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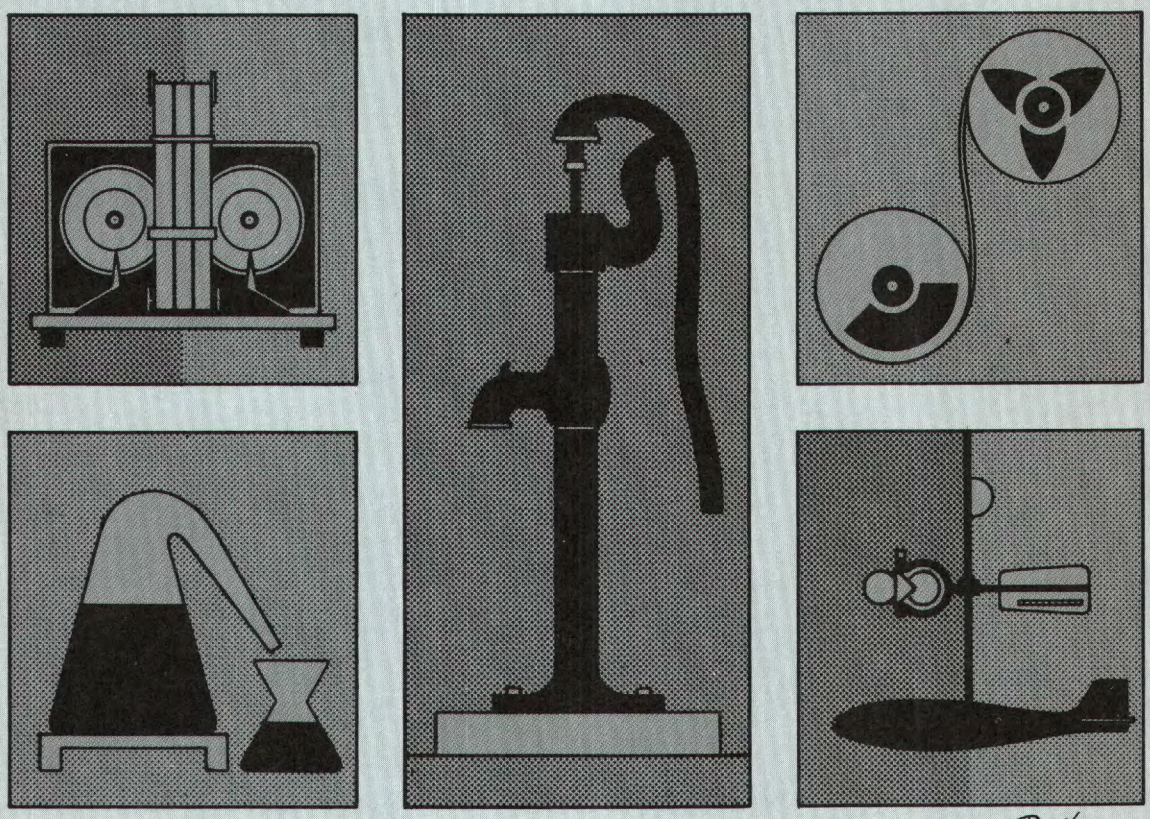
# WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--Fiscal Year 1979




U.S. Geological Survey
Open-File Report 79-402

# WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--Fiscal Year 1979

Compiled by Donald E. Hillier

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U.S. GEOLOGICAL SURVEY

Open-File Report 79-402


Lakewood, Colorado

March 1979

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ILLUSTRATIONS

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TABLE



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 1979

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## 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 1979 fiscal year (October 1, 1978, to September 30, 1979).

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:

J. F. Blakey, District Chief
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225
Telephone: 303-234-5092

R. U. Grozier
Associate District Chief
U.S. Geological Survey
Water Resources Division
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Denver Federal Center
Lakewood, CO 80225
Telephone: 303-234-5092

J. F. McCain
Chief, Hydrologic Studies Section
U.S. Geological Survey
Water Resources Division
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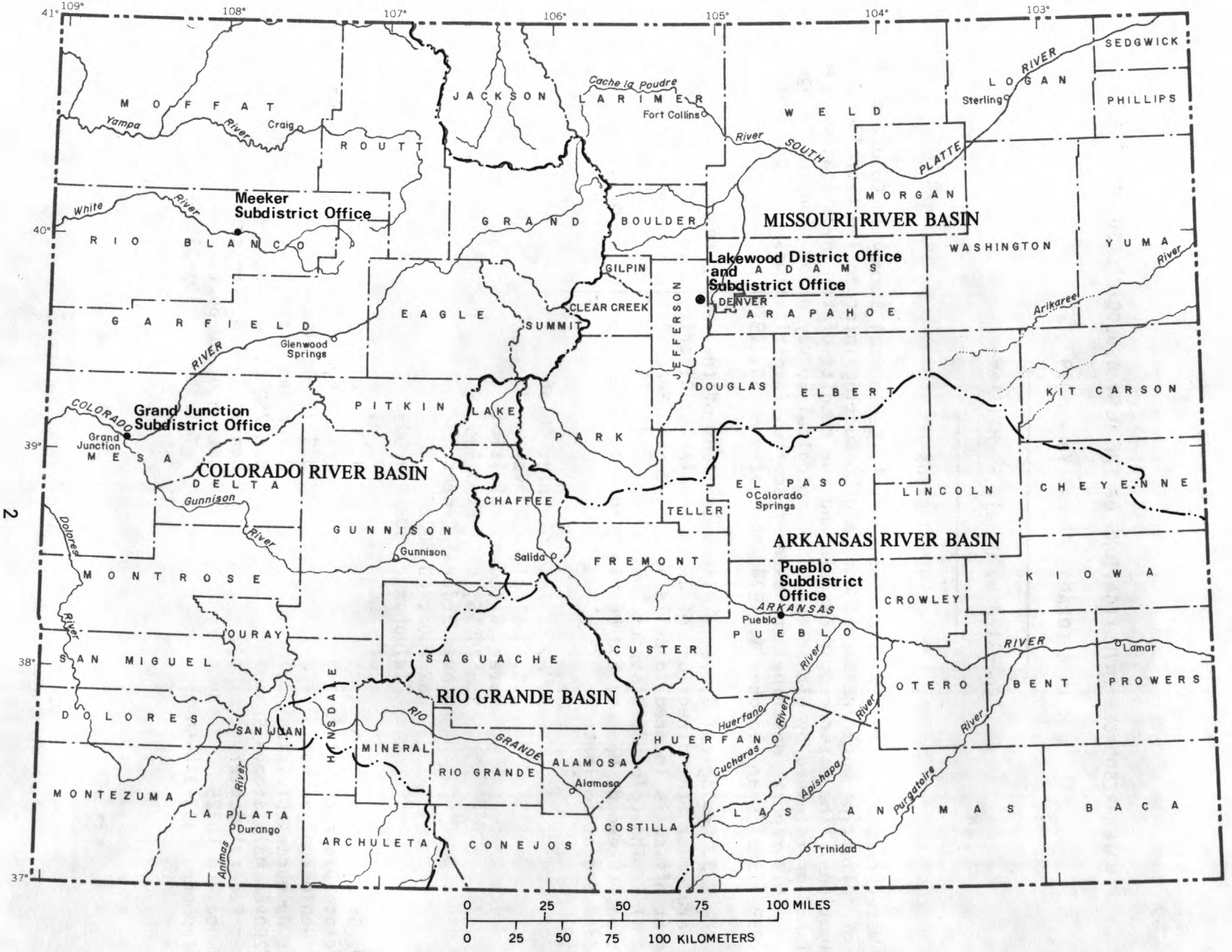


Figure 1.--Location of major river basins and offices of the U.S. Geological Survey's Colorado District.

D. L. Collins, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
P.O. Box 2027
Grand Junction, CO 81501
Telephone: 303-242-0731, X302

R. K. Livingston, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 423
Denver Federal Center
Lakewood, CO 80225
Telephone: 303-234-4061

V. W. Norman, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
P.O. Box 810
Meeker, CO 81641
Telephone: 303-878-5086

J. L. Hughes, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
P.O. Box 1524
Pueblo, CO 81002
Telephone: 303-544-5277, X248

## 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 1979 are:

Adams County Board of Commissioners
Arapahoe County
Arkansas River Compact Administration
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 Northglenn
Colorado City Water and Sanitation District
Colorado Department of Health
Colorado Department of Highways
Colorado Department of Natural Resources
    Division of Water Resources,
      Office of the State Engineer
    Colorado Water Conservation Board
Colorado River Water Conservation District
Douglas County
Eagle County Board of Commissioners
Elbert County Planning Department
El Paso County Board of Commissioners
Jackson County

Kiowa County Board of Commissioners
Northern Colorado Water Conservancy District
Pikes Peak Area Council of Governments
Pitkin County Board of County Commissioners
Purgatoire River Water Conservancy District
Rio Grande Water Conservation District
Southeastern Colorado Water Conservancy District
Southwestern Colorado Water Conservation District
St. Vrain and Left Hand 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 the Interior
    Bureau of Indian Affairs
    Bureau of Land Management
    Bureau of Mines
    Bureau of Reclamation
    Fish and Wildlife Service
U.S. Environmental Protection Agency
U.S. General Services Administration
U.S. Water Resources Council

## 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 | | 553 |
| Continuous record | 474 | |
| Partial record | 79 | |
| Lake and reservoir stations | | 24 |
| Total | | 577 |

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 21 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 | | 163 |
| Water temperature | 160 | |
| Daily | 76 | |
| Monthly | 59 | |
| Quarterly | 12 | |
| Intermittently | 13 | |
| Specific conductance | 162 | |
| Daily | 73 | |
| Monthly | 61 | |
| Quarterly | 12 | |
| Intermittently | 16 | |
| pH | 156 | |
| Daily | 4 | |
| Monthly | 117 | |
| Quarterly | 20 | |
| Intermittently | 15 | |
| Suspended-sediment data | | 79 |
| Daily | 39 | |
| Monthly | 40 | |
| Chemical data (inorganic constituents) | | 152 |
| Monthly | 116 | |
| Quarterly | 20 | |
| Semiannually | 3 | |
| Intermittently | 13 | |
| Chemical data (pesticides) | | 25 |
| Quarterly | 1 | |
| Semiannually | 9 | |
| Annually | 15 | |
| Radiochemical data | | 28 |
| Quarterly | 10 | |
| Semiannually | 16 | |
| Annually | 2 | |
| Bacteriological data | | 43 |
| Monthly | 26 | |
| Quarterly | 11 | |
| Semiannually | 6 | |
| Biological data | | 41 |
| Monthly | 31 | |
| 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 1,585 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 | 5 |
| Monthly | 75 |
| Bimonthly | 51 |
| Quarterly | 75 |
| Annually | 2,606 |
| Intermittently | 750 |
| Total | 3,562 |

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

Forty-nine interpretive hydrologic investigations are being conducted during fiscal year 1979. These include 6 statewide investigations, 5 regional investigations, 10 investigations in the Missouri River basin, 8 investigations in the Arkansas River basin, 3 investigations in the Rio Grande basin, 15 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 | 4 | 0 | 0 | 218 |
| Alamosa------- | 1 | 0 | 0 | 0 | 77 |
| Arapahoe------ | 3 | 4 | 0 | 4 | 163 |
| Archuleta----- | 7 | 0 | 0 | 0 | 5 |
| Baca---------- | 0 | 2 | 0 | 0 | 60 |
| Bent---------- | 3 | 0 | 1 | 1 | 127 |
| Boulder------- | 6 | 7 | 0 | 3 | 163 |
| Chaffee------- | 8 | 0 | 0 | 0 | 7 |
| Cheyenne------ | 0 | 0 | 0 | 0 | 57 |
| Clear Creek--- | 1 | 0 | 0 | 0 | 0 |
| Conejos------- | 10 | 0 | 1 | 1 | 21 |
| Costilla------ | 6 | 0 | 0 | 0 | 34 |
| Crowley------- | 0 | 0 | 0 | 0 | 37 |
| Custer-------- | 3 | 4 | 0 | 0 | 32 |
| Delta--------- | 15 | 0 | 0 | 1 | 20 |
| Denver-------- | 1 | 3 | 0 | 0 | 63 |
| Dolores------- | 2 | 0 | 0 | 0 | 1 |
| Douglas------- | 2 | 0 | 1 | 0 | 123 |
| Eagle--------- | 26 | 1 | 0 | 5 | 9 |
| Elbert-------- | 0 | 2 | 0 | 0 | 135 |
| El Paso------- | 18 | 0 | 0 | 9 | 185 |
| Fremont------- | 5 | 0 | 0 | 2 | 7 |
| Garfield------ | 17 | 0 | 0 | 9 | 14 |
| Gilpin-------- | 0 | 0 | 0 | 0 | 0 |
| Grand--------- | 27 | 0 | 4 | 3 | 14 |
| Gunnison------ | 9 | 0 | 2 | 2 | 4 |
| Hinsdale------ | 6 | 0 | 0 | 0 | 1 |
| Huerfano------ | 2 | 1 | 0 | 0 | 5 |
| Jackson------- | 10 | 0 | 0 | 8 | 10 |
| Jefferson----- | 8 | 12 | 1 | 7 | 51 |
| Kiowa--------- | 0 | 0 | 0 | 0 | 20 |
| Kit Carson---- | 0 | 1 | 0 | 0 | 209 |
| Lake---------- | 7 | 0 | 1 | 2 | 3 |
| La Plata------ | 12 | 0 | 1 | 2 | 3 |

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 |
| Larimer------- | 15 | 3 | 2 | 9 | 31 |
| Las Animas---- | 15 | 5 | 1 | 9 | 6 |
| Lincoln------- | 0 | 2 | 0 | 0 | 33 |
| Logan--------- | 0 | 2 | 0 | 0 | 41 |
| Mesa[1]--------- | 32 | 3 | 1 | 16 | 14 |
| Mineral------- | 6 | 0 | 0 | 0 | 0 |
| Moffat-------- | 10 | 3 | 0 | 11 | 47 |
| Montezuma----- | 8 | 1 | 0 | 3 | 5 |
| Montrose------ | 8 | 1 | 1 | 5 | 6 |
| Morgan-------- | 3 | 1 | 0 | 2 | 90 |
| Otero--------- | 6 | 0 | 0 | 0 | 176 |
| Ouray--------- | 2 | 0 | 0 | 0 | 2 |
| Park---------- | 10 | 0 | 1 | 1 | 14 |
| Phillips------ | 0 | 0 | 0 | 0 | 48 |
| Pitkin-------- | 30 | 0 | 1 | 0 | 7 |
| Prowers[1]------ | 4 | 2 | 0 | 1 | 200 |
| Pueblo-------- | 9 | 3 | 2 | 4 | 90 |
| Rio Blanco[1]--- | 39 | 1 | 0 | 29 | 70 |
| Rio Grande---- | 4 | 0 | 0 | 0 | 29 |
| Routt--------- | 10 | 1 | 0 | 5 | 34 |
| Saguache------ | 7 | 0 | 0 | 0 | 45 |
| San Juan------ | 1 | 0 | 0 | 0 | 0 |
| San Miguel---- | 9 | 2 | 0 | 2 | 5 |
| Sedgwick------ | 1 | 1 | 0 | 1 | 21 |
| Summit-------- | 19 | 0 | 2 | 1 | 5 |
| Teller-------- | 0 | 0 | 0 | 0 | 0 |
| Washington---- | 0 | 1 | 0 | 0 | 121 |
| Weld---------- | 6 | 4 | 0 | 6 | 279 |
| Yuma---------- | 3 | 2 | 1 | 0 | 265 |
| Totals--- | 474 | 79 | 24 | 164 | 3,562 |

[1]Includes stations in adjacent States, as shown on plate 1.


**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*.--Water-rights tabulation has been completed. Areas of surface-water distribution are being mapped. Well-data tabulation has been completed and includes total yields of wells by township, county, irrigation district, and State water division. Irrigated acreage being delineated.

*Plans*.--Continue mapping of surface-water distribution and irrigated acreage. Develop a questionnaire for use in determining municipal water use.

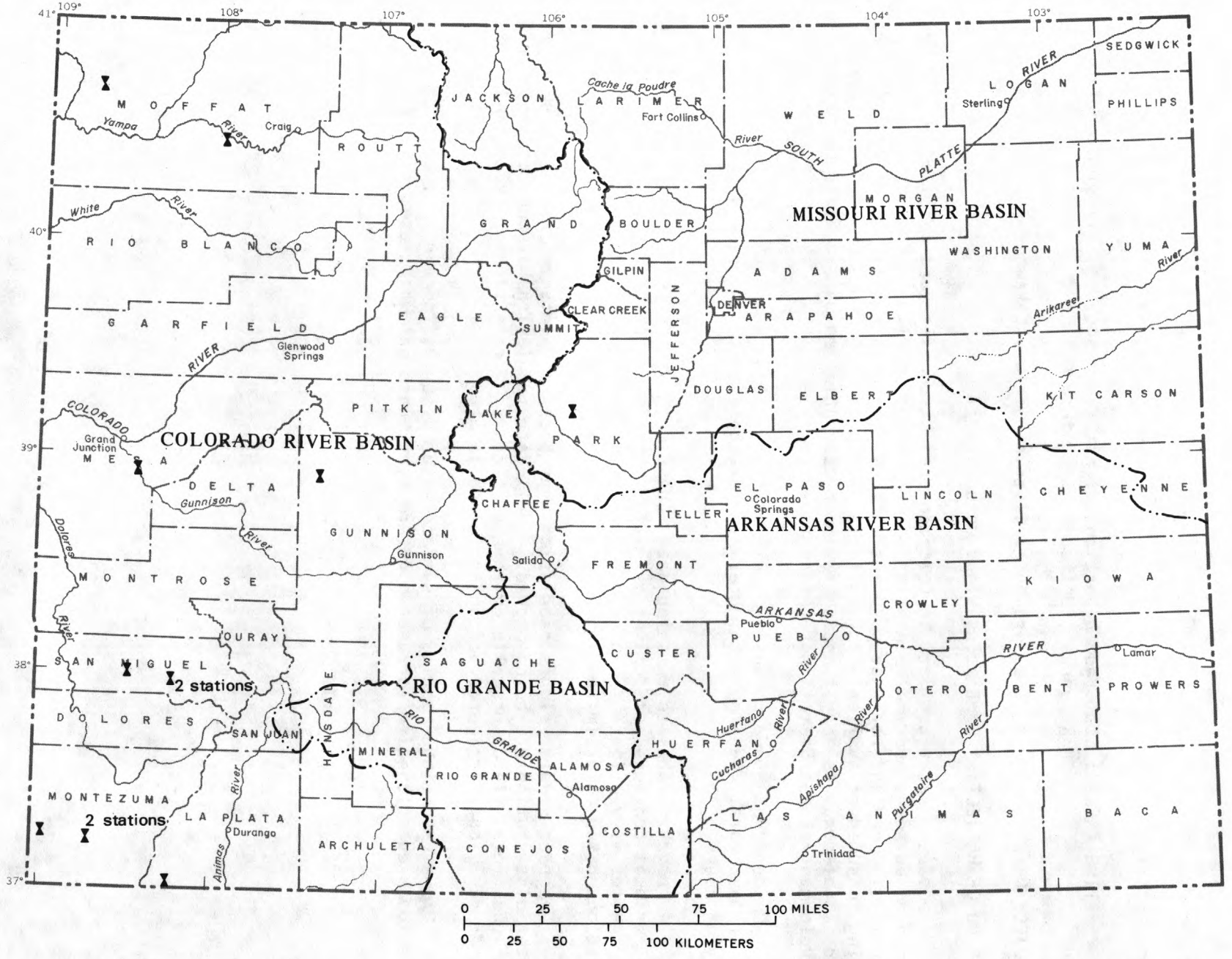


Figure 3.--Location of stations monitoring surface–water flow and quality in coal–mining areas.

