resources Division subregion unit basis.

OBJECTIVES: Determine deviations between values from the National Weather Service national evaporation map and values from site-specific studies. Using test basins, determine order and magnitude and feasibility of computing natural basin-evapotranspiration losses as compared to gross-reservoir evaporation. Create a data-base system of reservoirs having storage capacity greater than 5,000 acre-feet. Using created data base, develop history of reservoir development by hydrologic unit. Develop regional relations to estimate surface area from storage capacity; current data do not include measurements of surface area.

APPROACH: Tabulate published and unpublished evaporation rates from energy-budget studies and compare to values from National Weather Service map. Evaluate techniques to determine water-budget components (evaporation and evapotranspiration) on a national basis, using selected test basins; test basins will be selected, based on criteria to simplify water-budget assumptions, that is, best possible cases. If method will not work for best possible conditions, it will not work on a national basis. Using the U.S. Army Corps of Engineers' master inventory of dams, a file of reservoirs with storage capacity greater than 5,000 acre-feet has been generated; this file will be used as a reservoir-data base.

PROGRESS: Storage ratios, drainage areas, and other missing attributes in the reservoir data base were determined. The method of combining national precipitation, runoff, and evaporation maps, using ARC/INFO, was determined.

PLANS FOR FY 86: National maps of runoff, precipitation, and evaporation will be digitized and computer-combined to determine net-reservoir evaporation by hydrologic unit for the United States. Writing of an Open-File Report on the reservoir data base and an update to Water-Supply Paper 1838 will be initiated. Reservoir data base, in a menu-driven INFO data-base system, will be completed.

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, Lakewood

PROJECT DURATION: April 1984 to September 1986

PROBLEM: Knowledge of the amount of sediment transported by the various rivers of the United States is essential to: (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 absorbed 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 impact on sediment production.

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

PROGRESS: Sediment loads are being determined for major river basins of the United States. Development of a data-handling technique is helping to quickly search through sediment records and generate sediment-load values of streamflow-gaging stations.

PLANS FOR FY 86: Load maps and ancillary information will be completed for the 17 basins. Writing of an interpretive report will be initiated.

PROJECT TITLE: Significant Accomplishments in Coal Hydrology, 1974-1984

PROJECT NUMBER: CO-84-185

STUDY LOCATION: Nationwide

COOPERATING AGENCY: U.S. Bureau of Land Management and U.S. Geological Survey

PROJECT CHIEF AND OFFICE: Linda J. Britton, District Office, Lakewood

PROJECT DURATION: March 1984 to October 1986

PROBLEM: During the past 10 years, the U.S. Geological Survey has conducted more than 250 hydrologic studies nationwide to assess the hydrologic effects of coal mining. This information needs to be summarized, and the major study findings and accomplishments need to be disseminated for informational and program-development purposes.

OBJECTIVE: Provide a general source of information on the accomplishments of the coal-hydrology program to Federal and State agencies that are concerned with planning, regulating, and enforcing land use and that are making water-resources and development decisions. The report also will contain a section on hydrologic information and research that is needed.

APPROACH: Compile the accomplishments and findings of the coal-hydrology program, as related to issues and problems, through a coordinated effort by personnel of the U.S. Geological Survey and other Federal agencies. Discuss history, objectives, program design, application of results, and study needs from a national perspective in this report.

PROGRESS: All the sections of the report have been prepared; editing of the draft for colleague review is complete. The base map and maps for individual coal areas also have been completed, and a storyboard review (colleague) was completed in November 1985.

PLANS FOR FY 86: The report will be submitted for approval in April 1986.

PROJECT TITLE: Water Quality of Kenney Reservoir

PROJECT NUMBER: CO-84-186

STUDY LOCATION: Rio Blanco County, Colorado

COOPERATING AGENCY: Colorado River Water Conservation District

PROJECT CHIEF AND OFFICE: Robert L. Tobin, Subdistrict Office, Meeker

PROJECT DURATION: April 1984 to December 1987

PROBLEM: Kenney Reservoir is a small-capacity reservoir (13,000 acre-feet) scheduled for completion on the White River in summer 1984. The reservoir will have a short hydraulic residence time, except during late summer and fall and in low-flow years. During these periods, the reservoir may develop thermal stratification with associated changes in dissolved oxygen, and in biological and chemical constituents. To evaluate these changes and the impacts of sediment loading to the reservoir, data needs to be collected at several depths throughout the year. This information, combined with sediment inflow-outflow data, will provide a three-dimensional definition of the physical state of the reservoir, including the rate of sediment deposition.

OBJECTIVES: Collect sufficient data to describe chemical and biological conditions and the dynamics that occur within the reservoir during the first 2 years after filling. Make estimates of sediment retention and reservoir trap efficiency. Summarize all data in an interpretive report.

APPROACH: Determine water-quality characteristics with depth seasonally at two or three sites, from profile measurements of temperature, specific conductance, pH, and dissolved oxygen. Determine major ions, nutrients, trace metals, phytoplankton identification, chlorophyll *a* and *b*, and bacteria from samples taken at specific depths. Determine sediment loading to the reservoir from bedload and suspended-sediment collections at streamflow-gaging stations above and below the reservoir. Review data annually for their applicability to meeting study objectives, and make necessary program changes.

PROGRESS: Chemical, physical, and biological data were collected from two sites in Kenney Reservoir and from one upstream streamflow-gaging station on the White River during 1985. Collections occurred under ice, during mixing periods, and during thermal stratification; no downstream streamflow-gaging station was funded. Minimal water-quality degradation with depth occurred in the reservoir, principally because of the quantity and quality of inflowing waters and bottom releases of the dam. Preliminary data show that suspended sediment provided more than 95 percent of load deposited in the reservoir.

PLANS FOR FY 86: Data will continue to be collected at two sites in the reservoir and at the upstream station on the White River. Past and present data will be collated, and a report outline will be prepared.

PROJECT TITLE: Total Sediment Transport at Colorado Reservoir Sites--Una Site, Colorado River near De Beque, Colorado

PROJECT NUMBER: CO-84-187

STUDY LOCATION: Mesa County, Colorado

COOPERATING AGENCY: Colorado River Water Conservation District

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

PROJECT DURATION: April 1984 to September 1987

PROBLEM: Sediments transported by rivers flowing into reservoirs are deposited throughout the length of the impoundment. Deposits may occur in the upper reaches of the reservoir that are controlled by hydraulics; as water depths increase and flow velocity decreases, bedload or coarser material is dropped 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.

OBJECTIVE: Measure the total inflow of suspended sediment and bedload into reservoirs or through reaches where reservoirs may be impounded. Estimate the effect of sediment deposition.

APPROACH: (1) Using standard techniques, collect suspended-sediment, bed material, and bedload data; (2) develop suspended-sediment, bedload, and total sediment-discharge relations, based on the collected data and on estimates from empirical techniques such as the Colby and modified Einstein equations; (3) compute annual sediment discharges at potential reservoir locations, using the sediment ratings and streamflow data; and (4) estimate trap efficiency of the reservoir, specific weight of the deposited sediment, and distribution of the sediment within the reservoir to assist in the design of reservoir structure and operating pilings.

PROGRESS: Samples were collected for total sediment at an active gage, Rock Creek at Crater, and upstream at an inactive gage near Toponas. Suspended-sediment samples were available for May samples only; concentrations were less than 50 mg/L (milligrams per liter) for all but one sample. No bedload data were available. Additional suspended-sediment data, collected from 1976 to 1984, were obtained for the Toponas site from the U.S. Forest Service.

