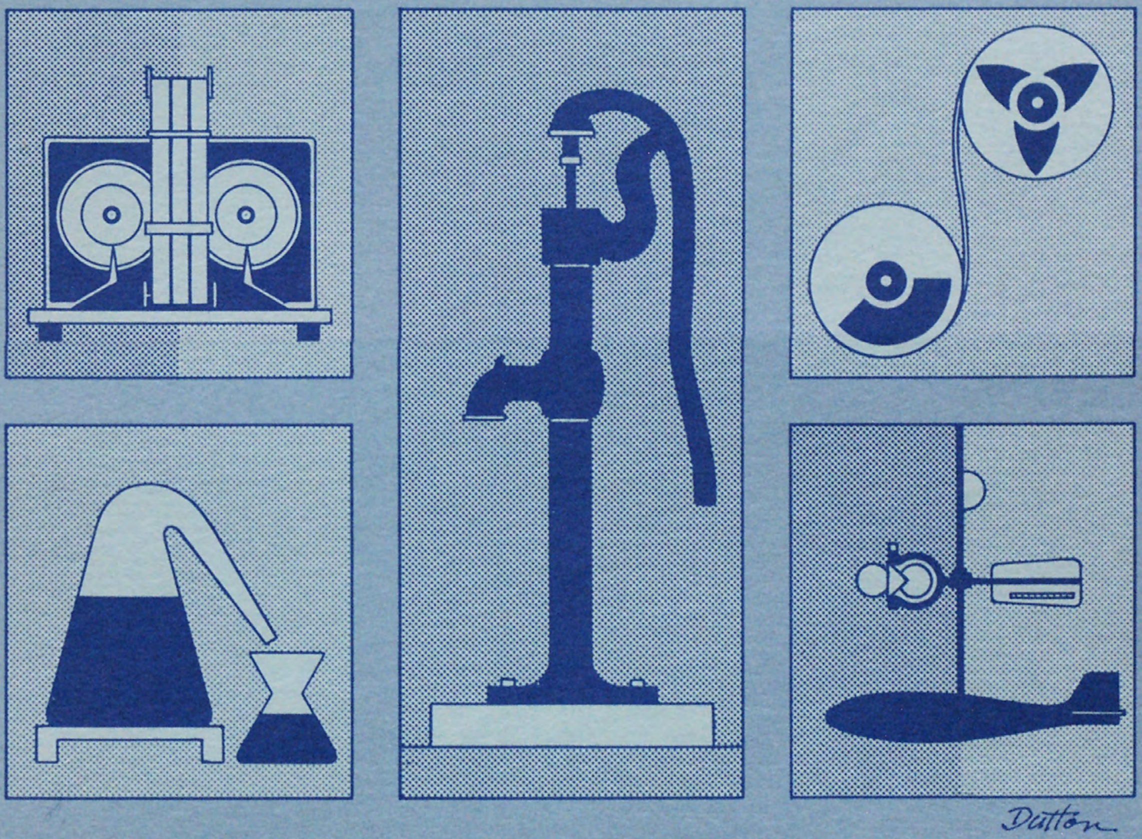
WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--Fiscal Year 1980



U.S. Geological Survey
Open-File Report 80-442

WATER-RESOURCES INVESTIGATIONS
OF THE U.S. GEOLOGICAL SURVEY
IN COLORADO--Fiscal Year 1980

Compiled by Steven R. Blakely

U.S. GEOLOGICAL SURVEY

Open-File Report 80-442

Lakewood, Colorado

March 1980

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

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METRIC CONVERSION FACTORS

Multiply	*By*	*To obtain*
foot	0.3048	meter
mile	1.609	kilometer
acre	0.4047	hectare
square mile	2.590	square kilometer
gallon per minute	0.06309	liter per second
acre-foot	0.001233	cubic hectometer
ton	0.9072	metric ton

WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--Fiscal Year 1980

Compiled by Steven R. Blakely

INTRODUCTION

Water-resources investigations 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 1980 fiscal year (October 1, 1979, to September 30, 1980).

The U.S. Geological Survey's investigations of the water resources of Colorado are under the direction of James F. Blakey, District Chief. The Colorado District office is located in Building 53, Denver Federal Center, Lakewood, Colo. (fig. 1). The Colorado District has four subdistrict offices located in Grand Junction, Lakewood, Meeker, and Pueblo (fig. 1). Requests for information should be addressed as follows:

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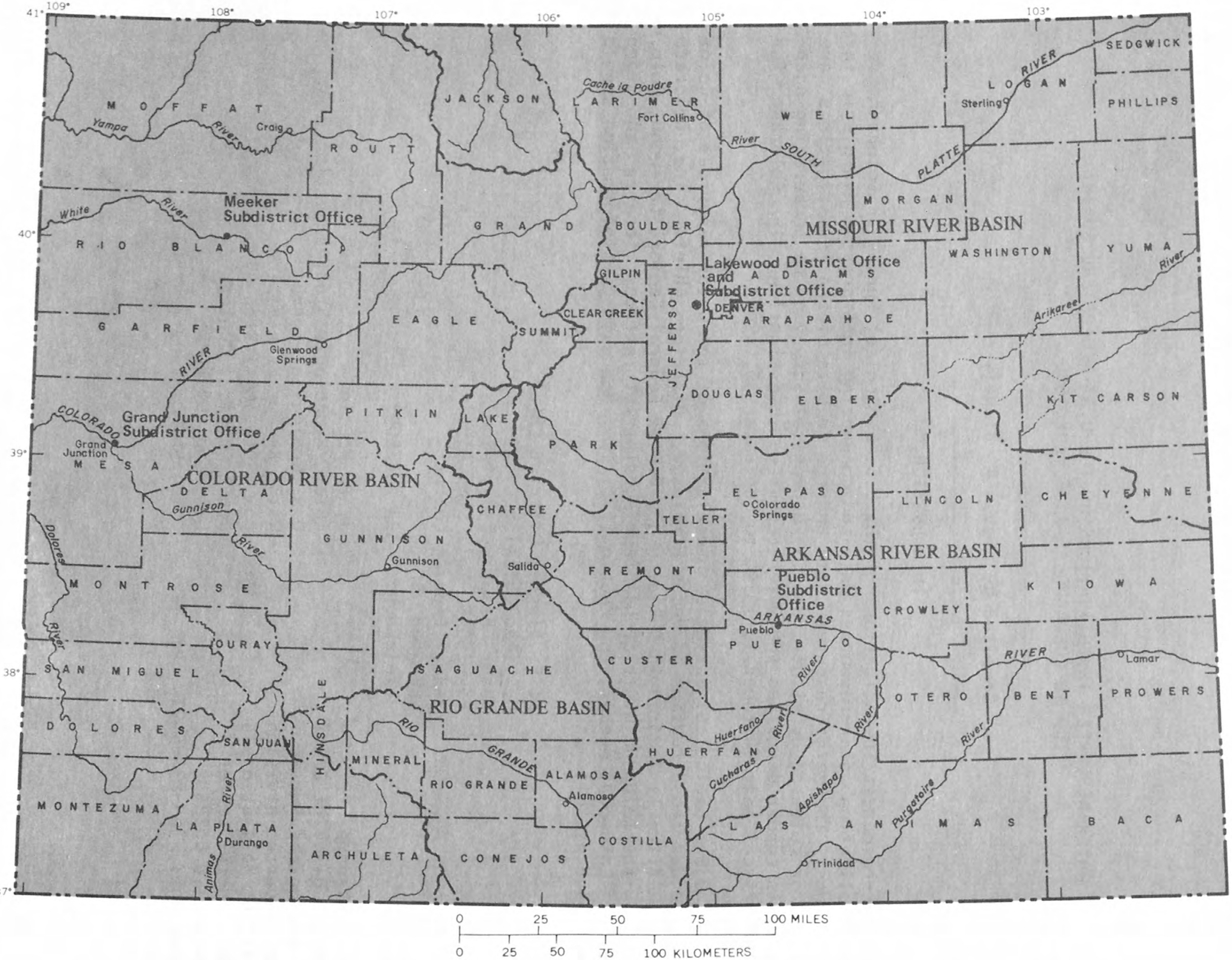

Figure 1.--Location of major river basins and offices of the U. S. Geological Survey's Colorado District.

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COOPERATING AGENCIES

In Colorado, the collecting of some of the water-resources data and the conducting of some of the interpretive hydrologic investigations are accomplished in cooperation with Federal, State, and local agencies. Those agencies cooperating with the U.S. Geological Survey during fiscal year 1980 are:

Adams County Board of Commissioners
Arapahoe County
Arkansas River Compact Administration
Central Yuma Groundwater Management District
Cherokee Water District
City of Aspen
City of Aurora
City of Colorado Springs, Department of Public Utilities
City of Colorado Springs, Office of the City Manager
City and County of Denver
City and County of Denver, Board of Water Commissioners
City of Fort Collins
City of Glenwood Springs
City of Idaho Springs
City of Northglenn
Colorado Department of Health
Colorado Department of Highways
Colorado Department of Natural Resources
- Colorado Geological Survey
- Colorado Water Conservation Board
- Division of Water Resources, Office of the State Engineer
- Division of Wildlife

Colorado River Water Conservation District
Denver Regional Council of Governments
Eagle County Board of Commissioners

Elbert County Planning Department
El Paso County Board of Commissioners
Frenchman Groundwater Management District
Jackson County
Larimer-Weld Regional Council of Governments
Marks Butte Groundwater Management District
Metropolitan Denver Sewage Disposal District No. 1
Northern Colorado Water Conservancy District
Pikes Peak Area Council of Governments
Pitkin County Board of County Commissioners
Pueblo Area Council of Governments
Purgatoire River Water Conservancy District
Rio Grande Water Conservation District
Sand Hills Groundwater Management District
Southeastern Colorado Water Conservancy District
Southwestern Water Conservation District
St. Vrain and Left Hand Water Conservancy District
Uncompaghre Valley Water Users Association
Upper Arkansas River Water Conservancy District
Urban Drainage and Flood Control District
White River Soil Conservation 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 Indian Affairs
- Bureau of Land Management
- Bureau of Mines
- Fish and Wildlife Service
- Water and Power Resources Service

U.S. Environmental Protection Agency
U.S. General Services Administration

COLLECTION OF WATER-RESOURCES DATA

Hydrologic-data stations are maintained at selected locations throughout Colorado to 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 stations are added and others are terminated; thus, the U.S. Geological Survey has both a current and a historical file of hydrologic data. All data collected are stored in the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTØRE) 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 or graphs, statistical analyses, and digital plots. Local assistance in the acquisition of services or products from WATSTØRE can be obtained from the District Chief, Lakewood, Colo.

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. Discharge and stage data currently are being obtained at the number of stations given below.

Station classification		*Number of stations*
Stream stations		551
Continuous record	458	
Partial record	93	
Lake and reservoir stations		22
Total		573

The number and type of stations located in each county are shown on plate 1 and in table 1 (p. 8, 9).

Water-quality data are obtained at 143 of the surface-water stations listed above and also at 20 other surface-water-quality sites where discharge and stage are not measured routinely (pl. 1 and table 1). These stations are used to monitor the quality of surface water in Colorado. Some of these stations also are part of a U.S. Geological Survey nationwide network known as the National Stream Quality Accounting Network (NASQAN), which is used to detect nationwide trends in water quality. The types of data determined at these stations are given below. Inasmuch as several types of data may be determined at a particular station and not all types of data are determined at each station, the numbers given below will not equal the total number of stations given earlier.

Data classification			*Number of stations*
Physical data			162
Water temperature		159	
Daily	84		
Monthly	53		
Quarterly	9		
Intermittently	13		
Specific conductance		162	
Daily	82		
Monthly	55		
Quarterly	9		
Intermittently	16		
pH		151	
Daily	4		
Monthly	112		
Quarterly	22		
Intermittently	13		
Suspended-sediment data			87
Daily		40	
Monthly		47	
Chemical data (inorganic constituents)			147
Monthly		105	
Quarterly		26	
Semiannually		3	
Intermittently		13	
Chemical data (pesticides)			22
Semiannually		8	
Annually		14	
Radiochemical data			27
Quarterly		9	
Semiannually		16	
Annually		2	
Bacteriological data			40
Monthly		24	
Quarterly		10	
Semiannually		6	
Biological data			37
Monthly		27	
Quarterly		9	
Annually		1	

In addition to the water-quality data collected at the stations, a variety of water-quality data also are collected at numerous sites during the course of many interpretive hydrologic studies. These data are available from the files of the U.S. Geological Survey.

Ground-Water Data

Water levels in wells are a key parameter for monitoring ground-water trends; however, they must be integrated with other observations and ground-water investigations in order to have the fullest meaning and usefulness. A network of 55 observation wells (pl. 1) is maintained in Colorado by the U.S. Geological Survey. In addition, a network of about 1,207 observation wells is maintained in Colorado in cooperation with the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, for monitoring fluctuations in water levels. Other wells known as "project wells" are used for specific (generally short-term) investigations and, although they are not part of the observation-well networks, data obtained from them also are available. The numbers of wells currently being measured are given below.

Frequency of measurement	*Number of wells*
Continuous	35
Monthly	65
Semiannually	150
Annually	2,600
Intermittently	750
Total	3,600

The numbers of wells located in each county are shown in table 1 (p. 8, 9).

Water-quality data are not collected routinely from wells in the statewide networks. However, a variety of water-quality data are collected at numerous wells during the course of many interpretive hydrologic investigations, which may include water-quality data from some statewide observation wells. These data are available from the files of the U.S. Geological Survey.

INTERPRETIVE HYDROLOGIC INVESTIGATIONS

Fifty-four interpretive hydrologic investigations are being conducted during fiscal year 1980. These include 9 statewide investigations, 6 regional investigations, 11 investigations in the Missouri River basin, 7 investigations in the Arkansas River basin, 3 investigations in the Rio Grande basin, 16 investigations in the Colorado River basin, and 2 multistate investigations. The summaries of each of the investigations that follow consist of a map showing the location of the area of the investigation and a brief description of the investigation's purpose, objective, approach, progress, and plans.

Table 1.--*Water-resources data-collection stations operated during fiscal year 1979, by county*

County	Surface-water stations				Ground-water stations
	Continuous record	Partial record	Lake and reservoir	Water quality	Wells
Adams---------	2	5	0	0	218
Alamosa-------	1	0	0	0	85
Arapahoe------	3	4	0	4	163
Archuleta-----	8	0	0	0	5
Baca----------	0	2	0	0	60
Bent----------	4	0	1	1	127
Boulder-------	10	7	0	2	163
Chaffee-------	7	2	0	0	7
Cheyenne------	0	0	0	0	57
Clear Creek---	1	0	0	0	0
Conejos-------	7	0	1	1	25
Costilla------	5	0	0	0	44
Crowley-------	0	0	0	0	37
Custer--------	1	0	0	0	32
Delta---------	13	0	0	0	20
Denver--------	2	3	0	0	63
Dolores-------	2	0	0	0	1
Douglas-------	3	0	1	0	123
Eagle---------	29	2	1	3	9
Elbert--------	0	2	0	0	135
El Paso-------	18	0	0	9	185
Fremont-------	5	0	0	1	7
Garfield------	20	0	0	11	14
Gilpin--------	1	0	0	0	0
Grand---------	23	0	4	3	14
Gunnison------	11	0	2	2	4
Hinsdale------	3	0	0	0	1
Huerfano------	2	1	0	0	5
Jackson-------	10	0	0	8	10
Jefferson-----	9	15	1	6	51
Kiowa---------	0	0	0	0	20
Kit Carson----	0	1	0	0	209

Table 1.--*Water-resources data-collection stations operated during fiscal year 1979, by county*--Continued

County	Surface-water stations				Ground-water stations
	Continuous record	Partial record	Lake and reservoir	Water quality	Wells
Lake----------	4	0	2	2	3
La Plata------	9	2	1	2	3
Larimer-------	18	5	1	12	31
Las Animas----	13	8	1	9	6
Lincoln-------	0	2	0	0	33
Logan---------	0	3	0	0	41
Mesa----------	28	4	1	15	14
Mineral-------	3	0	0	0	0
Moffat--------	11	3	0	11	47
Montezuma-----	8	1	0	3	5
Montrose------	10	2	1	6	6
Morgan--------	3	1	0	1	90
Otero---------	6	0	0	0	176
Ouray---------	3	0	0	0	2
Park----------	12	0	1	1	14
Phillips------	0	0	0	0	48
Pitkin--------	27	0	0	0	7
Prowers-------	3	2	0	1	200
Pueblo--------	9	4	0	4	90
Rio Blanco----	37	1	0	29	70
Rio Grande----	4	0	0	0	38
Routt---------	13	2	0	7	46
Saguache------	5	0	0	0	40
San Juan------	1	0	0	0	0
San Miguel----	9	1	0	2	5
Sedgwick------	1	1	0	1	21
Summit--------	13	0	2	0	5
Teller--------	0	0	0	0	0
Washington----	0	1	0	0	121
Weld----------	7	2	0	6	279
Yuma----------	1	4	1	0	265
Totals---	458	93	22	163	3,600

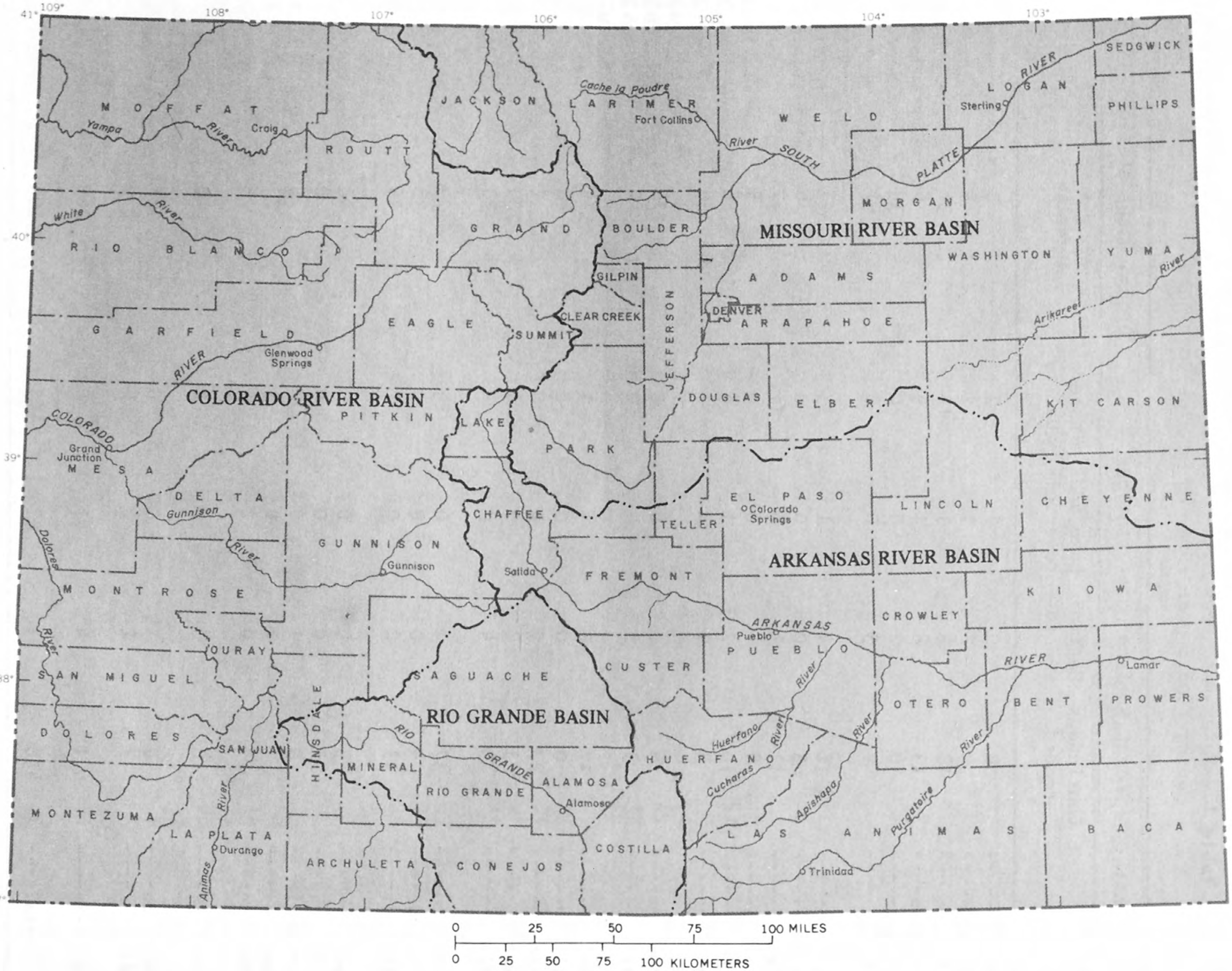

Figure 2.-- Location of area included in water-use inventory.

PROJECT TITLE: Statewide Water-Use Inventory (fig. 2)

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

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

PERIOD OF PROJECT: Continuous since October 1977

Problem.--Water-use data in Colorado are not complete and detailed enough for planning purposes and implementation of a State Water Plan. The sources of water supplies, where and for what purposes water is being used, and the volume of water being consumed or available for multiple use need to be documented so that State and local managers and planners may be better able to make decisions regarding 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.--Tabulate existing data. Develop a water-use questionnaire for use in personal contacts or replies by mail. Obtain water-use data using the questionnaire. Investigate the possibility of using statistical analyses to make projections based on a limited sample.

Progress.--A State data base has been created for storage and retrieval of water-use data. Data accumulated include: Water-rights tabulation; surface-water distribution maps; irrigated-acreage tabulation; and total yields of wells by county, township, irrigation district, and State water division. All major municipalities in the State have agreed to provide water-use and Standard Industrial Classification data. Thirty-one utility companies with irrigation accounts have agreed to provide energy-consumption data for use in estimating ground-water withdrawals.

Plans.--Collection of water-use data based on power generation will begin. Additional municipalities will be contacted to complete the statewide-municipal water-use catagory.

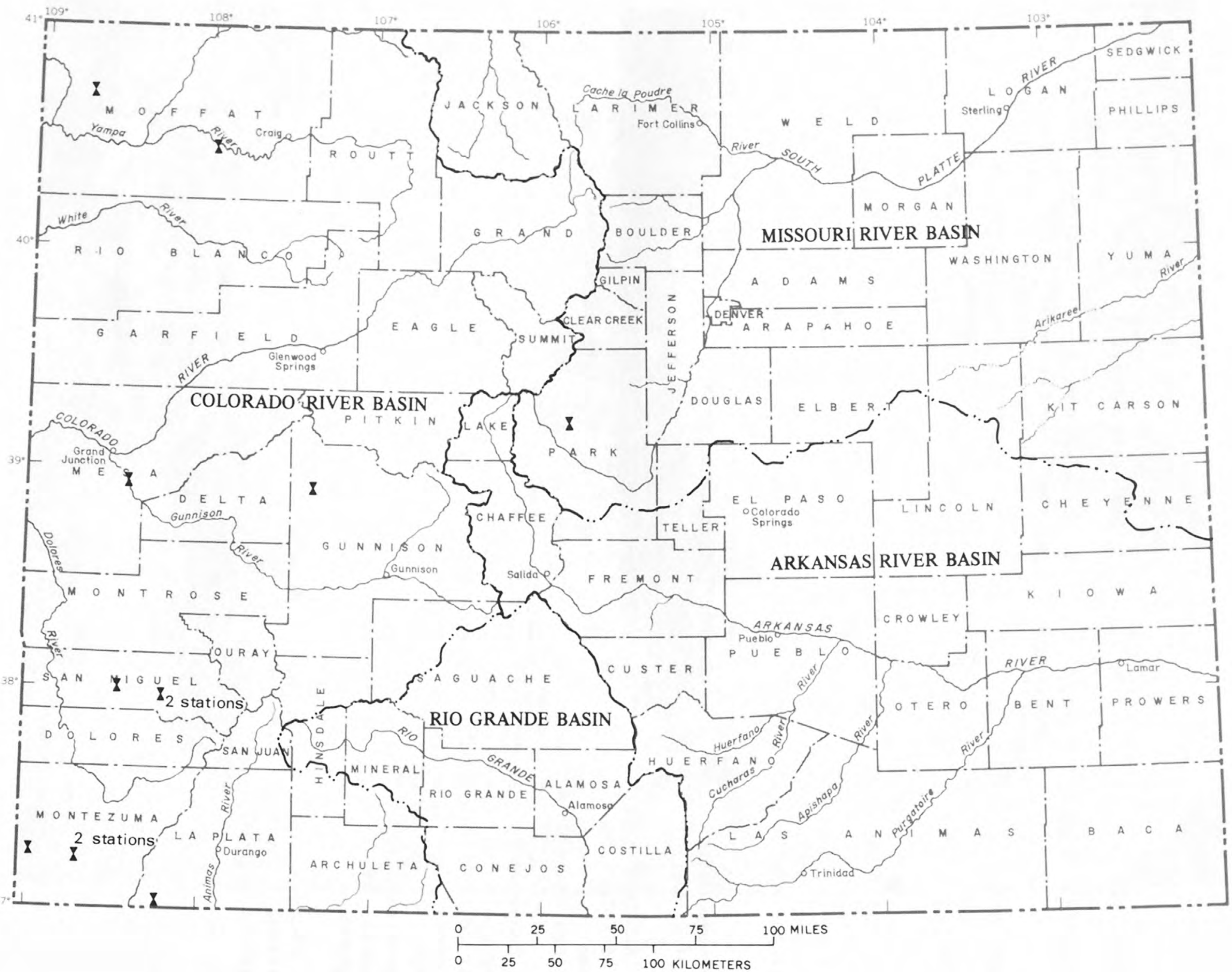

Figure 3.--Location of stations monitoring surface-water flow and quality in coal-mining areas.

PROJECT TITLE: Monitoring of Surface-Water Flow and Quality in Coal-Mining Areas (fig. 3)

COOPERATING AGENCY: None

PROJECT CHIEF: Theron R. Dosch, District Office, Lakewood

PERIOD OF PROJECT: Continuous since February 1977

Problem.--Coal mining may have adverse effects on surface-water resources in the vicinity of and downstream from mine areas. Mine dewatering, changes in land use, disposal of wastes, stream channel realinement, and withdrawal of water for industrial and related uses may alter existing surface-water resources, limit available supplies, and cause deterioration of water quality.

Objectives.--Develop a surface-water-monitoring network. Monitor surface-water flow and quality prior to, during, and after coal mining to determine the effects on surface-water resources.

Approach.--Evaluate existing surface-water stations for inclusion in monitoring network. Establish monitoring network by installing new stations or modifying existing stations as needed.

Progress.--Monitoring network of 12 stations has been established. Contract has been awarded to the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, to operate the stations and to collect streamflow data. U.S. Geological Survey has collected monthly water-quality and sediment data. Data interpretation has begun.

Plans.--Continue data collection and interpretation. Publish data in annual State report. Prepare regional hydrologic report for the San Juan basin.

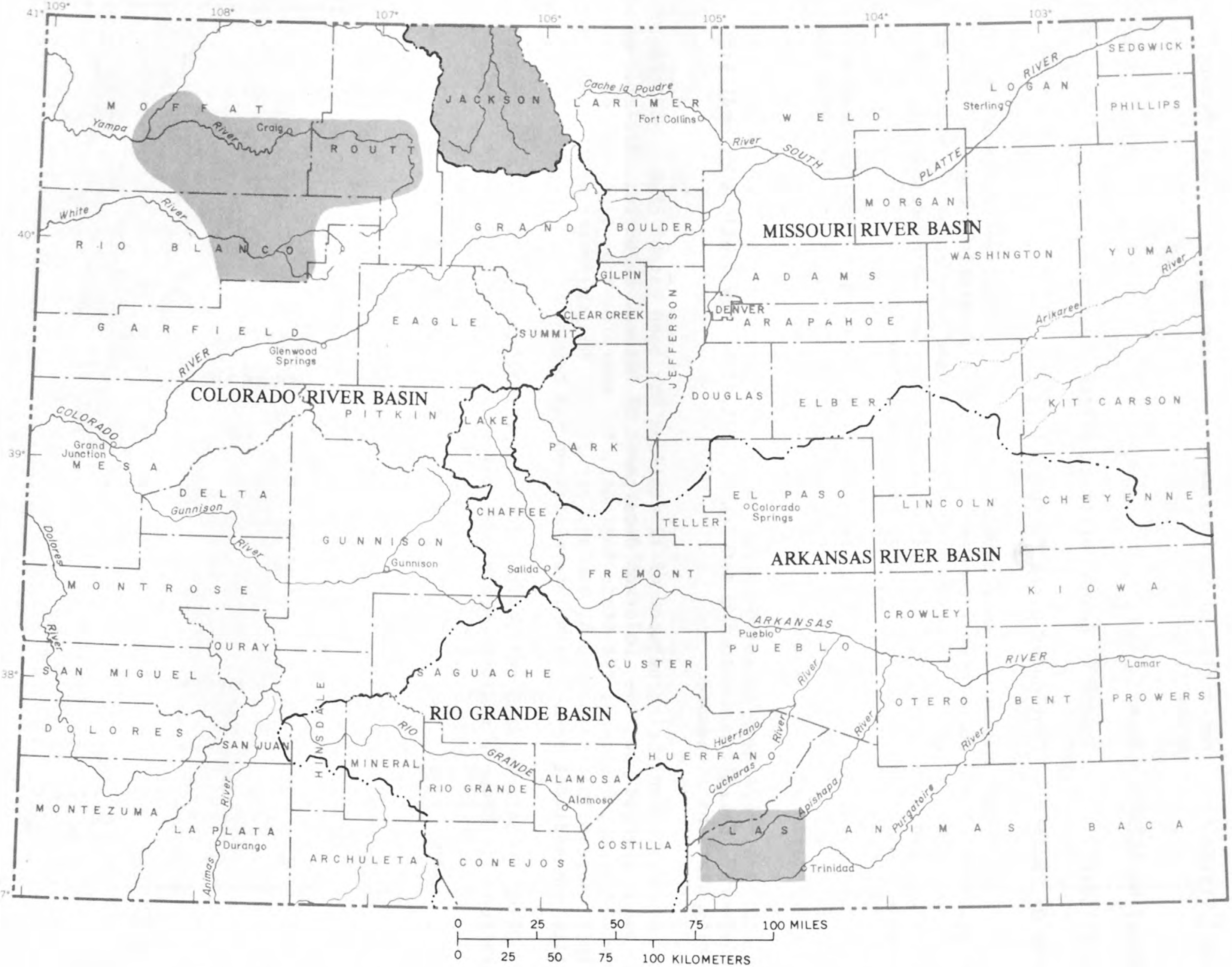

Figure 4.--Location of coal-mining areas where ground-water studies are in progress.

