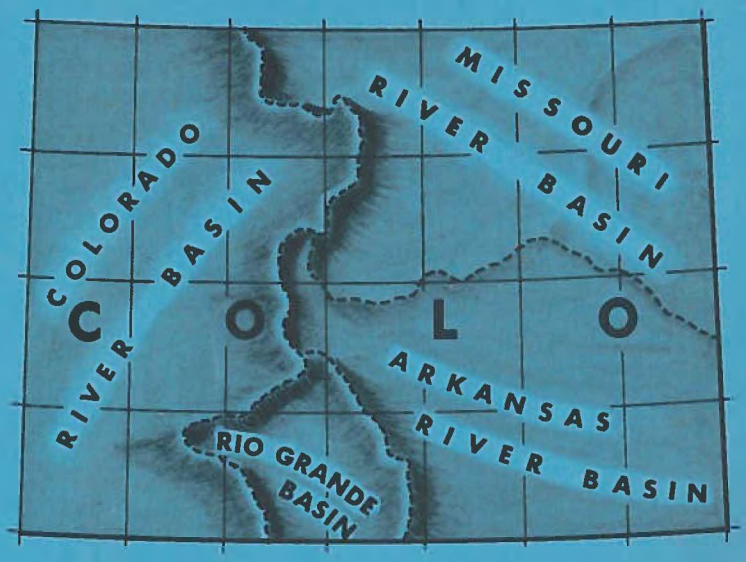
WATER FOR TOMORROW



COLORADO STATE WATER PLAN

Phase I - Appraisal Report

BUREAU OF RECLAMATION IN COOPERATION WITH THE STATE OF COLORADO

FEBRUARY 1974

DEPARTMENT OF THE INTERIOR
ROGERS C.B. MORTON, SECRETARY
BUREAU OF RECLAMATION
, COMMISSIONER

STATE OF COLORADO
JOHN D. VANDERHOOF, GOVERNOR
DEPARTMENT OF NATURAL RESOURCES
Colorado Water Conservation Board
FELIX L. SPARKS, DIRECTOR

WATER FOR TOMORROW

COLORADO STATE WATER PLAN

PHASE I

APPRAISAL REPORT
on
Water and Related Land Resources
and
Their Present Utilization

United States Department of the Interior
Bureau of Reclamation
in cooperation with
The State of Colorado

February 1974

THIS REPORT WAS PREPARED PURSUANT TO THE OCTOBER 8, 1969, ACT OF CONGRESS, PUBLIC LAW 91-81. PUBLICATION OF THE FINDINGS AND RECOMMENDATIONS HEREIN SHOULD NOT BE CONSTRUED AS REPRESENTING EITHER THE APPROVAL OR DISAPPROVAL OF THE SECRETARY OF THE INTERIOR. THE PURPOSE OF THIS REPORT IS TO PROVIDE INFORMATION AND ALTERNATIVES FOR FURTHER CONSIDERATION BY THE BUREAU OF RECLAMATION, THE SECRETARY OF THE INTERIOR, AND OTHER FEDERAL AGENCIES.

PREFACE

This report is the result of cooperative investigations and efforts between the Colorado Water Conservation Board and the Lower Missouri, Upper Colorado, and Southwest Regions of the Bureau of Reclamation. Authority for these investigations is contained in the provisions of the Water Resources Planning Act of July 22, 1965, with respect to the coordination of studies, investigations, and assessments for the purpose of developing a general plan to meet the future water needs for the Western United States. The Colorado Water Conservation Board, in 1970, requested Federal assistance in making the investigations that will develop various options and alternatives from which to select a Statewide water management plan. Beginning in fiscal year 1970, Federal funds were appropriated for the Bureau to initiate the investigations.

The initial efforts were the preparation of a study plan which was presented in a publication entitled "Colorado State Water Plan--Plan of Study," dated March 1971. The plan of study established an orderly process for conducting the overall investigations and accomplishing the objectives. The plan of study also identified and defined the following three phases: Phase I--Appraisal of Present Conditions, Phase II--Legal and Institutional Considerations, and Phase III--Plans for Development. Phase I is an appraisal of the water and related land resources and is also a summation of the current status of development and utilization of these resources. This report also identifies and describes the critical issues and problems concerning present water resource developments and utilization in Colorado. The data are presented in the report by the State's four major river basins - Arkansas, Colorado, Missouri, and Rio Grande. Economic data are presented by economic areas which are essentially the same as the four major river basins. The base year for compiling data was 1970, except that earlier data were used when 1970 data were unavailable. No projection of data for future conditions is included as part of this report.

Phase II, Legal and Institutional Considerations, scheduled for completion in March 1974, will provide for an analysis of the legal and institutional factors which have governed and will govern the development, use, and management of water and related land resources in the State.

Phase III, Plans for Development, scheduled for release later in 1974, will present alternative plans for the development and future available surface and ground-water supplies and related land resources to meet future needs and objectives. All potential ways for augmenting Colorado's water supplies will

be identified including weather modification, desalting, conservation and reuse of water, and surface water imports. Initial study and formulation of the State Water Plan were accomplished through the efforts of the Colorado-Westwide Study Team.[1/] This study team was organized in the fall of 1972 to direct State input into the Western U.S. Water Plan studies and was composed of representatives of all appropriate Federal and State agencies. After the Western U.S. Water Plan was rescoped for early and abbreviated completion, the planning efforts for the preparation of a separate Colorado State Water Plan were continued by the study team. Work accomplishment will be taken up by smaller task forces composed also of Federal and State officials.

The Colorado State Water Plan studies are being guided by concepts contained in the new multiobjective planning guidelines, developed by the Bureau of Reclamation from the Water Resources Council's "Principles and Standards for Planning Water and Related Land Resources." These new principles and standards (Federal Register, Volume 38, No. 174, Part III, September 10, 1973) became effective October 25, 1973.

1/ The Colorado River Project Act of 1968 (Public Law 90-537) authorized the Bureau of Reclamation to develop comprehensive reconnaissance plans to meet the future water needs of the 11 Western states, to be called the Western U.S. Water Plan (Westwide Study).

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LOCATION MAP

COLORADO

GENERAL MAP

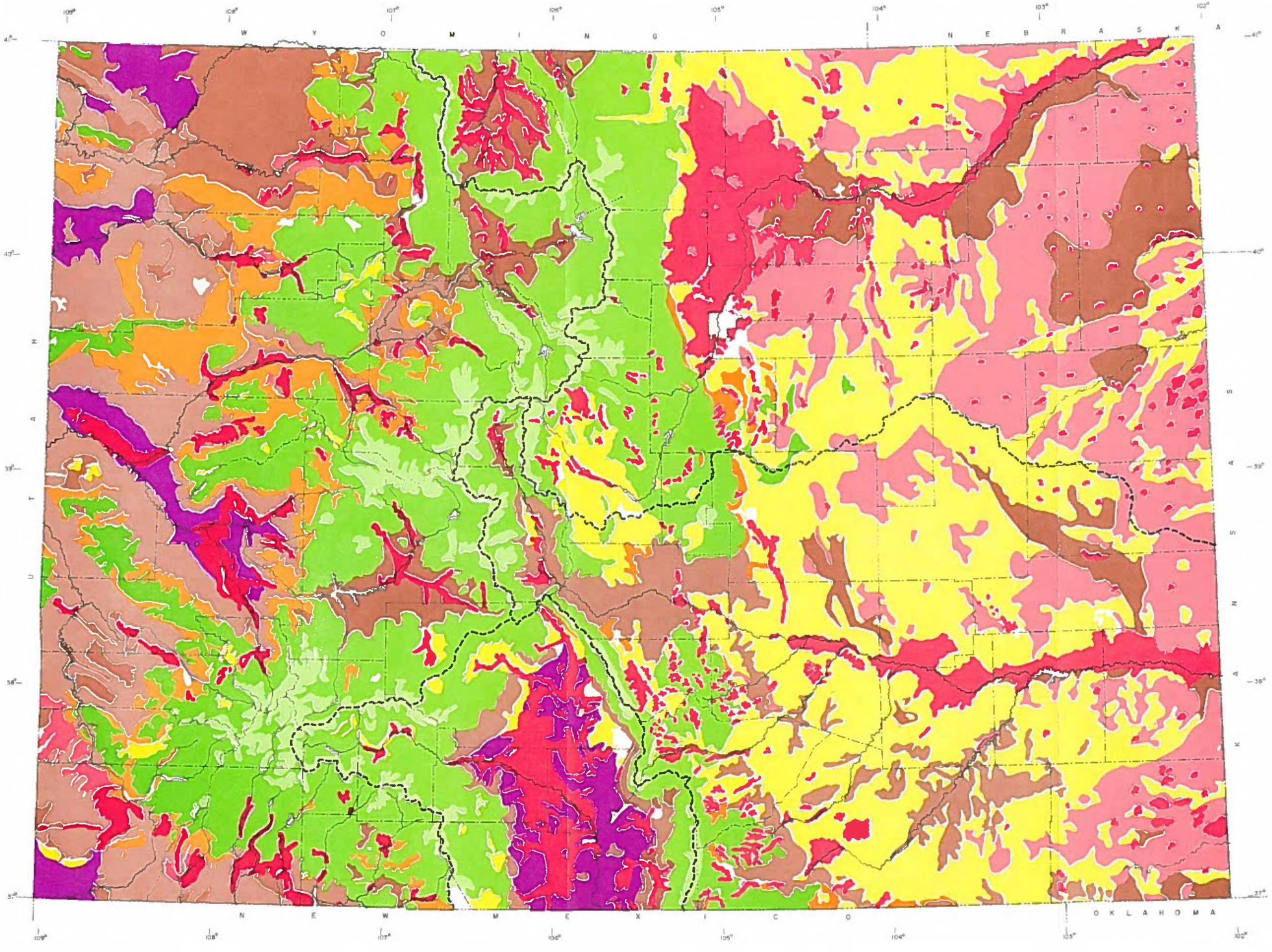
RIVER BASIN BOUNDARIES

10 0 10 20 30 40
SCALE OF MILES

1973

MAP NO. X-700-109

EXHIBIT 2.1



RIVER BASIN LOCATION MAP

COLORADO STATE WATER PLAN

VEGETAL COVER TYPES AND LAND USE

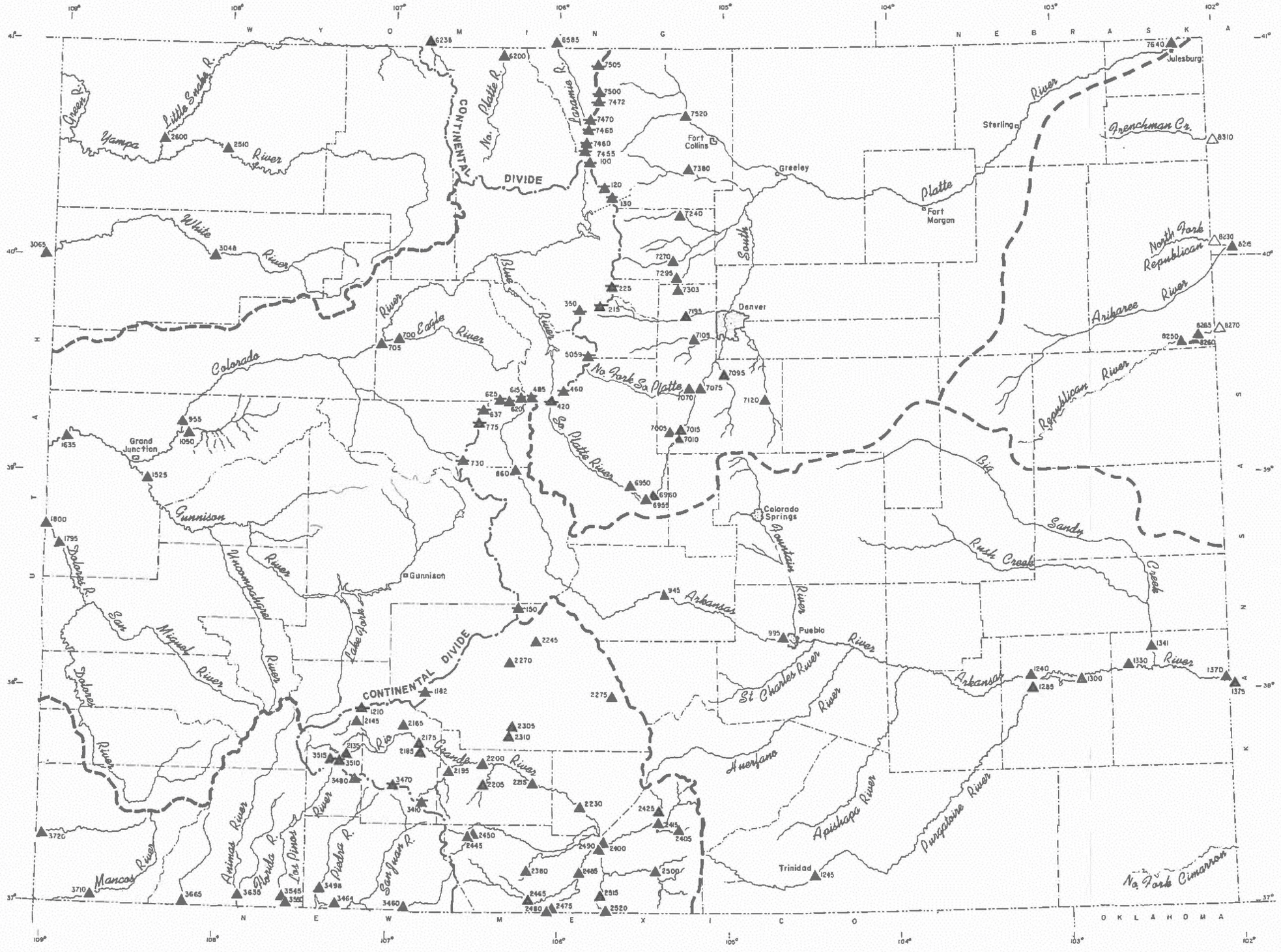
COLORADO

Compiled by the United States Department of the Interior
Bureau of Reclamation, Regions UC, SW and LM