PLANS FOR FY 86: Relations of sediment discharge to stream discharge will be developed for suspended and bedload sediment. Whether or not relations are equivalent between the Crater and Toponas sites will be determined. The mean annual-sediment discharge from the historical discharge record for the Toponas site will be estimated. The sedimentation rate of the proposed reservoir will be estimated. A draft report will be written. Total inflow of sediment transported by Fortification Creek at the reservoir site will be determined.

PROJECT TITLE: Study of Colorado Water-Quality Monitoring Activities

PROJECT NUMBER: CO-84-192

STUDY LOCATION: Statewide

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

PROJECT CHIEF AND OFFICE: Tom Chaney, District Office, Lakewood

PROJECT DURATION: September 1984 to December 1986

PROBLEM: Water-quality information is collected by universities, private companies, and local agencies. No systematic information base has been available that identifies organizations that collect water-quality data, what type of data are collected, where data are collected, availability and accuracy of the data, and the costs of collecting the data. Without knowledge of the type and quantity of data available, agencies may be duplicating efforts, or agencies may not be aware of existing data that would meet their needs. Federal, State, and local agencies, by coordinating their sampling activities, may increase the efficiency of their data-collection operations.

OBJECTIVES: Determine the number of Federal, State, and local agencies, as well as universities and private laboratories, conducting water-quality sampling programs and analyses. Also determine the type, quantity, and purpose of data collected by these organizations and their annual expenditures and sources of funding. A second and third phase of this study will evaluate the feasibility of using the available data to address regional water-quality questions.

APPROACH: The first phase of the study will include: (1) Interviewing key officials from agencies such as the Environmental Protection Agency, Colorado Department of Health, Colorado State University, and the Water Resources Institute obtaining background information on sampling strategies and identifying contacts at local government levels for operation of water-supply systems and sewage-treatment plants; identifying major ongoing projects; (2) mailing questionnaires to Federal, State, or local agencies and universities and private laboratories as appropriate; providing followup letters or telephone calls as appropriate; (3) compiling and tabulating data by level of government, by type of sampling activity, and by funding source; (4) estimating the costs of water-quality data collection activities in Colorado; and (5) writing a report describing an overview of data results.

The second phase of the study will entail evaluation of data to determine if quality-assurance criteria are met, and to select water-quality data that can be used to define existing water-quality conditions and trends in Colorado. A report will be written describing the quality-assurance criteria and the availability of data for addressing key concerns.

The third phase of the study will use the available data (compiled in phase II) to determine near-natural water-quality conditions, existing water-quality conditions, and water-quality trends for selected issues of statewide concern. The final report will summarize the results of this analysis and provide an evaluation of the adequacy of the data base for addressing regional issues.

PROGRESS: Survey was completed of all agencies undertaking water-quality monitoring activites; results of survey were compiled; an interpretive report was prepared. A second survey of selected agencies was completed to identify their sampling techniques and laboratory-analysis methods and to compile the second survey results. Compilation of data from the U.S. Geological Survey and other agencies was initiated. Phase I report was completed and approved.

PLANS FOR FY 86: A Phase II report discussing agency-sampling techniques and laboratory-analysis methods will be prepared. Data from selected agencies will be compiled to analyze for existing conditions and trends in monitoring dissolved-solids, suspended-sediment, dissolved-oxygen, and fecal-coliform concentrations. A draft Phase III report presenting results of this data analysis will be started.

PROJECT TITLE: Wetland, Ground-Water, and Surface-Water Relationships in a Subalpine Valley in Grand County, Colorado

PROJECT NUMBER: CO-85-193

STUDY LOCATION: North-central Colorado

COOPERATING AGENCY: City and County of Denver, Board of Water Commissioners

PROJECT CHIEF AND OFFICE: Robert S. Williams, Subdistrict Office, Lakewood

PROJECT DURATION: October 1984 to October 1987

PROBLEM: Surface water from the South Fork of the Williams Fork River is being considered for diversion to another basin. Wetland areas along the banks of the South Fork receive water from side-slope discharge, from riverbank overflow, from subsurface contribution along losing reaches of the river, or from a combination of these sources. If the wetlands are receiving significant amounts of water from the river, then a reduction in river discharge may impact the wetland areas.

OBJECTIVES: Identify the hydrologic connection between the South Fork Williams Fork River, the adjacent wetlands, and the wetland ground-water system. Evaluate the hydrologic effects of diverting water from the South Fork River on adjacent wetlands.

APPROACH: Collect hydrologic data at four wetland sites and meteorological data at two stations. Design the well network at each site to define the geometry of the wetland water table; determine the direction of wetland ground-water flow from this information. Determine the chemical nature of the wetland ground water from this water-quality information, and if it is different from the surface water. Denote the time and duration of any overbank flooding from streamflow-gaging stations. Combine the streamflow information with the wetland ground-water information to help delineate interaction between the river, the wetland ground water, and the wetlands.

PROGRESS: Five surface-water gages were installed; 26 wells were drilled; 2 weather stations were constructed. Surface-water and ground-water levels were measured. Water-quality samples were taken quarterly from each surface-water site and from three ground-water sites; wetlands appeared to be gaining reaches.

PLANS FOR FY 86: Monitoring will be continued, and possibly new wells and a new surface-water gage will be installed.

PROJECT TITLE: Hydrologic Response of the Denver Basin Bedrock Aquifers to Pumpage in Northern El Paso County, Colorado

PROJECT NUMBER: CO-85-194

STUDY LOCATION: Denver Basin, east-central Colorado

COOPERATING AGENCY: City of Colorado Springs, Department of Public Utilities

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

PROJECT DURATION: October 1984 to October 1986

PROBLEM: Large-scale development of bedrock-water supplies in northern El Paso County will produce large water-level declines in the aquifers and could cause dewatering in updip parts of the bedrock formations, which may reduce the volume of water supplied from wells. Further reductions in pumping rates might be required, if existing water rights along Monument and Fountain Creeks are damaged by development of the bedrock aquifers.

OBJECTIVE: Provide a current hydrologic evaluation of conditions in the bedrock aquifers of El Paso County and use this information as a basis for an updated model capable of simulating the response of the aquifers to proposed pumpage in El Paso County.

APPROACH: Collect additional water-level measurements, aquifer tests, and well logs to update similar data collected in 1980. Rebuild the southern part of the existing Denver Basin model at a finer grid spacing, using these data. Calibrate the updated model against rates of measured ground-water discharge to base flow in Monument and Fountain Creeks. Use the calibrated model to simulate the response of the aquifers to proposed pumping in northern El Paso County.

PROGRESS: Water-level data were collected to define the 1985 potentiometric surfaces of the four Denver Basin bedrock aquifers in El Paso County. The source code for the model was transferred from the U.S. Bureau of Reclamation CDC Cyber computer to the U.S. Geological Survey Prime computer. Substantial rewriting of the code consequently was required to make the model properly operate on the Prime computer. The model grid was revised to a 64- by 40-node network. Input arrays were coded for geologic structure, transmissivity, vertical conductance, and storage coefficient or specific yield. Calibration of a steady-state model was started.