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

COOPERATING AGENCY: None

PROJECT CHIEF: John R. Little, 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 the data. Data collection and interpretation have begun.

*Plans*.--Continue data collection and interpretation.

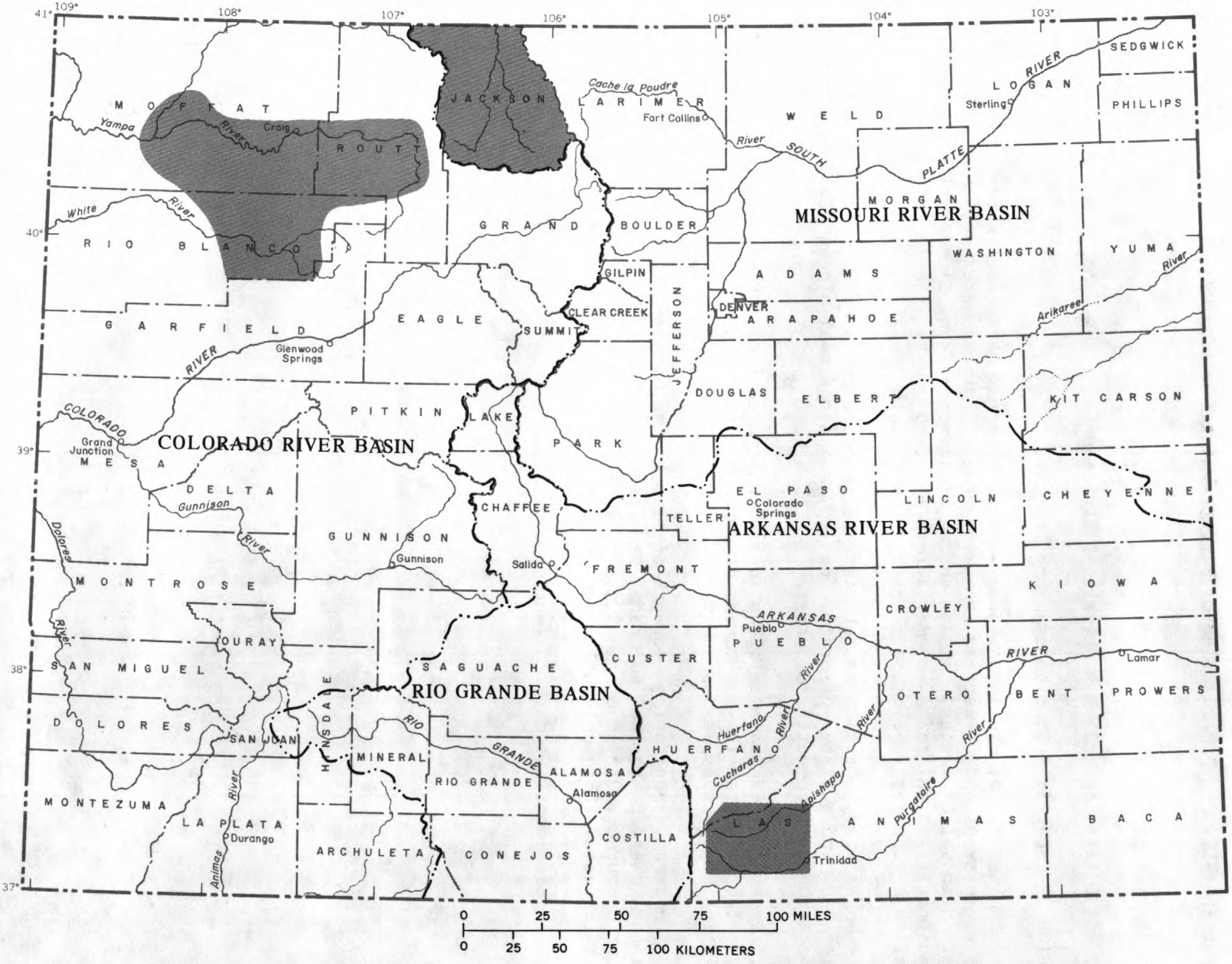


**Figure 4.--Location of coal–mining areas where ground–water studies are in progress.**

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. Water levels are being measured in all wells. Geophysical logs have been obtained.

*Plans*.--Expand observation-well network as needed. Install continuous water-level recorders and continue to measure water levels. Conduct aquifer tests and have drill cores analyzed for mineral composition and determination of hydraulic conductivity. Collect water samples for chemical analysis.

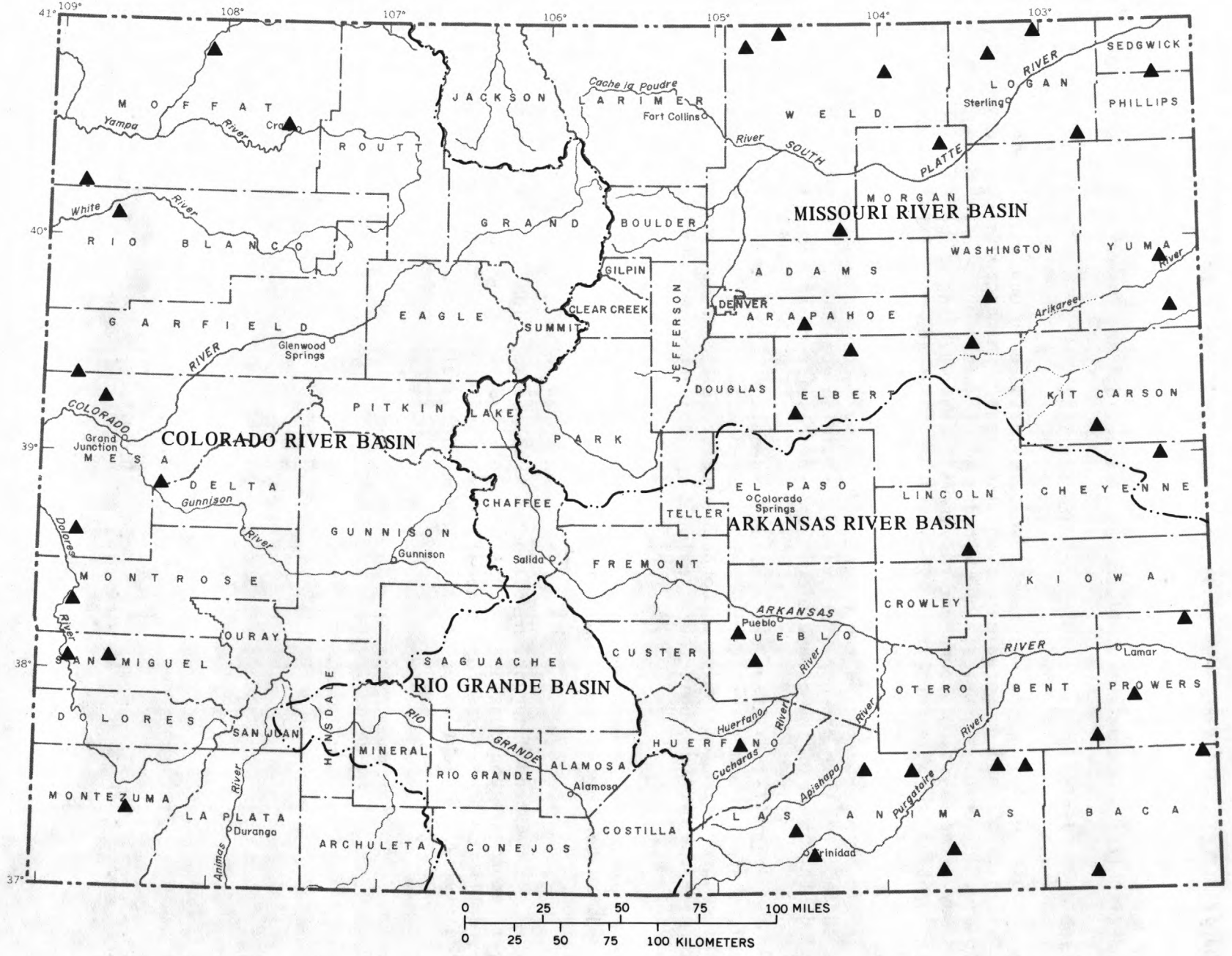


**Figure 5.--Location of rainfall–runoff stations in small watersheds crossed by State highways.**

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

COOPERATING AGENCY: Colorado Department of Highways

PROJECT CHIEF: Russell K. Livingston, 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 stream-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 compiled; report to be released during fiscal year 1979.

*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 Arkansas River basin; continue data collection at remainder of stations. Complete analysis of stations in Arkansas River basin and prepare a report describing the results of this part of the study.

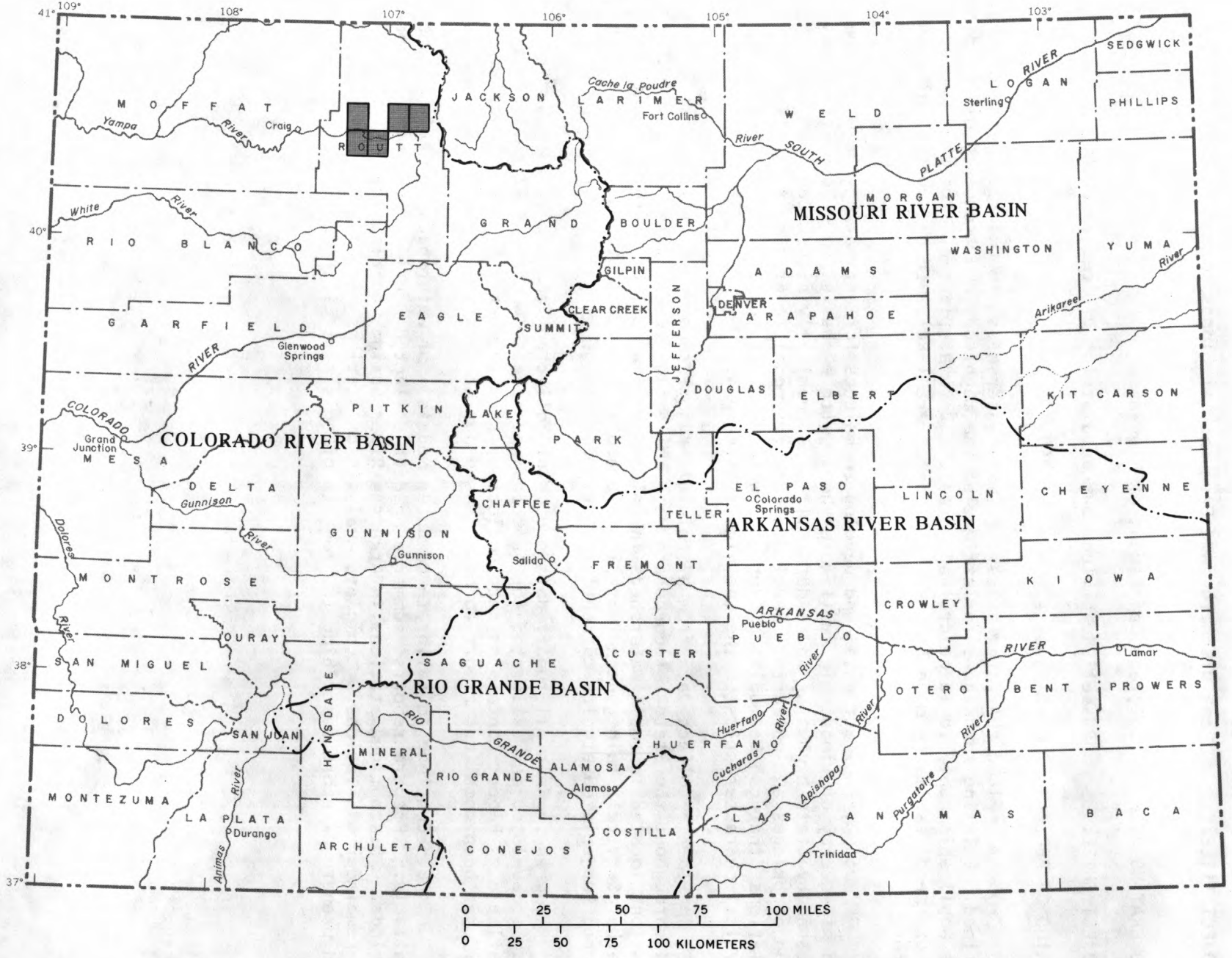


**Figure 6.--Location of topographic quadrangles for which flood–prone areas are being delineated.**

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 eighty-eight maps have been completed prior to fiscal year 1979. Five maps are in various stages of completion.

*Plans*.-Complete and release the five maps presently being compiled.

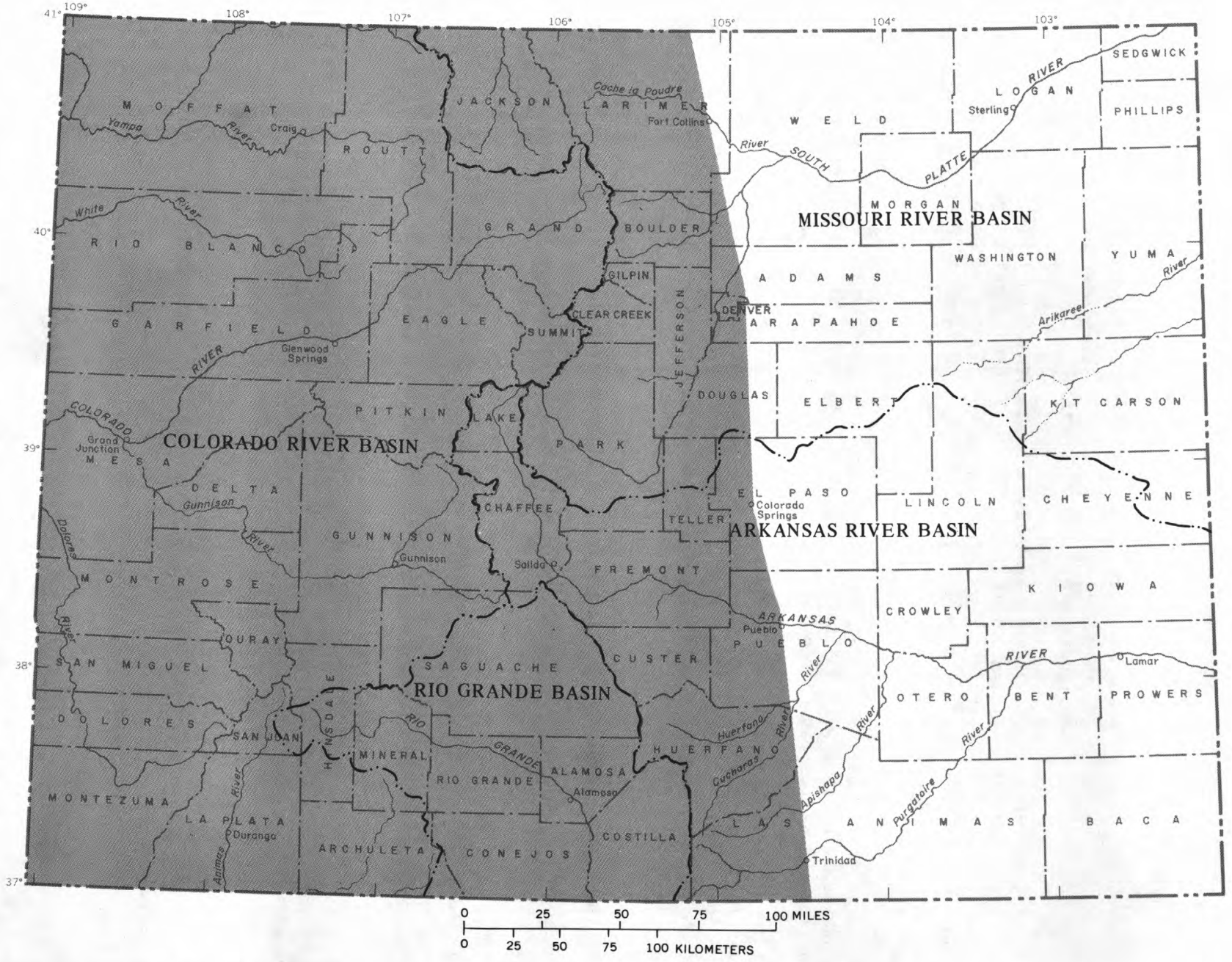


Figure 7.--Location of area for which flood hydrology of foothill streams is being determined.

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. Bureau of Reclamation

PROJECT CHIEF: Rulon C. Christensen, District Office, Lakewood

PERIOD OF PROJECT: July 1976 to September 1981

*Problem*.--More than three-fourths of Colorado's total 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, 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. Sixteen crest-stage gages have been installed and data are being collected.

*Plans*.--Install four additional crest-stage gages and continue data collection. Continue analysis of flood records for areas where mixed-population floods occur. Continue geomorphic, botanic, and channel-geometry studies.

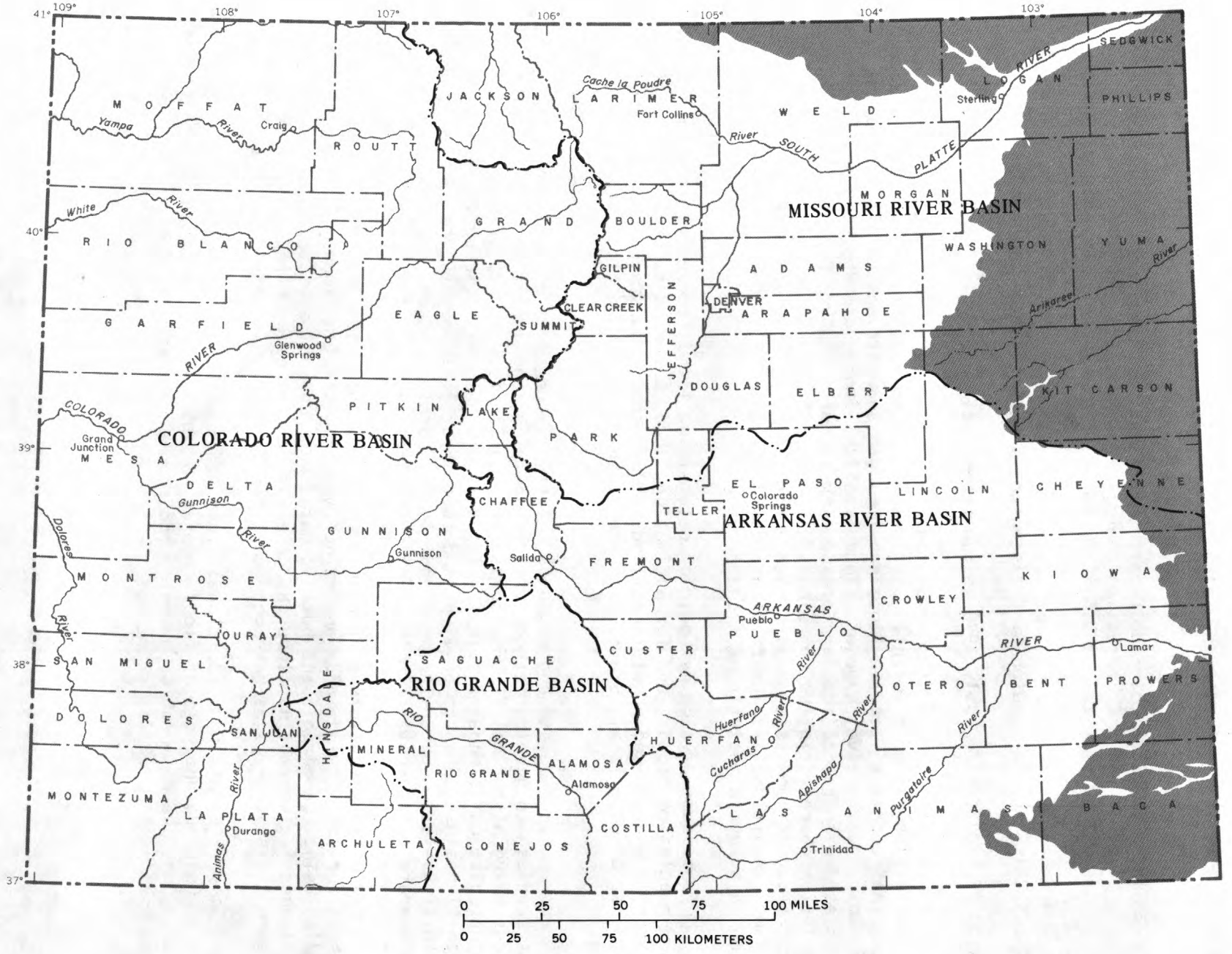


Figure 8.-- Location of the areas of the High Plains regional aquifer in Colorado.