EXHIBIT 3.1

COLORADO

RIVER BASINS AND
KEY GAGING STATIONS

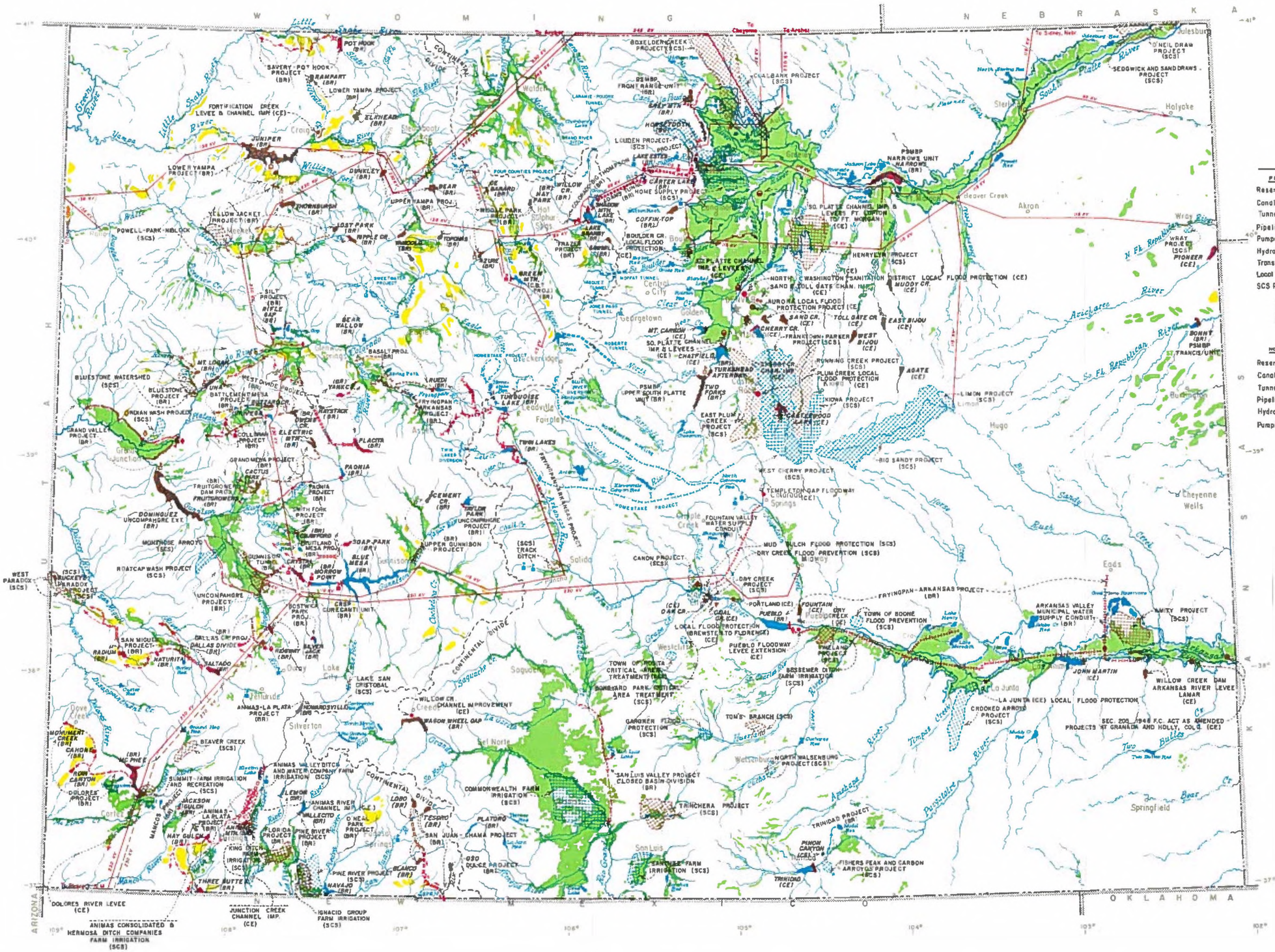


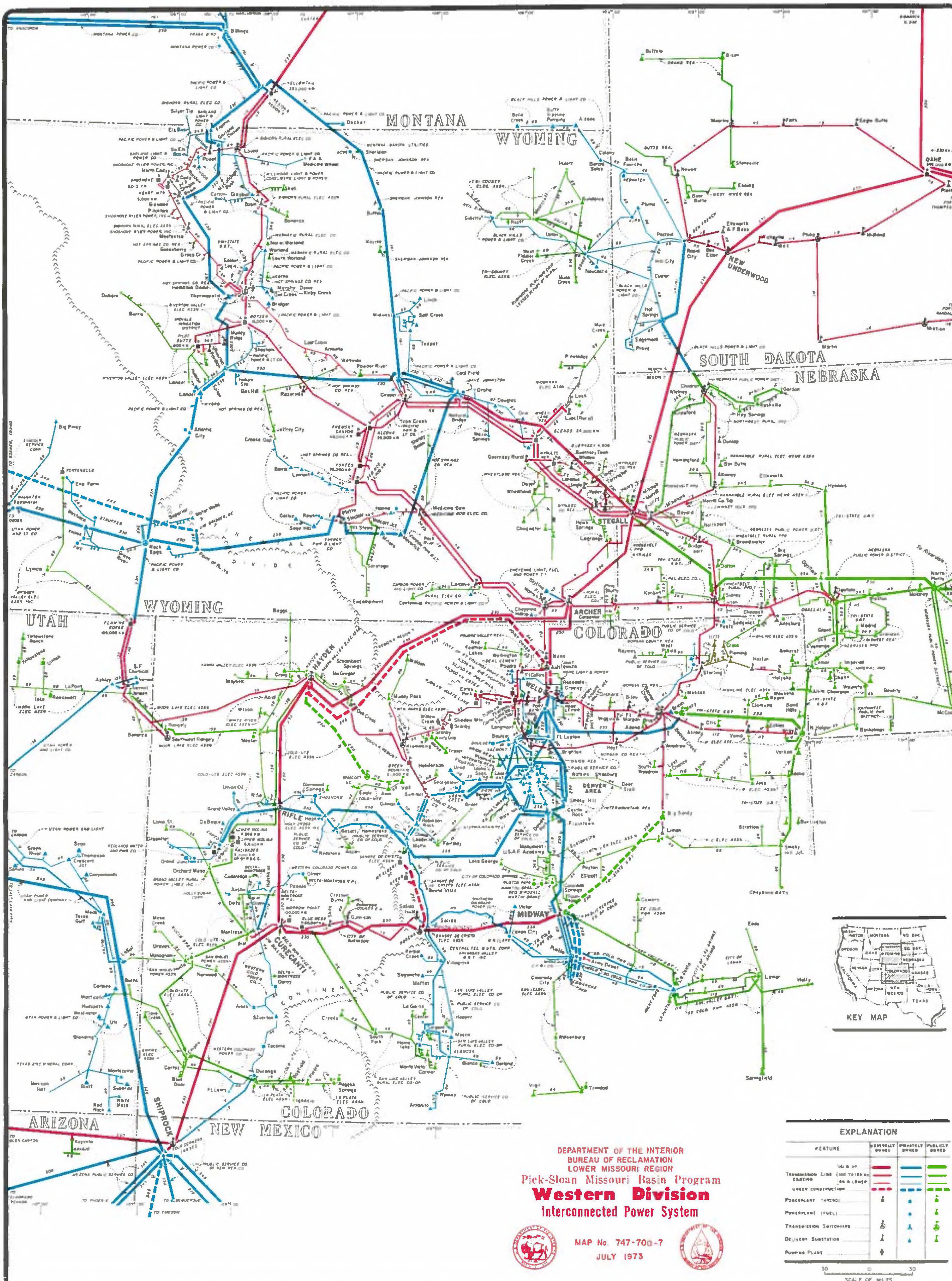
Explanation

- CONTINENTAL DIVIDE
- RIVER BASIN BOUNDARY
- COUNTY LINE
- ▲ STREAM FLOW OR RESERVOIR STATION
- ★ TRANSMOUNTAIN DIVERSION
- △ DISCONTINUED STATION

0 5 10 15 20 25 30 35 40 45 50
SCALE IN MILES

EXHIBIT 3.3

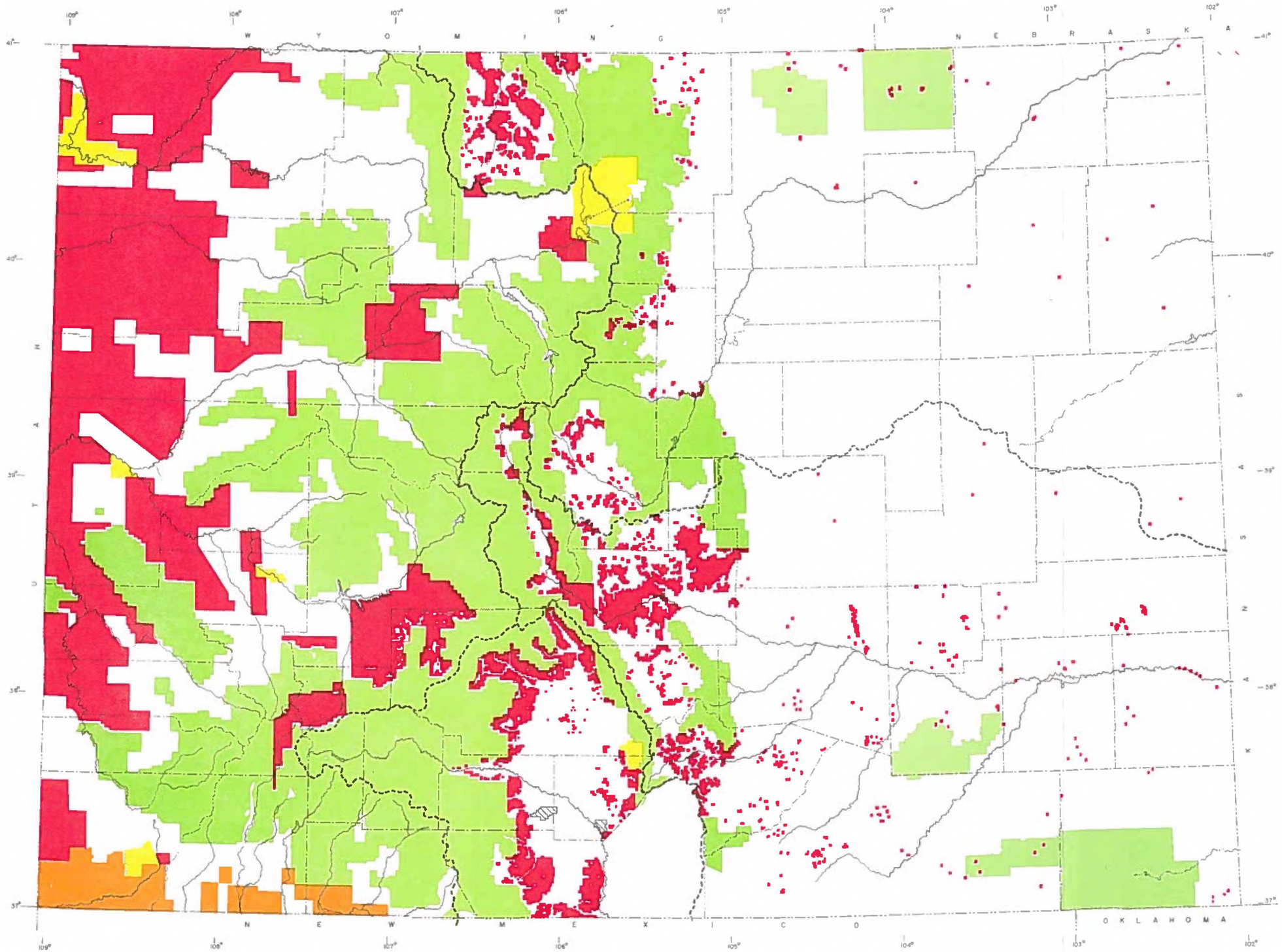

WYOMING
NEBRASKA
KANSAS
OKLAHOMA
NEW MEXICO
ARIZONA
UTAH
Explanation
FEATURE
COMPLETED OR UNDER CONSTRUCTION
AUTHORIZED FOR CONSTRUCTION OR PROPOSED FOR DEVELOPMENT
POTENTIAL
FEDERAL DEVELOPMENTS
Reservoir
Canal
Tunnel
Pipeline
Pumping Plant
Hydroelectric Powerplant
Transmission Line
Local Flood Protection
SCS Project Area
NONE
BR = DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION *
CE = DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS.
SCS = DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE.
* PSMBP = PICK-SLOAN MISSOURI BASIN PROGRAM
CRSP = COLORADO RIVER STORAGE PROJECT
NON-FEDERAL DEVELOPMENTS
Irrigated Land
Irrigable Land
SCALE OF MILES
COLORADO
WATER RESOURCE DEVELOPMENT
COMPILED BY
BUREAU OF RECLAMATION
UNITED STATES DEPARTMENT OF THE INTERIOR
1974
MAP NO. X-700-84