PLANS FOR FY 86: Calibration of the steady-state model will be completed. The transient model will be calibrated and analyzed for sensitivity. If the model is shown to be overly sensitive to input parameters, that would be defined better by collecting gain-and-loss or aquifer-test data, and if time allows, these data will be collected. Simulation runs of the model will be made. The report first draft will be written; it is expected to be delivered to colleague review by the end of the fiscal year.

PROJECT TITLE: Transit Losses along Fountain Creek Associated with Return Flows of Transmountain Water Utilized by the City of Colorado Springs

PROJECT NUMBER: CO-85-195

STUDY LOCATION: Fountain Creek from Colorado Springs to Pueblo, Colorado

COOPERATING AGENCY: City of Colorado Springs, Department of Public Utilities

PROJECT CHIEF AND OFFICE: Gerhard Kuhn, Subdistrict Office, Lakewood

PROJECT DURATION: January 1985 to January 1987

PROBLEM: Return flows of imported water used by the City of Colorado Springs flow into Fountain Creek, where they have been treated as natural streamflow in the past. However, in the future, the City of Colorado Springs intends to make full use of its transmountain-diversion rights, through a complex water-rights exchange agreement. Because the return flows have been treated as natural streamflow, existing streamflow records are insufficient in documenting that part of the return flows reaching the mouth of Fountain Creek, one of the points for the exchange agreement. In addition to the complex effects that diversion and reuse have on streamflow along Fountain Creek, the system also is subject to variable ground-water pumpage, localized runoff from thunderstorms, occasional dry reaches during low-flow periods, and significant streamflow losses, as recharge to the Widefield aquifer and Fountain Creek alluvium.

OBJECTIVES: Identify the fate of transmountain-return flows to Fountain Creek in the reach between their wastewater-treatment plant and the mouth of Fountain Creek; this identification will result in the establishment of the "natural" flow of Fountain Creek downstream from Colorado Springs. Determine the transit loss associated with both continuous or noncontinuous releases of return flows into Fountain Creek; this determination will allow quantification of return flows reaching the Arkansas River.

APPROACH: Because the hydrologic complexity of the problem will require the development and use of hydrologic or hydraulic models of the Fountain Creek system, select or develop the models on the basis of their data requirements and their ability to meet study objectives within a reasonable level of accuracy. Test the models, using existing records of streamflow, surface-water diversions, ground-water pumpage, and water use. Include in the final report a data summary, description of technical approach, and discussion of the transit losses of the return flows, for a variety of release and streamflow conditions.

PROGRESS: Three streamflow-gaging stations were installed--one on Fountain Creek and two on ditches. Two gain-loss investigations of Fountain Creek were conducted. Streamflow and diversion records were compiled. Study reach was divided into 18 reaches for purposes of modeling; physical

characteristics of each reach were compiled. The J349 model "Streamflow routing with losses to bank storage and wells," by L. F. Land was chosen for the study. Preliminary model runs were made to gain some familiarity with the J349 model.

PLANS FOR FY 86: Two or three more gain-loss runs will be conducted. Groundwater and pumping data will be compiled for use in model input. Calibration of the model will begin, using existing streamflow data and model calibration. Increased transit losses, with addition of transmountain water to Fountain Creek, will be simulated by the calibrated model. The final report will be written and submitted for colleague review.

PROJECT TITLE: Sediment-Transport Characteristics and their Effects on Aquatic Life in the Fountain Creek Basin above Widefield, Colorado

PROJECT NUMBER: CO-85-196

STUDY LOCATION: Colorado Springs and vicinity in Arkansas River basin

COOPERATING AGENCY: City of Colorado Springs, Department of Public Utilities

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

PROJECT DURATION: January 1985 to September 1989

PROBLEM: Expanding urbanization in the Colorado Springs area is likely to increase stream-sediment loads during development. As development continues, the increase in impervious land areas may cause an increase in the magnitude and frequency of streamflow peaks. Resultant increase in bed scour and bank erosion will effect changes in channel morphology and may be detrimental to existing aquatic life. Increased channel erosion may affect riparian vegetation, stream-side recreation, diversion headgates, and other manmade structures.

OBJECTIVES: Define source areas of sediment and provide information on current sediment loads, on channel stability, and on changes observed during the study. Relate existing stream-sediment conditions to aquatic life in Fountain and Monument Creeks.

APPROACH: Incorporate systematic collection of sediment and biological data at a network of six sites. Collect 50 sediment samples at each site. Collect three bedload samples per site, with bottom material and suspended samples for full-size analysis. Establish channel cross sections at each site. Conduct biological sampling for benthic invertebrates at five sites. Delineate sediment-source areas by synoptic sampling at 20 sites.

PROGRESS: Data collection began during the spring of 1985. A series of benthic samples were collected through the hydrologic cycle. Suspended and bedload sampling began in April. Two synoptic sediment-sampling runs were made during snowmelt and rainfall-runoff events. Channel cross sections were established and monitored.

PLANS FOR FY 86: Collection of sediment-transport, channel-morphology, and stream-biology data will be continued. A report on sediment-source areas will be prepared, using information from the synoptic-sampling, geology, soils, and land-use information in the area.

PROJECT TITLE: Ground-Water-Quality Effects of Soil Application of Sewage Sludge on Farmland near Denver, Colorado

PROJECT NUMBER: CO-85-197

STUDY LOCATION: North-central Colorado

COOPERATING AGENCY: Metropolitan Denver Sewage Disposal District No. 1

PROJECT CHIEF AND OFFICE: Neville G. Gaggiani, Subdistrict Office, Lakewood

PROJECT DURATION: October 1984 to September 1987

PROBLEM: Metropolitan Denver Sewage Disposal District No. 1 is beginning a program of disposal of anaerobic, digested, activated sludge, by land application to farmland. The sludge will be injected about 6 to 10 inches into the soil, using a vehicle with a device that plows at the same time. Although the sludge will be applied at agronomic rates, the potential exists for leaching of organic and inorganic compounds into the ground water.

OBJECTIVE: Determine the effects of soil application of sewage on the ground-water quality. To accomplish this, determine the general flow rate, amount, and quality of the water in the saturated and unsaturated zones.

APPROACH: After a suitable site has been selected, install piezometers, lysimeters, and a recording rain gage. Collect water samples from the saturated and unsaturated zone before sludge is applied, so that normal background conditions can be determined. After sludge is applied, sample the wells and lysimeters three times each growing season. Determine direction of flow from water levels in wells on and near the site. Use the Kendall rank correlation coefficient to test areal-concentrations variations.

PROGRESS: A site was selected where both dry-land wheat and irrigated crops are raised. Fifteen wells were drilled on the site; four existing privately owned wells outside the site completed the observation-well network. Two gages were installed at the center of the 1-square mile site to measure and record precipitation. One of the gages measured and recorded snowfall as well as rainfall. Eight suction lysimeters also were installed at various depths at three locations within the site. Water samples were collected for chemical analysis from the well network twice during the summer, before the sewage sludge was applied. Water levels in the wells were measured periodically. Application of sewage sludge to the site began in the first part of September.

PLANS FOR FY 86: Water-quality samples will be taken from the observation wells during the summer season. Snowfall and rainfall precipitation will be measured and recorded. Water samples will be collected from the lysimeters, if possible.