REGIONAL

PROJECT TITLE: Hydrology of the High Plains Regional Aquifer System (fig. 8)

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.

*Plans*.--Continue data collection.

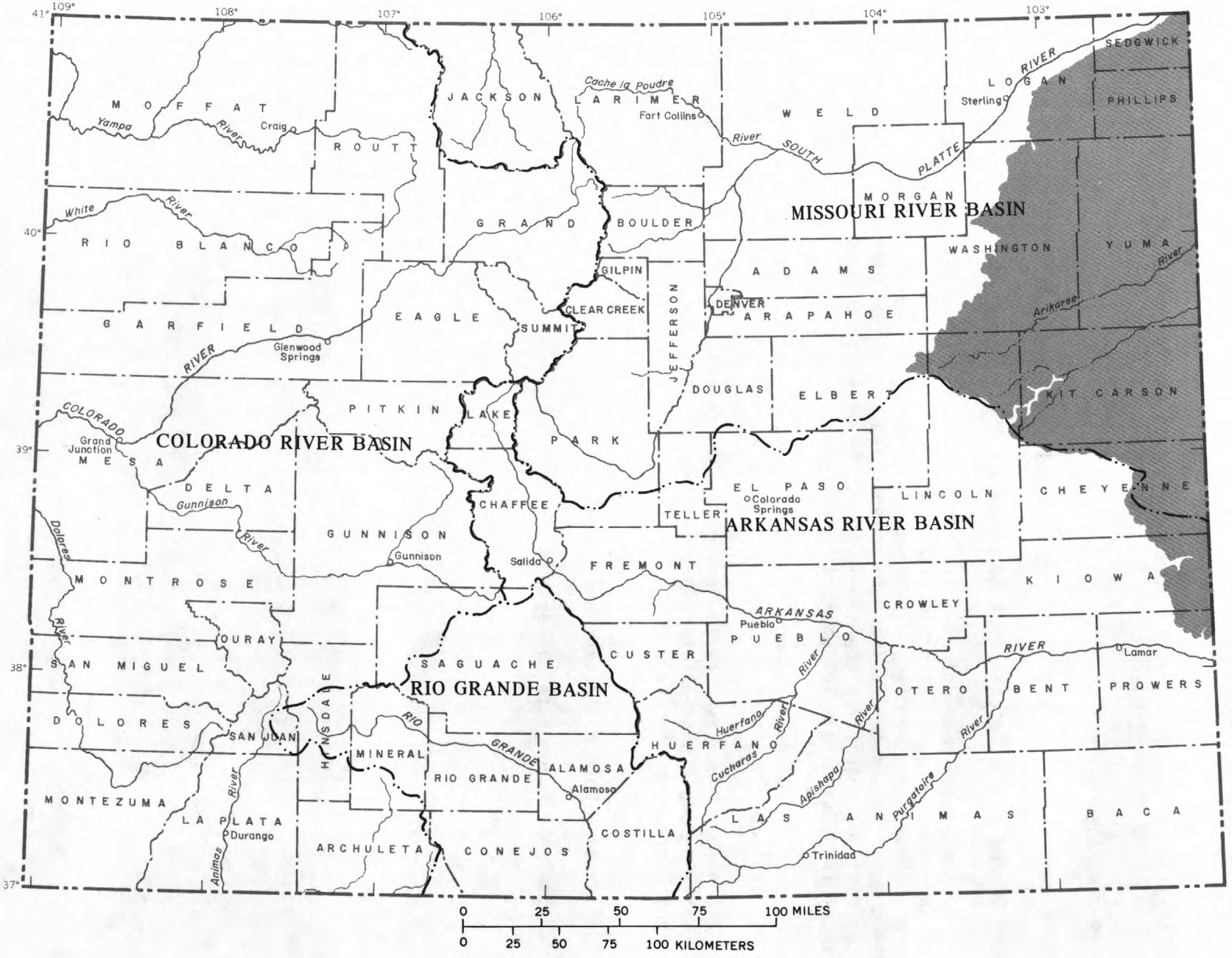


**Figure 9.--Location of the Northern High Plains of Colorado.**

PROJECT TITLE: Water-Management Study of the Northern High Plains of Colorado (fig. 9)

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

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 600 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.

*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 years 1977 and 1978.*--See references 1 and 7 under Water-Resources Data Reports, and references 8, 24, and 25 under Water-Resources Interpretive Reports at back of report.

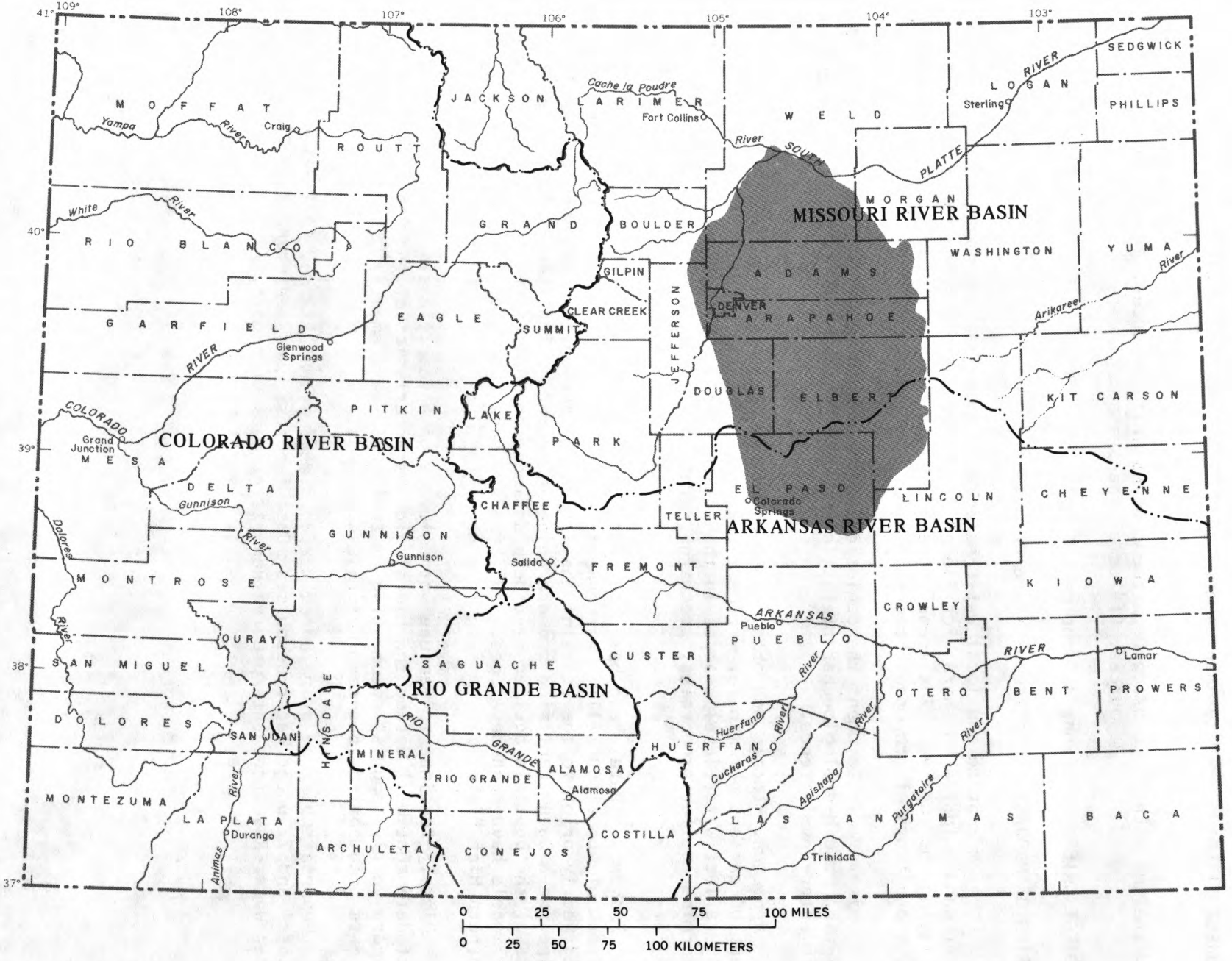


**Figure 10.--Location of the Denver Basin.**

PROJECT TITLE: Ground-Water Resources of the Denver Basin (fig. 10)

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; Douglas County; 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 model 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.

*Plans*.--Continue to monitor water levels. Obtain hydraulic data. Begin compilation of maps. Compile and publish a report summarizing the data collected.

*Reports published or released during fiscal years 1977 and 1978*.--See reference 19 under Water-Resources Interpretive Reports at back of report.

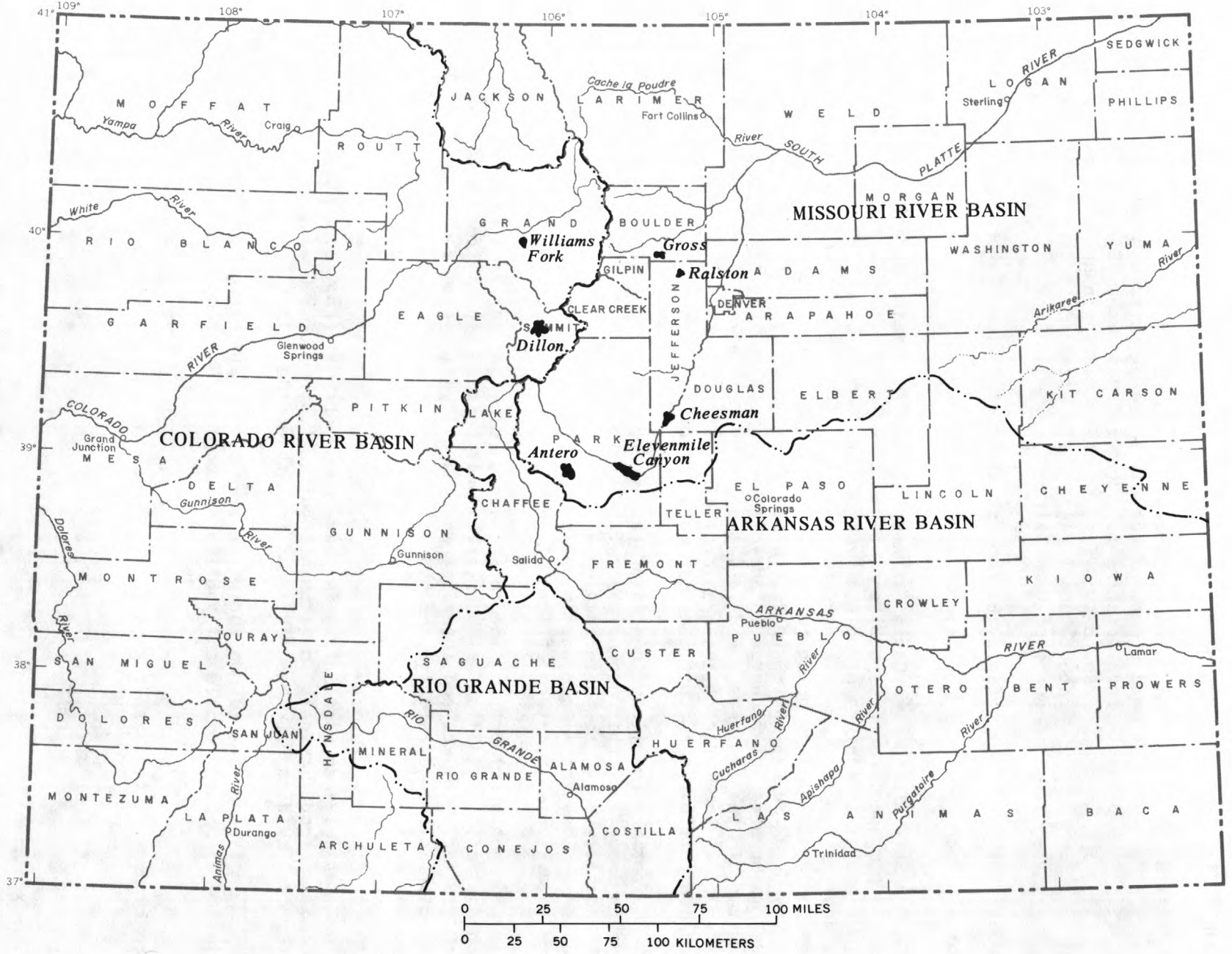


Figure 11.--Location of water-supply reservoirs.

PROJECT TITLE: Determination of Evaporation and Thermal Regime of Selected Reservoirs and Lakes (fig. 11)

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

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

PERIOD OF PROJECT: Continuous since May 1972

*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 Dillon, Elevenmile Canyon, Gross, and Ralston Reservoirs. Energy-budget analyses have been started for Antero Reservoir and Cheesman Lake. Climatic study in South Park completed.

*Plans*.--Complete energy-budget analysis at Antero Reservoir and Cheesman Lake. Begin energy-budget analysis at Williams Fork Reservoir. Continue mass-transfer analyses at all reservoirs. Prepare a report describing the result of the climatic study in South Park.

*Reports published or released during fiscal years 1977 and 1978*.--See reference 14 under Water-Resources Interpretive Reports at back of report.

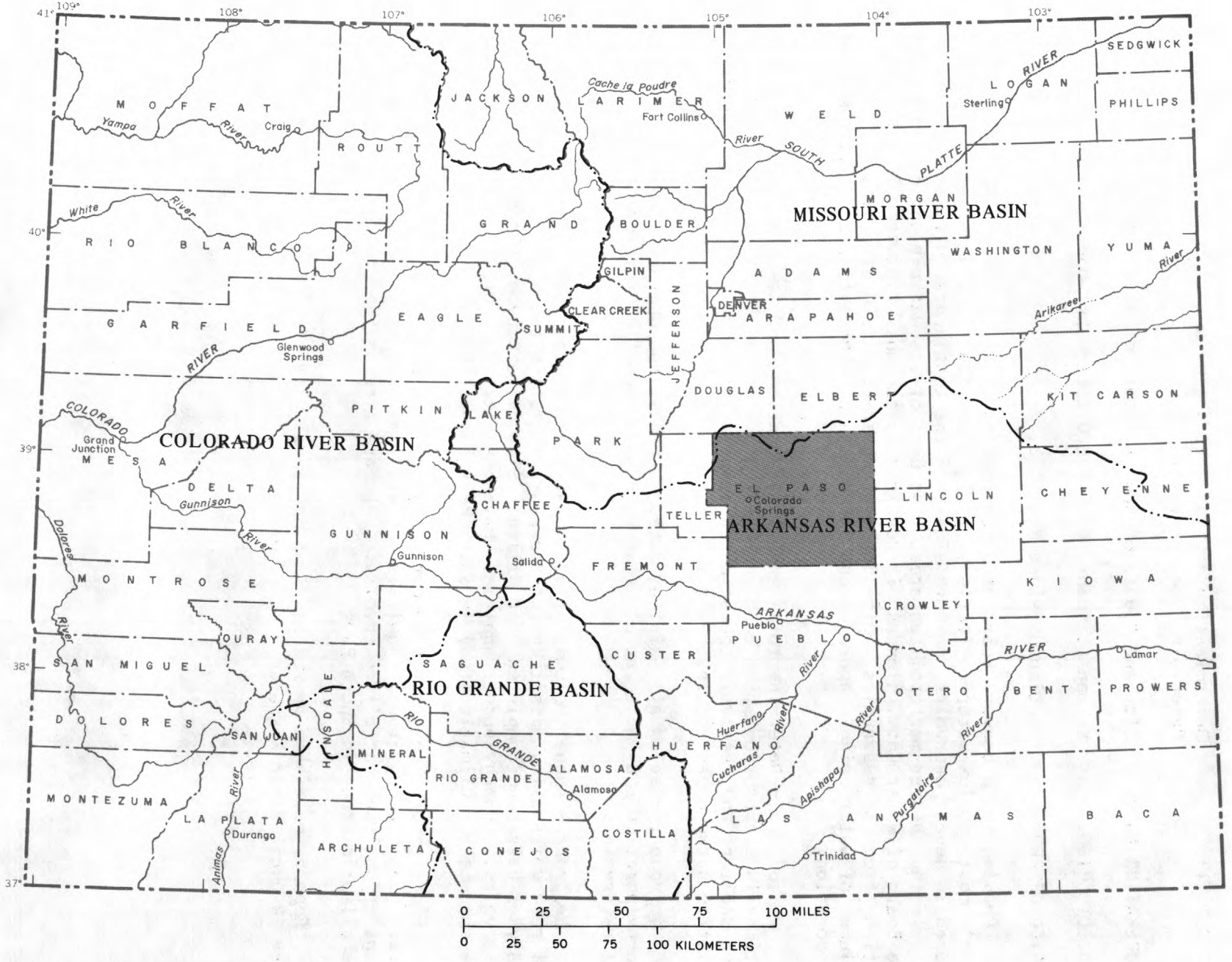


**Figure 12.--Location of El Paso County.**

PROJECT TITLE: Water Resources of El Paso County (fig. 12)

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: Patrick J. Emmons, 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.

*Plans*.--Continue to collect selected hydrologic data for additional refinement of results and improving the predictive capability of the computer model.

*Reports published or released during fiscal years 1977 and 1978*.--See references 13, 32, and 33 under Water-Resources Interpretive Reports at back of report.