MONTANA
WYOMING
SOUTH DAKOTA
NEBRASKA
UTAH
COLORADO
ARIZONA
NEW MEXICO
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
LOWER MISSOURI REGION
Pick-Sloan Missouri Basin Program
Western Division
Interconnected Power System
MAP No. 747-700-7
JULY 1973
EXPLANATION
FEATURE
Transmission Line
Existing
Under construction
Powerplant (hydro)
Powerplant (fuel)
Transmission Switchyard
Delivery Substation
Pumping Plant
SCALE OF MILES
KEY MAP

EXHIBIT 3.4

EXHIBIT 4.1



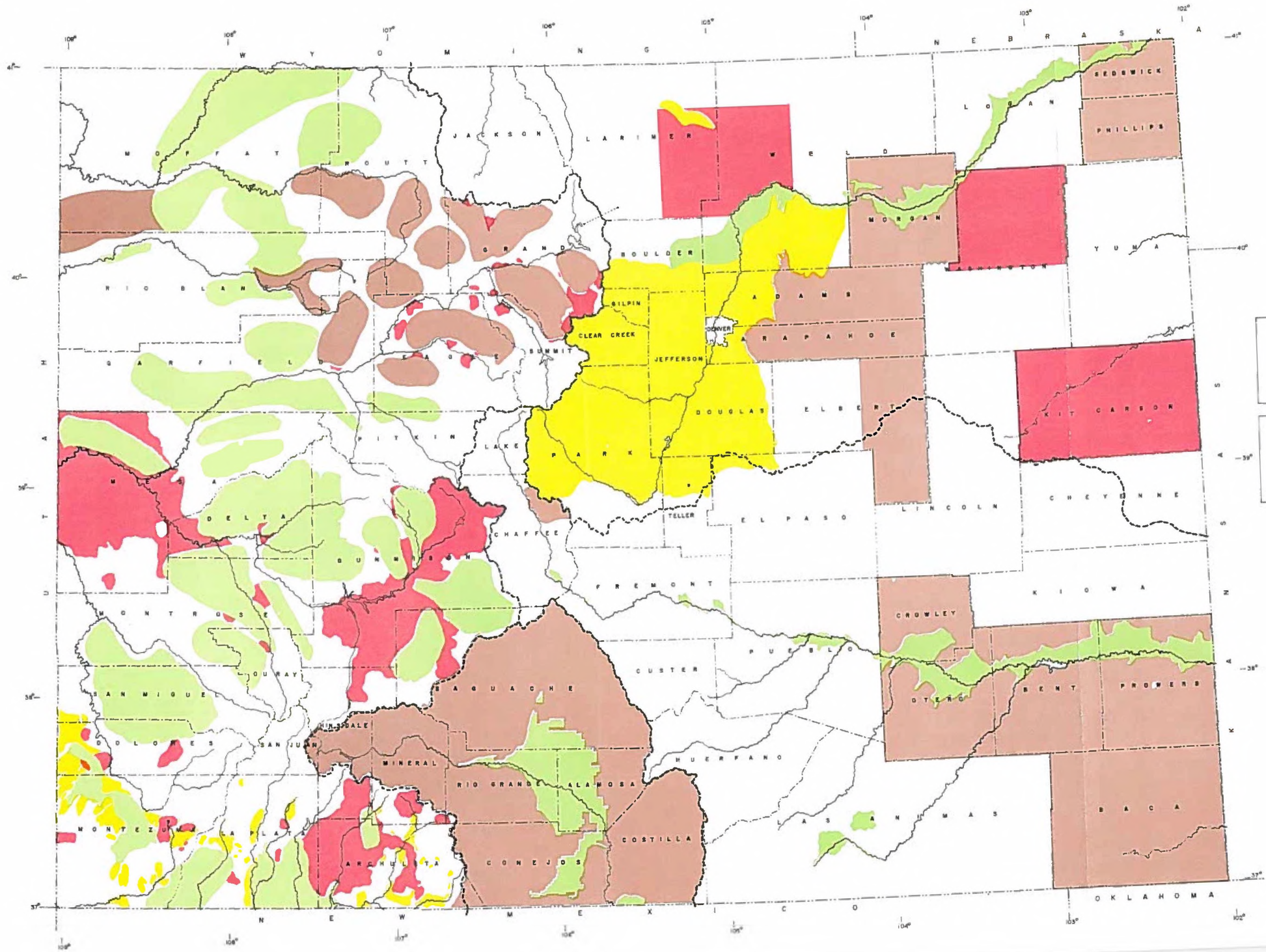
COLORADO STATE WATER PLAN

LAND OWNERSHIP AND ADMINISTRATION
COLORADO

Compiled by the United States Department of the Interior

Bureau of Reclamation, Regions UC, SW, and LM

EXHIBIT 4.2



LEGEND

DEPARTMENT OF INTERIOR (U.S.B.R.)

- DETAILED OR SEMI-DETAILED
- RECONNAISSANCE OR SUB-RECONNAISSANCE

DEPARTMENT OF AGRICULTURE (S.C.S.)

- RECENT DETAILED
- OLD DETAILED

Note: Some of the areas covered by U.S.B.R. Detailed or Semi-detailed surveys have been covered by the old S.C.S. surveys. Some limited areas covered by U.S.B.R. reconnaissance and sub-reconnaissance surveys within areas surveyed by the S.C.S. are not shown.

COLORADO STATE WATER PLAN

LAND CLASSIFICATION STATUS COLORADO

Compiled by the United States Department of the Interior

Bureau of Reclamation, Regions UC, SW, and LM

PART I
INTRODUCTION

PART I--INTRODUCTION

Few, if any, issues are more crucial for future development of Colorado than effective use and management of the State's water and related natural resources. Unprecedented population and economic growth during the past 30 years has resulted in unanticipated needs and use of water. Coupled with this, the State is now faced with declining ground-water tables in the Great Plains sector of eastern Colorado, some streams and lakes are seriously polluted and critical water shortages prevail in some areas.

Colorado must continue to assess, plan, use, and manage its water and related natural resources in an intelligent and prudent manner. In doing so, future water resource developments and use must be more responsive to environmental needs as well as regional and national economic objectives. And more recently, a growing national energy crisis has focused on Colorado's large untapped oil shale and coal deposits as a possible next level of mineral resources development to help meet the long range national energy demands.

PURPOSE AND SCOPE

This Appraisal Report summarizes Phase I of the investigations to develop a long range Statewide water plan for Colorado. This report presents a compilation of statistical data on an inventory of the water and related natural resources of the State and current status of development and use of these resources. The data are presented in this report by the State's four major river basins - Arkansas, Colorado, Missouri, and Rio Grande. The base year for compilation of data is 1970. Data compiled for earlier years were used only when 1970 data were unavailable. No projections of future conditions are included.

Another purpose of this report is to stimulate thinking among Colorado citizens about the future of their State. Part VI of this report identifies and describes the major critical issues and problems that are closely associated with the present level of water development and use in Colorado. Although some considerations for action are presented for resolving these issues and problems, no recommendations are made as part of this Phase I report.

Included also in this report is a bibliography of publications concerning or relevant to these resource developments.

AUTHORITY FOR REPORT

This report is authorized by the Water Resources Planning Act of 1965 (Public Law 89-80, 89th Congress), the Colorado River Project Act (Public Law 90-537), and by the Federal Reclamation Laws (Act of June 17, 1902, Stat. 388, and Acts amendatory thereof or supplementary thereto). Amendments to the basic legislation in 1967 provided for State participation and cooperation in comprehensive water planning programs authorized in the Water Resources Planning Act of 1965.

Authority was delegated to the Colorado Water Conservation Board to make water resource investigations when the board was created by the Colorado General Assembly in 1937. In 1967, the State assented to the provisions of the Federal Water Resources Planning Act of 1965. Under this legislation, the board was authorized, empowered, and directed to perform such acts as may be necessary to the conduct and establishment of a comprehensive water planning program.

ACKNOWLEDGMENTS

Numerous reports by federal, State, and local agencies and universities have furnished much information and data for this report. The report has benefited greatly from the active participation by the Colorado State Study Team in preparation of Colorado's portion of the Western U.S. Water Plan.

PART II
GENERAL DESCRIPTION OF THE ENVIRONMENT

PART II--GENERAL DESCRIPTION OF THE ENVIRONMENT

LOCATION AND SIZE

The location of Colorado with reference to its surrounding states and its longitude and latitude is shown on exhibit 1.1. Colorado's eastern boundary is approximately 170 miles west of the Historic Center of the 48 contiguous states, its northern boundary approximately 570 miles from the Canadian border and its southern boundary approximately 340 miles from the Mexican border. The southwest corner of Colorado is approximately 700 miles from the nearest point on the Pacific Ocean.

Colorado, with an area of 104,247 square miles, ranks seventh in size among the 48 contiguous states. Colorado is 387 miles east to west and 276 miles north to south.

PHYSIOGRAPHIC PROVINCES AND RIVER BASINS

Five physiographic provinces of the North American Continent extend across or into Colorado. The Great Plains extend into the eastern part of the State and make up approximately 45 percent of its area. The Southern Rocky Mountains extend through the center of Colorado and constitute approximately 32 percent of the State's area. The western part of Colorado extends into the Colorado Plateau, sometimes referred to as the Canyon Lands. This province covers approximately 16 percent of Colorado. Other provinces that make up a small part of the State are the Wyoming Basin and the Middle Rocky Mountains. They extend into the northwestern part and constitute nearly 5 and 1 percent, respectively, of the State's area.

For planning purposes, the State was divided along its major drainage basin boundaries. These boundaries represent hydrologic lines which are of major importance in studies concerning water resources. For reporting economic conditions, the same divisions were used except the boundaries follow the county lines which most nearly approximate the basin boundaries.

Three major river systems, the Arkansas, Colorado, and the Rio Grande, originate in the Rocky Mountains of Colorado as do the North and South Platte Rivers which are major tributaries of the Missouri River. The Republican

River, a third tributary to the Missouri River System, originates in the plains of eastern Colorado. Major tributaries of the Colorado River System also originating in Colorado include the San Juan, Dolores, Gunnison, White, and Yampa Rivers. The basins of these major streams are shown on exhibit 1.1. The distribution of the State's area (104,247 mi^2) is shown by major drainage basins in table 2.1.

Table 2.1--Drainage basins of Colorado

River basin	Square miles	Percent of State
Arkansas	28,297	27
Colorado	38,542	37
Missouri	29,877	29
Rio Grande	7,531	7
State total	104,247	100

GEOLOGY

The Southern Rocky Mountain Province is a rugged zone of north-south trending mountain ranges which form a continuous belt across central Colorado. The typical mountains have cores of igneous and metamorphic rocks. They originated by repeated uplifts of igneous rocks through the sedimentary rocks that were once continuous across this mountainous region. The uplifted rocks have been modified through the ages by glaciation and other forces of erosion. Steeply dipping sedimentaries still flank the mountains and extend eastward under the Great Plains and westward under the Colorado Plateau.

The repeated uplifts combined with erosion have removed nearly all evidence of the sedimentaries from the mountain province. Exceptions occur within the South, Middle, and North Parks and the San Luis Valley which are structural basins resulting from being inactive during the periods of uplift. Sedimentary rocks, mainly shale, sandstone, and siltstone, are found in the three parks while the San Luis Valley has been filled with alluvium (sand, gravel, and clay).

Structurally the Great Plains is a large basin with part of Colorado being situated on its western edge. The Great Plains area of Colorado is subdivided into the Colorado Piedmont, High Plains, and the Raton Section. The Colorado Piedmont, which butts against the mountains, is elevated and dissected, the South Platte and the Arkansas Rivers being the main drainages. These rivers and some of their tributaries have been the primary agents in the evolution of this large elevated area which is now a rolling plain with a thin mantling of unconsolidated materials overlying shale and occasional limestones and sandstones.

The High Plains, occurring at the eastern limit of Colorado, consists of erosional remnants of fluvial plains formed by outwash from the Rockies. The material forming these fluvial deposits is largely silt with varying amounts of sand and gravel. The material is generally unconsolidated but local lime cementation is common.

The Raton section, occurring at the southern edge of Colorado, is underlain by the same sedimentaries as the Colorado Piedmont. However, the high mesas that are characteristic of this section are usually capped with volcanic flows.

Three of the six subdivisions of the Colorado Plateau extend into southwestern Colorado. The main distinguishing features of this province are horizontal lying sedimentary strata, the high elevation of the entire plateau, and numerous steep canyons.