PROJECT TITLE: Comprehensive Water-Quality Evaluation of Pueblo Reservoir, Including the Effects of Potential Contamination

PROJECT NUMBER: CO-85-198

STUDY LOCATION: Central Colorado

COOPERATING AGENCY: Southeastern Colorado Water District; Fountain Valley Authority; Pueblo West Metropolitan Water District

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

PROJECT DURATION: March 1985 to September 1989

PROBLEM: Pueblo Reservoir is a multiple-use reservoir. Reservoir water is used for municipal, industrial, agricultural, and recreational purposes. Pueblo Reservoir receives storm runoff, salt loading from irrigation-return flows, extensive recreational use, upstream mine drainage, discharge from municipal and industrial wastewater, and transportation spills. Recent concerns over marked increase in taste and odor problems and other potential water-quality problems that may affect Pueblo Reservoir's many uses have led to a comprehensive water-quality evaluation of Pueblo Reservoir.

OBJECTIVES: Define vertical, areal, and seasonal variations of physical, chemical, and biological characteristics in Pueblo Reservoir. Develop methods to predict reservoir response to various contaminants. Evaluate management alternatives to maximize the reservoir's long-term suitability for various uses.

APPROACH: Collect and evaluate physical, chemical, and biological data on the reservoir inflow, the reservoir, and the reservoir outflow for 3 years. Compile and classify potential contaminants. Calibrate reservoir model to aid in understanding circulation patterns and residence-time stratification. Using information from data-collection effort, the model, and list of potential contaminants, predict reservoir response to various contaminants. Evaluate various management alternatives.

PROGRESS: Twenty-one sites on Pueblo Reservoir were profiled for pH, temperature, dissolved oxygen, and specific conductance to assess longitudinal and lateral variations. In addition, chemical and biological analyses were made on samples collected from seven reservoir sites and inflow and outflow sites.

PLANS FOR FY 86: 1985 data will be analyzed, using graphs and statistics. Model simulations will be made of reservoir, using the "Better model," 1985 inflow, and climatological data. Report assessing the quality of water of Pueblo Reservoir will be drafted, based on 1985 data. A list of potential contaminants will be compiled.

PROJECT TITLE: Trends in Water Quality of Monument and Fountain Creeks, El Paso and Pueblo Counties, Colorado

PROJECT NUMBER: CO-85-200

STUDY LOCATION: Central Colorado

COOPERATING AGENCY: City of Colorado Springs, Department of Public Utilities

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

PROJECT DURATION: January 1985 to September 1989

PROBLEM: Development of land and ground water in the Colorado Springs area is likely to cause changes in the water quality of Monument and Fountain Creeks. These changes could cause water quality to become a limiting factor for some stream uses.

OBJECTIVES: Evaluate spatial changes in water quality of Monument and Fountain Creeks. Determine time trends for selected water-quality constituents, where data permit. Make a preliminary assessment of the effects of ground-water seepage on the water quality of Monument Creek.

APPROACH: Continue water-quality-data collection on Monument and Fountain Creeks. Collect ground-water samples from wells adjacent to Monument Creek. Evaluate surface-water-quality data, using various statistical techniques to test for trends.

PROGRESS: Monthly surface-water samples were collected and analyzed for four stations on Monument Creek and five stations on Fountain Creek.

PLANS FOR FY 86: Surface-water-quality data will be collected monthly at four stations on Monument Creek and five stations on Fountain Creek. Preliminary graphical and statistical evaluation of the data will be made, as data become available.

PROJECT TITLE: Geomorphic Stability of Reclaimed Land Surfaces in the Green River Coal-Resource Region

PROJECT NUMBER: CO-85-201

STUDY LOCATION: Northwestern Colorado

COOPERATING AGENCY: Colorado Division of Mined Land Reclamation

PROJECT CHIEF AND OFFICE: John G. Elliott, District Office, Lakewood

PROJECT DURATION: February 1985 to April 1987

PROBLEM: Recently reclaimed surface-mined areas in the western United States have a large potential for erosion problems. Hillsides often are regraded to slopes or shapes different from their original configuration, and they undergo severe rilling, gullying, or slumping. Several of the reclaimed mine sites in northwestern Colorado have exhibited these problems. This type of erosion may be from the lack of established vegetation on regraded slopes, or it may be from improper reconstruction of the reclaimed surfaces. Previous studies have examined some of the variables that are critical to slope and channel stability; other studies have attempted to predict general erosion potential and long-term sediment loss. By studying specific sites that exhibit a variety of soil, slope, vegetation, and climatic characteristics, dominant factors that control erosion can be identified; mitigating actions can be outlined by management agencies; and some future problems may be avoided.

OBJECTIVES: Document the type, severity, and location of erosion problems in surface-mined areas of northwestern Colorado, where reclamation has been attempted. Identify the hydrologic and geomorphic processes responsible for erosion problems at these sites. Develop a threshold-type model of slope stability-instability, using data from sites that show no evidence of severe erosion and from sites that are experiencing severe erosion.

APPROACH: Collect geomorphic, hydrologic, and climatic data from 20 to 30 mined and unmined sites in northwestern Colorado. Include these sampled variables: Slope angle and aspect, type and density of vegetation cover, drainage-basin size and shape, soil type, precipitation, size and spacing of gullies or slumps, and age of reclamation. Develop regression equations illustrating the relations between dependent variables and "quasi-independent" variables for both disturbed and undisturbed sites. Develop guidelines for future collection and interpretation of data in other areas.

PROGRESS: Literature search, acquisition of topological maps, and reconnaissance has begun. Preliminary data-collection scheme and approach to analysis has begun. Two sites were surveyed and sampled in September 1985.

PLANS FOR FY 86: Geomorphic, vegetation, soil, and climatic data will be collected from numerous additional mined and unmined sites. Analysis and interpretation will be continued. Report preparation will begin.

PROJECT TITLE: Modeled Impacts of Surface-Coal Mining on Dissolved Solids in the Yampa River Basin, Northwest Colorado

PROJECT NUMBER: CO-85-202

STUDY LOCATION: Northwestern Colorado

COOPERATING AGENCY: Colorado Division of Mined Land Reclamation

PROJECT CHIEF AND OFFICE: George W. Linn, District Office, Lakewood

PROJECT DURATION: July 1985 to September 1986

PROBLEM: Many new mines and expansion of old mines are proposed within coal-mining areas. These proposals need to be considered with respect to the cumulative impacts on the dissolved-solids concentration downstream. An available model allows the insertion of new mining activity and the routing of the additional dissolved solids downstream, which provides the user with values for increased dissolved-solids concentrations and loads at specific downstream points. Unfortunately, this model only operates through batch processing. An interactive version would provide individuals concerned with environmental impacts greater flexibility in decision making. The model uses graphics packages that may not be available in some computer systems.

OBJECTIVE: To revise the existing dissolved-solids model to provide interactive capability, to calibrate the model, and to write a complete user document.

APPROACH: Convert the model to operate interactively on a time-sharing computer. Develop additional flexibility to allow the user to insert proposed mines, streamflow-gaging stations, and sampling sites for calibration points at any location in the system. Revise to allow interactive changes of node parameters, and consider converting the interactive version of the model to other computer systems, particularly a personal computer, after identifying the compatibility of the model with various other computers.

PROGRESS: Met with cooperators and determined that model will be run on the Colorado District Prime computer, because of the lack of suitable graphics software on the cooperator's computer. Model conversion and testing was begun.

PLANS FOR FY 86: A Water-Resources Investigations Report will be completed, describing time-share version of dissolved-solids model and application of that model to the Yampa River basin.