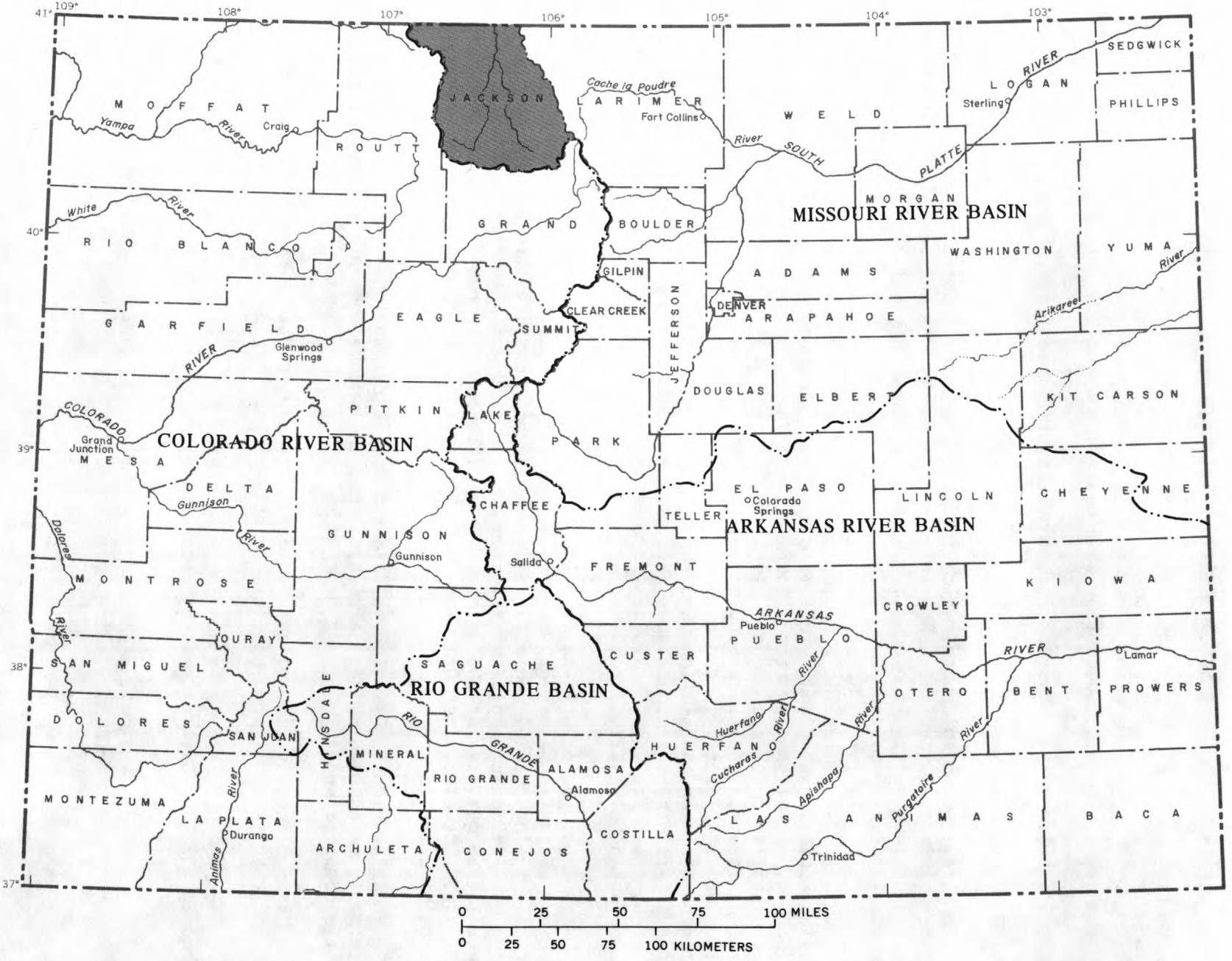


**Figure 13.--Location of Jackson County.**

## MISSOURI RIVER BASIN

PROJECT TITLE: Monitoring of the Hydrologic System in North Park, Jackson County (fig. 13)

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. 15).

*Progress*.--Data collection has begun.

*Plans*.--Install climatological station, continue data collection, and begin data interpretation.

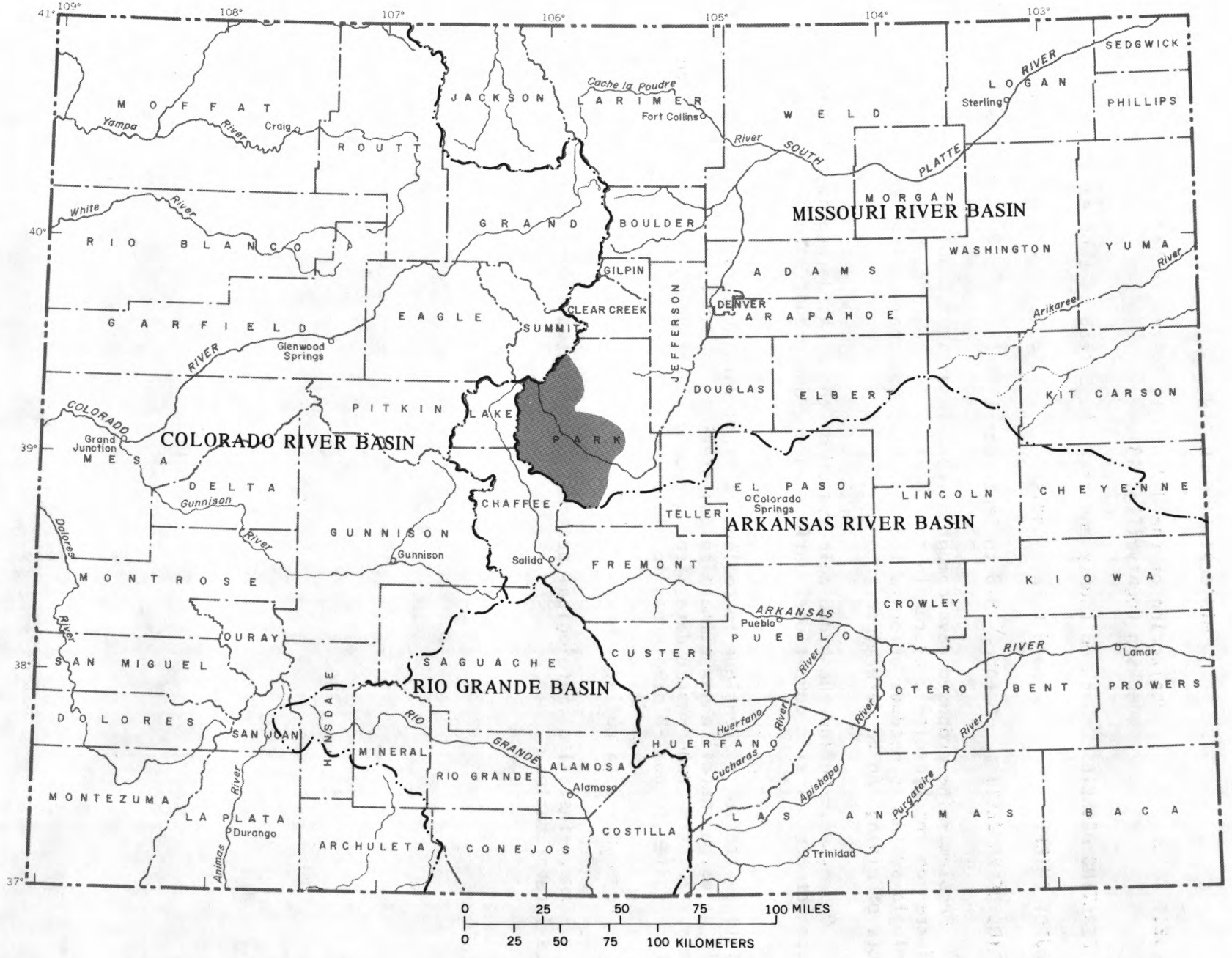


**Figure 14.--Location of South Park.**

PROJECT TITLE: Water Budget for South Park, Park County (fig. 14)

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 stream-gaging stations and three rain-gaging stations have been installed. Water levels have been measured monthly in 14 shallow wells.

*Plans*.--Continue data collection. Obtain color-infrared aerial photographs. Conduct three gain-and-loss studies on streams.

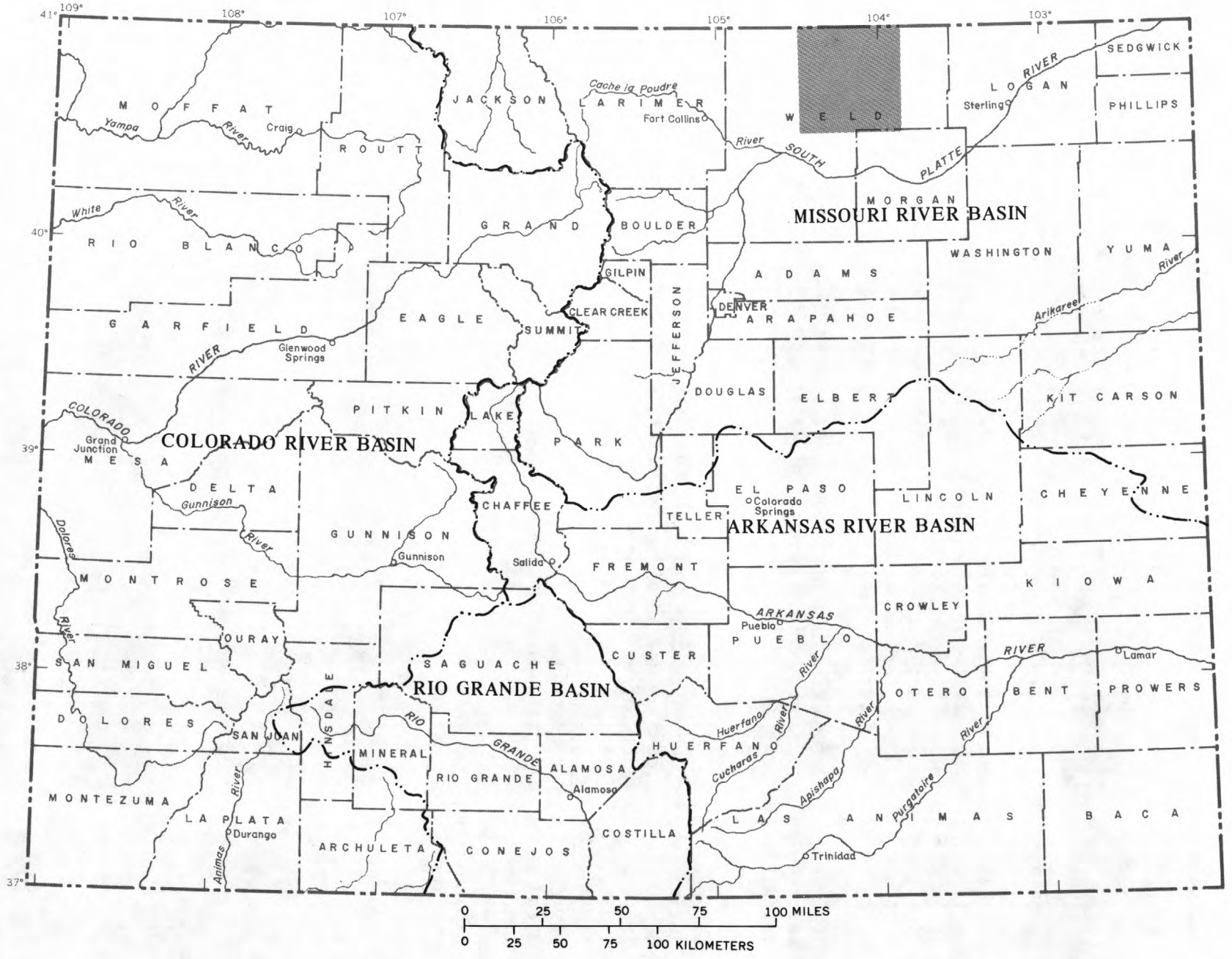


**Figure 15.--Location of area where effects of in-situ mining of uranium ores are being studied.**

PROJECT TITLE: Hydrologic Impact of In-situ Mining of Uranium Ores (fig. 15)

COOPERATING AGENCY: U.S. Environmental Protection Agency

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

PERIOD OF PROJECT: October 1976 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 for determining the geohydrologic system and for developing the model has begun. Water-level and water-quality data have been obtained from about 100 wells.

*Plans*.--Continue data collection, determine the geohydrologic system, and begin development of the model.

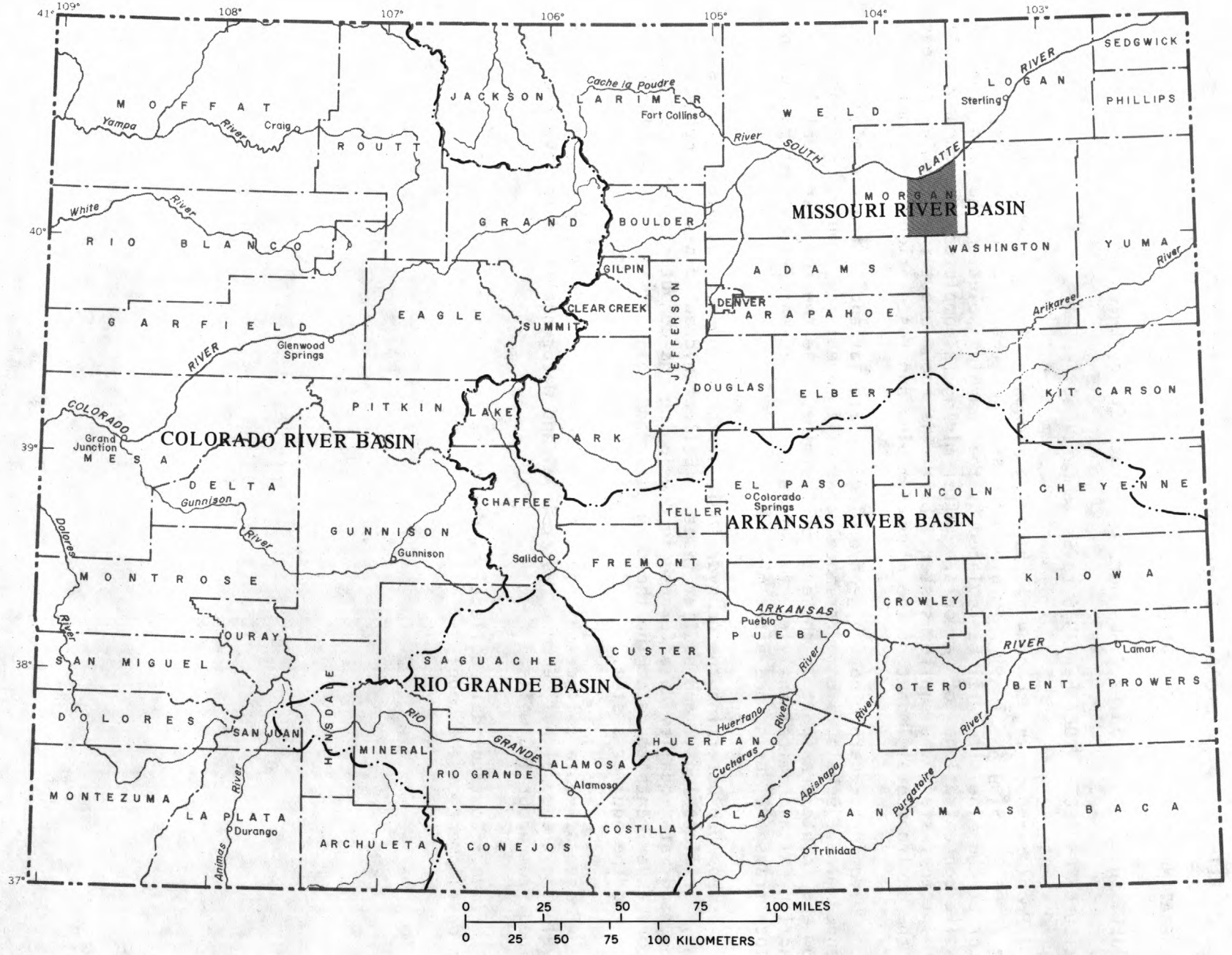


**Figure 16.--Location of artificial--recharge project, Badger and Beaver Creeks.**

PROJECT TITLE: Hydrologic Feasibility of an Artificial-Recharge Project, Badger and Beaver Creeks (fig. 16)

COOPERATING AGENCY: U.S. Fish and Wildlife Service

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

PERIOD OF PROJECT: March 1978 to September 1979

*Problem.*--The Badger and Beaver Creeks Water Conservancy District plans to annually divert about 90,000 acre-feet of water from the South Platte River for the purposes of artificially recharging the alluvial aquifers along the two creeks. The artificial-recharge project would not only provide irrigation water during droughts but could enhance fish and wildlife management in the area. The effects of the project on local and basin water resources needs to be determined.

*Objectives.*--Determine the availability of water from the South Platte River. Determine how much water will actually be recharged. Determine the effects of recharge on the ground-water system. Determine the total impact of the project on water resources in the South Platte River basin.

*Approach.*--Make a statistical analysis of historic streamflows considering water rights to determine availability. Develop a computer model to determine transit and evapotranspiration losses that would affect the volume of water actually recharged. Develop a computer model to predict effects of recharge on the ground-water system. Use an existing computer model to determine the impacts of the project on the basin's water resources.

*Progress.*--Statistical analysis has been completed. Computer model for transit and evapotranspiration losses has been developed and computer model for predicting effects of recharge is being developed.

*Plans.*--Complete development of computer model and begin analyses. Prepare a report describing the results of the study.

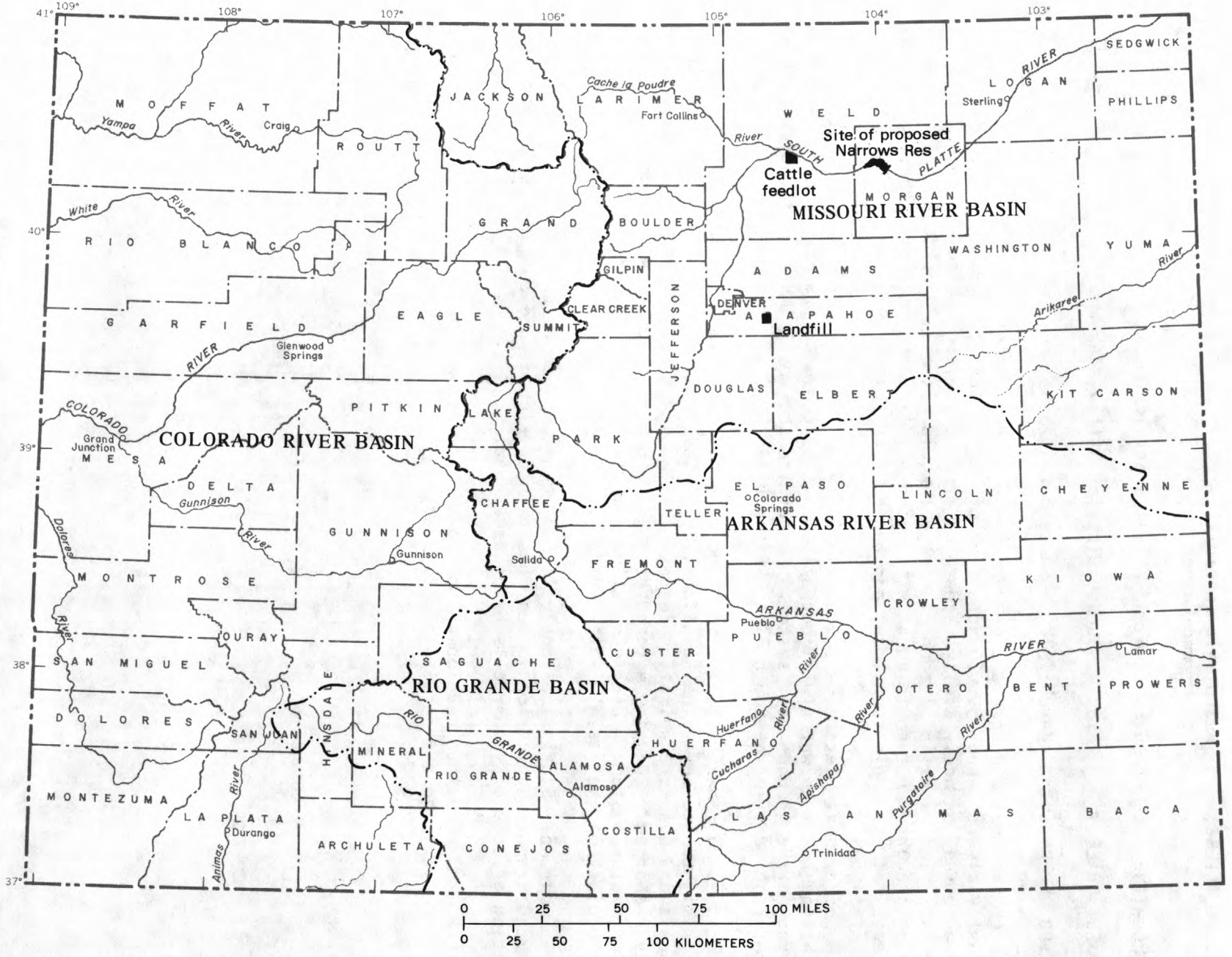


**Figure 17.--Location of the proposed Narrows Reservoir, cattle feedlot, and landfill.**

PROJECT TITLE: Effects of the Proposed Narrows Reservoir on Ground and Surface Water (fig. 17)

COOPERATING AGENCY: U.S. Bureau of Reclamation

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

PERIOD OF PROJECT: Continuous since October 1975

*Problem*.--Construction of the proposed Narrows Reservoir on the South Platte River will affect the ground- and surface-water systems at and in the vicinity of the reservoir. The magnitude of the effects of constructing, filling, and operating the reservoir needs to be known so that the impact of the reservoir on the ground- and surface-water systems can be evaluated and related to water use in the area.