The Uinta Basin subdivision, an area of deeply dissected plateaus and badlands, lies just south of the Uinta Mountains. The lava-capped Grand Mesa marks the southern limit of this subdivision.

The Canyon Lands subdivision is south of the Uinta Basin. The Canyon Lands of western Colorado are not typical of this subdivision as the Gunnison, Colorado, and Uncompahgre Rivers have formed broad valleys in the sedimentary beds as compared to the narrow deeply entrenched canyons they have created further west. Several large plateaus, such as the Uncompahgre and Mesa Verde, are defined by the wide river valleys.

The third subdivision is the Navajo Section which occupies a very small portion of southwestern Colorado along the headwaters of the San Juan River. Here, the predominant rock is sandstone with lesser amounts of shale. Inasmuch as the beds dip slightly, the forces of erosion that are associated with the arid climate have created an abundance of mesas, cuestas, rock terraces, retreating escarpments, and dry washes.

Only a small tip of the Middle Rocky Mountains occurs in the northwestern corner of the State and is an extension of the rugged east-west oriented Uinta Mountains. Structurally, the Uinta Mountains are formed by a severely eroded plateau which is flanked by steeply dipping strata. The center portion consists of pre-Cambrian quartzites which are flanked by younger sedimentary beds. The upturned sedimentary beds along the southern extent are covered by a lower flanking plateau composed of material eroded from the interior plateau.

Two deeply incised rivers, the Yampa and the Green Rivers, have drainages that enter or cross the Uinta Mountains in a manner independent of its structure.

Overall, the Wyoming Basin province is a large depositional basin encircled by the southern and middle Rocky Mountains with a small portion, the Yampa Basin sector, occurring in northwest Colorado. It is primarily an area of erosion features (scarps and cuestas) developed on mildly folded sedimentary beds. One rugged cuesta has enough relief to be labeled locally as the William River Mountains.

TOPOGRAPHY

The mountainous parts of Colorado are very rough and rugged except for the chain of four large parks which stretch across the State roughly from north to south. The parks are large plateaus (peneplains) of gentle relief with elevations in the 7,000 to 10,500 foot range.

The highest point in Colorado is Mount Elbert. Its elevation is 14,433 feet and is located about 10 miles southwest of Leadville. Other well known peaks with elevations above 14,000 feet are Pikes Peak, Longs Peak, Mount Evans, and Mount Massive. These are but five of the 54 peaks in Colorado that stretch above the 14,000-foot elevation. Some 1,500 other peaks rise above 10,000 feet but are less than 14,000 feet. Deep canyons and narrow valleys are also conspicuous features of the Colorado mountains.

The Great Plains are highlands made up mainly of areas of low relief. Monotony of landscape is usually the term applied to the province. This description, however, does not fit all of the land forms included in the province, as the forces of erosion working upon materials of different hardness and resistance has resulted in many types of topography and variations of relief. Sand dunes, cuestas, and tepee buttes are types of topography occurring in the plains in addition to the flat and rolling areas. The elevation of the plains ranges from

about 3,500 feet in the southeastern part of the State to nearly 8,500 feet where the Raton section butts against the mountains near the Colorado-New Mexico boundary.

The extreme western and southwestern parts of Colorado fall within a large area known as the Colorado Plateaus Province. Many spectacular canyons are within this area, and for that reason, it is sometimes referred to as the Canyon Lands. Other features of the topography are high elevations, and the constituent plateaus are separated from each other by escarpments.

In northwestern Colorado is a high-lying area whose surface is but slightly dissected by shallow water courses. The area is part of the Wyoming Basin which is really an intermountain plateau. Elevations are between 7,000 and 8,000 feet, and it is an area of gentle relief. The part of this basin that extends into Colorado is situated between the Uinta Mountains in the northwest corner and the Park Range Mountains to the east.

CLIMATE

Colorado has a continental type of climate due to its inland location, being characterized by wide ranges in temperatures and irregular annual and seasonal precipitation. The climate is temperate and is semiarid except in the high mountain areas where the precipitation averages more than 40-inches per year. Humidity is generally low which favors rapid evaporation. The thin atmosphere allows greater penetration of solar radiation and results in pleasant daytime conditions even during the winter.

The climate of a particular area is profoundly affected by its elevation and to a lesser degree by the orientation of mountain ranges and valleys with respect to general air movements. These influences can cause wide variations in weather conditions within short distances. Usually, temperatures decrease and precipitation increases with higher elevation, but the pattern is modified by the orientation of mountain slopes with respect to prevailing winds and by the effect of the topography on local air movement.

The prevailing westerly winds dominate Colorado's weather, especially during the cool and cold seasons. As the warm season advances, the westerly winds lose much of their predominance, and air masses carrying considerable moisture push in from the Gulf of Mexico. This change in the flow of air masses accounts for the greater precipitation during the spring and early summer in the eastern and central parts of the State.

In western Colorado, particularly in the lower valleys, greater uniformity of weather is experienced than in the eastern plains. Severe sudden temperature changes are relatively absent and growing seasons are longer. Precipitation west of the Continental Divide is more evenly spread over the year than is the case in the eastern plains. For much of western Colorado, the greatest monthly amounts of precipitation occur in the winter months, with June the driest month. The highest temperatures in summer occur in the lower valleys, and are comparable to those of the eastern plains. Winter temperature averages are lower than at comparable elevations in the plains, largely as the result of smaller day to day variation and the relative absence of chinook effects.

Climatic data at selected stations are summarized in table 2.2.

ECOLOGICAL RESOURCES

Vegetal Cover

Vegetal cover or the lack of it has an important bearing on water resources. Properties such as soil infiltration rates, evaporation, rate of snow melt, and the rate of erosion are influenced by the vegetal cover. These in turn influence the rate and volume of surface runoff, the ground water, and the sedimentation rate of both natural lakes and man-made reservoirs.

Vegetal cover is largely the product of the climate. Other factors that exert major influences are geological formations and the activities of man.

Many activities of man, such as the development of cities and highways, agriculture, and strip mining, destroy or radically change the vegetal cover.

In Colorado, several major types of vegetation have been recognized. Agricultural croplands are considered as two types in this report, that is, dry cropland and irrigated cropland. They, of course, have no permanent cover, but cannot be considered barren because they are covered by agricultural crops periodically.

Each major type of vegetal cover is discussed in the following sections, and the location of these types is shown on exhibit 2.1.

Table 2.2--Climatic data at selected stations

Basin and station	Elevation above MSL (feet)	Normal precipitation (inches/year) Total	Snow	Normal evaporation[1/] (inches/year)	Temperatures (degrees F,) Jan. mean	July mean	annual mean	Max-imum	Min-imum	Frost-free days/year
Arkansas:										
Colorado Springs	6,145	14.5	35	46	29	72	48	100	-27	148
Leadville	10,158	18.5	125	30	18	57	37	82	-31	82
Pueblo	4,639	12.1	31	48	30	75	51	105	-31	169
Rocky Ford	4,178	12.3	24	50	30	77	51	107	-32	162
Salida	7,060	10.9	46	38	27	65	46	100	-35	112
Springfield	4,575	14.7	28	58	*	*	52	105	-22	169
Trinidad	5,746	15.0	48	48	34	72	50	110	-32	156
Colorado:										
Cortez	6,177	13.2	47	42	28	71	49	100	-13	125
Crested Butte	8,855	23.0	178	30	14	58	37	95	-42	48
Durango	6,550	18.0	63	38	25	67	47	99	-27	117
Glenwood Springs	5,823	18.0	74	33	25	71	48	102	-38	138
Grand Junction	4,855	8.6	21	36	26	78	53	105	-21	188
Gunnison	7,664	11.0	59	33	17	62	38	96	-47	49
Montrose	5,722	9.1	29	35	26	73	49	106	-27	153
Steamboat Springs	7,936	23.5	164	33	15	62	39	99	-54	30
Telluride	8,722	23.8	166	30	21	58	40	96	-36	51
Missouri:										
Akron	4,663	17.5	43	49	25	74	48	109	-29	146
Burlington	4,165	16.4	23	54	30	75	50	112	-25	154
Cheesman	6,875	14.5	112	35	28	67	45	99	-40	121
Denver	5,283	14.5	57	42	29	73	52	105	-29	165
Estes Park	7,497	16.1	84	36	25	62	43	98	-39	88
Fort Collins	5,001	14.2	43	38	27	71	48	102	-41	144
Fort Morgan	4,321	12.9	27	48	24	74	49	109	-41	148
Idaho Springs	7,555	15.0	78	35	26	63	42	94	-30	58
Sedgwick	3,990	17.2	*	48	23	74	49	103	-16	150
Walden	8,099	9.4	47	34	*	*	36	94	-49	71
Rio Grande:										
Alamosa	7,536	6.6	28	45	17	65	40	91	-50	104
Monte Vista	7,667	7.2	*	36	12	61	40	94	-37	79
Wolf Creek Pass	10,642	33.8	416	30	16	54	35	88	-24	65

1/ 1946-1955 Average Annual Lake Evaporation, Plate 3, U.S. Geological Survey Professional Paper 272-D, 1962

* Data unavailable

Alpine

The alpine vegetal association usually occurs at elevations higher than 11,000 feet which is the approximate elevation of the timberline. Vegetal production is meager and the plant communities are fragile exhibiting extremely slow recuperation rates following disturbance. The species usually found in the alpine meadows are sedges, bluegrasses, spike trisetum, alpine timothy, willows, bistort, bluebells, gentian, clovers, and kobresia.

Alpine barren areas consist of shale, rock slides, snow fields, and glaciers. They are areas where growing conditions are too harsh for plants to become established.

Forests

Forest vegetation occurs at elevations below 11,000 feet and above 7,000 feet. Some forests have an understory of vegetation that is excellent forage and is often used for summer range.

The spruce-fir forest occurs at the higher elevations and below these are lodgepole pine, Douglas fir, and quaking aspen. Much of the forest has dense stands of trees and little undergrowth. Some of the important herbaceous species are tufted hair-grass, blue joint, sedges, and rushes. At still lower elevations are forests consisting mainly of ponderosa pine, intermixed with extensive areas of quaking aspen. Other important plants are mountain muhly, Arizona fescue, slender wheatgrass, and oatgrasses. Common shrubs are big sagebrush, serviceberry, snowberries, mountain mahogany, and bitterbrush. Streambank and meadow communities throughout the forest areas consist of woody plants such as willows, cottonwoods, aspen, birches, and dogwood. This zone also has potential for increasing water yield through intensive management of the vast areas of aspen, and other woody plant communities.

Oakbrush

Oakbrush is found below the forests and includes shrub types that commonly occur as a transition between forest and other vegetation types. Common shrubs of this type are oaks, mountain mahogany, serviceberry, ceanothus, bitterbrush, cliffrose, chokecherry, snowberry, and rose. Other plants commonly found in this zone are big sagebrush, bluebunch wheatgrass, needle-and-thread, junegrass, and annual bromes.

Pinion-Juniper Woodland

Occurring in foothill and low mountain areas, pinion-juniper types are not usually abundant at elevations higher than 7,000 feet or lower than 4,000 feet. The most common junipers are Utah, Rocky Mountain, and one-seed. Colorado pinion is the most common pine in this zone. Understory species include bitterbrush, big sagebrush, mountain mahogany, and cliffrose. Some herbaceous species present are blue grama, galleta, bluebunch wheatgrass, western wheatgrass, Indian ricegrass, Russian thistle, and cheatgrass.

Range

Range is a commonly used term that refers to a grouping of several specific nonforest types of vegetation which supports substantial wildlife and is also used for grazing livestock. The rangelands are generally found up to 7,000 feet where the forest types begin to dominate. The elevation of this vegetal type may be greater at the southern part of the State or lesser at northern parts. The three types included here are Grasses, Sagebrush, and Salt Desert Shrub.

Grasses--Perennial grasses mixed with shrubs or with forbs cover extensive areas. At the higher elevations this association occurs as small and scattered islands. The most common perennial grasses are eastern wheatgrass, bluebunch wheatgrass, squirreltail, and needlegrass. In the lower elevations the most abundant perennial grasses are blue grama and galleta.

Sagebrush--Sagebrush is commonly found on well drained, loamy soils that are not usually saline. Many woody and herbaceous species are associated with big sagebrush. Some of these shrubs are black sagebrush, little rabbitbrush, horsebrush, winterfat, and snakeweed. Understory grasses are galleta, blue grama, western wheatgrass, bluebunch wheatgrass, and squirreltail.

Salt Desert Shrub--This type may be further divided into four subtypes. Two of these, shadscale and greasewood, are common to Colorado. Shadscale is limited to soils that are slightly saline and relatively impermeable. Shadscale grows in some places in nearly pure stands but is commonly mixed with other shrubs such as sagebrush, horsebrush, and spiny hypsage. Nuttall saltbush commonly occurs locally as pure stands within this zone.

Greasewood grows on terraces above permanent streams and along intermittent stream channels at lower altitudes. Greasewood is very salt tolerant and deep rooted and usually indicates the presence of ground water. It usually grows as nearly pure stands but is, in some places, associated with shadscale, sagebrush, saltbush, and rabbitbrush. Herbaceous species commonly associated with greasewood are saltgrass and alkali sacaton, seepweed, and pickleweed. Much of the area within the Salt Desert Shrub type which is occupied by these species is sometimes typed separately as the Salt Marsh Zone. These areas consist of the salt marshes that occupy some playa bottoms. Species occupying these areas must have the capacity to exist partially submerged in water, part or all of the year, and also must have extreme salt tolerance.