PROJECT TITLE: Impacts of Coal-Mine Development on Ground-Water Resources in the Twentymile Park Area, Northwest Colorado

PROJECT NUMBER: CO-85-203

STUDY LOCATION: Routt County, Colorado

COOPERATING AGENCY: Colorado Division of Mined Land Reclamation

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

PROJECT DURATION: June 1985 to September 1988

PROBLEM: Existing mines and proposed new mines in the area will pump water from the Mesaverde Group to prevent mine flooding. This pumpage, coupled with leaching of soluble minerals from mine tailings into the bedrock or alluvial aquifers, may affect adversely the ground-water resources in the area. Asssessment of probable mining impacts on the water resources are required as part of the mine-permitting procedures followed by the Colorado Division of Mined Land Reclamation (CDMLR). The complex hydrologic system in the basin makes accurate assessment of the mining impacts difficult or impossible, without access to better data and state-of-the-art modeling techniques.

OBJECTIVE: Quantitatively define the ground-water flow system in the area and develop a three-dimensional solute-transport model of the basin capable of simulating mining impacts on the ground-water flow system.

APPROACH: Compile existing hydrologic data from files of State and Federal agencies; check data onsite; update with new onsite data. Map the geological structure of the Twentymile Park basin and subdivide the geologic units into hydrologic units, for purposes of modeling. Construct and use a multilayer ground-water-flow and solute-transport model to simulate impacts of mine pumping and leaching of tailings.

PROGRESS: Project activities began in June 1985. Basic hydrologic data was compiled from files of various State and Federal agencies. Base maps of the project area were drafted; existing data compilation on these maps has begun. Collection of rock samples from drill core and outcrops is in progress. Laboratory analyses of hydraulic properties of these samples are underway.

PLANS FOR FY 86: The basic data compiled from local sources will be field-checked and updated with new field (onsite) data. Geologic mapping will be checked, and the geologic units will be subdivided into hydrologic units. Hydraulic characteristics of the hydrologic units will be defined for use in subsequent modeling.

PROJECT TITLE: Geohydrology and Quality of Ground Water in the Lincoln Park Area, Canon City, Colorado

PROJECT NUMBER: CO-85-204

STUDY LOCATION: Central Colorado

COOPERATING AGENCY: U.S. Environmental Protection Agency

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

PROJECT DURATION: December 1984 to December 1985

PROBLEM: Aquifers underlying the Lincoln Park area have been contaminated by raffinate from industrial activity in the area. Previous studies have: (1) Described the extent of contamination of the shallow ground-water system in the Lincoln Park area; (2) identified the nearby uranium mill as a probable source of raffinates; (3) located the probable pathway of migration from the mill to Lincoln Park as passing near the U.S. Soil Conservation Service dam on Sand Creek; and (4) identified several weaknesses in the available data base. This study will focus on improving the data base and on interpreting the ground-water flow system.

OBJECTIVES: Describe the chemical characteristics of possible sources and the distribution of water-quality characteristics in the shallow aquifers of the Lincoln Park study area. Define the aquifer characteristics and head in the ground-water flow system. Determine geochemical characteristics of aquifer materials and ground water that affect transport of contaminants, including oxidation-reduction potentials and ion-exchange capacities.

APPROACH: Describe raffinate distribution and its source by using results of new and existing water-quality information. Define the ground-water flow system by using data from both existing and new wells. Interpret ground-water geochemistry using available geochemical tools.

PROGRESS: Seven observation holes were drilled and completed to nine intervals (two dual-completion holes) in the Vermejo Formation and overlying alluvium. Head data and water samples were collected from these and selected existing wells. None of the seven holes penetrated saturated alluvium; water in the Vermejo Formation was confined and chemically dissimilar to shallow water, both south of the U.S. Soil Conservation Service dam and in Lincoln Park.

PLANS FOR FY 86: The report will be written, reviewed, and published.

PROJECT TITLE: Potential Hydrologic Effects of Underground Coal Mining near Palisade, Colorado

PROJECT NUMBER: CO-85-205

STUDY LOCATION: Rapid Creek Drainage Basin

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF AND OFFICE: Thomas D. Brooks, Subdistrict Office, Grand Junction

PROJECT DURATION: March 1985 to September 1986

PROBLEM: Present coal-mining leases are in the lower part of the Rapid Creek drainage basin; additional leases would be higher in the drainage basin. Surface water in reservoirs within the Rapid Creek drainage basin is the sole municipal water source for the town of Palisade, Colorado. Underground mining cannot be permitted by the Bureau of Land Management (BLM) if any reasonable potential exists for disturbing the developed water supply. Subsidence fracturing from underground mining could disturb that supply. An understanding of local geohydrology would allow a better assessment of the suitability of Rapid Creek basin for coal-mine leasing.

OBJECTIVES: Collect data to better describe the local geohydrology to determine the potential impact of additional coal mining by: (1) Describing local geology and structure; (2) determining relations between hydrology and potential underground mining; and (3) reporting the conclusions.

APPROACH: Compile a study bibliography. Inventory springs, wells, streams, and reservoirs. Collect hydrologic and geologic information necessary for a hydrogeologic study. Make an isopach map of overburden thickness. Measure spring discharges, depths to water in wells, and gain-and-loss measurements of Rapid and Cottonwood Creeks. Locate and map reservoirs. Measure onsite pH, specific conductance, and temperature for water samples. Do an onsite investigation of fractures caused by subsidence. Determine and describe ground-water-flow systems in the Rapid Creek drainage. Determine and describe potential hydrologic effects from underground mining.

PROGRESS: Discharge measurements were done on Rapid and Cottonwood Creeks; inventories were made at 6 reservoirs, 24 springs, and 10 wells.

PLANS FOR FY 86: Data will be analyzed, and a report will be written, reviewed, and approved for publication.

PROJECT TITLE: Hydrologic Characterization of the Hart Syncline Area, Northwest Colorado

PROJECT NUMBER: CO-85-206

STUDY LOCATION: Northwestern Colorado

COOPERATING AGENCIES: U.S. Bureau of Land Management and Moffat County

PROJECT CHIEF AND OFFICE: William P. Van Liew, Subdistrict Office, Lakewood

PROJECT DURATION: July 1985 to September 1987

PROBLEM: The U.S. Bureau of Land Management (BLM) has the responsibility of determining suitability of potential coal-lease tracts for mining. To facilitate the decision-making processes, that include whether or not to lease, type of mining to permit, and amount of control necessary in handling waste discharge and overburden material, the existing ground- and surface-water systems need to be understood and described in terms of water availability, flow characteristics, and quality.

OBJECTIVE: Describe baseline hydrogeologic conditions in the Hart Syncline area.

APPROACH: Drill and complete 14 wells and obtain water samples for chemical analysis. Run pumping tests on selected wells. Install continuous recorders on two streams, Waddle Creek and Deep Rock Creek. Take water-quality samples at the streamflow-gaging sites. Interpret new and existing data to: (1) Determine aquifer(s) location, aquifer(s) hydraulic properties, and aquifer(s) water chemistry; and (2) determine surface-water discharge, surface-water chemistry, sediment load, and gaining and losing sections of the stream.