PROJECT TITLE: Ground-Water Studies in Coal-Mining Areas (fig. 4)

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF: Joseph J. D'Lugosz, District Office, Lakewood

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Coal mining may have adverse effects on ground-water resources in the vicinity of and downgradient from mine areas. Mine dewatering, changes in land use, disposal of wastes, and withdrawal of water for industrial and related uses may alter existing ground-water systems, limit available supplies, and cause deterioration of water quality. Few data are available for the ground-water systems containing coal beds.

Objectives.--Determine the potentiometric surface and subsequent changes in the surface for each ground-water system containing coal beds. Determine the spatial distribution of the geohydrologic characteristics of the aquifers.

Approach.--Establish an observation-well network to determine the potentiometric surfaces and to monitor water-level changes. Install continuous water-level recorders on some wells. Conduct aquifer tests and use geophysical logs to determine the geohydrologic characteristics. Collect water samples for chemical analysis.

Progress.--Observation-well network consisting of 130 wells has been established. Eight continuous water-level recorders have been installed. Water levels are being measured in all wells. Geophysical logs have been obtained. Four additional observation wells have been completed; drill cores have been analyzed. Transmissivity and areal variations of hydraulic conductivity have been determined using data from 65 single-well aquifer tests. Water samples have been collected and analyzed for major ions and trace elements.

Plans.--Continue work in critical areas designated by the cooperating agency. Begin interpretation of geophysical logs. Prepare land-disturbance maps. Conduct hydrologic reconnaissance in Gunnison County. Prepare report summarizing aquifer-test data. Prepare hydrologic-data report for northwestern Colorado.

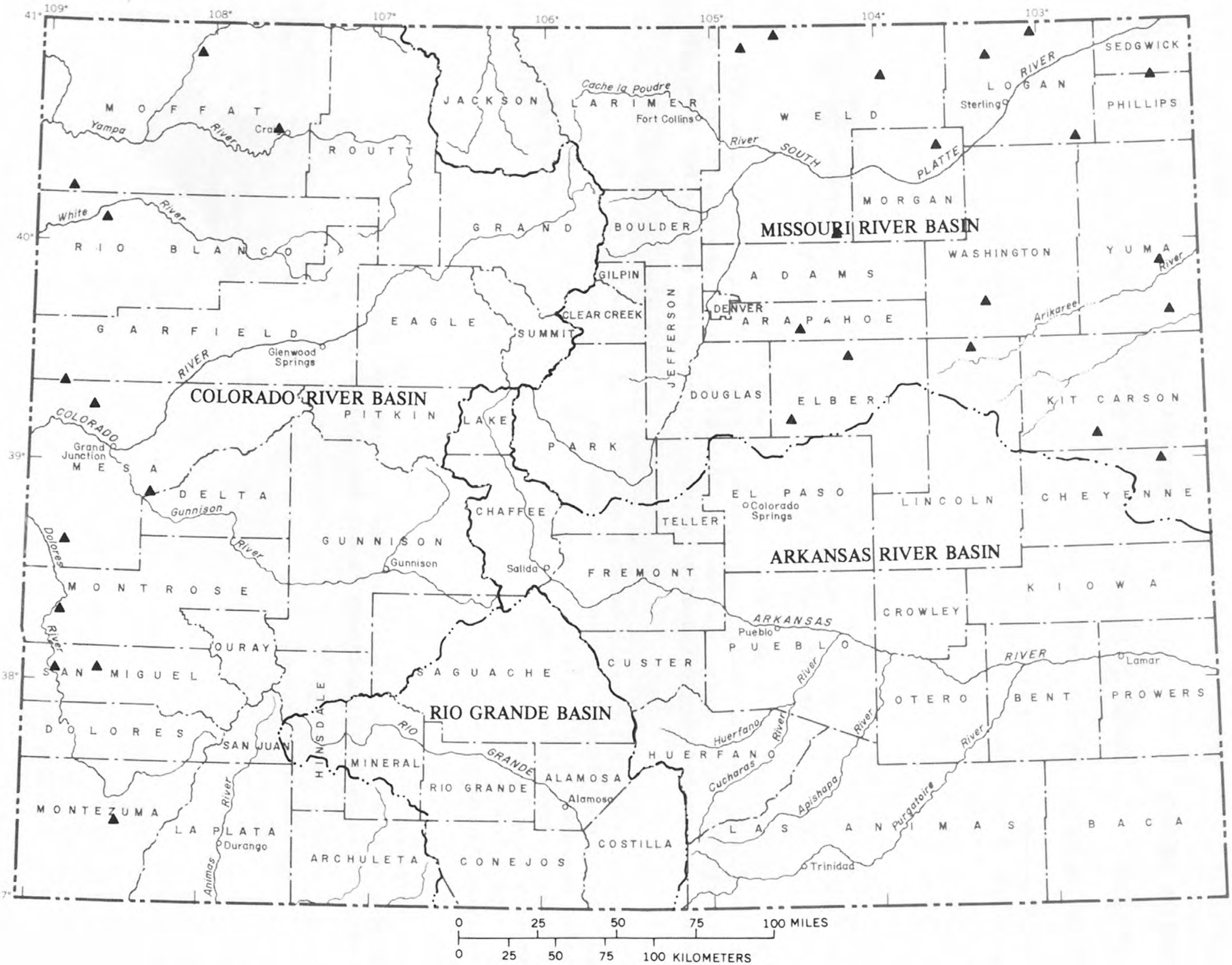

Figure 5.--Location of rainfall-runoff stations in small watersheds crossed by State highways.

PROJECT TITLE: Peak Discharge and Frequency of Floods in Small Watersheds (fig. 5)

COOPERATING AGENCY: Colorado Department of Highways

PROJECT CHIEF: Donald R. Minges, Subdistrict Office, Lakewood

PERIOD OF PROJECT: Continuous since July 1968

Problem.--Flood characteristics of small watersheds in Colorado are poorly defined. Existing techniques for estimating the magnitude and frequency of floods are applicable only to large drainage areas. Data are lacking for small watersheds, and estimates made from existing data are likely to be substantially in error.

Objective.--Collect data and develop techniques for estimating the magnitude and frequency of floods in small watersheds with emphasis on those watersheds crossed by State highways where data will be economically significant in the design of bridges and culverts. Develop a computer model to predict rainfall-runoff relations that can be modified for each watershed based on the hydrologic and physical characteristics of the individual watersheds.

Approach.--Collect data from 47 rainfall-runoff recorder installations located throughout the State. Incorporate data collected from long-term streamflow-gaging stations located in small watersheds in Colorado, data collected from the National Weather Service's rain-gage network in Colorado and adjacent States, and data collected for related studies currently in progress.

Progress.--Rainfall-runoff data are being collected and analyzed. Computer models developed and calibrated for selected watersheds where sufficient data are available. Report containing data collected from October 1974 through September 1977 has been released. Discontinued stations in Arkansas River basin. Data analysis and model calibration completed for sites in the Arkansas River basin; report being prepared.

Plans.--Continue to calibrate computer models for watersheds as data become available. Prepare reports summarizing data collected during successive 3-year periods. Discontinue stations in Missouri River basin; continue data collection at 12 stations in Colorado River basin. Complete analysis of stations in Missouri River basin and prepare a report describing the results of this part of the study.

Reports published or released during fiscal year 1979.--See reference 1 under Water-Resources Data Reports at back of report.

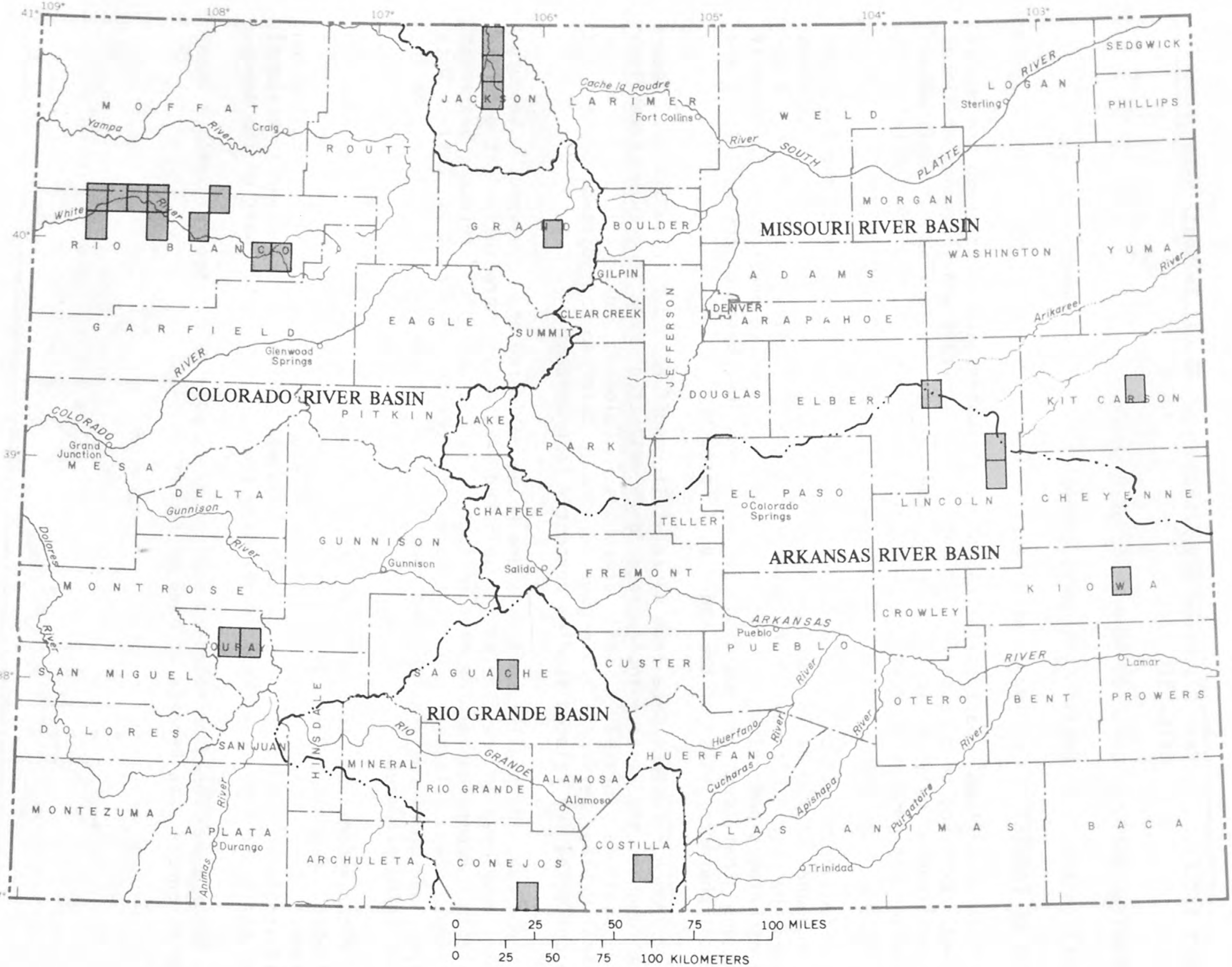

Figure 6.--Location of topographic quadrangles for which flood-prone areas are being delineated.

PROJECT TITLE: Flood-Hazard Mapping (fig. 6)

COOPERATING AGENCY: None

PROJECT CHIEF: Theron R. Dosch, District Office, Lakewood

PERIOD OF PROJECT: Continuous since February 1973

Problem.--U.S. House of Representatives Document 465 outlines a national program to provide flood-hazard information. The U.S. Geological Survey has been assigned the responsibility to outline on Geological Survey topographic maps those flood-prone areas that would be inundated by a flood with a 100-year recurrence interval, using information on the maps and data from existing flood-frequency studies.

Objective.--Delineate on topographic maps the extent of areas that would be inundated by a flood with a 100-year recurrence interval in and adjacent to communities and cities having populations greater than 2,500.

Approach.--Use data from existing flood-frequency studies. Use relations between flood depth, discharge, frequency of occurrence, and drainage area to define flood profiles and flood boundaries (100-year recurrence interval) along streams for which data from historical floods may or may not exist. Use regional flood-depth frequency relations where they can be defined.

Progress.--One hundred ninety-three maps have been completed prior to fiscal year 1980. Twenty-four maps are in various stages of completion.

Plans.--Complete and release 13 maps presently being compiled; continue preparation of 11 maps.

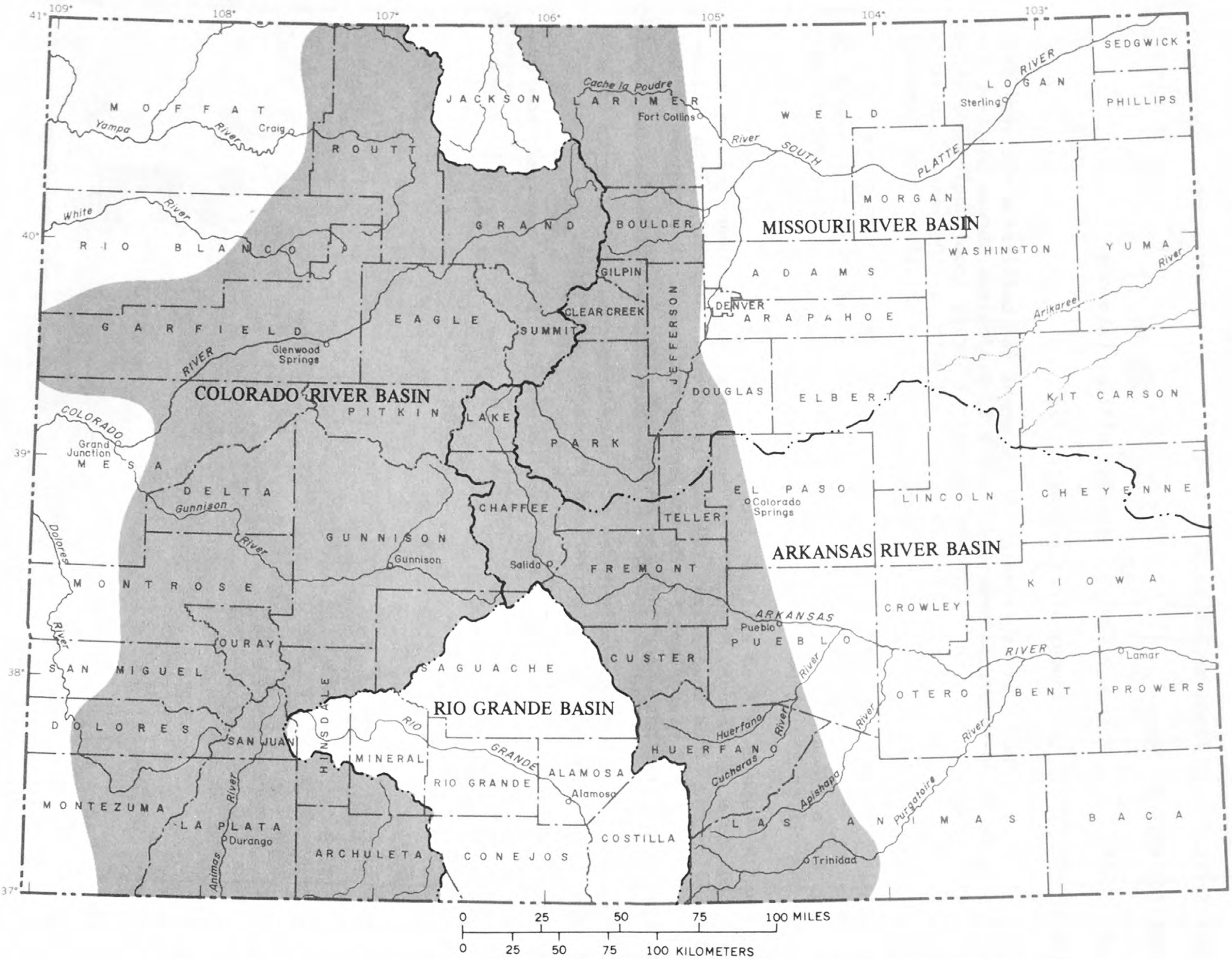

Figure 7.--Location of area for which flood hydrology of foothill streams is being determined.

PROJECT TITLE: Flood Hydrology of Foothill Streams in Colorado (fig. 7)

COOPERATING AGENCIES: Colorado Department of Natural Resources, Colorado Water Conservation Board; Urban Drainage and Flood Control District; U.S. Army Corps of Engineers; and the U.S. Water and Power Resources Service

PROJECT CHIEF: Robert D. Jarrett, District Office, Lakewood

PERIOD OF PROJECT: October 1977 to September 1981

Problem.--More than three-fourths of Colorado's demographic population is concentrated along or near foothill sections at the base of high mountains. Streams along the foothills receive flooding from both snowmelt and rainfall (mixed population), but by far the most destructive type of flood results from "cloudburst-type" rainfall associated with severe thunderstorms during summer months. Because of the mixed-population characteristics of floods in foothill areas, standard techniques for flood-frequency analysis are inadequate for defining flood characteristics for the streams. Additionally, insufficient hydrologic data exist for foothill streams to allow an adequate analysis of flood frequency.

Objectives.--Develop methods for determining flood frequency from records of mixed-population floods and for estimating flood characteristics at ungaged sites on streams where mixed-population floods occur; the methods are to be developed in coordination with local, State, and Federal agencies making flood studies in Colorado.

Approach.--Tabulate and evaluate existing flood and precipitation data. Conduct studies to develop methods for identifying and analyzing mixed-population floods using historical flood records; to develop techniques for estimating flood characteristics at ungaged sites using physical and climatic characteristics of foothill basins; and to develop and test hydrologic models for application in foothill basins. Determine what additional hydrologic data is needed and develop and operate a data-collection network to collect the needed data.

Progress.--Literature search and review has been completed. Development of methods for identifying and analyzing mixed-population floods is in progress. Studies using geomorphic and botanic data and channel-geometry data to develop techniques for estimating flood characteristics at ungaged sites are in progress. Twenty crest-stage gages have been installed and data are being collected. A potential method of flood-frequency analysis has been identified. Project-planning report has been released.

Plans.--Continue data collection. Continue analysis of flood records for areas where mixed-population floods occur. Continue geomorphic, botanic, and channel-geometry studies.

Reports published or released during fiscal year 1979.--See reference 5 under Water-Resources Data Reports at back of report.

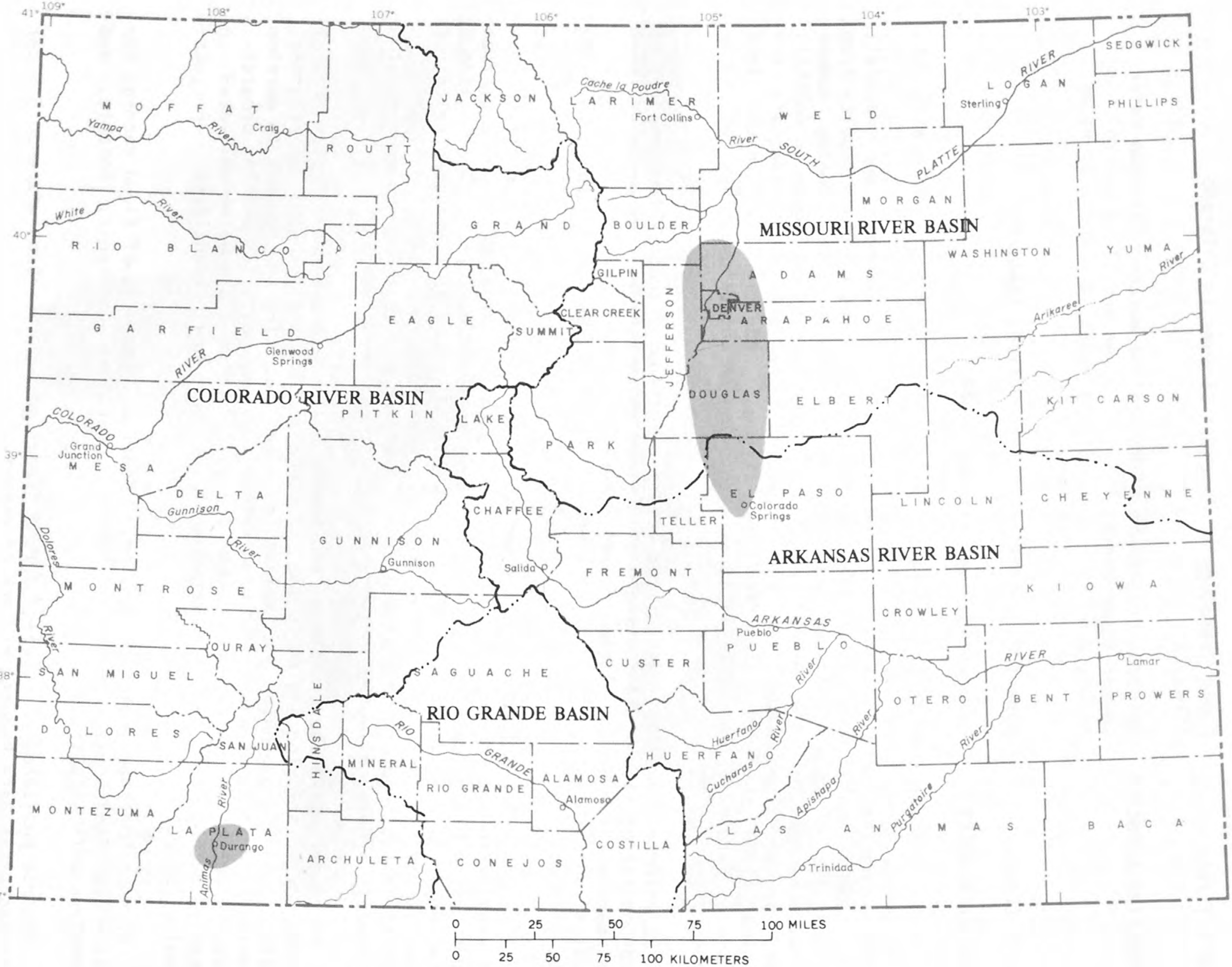

Figure 8.--Location of land fill-leachate study areas.

PROJECT TITLE: Reconnaissance of Ground-Water Contamination by Landfill Leachate (fig. 8)

COOPERATING AGENCIES: Colorado Department of Health

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

PERIOD OF PROJECT: February 1979 to September 1980

Problem.--Many landfills in Colorado were constructed without regard for possible contamination of ground water by leachate from the landfills. Potential ground-water contamination and the possibility of exploding methane gas pose hazards to persons working at or living near the landfills. Data regarding the degree and areal extent of ground-water contamination and potential for methane-gas generation are not available.

Objectives.--Determine the character and areal extent of ground-water contamination by leachate at selected landfills. Determine the time required for contaminated water to reach production wells in the vicinity of the landfills. Delineate the extent of contaminated ground water in areas where currently there are no wells.

Approach.--Drill test wells at and in the vicinity of the landfills. Determine the vertical and horizontal extent of leachate plumes by plotting specific conductance of water samples from wells at and in the vicinity of the landfills. Determine the composition of the leachate by analyzing water samples for major ions, trace metals, nitrogen species, and phenols. Determine direction of ground-water flow by determining altitude of potentiometric surfaces using water-level measurements.

Progress.--Test drilling has been completed. Sites are being surveyed. Specific conductance measurements are being made in preparation for collecting samples for chemical analysis.

Plans.--Complete site surveys and analysis of water samples. Complete interpretation of data and preparation of report.

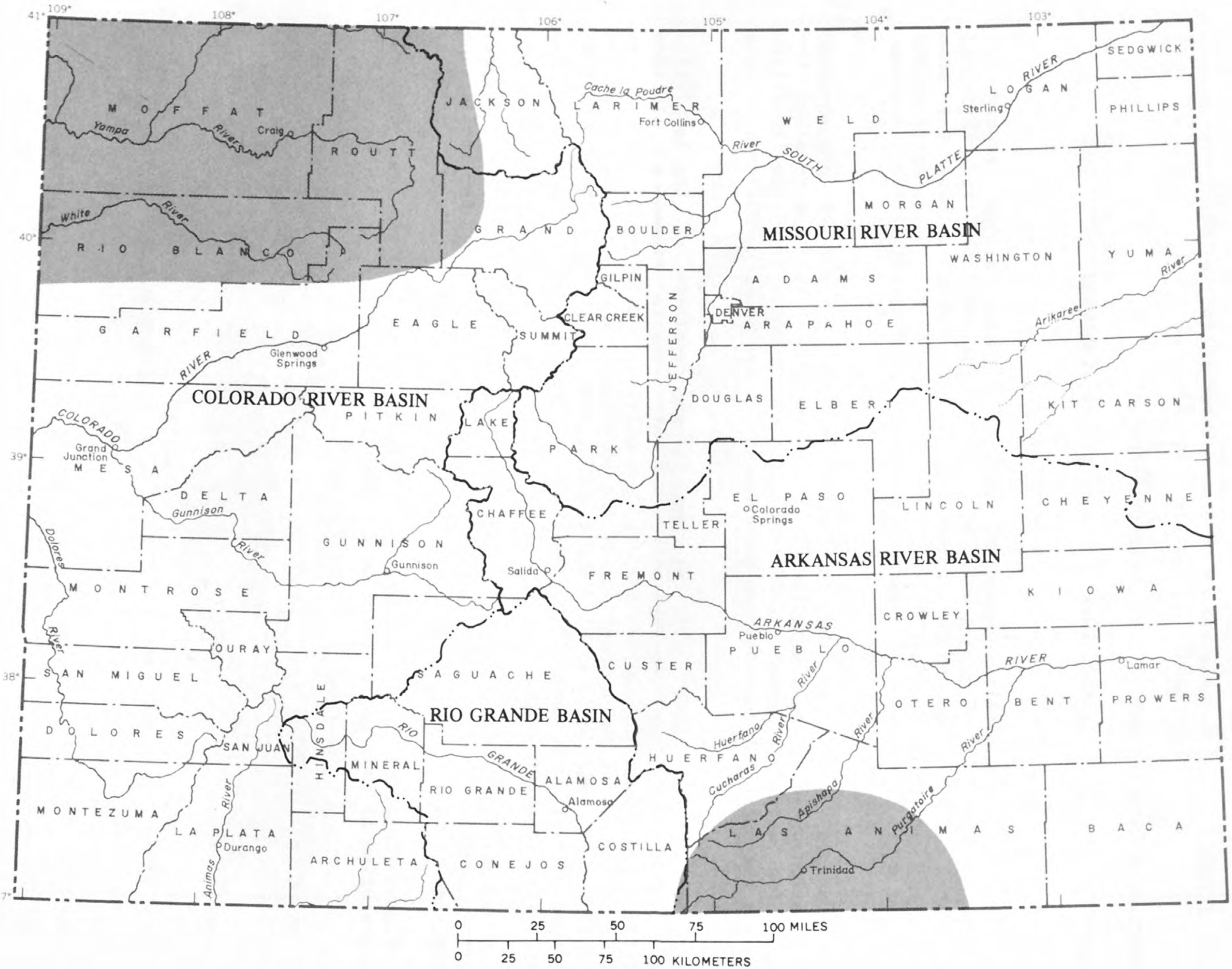

Figure 9.--Location of surface-mining sites in sediment-chemistry study.

PROJECT TITLE: Sediment Chemistry at Prospective Surface-Mining Sites (fig. 9)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1979 to September 1982

Problem.--Surface mining of coal can affect stream chemistry by changing the chemical composition of suspended sediment transported by the stream. Spoil-pile leachate may deposit chemical coatings on existing soils and stream-bottom materials or dissolve existing coatings. Material washed from spoil piles may be of a different composition from native-soil material. Data do not exist to define the present chemistry of soil and stream-bottom material at prospective surface-mining sites in Colorado.

Objectives.--Define the present composition of soil and stream-bottom material in selected basins in Colorado. Interpret the chemistry of suspended material in the streams, and provide a data base against which to evaluate changes in soil and bottom-material chemistry following surface mining of coal.

Approach.--Seive composited-soil and bottom-material samples from areas and streams within the basins. Determine the chemistry of insoluble materials for the minus 80-mesh fraction. Compare data within and among basins. Compare ratio of chemical concentration to suspended sediment during periods of peak discharge.

Progress.--Samples have been collected from watershed areas in the Craig-Steamboat Springs area in the northwestern part of the State.

Plans.--Samples will be collected from additional areas of the State. Chemical-analysis data will be interpreted with the aid of an analysis of variance to determine the most desirable sampling locations within a basin and the utility of soil-and-bottom analyses for predicting suspended sediment chemistry.

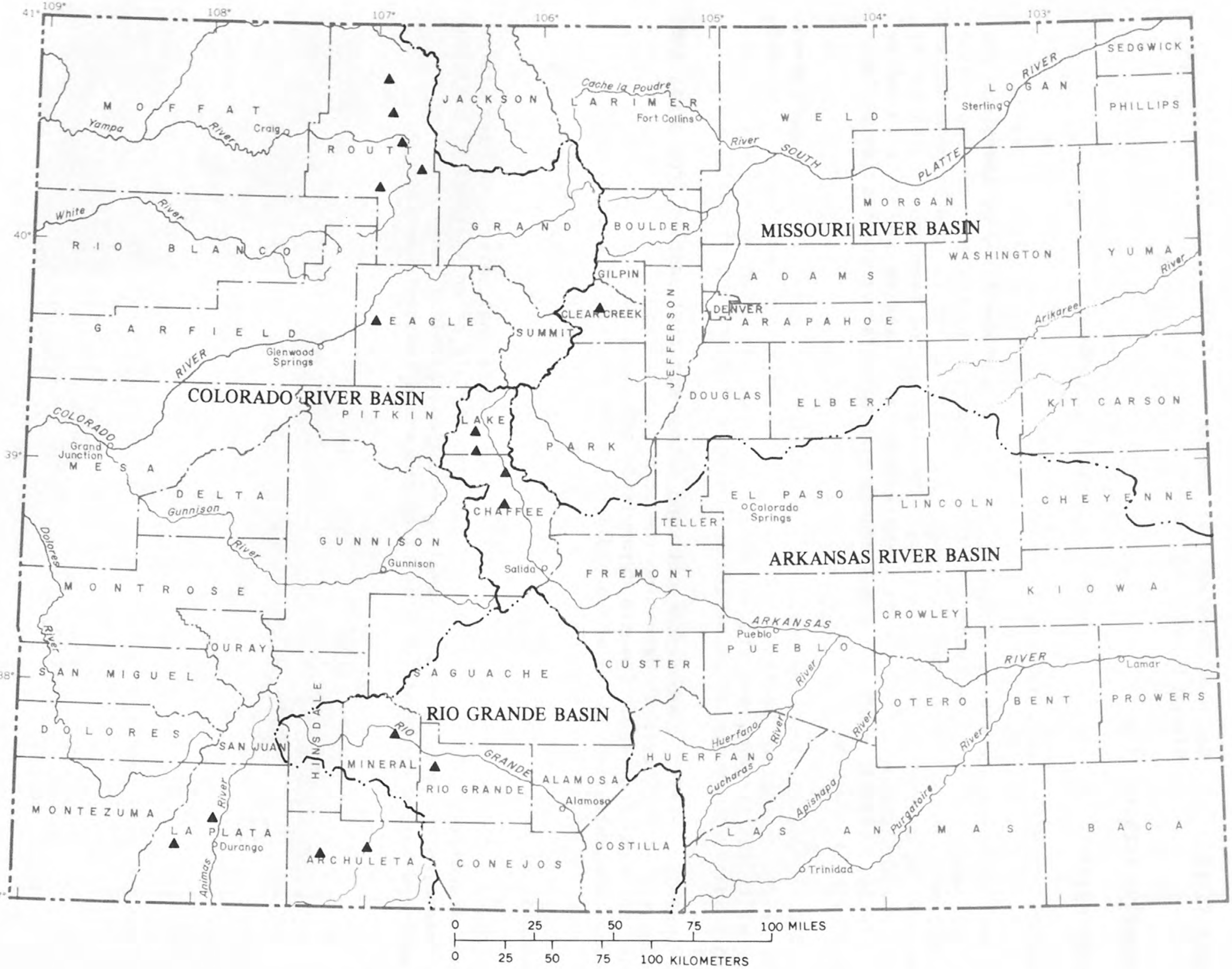

Figure 10.--Location of sites for flow-resistance study.