*Objective*.--Determine the impact of the proposed reservoir on the ground- and surface-water systems.

*Approach*.--Develop steady-state and transient computer models to predict the effects of filling and operating the reservoir on the ground-water system. Collect streamflow, water-quality, and sediment-load data to determine existing water-quality and sediment-transport characteristics of the river. Conduct gain-and-loss studies to determine existing relations between ground and surface water.

*Progress*.--Steady-state and transient analyses have been completed. Results of steady-state analysis have been published. Streamflow, water-quality, and sediment-load data are being collected. Gain-and-loss studies are in progress.

*Plans*.--Continue data collection. Complete gain-and-loss studies. Complete reports on transient analysis and gain-and-loss studies.

PROJECT TITLE: Effects of Wastes from a Cattle Feedlot on the Chemical Quality of Water in an Alluvial Aquifer (fig. 17)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1973 to June 1979

*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 sampling from wells is continuing. A marked change in ground-water quality has not been observed.

*Plans*.--Complete water-quality sampling. Prepare a report describing the results of the study.

PROJECT TITLE: Monitoring Ground-Water Quality at a Landfill (fig. 17)

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.

*Plans*.--Continue to monitor water quality.

*Reports published or released during fiscal years 1977 and 1978*.--See reference 37 under Water-Resources Interpretive Report at back of report.

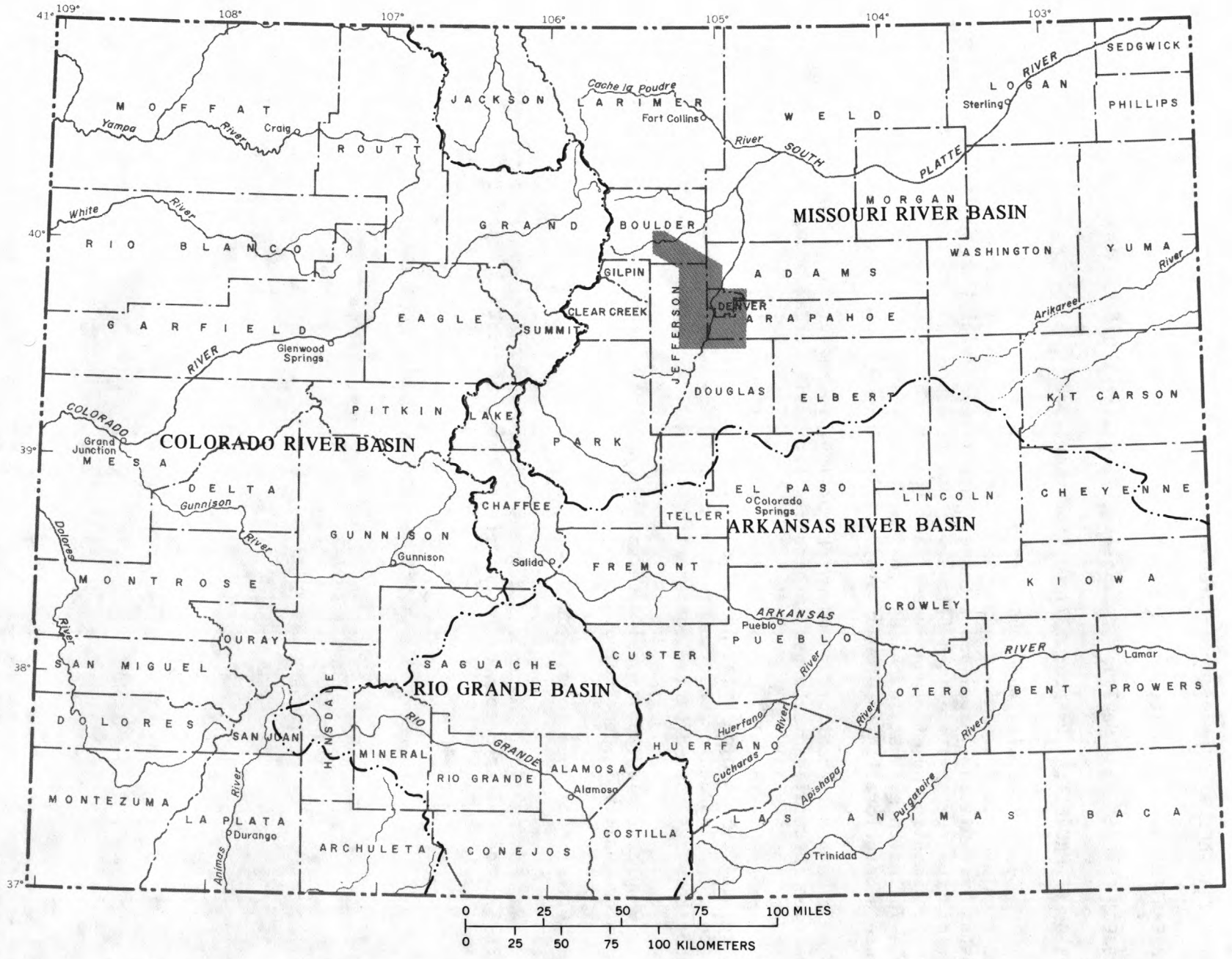


Figure 18.-- Location of the Denver–Boulder urban area.

PROJECT TITLE: Flood Frequency in Urban Areas (fig. 18)

COOPERATING AGENCY: Urban Drainage and Flood Control District

PROJECT CHIEF: Russell K. Livingston, 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 stimates 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 16 watersheds. Watershed characteristics have been determined. Computer models have been developed and calibrated for selected watersheds where sufficient data are available. Report containing data collected from October 1974 to September 1977 has been compiled; report to be released during fiscal year 1979.

*Plans*.--Modify data-collection network as necessary. Continue data collection. Calibrate additional computer models as sufficient data become available.

PROJECT TITLE: Rainfall-Runoff Management Model for the Denver Federal Center (fig. 18)

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. A contract was awarded to a private firm to prepare the orthophotographic base map. 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 but not calibrated because storms have been so infrequent that sufficient data to calibrate the model have not been collected.

*Plans.*--Continue data collection. Investigate the feasibility of calibrating the computer model using data collected from similar areas in the Denver metropolitan area.

PROJECT TITLE: Storm Runoff, Grange Hall Creek Basin, Northglenn (fig. 18)

COOPERATING AGENCY: City of Northglenn

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

PERIOD OF PROJECT: September 1977 to September 1981

*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 begun and includes 12 months of streamflow data at 2 sites; 6 months of precipitation data at 4 sites; 6 bimonthly water-quality analyses at 5 stream sites; 8 weekly water-quality analyses at 2 stream sites; and 118 water-quality analyses of snowmelt and rainfall runoff.

*Plans*.--Continue data collection and begin data interpretation.

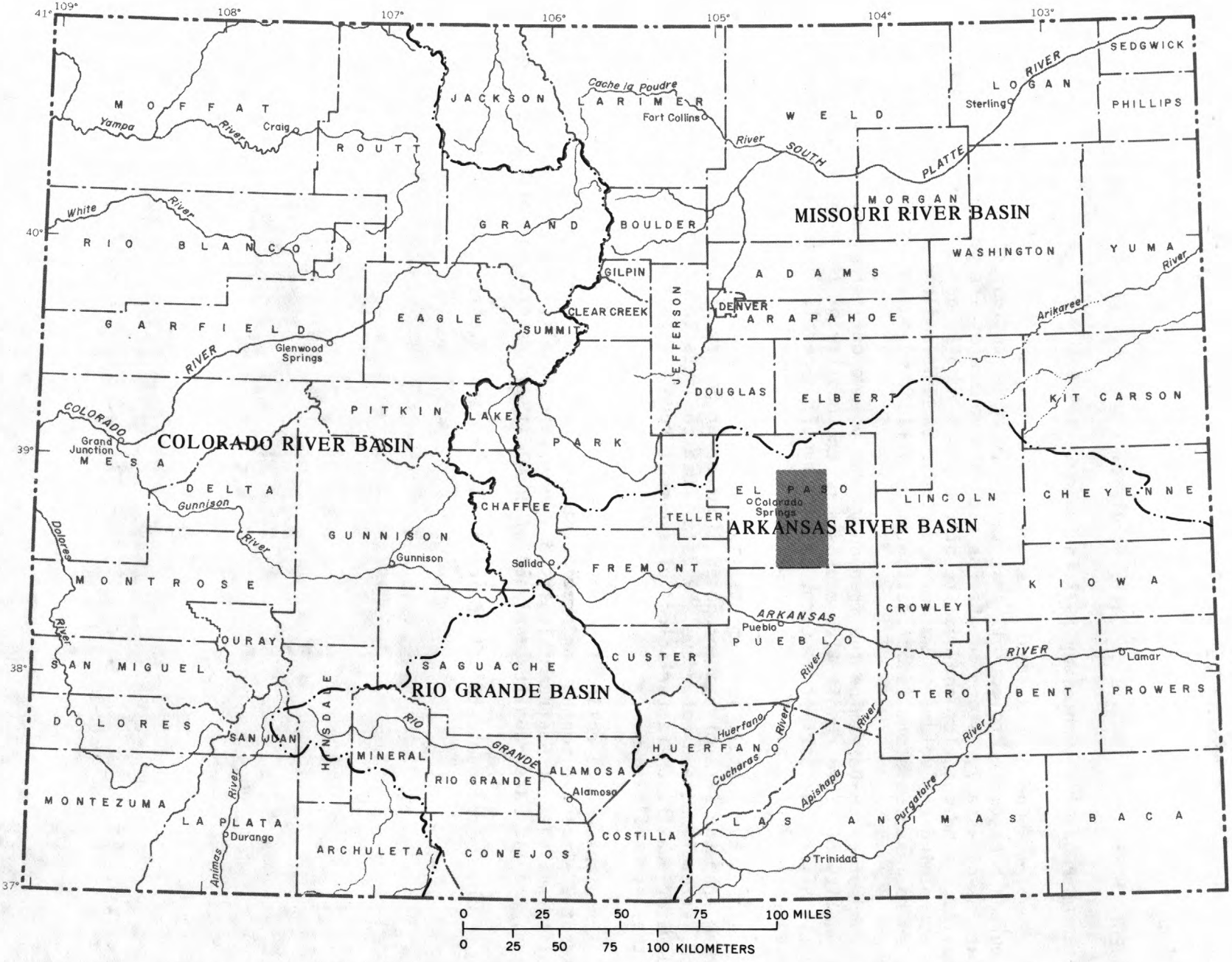


Figure 19.--Location of upper Black Squirrel Creek basin.

PROJECT TITLE: Ground Water in the Upper Black Squirrel Creek Basin (fig. 19)

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

PROJECT CHIEF: Patrick J. Emmons, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1977 to September 1980

*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. Data collection from about 30 wells has begun. Preparation of hydrogeologic maps has begun.

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

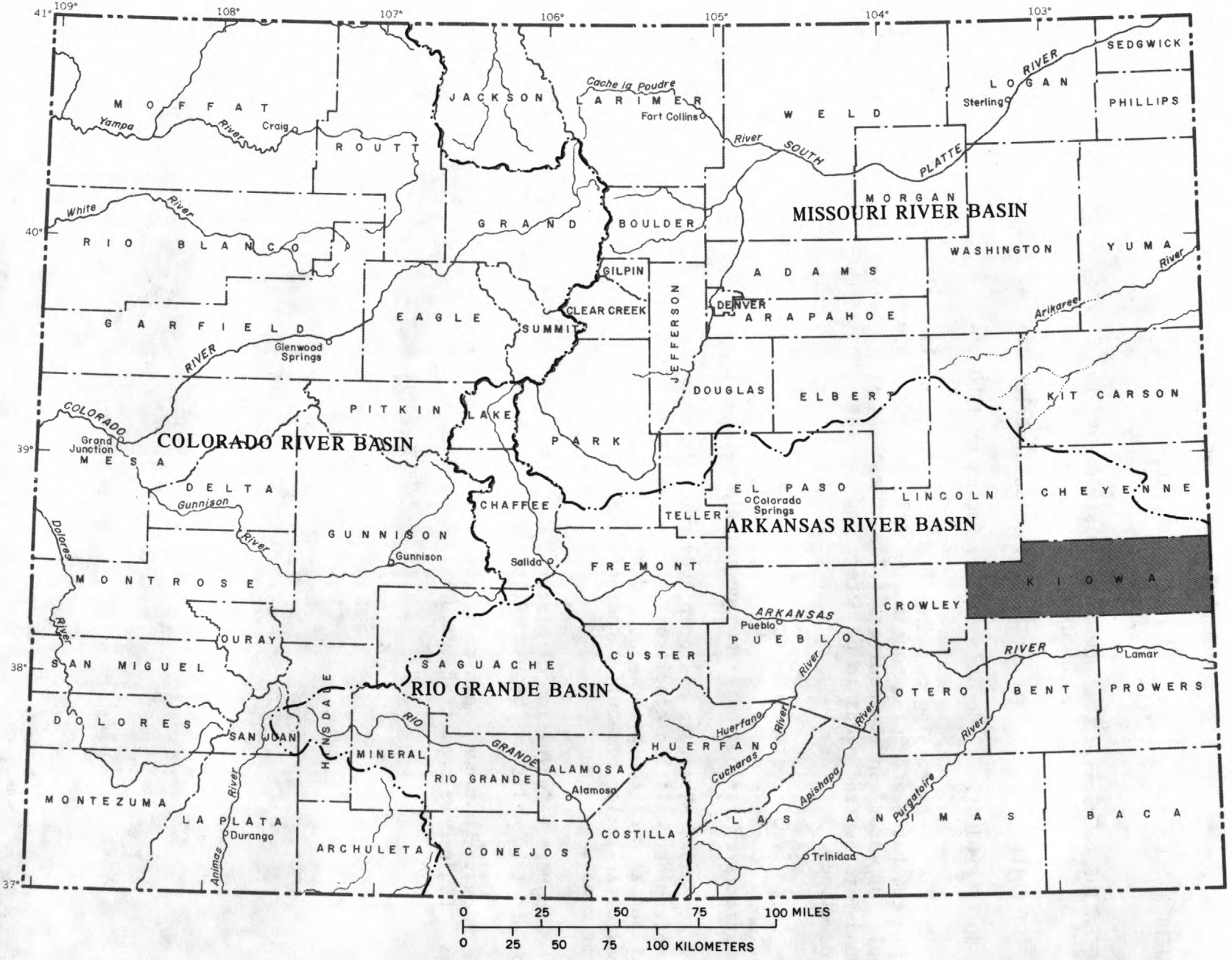


**Figure 20.--Location of Kiowa County.**

PROJECT TITLE: Availability and Chemical Quality of Ground Water in Kiowa County (fig. 20)

COOPERATING AGENCY: Kiowa County Board of Commissioners

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

PERIOD OF PROJECT: December 1977 to September 1979

*Problem*.--Increasing use of ground water for agricultural, domestic, and municipal water supplies has resulted in a need for an appraisal of the ground-water resources in the county.

*Objectives*.--Determine the availability and chemical quality of ground water in the county.

*Approach*.--Evaluate historic hydrogeologic data. Collect new hydrogeologic data to determine the location and areal extent of the major aquifers, depths and yields of wells completed in each aquifer, and the altitude of the water table or potentiometric surface in each aquifer. Collect water samples for chemical analysis from wells to determine the chemical quality of water in each aquifer.

*Progress*.--Historic hydrogeologic data has been collected. Data collection has begun.

*Plans*.--Evaluate historic hydrogeologic data. Complete data collection. Prepare a report describing the results of the study.

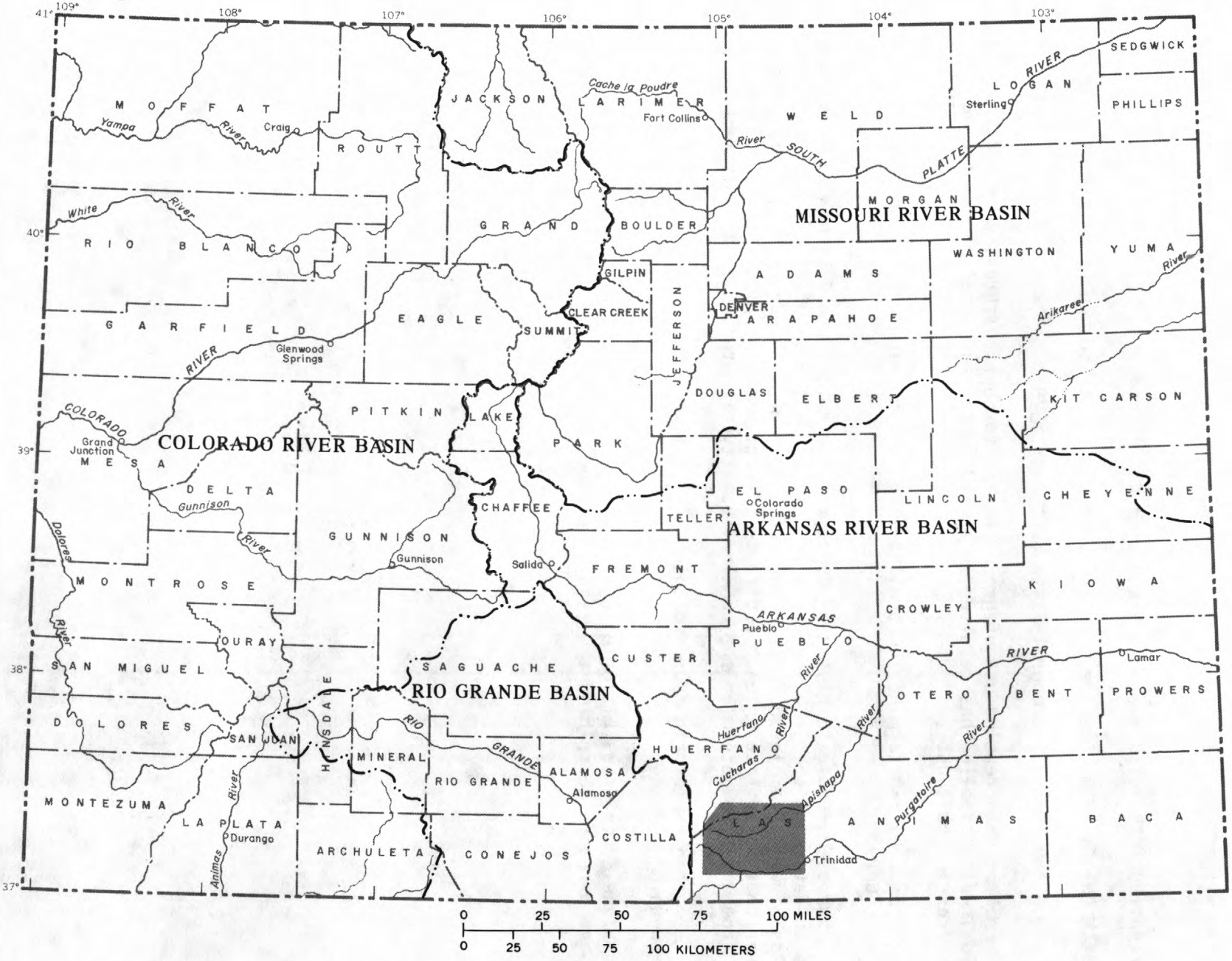


**Figure 21.--Location of Raton Mesa.**

PROJECT TITLE: Monitoring of the Hydrologic System of Raton Mesa (fig. 21)

COOPERATING AGENCY: U.S. Bureau of Land Management

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.