PROGRESS: Twenty-four exploratory boreholes were drilled into bedrock formations. Geologic logs were taken, and a suite of geophysical logs were run in each borehole. Fourteen of the boreholes were completed as water-monitoring wells, several with multiple completions. Twenty-six wells were constructed in these 14 boreholes. Water levels were measured in all the wells. Four bedrock aquifers were identified tentatively. Three boreholes flowed at land surface; two of them were completed as wells and shut-in. Twelve boreholes were drilled in the unconsolidated sediments in the valleys of Waddle Creek and Deep Rock Gulch; one monitoring well was constructed in each valley. Two streamflow-gaging stations were constructed, one on Waddle Creek and one on Deep Rock Creek. Fourteen water samples were collected from wells, streams, and springs for analysis of chemical constituents.

PLANS FOR FY 86: Water levels will be monitored in wells monthly; streamflow gages will be serviced monthly; wells, streams, and springs will be sampled for chemical quality quarterly; streams will be sampled for suspended sediment during high flow. Aquifer tests will be conducted on three to five bedrock wells and on two or more alluvial wells. One seepage run on Waddle Creek and one on Deep Rock Creek will be conducted. Predevelopment hydrologic conditions in the area will be characterized, using these data.

PROJECT TITLE: Conversion and Validation of Ground-Water Data for the National Water Information System Site Index

PROJECT NUMBER: CO-85-208

STUDY LOCATION: Topical Research

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

PROJECT CHIEF AND OFFICE: Sandra R. Turner, District Office, Lakewood

PROJECT DURATION: July 1985 to September 1986

PROBLEM: A Master Water Data Index (MWDI) is required as a mechanism for documenting the existence and location of site-specific water data stored in the National Water Information System (NWIS). The Master Water Data Index will be designed to integrate the contents and perform the functions of the existing data bases of National Water Data Exchange (NAWDEX), National Water Data Storage and Retrieval System (WATSTORE), and Ground-Water Site Inventory (GWSI).

OBJECTIVES: Receive, review, and clarify program specifications; develop code design; conduct code-design review; write code; debug executable code; test code; acceptance-test code.

PROGRESS: Pseudo code for conversion of GWSI data to MWDI format was developed and approved.

PLANS FOR FY 86: Programs will be written to convert GWSI data to MWDI format. Programs will be tested. Use of programs will be documented in an Open-File Report.

PROJECT TITLE: Evaluation of Effects of Proposed Reservoirs on the Water Quality of the White River, Colorado and Utah

PROJECT NUMBER: CO-86-210

STUDY LOCATION: Western Colorado and Eastern Utah

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

PROJECT CHIEF AND OFFICE: Sherman R. Ellis, District Office, Lakewood

PROJECT DURATION: October 1985 to September 1986

PROBLEM: Large quantities of water will be needed, if a sizable oil-shale industry is established in the Piceance basin in Colorado or in the Uinta Basin in Utah. The White River is the most probable source of high-quality water for this development. It has been estimated that a reservoir with 300,000 acre-feet of storage will be necessary to provide water for a large-scale oil-shale industry. The major potential effects of reservoirs on the quality of water in the reservoirs and releases are: (1) Thermal and dissolved-solids stratification; (2) nutrient accumulation in the reservoir; (3) sedimentation of the reservoir; and (4) channel-morphology changes downstream from the reservoir site.

OBJECTIVES: The overall objective is to evaluate and apply methods of determining hydrologic impacts of proposed reservoirs on the White River. Specific objectives are: (1) Determine stratification potential of proposed reservoir sites and temperature, and dissolved solids in outflow; (2) determine dissolved-oxygen depletion potential of proposed reservoir and dissolved-oxygen concentrations in outflow; (3) estimate sedimentation rate of proposed reservoir; and (4) estimate the effects of proposed reservoirs on downstream-channel morphology.

APPROACH: Collect data at four existing reservoir sites. Two sites will be used to calibrate existing reservoir models; two sites will be used for verification. Evaluate and complete empirical methods to estimate dissolved-oxygen depletion, using the data collected at existing reservoirs. Collect data at proposed reservoir sites and input to reservoir models and empirical equations that calibrate and verify best on existing reservoirs. Using the sediment-transport curve method, make long-term estimates of total sediment loads at potential reservoir sites and estimate trap efficiencies, using well-established methods. Estimate downstream channel-morphology changes, using findings from previous works below existing reservoirs, such as the Flaming Gorge Reservoir on the Green River.

PLANS FOR FY 86: Instruments will be installed; quality of inflow and outflow to reservoirs will be monitored.

PROJECT TITLE: Effects of Proposed Reservoirs on Water Quality in Western Colorado

PROJECT NUMBER: CO-86-211

STUDY LOCATION: Colorado River basin, Western Colorado

COOPERATING AGENCY: Colorado River Water Conservancy District

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

PROJECT DURATION: November 1985 to September 1988

PROBLEM: Impoundment of water in reservoirs can have major effects on the quality of waters stored in and released from the reservoirs. Water-quality changes can result from: (1) Thermal and dissolved-solids stratification; (2) increased nutrient concentration; and (3) sedimentation. In addition, reservoirs can affect downstream channel morphology because of reduced peak streamflow and reduced suspended sediment. Thermal stratification and increased nutrients can cause undesirable algae blooms and depletion of dissolved oxygen in reservoirs. Release of cold water with depleted dissolved oxygen can affect adversely downstream-fishing habitat. Trapping of sediment by reservoirs causes sedimentation in the reservoirs and could accelerate erosion of the downstream channel.

OBJECTIVES: (1) Estimate thermal and dissolved-solids stratification potential in proposed reservoirs and temperature and dissolved-solids concentration of the outflows; (2) estimate dissolved-oxygen depletion potential in proposed reservoirs and dissolved-oxygen concentration of the outflows; (3) estimate effect of proposed reservoirs on sediment load and sedimentation rates; and (4) estimate effects of proposed reservoirs on downstream-channel morphology.

APPROACH: (1) Collect daily discharge, temperature, and specific-conductance data at major inflow streams; (2) measure dissolved oxygen at inflow sites to define seasonal and diurnal variation; (3) collect periodic samples for common ions, dissolved solids, nitrogen, and phosphorus at the inflow sites to relate constituent concentrations to stream discharge; (4) collect suspended and bedload sediment at the proposed reservoir sites; (5) gather climatological data and information about reservoir geometry and operating plans for the proposed reservoirs; (6) several models and empirical equations used for estimating temperature, dissolved oxygen, and dissolved solids in reservoirs are being evaluated for existing reservoirs in the Upper Colorado River Basin by an ongoing project; apply models and equations most applicable to western Colorado for the potential reservoirs; (7) determine total sediment load from the stream-discharge data and suspended and bedload data; calculate trap efficiencies for the proposed reservoirs to estimate the sedimentation rate of each proposed reservoir; and (8) research literature for methods to estimate qualitative changes to channel morphology downstream of reservoirs; collect data required to use such methods, such as channel width, depth, slope, and sinuosity.

PLANS FOR FY 86: Install streamflow gages on Indian Creek and 2-parameter monitors at the three reservoir sites. Water-quality and sediment data will be collected. Reservoir-geometry data, operating plans, and climatological data will be gathered. Literature on reservoir processes, reservoir models, and channel-morphology changes caused by reservoirs will be reviewed. Base maps needed for the report will be prepared.