PROJECT TITLE: Flow Resistance in Steep-Mountain and Ephemeral Streams in Colorado (fig. 10)

COOPERATING AGENCY: Colorado Department of Natural Resources, Colorado Water Conservation Board

PROJECT CHIEF: Robert D. Jarrett, District Office, Lakewood

PERIOD OF PROJECT: May 1979 to January 1981

Problem.--Recent legislative actions involving land-use planning and flood-insurance programs have greatly increased the demand for detailed flood studies. Hydraulic computations for these studies are largely based on the Manning equations, which require the selection of a roughness coefficient ("n" value) to represent flow resistance along a stream channel. Although guidelines are available to aid in selection of roughness coefficients for many types of channels, insufficient data exist for the range of hydraulic conditions found in steep-mountain and ephemeral streams in Colorado.

Objectives.--Verify Manning's roughness coefficients for selected reaches on steep-mountain and ephemeral streams to provide guidelines for the selection of "n" for flow regimes in Colorado. Use study data to evaluate existing guidelines for selection of roughness coefficients and to compile a manual presenting the selection criteria and photographs of representative-channel types. Use study results as a basis for design of a more comprehensive project if evidence indicates selection guidelines for roughness coefficients are not valid for the types of streams being studied.

Approach.--Collect data at selected sites to compute roughness coefficients. Data will include discharge measurements at high stages, color stereo-slides during each measurement and at low stream stage, channel cross sections, water-surface elevations, and selections of roughness coefficients. Verification of roughness coefficients will be made using the data. A comparison between the values selected and the verified values will be made to evaluate present roughness coefficient guidelines.

Progress.--Computation of Manning's "n" has been started using data collected and analyzed from 10 streams.

Plans.--Collect data from seven streams. Complete analysis and prepare report.

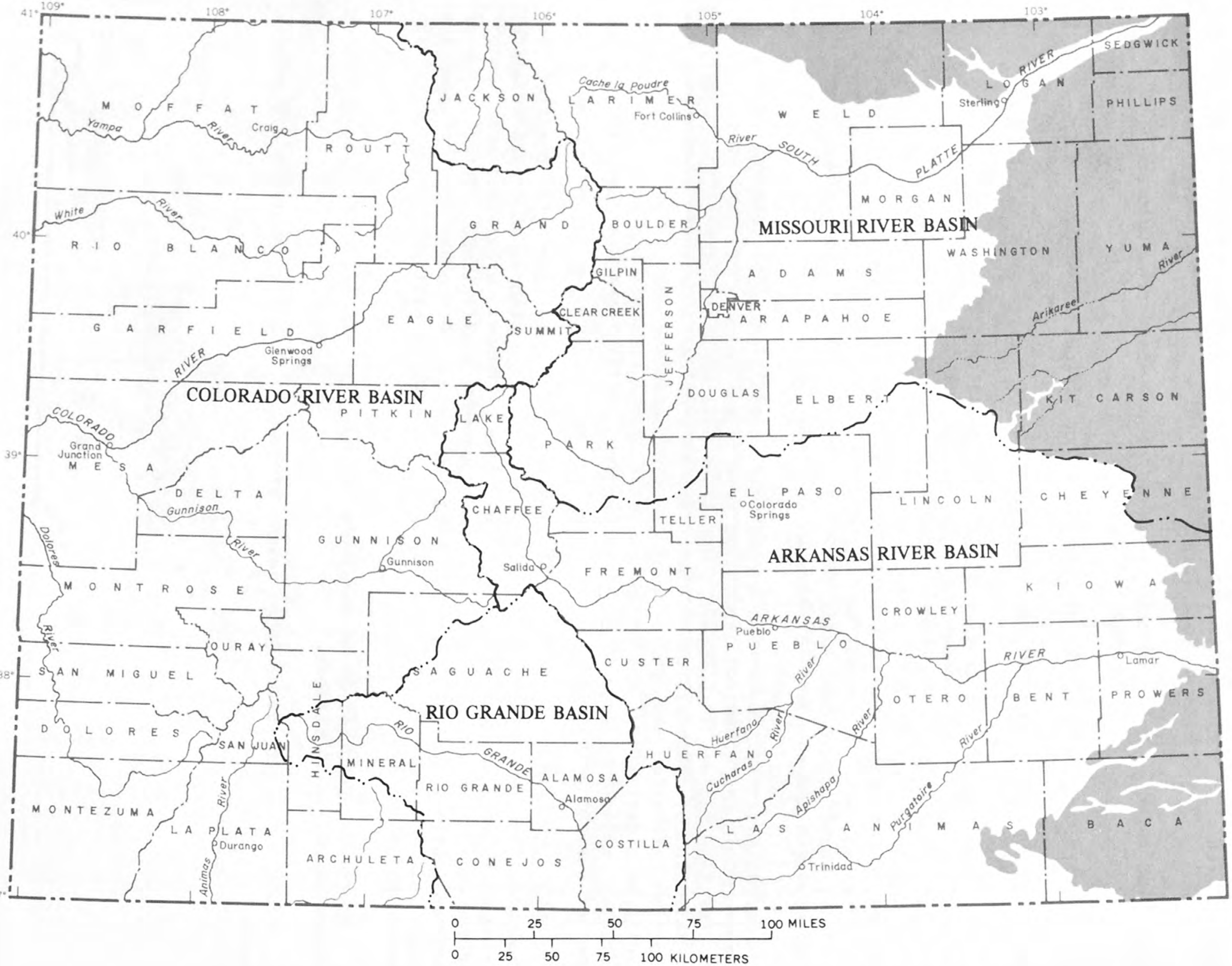

Figure 11.--Location of the areas of the High Plains regional aquifer in Colorado.

PROJECT TITLE: Hydrology of the High Plains Regional Aquifer System (fig. 11)

COOPERATING AGENCY: None

PROJECT CHIEF: Ronald G. Borman, Subdistrict Office, Lakewood

PERIOD OF PROJECT: October 1977 to September 1982

Problem.--Pumpage, principally for irrigation, from the Ogallala aquifer, which underlies parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, is exceeding recharge to the aquifer in many areas, causing water levels to decline. In some areas, including Colorado, the magnitude of the declines may limit continued use of the aquifer as a source of supply for wells yielding more than 100 gallons per minute.

Objective.--Develop a computer model of the entire aquifer system that can be used to evaluate long-term effects of various water-management alternatives.

Approach.--Expand and refine the present data base in Colorado by collecting and analyzing additional water-level, well-yield, and water-quality data, especially for areas north of the South Platte River and south of the Arkansas River. Prepare maps showing hydrogeologic characteristics of the aquifer system.

Progress.--Data collection has begun. About 2,500 wells have been inventoried; discharge was measured at about 100 wells. Maps showing bedrock topography and geology and the altitude and configuration of the water table during 1975 have been completed.

Plans.--Continue well inventory; enter well information and historical water-quality data into the U.S. Geological Survey's computer storage and retrieval system. Install pumping-time meters on 100 irrigation wells and measure discharge from 70 wells. Prepare maps showing the altitude and configuration of the water table for prepumping conditions, 1960, 1965, 1970, and 1980; hydraulic conductivity of the aquifer; and specific yield of the aquifer.

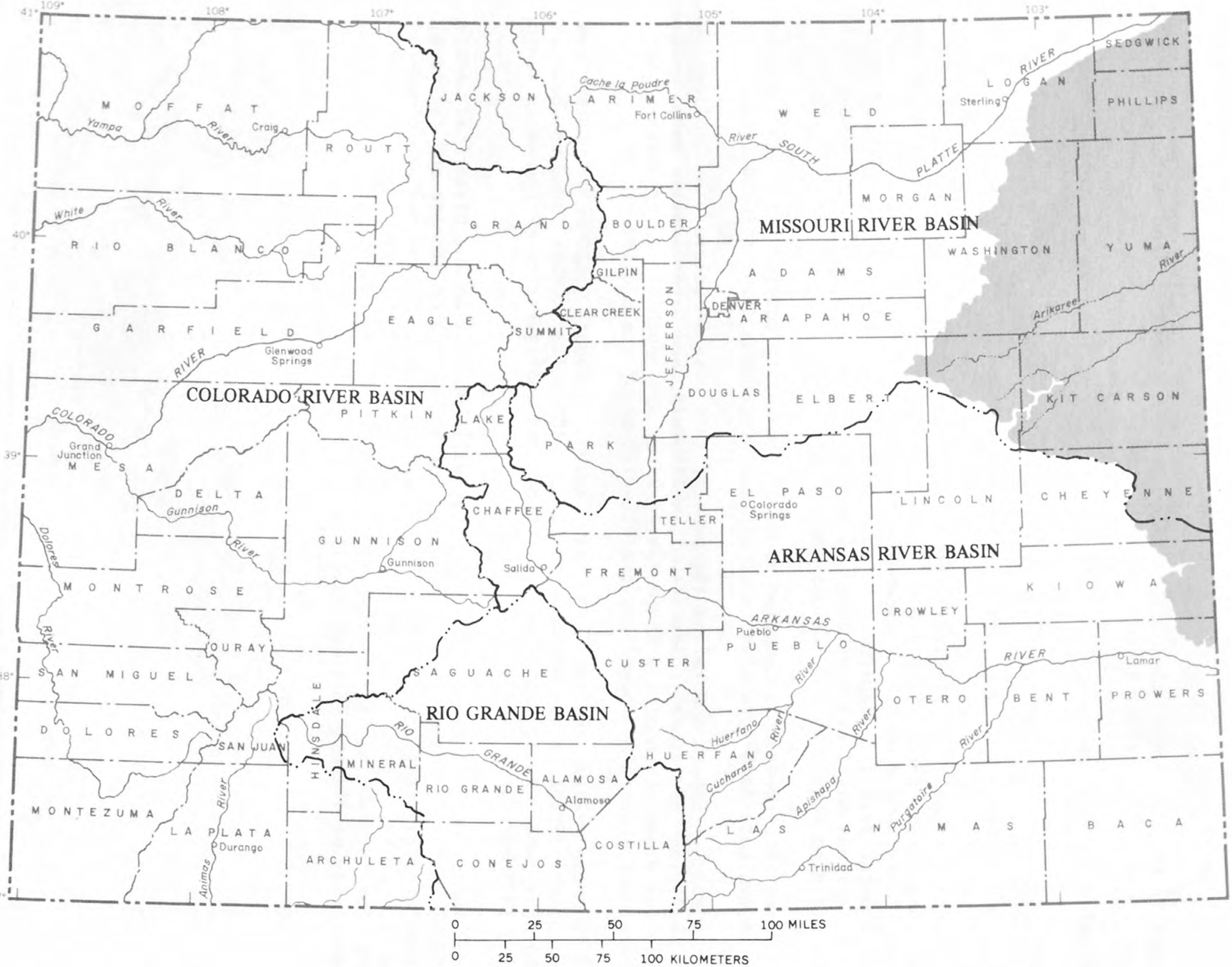

Figure 12.--Location of the Northern High Plains of Colorado.

PROJECT TITLE: Water-Management Study of the Northern High Plains of Colorado (fig. 12)

COOPERATING AGENCY: Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, and the Central Yuma, Frenchman, Marks Butte, and Sand Hills Ground Water Management Districts

PROJECT CHIEF: Ronald G. Borman, Subdistrict Office, Lakewood

PERIOD OF PROJECT: Continuous since July 1968

Problem.--State and local water-management agencies are managing the ground-water supply in the Northern High Plains where increased pumpage for irrigation is depleting the supply. The agencies need a basis for predicting and then evaluating the effects of proposed changes in ground-water use.

Objectives.--Document the depletion of the ground-water supply. Collect data defining the hydrologic characteristics of the Ogallala aquifer. Monitor long-term water-level trends.

Approach.--Locate and obtain hydrologic data from all wells that pump more than 100 gallons per minute. From these wells, develop a monitoring network that will reflect water-level changes in the entire area. Collect and compile data to determine aquifer properties, recharge, return flow, consumptive use, and water quality.

Progress.--Data have been collected from about 3,200 wells. A monitoring network of about 650 wells has been established and water levels are being measured yearly prior to the start of the irrigation season. Areas of water-level declines have been identified and are being monitored. The hydrologic characteristics of the Ogallala aquifer have been defined for much of the study area. Computer models have been developed, calibrated, and tested for five areas within the Northern High Plains. Report showing the altitude and configuration of the water table and the depth to water during January 1978 has been published.

Plans.--Continue to measure water levels on a yearly basis. Continue to collect data that will define the hydrologic characteristics of the Ogallala aquifer. Prepare yearly reports documenting water-level measurements. Prepare periodic reports documenting long-term water-level trends.

Reports published or released during fiscal year 1979.--See reference 7 under Water-Resources Interpretive Reports at back of report.

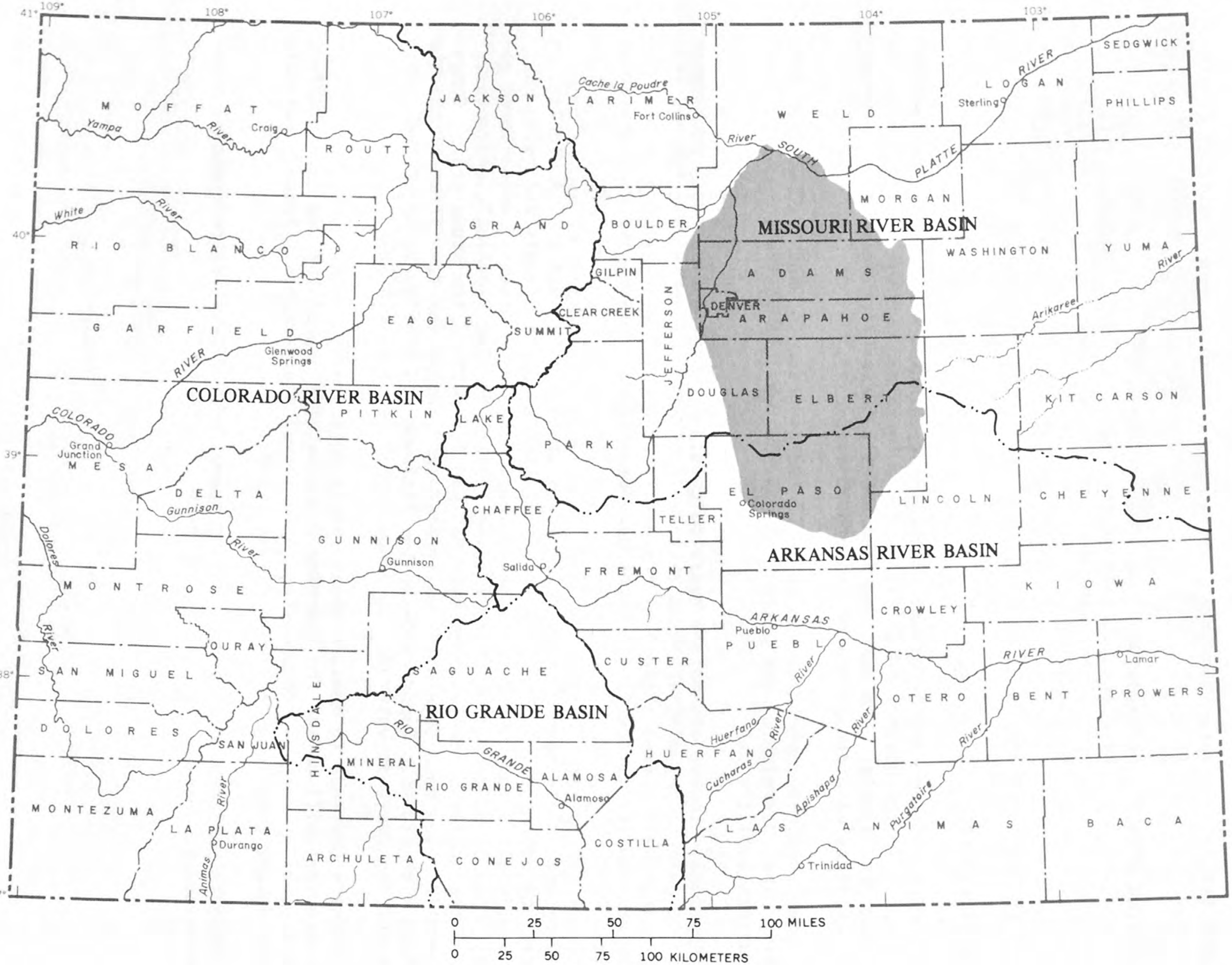

Figure 13.--Location of the Denver Basin.

PROJECT TITLE: Ground-Water Resources of the Denver Basin (fig. 13)

COOPERATING AGENCIES: Adams County Board of Commissioners; Arapahoe County; City and County of Denver, Board of Water Commissioners; Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer; Elbert County Planning Department; and the El Paso County Board of Commissioners

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

PERIOD OF PROJECT: July 1975 to September 1984

Problem.--The Denver Basin is underlain by four major bedrock aquifers. Increased pumpage from these aquifers, especially in localized areas in and near the major population centers along the Front Range, has resulted in a rapid decline of the aquifers' potentiometric surfaces as water is being withdrawn from the aquifers faster than it is being recharged. The geohydrology of the basin is complex and few data are available to determine water movement within and between aquifers, major areas of recharge to and discharge from the aquifers, chemical quality of water in the aquifers, and development potential of the multiple-aquifer system. A knowledge of the geohydrologic system of the basin is needed by State and local officials so that they can more effectively manage the resource.

Objectives.--Collect and interpret geohydrologic data needed to develop a computer model of the ground-water-flow system. Collect and interpret ground-water-quality data to better evaluate the water-supply potential of the bedrock aquifers. Develop a computer model of the ground-water flow system that can be used to evaluate long-term effects of various water-management alternatives.

Approach.--Collect and interpret geohydrologic data from wells completed in each aquifer. Establish an observation-well network to monitor water levels in each aquifer. Collect and interpret water-quality data from each aquifer. Determine coefficients of storage and hydraulic conductivity for each aquifer. Prepare maps summarizing all data collected. Develop a computer model of the ground-water-flow system.

Progress.--Geohydrologic data have been obtained from about 700 wells. Selected water-quality data have been obtained from about 500 wells; comprehensive water-quality data have been obtained from about 100 wells. Data analysis has begun. Maps prepared showing the extent, thickness, structure, sand content, and water quality of the four bedrock aquifers. A hydrologic-data report also is being prepared.

Plans.--Continue to monitor water levels. Complete mapping and hydrologic-data report. Determine hydraulic characteristics of the aquifers.

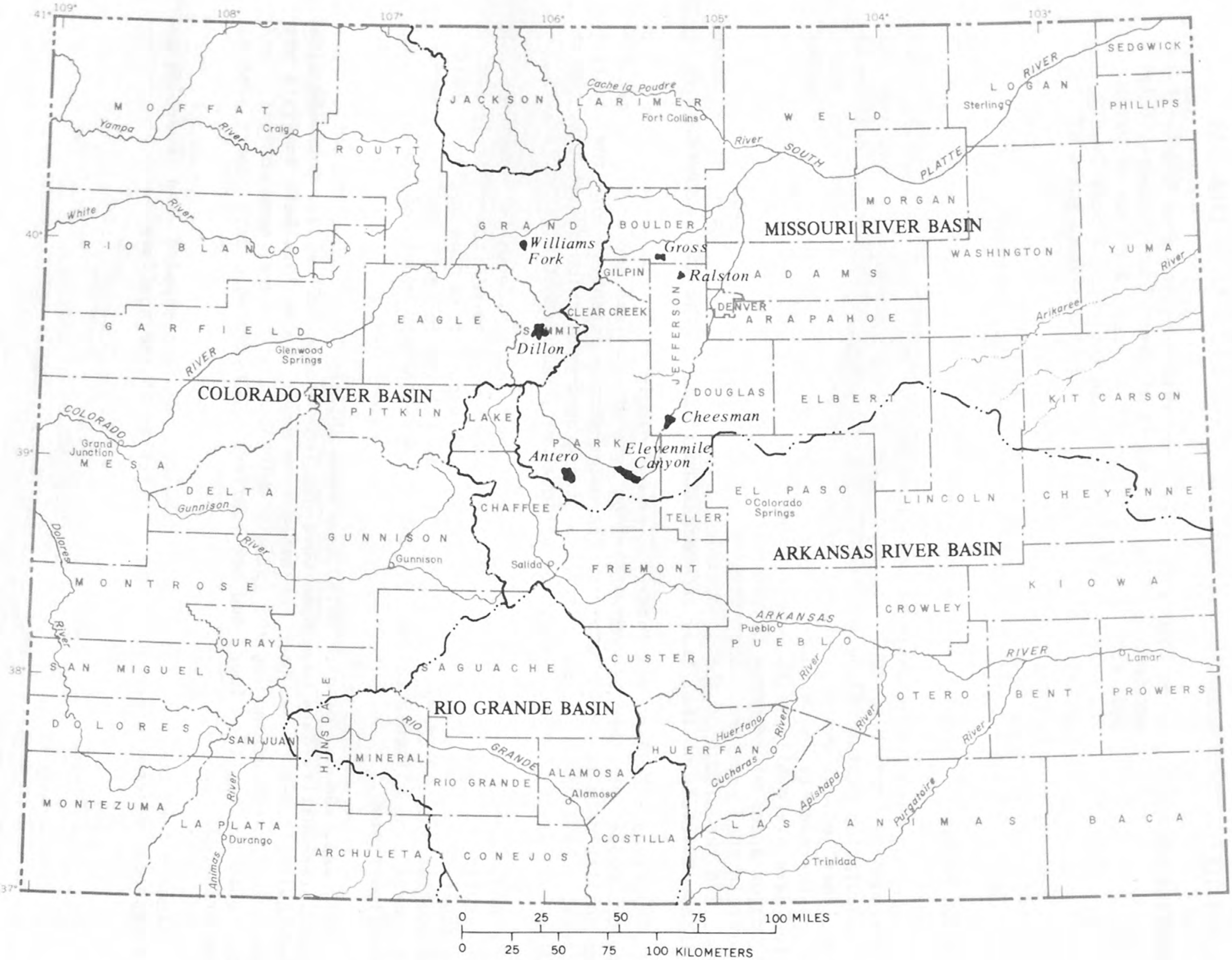

Figure 14.--Location of water-supply reservoirs.

PROJECT TITLE: Determination of Evaporation and Thermal Regime of Selected Reservoirs and Lakes (fig. 14)

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

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

PERIOD OF PROJECT: May 1972 through May 1982

Problem.--The Denver Board of Water Commissioners operates one of the Nation's most complex water-collection, storage, and distribution systems. Water is stored in seven reservoirs on both sides of the Continental Divide for eventual use in the Denver metropolitan area. As part of its water-right appropriation, the Board of Water Commissioners is required to account for water loss by evaporation from the reservoirs. The Board of Water Commissioners needs to know the volume of water being evaporated and if there are methods to reduce the amount of evaporation.

Objectives.--Determine total annual evaporation and seasonal and annual variations in evaporation from each reservoir. Determine the effects of altitude, wind shelter, and reservoir operation on evaporation. Study methods for improving relation between pan and reservoir evaporation.

Approach.--Review all existing data. Install and operate mass-transfer and pan-evaporation equipment at all reservoirs. Conduct energy-budget analyses at all reservoirs.

Progress.--Annual volumes of water being evaporated have been determined for all reservoirs using mass-transfer and pan-evaporation techniques. Energy-budget analyses have been completed for all reservoirs except the Williams Fork Reservoir. Energy-budget analyses have been started at the Williams Fork Reservoir. Climatic study in South Park completed.

Plans.--Continue energy-budget analysis at Williams Fork Reservoir. Continue mass-transfer analyses at all reservoirs. Begin report on evaporation from the seven reservoirs. Complete report of the climatic study in South Park.

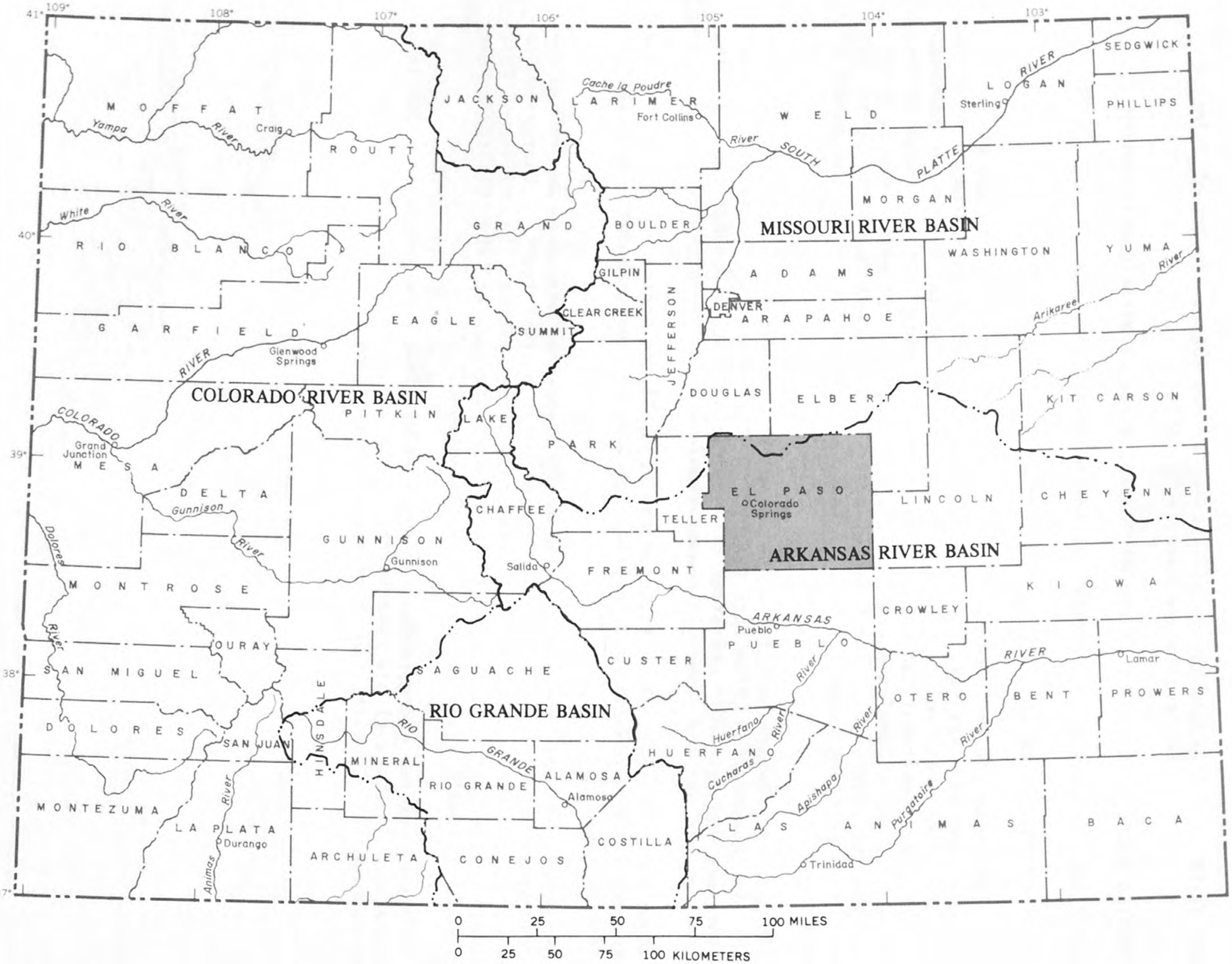

Figure 15.--Location of El Paso County.

PROJECT TITLE: Water Resources of El Paso County (fig. 15)

COOPERATING AGENCIES: City of Colorado Springs, Department of Public Utilities; City of Colorado Springs, Office of the City Manager; El Paso County Board of Commissioners; Pikes Peak Area Council of Governments; and the U.S. Air Force Academy

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: July 1972 to June 1981

Problem.--El Paso County, which includes the city of Colorado Springs, is one of the most rapidly growing urban areas in the State. Knowledge of the water resources of the county is needed by State and local officials to adequately plan for future development.

Objectives.--Determine the occurrence and availability of ground water, including depth to water and yield of aquifers. Document current ground-water development, annual ground-water withdrawal, and the effects of current development. In conjunction with the county planning director, who will provide estimates of rate and location of future population increases, predict future ground-water development and identify and describe the effects of this anticipated development. Estimate the mean annual flow and the 2-, 5-, 10-, and 50-year peak discharges of streams draining the mountainous part of the county. Determine the water quality of streams and aquifers. Synthesize these data so that the feasibility of water projects can be readily determined.

Approach.--Make an inventory of all wells yielding more than 100 gallons per minute. Establish a network of observation wells. Determine streamflow characteristics using channel geometry and other techniques. Determine stream quality using on-site measurements of selected constituents and parameters that indicate the relative quality of the water. Collect samples of ground water for chemical analysis. Develop a computer model of the Dawson aquifer, which is the principal source of water in the northern one-half of the county.

Progress.--Most objectives attained and results published. Current data collection is being used to refine results and to improve the predictive capability of the computer model. Conducted gain-loss studies on two streams.

Plans.--Continue to collect selected hydrologic data for additional refinement of results and improving the predictive capability of the computer model. Advise cooperating agencies of significant changes in the hydrologic system.