Irrigated Cropland

Irrigated cropland is land on which water is applied artificially for the production of crops. The areas are scattered throughout the State.

Dry Cropland

Dry cropland is land that will produce crops in rotation with or without fallow and rotation hay or pasture with natural precipitation. Generally large acreages are required to make an economic operating unit.

Wildlife

Ecological variety, induced by diversity in land and water and wide range in elevation, provides suitable habitat for many kinds of wildlife. Progressive management has maintained significant numbers of deer, elk, mountain sheep, mountain goats, antelope, and black bear. Other types of wildlife occurring in significant numbers include pheasant, partridge, mourning dove, sage grouse, blue grouse, ptarmigan, wild turkey, ducks, geese, cottontail rabbits, and fox squirrel. The main fur animals in the State are beaver, muskrat, mink, weasel, marten, bobcat, red fox, raccoon, ringtail cat, badger, and opposum. A wide variety of song birds, small mammals, and reptiles also inhabit the State.

Many of Colorado's lakes and streams are excellent warm or cold water fisheries. Main warm water species include largemouth bass, perch, crappies, catfish, northern pike, walleye, and white bass. Cold water species are rainbow, brown, native, cutthroat, and brook trout, and kokanee salmon.

AESTHETIC RESOURCES

Among Colorado's natural attractions are great forests of conifers and aspens, but there are also many varieties of ferns, mosses, and wild flowers. Shaded uplands, stream valleys, ledges, marshes, and prairies provide the varied site conditions required for great diversity in plant life, ranging from short grass prairie in the east, alpine tundra in the high mountains, and mountain shrubs in the west. Plant diversity, in turn, supports a wide variety of birds, and mammals, further contributing to the State's capacity for varied environmental resources. About 12,000 lakes, and 1,350 streams add to the State's aesthetic features.

Public use is permitted on 24,800,000 acres of land and water in Colorado. Some of this acreage is developed for a wide variety of activities. Other lands and waters are accessible but have received little or no usage.

Water constitutes about 200,000 acres of public-use areas and is fairly well distributed throughout the State. Large reservoirs comprise 145,000 acres, about two-thirds of the open waters. High mountain lakes constitute 19,200 acres and about 9,400 acres are included in small farm ponds. In addition, there are 27,700 acres (14,100 miles) of flowing streams including 18,500 acres (8,800 miles) of mountain trout streams.

About 22,500,000 acres, or 33 percent of the total State area, are national forests, parks, monuments, historic sites, recreation areas, military reservations, Indian reservations, and public domain lands.

The U.S. Forest Service administers eleven national forests and two grasslands, including six primitive and five wilderness areas. The forests have 42 ski areas, many campgrounds, and a variety of other outdoor recreation facilities.

The U.S. Bureau of Land Management controls 8,500,000 acres of federal land in the State. These lands are highly important for hunting and fishing and include substantial big game winter range.

Two national parks in Colorado, Rocky Mountain and Mesa Verde, comprise nearly 800,000 acres. Rocky Mountain offers mountain grandeur and Mesa Verde is a famous remnant of ancient cliffdweller culture.

The U.S. Bureau of Sport Fisheries and Wildlife administers four national wildlife refuges totaling over 44,000 acres.

The State Divisions of Wildlife, and Parks and Outdoor Recreation have jurisdiction over 161 areas, totaling about 100,000 acres. The parks program involves 23 properties located throughout the State.

The U.S. Army Corps of Engineers administers about 98,000 acres of land for recreational use in the State, most of which is leased to other agencies for management.

The Shadow Mountain National Recreation Area comprises about 18,240 acres of land and water and provides facilities for several types of outdoor recreation.

Seven national monuments add to the State's environmental resources. These include the Black Canyon of the Gunnison, the Colorado National Monument, the Dinosaur National Monument, the Great Sand Dunes National Monument, the Hovenweep National Monument, the Yucca House National Monument, and the Florissant Fossil Beds National Monument.

There are 139 county, 453 city, and 37 quasi-public recreation areas in Colorado. Most feature various types of outdoor activities. Privately owned recreational areas number 725, involving 1,500,000 acres.

CULTURAL RESOURCES

Cultural activities and attractions are numerous and varied, providing many outlets for entertainment and relaxation. Some 400 special events are staged throughout the State each year. There are more than 60 rodeos and 30 fairs, authentic western melodrama, and square dance spectaculars. Other theatrical and musical events include Broadway shows, free outdoor musicals, operas and instrumental music featuring internationally famous artists. Winter brings ski races and jumping competition of world importance. Commercial sports include pari-mutual horse and dog racing, auto racing, professional baseball, football, basketball, and hockey.

HISTORICAL RESOURCES

Historical sites are areas set aside to preserve the location of or to commemorate special events. Visits to such sites are educational experiences, giving visitors sufficient background to appreciate the historical impact of the events. Significant historical landmarks and sites are listed in table 2.3.

POPULATION

The population of Colorado, according to the 1970 census, was 2,207,259, an increase of 25.8 percent over 1960. Total urban population was over 1.7 million, a 34 percent increase over 1960. The people living in urban areas in 1970 constituted 78.5 percent of the total population as compared to 73.7 percent in 1960. Total rural population in 1970 was almost 474,000, an increase of only 2.8 percent over 1960. The number of people living in communities of 1,000 to 2,500 increased 4.3 percent during the decade. The average population density in 1970 was 21 people per square mile as compared to 17 in 1960. Almost 72 percent of Colorado's population is concentrated within the Standard Metropolitan Statistical Areas (SMSA) of Denver, Colorado Springs, and Pueblo.[1/]

1/ A Standard Metropolitan Statistical Area is a county or group of contiguous counties that contains at least one city of 50,000 inhabitants or more.

Table 2.3--Historical landmarks and sites

County	Name	Specific location
Clear Creek	Georgetown-Silver Plume Historic District	Georgetown-Silver Plume Vicinity
Conejos	Pike's Stockade	4 miles east of Sanford
Denver	Daniels & Fisher Tower	1101 16th Street
	Emanuel Shearith Israel Chapel	1201 10th Street
	Four Mile House	715 South Forest Street
	Governor's Mansion	400 East 8th Avenue
	St. Elizabeth's Church	1062 11th Street
El Paso	Pike's Peak	15 miles west of Colorado Springs
Gilpin	Central City Historic District	Central City
Lake	Leadville Historic District	Leadville
La Plata	Narrow Gauge Railroad	Durango-Silverton
Larimer	Lindenmeier Site	28 miles north of Fort Collins
Las Animas	Raton Pass	Colorado-New Mexico
Montezuma	Hovenweep National Monument	Cortez vicinity
	Mesa Verde National Park	10 miles east of Cortez
	Yucca House National Monument	12 miles south of Cortez
	Lowry Ruin	30 miles northwest of Cortez
Otero	Bent's Fort	8 miles west of Las Animas
San Juan	Silverton Historic District	Silverton
San Miguel	Telluride Historic District	Telluride
Teller	Cripple Creek Historic District	Cripple Creek

The growth of Colorado's population during the last decade was substantially above the national rate and in recent years the spread has increased making Colorado one of the fastest growing states in the nation. Table 2.4 lists selected segments of the population for 1960 and 1970.

Table 2.4--Distribution of the population by economic areas

Item	Economic area[1/]				
	Arkansas	Colorado	Missouri	Rio Grande	State
Total population - 1970	482,661	189,892	1,497,240	37,466	2,207,259
Total population 1960	395,349	176,572	1,143,322	38,704	1,753,947
Percent change 1960-1970	22.1	7.5	31.0	-3.2	25.8
Urban population - 1970	373,258	65,473	1,283,686	10,894	1,733,311
Percent change 1960-1970	37.0	7.5	35.1	13.6	34.1
Rural population - 1970	109,403	124,419	213,554	26,572	473,948
Percent change 1960-1970	-11.0	7.6	10.4	-8.7	2.8
1970 percent of total:					
Urban	77.3	34.5	85.7	29.1	78.5
Rural	22.7	65.5	14.3	70.9	21.5

Source: 1960 and 1970 Census of Population, Colorado, U.S. Department of Commerce, Bureau of the Census

1/ Boundaries of Economic Areas are shown on exhibit 5.1 which is presented subsequently in Part V--Economic Base and Present Economic Conditions

PART III

WATER RESOURCES, UTILIZATION and DEVELOPMENT

PART III--WATER RESOURCES UTILIZATION AND DEVELOPMENT

WATER SUPPLY SOURCES

The water resources available for use in Colorado are derived almost exclusively from precipitation that falls within its boundaries inasmuch as the drainage flowing into Colorado is very limited. Precipitation varies seasonably and annually in both form and amount in different physiographic regions. Runoff from mountain snow packs constitutes the most consistent and the largest amount of Colorado's surface water supplies. Runoff from rainfall contributes substantially to the surface water supplies; however, both the amount and the time of occurrence varies widely in different parts of the State and is much less predictable than that derived from the mountain snow packs.

The Geological Survey, an agency of the U.S. Department of the Interior, collects and publishes data on streamflow, chemical quality of water, water temperature, and sediment loads. The records are maintained on the basis of water years--a water year begins on October 1 and ends on September 30, being identified by the calendar year in which the latter falls. The location of the key gaging stations operated in 1970 are shown on exhibit 3.1.

Ground water is an important source of supplies in many parts of Colorado. Abundant supplies occur in the valley alluvium of the Rio Grande, South Platte, and Arkansas Rivers. Other geologic formations in which vast quantities of ground water have accumulated are the Ogallala and the Dakota sandstones that underlie the plains of eastern Colorado.

In western Colorado, ground water has also accumulated in the valley alluvial and other geologic formations of sedimentary origin, but in much lesser quantities than in the eastern part of the State. In the Colorado mountains, neither the geology nor the topography is favorable for the accumulation of significant amounts of ground water. Usually, the igneous bedrocks in the mountains are poor aquifers and the unconsolidated soil mantle is too shallow to permit significant accumulations of ground water.

WATER SUPPLIES AND DEPLETIONS

The total water supply available to the State is derived through complex usage of supplies from several sources. Supplies pumped from deep and shallow aquifers usually have a close relationship with the surface water supply. The normal water supply situation including State water outflow and transmountain diversions that prevailed in 1970 is summarized in table 3.1 and exhibit 3.2. Adjustment of historical averages to reflect 1970 depletions is referred to as the 1970 normalized conditions.

The annual surface runoff in any particular stream varies widely from year to year depending upon the precipitation. Other factors that influence the runoff are the soils, topography, geology, and vegetative cover. The average annual runoff ranges from 20 inches in the high mountains to less than 0.25 inches in the arid parts of the plateau and plains sectors. By subbasins, the Upper Colorado subbasin experiences the highest runoff, the average annual being 6.6 inches. The Republican River subbasin has an average annual runoff of 0.4 inches which is the lowest in the State.

The water depletions in the State occur as a result of the utilization of a complex surface and ground water resource system. Some uses such as the generation of hydroelectric power cause little, if any, depletions. Also, in most cases water depletions for fish and wildlife, and recreational uses are minor; however, there can be substantial nonbeneficial evaporation losses from reservoirs held at a constant level for these uses. Water supplies used for irrigation results in much greater depletions than any other purpose or combination of purposes. However, substantial return flows result from irrigation which are in turn put to successive uses. Other uses which result in lesser but substantial water depletions are municipal and industrial use, and mining and processing of minerals.

Interstate compacts require Colorado to permit specified quantities of water to cross its boundaries into other states for downstream use. In addition to the outflows required to satisfy the compacts, some flood flows which cannot be managed by existing water resource developments also leave the State.

The native water supplies referred to in table 3.1 have been computed by starting with the measured outflows leaving the State, then adding the estimated depletions, applying an adjustment for the imports and exports which results in a hypothetical quantity identified as "native." This quantity is a mixture of surface and ground water supplies and is not readily definable by any other means of examination or evaluation of flow records.