PROJECT TITLE: Estimating Water-level Declines Due to Pumping in the Closed Basin Division of the San Luis Valley, South-central Colorado

PROJECT NUMBER: CO-86-212

STUDY LOCATION: San Luis Valley, south-central Colorado

COOPERATING AGENCY: U.S. Bureau of Reclamation

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

PROJECT DURATION: October 1985 to September 1987

PROBLEM: Drawdown in the water-table aquifer resulting from ground-water withdrawals in the Closed Basin Division of the San Luis Valley Project is limited to a maximum of 2 feet at the project's boundary. Because seasonal and long-term variations in natural recharge and discharge, and in irrigation practices, also produce water-level changes, it will be difficult to differentiate between water-level response to project pumpage and to climatic conditions and irrigation practices.

OBJECTIVE: Determine water-level response to project pumpage at the boundary of the Closed Basin Division. Determine water-level response to climate and irrigation practices because water-level observations record total response to all recharge and discharge.

APPROACH: Analyze water-level data from about 50 wells to define long-term trends and cyclic fluctuations of the water table for the period prior to project pumping, pre-1985. Use equations developed from multiple-linear regression and harmonic analysis (a method for transforming cyclic data) to predict water-level response to climate and irrigation. Assume the difference between observed and predicted water levels (after project pumping begins), if significantly different from regression error, to be water-level response to project pumpage.

PLANS FOR FY 86: Work plan will be developed; literature will be reviewed; water-level, climatological, streamflow, and water-use data for 1978-85 will be compiled. Regression equations, used to predict water levels, based on independent variables, will be developed. Observed water-level changes will be compared with predicted changes and tested to see if they are significantly different from regression error.

PROJECT TITLE: Applied Hydrology Seminar for PHC's (Probable Hydrologic Consequence) and CHIA's (Cumulative Hydrologic Impact Analysis)

PROJECT NUMBER: CO-86-213

STUDY LOCATION: Denver

COOPERATING AGENCY: Office of Surface Mining

PROJECT CHIEF AND OFFICE: R. Theodore Hurr, District Office, Lakewood

PROJECT DURATION: January 1986 to September 1987

PROBLEM: Due to the diversity of educational and training background, State and Federal reviewers of surface-mining applications may not have extensive enough hydrologic training and background to properly and adequately evaluate mining applications and to prepare cumulative hydrologic-impact analyses.

OBJECTIVE: Provide mine-plan reviewers with training and knowledge to recognize and evaluate the adequacy of hydrologic data; the description of problem hydrologic consequences, based on the interpretation of these data; and the procedures and methods for developing cumulative hydrologic impact analyses.

APPROACH: Develop a training course primarily directed to, but not limited to, permit reviewers and inspectors. Include in topics to be covered in the course material: A background and history of the environmental considerations of PHC's and CHIA's; the review of PHC's in permit applications; and the preparation, scope, and use of CHIA's.

PLANS FOR FY 86: Outline of course content will be drafted, sufficient to demonstrate scope and perspective of topics to be presented. Course outline will be expanded and revised, based on Office of Surface Mining comments, to include draft lesson-plan outlines and primary audio-visual support materials. Complete course outline, detailed lesson plans, and all audio-visual aids intended for presentation will be drafted. Preview will be given to audience selected by the Office of Surface Mining. Student workbook (notes) will be drafted. A second preview will be given of the course or any part of the course deemed necessary by the Office of Surface Mining; first presentation will be on or about June 1, 1986, as scheduled by the Office of Surface Mining.

PROJECT TITLE: Hydrologic Analysis of High-water Table near North La Junta, Colorado

PROJECT NUMBER: CO-86-214

STUDY LOCATION: Arkansas River valley near North La Junta, Colorado

COOPERATING AGENCY: North La Junta Water Conservancy District

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

PROJECT DURATION: January 1986 to December 1987

PROBLEM: The high-water table that has developed in the Arkansas River Valley alluvial aquifer has caused economic loss to local residents because of flooded basements and structural damage to basements. The high-water table probably results from changes in water use, climate, streamflow, and channel geometry, but the relative importance of these factors is not known. The effects of proposed remedial measures to lower the water table need to be evaluated.

OBJECTIVE: Define and quantify the causes of the high-water table in the North La Junta area: specifically quantify stream-aquifer interaction; determine causes of the high-water table; and evaluate remedial actions to lower the water table.

APPROACH: Evaluate quantitatively the inflow-outflow of the stream-aquifer system. Collect data to define ground-water use, water-level fluctuations, leakage from Fort Lyon Canal, stream-aquifer flux, changes in channel geometry, and surface-water use. Develop a numerical model of transient-flow conditions and use to evaluate remedial actions to lower the water table.

PLANS FOR FY 86: Data collection and analyses and ground-water model will be completed. Report will be completed. Report review-revision will be started.

PROJECT TITLE: Preliminary Assessment of Water in Bedrock Aquifers Beneath Land Administered by the Bureau of Land Management in western Colorado

PROJECT NUMBER: CO-86-215

STUDY LOCATION: Western Colorado

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF AND OFFICE: Glenn A Hearne, District Office, Lakewood

PROJECT DURATION: February 1986 to September 1987

PROBLEM: Recently enacted State legislation has defined the term "nontributary ground water." For most areas, water is considered nontributary if withdrawal of ground water does not capture the flow of a stream at a rate greater than one-tenth of one percent of the annual rate of withdrawal after 100 years. The U.S. Bureau of Land Management needs to know where streamflow capture could be less than 0.1 percent of the annual rate of withdrawal after 100 years and the volume of water in storage under these public lands.

OBJECTIVES: Estimate whether withdrawals from the major aquifers beneath land administered by the U.S. Bureau of Land Management in Colorado will result in streamflow capture greater than or less than 0.1 percent of the rate of withdrawals after 100 years. Quantify the volume of water under lands administered by the U.S. Bureau of Land Management that is estimated to result in streamflow capture of less than 0.1 percent of the rate of withdrawals after 100 years.

APPROACH: Identify those areas and geologic units for which data are not adequate to estimate streamflow capture. Estimate streamflow capture, assuming the simple geometry of a semi-infinite two-dimensional aquifer bounded on one side by a linear stream. For selected regions, use simulation models to project the rate of streamflow capture resulting from the pumping of hypothetical wells for 100 years; using the simulation model results, a 0.001-percent stream depletion line will be approximately located. Estimate as a product of area and specific yield the volume of water under lands administered by the U.S. Bureau of Land Management, that is estimated to result in streamflow capture of less than 0.1 percent of the rate of withdrawals after 100 years.

PLANS FOR FY 86: A preliminary estimate will be made of the area of land administered by the U.S. Bureau of Land Management for which the water in major aquifers can be withdrawn, without the capture of a stream exceeding 0.1 percent of the rate of withdrawal after 100 years. For areas and aquifers with adequate data bases, capture will be estimated using analytic or simulation models; from these, a 0.1-percent depletion line will be approximately located.

PROJECT TITLE: Assessing peak streamflow from snowmelt in Colorado

PROJECT NUMBER: CO-86-216

STUDY LOCATION: Selected river basins in mountainous areas in Colorado

COOPERATING AGENCY: Colorado Department of Natural Resources

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

PROJECT DURATION: February 1986 to September 1988

PROBLEM: Cloud seeding to increase mountain snowpack in Colorado is done by commercial operators, and cloud-seeding research is done by government agencies. These programs in Colorado are regulated by the Colorado Department of Natural Resources (DNR), and permits require that seeding be suspended when the water content of the snowpack reaches a given percentage. As more cloud-seeding projects develop and public awareness of these activities increases, understanding the relation between the snowpack and potential flooding downstream becomes more important. Physically based criteria using meteorologic and hydrologic parameters are needed, including a mechanism to translate the water content of the snowpack in the watershed to downstream flood peaks and volumes.