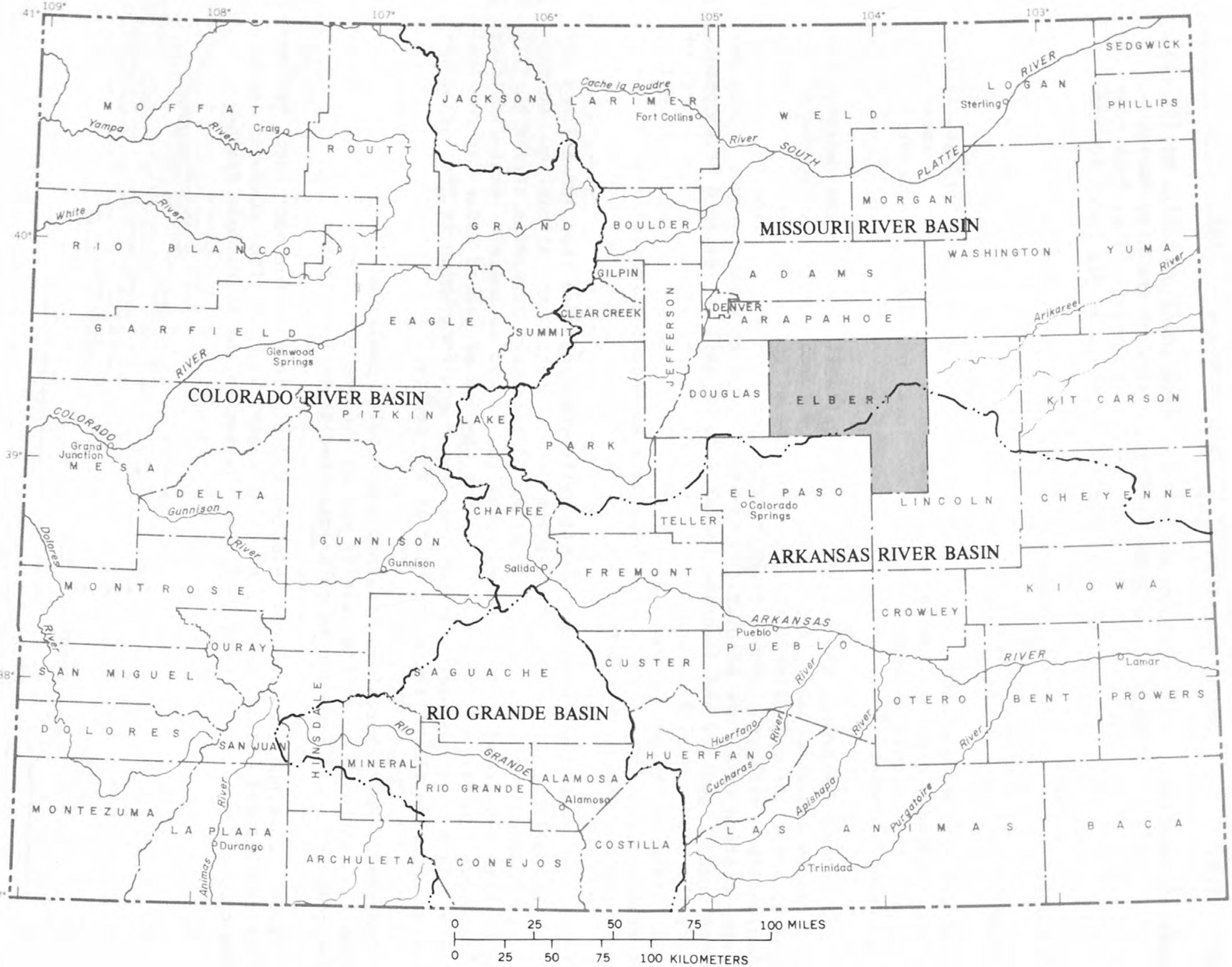

Figure 16.--Location of Elbert County.

PROJECT TITLE: Flood Study for Elbert County (fig. 16)

COOPERATING AGENCIES: Colorado Department of Natural Resources, Colorado Water Conservation Board; and Elbert County Planning Department

PROJECT CHIEF: Theron R. Dosch, District Office, Lakewood

PERIOD OF PROJECT: January 1979 to September 1981

Problem.--Elbert County, located southeast of Denver and northeast of Colorado Springs is undergoing rapid residential development without benefit of flood-plain regulations. County officials need flood-plain information that is more accurate than that provided by flood-prone area maps, but detailed flood studies would be too expensive. An intermediate type of study will provide accurate information about flood hazards in the county.

Objectives.--Provide flood information, including flood-plain widths, flood depths, and average flood velocities at selected sites on streams where the width of inundation during a 100-year flood would exceed 60 feet so that county officials can use the information to evaluate development proposals and establish flood-plain regulations.

Approach.--Compile existing hydraulic and hydrologic data including historical-flood information. Collect additional data as needed. Compile data on 1:12,000 scale maps made from 1:24,000 scale U.S. Geological Survey topographic quadrangles. Provide a set of maps to Elbert County officials for duplication as needed.

Progress.--Cross section characteristics and 100-year flood levels computed for 50 of 93 stream sites in the western one-third of the county. Maps for compilation obtained.

Plans.--Complete maps for western one-third of county. Begin study of central one-third of county.

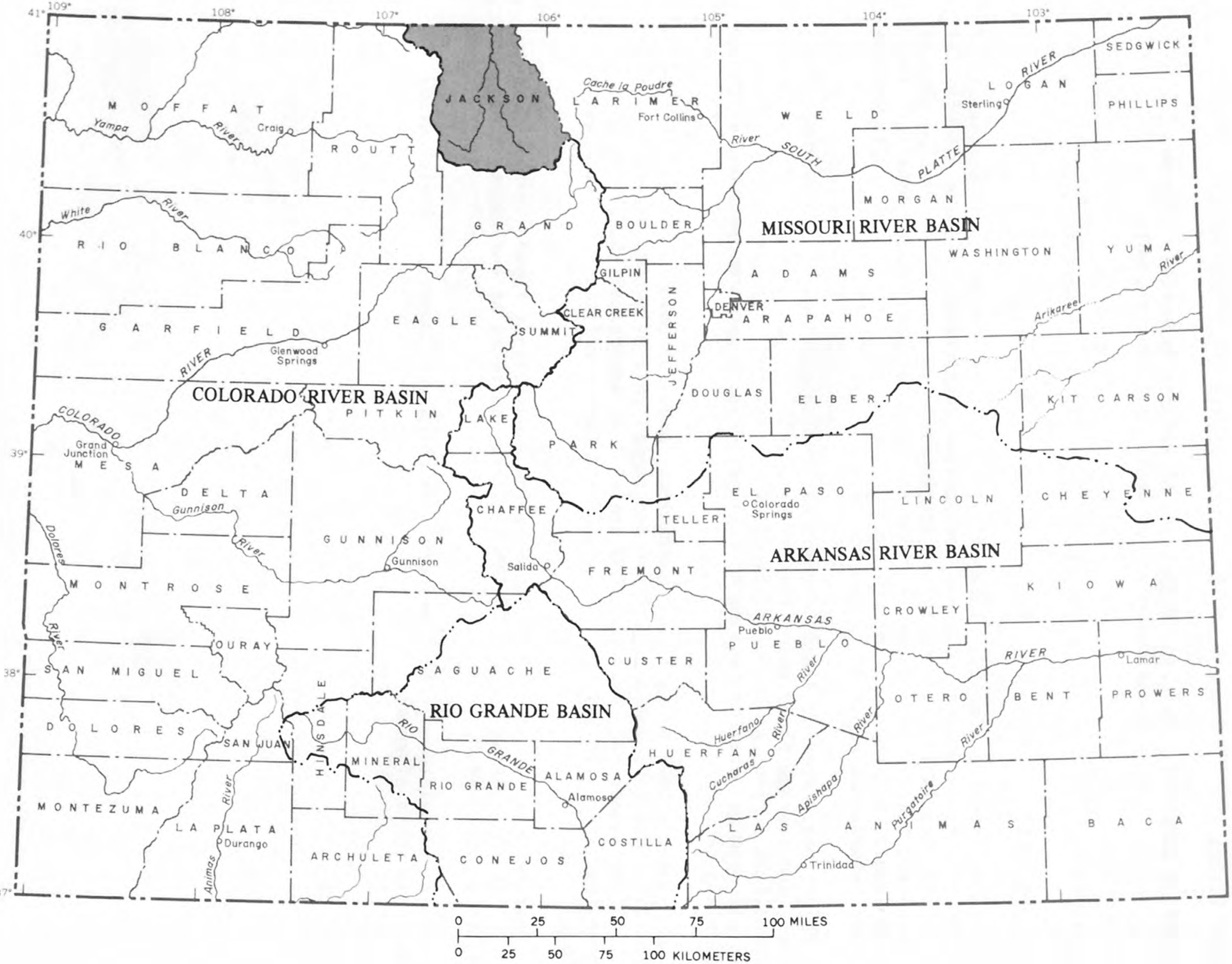

Figure 17.--Location of Jackson County.

MISSOURI RIVER BASIN

PROJECT TITLE: Monitoring of the Hydrologic System in North Park, Jackson County (fig. 17)

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

PROJECT CHIEF: Gerhard Kuhn, Subdistrict Office, Lakewood

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--The proposed development of coal in Jackson County may have adverse effects on the hydrologic system in the county. A knowledge of the existing hydrologic system is needed prior to the beginning of coal mining so that the effects of mining can be determined.

Objective.--Define the hydrologic system of the area; determine the relationships between climatic conditions, surface water, and ground water.

Approach.--Continue to collect surface-water-flow and quality data at seven existing stations. Continue to collect rainfall data at three existing recording rain gages. Install a new climatological station in the Canadian River drainage basin. Obtain ground-water data from personnel working on the project "Ground-Water Studies in Coal-Mining Areas (p. 19).

Progress.--Data collection continued at the seven existing streamflow-gaging stations, three existing rain gages, and two existing water-quality monitors. A climatological station was installed in the Canadian River drainage basin to monitor air temperature, wind, and solar radiation. A parshall flume, a rain gage and two rainfall-runoff recorders were installed in the Williams Draw drainage basin.

Plans.--Continue data collection at all stations. Install snow courses and monitor soil moisture and air temperature in the Williams Draw drainage basin. Begin analysis of water-quality data.

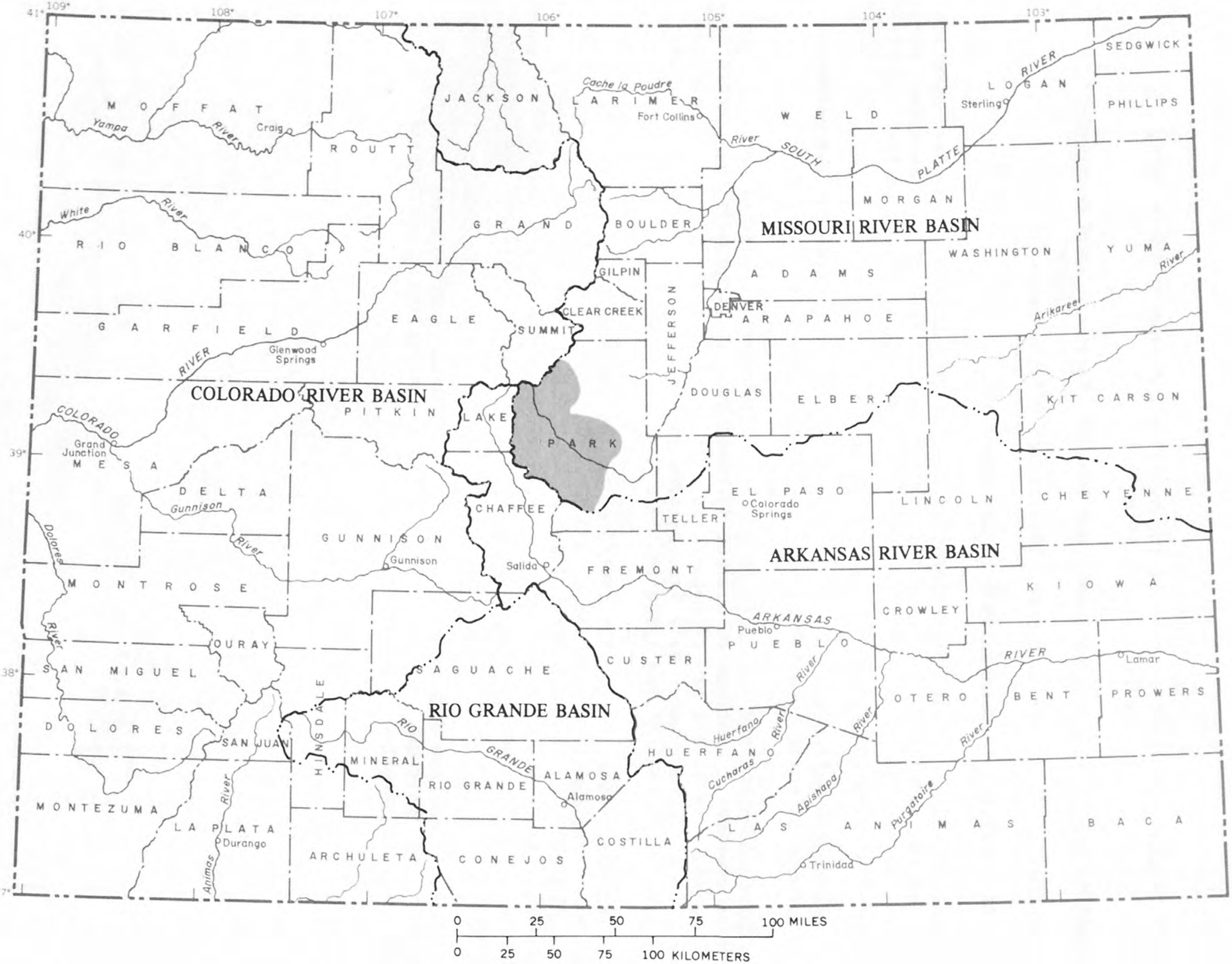

Figure 18.--Location of South Park.

PROJECT TITLE: Water Budget for South Park, Park County (fig. 18)

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

PROJECT CHIEF: Dennis C. Hall, Subdistrict Office, Lakewood

PERIOD OF PROJECT: October 1977 to September 1981

Problem.--According to Colorado water law, any transfer of surface-water rights from irrigation use to municipal use must protect the decreed surface-water rights of downstream users. Only that part of a surface-water right used for irrigation that is evapotranspired from irrigated fields may be transferred. Because of anticipated transfers of water rights in South Park, the amount of water evapotranspired from irrigated fields needs to be determined.

Objectives.--Determine the water budget for South Park. Use the data from the water budget to determine the amount of water being evapotranspired from irrigated fields.

Approach.--Use color-infrared aerial photographs to determine irrigated acreage and areas where the water table is at or near the land surface. Collect precipitation and ground-water data to determine the amount of water entering the area. Collect streamflow and ground-water data to determine the amount of water leaving the area. Evapotranspiration will be estimated as the difference between water entering and leaving the area.

Progress.--Four continuous-record and six partial-record streamflow-gaging stations and three rain-gaging stations have been installed. Water levels have been measured monthly in 14 shallow wells. Data have been collected for 2 years and data collection is continuing. Three gain-loss studies have been made. Determination of irrigated areas using color infrared aerial photographs has begun.

Plans.--Continue data collection. Complete determination of irrigated areas. Begin data analysis.

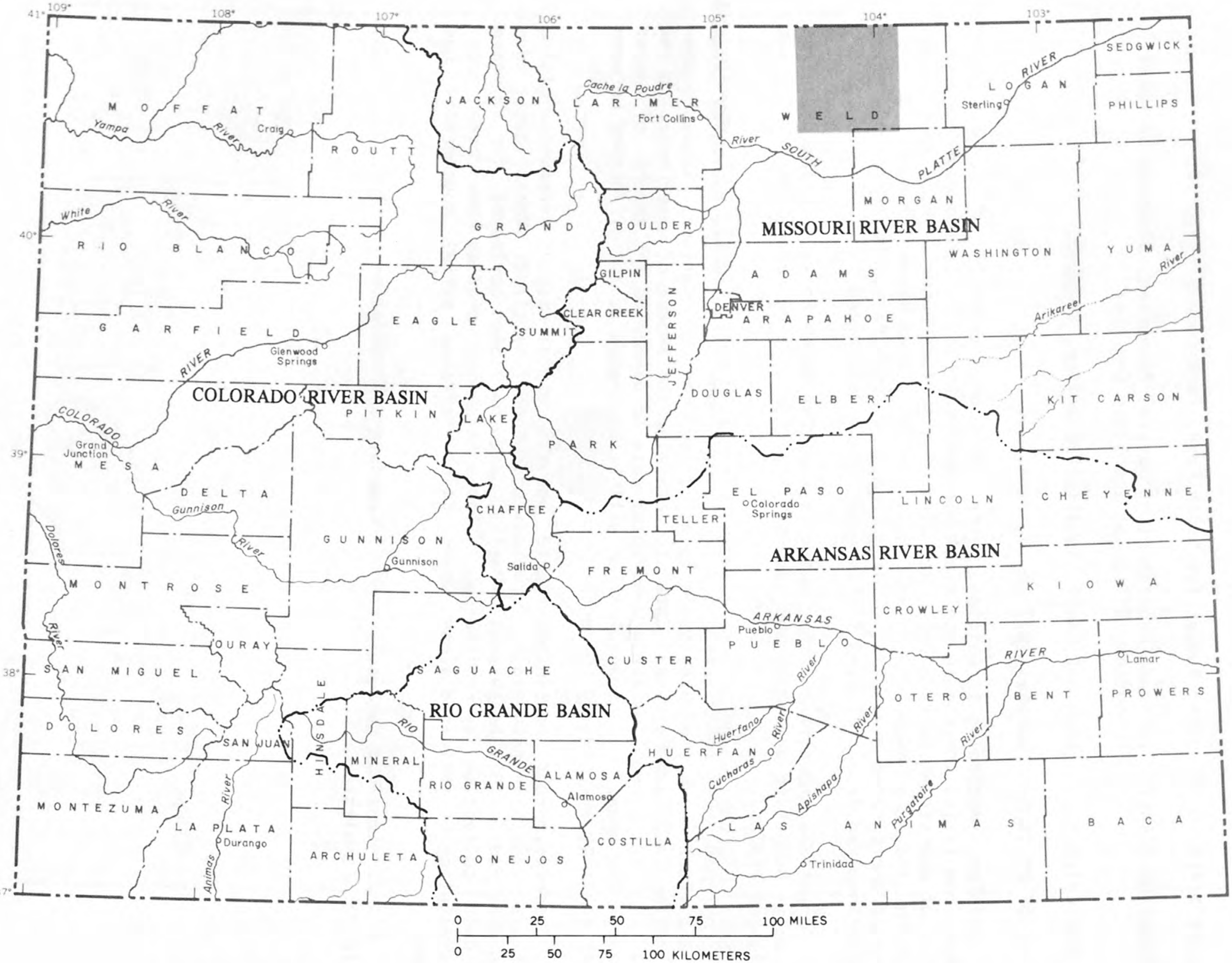

Figure 19.-- Location of area where effects of in-situ mining of uranium ores are being studied.

PROJECT TITLE: Hydrologic Impact of In-situ Mining of Uranium Ores (fig. 19)

COOPERATING AGENCY: U.S. Environmental Protection Agency

PROJECT CHIEF: James W. Warner, District Office, Lakewood

PERIOD OF PROJECT: October 1977 to September 1980

Problem.--A mining company is planning to extract uranium from a low-grade ore deposit using an in-situ mining process. In the leaching process, ground water at the mine site will be replaced by the leaching solution that contains excessive concentrations of ammonia. After mining is completed, the company will attempt to restore the aquifer system. Little is known about the leaching process or the environmental impact of the planned mining and restoration operation.

Objectives.--Determine the geohydrologic system at and in the vicinity of the planned mine. Develop a computer model that will be able to simulate ground-water flow and solute transport in the area of the mine. Use the computer model in conjunction with chemical analyses to define the ground-water-flow system and the solute transport during and after mining.

Approach.--Determine the geohydrologic system using core samples, geophysical logs, drillers logs, and aquifer tests. Collect hydraulic-head, ground-water-flow, and water-quality data for use in developing the computer model. Use laboratory experiments to determine the chemical reactions between the leaching solution and the aquifer system.

Progress.--Data collection has been completed along with preliminary analysis of geohydraulic conditions in the vicinity of the mine site. Model development is in progress.

Plans.--Complete model development and write report.

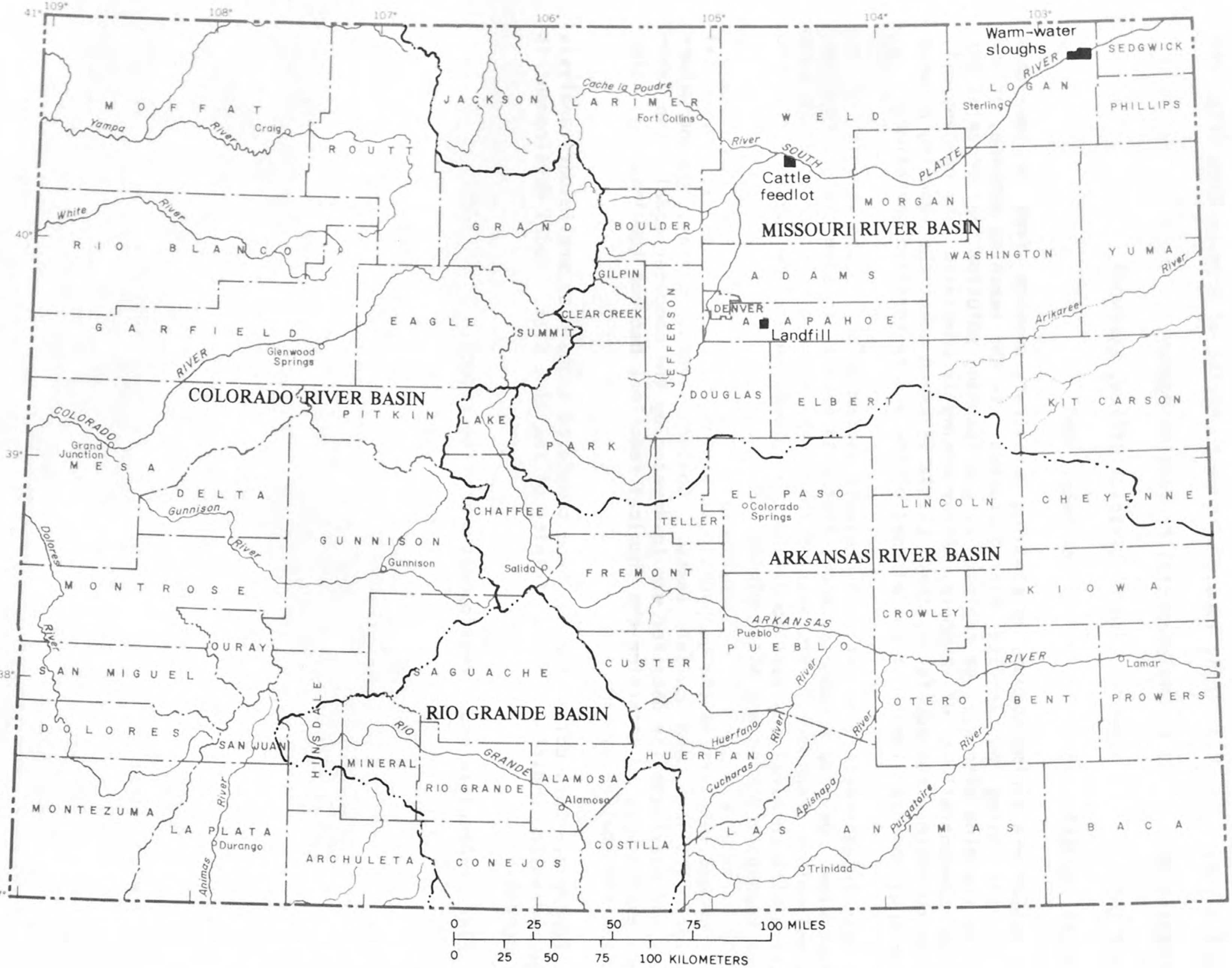

Figure 20.--Location of the cattle feedlot, warm-water sloughs, and landfill.

PROJECT TITLE: Effects of Wastes from a Cattle Feedlot on the Chemical Quality of Water in an Alluvial Aquifer (fig. 20)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1973 to October 1981

Problem.--Because large cattle feedlots may produce wastes on a daily basis comparable in volume to daily wastes produced by a medium-size city, there is a great potential for ground-water contamination due to infiltration of the wastes into aquifers beneath and adjacent to the feedlot. Greater-than-normal concentrations of nitrate and other dissolved ions have been reported in ground water beneath and adjacent to large feedlots. These constituents are a contamination hazard to nearby wells and streams.

Objective.--Monitor and describe any changes that occur in the chemical quality of ground water resulting from the operation of a large cattle feedlot.

Approach.--Establish an observation-well network on and adjacent to the area where a large cattle feedlot is to be constructed. Determine the chemical quality of ground water in both areas prior to construction of the feedlot. After construction, collect samples of ground water for chemical analysis from both the feedlot and the control areas. Determine changes in chemical quality resulting from operation of the feedlot.

Progress.--Water-quality data now collected annually; last samples collected during June 1979. A marked change in ground-water quality has not been observed. Summary report being prepared.

Plans.--Determine water quality during June 1980. Drill a well or a series of wells down gradient from the northeast retention pond to monitor water-quality changes. Complete report describing the results of the study.

PROJECT TITLE: Hydrologic Analysis of Warm-Water Sloughs along the South Platte River in Logan County (fig. 20)

COOPERATING AGENCY: Colorado Department of Natural Resources, Division of Wildlife

PROJECT CHIEF: Alan W. Burns, District Office, Lakewood

PERIOD OF PROJECT: February 1979 to June 1981

Problem.--The Colorado Division of Wildlife maintains and operates Tamarack Ranch, a wildlife management area along the South Platte River in northeastern Logan County. A primary feature of this area is the warm-water sloughs within the flood plain of the river. Because of the sensitivity of these unique waterfowl habitats to water management changes, the Colorado Division of Wildlife needs to understand the hydrologic regime of these sloughs so it may better evaluate proposed water-management changes.

Objective.--Determine the hydrologic conditions of warm-water sloughs; specifically evaluate possible effects on water levels and temperatures of selected sloughs within the Tamarack Ranch Wildlife Area as a result of the following: upstream diversions; upgradient artificial recharge; and increased ground-water pumpage.

Approach.--Use aerial photography to delineate warm-water sloughs from Greeley to Julesburg in the South Platte River valley. Within Tamarack Ranch, collect water levels and temperature data from the river, sloughs, and wells. Use a harmonic-temperature model for the river, develop a ground-water flow model and a mass-balance, energy-balance model of selected sloughs.

Progress.--A water-level network has been evaluated for monthly measurement of water levels and specific conductance. Observation wells were drilled and available historic data on aquifer characteristics, ground-water levels, and streamflow data (discharge, temperature, and specific conductance) have been collected.

Plans.--Obtain color-infrared aerial photographs during the winter to locate sloughs. Use thermal scanners during the spring to detect water-temperature variations. Continue monthly measurement of water levels and specific conductance. Develop models for ground water and sloughs.

PROJECT TITLE: Monitoring Ground-Water Quality at a Landfill (fig. 20)

COOPERATING AGENCY: City and County of Denver

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

PERIOD OF PROJECT: October 1977 to September 1982

Problem.--The City and County of Denver operates a landfill where both solid and liquid wastes are disposed. Solid wastes are compacted and buried. Liquid wastes are placed in unlined trenches until several million gallons are accumulated; the trenches are then filled with solid wastes and covered with a layer of earth. Monitoring of ground-water quality by the U.S. Geological Survey during 1974-76 indicated that leachates from the solid wastes and the liquid wastes could cause a deterioration in ground-water quality in the vicinity of the landfill.

Objectives.--Monitor ground-water quality in the vicinity of the landfill. Describe in detail any changes in ground-water quality that occur.

Approach.--Install two additional observation wells. Continue to monitor water quality in nine existing wells. Collect samples for analysis of selected organic and inorganic constituents at 5-month intervals; analyses to be made in a laboratory designated by the cooperator.

Progress.--Two additional observation wells have been installed. Monitoring of water quality is continuing; samples are collected in January and June. The effects on water quality of brine ponds near the landfill also are being monitored by collecting and analyzing samples from two wells drilled downgradient from the ponds and from wells owned by the operator of the brine ponds.

Plans.--Continue to monitor water quality in the vicinity of both the landfill and the brine ponds.

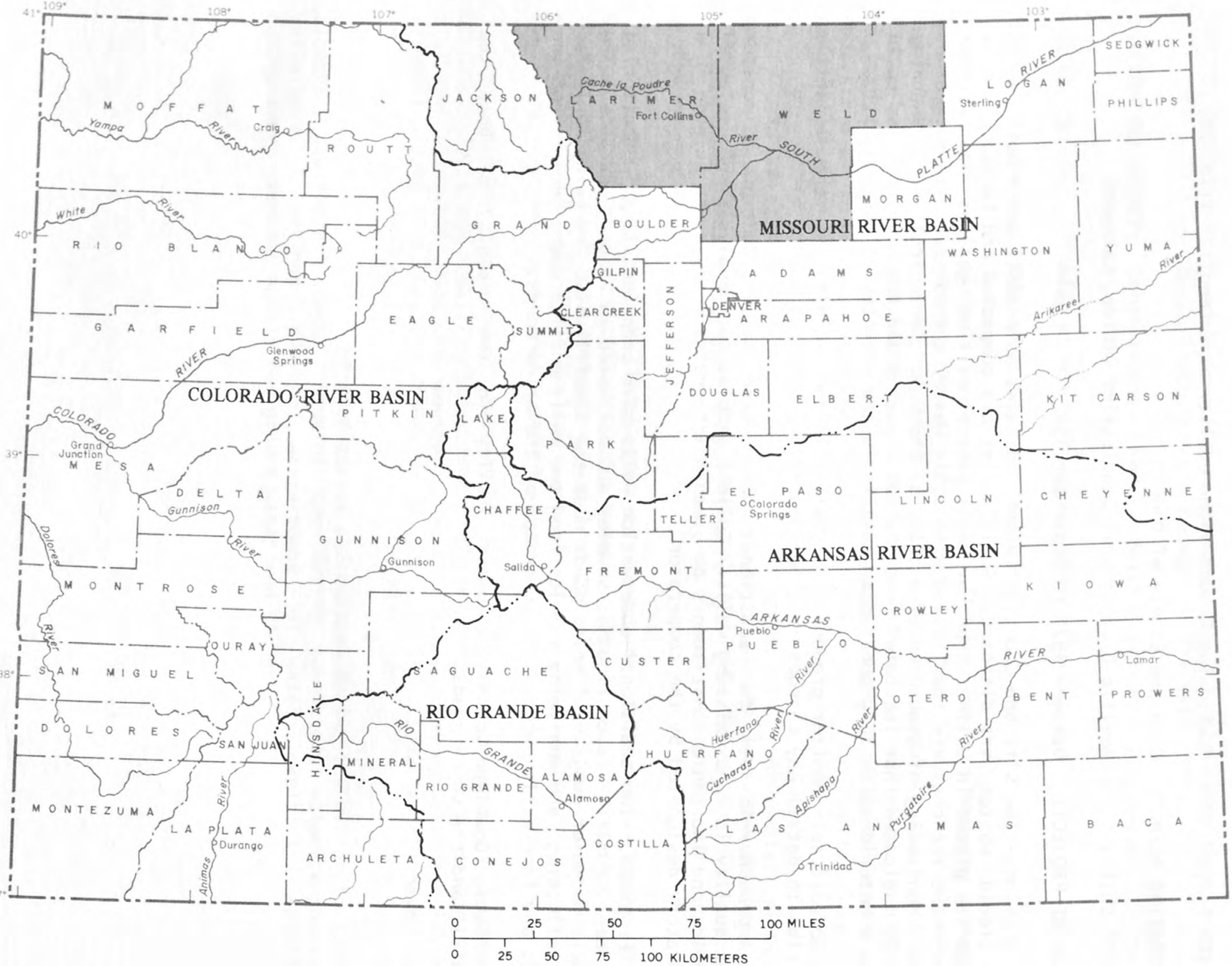

Figure 21.-- Location of Larimer and Weld Counties.