Table 3.1--Annual water supplies and depletions

(1,000 acre-feet)

Basin and subbasin	Water supplies				Water depletions[1/]				
	Native[2/]	Exports[3/]	Imports[3/]	Available	Irrigation[4/]	M&I and rural domestic[5/]	Other	Total	Basin outflow
Arkansas River	875	7	101[6/]	969	704	58	29	791	178[7/]
Colorado River									
Green River	2,013[8/]	0	0	2,013	113	2	12	127	1,886
Upper Main Stem	6,738	539[9/]	0	6,199	969	14	45[10/]	1,028	5,171
San Juan-Colorado	1,987	3	130[9/]	2,114	195	3	8	206	1,908
Basin total	10,738	412	0	10,326	1,277	19	65	1,361	8,965[11/]
Missouri River									
North Platte River	600	22[12/]	0	578	108	1	1	110	468
South Platte River	1,441	0	336[12/]	1,777	1,251	164	58	1,473	304
Kansas River	353	0	0	353	220	3	8	231	122
Basin total	2,394	0	314[13/]	2,708	1,579	168	67	1,814	894[7/]
Rio Grande	1,576[14/]	0	4	1,580	617	6	679[15/]	1,302	278
State Summary	15,583	419	419	15,583	4,177	251	840	5,268	10,315

1/ Estimated depletions under 1970 conditions of development
2/ Undepleted average annual water supply
3/ 1968 to 1970 annual average
4/ Irrigation consumptive use and associated consumptive reservoir and conveyance losses
5/ Rural domestic, municipal and industrial consumptive uses and related reservoir losses
6/ Includes 7,000 acre-feet exported to South Platte River
7/ 1950 to 1970 annual average
8/ Includes 237,000 acre-feet inflow of Little Snake River from Wyoming
9/ Includes internal basin diversion of 130,000 acre-feet from Dolores River to the San Juan River
10/ Includes 19,000 acre-feet of main stem reservoir evaporation from Curecanti Project
11/ 1914 to 1970 annual average
12/ Includes internal basin diversions of 22,000 acre-feet from North Platte River to the South Platte River
13/ Includes 14,000 acre-feet evaporation attributable to imports from Colorado River
14/ 1924 to 1969 annual average
15/ Includes 658,000 acre-feet nonbeneficial use in Closed Basin

SURFACE WATER QUALITY

The melting snows and rainfall in the mountains supply high quality water to the headwaters of the four major river basins in Colorado. However, through natural phenomena and many activities of man, the water ultimately picks up various types of impurities which in many instances alters the quality so as to reduce the suitability of the affected supplies for beneficial use.

This section of the report presents information on the major sources of impurities that adversely affect the surface waters in Colorado.

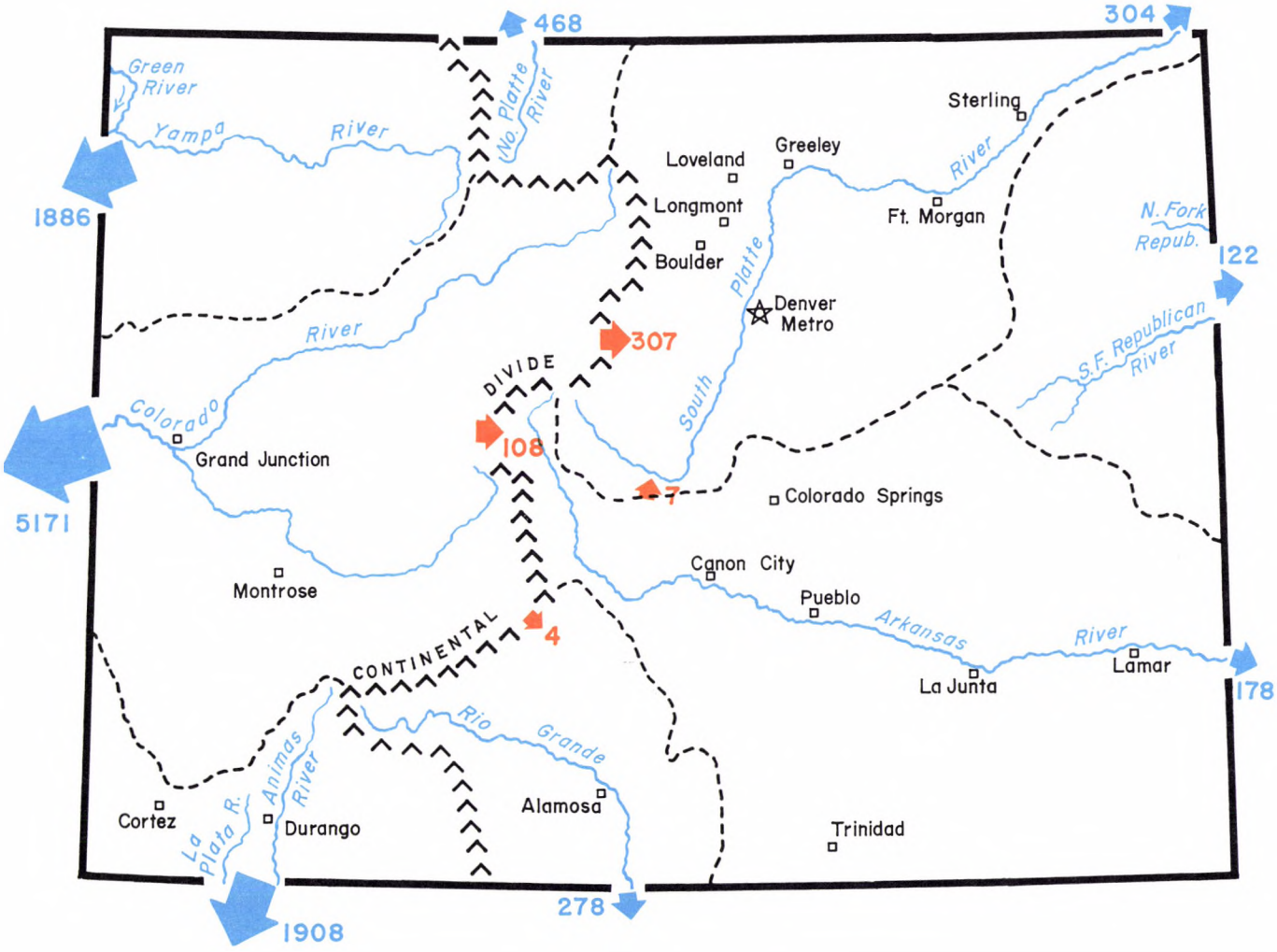
While some specific and some general problem areas are known, much study remains to be done to get an accurate picture of water quality statewide. To this end, several studies are already in progress, and other programs will be developed to fully implement the policy enunciated by the Federal Water Pollution Control Act.[1/] Implementation of this act by Colorado was authorized by the recently adopted Colorado Water Quality Control Act of 1973.

Municipal Wastes

By vigorous pursuit of a goal of secondary treatment for all municipal waste water, Colorado has achieved a marked reduction in pollution from these sources over the past 5 years. As of December 31, 1971, 99.8 percent of the population of the State was served by secondary treatment facilities.[2/] However, occasional quality problems continue to exist in the South Platte and Arkansas River basins downstream from heavily populated areas during periods of low flow in the receiving streams.

1/ Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500)

2/ Status Report of Domestic Waste Water Treatment, Colorado Department of Health, December 31, 1971



COLORADO

STATE OUTFLOWS AND
TRANSMOUNTAIN DIVERSIONS

EXPLANATION

0 State Outflows
Normalized 1970 Conditions

0 Transbasin Diversions
1968 - 1970 AVERAGE

Flows and diversions shown
in thousands of acre-feet.

Total Transbasin Diversions from the Colorado River Basin.....419,000 A.F.

Total state outflow.....10,315,000 A.F.

EXHIBIT 3.2

Perhaps the greatest potential for future water quality problems due to municipal wastes exists in the mountain areas of the State that are being rapidly developed for resort and summer home sites. Examples are the Dillon Reservoir area and the areas surrounding Grand Lake, Shadow Mountain Lake, and Lake Granby which are interconnected.[3/]

Industrial Wastes

Substantial water quality problems resulting from the discharge of industrial wastes have, in the past, been quite common, again in the South Platte and Arkansas River Basins. These discharges have come from packing and canning plants, beet sugar mills, steel mills, and particularly in the case of Denver, from many miscellaneous industries discharging to storm sewers or directly to the river. As the result of the Federal Water Pollution Control Administration Conference in 1966, much as been achieved through use of waste water for irrigation, recycling inplant, and connection of waste treatment facilities.[4/]

In the past, serious problems have occurred in the Colorado River Basin due to the discharge of radioactive uranium mill effluents. Although most of the mills are now closed, the existing piles of mill tailing are still a potential source of dangerous pollution.[5/]

Sediment

Sediment has been identified as one of the more serious pollutants in the nation's waterways. All of Colorado's streams carry sediment as the result of natural erosion, expecially during times of high flow. Cultivation of the land, construction of highways, and grading associated with housing and industrial developments and miscellaneous construction work are some of man's activities which add to the sediment load.

3/ A Regional Water Quality and Sewerage Master Plan for the Three Lakes Water and Sanitation District, Nelson, Haley, Patterson, and Quirk Inc., November 21, 1972

4/ Proceedings - Conference in the Matter of Pollution of the South Platte River Basin in the State of Colorado, Federal Water Pollution Control Administration, April 27 and 28, 1966

5/ Quality of Water, Colorado River Basin, Progress Report No. 6, January 1973, U.S. Department of the Interior.

The most serious sediment problems for the Arkansas River Basin are associated with floods which are more severe above John Martin Dam.

In the South Platte River Basin the highest concentrations of suspended sediment occur in the ephemeral runoff resulting from intense rains on the Colorado Piedmont east of the mountain front. The Kiowa and Bijou Creek area has an estimated sediment yield of 700 tons per square mile per year.[6/]

Several sediment studies have been made throughout the Colorado River Basin in connection with existing and potential storage reservoirs. Within the basin, a wide range of concentrations occurs. Extremes range from less than 10 p/m to more than 10,000 p/m.

Construction of dams on the Colorado River and tributaries has produced dramatic reductions in the sediment loads transported by these streams. The streams immediately below the dams have been changed to relatively clean trout fishery waters as well as desirable boating and recreation areas.

Tabulated sediment data below are from selected sites within the State.

Site	Weighted average concentration p/m	Annual discharge 1,000 tons/year	Annual discharge Tons/Miles^2/year
Arkansas River Basin			
Arkansas River near Pueblo	2,100	1,492	318
Arkansas River below John Martin Dam	5,210	2,218	117
Colorado River Basin			
Yampa River near Maybell	196	308	90
Gunnison River near Grand Junction	806	2,067	258
Colorado River near Cameo	2,270	9,248	1,150
Colorado River near Cisco, Utah	1,050	14,351	595
Dolores River near Cisco, Utah	3,370	2,524	545
Animas River at Teft diversion	130	36.1	104
La Plata River near State Line	2,154	68.9	208
San Juan River at Rosa, NM	3,800	4,400	2,211
McElmo Creek near Cortez	2,600	141	605
Missouri River Basin			
South Platte River near Fort Morgan	3,703	1,827	124

6/ Missouri River Basin Comprehensive Framework Study Report, Volume 1, June 1969

Agricultural and Urban Area Runoff

Pollutants in surface runoff differ, depending on whether their origin is rural or urban.

In rural areas, pollution by agricultural runoff occurs throughout the State varying in character and occurrence with land use. Pollutants include not only sediments but also dissolved chemicals, crop nutrients, herbicides and pesticides adsorbed on soil particles, and organic residue.

Runoff from large urban areas is an important source of pollution. Urban runoff contains in different degree the same pollutants as that from rural areas, and in addition, other pollutants such as hydrocarbon residues and contaminants generated by large concentrations of people, industries, and vehicles.

Irrigation Return Flows

While there are other sources of salinity, a major reason for substantial increases in dissolved mineral concentrations in many Colorado streams is the leaching effect of water used and reused for irrigation, a portion of which returns to the streams as diffuse or point source return flows.

The concentration of dissolved solids for the Arkansas River and some of its tributaries near their junctures with the main stream are shown in the following tabulation:

Stations[1/]	Number of samples[2/]	Dissolved solids (mg/l)		
		Max.	Min.	Average of Samples
Halfmoon Creek near Malta, Colorado	10	62	40	53
Arkansas River at Canon City, Colorado	12	190	86	150
Arkansas River near Portland, Colorado	12	389	138	288
Arkansas River below John Martin Res., Colorado	4	3,110	1,650	2,195
Arkansas River at Lamar, Colorado	12	4,320	2,870	3,794
Arkansas River near Coolidge, Kansas	12	4,060	2,520	3,592

Source: Water Resource Data for Colorado, Part 2, Water Quality Records, 1969, U.S. Geological Survey

1/ Listed in downstream order

2/ Samples were taken during the 1970-1971 water year

Information on salinity levels (dissolved solids) for the Colorado River Basin was obtained from the Bureau of Reclamation's Progress Report No. 5. At the gaging stations in Colorado, the salinity level of the Colorado River is less than the 500 mg/l upper range recommended by the Public Health Service for drinking water. However, the salinity increases progressively downstream, and at the Cisco, Utah station, the salinity is greater than the recommended level. The following tabulation shows the salinity level at three gaging stations on the Colorado River.

Station	Dissolved solids (mg/l) 1968	28 year average
Colorado River		
near Glenwood Springs, Colorado	312	272
near Cameo, Colorado	439	406
near Cisco, Utah	680	620

Source: Quality of Water, Colorado River Basin, Progress Report No. 6, January 1973, U.S. Department of the Interior

The ongoing salinity studies include the major tributaries of the Colorado River. The results of the sampling and testing program are shown in the following tabulation:

Station*	Water year	Number of samples	Dissolved solids (mg/l) Max.	Min.	Avg. of samples
Yampa River near Maybell, Colorado	67-68	22	656	120	201(time weighted)
White River near Watson, Utah	67-68	31	1,050	243	475(time weighted)
Gunnison River near Grand Junction, Colorado	67-68	41	1,570	308	720(time weighted)
Dolores River near Cisco, Utah	67-68	39	3,980	222	664(time weighted)
San Juan River near Carracas, Colorado	69-70	10	298	98	184
Navajo River near Edith, Colorado	69-70	5	166	94	138
Piedra River near Arboles, Colorado	69-70	10	282	105	197
Los Pinos River near LaBoca, Colorado	69-70	10	165	80	130
Animas River near Cedar Hill, New Mexico	69-70	12	479	162	287
McElmo Creek near State Line	69-70	5	3,350	1,100	2,510

Source: Water Resources Data for Colorado, Part 2, Water Quality Records, 1968 and 1970 issues, U.S. Geological Survey

* The stations listed are those located on the larger tributaries of the Colorado nearest to the Colorado State Line.