*Plans*.--Continue data collection.

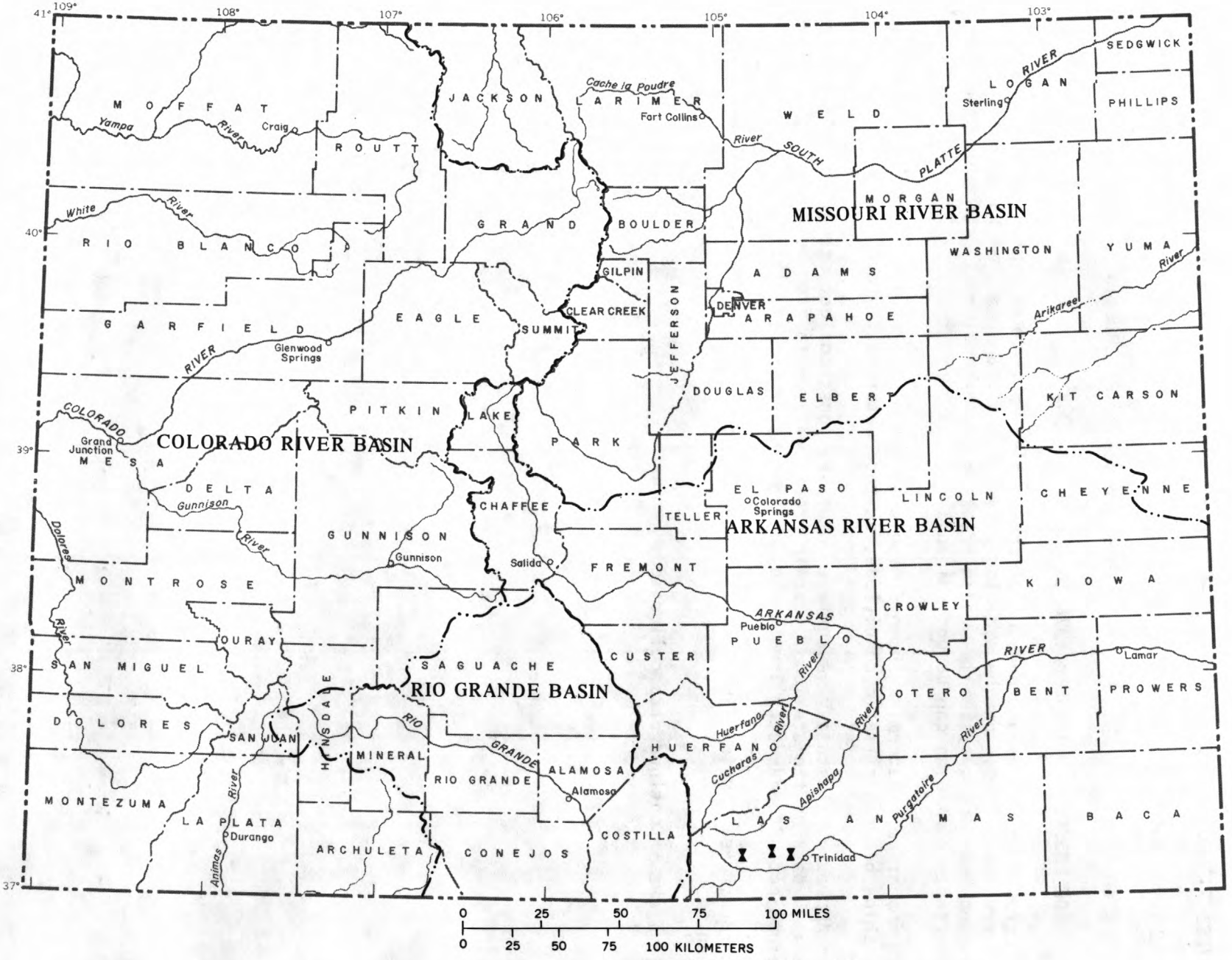


**Figure 22.--Location of stations monitoring the hydrologic system in three small basins, Raton Mesa coal fields.**

PROJECT TITLE: Intensive Hydrologic Monitoring of Small Basins in the Raton Mesa Coal Fields (fig. 22)

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 has begun.

*Plans*.--Continue data collection and begin development of computer models.

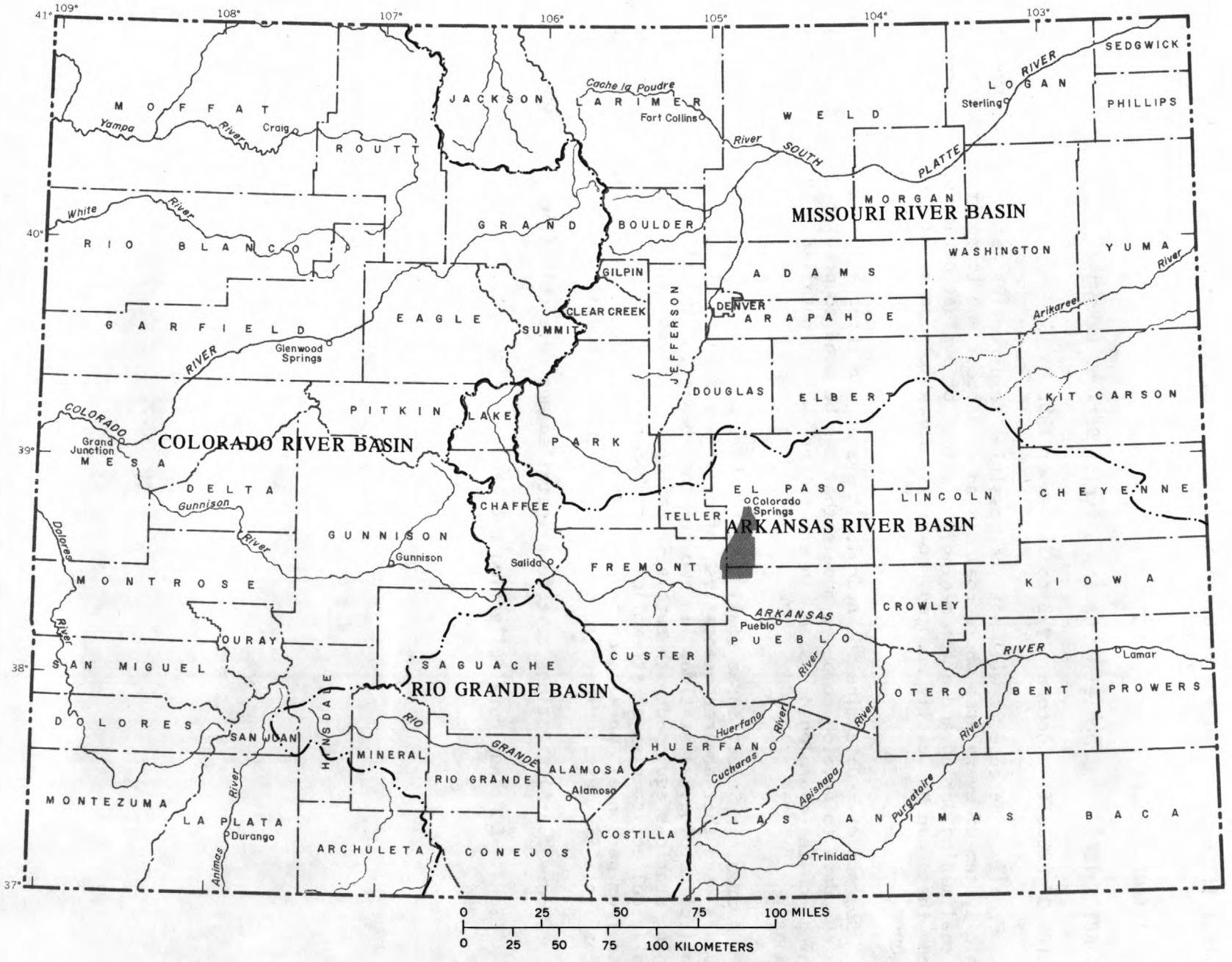


Figure 23.--Location of the Fort Carson Military Reservation.

PROJECT TITLE: Water-Resources Appraisal of the Fort Carson Military Reservation (fig. 23)

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

PROJECT CHIEF: Patrick J. Emmons, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1977 to September 1980

*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. Nineteen streamflow-gaging stations have been installed and data collection has begun. Selected data have been collected from existing wells. Samples of surface and ground water have been collected for water-quality analysis.

*Plans*.--Continue data collection and begin data interpretation.

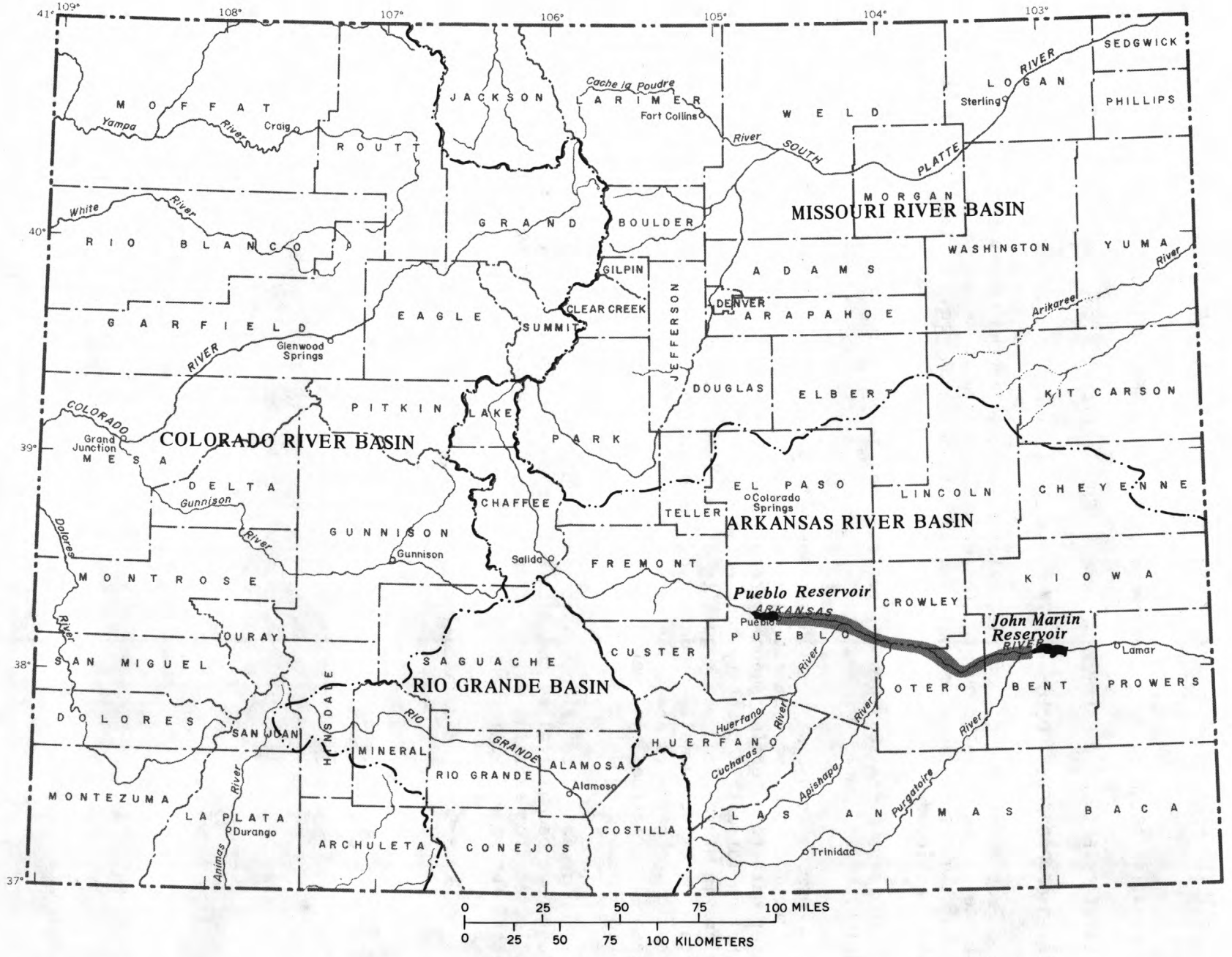


Figure 24.--Location of the reach of the Arkansas River between Pueblo and John Martin Reservoirs.

PROJECT TITLE: Travel Time and Transit Losses of Reservoir Releases, Arkansas River from Pueblo Reservoir to John Martin Reservoir (fig. 24)

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, that can predict the volume of water lost during transit, and that can 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.

*Plans*.--Collect streamflow and diversion data during a second test release or other suitable reservoir release for purposes of refining the predictive capability of the model.

*Reports published or released during fiscal years 1977 and 1978*.--See reference 31 under Water-Resources Interpretive Reports at back of report.

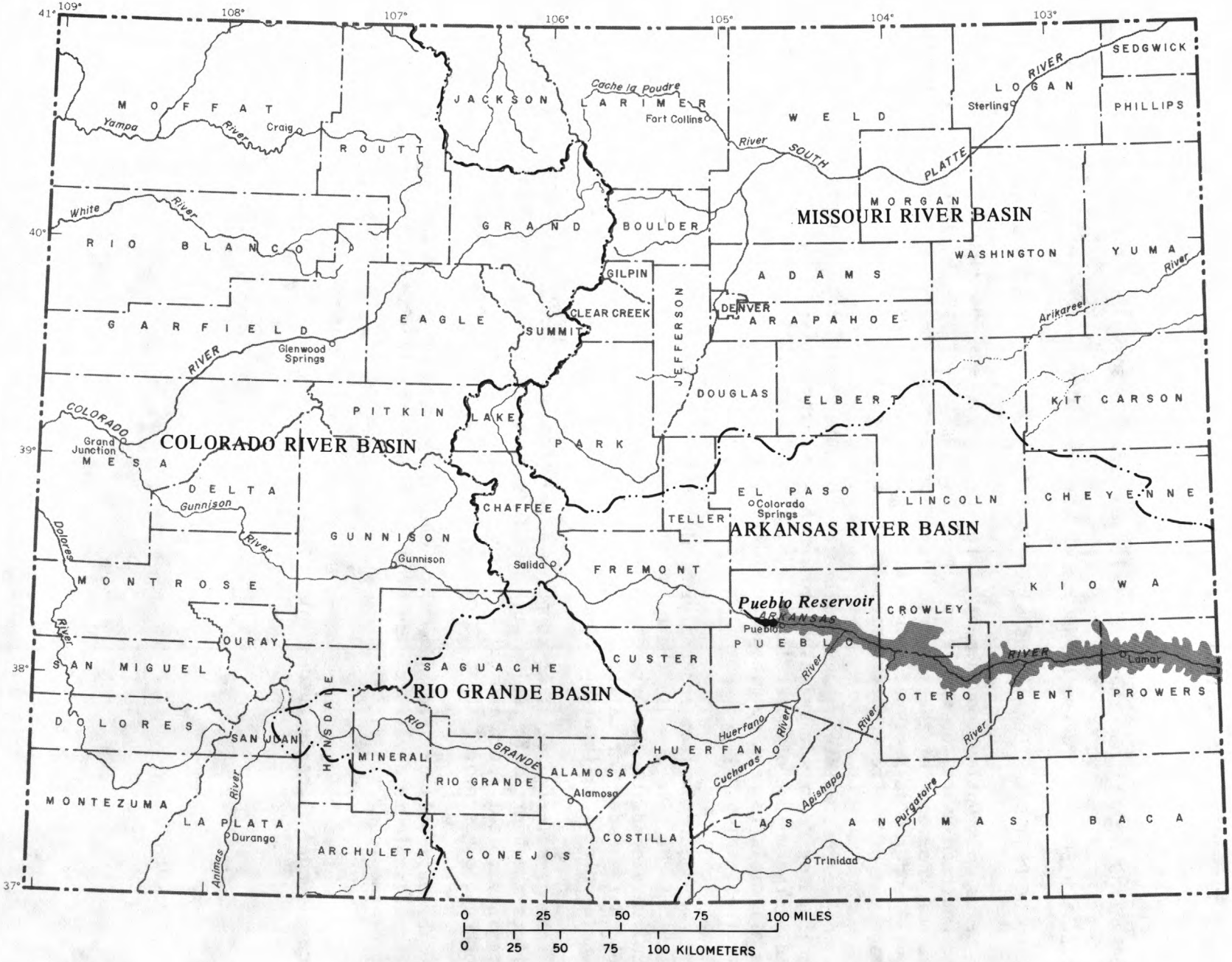


Figure 25.--Location of the Arkansas River valley downstream from Pueblo Reservoir.

PROJECT TITLE: Hydrology of the Arkansas River Valley, Pueblo Reservoir to Colorado-Kansas State Boundary (fig. 25)

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 800 wells in the valley.

*Plans.*--Collect water-level data from wells, evaluate the data, and develop an optimum observation-well network. Update and revise the water-management model as required.

*Reports published or released during fiscal years 1977 and 1978.*--See reference 10 under Water-Resources Data Reports at back of report.

PROJECT TITLE: Surface-Water Return Flow from Irrigated Lands to the Arkansas River, Pueblo Reservoir to the Colorado-Kansas State Boundary (fig. 25)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

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

PERIOD OF PROJECT: October 1976 to September 1979

*Problem.*--Surface water flowing from irrigated lands to the Arkansas River contains chemical constituents that affect the water quality of the river. A knowledge of the types and quantities of the chemical constituents is needed by local officials to better manage the water resources of the area.

*Objectives.*--Delineate the areal extent of irrigated lands contributing return flows to the Arkansas River. Determine the volume and water quality of the return flows.

*Approach.*--Use existing land-use maps and recent aerial photography to delineate the areal extent of irrigated lands. Use records from existing streamflow stations to determine the volume of return flows. Collect samples for chemical analysis; analyze for constituents, such as chloride, nitrate, and pesticides.

*Progress.*-Delineation of irrigated land and collection of streamflow-discharge and chemical-quality data are in progress.

*Plans.*-Complete delineation of irrigated lands and data collection. Interpret data and prepare a report describing the results of the study.