PROJECT TITLE: Regional Streamflow and Water-Quality Monitoring in Larimer and Weld Counties (fig. 21)

COOPERATING AGENCY: Larimer-Weld Regional Council of Governments

PROJECT CHIEF: Russell K. Livingston, Subdistrict Office, Lakewood

PERIOD OF PROJECT: June 1979 to September 1982

Problem.--A streamflow quantity and water-quality data base is needed to define existing conditions, particularly with regard to the impact of urban runoff, non-point agricultural pollution, and sewage-return flow. An accurate and comprehensive data base also will be necessary in order to achieve other phases of the planning process, including assessing water quality of streams and lakes, determining the low-flow stream characteristics, modeling of the ground-water system, and demonstrating adherence to Federal and State water-quality regulations.

Objectives.--Define the quality and quantity of streamflow, the water quality in lakes and reservoirs, and the interaction between surface water and ground water.

Approach.--Establish and operate streamflow stations, collect and analyze water-quality samples of river and lake water, and conduct gain-loss investigations.

Progress.--One continuous-record gaging station and three water-quality stations have been installed and are operating.

Plans.--Install 1 continuous-record gaging station and 12 water-quality stations. Continue data collection. Conduct two gain-loss investigations along either the Big Thompson River or the Cache la Poudre River.

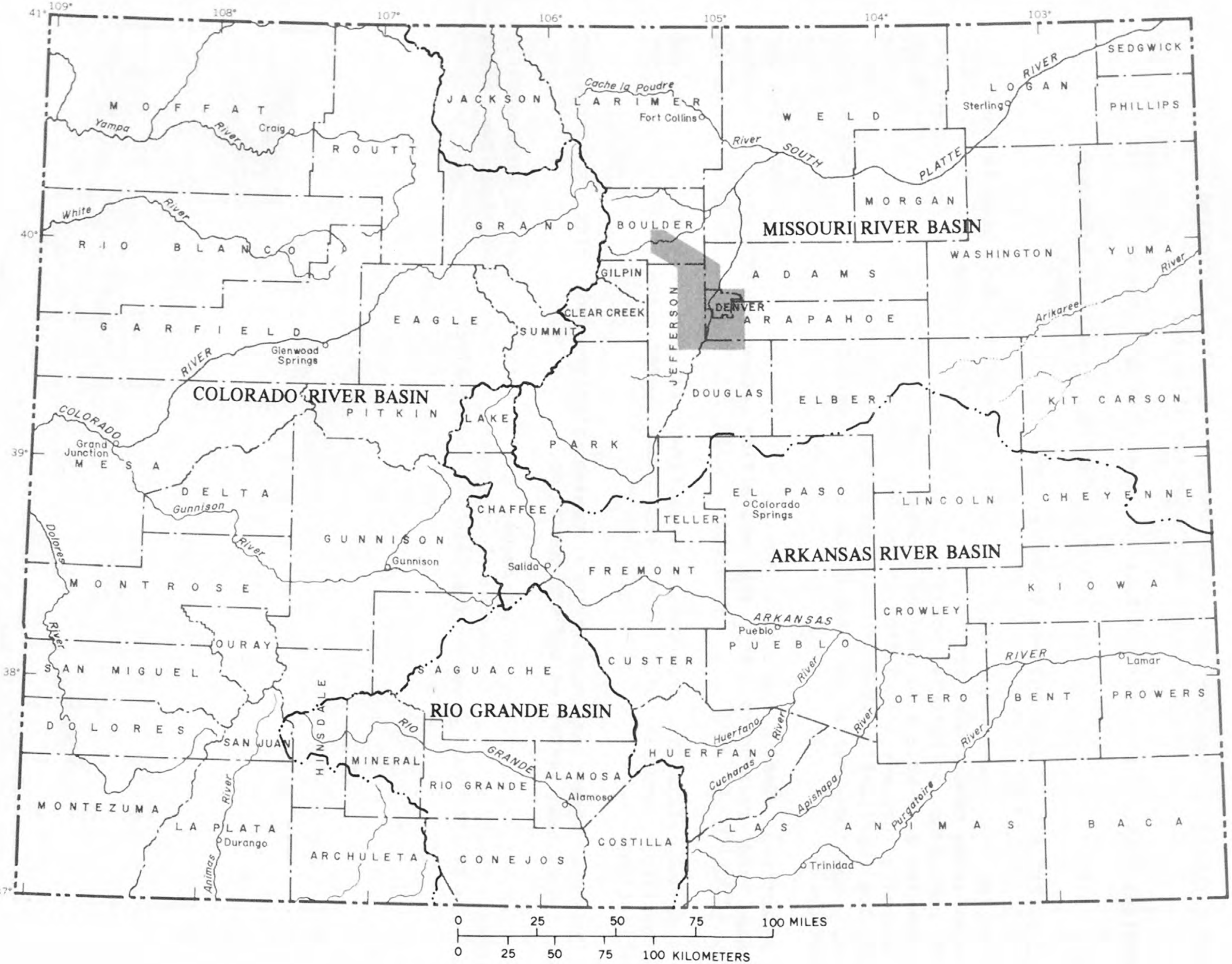

Figure 22.--Location of the Denver-Boulder urban area.

PROJECT TITLE: Flood Frequency in Urban Areas (fig. 22)

COOPERATING AGENCY: Urban Drainage and Flood Control District

PROJECT CHIEF: Charles V. Reeter, Subdistrict Office, Lakewood

PERIOD OF PROJECT: Continuous since December 1967

Problem.--Flood flows are an important aspect in designing urban drainage works. Data are lacking for small watersheds and estimates made from existing data are likely to be substantially in error. Data are needed to define rainfall-runoff relations in small watersheds located in urban areas.

Objectives.--Collect data to define the relations between rainfall intensity, duration, and runoff in small watersheds in the urban parts of Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson Counties. Develop techniques for extrapolating the data both in time and space. Develop a computer model to predict rainfall-runoff relations that can be modified for each watershed, based on the hydrologic and physical characteristics of the individual watersheds.

Approach.--Collect rainfall-runoff data from 30 watersheds in the 6-county area. Rainfall data to include continuous records supplemented by data from standard rain gages. Runoff data to include continuous records from each watershed. Watersheds to be selected to sample the ranges of the following parameters: (1) Size--40 acres to 2 square miles, (2) vegetative cover--natural to none, (3) drainage by sewers--nonsewered to completely sewered, and (4) urban development--natural to completely urbanized.

Progress.--Data-collection network has been modified; data collection is continuing at 12 watersheds. Additional watershed characteristics have been determined. Verification of discharge ratings was completed. Computer models have been developed and calibrated for selected watersheds where sufficient data are available. Report containing data collected from October 1974 through September 1977 has been released.

Plans.--Reduce data-collection network to seven watersheds. Continue data collection. Calibrate additional computer models as sufficient data become available. Begin data analysis and preparation of summary report.

Reports published or released during fiscal year 1979.--See reference 1 under Water-Resources Data Reports at back of report.

PROJECT TITLE: Rainfall-Runoff Management Model for the Denver Federal Center (fig. 22)

COOPERATING AGENCY: U.S. General Services Administration

PROJECT CHIEF: Robert D. Jarrett, District Office, Lakewood

PERIOD OF PROJECT: Continuous since July 1975

Problem.--Rapid urbanization of the area west of the Denver Federal Center has increased the possibility of flooding on the Federal Center. The magnitude and frequency of floods need to be determined so that appropriate flood-control structures can be constructed on the Federal Center and future facilities located in areas that are not subject to flooding.

Objectives.--Develop a computer model to predict the magnitude and frequency of floods. Prepare a flood-prone area map of the Federal Center. Determine the physical characteristics of catchment areas on the Federal Center and in upstream tributary areas.

Approach.--Install rain gages on the Federal Center and in the upstream tributary areas west of the Federal Center. Install stream-stage stations to measure inflow to and outflow from the Federal Center. Install stage recorders in non-urbanized and urbanized watersheds to determine runoff characteristics. Make current-meter measurements at all stream-stage locations to define stage-discharge relations. Obtain an orthophotographic base map with 2- and 4-foot contour intervals to determine the physical characteristics of the catchment and tributary areas.

Progress.--Nine recording and seven nonrecording rain gages have been installed on the Federal Center and in the McIntyre Gulch drainage basin. Eight recording and one nonrecording stream-stage stations have been installed within or immediately adjacent to the Federal Center. Stage recorders have been installed in a natural-grass watershed and a storm-sewered area. An orthophotographic base map has been prepared. The physical characteristics of the catchment and tributary areas have been determined. The flood-prone area map has been prepared and three flood-retention ponds constructed on the Federal Center by the General Services Administration. The computer model has been developed and sufficient data now exist to test the model. Data analysis has begun. Report containing data collected from October 1974 through September 1977 has been released.

Plans.--Continue data collection. Complete testing of model and begin calibration of model. The feasibility of including water-quality sampling and analyses in the study is being investigated.

Reports published or released during fiscal year 1979.--See reference 1 under Water-Resources Data Reports at back of report.

PROJECT TITLE: Storm Runoff, Grange Hall Creek Basin, Northglenn (fig. 22)

COOPERATING AGENCY: City of Northglenn

PROJECT CHIEF: Dennis C. Hall, Subdistrict Office, Lakewood

PERIOD OF PROJECT: September 1977 to September 1980

Problem.--One of the provisions of the Northglenn and FRICO Land and Water Resources Management Project is that the City of Northglenn collect, store, and treat, as necessary, storm runoff for use as a source of irrigation and municipal supplies. The quantity and quality of the storm runoff needs to be known to aid in determining the volume of water requiring treatment and the extent of treatment needed to make the storm runoff suitable for irrigation and municipal uses.

Objectives.--Determine the frequency and volume of storm runoff. Determine the quality of storm runoff with emphasis on the quality of the runoff that begins shortly after the start of a storm, as this runoff generally contains the greatest concentrations of dissolved constituents.

Approach.--Install instruments in the Grange Hall Creek drainage basin upstream from the site of the proposed Stonehocker Reservoir to collect precipitation, streamflow, and water-quality data. Use the data to determine the hydraulic and water-quality characteristics of snowmelt runoff, rainfall runoff, and dry weather streamflow.

Progress.--Data collection has been completed at all but one station. A hydrologic-data report has been prepared; summary report is being prepared.

Plans.--Continue data collection at downstream station. Release hydrologic-data report; complete summary report.

PROJECT TITLE: Quantity and Quality of Urban Runoff (fig. 22)

COOPERATING AGENCY: Denver Regional Council of Governments

PROJECT CHIEF: Sherman R. Ellis, Subdistrict Office, Lakewood

PERIOD OF PROJECT: April 1979 to September 1981

Problem.--Section 208 of the Federal Water Pollution Control Act, Amendment of 1972, Public Law 92-500 requires the development and implementation of a plan for a coordinated waste-treatment management system. Major sources of water pollution have been examined but less obvious sources such as storm runoff have not been examined. Data must be developed to permit determination of the magnitude and type of pollution caused by storm-water runoff.

Objectives.--Provide data to improve knowledge of the types, concentrations, sources, build-up rates, and movement of materials in storm water runoff in the Denver Metropolitan Area. An attempt will be made to quantify the effect of urban storm runoff on the quality of the South Platte River. This phase of the study will concentrate on selection of the site to be monitored in the National Urban Runoff Study.

Approach.--Use maps, field surveys, aerial photography, and interviews with local officials to select nine urban-runoff sites that are representative of the following land uses: multi-family, single family, open space, shopping center, mixed multi-family, and light commercial. Collect samples and analyze for nitrogen and phosphorus compounds, organic and pesticide compounds, and heavy metals; collect discharge data.

Progress.--Selection of study sites completed. Instrumentation completed at five sites.

Plans.--Begin data collection at five sites. Install instruments at remaining four sites and begin data collection.

Reports published or released during fiscal year 1979.--See reference 2 under Water-Resources Interpretive Reports at back of report.

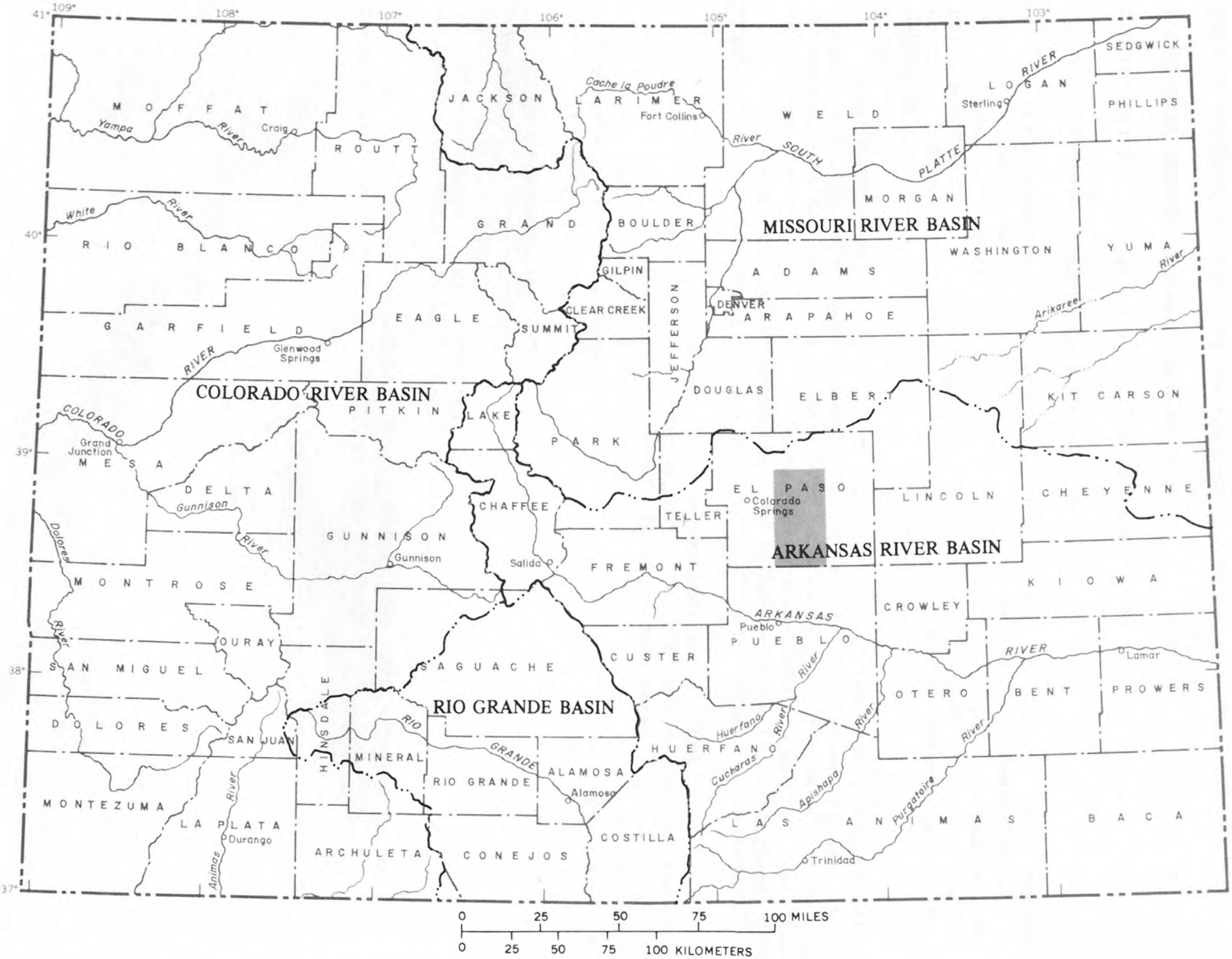

Figure 23.--Location of Upper Black Squirrel Creek basin.

PROJECT TITLE: Ground Water in the Upper Black Squirrel Creek Basin (fig. 23)

COOPERATING AGENCIES: Cherokee Water District and the El Paso County Board of Commissioners

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1977 to September 1981

Problem.--Increasing pumpage of water from the alluvial aquifer for use both within the basin and for export to the Colorado Springs area may be depleting the supply of water in the aquifer. The effects of the increasing pumpage on the ground-water system needs to be determined so that long-term management plans can be developed.

Objectives.--Determine the existing conditions in the ground-water system. Develop a computer model of the ground-water system that can be used to simulate the effects of various water-management plans.

Approach.--Evaluate historic hydrogeologic data and collect new data needed to determine existing conditions. Prepare hydrogeologic maps that describe the configuration of the prepumping and present water table, saturated thickness, and areal distribution of aquifer characteristics. Use the data to develop the computer model.

Progress.--Evaluation of historic data has been completed. The Cherokee Water District is providing water-level data for about 60 wells in the area. Continuous water-level recorders have been installed on four wells.

Plans.--Continue data collection. Complete preparation of hydrogeologic maps. Begin development of computer model.

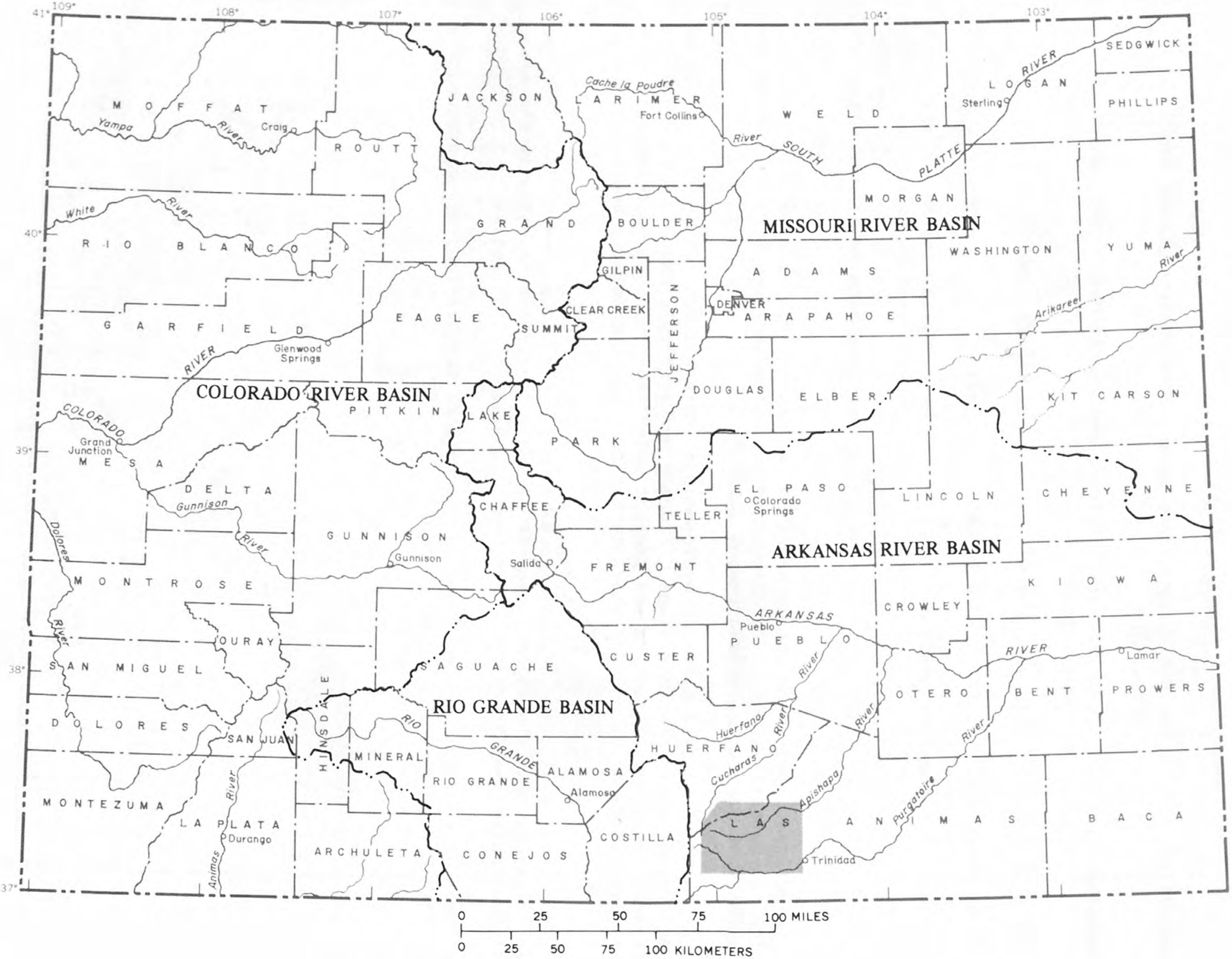

Figure 24.--Location of Raton Mesa.

PROJECT TITLE: Monitoring of the Hydrologic System of Raton Mesa (fig. 24)

COOPERATING AGENCY: None

PROJECT CHIEF: Alan P. Hall, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Proposed expansion of coal mining in the Raton Mesa coal fields may have adverse effects on the hydrologic system in the area. A knowledge of the existing hydrologic system is needed prior to the expansion of coal mining so that the effects of mining can be determined.

Objective.--Determine the hydrologic system of the area; determine the relationships between climatic conditions, surface water, and ground water.

Approach.--Install five surface-water stations; collect streamflow and water-quality data at the stations. Obtain ground-water data from personnel working on the project "Ground-Water Studies in Coal-Mining Areas" (p. 15).

Progress.--Surface-water stations have been installed and data collection has begun. Surface-water ratings and sediment loads have been computed for each station. Data compilation and analyses has begun.

Plans.--Continue data collection. Modify equipment to measure anticipated large streamflows and sediment loads. Prepare hydrologic-data report.

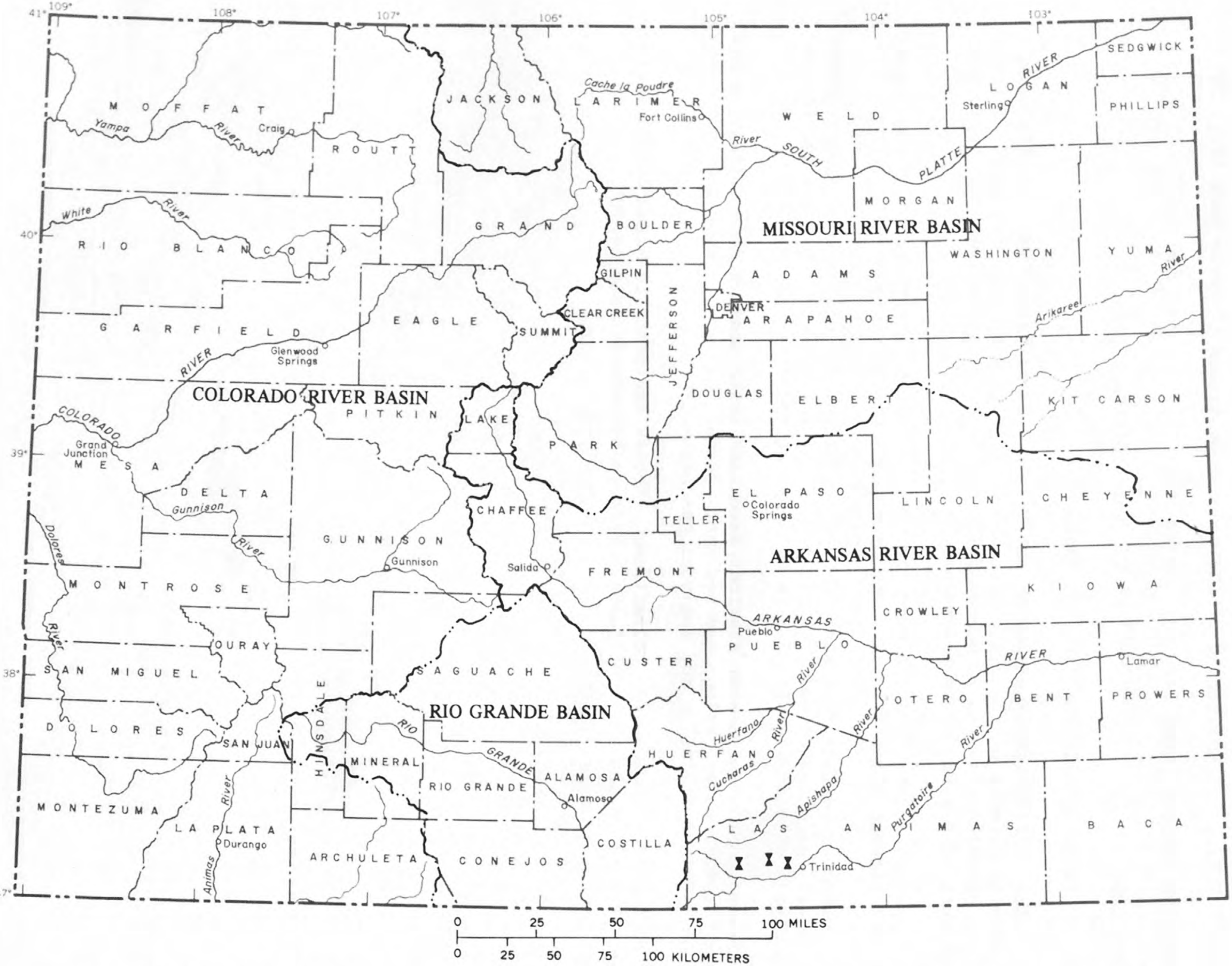

Figure 25.--Location of stations monitoring the hydrologic system in three small basins, Raton Mesa coal fields.

PROJECT TITLE: Intensive Hydrologic Monitoring of Small Basins in the Raton Mesa Coal Fields (fig. 25)

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF: Daniel P. Bauer, District Office, Lakewood

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Because it will not be possible to directly determine the hydrologic system of every area where coal mining will occur and to monitor the effects of coal mining during and after mining, a method of evaluation needs to be developed that can be easily adapted to areas for which detailed studies are not planned.

Objectives.--Determine the hydrologic system in three small unmined basins. Use the data to develop computer models that can be used to predict the effects of mining on the hydrologic system in areas for which detailed studies are not planned.

Approach.--Select three small basins where coal mining may occur within 3 to 5 years and that are representative of other areas where mining may occur. Install climatological stations in two of the basins. Install two surface-water gaging stations equipped with automatic sediment samplers in each basin. Periodically collect samples of streamflow for chemical analysis. Obtain ground-water data from personnel working on the project "Ground-Water Studies in Coal-Mining Areas" (p. 15). Use the data to develop the computer model.

Progress.--All stations have been installed and data collection is continuing. All data collected have been entered into the U.S. Geological Survey's computer storage and retrieval system.

Plans.--Continue data collection and begin development of computer models. Install a monitoring station to determine the impact of a recently completed reservoir.

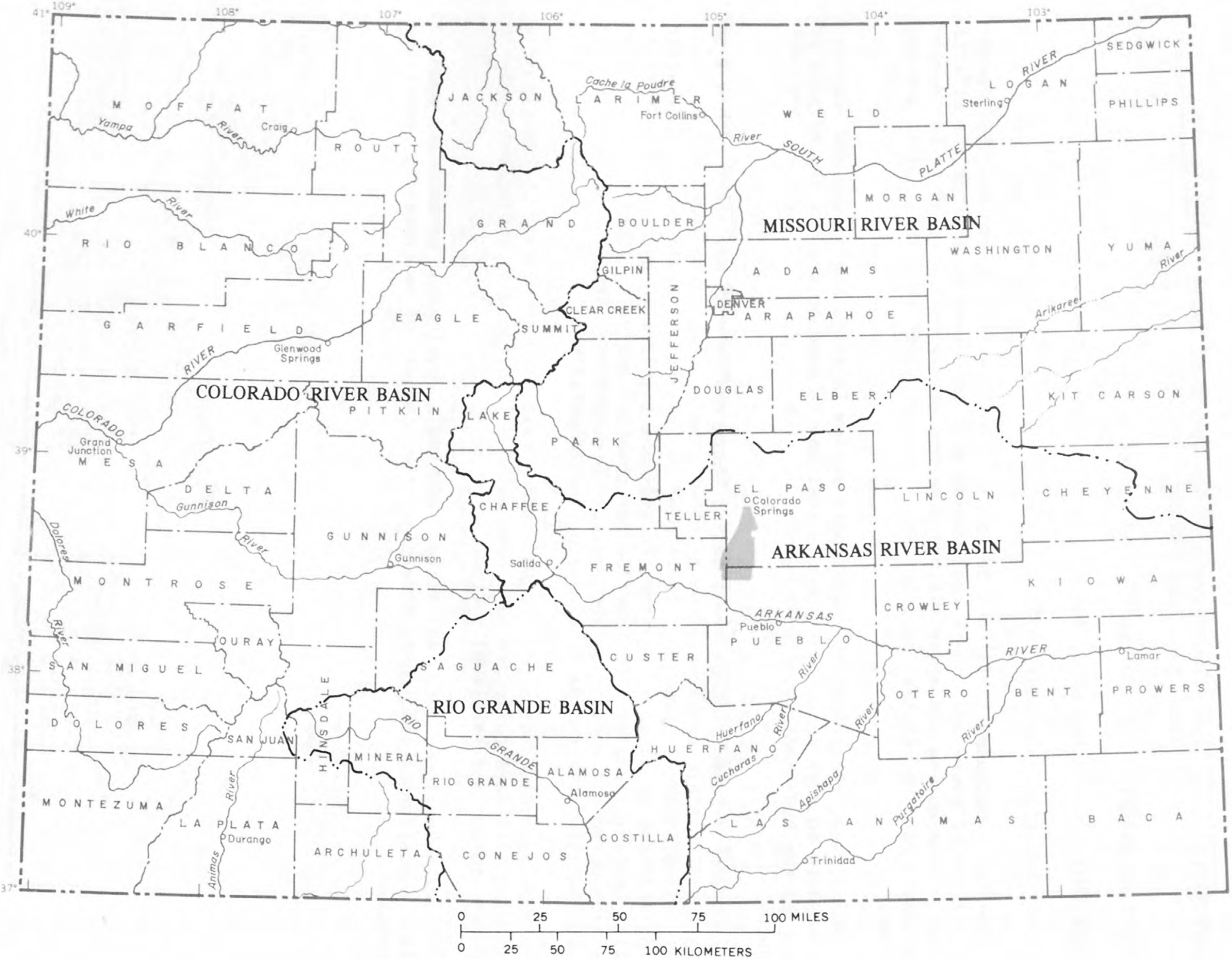

Figure 26.--Location of the Fort Carson Military Reservation.