Three areas in Colorado within the Colorado River Basin which may be of concern as sources of salinity from irrigation return flows are:

Grand Valley - 76,000 irrigated acres along the Colorado River
Lower Gunnison - 160,000 irrigated acres in the Gunnison River Basin
McElmo Creek - receives return flows from lands irrigated by water from the Dolores River

Source: Colorado River Water Quality Improvement Program, U.S. Department of the Interior, Bureau of Reclamation, February 1972

Water quality in the receiving streams is influenced by salinity from natural and other sources as well as irrigation return flows. At present, it is difficult, if not impossible, to quantify the salinity by sources.

The Rio Grande River in Colorado experiences an increase in salinity due to irrigation, but the flows that leave the State are of good quality, as shown by the following tabulation:

Station	Number of samples*	Dissolved solids (mg/l) Max.	Min.	Avg. of samples
Rio Grande River				
near Del Norte, Colorado	12	100	38	75
near Lobatos, Colorado	12	492	119	230

Source: Water Resources Data for Colorado, Part 2, Water Quality Records, 1968, U.S. Geological Survey

* Samples were taken during the 1967-1968 water year

Water quality in terms of dissolved solids in the South Platte River from Denver downstream is largely the result of irrigation return flows. The following tabulation clearly shows the progressive downstream increase.

Stations progressing downstream	Number of samples*	Dissolved solids (mg/l) Max.	Min.	Avg. of Samples
South Platte River				
at Henderson, Colorado	12	783	181	516
near Kersey, Colorado	12	1,450	373	965
at Balzac, Colorado	12	1,530	605	1,159
at Julesburg, Colorado	12	1,590	672	1,330

Source: Water Resources Data for Colorado, Part 2, Water Quality Records, 1970, U.S. Geological Survey

* Samples were taken during the 1969-1970 water year

Natural Salinity

As indicated by the previous discussion on "Irrigation Return Flows," salinity as a natural phenomenon is considered to be a serious problem only in the Colorado River Basin.

According to studies conducted by the Bureau of Reclamation, two point sources in Colorado are worthy of feasibility studies.[7/] These are Paradox Valley and Glenwood-Dotsero Springs. Paradox Valley is estimated to contribute 200,000 tons of salt per year to the Dolores River, while Glenwood-Dotsero Springs discharge an estimated 500,000 tons annually to the Colorado River. The salinity studies also establish that salt pickup occurs over large areas of surface and underlying soils, from stream channels and banks, and is difficult to identify, measure, or control. This source contributes the largest overall share of the salts to the Colorado River.[8/]

7/ Colorado River Water Quality Improvement Program, U.S. Department of the Interior, Bureau of Reclamation, February 1972

8/ Quality of Water, Colorado River Basin, Progress Report No. 6, January 1973, U.S. Department of the Interior

Mining Wastes

Quite the opposite of most other forms of pollution, mining wastes generally affect the smaller headwater tributaries rather than the downstream main stem. This is because the quantities of pollutants involved are usually small, are oxidized, settled out, neutralized, and diluted with downstream travel. Their greatest impact is the destruction of quality fisheries in otherwise fine mountain streams.

Some limited studies of mining wastes have been made, and are discussed later. However, the only study that has Statewide coverage is one being conducted by the U.S. Geological Survey at the request of the Colorado Department of Health. The reconnaissance phase, which identified over 1,000 sites, has been completed, and more detailed studies are now going forward at a limited number of sites, a site being defined as an affected reach of a stream that may include several sources of pollution. An official report on these studies is not yet available.

The upper Arkansas River and tributaries above Buena Vista are known to be affected by drainage from numerous abandoned mine workings. Perhaps the most seriously polluted stream is California Gulch which enters the river just below Leadville. Pollution from this source renders several miles of the main-stem incapable of supporting a self-sustaining fishery.

Several degraded reaches of stream in the Colorado River Basin were identified in a 1966-1968 survey. The degraded reaches constitute about 120 miles of streams. In many instances, concentrations of heavy metals exceeded the Public Health Service Drinking Water Standards. Table 3.2 summarizes the results of the 1966-1968 survey.

The headwaters area of the Rio Grande has been the site of much mining activity. It is expected that the USGS study will pinpoint water quality problems. Of recent concern (1971) was a fish kill in Willow Creek above Creede caused by an accidental spill from a zinc mill settling pond containing zinc concentrations of 125 mg/l. Several miles of stream were affected.

In 1966-1967, the FWPCA (now EPA) made a restricted Mining Waste Evaluation Study in the South Platte River Basin. This study covered the Upper South Platte River, Clear Creek, and St. Vrain Creek Basins. Some 15 sources of pollution from mine drainage were discovered and their effects on the receiving streams were determined. The report on this study was concluded by the statement that it gave "..... only a perspective to the

Table 3.2--Mine drainage sources and effects--Colorado River Basin

Stream	Area of investigation	Major sources	Effects
Blue River			
Tenmile Creek	Headwaters to mouth at Frisco, Colorado	Wilfrey Mine; pump failure at Amax tailings ponds	Some areas devoid of aquatic life due to high heavy-metals concentrations
Eagle River	Homestake Creek near Radcliff to Minturn, Colorado	Mineral spring near Belden, Colorado; former seepage from old tailings pile; New Jersey Zinc Corp. decant.	Aesthetics; destruction of biological productivity; high heavy-metals concentration; predominantly zinc
Gunnison River			
Lake Fork	Headwaters to Lake City, Colorado	Golden Fleece Mine	Aesthetics in northwest portion of Lake San Cristobal
Uncompahgre	Headwaters through Dexter Creek, upstream of Ouray, Colorado	Red Mountain Creek; via Genessee, Rouville, and Joker Tunnels, and Red Mountain adit; natural sources	Aesthetics; low pH; high heavy-metals and mineral concentration; devoid of aquatic life
Dolores River	Mouth of Coal Creek to Dolores-Montezuma County line	St. Louis and Blaine Tunnels; Silver Swan adit; and others	Aesthetics; minimal effect due to neutralization of mine drainage by natural river alkalinity
San Miguel River	Upstream of confluence with South Fork	Iron Springs; Penn Tunnel; other mine drains; natural sources	Aesthetics; high heavy-metals concentration; minor effects on biological productivity
San Juan River			
Animas River	Headwaters through Mineral Creek south of Silverton, Colorado	Cement Creek, north Mineral Creek via Bagley, American, and Koehler Tunnel; other adits, mills, and mine drains, natural sources	Aesthetics; high heavy-metals concentration, particularly zinc; many areas devoid of aquatic organisms
La Plata River	Headwaters to Hesperus, Colo.	Natural sources	Minimal effects
Mancos River	Headwaters to confluence of Middle and East Forks	Natural mineral seep.	Some destruction of aquatic life, particularly fish

Source: Quality of Water, Colorado River Basin, Progress Report No. 6, January 1973, U.S. Department of the Interior

overall problem existing in the Basin and the State of Colorado. These studies could not, and did not, consider any large number of mine waste sources, but nevertheless indicate the widespread nature and approximate magnitude of the problem."

Feedlot Runoff

Colorado, in 1971, had approximately 2,000 feedlots and dairies, most of them being concentrated along the South Platte River. Adequate control of runoff has been achieved for a large majority of the facilities, and a substantial part of the others cause no problems due to location. Total compliance with the Colorado Department of Health's control regulations was anticipated by the end of 1974.[9/] The rules and guidelines of the State require that State waters be protected from a 10 year - 24 hour precipitation runoff from a confinement facility which, in most cases, means complete retention of runoff with later land irrigation.

GROUND WATER QUALITY

General

The quality of the ground water in Colorado is described in broad terms in the U.S. Geological Survey Atlas HA-199, 1965. Following is an excerpt from that atlas:

> "The Great Plains flanks the Rocky Mountains on the east..... Supplies of mineralized ground water are available throughout virtually the entire area. There is a general shortage of water low in mineral content in the Great Plains, although locally, large supplies of less mineralized ground water overlie the aquifers that yield water containing more than 1,000 ppm of dissolved solids. Large amounts of mineralized water are used in this area, as ground water containing less than 1,000 ppm is not widespread."

9/ Status Report, Industrial Waste Water Treatment, Colorado Department of Health, December 31, 1971

"The mountainous West includes the Rocky Mountains and..... Within it are high plateaus, elongate mountain ranges, and intermontane basins. In the main....especially in the Southwest... it is an area of water shortage.....Known areas of mineralized water are scattered and many of them are small.....The high mountains receive 40 inches or more of precipitation per year..... In many of the mountain areas that receive abundant precipitation, ground water is scarce, but is of excellent quality where present .....It is probable that wherever permeable rocks extend to depths of a few thousand feet, the deeper water-bearing zones are occupied by mineralized water."

Maps included in the aforementioned atlas show these general conditions for Colorado:

The northern two-thirds of the eastern one-half of the State is underlain by aquifers at depths of over 1,000 feet containing water of 3,000-10,000 p/m dissolved solids.

The remainder of the eastern one-half and the western one-third of the State are underlain at depths of less than 500 feet by aquifers containing water of 1,000-3,000 p/m dissolved solids.

The high intermontane valleys are inferred to contain mineralized water at considerable depth while the mountains themselves contain no mineralized water of consequence.

Of primary importance in the State are the shallow alluvial aquifers of the stream valleys which are largely recharged by surface water and which are parts of hydraulically integrated ground-surface water systems. The quality of the water in these aquifers is a reflection of the quality of the surface water with which they are recharged.

Deep Aquifers

Deep aquifers, and shallow ones as well, can have their quality impaired by contamination through poorly constructed wells or unsealed abandoned wells as indicated by the following statement: "Saline water from the shallow contaminated

zone in the vicinity of the Arsenal (downstream from Denver) has likely entered the underlying bedrock aquifers through at least three defective deep wells. However, the actual number of defective wells is unknown....."[10/]

A fairly recent practice as a means of disposing of particularly troublesome wastes is the deep disposal well. Controls on such disposal in the State are so stringent that, to date, few, if any, applications have been made for such disposal.

Tests on samples from 126 wells drilled into sandstone aquifers at depths from 200 to 1948 feet showed the conductivity of the water to range from 175 to 3820 micro-mhos per cm, the deeper wells generally having the higher conductivities.[11/] Practically all of these wells are in eastern Colorado, either in the Arkansas River Basin or in the South Platte and Upper Republican River Basins. The quality of the ground water is somewhat different in the San Luis Valley which constitutes the major portion of the Rio Grande Basin in Colorado.[12/] The valley is underlain by "unconfined" (for our purpose shallow) aquifers and "confined" (deep) aquifers. Most of the deep wells take water from several of the confined artesian aquifers. For 41 wells ranging in depth from 60 to 4200 feet, water samples showed dissolved solids from 70 to 437 p/m. Six of 16 samples of artesian water showed fluoride in excess of 1.5 p/m with a maximum of 9.5 p/m.

Shallow Aquifers

The valley fill is the most productive aquifer in the Arkansas River Basin. It consists largely of saturated sand and gravel which yields water freely to wells. At present, there are about 3000 large capacity wells between Pueblo and the State line.[13/]

10/ Proceedings - Conference in the Matter of Pollution of the South Platte River Basin in the State of Colorado, Federal Water Pollution Control Administration, April 27 and 28, 1966

11/ Public Water Supplies of Colorado, 1959-60, U.S. Geological Survey and Colorado State University

12/ Ground Water Resources of the San Luis Valley, Colorado, 1950, Powell, W.J. - U.S. Geological Survey Water Supply Paper 1379

13/ Registered wells with State Engineers Office - 1971

The progressive downstream increase in salinity in the river and the aquifer as the result of irrigation return flows and pickup from soluble rock strata is shown in the following tabulation:

Station or town	Miles below Pueblo	Dissolved solids (mg/l) Arkansas River (average of samples)	Dissolved solids (mg/l) Well in alluvium (one sample)
above Pueblo	0	365[1]	
Boone	19		527[2]
near Nepesta	27	541[3]	
Fowler	35		1,160[4]
Rocky Ford	53		1,264[2]
LaJunta	64	1,377[5]	1,953[2]
Las Animas	84	2,314[3]	3,075[2]
bel. John Martin Res.	100	1,952[1]	
Lamar	120	3,780[1]	
Bristol	137	3,599[3]	
Granada	137	3,599[3]	
Holly	148		

1/ Water Resources Data for Colorado, Part 2, Water Quality Records, 1970, USGS

2/ Colorado Drinking Water Supplies, Chemical Quality, February 1971, Colorado Department of Health

3/ Water Resources Data for Colorado, Part 2, Water Quality Records, 1965, USGS

4/ Public Water Supplies of Colorado, 1959-60, USGS and CSU

5/ Water Resources Data for Colorado, Part 2, Water Quality Records, 1969, USGS

NOTE: The towns downstream from John Martin Reservoir obtain water supplies of usable quality from deep wells.