OBJECTIVE: Evaluate the probability distribution of peak streamflows from snowmelt for streams draining mountain watersheds, using a watershed model.

APPROACH: Calibrate and verify PRMS (Precipitation-Runoff Modeling System) on a series of watersheds, and couple the calibrated PRMS model to the ESP (Extended Streamflow Prediction) model to identify the probability of flood discharges for a range of historic and simulated climatic conditions.

PLANS FOR FY 86: PRMS will be calibrated for one basin that has streamflow records from the turn of the century, concurrent precipitation and air-temperature data for high and low elevations, and snow-course measurements dating back over 40 years. The complete data base will be used to derive streamflow values for ESP. A sensitivity analysis on the input climatic variables will be used to establish an estimate of error on the model results.

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, Lakewood

PROJECT DURATION: February 1986 to September 1989

PROBLEM: Past mining of ore deposits in the Leadville, Colo., area has yielded economic amounts of gold, silver, copper, lead, zinc, iron, and bismuth. Water flowing through abandoned tailings and from adits in the Leadville area contributes large amounts 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 in general.

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 metals, and determine the extent to which chemical equilibrium has been attained. Quantify suspended-sediment concentration and particle-size distribution at various stream-flow regimes.

APPROACH: Define the transition from natural conditions to areas of active chemical precipitation by water and sediment samples, and, finally, areas dominated by natural weathering and sediment transport. Determine concentration, mineralogy, and particle-size distribution of suspended and bed sediment. After size separation into clay, silt, and sand, analyze organic and metallic coatings on the sediment by extraction procedure to determine their chemistry. Use the chemical analyses, combined with x-ray diffraction and scanning electron microscopy, to determine the mineral and organic phases that control heavy-metal concentrations. Test these results by an in-stream transport experiment. Stable-isotope distributions also may prove useful in evaluating diagenetic changes.

PLANS FOR FY 86: Data from previous studies has been assembled; meetings with interested State and Federal agencies have been held, and sampling will begin in March of 1986. An initial synoptic sampling will determine the areawide sediment chemistry and mineralogy. Water quality also will be determined, and sites for regular sampling will be selected based on the synoptic results. Further synoptic sampling will be done to evaluate the geochemistry at different stages of flow.

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REPORTS PUBLISHED OR RELEASED DURING FISCAL YEARS 1984-86

Water-Resources Data Reports

[Reports are available from Open-File Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Denver Federal Center, Denver, CO 80225, except as indicated]

1. Ackerman, D. J., and Brooks, Tom, 1985, Ground-water data from the San Miguel River basin, southwestern Colorado: U.S. Geological Survey Open-File Report 85-191, 19 p.
2. Anderson, E. A., Valdez, P. E., and Hurr, R. T., 1985, Distribution of registered wells in Colorado by water-use category: U.S. Geological Survey Open-File Report 85-344*A* through *H* (in one package), 8 maps, scale 1:1,000,000 (in press).
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4. Galyean, K. C., Adams, D. B., and Collins, D. L., 1985, Hydrologic data from Naval Oil Shale Reserves, Parachute Creek basin, northwestern Colorado, 1980-81: U.S. Geological Survey Open-File Report 83-858, 70 p.
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6. Hawkinson, R. O., compiler, 1984, Summary of water-resources activities of the U.S. Geological Survey in Colorado--Fiscal Year 1984: U.S. Geological Survey handout, 82 p.; available for examination at the Office of the District Chief, U.S. Geological Survey, Water Resources Division, Colorado District, Room H-2104, Building 53, Denver Federal Center, Denver, Colorado.
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8. Marchand, J. P., Jarrett, R. D., and Jones, L. L., 1984, Velocity profile, water-surface slope, and bed-material size for selected streams in Colorado: U.S. Geological Survey Open-File Report 84-733, 82 p.
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14. _____1984, Water resources data for Colorado--Water year 1983, Volume 2, Colorado River basin above Dolores River: U.S. Geological Survey Water-Data Report CO 83-2, 300 p.; available only from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161 as PB85-123687.
15. _____1984, Water resources data for Colorado--Water year 1983, Volume 3, Dolores River basin, Green River basin, and San Juan River basin: U.S. Geological Survey Water-Data Report CO 83-3, 280 p.; available only from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161 as PB85-210946.
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[*, Contact Acting District Chief for availability of report]

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2. Ackerman, D. J., and Brooks, Tom, 1985, Reconnaissance of ground-water resources in the North Fork Gunnison River basin, southwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 85-4230, 21 p. (in press).
3. Banta, E. R., 1985, The Dakota aquifer near Pueblo, Colorado: Faults and flow patterns: U.S. Geological Survey Water-Resources Investigations Report 85-4186, 23 p.
4. Boyle, J. M., and Spahr, N. E., 1985, Traveltime, longitudinal-dispersion, reaeration, and basin characteristics of the White River, Colorado and Utah: U.S. Geological Survey Water-Resources Investigations Report 85-4050, 54 p.
5. Brooks, Tom, 1985, Hydrology of coal-lease areas near Durango, Colorado: U.S. Geological Survey Water-Resources Investigations Report 85-4125, 46 p. (in press).
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7. Burns, A. W., 1985a, Selected hydrographs and statistical analyses characterizing the water resources of the Arkansas River basin, Colorado: U.S. Geological Survey Water-Resources Investigations Report 85-4264, 199 p. (in press).
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9. Butler, D. L., 1985, Discharge and water quality of springs in Roan and Parachute Creek basins, northwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 85-4078, 151 p. (in press).
10. _____1986, Sediment discharge in the Colorado River near De Beque, Colorado: U.S. Geological Survey Water-Resources Investigations Report 85-4266, 30 p. (in press).
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PROJECTS COMPLETED EXCEPT FOR REPORTS DURING
FISCAL YEARS 1984, 1985, AND 1986

Project number	*Project title*	*Project Chief*
CO-034	Peak Discharge and Frequency for Small Watersheds in Colorado	Donald R. Minges
CO-066	Hydrology of Parachute Creek and Roan Creek Basins, Northwestern Colorado	James M. Norris
CO-096	Water Resources Monitoring, Region Seven--West Central Colorado	James M. Norris
CO-113	Hydrology of Proposed Coal-Mining Areas, Moffat, Rio Blanco, and Routt Counties	Randolph S. Parker
CO-114	Hydrology and Reclamation Potential of Coal-Spoil Piles	Robert S. Williams
CO-117	Monitoring of the Hydrologic System in North Park, Jackson County, Colorado	Gerhard Kuhn
CO-127	Hydrology of the Southwest Alluvial Valleys Regional Aquifer System--Upper Rio Grande Basin	Glenn A. Hearne
CO-133	Traveltime and Reaeration Study along Selected Stream Reaches in Coal Producing Areas of Colorado	Linda J. Britton
CO-147	Hydrologic and Water Quality Modeling of San Luis Valley, Colorado	Edward L. Nickerson
CO-173	Modeled Impacts of Surface Coal Mining on Dissolved Solids in the Yampa River Basin, Northwestern Colorado	Randolph S. Parker
CO-174	Hydrologic Reconnaissance of the San Juan River Region, Durango Coal Field in Southwest Colorado	David L. Butler