PROJECT TITLE: Water-Resources Appraisal of the Fort Carson Military Reservation (fig. 26)

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

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1977 to September 1981

Problem.--Knowledge of the water resources of the reservation is limited. Because of the recent drought, the U.S. Army wants to determine the water resources of the reservation so that development and management of the water resources can be achieved.

Objective.--Assess present surface- and ground-water resources on the reservation.

Approach.--Use water-rights records to determine existing water rights of the reservation and those affecting water use on the reservation. Collect surface-water data to determine annual streamflow onto and out from the reservation, seasonal variations in quantity and water quality of streamflow, and seasonal variations in storage and water quality of existing reservoirs. Collect ground-water data from existing wells to determine the extent of alluvial and bedrock aquifers, areas of recharge to and discharge from the aquifers, yield characteristics, and seasonal variations in water quality. Use the data to determine areas of potential development of the water resources.

Progress.--Water rights have been tabulated. Twenty streamflow-gaging stations have been installed and data collection has begun; samples for water-quality analysis routinely collected at nine stations. About 105 wells have been inventoried; water levels measured in 40 wells. Continuous water-level recorders installed at three wells. About 20 samples for water-quality analysis collected from wells.

Plans.--Continue data collection at present sites. Install two additional streamflow-gaging stations. Collect samples for water-quality analysis from 20 additional wells. Interpret data and prepare report.

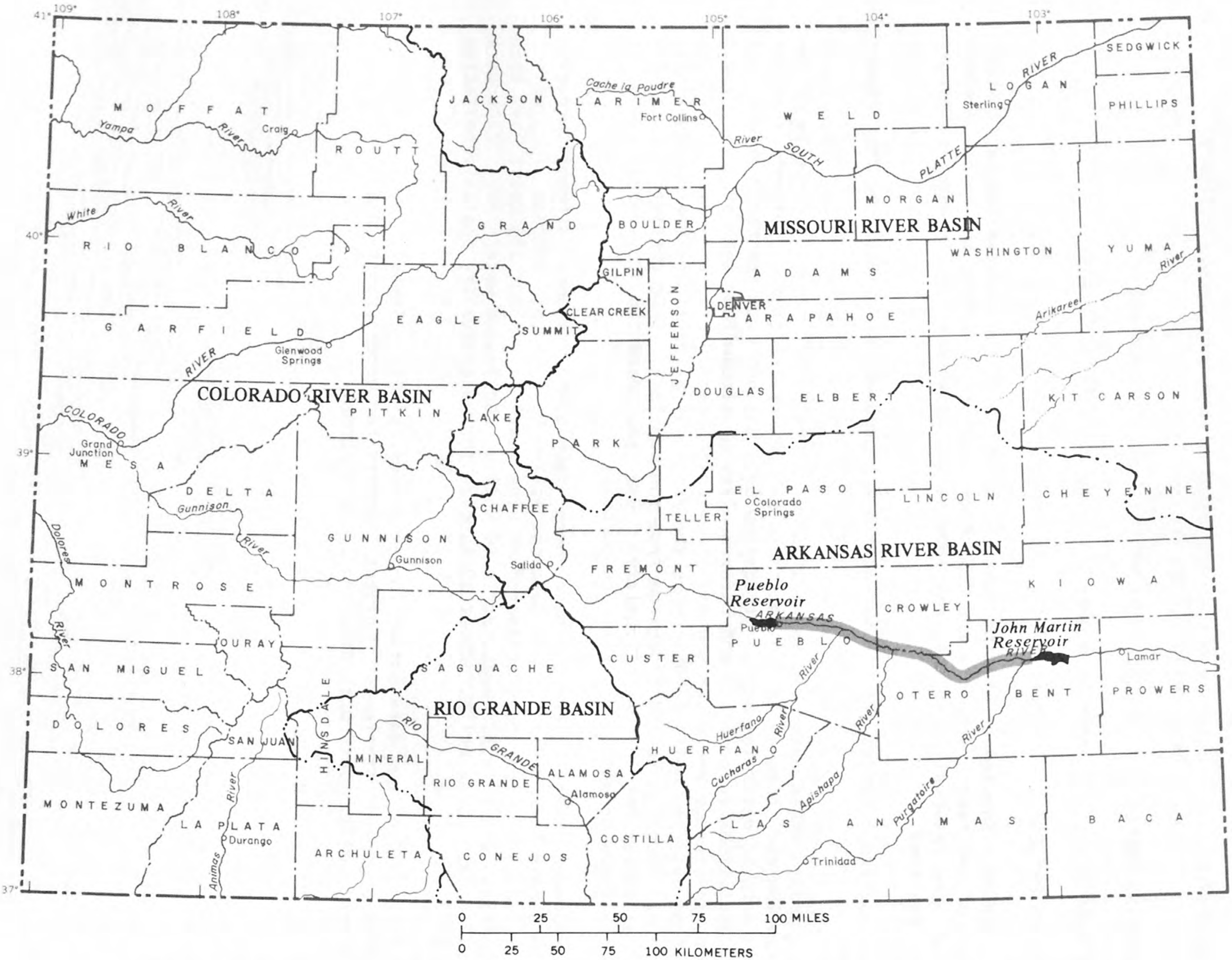

Figure 27.--Location of the reach of the Arkansas River between Pueblo and John Martin Reservoirs.

PROJECT TITLE: Travel Time and Transit Losses of Reservoir Releases, Arkansas River from Pueblo Reservoir to John Martin Reservoir (fig. 27)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since July 1974

Problem.--Optimum management of reservoir releases includes delivery of water to downstream users at specified times and identification of water loss in transit. A knowledge of the time required for reservoir releases to reach diversion points and the loss of water during transit is needed by local officials for the management of the reservoir system in the lower Arkansas River basin.

Objectives.--Develop and calibrate a computer model that can: Predict the time required for reservoir releases to reach downstream diversion points, predict the volume of water lost during transit, and be used by appropriate officials to develop management plans that will optimize deliveries and identify transit losses.

Approach.--Collect and analyze all existing streamflow data for the study reach of the river. Use the data to modify and calibrate an existing computer model developed for the Arkansas River upstream from Pueblo Reservoir. Collect field data needed for calibration of the model during an actual release from Pueblo Reservoir if calibration cannot be achieved using existing data.

Progress.--The existing computer model has been modified and calibrated to reflect the hydrologic regime of the study reach of the Arkansas River. It was necessary to collect field data to calibrate the model during an actual release from Pueblo Reservoir. Results of the first test release have been published. Additional data collected and analyzed following a release of 600 acre-feet from Pueblo Reservoir; data used to verify transit losses.

Plans.--Collect streamflow and diversion data during additional test releases or other suitable reservoir release for purposes of refining the predictive capability of the model. Determine feasibility and benefits of a similar study between John Martin Reservoir and Garden City, Kan.

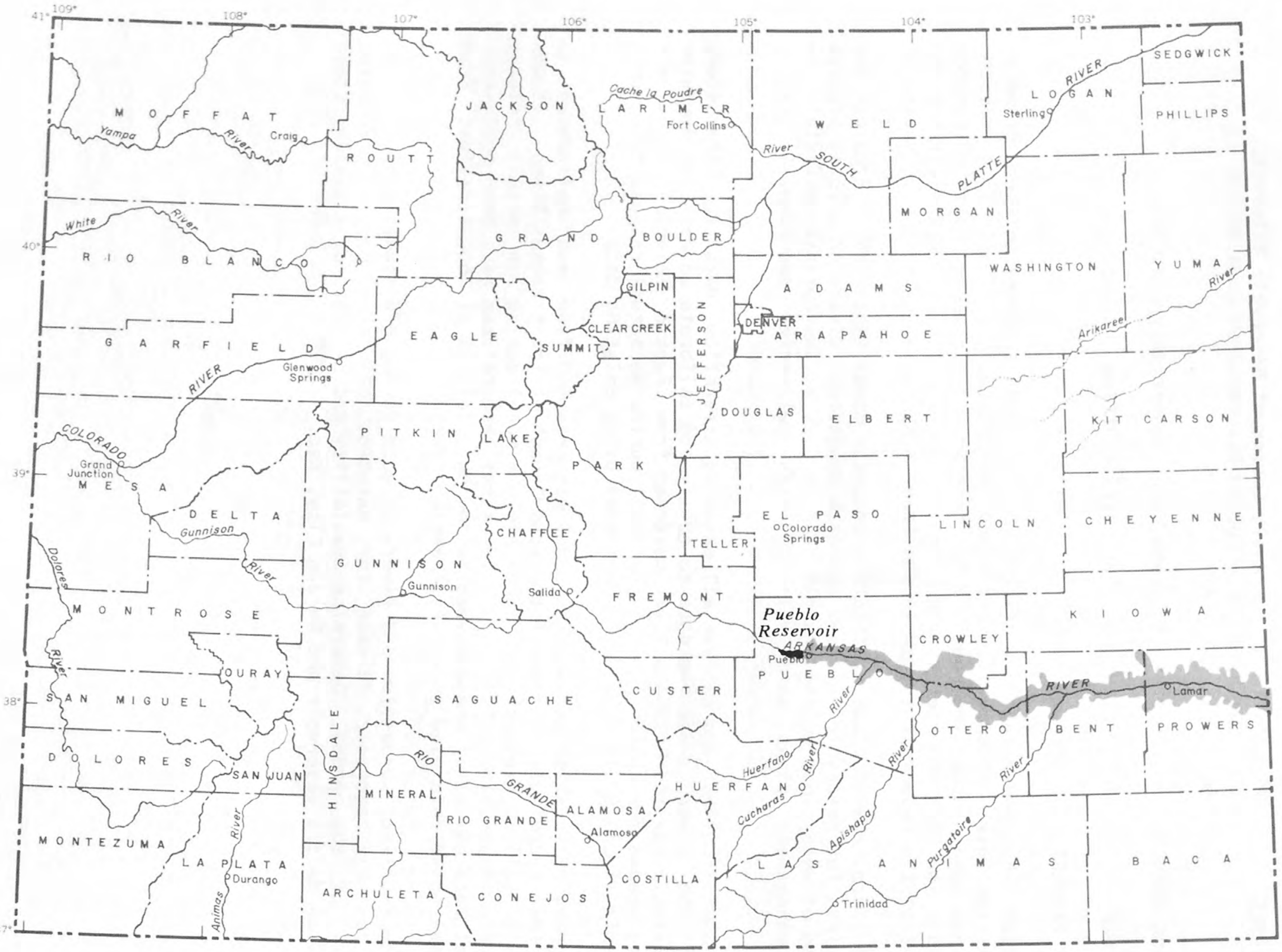

Figure 28.-- Location of the Arkansas River valley downstream from Pueblo Reservoir.

PROJECT TITLE: Hydrology of the Arkansas River Valley, Pueblo Reservoir to Colorado-Kansas State Boundary (fig. 28)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since July 1961

Problem.--The Arkansas River valley in Colorado, an area of intensive water use, has a variety of water problems. Snowmelt from the mountains provides most of the streamflow. Streamflow is supplemented by water from summer thundershowers and from transmountain diversions. Most of the water inflow occurs upstream from Canon City, but most of the use is downstream from Pueblo. Water in the Arkansas River is overappropriated and the distribution of water in time and space needs to be known to benefit water users in the valley. Computer models of the valley are needed so that alternative water-management plans involving conjunctive use of surface and ground water can be evaluated.

Objectives.--Collect and analyze hydrologic data needed to define the hydrologic system and to develop and calibrate computer models to be used for planning and administering water use.

Approach.--Provide a continuing inventory of both surface- and ground-water use. Collect data on the natural variations of water availability. Develop and calibrate computer models that will simulate the hydrologic system.

Progress.--The hydrology of the Arkansas River valley has been described and a water-management model of the Arkansas River aquifer system has been developed. Reports have been published on all phases of the study. Water-level data are collected from about 700 wells in the valley. Continued operation of satellite equipment at the Avondale streamflow-gaging station. Streamflow data from numerous sites have been collected and analyzed.

Plans.--Continue collecting surface-water, ground-water, and water-quality data for investigative activities.

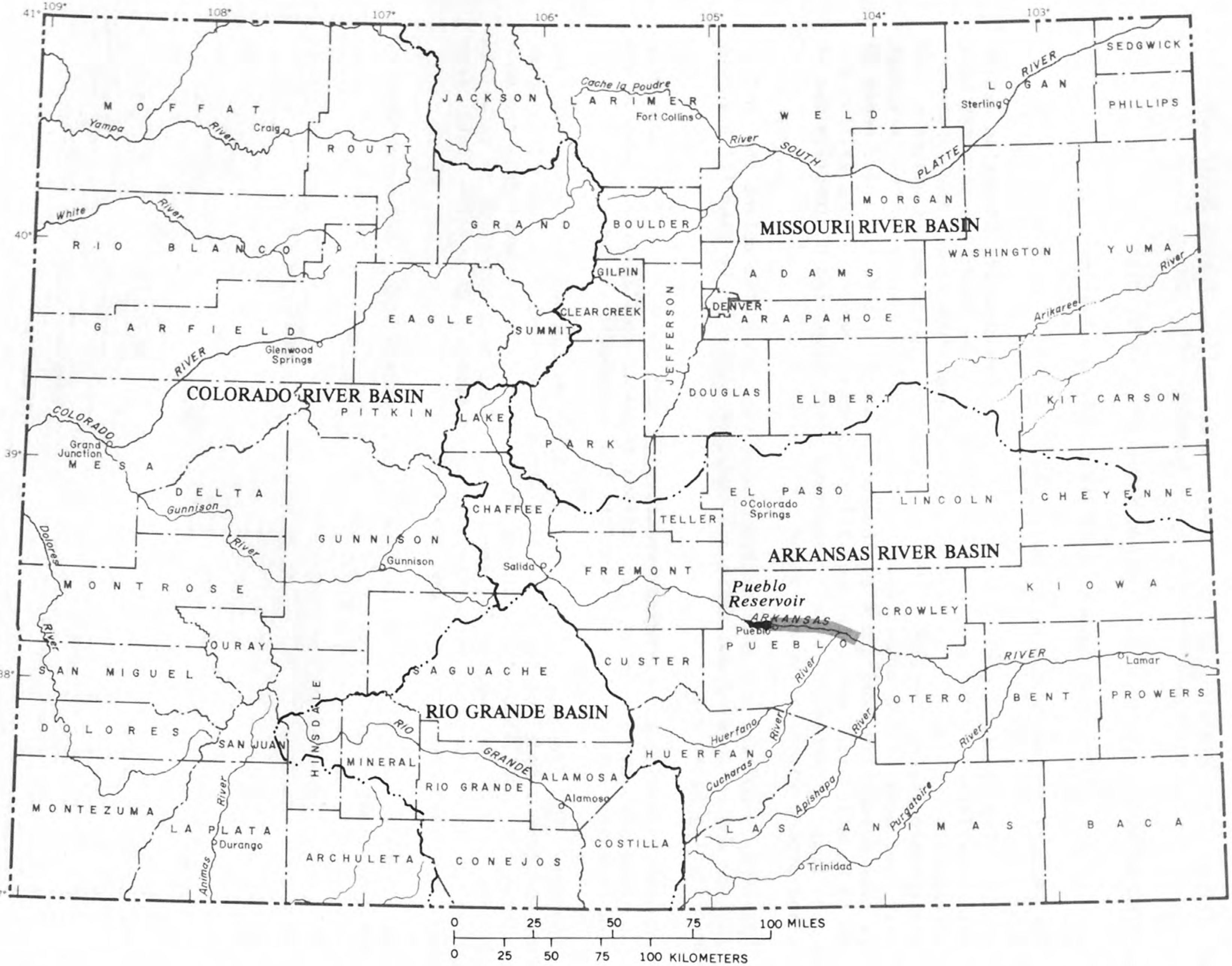

Figure 29.--Location of the reach of the Arkansas River in Pueblo County for which waste-assimilative capacity is being determined.

PROJECT TITLE: Waste-Assimilative Capacity of the Arkansas River in Pueblo County (fig. 29)

COOPERATING AGENCY: Pueblo Area Council of Governments

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since August 1976

Problem.--In order to comply with Section 208 of Public Law 92-500, the Pueblo Area Council of Governments needs to develop and implement water-pollution controls to meet the goal of making streams suitable for body-contact recreation and fish propagation by 1983. The Pueblo Area Council of Governments needs a predictive tool to evaluate the effects of proposed management alternatives on water quality of the Arkansas River in Pueblo County.

Objectives.--Calibrate and verify a steady-state water-quality model for a 42-mile reach of the Arkansas River between Pueblo Dam and the streamflow-gaging station at Nepesta. The model will be used by the Pueblo Area Council of Governments to predict the effects of proposed management alternatives. Determine the area and extent of waste mixing downstream from point sources of waste discharges.

Approach.--Calibrate and verify an existing U.S. Geological Survey model to conditions in the Arkansas River so that the model can predict concentrations of dissolved oxygen, biochemical oxygen demand, nitrogen and phosphorus species, and coliform bacteria. Calibrate and verify the model using data collected during high- and low-flow periods. Establish a water-quality monitoring network.

Progress.--Sufficient data have been collected to calibrate and test the model. A time-of-travel survey has been completed. The quantity and quality of discharge from ephemeral tributaries have been evaluated. A report on the calibration phase of the model has been prepared and is being reviewed.

Plans.--Complete report on calibration phase of the model. Verify the model. Identify the extent of mixing zones downstream from point sources of waste discharges.

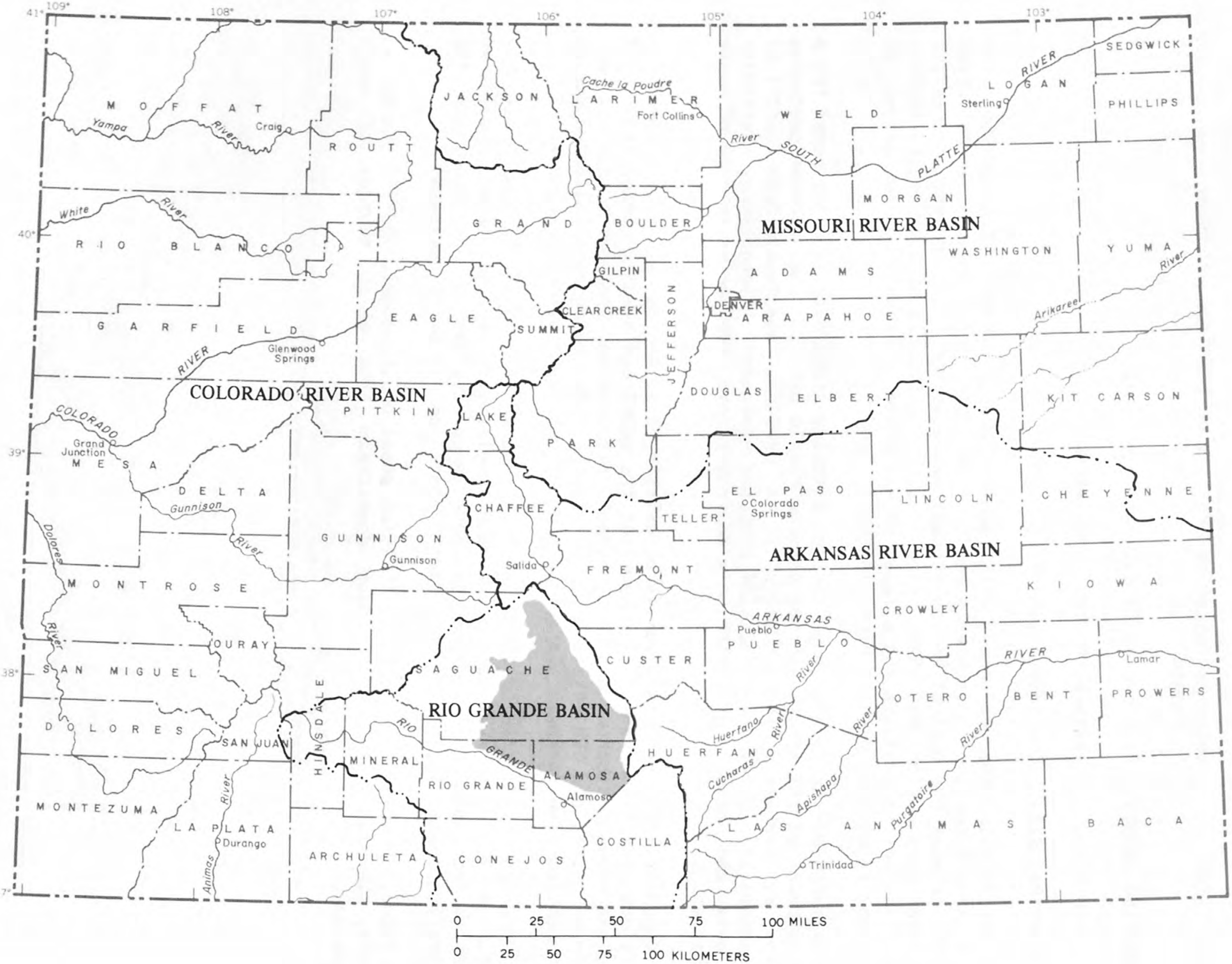

Figure 30.--Location of the closed-basin part of the San Luis Valley.

PROJECT TITLE: Hydrology of the Closed-Basin Part of the San Luis Valley in Colorado (fig. 30)

COOPERATING AGENCY: U.S. Water and Power Resources Service

PROJECT CHIEF: Guy J. Leonard, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since July 1976

Problem.--Extensive long-term application of water for irrigation has resulted in waterlogging and the accumulation of salts on and near the land surface in many areas of the closed-basin part of the San Luis Valley. Pumping ground water from a series of wells would lower the water table in the closed basin, reduce evaporation losses, and supplement the flow in the Rio Grande. The feasibility of salvaging ground water without adversely affecting the ground-water system in the closed basin and the water quality of the Rio Grande needs to be determined.

Objectives.--Determine the feasibility of salvaging ground water by pumpage from wells. Determine the quality of water pumped from the wells that would be discharged into the Rio Grande. Develop and calibrate flow and chemical-transport computer models of the closed basin.

Approach.--Select areas for installation of wells. Drill test wells in the areas selected. Conduct aquifer tests and geophysical surveys of the test wells. Obtain water samples for chemical analysis from the test wells. Convert suitable test wells to salvage wells. Use the existing electric analog model and existing water-level and water-quality data to develop the computer models. Use existing data and data from the test-well drilling program to calibrate the computer models.

Progress.--Collection of ground-water data continues. Water levels in about 450 wells are being measured monthly or annually; eight wells have been equipped with continuous water-level recorders and pressure gages. Two-dimensional computer model has been completed. Conversion of electric analog model to a three-dimensional computer model continues.

Plans.--Install five additional continuous water-level recorders. Continue and expand observation-well network. Make thermal profiles in selected wells to evaluate leakage in the confined zone and use data in two-dimensional computer model for well-field (salvage wells) design. Collect samples for water-quality analysis. Complete conversion of electric analog model to a three-dimensional computer model and prepare report documenting the procedure.

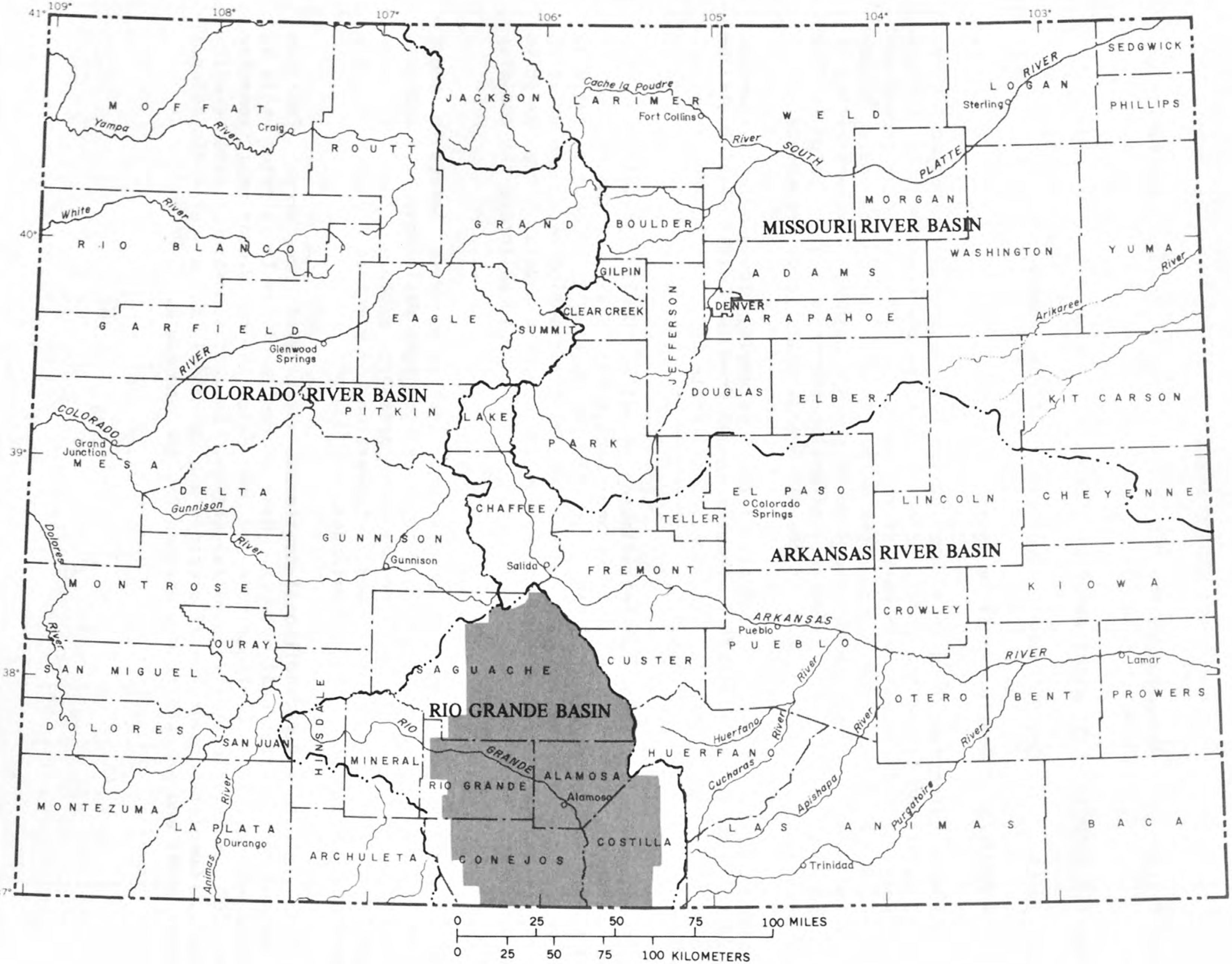

Figure 31.--Location of the San Luis Valley.

PROJECT TITLE: Water Resources of the San Luis Valley in Colorado (fig. 31)

COOPERATING AGENCIES: Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer; and the Rio Grande Water Conservation District

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since July 1966

Problem.--The San Luis Valley in Colorado is an area of intensive water use. Water problems include increasing competition for existing surface- and ground-water supplies and an alleged deficit in the amount of surface water to be delivered to downstream users in New Mexico and Texas, in accordance with the Rio Grande Compact. A knowledge of the hydrologic system of the valley is needed to determine the quantity and quality of the water resources and to provide State and local officials with data that they can use to effectively manage the water resources.

Objectives.--Quantitatively define the hydrologic system.

Approach.--Compile existing data and collect additional data to define the hydrologic system. Make a comprehensive inventory of wells and pumpage. Determine stream discharge. Define the areal extent, thickness, and hydrologic properties of the unconfined and confined aquifers. Determine the hydrologic relation between the aquifers.

Progress.--Sufficient data have been collected to define most of the hydrologic system. Data collection is continuing to complete the definition of the hydrologic system and to provide data for use in the computer models of the valley and the closed-basin part of the valley.

Plans.--Continue data collection.