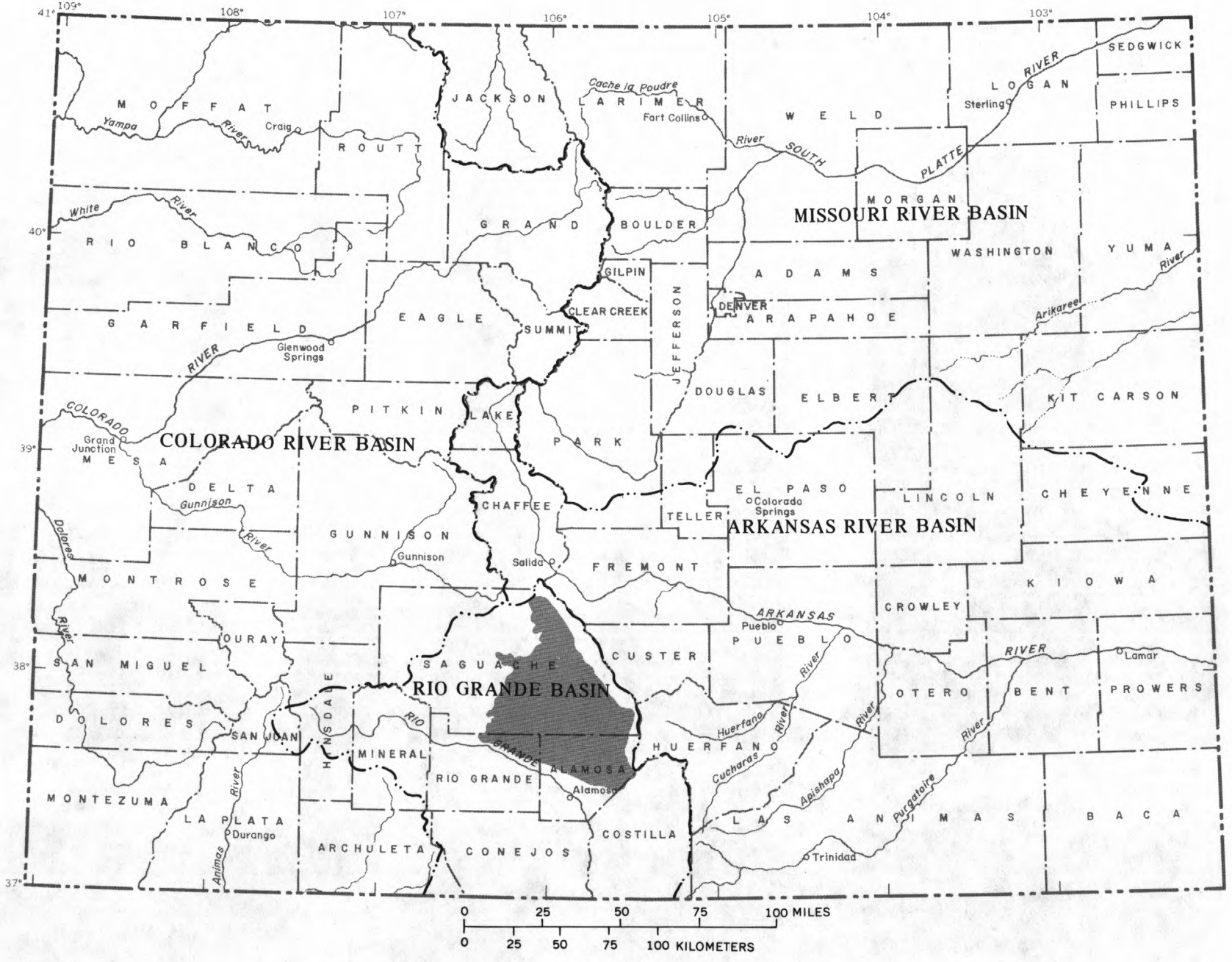


Figure 26.--Location of the closed--basin part of the San Luis Valley.

PROJECT TITLE: Hydrology of the Closed-Basin Part of the San Luis Valley in Colorado (fig. 26)

COOPERATING AGENCY: U.S. Bureau of Reclamation

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

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.*--Test wells and observation wells have been drilled at two aquifer-test sites by the U.S. Bureau of Reclamation. An aquifer test has been completed at one site. Vandalism of the wells at the second site has prevented the conducting of an aquifer test and geophysical logging by the U.S. Geological Survey. Water-quality data have been obtained from 16 wells, 3 streams and 1 lake. Development of the computer models has begun.

*Plans.*--Continue the test-well drilling and aquifer-testing program. Install continuous water-level recorders in about 10 wells. Complete development of the computer models.

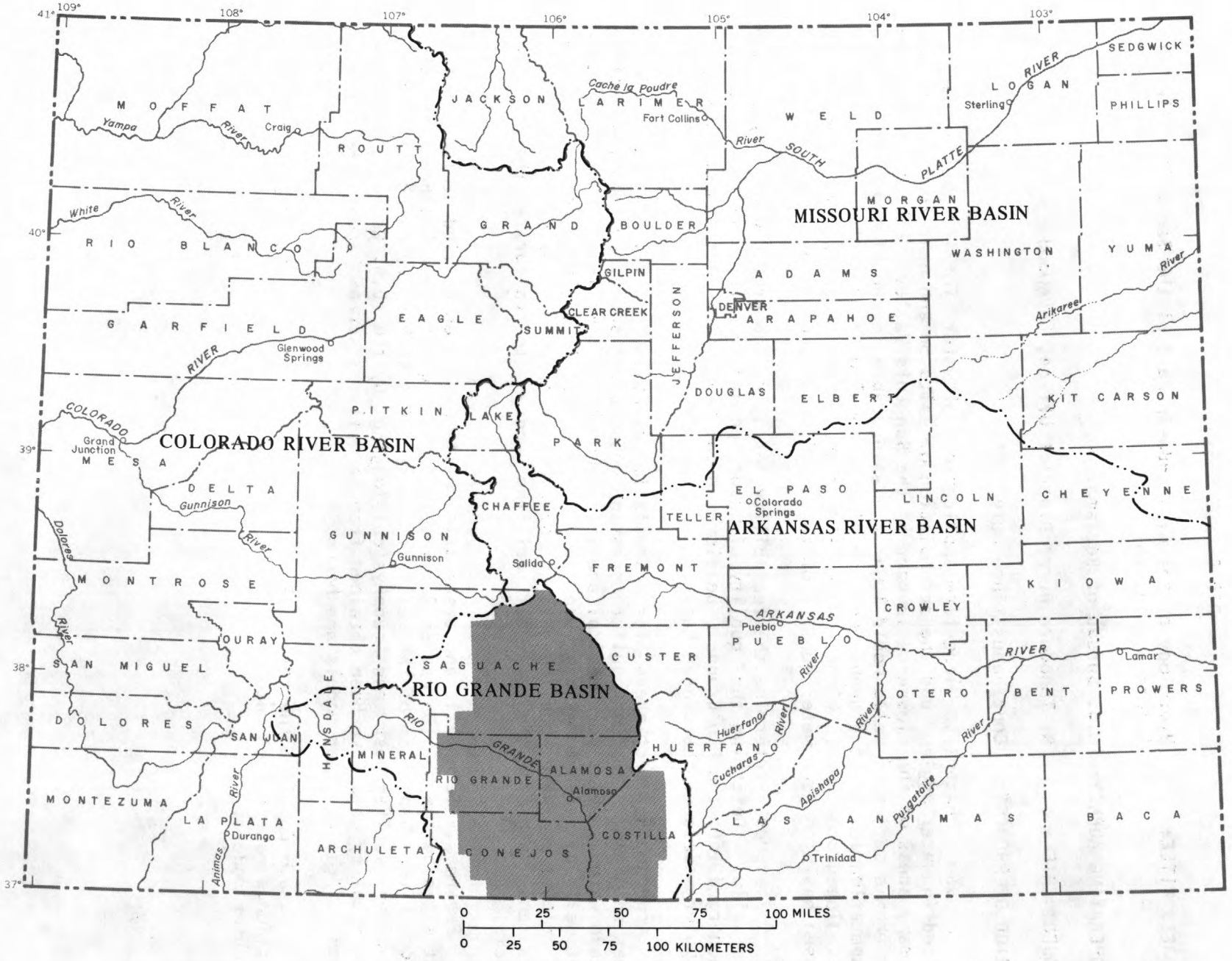


Figure 27.--Location of the San Luis Valley.

PROJECT TITLE: Water Resources of the San Luis Valley in Colorado (fig. 27)

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 groundwater 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 has 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.

*Reports published or released during fiscal years 1977 and 1978*.--See reference 9 under Water-Resources Data Reports at back of report.

PROJECT TITLE: Computer Model Study of the San Luis Valley (fig. 27)

COOPERATING AGENCY: Rio Grande Water Conservation District

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

PERIOD OF PROJECT: October 1977 to September 1979

*Problem*.--The effects of possible water-management alternatives on the ground-water system need to be known so that State and local officials can effectively manage the system.

*Objective*.--Develop a computer model that can be used to predict the effects of various water-management alternatives proposed by State and local officials.

*Approach*.--Use the existing electric-analog model, which was completed in the early 1970's, and data collected since completion of the model to develop a three-dimensional computer model of the ground-water system.

*Progress*.--Development of the computer model has begun.

*Plans*.--Complete development of the computer model.

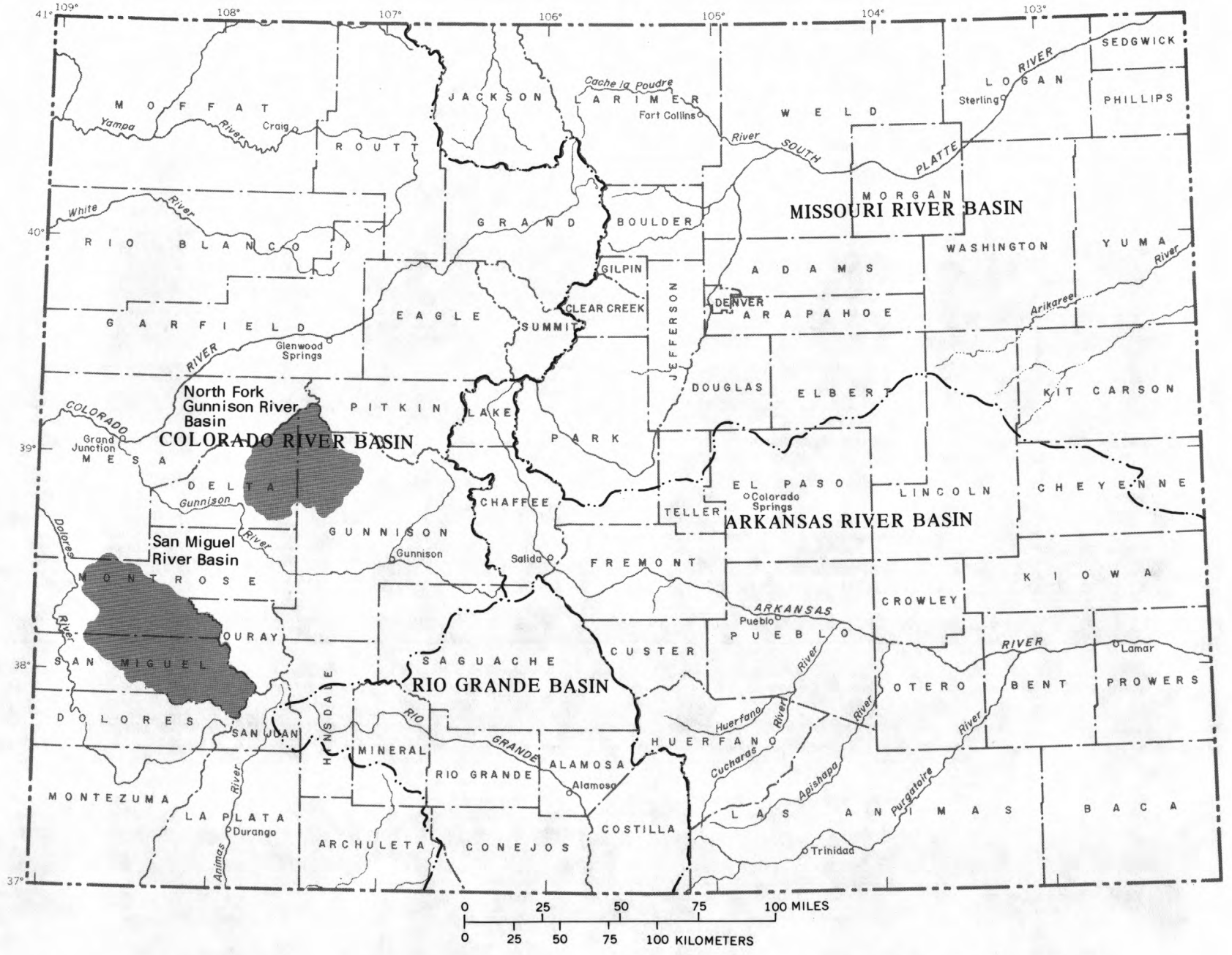


**Figure 28.--Location of the North Fork Gunnison River and San Miguel River basins.**

PROJECT TITLE: Evaluation of Aquifers, Western Colorado (fig. 28)

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

PROJECT CHIEF: Timothy F. Giles, 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 preparation. Data collection is in progress for the North Fork Gunnison River and the San Miguel River basins.

*Plans.*--Complete report in preparation. Complete the studies of the North Fork Gunnison River and the San Miguel River basins and prepare final reports describing the results of the studies. Select other areas for study in western Colorado.

*Reports published or released during fiscal years 1977 and 1978.*--See reference 3 under Water-Resources Data Reports and references 9 and 15 under Water-Resources Interpretive Reports at back of report.

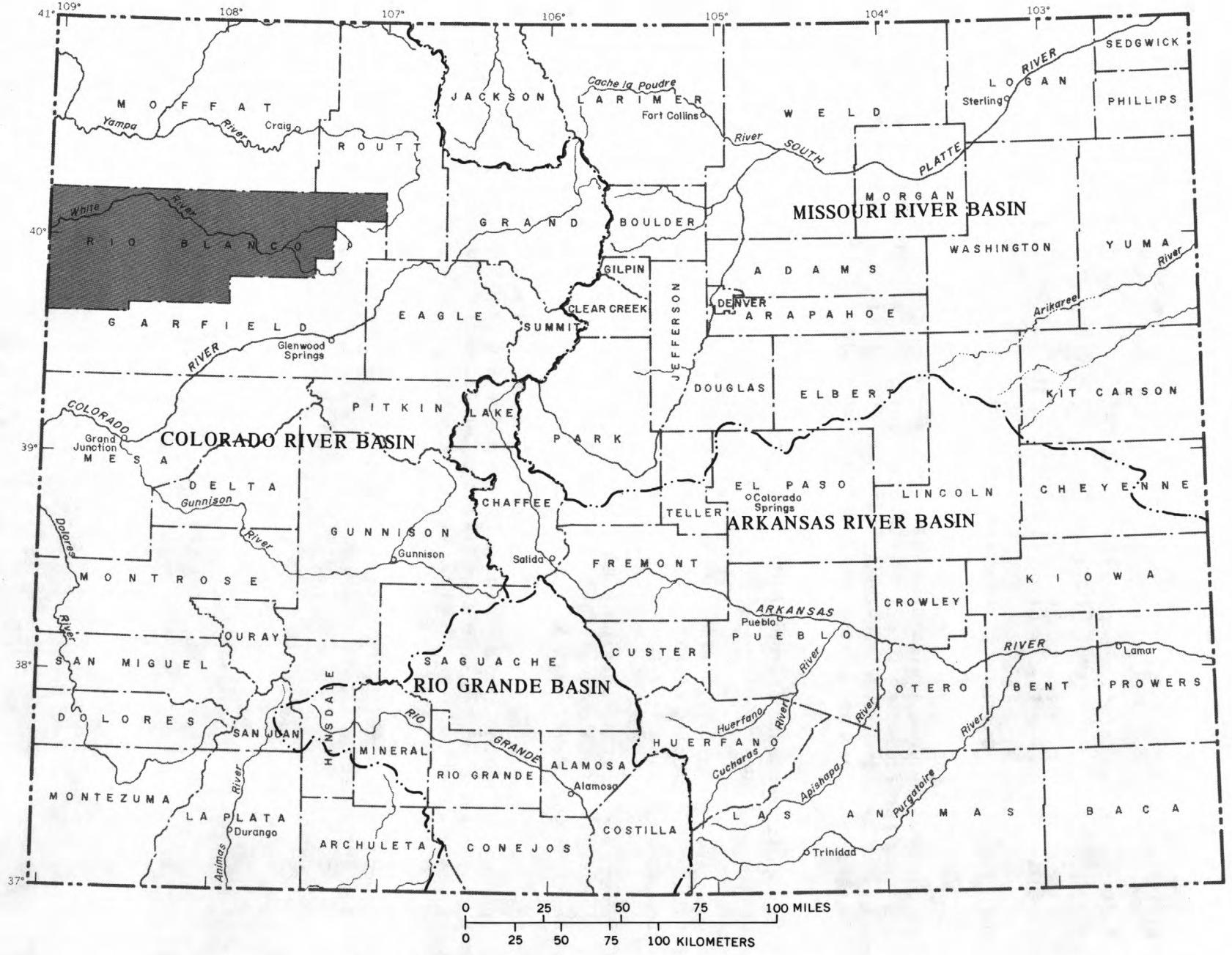


**Figure 29.--Location of Rio Blanco County.**

PROJECT TITLE: Ground-Water Resources of Rio Blanco County (fig. 29)

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 has begun.

*Plans*.--Continue data collection and begin data interpretation.

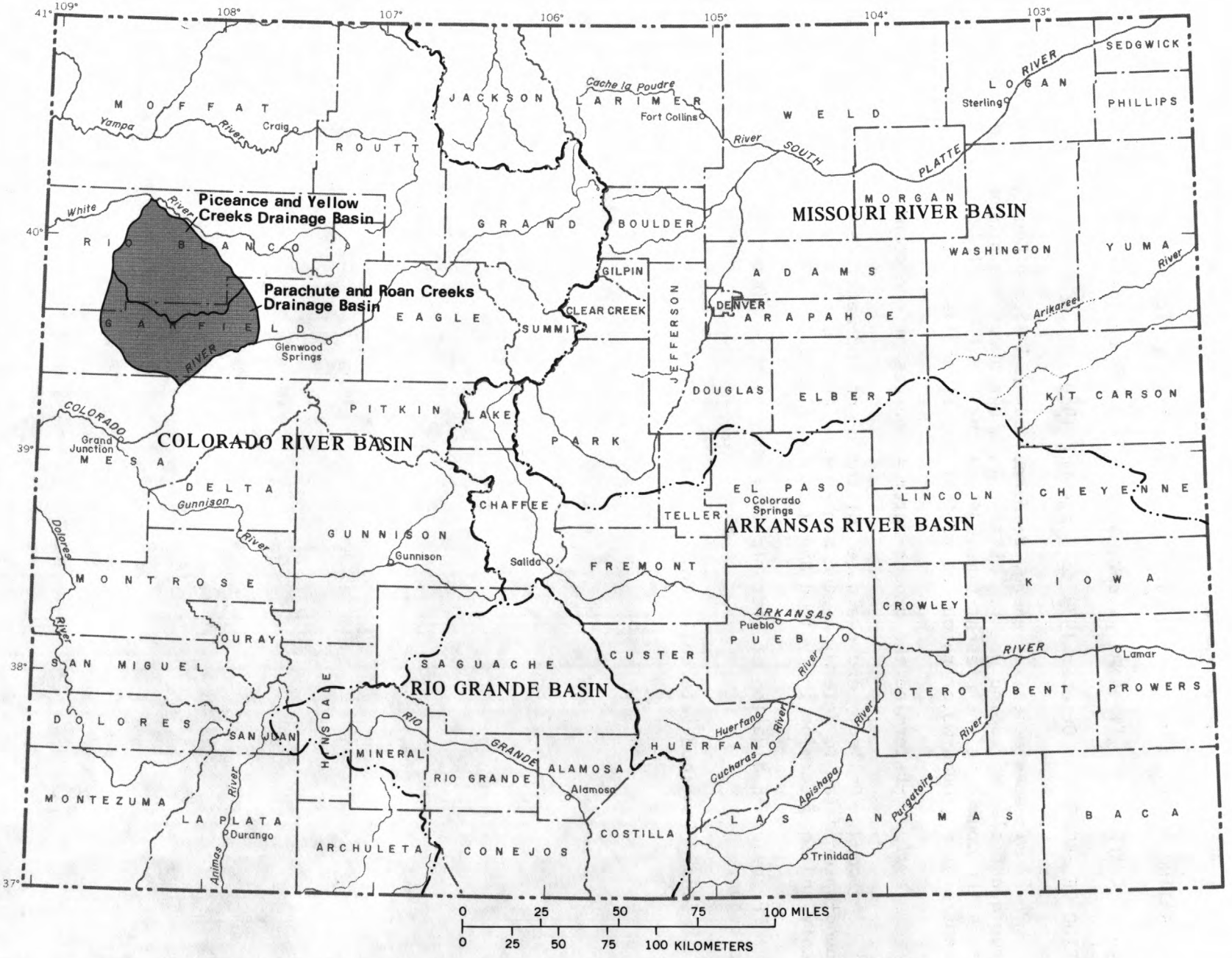


Figure 30.--Location of Piceance and Yellow Creeks and Parachute and Roan Creeks drainage basins.