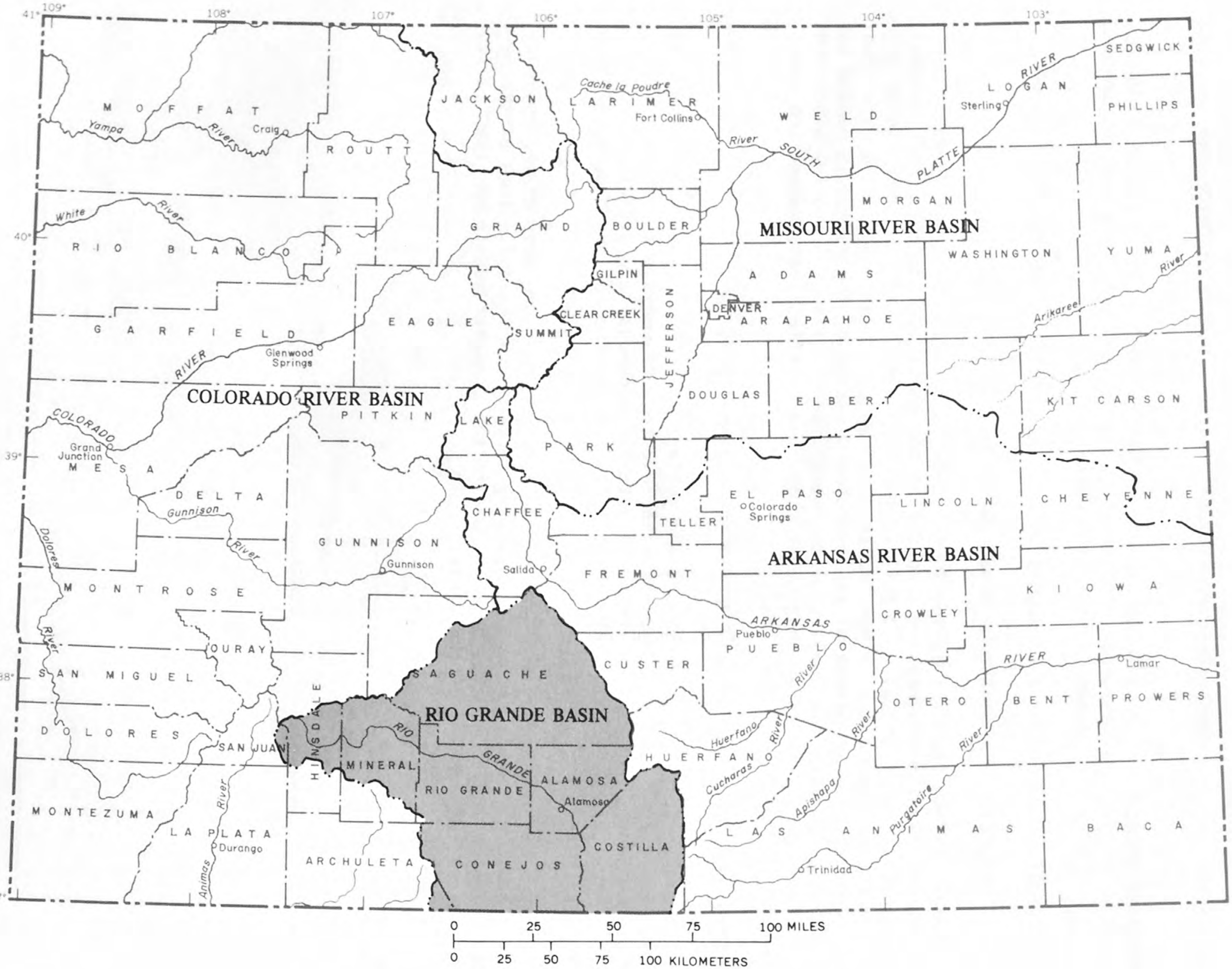

Figure 32.--Location of the Upper Rio Grande basin.

PROJECT TITLE: Hydrology of the Southwest Alluvial Valleys Regional Aquifer System--Upper Rio Grande Basin (fig. 32)

COOPERATING AGENCY: None

PROJECT CHIEF: Thomas M. Crouch, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Rapid population increases and consequent greater use of water resources is occurring in the "Sunbelt" States of the southwest. To augment surface-water supplies, ground water from alluvial fill in desert basins is being developed. This development has resulted in continued water-level declines, land subsidence, depletion of streamflow, and water-quality changes.

Objectives.--Define the hydrology of the alluvial-aquifer systems in the Upper Rio Grande basin as part of the analysis of the regional aquifer system. Determine the extent, hydraulic properties, water quality, and recharge to and discharge from the aquifers. Determine the relationship between ground and surface water. Describe the flow system in the area and the response of the system to ground-water development.

Approach.--Develop a predictive digital model of the entire Upper Rio Grande basin using existing models for the San Luis Valley as a base. The expanded model will include the Sunshine Valley in New Mexico.

Progress.--Completed 19 miles of seismic surveys in southern San Luis Valley and northern Sunshine Valley. Collation of existing data and conversion of existing models has begun.

Plans.--Complete seismic surveys and analyze data. Complete model conversion. Use hydrologic data collected since 1969 to verify model.

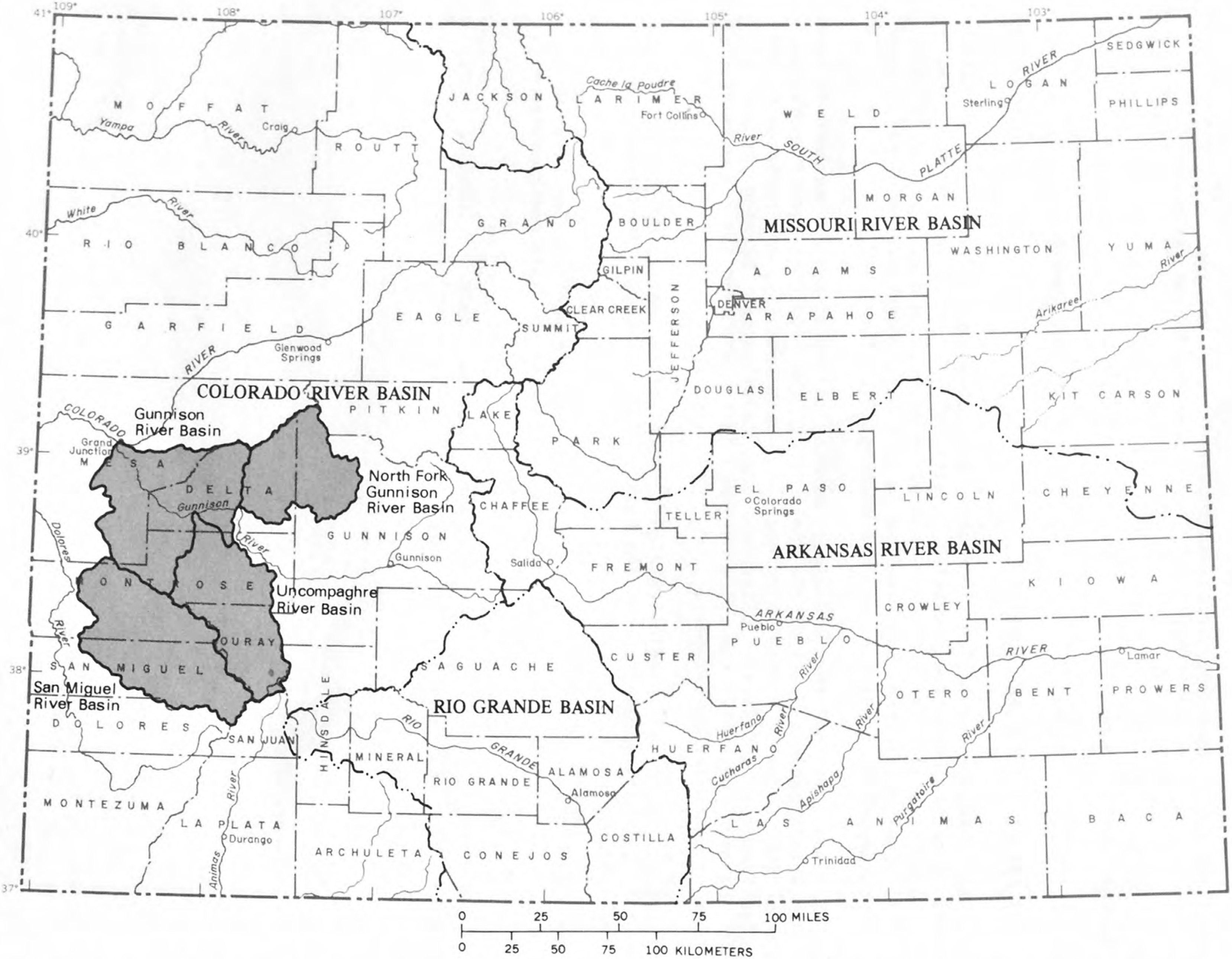

Figure 33.--Location of the Gunnison River, North Fork Gunnison River, San Miguel River, and the Uncompaghre River basin.

PROJECT TITLE: Evaluation of Aquifers, Western Colorado (fig. 33)

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

PROJECT CHIEF: Daniel J. Ackerman, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: Continuous since October 1974

Problem.--The use of ground water to meet residential, commercial, industrial, recreational, and agricultural needs in western Colorado is increasing because most existing surface-water supplies have been appropriated. To manage the development of the ground-water resources, State and local officials need to know the location and areal extent of the aquifers and the quantity and quality of water found in the aquifers.

Objectives.--Locate and determine the areal extent of aquifers. Determine the quantity and quality of water found in the aquifers.

Approach.--Compile existing geologic and hydrologic data. Determine areas where data collection is needed to establish the geohydrologic characteristics of selected aquifers. Collect and analyze the data required to meet the objectives.

Progress.--Reports describing four areas have been published. One report is in final preparation for publication. Reports for the North Fork Gunnison River and the San Miguel River basins are being prepared. Data collection has begun in the Gunnison River and Uncompahgre River basins.

Plans.--Complete reports in preparation. Continue data collection.

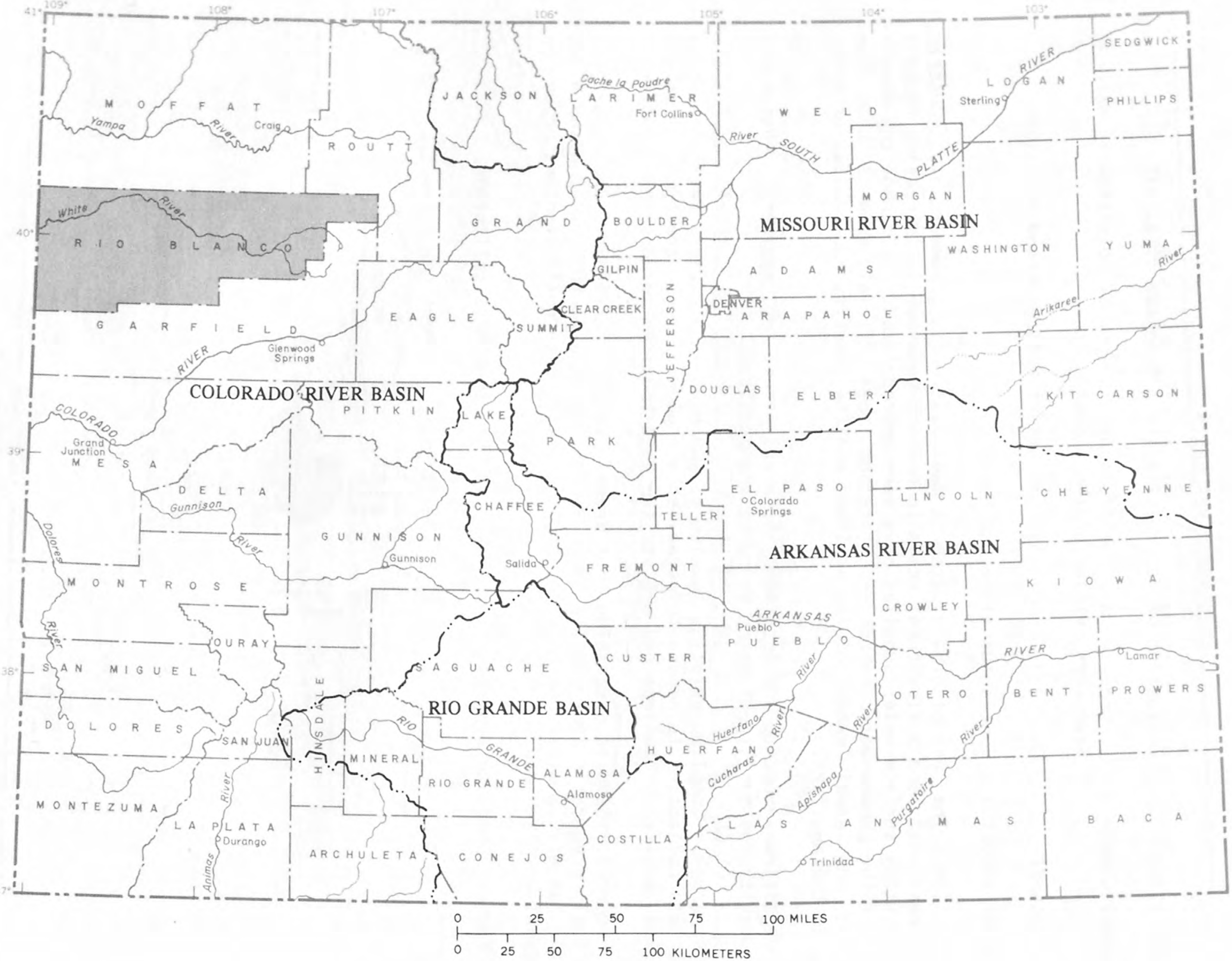

Figure 34.--Location of Rio Blanco County.

PROJECT TITLE: Ground-Water Resources of Rio Blanco County (fig. 34)

COOPERATING AGENCY: White River Soil Conservation District

PROJECT CHIEF: Frank A. Welder, Subdistrict Office, Meeker

PERIOD OF PROJECT: October 1977 to September 1980

Problem.--Development of energy resources in Rio Blanco County will require large quantities of ground water. Little is known about the ground-water resources in the county at the present time. State and local officials need to know the extent of the ground-water resources so they can effectively manage them.

Objective.--Determine the ground-water resources of the county.

Approach.--Collect and evaluate historic ground-water data. Collect new ground-water data to determine the number and areal extent of aquifers in the county and to determine the volume and quality of water in the aquifers.

Progress.--Evaluation of historic data has been completed. Data collection continues, 140 wells and springs have been inventoried.

Plans.--Continue data collection and prepare a hydrologic-data report.

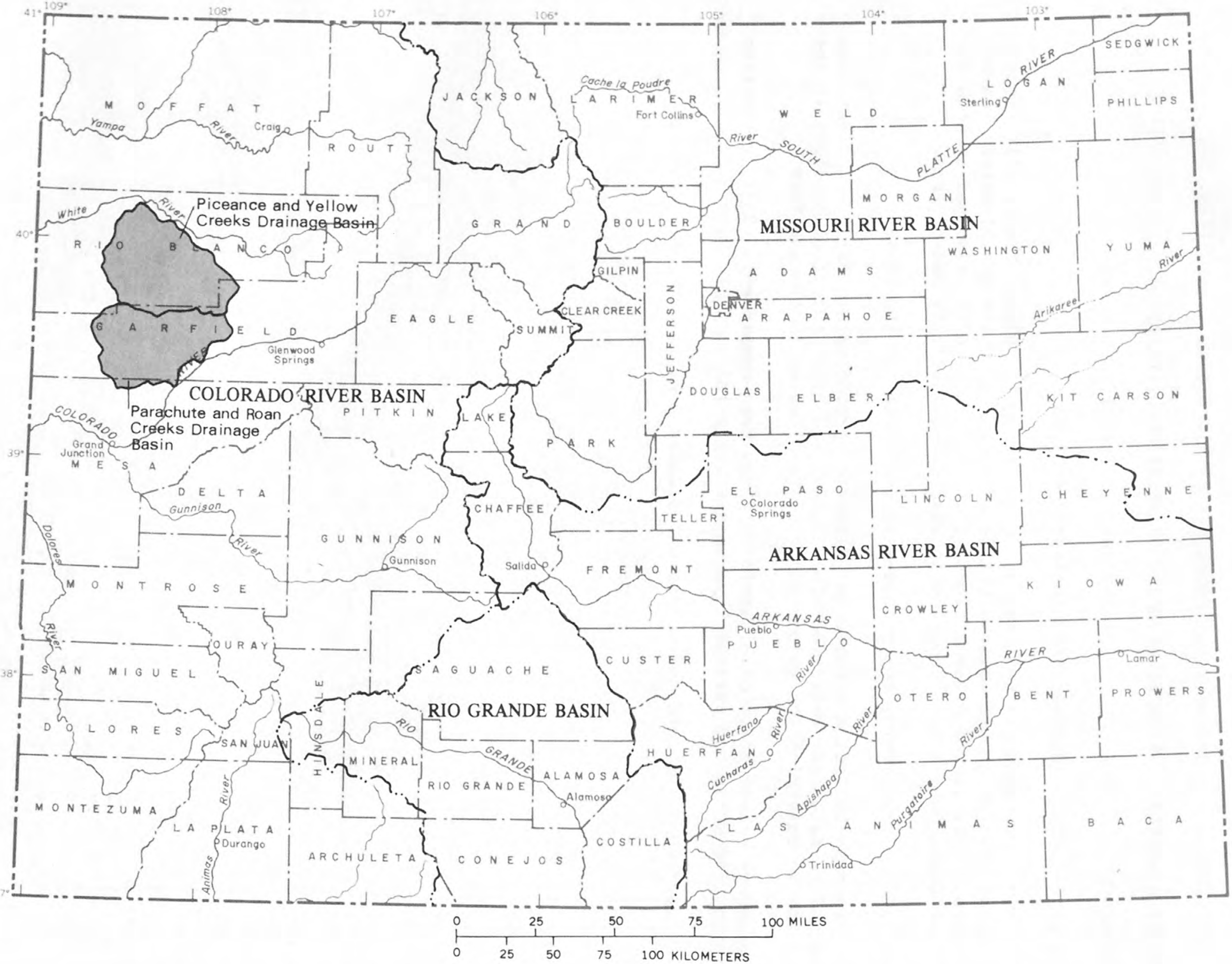

Figure 35.--Location of Piceance and Yellow Creeks and Parachute and Roan Creeks drainage basins.

PROJECT TITLE: Hydraulic Research of Springs, Piceance Creek and Yellow Creek Drainage Basins (fig. 35)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: Continuous since July 1974

Problem.--Aquifer dewatering resulting from oil-shale mining will reduce ground-water discharge to many springs that are used as a water supply for livestock and irrigation. Water quality also may be affected by aquifer dewatering. The geologic source, water quality, and hydraulics of the springs need to be known prior to the beginning of oil-shale mining so that the effects of aquifer dewatering on the springs can be determined.

Objectives.--Locate and determine the geologic source of major springs, determine their water quality and flow characteristics, and determine the effects of aquifer dewatering on water quality and discharge.

Approach.--Use infrared aerial photography and thermal imagery to locate the springs. Use concentrations of dissolved fluoride and chloride and water temperature to aid in determining the geologic source of the springs. Install flumes at about 90 springs to measure discharge.

Progress.--All springs have been located and field checked. A grant was awarded to the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, for the purpose of collecting water-quality samples and discharge measurements. Water-quality and discharge data have been collected from about 100 springs. Discharge, water temperature, and specific conductance have been measured monthly. Weekly monitoring of 10 springs near Lease Tract C-a was continued and weekly monitoring of 8 springs near Lease Tract C-b began in July 1979 after dewatering operations started on Lease Tract C-b. Report describing hydrology of springs and water rights being prepared by contractor. Report describing geologic sources of springs being prepared by U.S. Geological Survey.

Plans.--Complete reports. Plan for continued collection of water-quality and discharge data throughout the prototype phase of oil-shale development.

PROJECT TITLE: Observation-Well Drilling and Potentiometric-Surface Mapping, Piceance Creek and Yellow Creek Drainage Basins (fig. 35)

COOPERATING AGENCY: None

PROJECT CHIEF: Frank A. Welder, Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1982

Problem.--Aquifer dewatering resulting from oil-shale mining will alter the existing steady-state conditions of the ground-water system. The existing steady-state conditions need to be known prior to the beginning of oil-shale mining so the effects of aquifer dewatering on the ground-water system can be determined.

Objectives.--Determine the predevelopment potentiometric surfaces for the two bedrock aquifers in the basin. Use the data to improve the predictive capability of the existing computer model of the ground-water system.

Approach.--Drill 22 observation wells and convert existing core holes to observation wells to supplement the existing observation-well network. Complete 12 of the new observation wells in each of the aquifers. Collect water-quality and discharge data from each well during drilling. Determine geophysical characteristics of each well after drilling is completed. Install continuous water-level recorders on seven existing observation wells. Measure water levels periodically in all observation wells. Construct a potentiometric-surface map for each aquifer. Use the data to improve the calibration of the computer model.

Progress.--A drilling contract was awarded to a private firm; 25,092 feet were drilled. Water-temperature and specific-conductance data, water samples for chemical analysis, and discharge-rate measurements have been collected during the drilling. Geophysical logging has been completed. Water levels have been measured in 76 wells twice a year. Continuous water-level recorders have been installed in two wells on Lease Tract C-b. Water levels have been measured monthly in seven wells on and near Lease Tract C-a. A network of observation wells has been established on and near Lease Tract C-b; water levels have been measured monthly by lessee personnel.

Plans.--Plan for continued collection of water-level data throughout the prototype phase of oil-shale development.

PROJECT TITLE: Aquifer Testing, Piceance Creek and Yellow Creek Drainage Basins (fig. 35)

COOPERATING AGENCY: None

PROJECT CHIEF: Frank A. Welder, Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1982

Problem.--The effects of aquifer dewatering resulting from oil-shale mining can be predicted using a computer model. However, the accuracy of the model depends on the definition of the transmissive and storage properties of the two aquifers and of the vertical-hydraulic conductivity of the confining layer that separates the aquifers. Existing data are inadequate to reliably define the regional variations in aquifer properties. The vertical-hydraulic conductivity of the confining layer has been only estimated.

Objectives.--Determine the regional variations in aquifer properties and the vertical-hydraulic conductivity of the confining layer. Use the data to improve the predictive capability of the existing computer model.

Approach.--Select aquifer-test sites based on the data obtained from the observation-well drilling and potentiometric-surface mapping project. Drill one test hole for use as the production well at each site. The test holes will penetrate both aquifers and the confining layer. Use the observation wells mentioned above for the aquifer tests. Conduct the aquifer tests. Use the data to improve the calibration of the computer model.

Progress.--Based upon the results of three aquifer tests made by the U.S. Geological Survey and aquifer tests made by lessees of the oil-shale tracts, it was determined that leaky-aquifer tests cannot provide conclusive results within reasonable testing time and cost. Therefore, no additional leaky-aquifer tests were completed. Contracts were awarded to private firms to rehabilitate existing wells to prevent flow between aquifers in the well bores; the contracts have been completed. Six single-well aquifer tests have been completed. Three wells in the southern part of the area have been reconditioned to provide access to both the upper and lower aquifers.

Plans.--Conduct single-well aquifer tests at 18 sites. Drill two new observation wells for the purpose of conducting multiwell aquifer tests.

PROJECT TITLE: Geochemical Investigation, Piceance Creek and Yellow Creek Drainage Basins (fig. 35)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1974 to September 1981

Problem.--Aquifer dewatering resulting from oil-shale mining will induce recharge to the two bedrock aquifers and change existing flow patterns within the aquifers. The existing chemical equilibrium may be altered resulting in the solution of minerals and increased dissolved-solids concentrations. Presently, the dissolved-solids concentrations range from a few hundred to more than 60,000 milligrams per liter. The discharge of the very saline water into springs and streams could result in a serious pollution problem. The existing chemical equilibrium needs to be known prior to the beginning of oil-shale so that the effects of aquifer dewatering on the chemical equilibrium can be determined.

Objectives.--Determine the present water quality in the aquifers. Develop a solute-transport computer model that can be coupled with the existing ground-water-flow computer model to predict the effects of aquifer dewatering on water quality.

Approach.--Collect samples for chemical analysis from wells and springs. Develop a three-dimensional solute-transport model that will be able to predict water-quality changes both within and between the aquifers. Use the water-quality data collected from wells and springs to calibrate the model.

Progress.--Collection of water-quality data has been completed. In conjunction with the activities of the aquifer-testing project, 11 water samples were collected and analyzed to better define the chemistry of ground water at sites where samples previously were collected under adverse drilling conditions during 1975-76. Development of the solute-transport model has been completed. A report describing the results of the study has been approved for publication.

Plans.--Publish report. Establish a data-collection network to obtain additional data to refine the predictive capability of the model, to monitor water quality, and to assist the activities of the aquifer-testing project.

PROJECT TITLE: Sediment Yield of Streams, Piceance Creek and Yellow Creek Drainage Basins (fig. 35)

COOPERATING AGENCY: None

PROJECT CHIEF: Vernon W. Norman, Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1982

Problem.--Prototype oil-shale development will involve the mining, processing, and disposal of an estimated 150,000 tons of oil shale per day. Handling and disposal of this quantity of material may increase the sediment load in streams. Increases in sediment load alters channel geometry and morphology and reduces the conveyance capacity of streams. The existing sediment load of streams needs to be known prior to the beginning of oil-shale mining so that the effects of the mining on sediment load of streams can be determined.

Objectives.--Determine the present sediment load of streams draining the basin. Determine the erosion potential of the lands that are to be mined.

Approach.--Install automatic suspended-sediment samplers and automatic turbidity monitors on streams. Maintain and monitor channel cross sections and hillslope-erosion transects established during a previous project.

Progress.--Twenty-seven automatic suspended-sediment samplers and two automatic turbidity monitors have been installed. Fifty-two channel cross sections and 35 hillslope-erosion transects have been resurveyed periodically. Monitoring of sediment movement on hillslopes, into reservoirs and stream channels, and suspended in streamflow was continued. Effects of mine dewatering on Lease Tracts C-a and C-b on sediment processes are being monitored.

Plans.--Plan for continued collection of sediment data throughout the prototype phase of oil-shale development. Begin data analysis and report preparation.

PROJECT TITLE: Occurrence of Benthic Invertebrates, Piceance Creek Drainage Basin (fig. 35)

COOPERATING AGENCY: None

PROJECT CHIEF: Kenneth J. Covay, Subdistrict Office, Meeker

PERIOD OF PROJECT: October 1976 to September 1982

Problem.--Oil-shale mining may adversely affect the water quality in Piceance Creek. Because of their sensitivity to slight changes in water quality, benthic invertebrates can be used to determine the effects of mining on the water quality of the creek. However, it is necessary to know the types and numbers of benthic invertebrates living in the creek prior to the beginning of mining before they can be used as an indicator of changes in water quality.

Objectives.--Determine the types and numbers of benthic invertebrates living in the creek. Relate the populations of benthic invertebrates to the physical and chemical properties of the water. Determine which physical and chemical properties of the water are limiting factors for the various populations. Determine the influence of habitat on populations. After collection and removal of benthic invertebrates, determine the rate of recolonization at the collection sites.

Approach.--Collect benthic invertebrates at six sites on a monthly basis, four sites on Piceance Creek and two sites on tributaries. Use a Surber sampler when possible; otherwise use a hand-operated Eckman dredge. Install 2 to 5 artificial substrates at each site. Identify populations to the species level.

Progress.--Artificial substrates have been installed at all the sites. Benthic invertebrates are being collected at all sites. A reference collection has been started that contains representatives of all organisms collected.

Plans.--Continue data collection and reference collection. Begin data analysis and report preparation.

PROJECT TITLE: Computer Model Study, Parachute Creek and Roan Creek Drainage Basins (fig. 35)

COOPERATING AGENCIES: Colorado River Water Conservation District and the U.S. Department of Energy

PROJECT CHIEF: Ralph O. Patt, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: August 1977 to September 1980

Problem.--The effects of potential oil-shale development on the ground-water system need to be determined prior to the beginning of oil-shale mining so that State and local officials can effectively manage the ground-water system.

Objective.--Develop a computer model that can be used to predict the effects of oil-shale mining on the ground-water system.

Approach.--Enlarge the existing computer model of the Piceance Creek and Yellow Creek drainage basins to include the study area. Use data being collected in other studies of the Parachute Creek and Roan Creek drainage basins to develop the new part of the model.

Progress.--Existing computer model was redesigned to improve predictive capability; present model is a five-layer, three-dimensional model and incorporates anisotrophic effects of hydraulic conductivity due to intensive fracturing in the Piceance structural basin.

Plans.--Continue to calibrate model as additional data become available. Make a sensitivity analysis to determine critical hydrologic variables. Use model to simulate combined effects of dewatering by proposed major mines. Prepare summary report.

PROJECT TITLE: Hydrologic Reconnaissance, Parachute Creek and Roan Creek Drainage Basins (fig. 35)

COOPERATING AGENCY: None

PROJECT CHIEF: D. Briane Adams, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: July 1974 to September 1980

Problem.--Parachute Creek and Roan Creek drainage basins are sites of potential oil-shale development on privately owned lands. Previous investigations of the hydrology of the Piceance structural basin have not included an intensive hydrologic appraisal of these drainage basins. Both streams are tributary to the Colorado River, whose water-quality characteristics are of national and international interest. The present hydrologic conditions need to be known prior to the beginning of oil-shale mining so that the effects of the mining on the water quality of the Colorado River can be determined.

Objective.--Determine the present hydrologic conditions in the two basins.

Approach.--Install hydrologic monitoring stations to collect stream-discharge and sediment-yield data. Collect water-quality data from the streams. Locate springs and collect discharge and water-quality data. Contact land owners to determine the types of hydrologic data they are collecting and to obtain permission to establish an observation-well network using their existing wells. Coordinate project activities with the activities of the project that is to determine the hydrologic conditions on the U.S. Naval Oil Shale Reserve No. 1, which is located in the Parachute Creek drainage basin, and with the project that is to develop a computer model of the ground-water system in the Parachute Creek and Roan Creek drainage basins.

Progress.--Eight continuous-record streamflow stations have been installed; four are equipped with automatic suspended-sediment samplers and five are equipped with two-parameter water-quality monitors. Ten streamflow stations are maintained by land owners; records from these stations will be made available to the U.S. Geological Survey. discharge data and samples for water-quality analysis have been collected at 271 springs. An observation-well network has been established; 41 wells have been inventoried. Samples for water-quality analysis have been collected from wells and streams. Two production wells and 10 observation wells have been drilled for use in determining the hydraulic characteristics of the alluvial aquifer along Roan Creek; aquifer test completed. Channel geometry determined at 10 sites; gain-loss studies made. Computer model for entire Piceance structural basin completed; tests of steady-state conditions using available data have been made.

Plans.--Begin data interpretation using ground-water computer model, streamflow and snowmelt computer model for Parachute Creek drainage basin, and SOLMNEQ chemical-equilibrium model. Prepare summary report. Plan for continued collection of hydrologic data throughout the prototype phase of oil-shale development.

PROJECT TITLE: Hydrologic Reconnaissance of the U.S. Naval Oil Shale Reserve No. 1, Parachute Creek Drainage Basin (fig. 35)

COOPERATING AGENCY: U.S. Department of Energy

PROJECT CHIEF: D. L. Collins, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: October 1976 to September 1982

Problem.--The U.S. Naval Oil Shale Reserve No. 1 is a site of potential oil-shale development. Previous investigations of the hydrology of the Piceance structural basin have not included an intensive hydrologic appraisal of the reserve. Streams draining the reserve are tributary to the Colorado River, whose water-quality characteristics are of national and international interest. The present hydrologic conditions of the reserve need to be known prior to the beginning of oil-shale mining so that the effects of the mining on the water quality of the Colorado River can be determined.

Objective.--Determine the present hydrologic conditions of the reserve.

Approach.--Install hydrologic monitoring stations to collect precipitation, stream-discharge, and sediment-yield data. Collect water-quality data from the streams. Locate springs and collect discharge and water-quality data. Drill a minimum of 10 test holes. Collect geologic, discharge, and water-quality data during the drilling of the test holes. After drilling is completed, collect geophysical data from each test hole and conduct one to three aquifer tests in each test hole. Locate existing wells and collect water-level and water-quality data. Coordinate project activities with the activities of the project that is to determine the hydrologic conditions in the Parachute Creek and Roan Creek basins and with the project that is to develop a computer model of the ground-water system in the Parachute and Roan Creek drainage basins.

Progress.--A data-collection network consisting of five streamflow stations, two automatic sediment samplers, two precipitation gages, and one weather station has been established. Seven test wells have been completed. Aquifer tests have been completed on three of the wells.

Plans.--Continue data collection. Begin preparation of a hydrologic-data report.

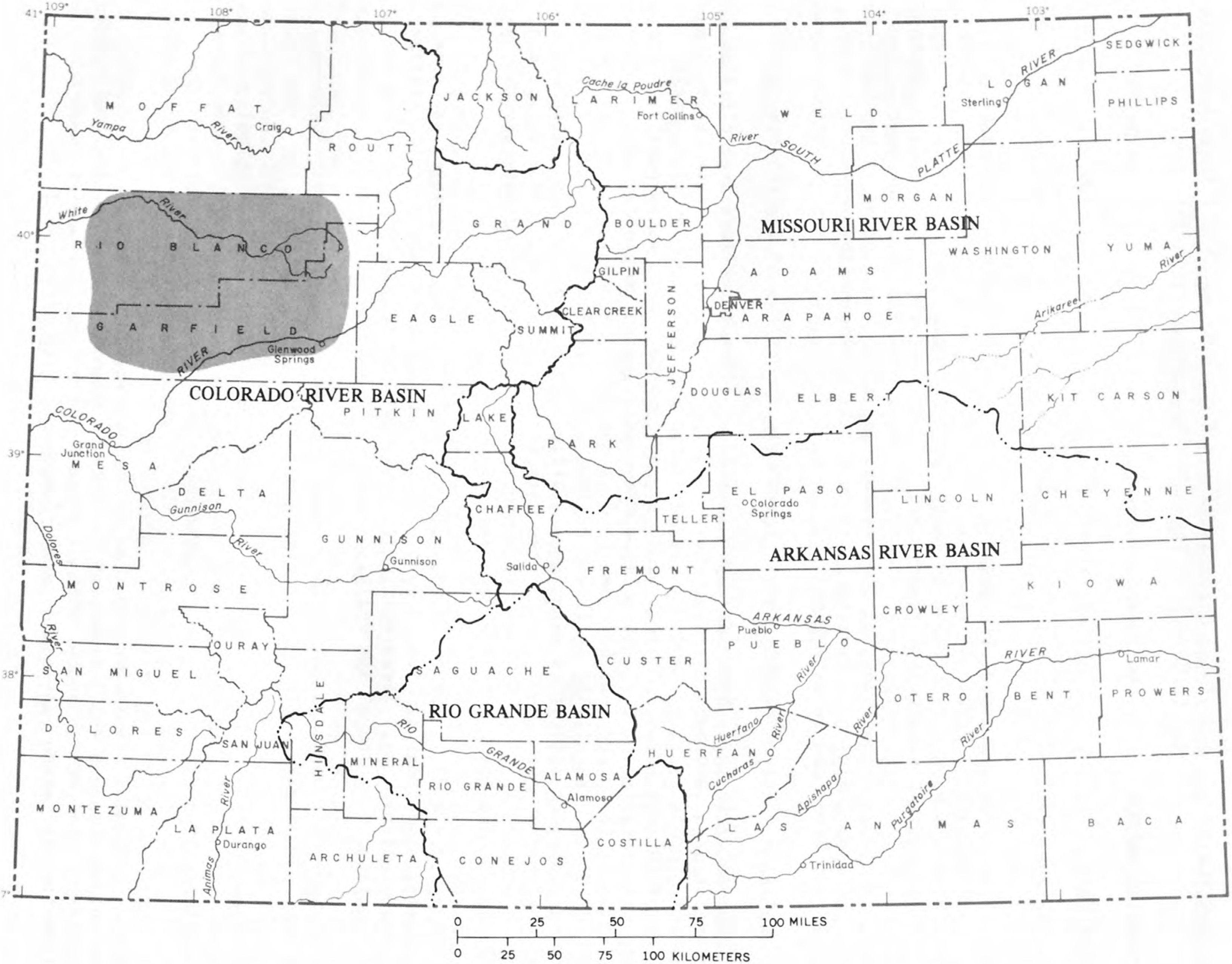

Figure 36.--Location of area in which effects of energy-production emmissions on lakes are being studied.

PROJECT TITLE: Effects of Energy-Production Emissions on Lakes (fig. 36)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: November 1979 to September 1982

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 water in lakes and streams. The lakes and streams in the Flat Tops Wilderness Area in western Colorado are located downwind from areas of oil-shale development and coal-burning power plants. The chemically unreactive geologic formations of the area, combined with the orogenic effect on precipitation may cause the area to be particularly susceptible to adverse effects of acid rain. Data on precipitation and lake quality do not exist to define predevelopment conditions.

Objectives.--Delineate areas in Colorado most susceptible to the effects of acid-rain. In each area, identify those lakes in which the water has little buffering capacity and small nutrient concentrations. Select lakes representative of other lakes within the susceptible areas for more detailed study. Determine predevelopment chemical quality of precipitation.

Approach.--Select areas most susceptible to acid rain based on: Downwind location from acid-gas sources, chemically unreactive geologic formations, and large snowpack accumulation. Determine relative buffering capacity of lakes by developing alkalinity titration curves and nutrient loading by measuring hypolimnetic-nutrient concentrations, snowpack amount and nutrient concentrations, and stream discharge and nutrient concentrations. Install precipitation and weather stations to collect samples for chemical analysis and data on wind direction and speed.

Progress.--Selection of lakes to be studied has begun.

Plans.--Complete selection of lakes to be studied. Install precipitation and weather stations. Begin data collection. Select index lakes for detailed study.

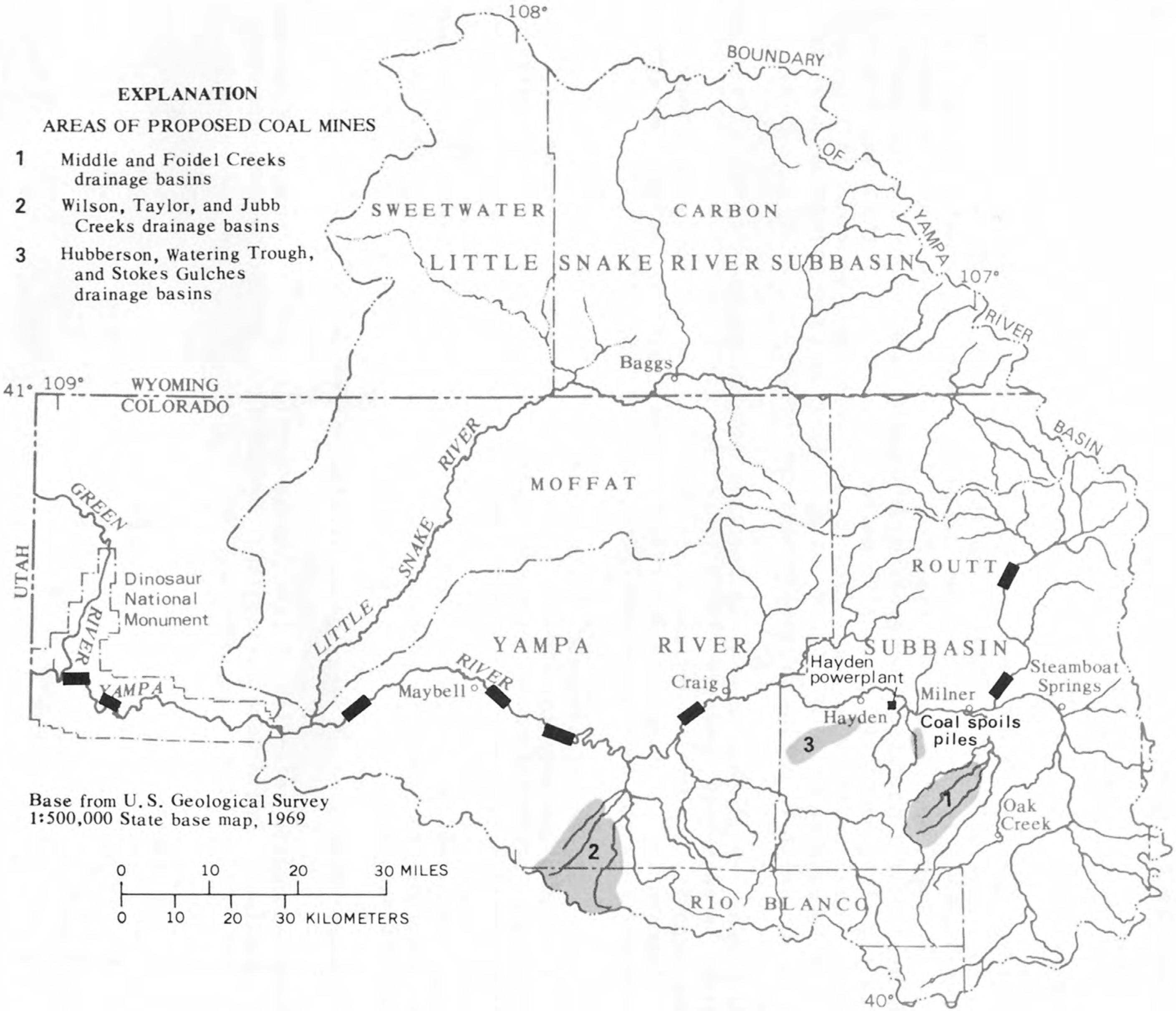

Figure 37.--Location of study reaches on the Yampa and Elk Rivers in the Yampa River basin, areas of proposed coal mines and coal-spoils piles, and the Hayden powerplant.

PROJECT TITLE: Hydrologic Characteristics for Instream Flow Requirements (fig. 37)

COOPERATING AGENCY: U.S. Environmental Protection Agency

PROJECT CHIEF: Daniel P. Bauer, District Office, Lakewood

PERIOD OF PROJECT: August 1978 to September 1980

Problem.--Throughout Colorado, as well as in many other parts of the country, intense competition exists for the available water supplies. This competition is especially intense in the arid and semiarid western States. One important water use commonly overlooked is the maintenance of a balanced aquatic environment to support fishery and other recreational activities. There is, therefore, a need to determine optimum streamflow, including velocity and depth characteristics for fishery and recreational uses. The velocity and depth characteristics required also can vary seasonally depending on the fish activity; for example, different flows are required for migration or reproduction. Several methods are available for determining depth-velocity characteristics at given locations in a stream reach and at different discharge conditions. Minimal information is known for method accuracies and applications for given stream reach types and flow conditions.

Objectives.--Evaluate three methods for determining depth-velocity characteristics of selected sites in a stream, to provide operational techniques for additional studies throughout Colorado and the United States.

Approach.--Determine individual cross-section velocity-depth characteristics and stream-reach velocities and depths. The cross-section velocity-depth data will be analyzed by two methods: (1) Step-backwater analysis and (2) stage-discharge and stage-velocity relationships. The mean-reach velocity-depth data will be analysed using a two-parameter dispersion and mean-velocity computer model. Velocity depth prediction accuracies will then be tested from additional measured velocity-depth data.

Progress.--Depth-velocity data were computed during the spring of 1979 for six study reaches on the Yampa and Elk Rivers. Two additional study reaches were established on the Yampa River in the Dinosaur National Monument area; these reaches were sampled three times during July, August, and September 1979. Reach-velocity and traveltime data, using a fluorescent dye tracer, were collected for the Elk and Yampa Rivers. A stream-reaeration study also was completed for three reaches downstream from Craig using two inert gas tracers during the low flow. Data analysis has begun.

Plans.--Continue data collection at reaches of Yampa River in Dinosaur National Monument. Complete data analysis and prepare report.

PROJECT TITLE: Hydrology of Proposed Coal-Mining Areas, Moffat, Rio Blanco, and Routt Counties (fig. 37)

COOPERATING AGENCY: U.S. Bureau of Land Management

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

PERIOD OF PROJECT: July 1974 to September 1982

Problem.--To evaluate the impact of coal mining in the Yampa River basin, the hydrologic system of proposed coal-mining areas needs to be defined prior to the start of mining activities. Because it will not be possible to directly determine the hydrologic system of every proposed coal-mining area, a method of evaluation needs to be developed that can be easily adapted to areas for which detailed studies of the hydrologic system are not planned.

Objectives.--Determine the existing quantity and quality of surface- and ground-water resources and predict the effects of coal mining on the hydrologic system. Develop a computer model that can be used to predict the effects of coal mining on the hydrology in areas for which intensive studies are not planned.

Approach.--Select areas for intensive study. Install streamflow-gaging stations and two-parameter water-quality monitors in each area. Collect water samples on a monthly basis for analysis of major chemical constituents. Collect water samples on a quarterly basis for analysis of trace elements. Install one climatological station and several precipitation gages in each area. Drill test wells in each area. Test all wells to determine the hydraulic characteristics of the alluvial and bedrock aquifers. After aquifer testing is completed, convert the wells to observation wells and measure water levels on a periodic basis. Collect water samples for chemical analysis.

Progress.--Three areas have been selected; area 1--drainage basins of Middle and Foidel Creeks, area 2--drainage basins of Wilson, Taylor, and Jubb Creeks, and area 3--drainage basins of Hubberson, Watering Trough, and Stokes Gulches. All data-collection instruments have been installed in areas 1 and 2 and in the Stokes Gulch basin of area 3. Test wells have been drilled, aquifer tests made, and test wells converted to observation wells. Collection of samples for water-quality analysis is in progress. Water-quality data collected have been analyzed to compare the chemical characteristics of streamflow from the monitored basins. Streamflow modeling has begun using a daily-flow computer model that includes a snowmelt option.

Plans.--Continue data collection and calibration of computer model. Begin to determine water losses by evaporation and sublimation from the snowpack as these data are critical to the calibration of the model.

PROJECT TITLE: Hydrology and Reclamation Potential of Coal-Spoils Piles (fig. 37)

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF: Robert S. Williams, District Office, Lakewood

PERIOD OF PROJECT: July 1975 to September 1980

Problem.--Coal mining will create large areas of spoils piles. The hydrology and reclamation potential of the piles needs to be known so that the effects of the piles on the hydrologic system beneath and adjacent to the piles can be determined. Because it will not be possible to directly determine the hydrology and reclamation potential of all spoils piles, a method of evaluation needs to be developed that can be easily adapted to spoils piles for which detailed studies are not planned.

Objectives.--Determine the hydrologic characteristics of coal-spoils piles. Determine changes in chemical quality as water moves through the piles. Determine the effects of various reclamation procedures on the hydrology of the piles. Determine the effects of the piles on the hydrologic system beneath and adjacent to the piles. Develop a computer model that can be used to predict the hydrology and reclamation potential of the piles and the effects of the piles on the hydrologic system beneath and adjacent to the piles in areas for which intensive studies are not planned.

Approach.--Install nine lysimeters, five in a spoils area and four in an unmined area. Use rainfall simulators to produce runoff into four lysimeters in the spoils area and two lysimeters in the unmined area. Determine the quantity and quality of water percolating into the lysimeters. Drill observation wells adjacent to the lysimeters to determine soil-moisture regimes. Apply various reclamation treatments to the surface of the spoils areas. Use rainfall simulators to stress the treated areas. Drill six wells of equivalent depth in the spoils and unmined areas. Measure water levels in and collect water samples for chemical analysis from all the wells. Use the drill cuttings from the wells to construct laboratory columns; percolate water through the columns and collect water samples for chemical analysis at predetermined times. Correlate water-quality analyses from the lysimeters, observation wells, and laboratory columns. Develop a computer model.

Progress.--All lysimeters have been installed and all wells have been drilled including four new wells drilled during 1979. Data collection continuing. Analysis of water quality from lysimeters, wells, and columns has begun. Development of computer model begun.

Plans.--Continue data collection and interpretation including chemical analysis of snow. Complete development of computer model and prepare report.

PROJECT TITLE: Effects on the Ground-Water System of Waste disposal from a Coal-Burning Powerplant (fig. 37)

COOPERATING AGENCY: U.S. Environmental Protection Agency

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

PERIOD OF PROJECT: April 1978 to September 1980

Problem.--Wastes resulting from burning coal in powerplants may adversely affect the ground-water system if the wastes are disposed using evaporation ponds. The effects of disposal using evaporation ponds need to be known so that adequate disposal facilities can be designed.

Objectives.--Determine present ground-water conditions at and in the vicinity of the Hayden powerplant. Determine present chemical quality of the Yampa River upstream and downstream from the powerplant. Document the volume and chemical composition of the wastes generated. Document waste-handling and treatment methods. Determine the effects of waste disposal using evaporation ponds on the movement of ground water and on the chemical quality of both ground and surface water. If water quality is degraded, develop the capability to predict the movement and chemical quality of the degraded water.

Approach.--Collect data from an observation network of about 20 wells to determine present ground-water conditions. Collect samples of ground and surface water for chemical analysis to determine present water quality. Use powerplant records to document the volume and chemical composition of the wastes and waste-handling and treatment methods. Collect data from ponds, wells, and streams to monitor the effects of the waste disposal.

Progress.--Data collection has been completed.

Plans.--Begin data interpretation and report preparation.

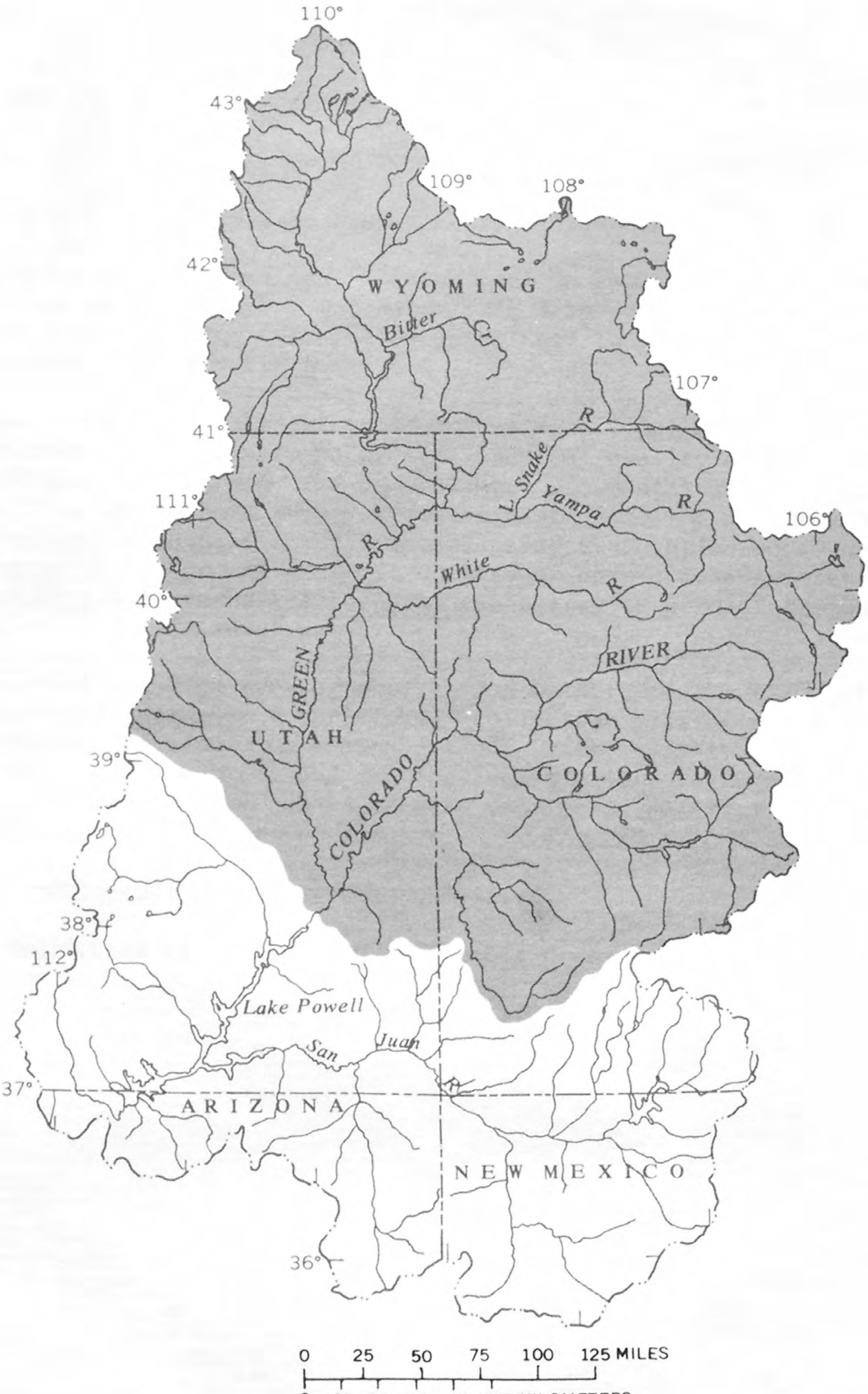

Figure 38.--Location of the Upper Colorado River Basin upstream from Lake Powell.

MULTISTATE

PROJECT TITLE: Ground-Water Contribution to Salinity of Streams in the Upper Colorado River Basin Upstream from Lake Powell (fig. 38)

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF: Kimball E. Goddard, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: October 1977 to October 1982

Problem.--Salinity of the Colorado River and its tributaries results in substantial economic losses each year. The U.S. Bureau of Land Management, which is responsible for controlling salinity in streams on federally-owned lands, needs to know where saline ground water enters streams and the magnitude of the contamination resulting from the ground-water inflow.

Objective.--Determine the ground-water contribution to salinity of streams in the area.

Approach.--Use historic water-quality data to identify streams affected by saline ground-water inflow. Collect ground-water, surface-water, and water-quality data to determine the rate and quality of saline ground water entering the streams. Establish a monitoring network on those streams where salinity is a significant problem.

Progress.--Reconnaissance evaluation of area and data interpretation have been completed. Two streams, Salt Creek in Colorado and Onion Creek in Utah, have been selected for additional study to determine the causes of the salinity and to determine the feasibility of controlling the salinity. A monitoring network of seven stations has been established on streams in Colorado and Utah. Report describing results of the reconnaissance phase of the study is being prepared.

Plans.--Continue data collection. Complete a report describing the results of the reconnaissance phase of the study. Complete investigation of Salt and Onion Creeks and prepare a report describing the results of this phase of the study. Establish an additional monitoring network of about 10 stations on selected streams in Colorado.

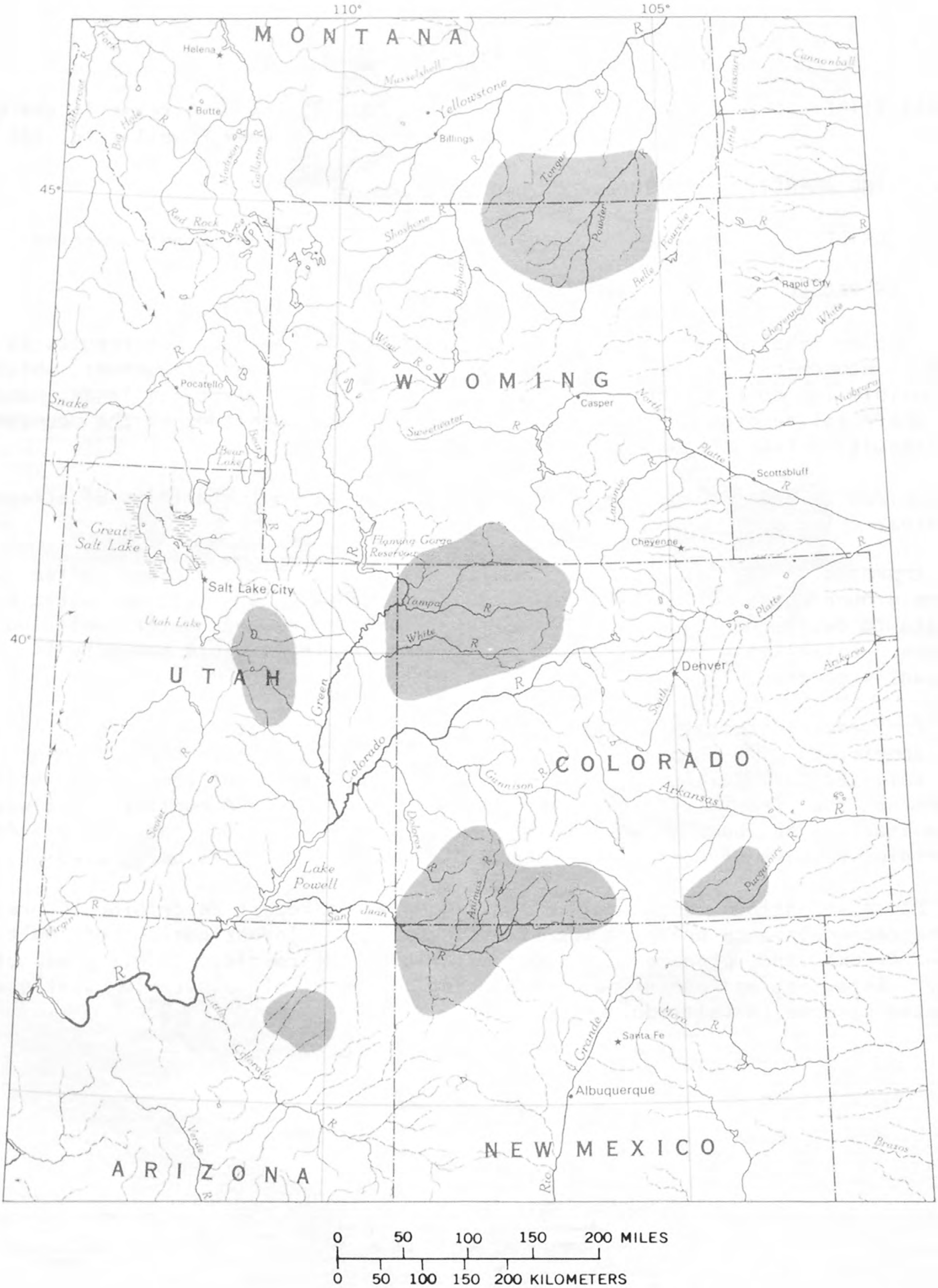

Figure 39.--Locations of study areas for which hydraulic and geomorphic characteristics of stream channels are being determined.

PROJECT TITLE: Hydraulic and Geomorphic Characteristics of Stable Alluvial Stream Channels in The Rocky Mountain Region (fig. 39)

COOPERATING AGENCY: None

PROJECT CHIEF: Edmund D. Andrews, District Office, Lakewood

PERIOD OF PROJECT: February 1979 to February 1982

Problem.--Development of coal and oil-shale resources in the Rocky Mountain Region by surface-mining techniques during the 1980's will disturb large areas of land. As a result, the hydrologic balance of many streams will be altered, and, in some instances, completely destroyed during mining. In order to protect and restore the hydrologic balance of these stream channels, it is necessary to acquire detailed knowledge of the hydraulic and geomorphic factors that control the stability of alluvial streams in the region.

Objectives.--Develop consistent hydraulic and geomorphic relations that are indicative of stream-channel stability. These relations will link the sediment and water discharge of a stream with the values of velocity, depth, width, roughness, slope, and sinuosity required to maintain stability. Direct data collection and analysis towards determining the hydraulic and geomorphic factors that affect alluvial-channel stability and the amount of time required for a stream to adjust to a change in quantity of water and sediment supplied to it from the watershed.

Approach.--Collate historic data such as streamflow gaging-station records, stream-channel surveys, sediment-concentration and load records, and reports describing stream-channel adjustments to long-term changes in discharge. Collect additional data as needed.

Progress.--Methods for determining total bed-material discharge of streams with various size distributions of bed material have been evaluated.

Plans.--Determine the hydraulic adjustment of streams with poorly sorted bed material. Develop relationships between flow characteristics and the supply of water and sediment to the stream channel.

REPORTS PUBLISHED OR RELEASED DURING FISCAL YEAR 1979

Reports published or released during fiscal year 1979 may be purchased or inspected as follows:

U.S. GEOLOGICAL SURVEY: PROFESSIONAL AND WATER-SUPPLY PAPERS--May be purchased over the counter or by mail from:

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1. Cochran, B. J., Hodges, H. E., Livingston, R. K., and Jarrett, R. D., 1979, Rainfall-runoff data from small watersheds in Colorado, October 1974 through September 1977: U.S. Geological Survey Open-File Report 79-1261, 673 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $88; microfiche $3.50.
2. Hall, D. C., Boyd, E. L., and Cain, Doug, 1979, Hydrologic data for streams, wells, and springs in Boulder County, Colorado: U.S. Geological Survey Open-File Report 79-979, 106 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $16; microfiche $4.
3. Hillier, D. E., compiler, 1979, Water-resources investigations of the U.S. Geological Survey in Colorado--Fiscal Year 1979: U.S. Geological Survey Open-File Report 79-402, 101 p.
4. Hillier, D. E., Schneider, P. A., Jr., and Hutchinson, E. C., 1979, Hydrologic data for water-table aquifers in the greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geological Survey Open-File Report 79-214, 68 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $14.25; microfiche $4.
5. McCain, J. F., and Ebling, J. L., 1979, A plan for study of flood hydrology of foothill streams in Colorado: U.S. Geological Survey Open-File Report 79-1276, 29 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $6; microfiche $4.
6. Petsch, H. E., Jr., 1979, Streamflow statistical summaries for Colorado streams through September 30, 1975, Volume 1, Missouri River, Arkansas River, and Rio Grande basins: U.S. Geological Survey Open-File Report 79-681, 515 p.
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CORRECTION IN U.S. GEOLOGICAL SURVEY OPEN-FILE REPORT 79-402, Emmons, P. J., 1976, U.S. Geological Survey Water-Resources Investigations 78-28 is incorrect. Correct to U.S. Geological Survey Water-Resources Investigations 76-53.

PROJECTS COMPLETED DURING FISCAL YEAR 1979 EXCEPT FOR REPORT(S)

1. Hydrologic feasibility of an artificial-recharge project, Badger and Beaver Creeks.

2. Effects of the proposed Narrows Reservoir on ground and surface water.

3. Availability and chemical quality of ground water in Kiowa County.

4. Surface-water return flow from irrigated lands to the Arkansas River, Pueblo Reservoir to the Colorado-Kansas State boundary.

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OPEN-FILE REPORT 80-442
PLATE 1