PROJECT TITLE: Hydraulic Research of Springs, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: George J. Saulnier, Jr., 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 89 springs. Data collection has been completed. A report on geologic sources of springs is being prepared.

*Plans*.--Complete report. 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. 30)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: Continuous since July 1974

*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 58 wells twice a year. Continuous water-level recorders have been installed in two wells on oil-shale Tract C-b.

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

*Reports published or released during fiscal years 1977 and 1978*.--See reference 19 under Water-Resources Data Reports at back of report.

PROJECT TITLE: Aquifer Testing, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: Continuous since July 1974

*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.

*Plans*.--Conduct conventional aquifer tests at 12 sites. Prepare a contract to rehabilitate three additional existing wells.

PROJECT TITLE: Geochemical Investigation, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: George J. Saulnier, Jr., Subdistrict Office, Meeker

PERIOD OF PROJECT: Continuous since July 1974

*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 mining 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 groundwater-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. Development of the solute-transport model has been completed. A report describing the results of the study is being prepared.

*Plans.*--Complete report. Establish a data-collection network to obtain additional data to refine the predictive capability of the model and to monitor water quality.

*Reports published or released during fiscal years 1977 and 1978.*--See reference 38 under Water-Resources Interpretive Reports at back of report.

PROJECT TITLE: Sediment Yield of Streams, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: Continuous since July 1974

*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 yield alters channel geometry and morphology and reduces the conveyance capacity of streams. The existing sediment yield of streams needs to be known prior to the beginning of oil-shale mining so that the effects of the mining on sediment yield of streams can be determined.

*Objectives.*--Determine the present sediment yield 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. Data collection has been completed.

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

PROJECT TITLE: Occurrence of Benthic Invertebrates, Piceance Creek Drainage Basin (fig. 30)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: Continuous since October 1976

*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.

PROJECT TITLE: Hydrologic Reconnaissance of Parachute Creek and Roan Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: Continuous since July 1974

*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 ollect 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 of the stations are equipped with automatic suspended-sediment samplers and five stations 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 35 springs. An observation-well network has been established. 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.

*Plans.*--Continue data collection. Expand spring and observation-well network. Complete aquifer tests in alluvial aquifer along Roan Creek. Begin data interpretation. Plan for continued collection of hydrologic data throughout the prototype phase of oil-shale development.

PROJECT TITLE: Computer Model Study of the Parachute Creek and Roan Creek Drainage Basins (fig. 30)

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

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

PERIOD OF PROJECT: August 1977 to January 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*.--Computer model has been constructed.

*Plans*.--Calibrate and verify the computer model.

PROJECT TITLE: Hydrologic Reconnaissance of the U.S. Naval Oil Shale Reserve No. 1, Parachute Creek Drainage Basin (fig. 30)

COOPERATING AGENCY: U.S. Department of Energy

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

PERIOD OF PROJECT: October 1976 to September 1979

*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.*--Complete data collection and interpretation. Prepare a report describing the results of the study.

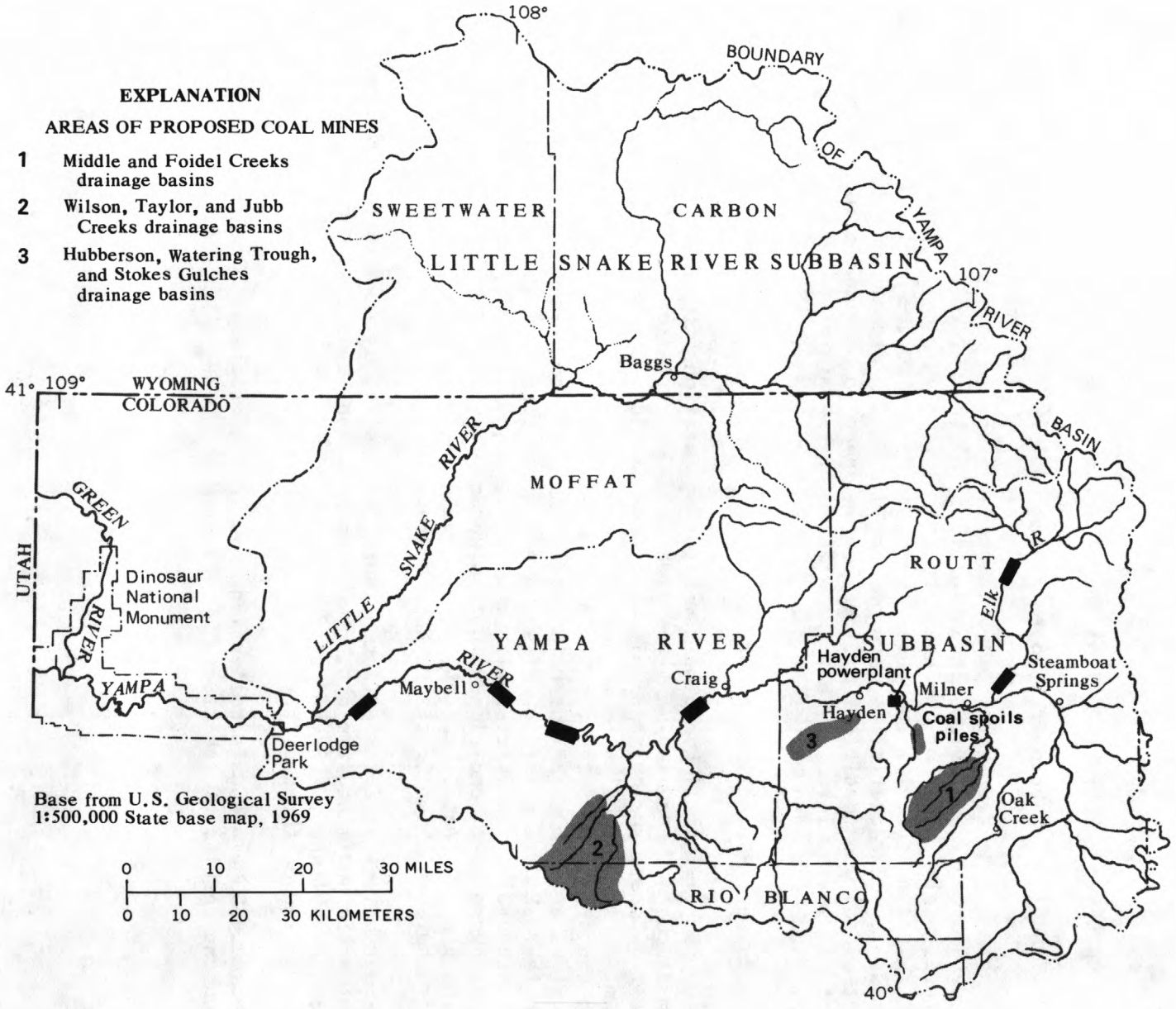


Figure 31.--Location of study reaches on the Yampa and Elk Rivers in the Yampa River Basin, areas of proposed coal mines and coal-spoils piles, and the Hayden powerplant.

PROJECT TITLE: Evaluation of Streamflow for Recreational Uses (fig. 31)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: August 1978 to September 1980

*Problem.*--Competition for limited surface-water supplies to meet the needs of increasing industrial and municipal development may adversely affect streamflows required to support aquatic life. The hydraulic characteristics of streamflow required to support aquatic life need to be determined to maintain a balanced aquatic environment.

*Objectives.*--Evaluate three methods for determining depth-velocity characteristics in streams. Determine depth-velocity relations needed for optimum fish-habitat conditions.

*Approach.*--Collect streamflow data to evaluate the following methods for determining depth-velocity characteristics in selected reaches of the Yampa and the Elk Rivers: Step-backwater analysis; stage-discharge and stage-velocity relations; and mean-stream reach velocity-depth relations. Develop a computer model to predict streamflow velocity and depth. Evaluate results to determine if streams in other river basins within the State should be studied.

*Progress.*--Data collection has been completed. Data interpretation has begun.

*Plans.*--Complete data interpretation and development of computer model. Evaluate results to determine if other streams should be studied, and develop plans for additional studies.

PROJECT TITLE: Hydrology of Proposed Coal-Mining Areas, Moffat, Rio Blanco, and Routt Counties (fig. 31)

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.

*Plans*.--Complete installation of equipment and continue to collect hydrologic data. Begin calibration of computer model.

PROJECT TITLE: Hydrology and Reclamation Potential of Coal-Spoils Piles (fig. 31)

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. Data collection and interpretation has begun.

*Plans.*--Continue data collection and interpretation. Begin development of computer model.

PROJECT TITLE: Effects of Disposing Wastes from a Coal-Burning Powerplant on the Ground-Water System (fig. 31)

COOPERATING AGENCY: U.S. Environmental Protection Agency

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

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 30 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 the wells and river to monitor the effects of the waste disposal.

*Progress*.--Data-collection network established. Data collection has begun.

*Plans*.--Continue data collection and begin data interpretation.

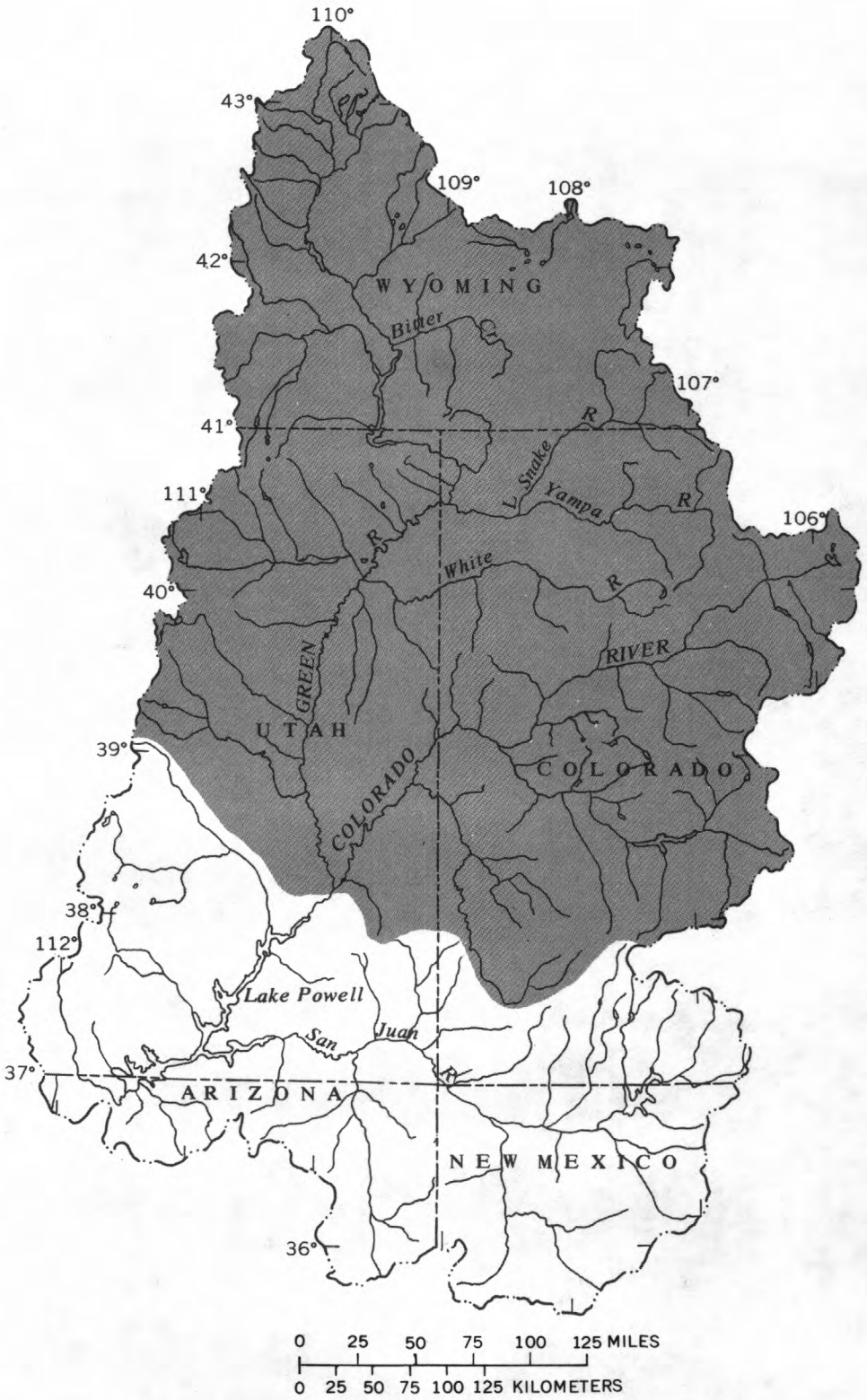


Figure 32.--Location of the Upper Colorado River Basin upstream from Lake Powell.

PROJECT TITLE: Ground-Water Contribution to Salinity of Streams in the Upper Colorado River Basin Upstream from Lake Powell (fig. 32)

COOPERATING AGENCY: U.S. Bureau of Land Management

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

PERIOD OF PROJECT: October 1977 to September 1979

*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.

*Plans.*--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 a monitoring network of about 10 stations on selected streams.

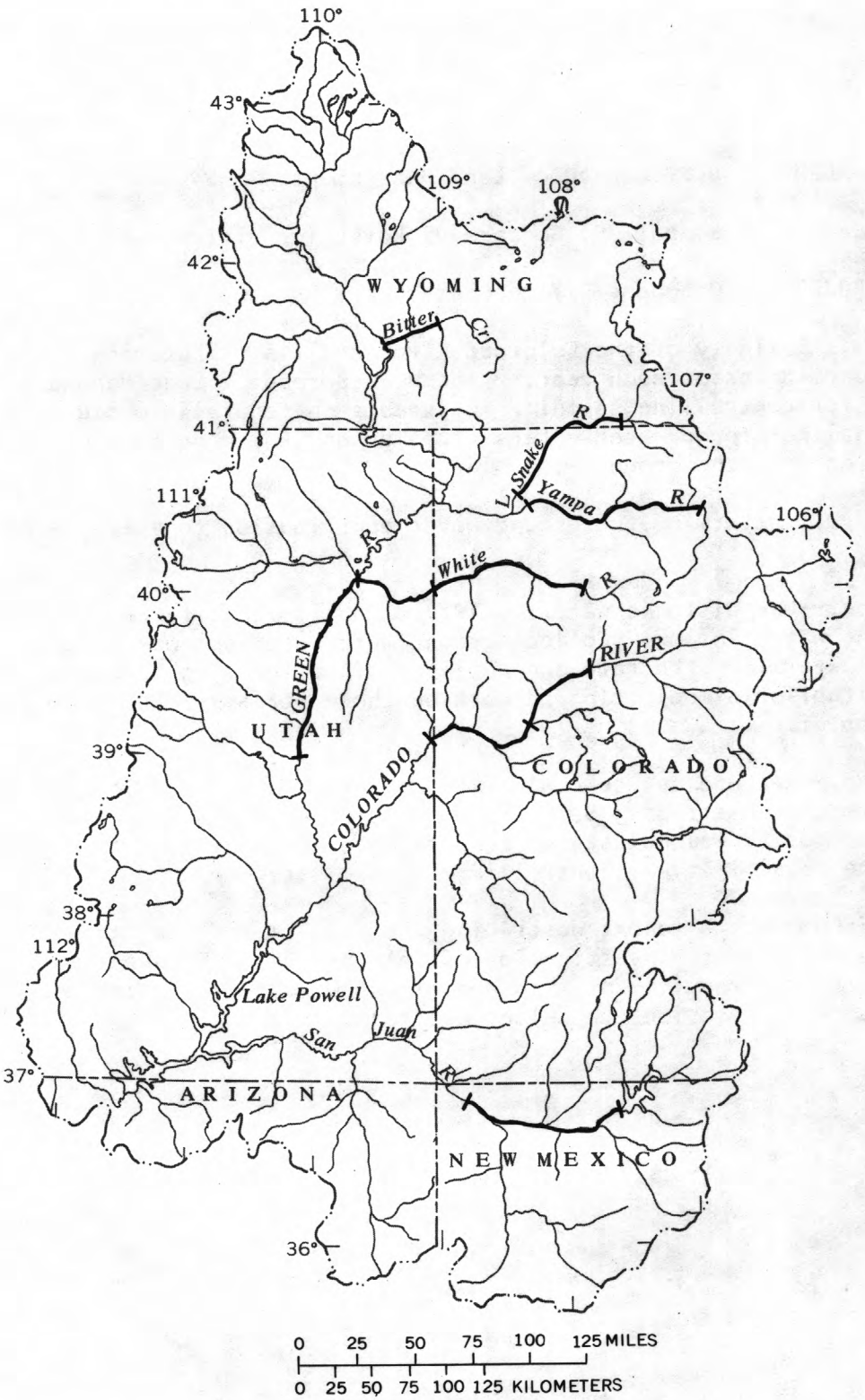


Figure 33.--Location of the nine areas in the Upper Colorado River Basin where projected changes in surface–water quality were estimated.

PROJECT TITLE: Projected Changes in Surface-Water Quality as a Result of Alternative Methods of Energy-Resource Development in Nine Areas of the Upper Colorado River Basin (fig. 33)

COOPERATING AGENCY: U.S. Water Resources Council

PROJECT CHIEF: Timothy D. Steele, District Office, Lakewood

PERIOD OF PROJECT: July 1978 to January 1979

*Problem*.--Surface-water quality may be degraded in areas where energy development occurs. The magnitude of possible changes in surface-water quality that could result from alternative methods of energy development needs to be determined to assess the total potential impact of energy development on surface-water quality in the Upper Colorado River Basin.

*Objective*.--Estimate the possible changes in surface-water quality resulting from alternative methods of energy development in areas where alternative development methods have been proposed and evaluated.

*Approach*.--Obtain required data for the nine areas. Use computer models developed by the U.S. Geological Survey to estimate possible impacts on surface-water quality that could occur as a result of various combinations of development alternatives. The number and results of estimations will depend on the type and amount of available data.

*Progress*.--All computer simulations have been completed.

*Plans*.--Prepare a report describing the results of the study.

## REPORTS PUBLISHED OR RELEASED DURING FISCAL YEARS 1977 AND 1978

Reports published or released during fiscal years 1977 and 1978 may be purchased or inspected as follows:

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COLORADO WATER CONSERVATION BOARD: WATER-RESOURCES CIRCULARS--May be purchased from:

Colorado Water Conservation Board
1313 Sherman Street
Denver, CO 80203

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