In the Colorado River Basin, ground water is an important source of domestic supplies for farms and ranches. In general, however, ground water in the basin is inadequate to meet major irrigation, municipal, and industrial requirements. Dissolved solids in the ground water are generally higher than in the surface water. Ground water having the lowest concentrations of dissolved solids is usually found in the higher mountain areas of the basin where there is seasonal or perennial recharge from infiltrating precipitation and streamflow,

a free circulation of the ground water, and few soluble salts in the consolidated formations forming the mountains. These areas are limited to the headwaters of the San Juan River in the southeastern part of the basin, and to the headwaters of the Colorado River.

Concentrations of dissolved solids in the ground water of these areas is generally less than 500 mg/l and in many instances is less than 250 mg/l. Ground water having the highest concentration of dissolved solids occurs in areas underlain by extensive marine shale and siltstone formations. The concentrations of dissolved solids in water from these formations, which are most widely exposed in the northwestern and central parts of the basin, typically range from about 1,000 mg/l to 3,000 mg/l. (See section on "Natural Salinity" under "Surface Water" for natural sources which no doubt affect ground water as well as surface water.)

In the shallow (unconfined) aquifer of the San Luis Valley (Rio Grande River Basin) the chemical quality of the ground water varies throughout the basin. The water is of good quality in the western part due to the use of high quality irrigation water, and on the eastern side due to recharge from the alluvial fans at the base of the Sangre de Cristo Mountains. Within the Closed Basin, northeast of the Rio Grande, the ground water tends to move to the sump area where it is consumed by evapotranspiration. The concentration of dissolved solids increases as the water moves toward the sump area, although its chemical content is altered by ion exchange in the soil. The highest concentration of dissolved solids occurs in the vicinity of San Luis Lake where it generally exceeds 10,000 p/m. The quality improves rapidly to the east, the dissolved solids decreasing to 100 p/m within a few miles. The water quality also improves to the west with concentrations of 200 p/m in the vicinity of Del Norte and Monte Vista.

The ground water of the South Platte River Basin between Denver and Brighton (22 miles) has been studied intensively. The ground water of the area, which is tapped by more than 1,000 wells for various uses, has been polluted from many sources as described in the following excerpt:[14/]

> "Over a period of years, discharges from the valley-fill aquifer are balanced by recharge. The chief source of recharge to the aquifer is from seepage derived from South Platte River water

14/ Proceedings - Conference in the Matter of Pollution of the South Platte River Basin in the State of Colorado, FWPCA, April 27 and 28, 1966

diverted to the irrigation ditches in the area. Approximately 50 percent of the river water diverted to the irrigation ditches enters the shallow aquifer.

Two incidents of ground-water contamination by gasoline spills or leakages have occurred. Portions of the shallow aquifer in these two localities most likely remain contaminated.

Much of the valley-fill aquifer in Sand Creek Valley is probably contaminated by petroleum wastes. In the Commerce City area, two public supply wells owned by Town & Country Mutual Water Company have been contaminated by hydrocarbons since 1957.

Alkyl benzene sulfonate (ABS) is found throughout most of the valley-fill aquifer. Most shallow public supply wells yield water containing significant concentrations of ABS. The principal source of ABS in the aquifer is sewage-laden recharge water from the South Platte River, Sand Creek and Clear Creek.

Nearly all bacteria are removed by infiltration through the saturated zone. However, residual bacteria may be found after travel over appreciable distances. Bacteriological data from two public water supplies adjacent to the South Platte River indicate fecal coliforms were present in the aquifer 300 feet from the river.

The principal source of nitrates in the shallow aquifer is fertilizer applied to irrigated farms. Feedlot operations and sewage-laden waters diverted from the river have also contributed nitrates to the aquifer. Highest nitrate concentrations generally occur in and near the irrigated lowland areas where nitrates commonly exceed 35 parts per million and are as high as 90 ppm. Two public supply wells owned by the South Adams Water and Sanitation District yield water having nitrate concentrations of 50 parts per million. Nitrate concentrations of water from the City of Brighton's wells currently range from 55 to 72 ppm. Waters from these public supply wells contain nitrates in excess of 45 mg/l, the upper limit of the United States Public Health Service Drinking Water Standards, and is potentially dangerous when used for infant feeding.....

The shallow aquifer underlying approximately 12 square miles in the vicinity of the Rocky Mountain Arsenal has been severely contaminated by chemical wastes discharged into unlined holding ponds and First Creek prior to 1957. Contaminants known to be present in the shallow aquifer include chloride, fluoride, arsenic, chlorate, the herbicide 2, 4-D, and the pesticides aldrin and dieldrin. Severe damages to crops and ground water supplies have resulted from the contamination. Contamination in the vicinity of the Rocky Mountain Arsenal will persist for many decades in the future, principally due to the relatively slow movement of ground water in the heavily contaminated parts of the aquifer."

Further down the South Platte Valley, the quality of the ground water like that of the surface water reflects principally the effects of irrigation. The dissolved solids at downstream locations are shown in the following tabulation:

Station or town	Miles below Denver	Dissolved solids (mg/l) South Platte River[1] (average of samples)	Dissolved solids (mg/l) Well in alluvium (average of samples)
at Henderson	15	516	
Brighton	22		1,332[2]
			(74[3]
near Kersey	62	965	(1,410[4]
at Balzac	122	1,159	
Merino	136		1,707[2]
at Julesburg	198	1,330	1,545[2]

1/ Water Resources Data for Colorado, Part 2, Water Quality Records, 1970, USGS

2/ Colorado Drinking Water Supplies, Chemical Quality, February 1971, Colorado Department of Health

3/ Present supply is Carter Lake water from central Weld County Water District

4/ Public Water Supplies of Colorado, 1959-1960, USGS and CSU

Seepage from holding ponds and waste stabilization ponds can also result in ground water pollution. The same can be true of seepage from solid waste disposal landfill operations if improperly sited, constructed, or operated.

WATER RESOURCE DEVELOPMENT

Many facilities have been constructed for putting Colorado's water resources to use. Some facilities such as those for providing domestic supplies to individual homes or small numbers of livestock are small and simple. Others which control vast quantities of water from several sources are large and complex.

The small projects have been developed mainly by private individuals and small entities including small towns and water user organizations. The larger projects have been developed through federal agencies and municipal governments. The Bureau of Reclamation and the Denver Board of Water Commissioners have constructed the largest and most complex systems in Colorado.

In addition to the Bureau of Reclamation, other agencies of the Federal Government, including the Corps of Engineers, and the Soil Conservation Service, have constructed water resource projects. Three well-known major water resource developments in Colorado include the Colorado-Big Thompson Project, Denver's water supply system, and the Fryingpan-Arkansas Project, the latter under construction with the basic plan scheduled for completion in 1978. The Curecanti Unit, a major power and water storage feature of the Colorado River Storage Project is also under construction with completion scheduled in 1977. The first three of these involve transmountain diversions and they control large quantities of water. The principal water resource developments and potential developments are shown on exhibit 3.3. The powerplants and associated transmission facilities of the Western Division Interconnected Power System, which includes Colorado, are shown on exhibit 3.4.

There are approximately 1900 lakes and man-made reservoirs in Colorado. The capacity of those included in this inventory range from a few hundred to many thousand acre-feet. Their combined storage capacity is roughly 7,000,000 acre-feet with surface areas totaling about 350 square miles.

The water resources controlled and regulated by the developments are used mainly for irrigation to produce food and fiber, and for municipal and industrial (M&I) supplies of metropolitan areas. Flood control, the control of soil erosion, the enhancement of recreation opportunities, the improvement of habitat for fish and wildlife, and the generation of hydroelectric power are also purposes for which projects have been constructed. Some of the large multiple purpose projects serve two or more of these purposes.

The irrigation facilities, in addition to the reservoirs, include the distribution systems of some 2,000 separate service areas. These systems range from short ditches with small capacity to long and large canals with networks of laterals. The lands developed for irrigation service, as of 1970, totaled 2,932,000 acres, most of which is the plains area of eastern Colorado, the San Luis Valley to the south, and portions of the Colorado Plateau to the west and southwest. This acreage includes lands supplied from surface supplies as well as ground water.

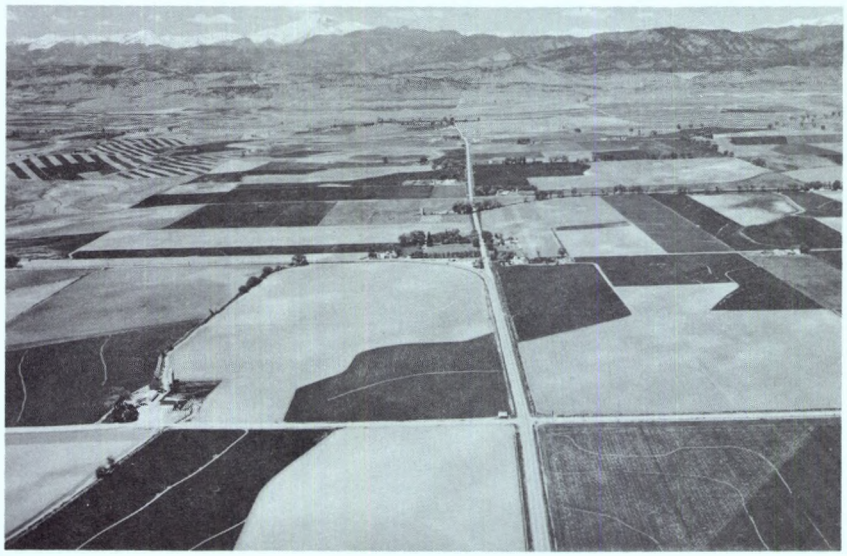
In the high country of Colorado, which is sparsely populated, an abundance of water nurtures the native vegetation and supports an abundant and wide variety of wildlife and cold water fish species. A part of this surplus water in the high country has been developed for processing minerals, for flood irrigation of high mountain hay meadows and other uses on ranches, and for use by mountain communities serving a growing economy based on summer tourism and winter sports activities.

Owing to the rapidly dwindling known supplies of natural gas and oil and a growing national shortage of energy, the near future development of oil shale and fossil fuel reserves in western Colorado may play a significant role in meeting future national energy demands. Colorado River water will have a significant role in the mining of these new fuel supplies and related energy developments.

East of the Continental Divide where nearly 90 percent of the people live, the towns, cities, and other entities situated along the front range and on the plains have constructed large reservoirs on both sides of the Continental Divide in order to regulate and control surplus waters from the high mountain area. Water from these mountain reservoirs have been conveyed eastward by transmountain tunnels and canals for municipal and industrial use, to generate hydroelectric power, and to irrigate the abundant high quality lands of the eastern plains. Many of these same mountain reservoirs serving the front range area have been highly developed for important recreation and fish and wildlife uses.

Although Federal and State assistance have played a major role in development of the above water facilities, privately owned canal, ditch, and storage companies have also participated in bringing water to the people of eastern Colorado.

The scarcity of water east of the Continental Divide and in portions of western Colorado, plus the rapid outflow of water from the mountains, brought about the adjudication of water rights and priority designations for the utilization of water. Compacts were established with other states that are dependent upon water originating in Colorado. The details of Basin and State water rights and agreements are presented in the Phase II Report, "Legal and Institutional Considerations" of the Colorado State Water Plan.



PART IV
LAND RESOURCES

PART IV--LAND RESOURCES

PHYSICAL ASPECTS

Colorado is characterized by a wide variety of land resources, ranging from wide expanses of rich, level agricultural lands to rugged mountains of barren rocks. The land itself cannot be disassociated from other factors such as its elevation, climate, vegetative cover, mineral content, and even its appearance and location.

The total land area of Colorado is 104,247 square miles, of which approximately 0.4 percent is covered by water in the form of natural lakes, manmade reservoirs, and streams.

OWNERSHIP AND ADMINISTRATION

All of the land resources of Colorado except some areas in the southwest that were included in Spanish land grants, were originally in federal ownership. In the process of settling the State, ownership of the lands was gradually transferred to other sectors, which includes private individuals, corporations, and local and state governments. Management practices in the private sector are controlled basically by economic conditions. Thus, the lands with the highest economic promise were the first to move from federal to nonfederal ownership. At present, the lands remaining in federal ownership are those of low economic potential or lands which because of special or unusual characteristics were retained as a benefit to the Nation in its entirety. The national parks, monuments, forests, and wilderness areas are examples of lands of national interest. The ownership distribution of the State's land resources are shown in exhibit 4.1 and table 4.1.

LAND USES

Nearly all of Colorado's land resources, including the water surfaces, have been appropriated for a primary use, and many lands have one or more ancillary uses. The diverse primary uses plus the often conflicting ancillary

Table 4.1--Distribution of lands by ownership

(1,000 acres)

Ownership	Economic areas[1/]				
	Arkansas	Colorado	Missouri	Rio Grande	State
Public Sector					
U.S. Forest Service	1,708	8,146	2,374	2,053	14,281
Bureau of Land Management	648	6,689	344	632	8,313
National Park Service	-	339	165	35	539
Department of Defense	106	188	91	-	385
State of Colorado	1,423	402	1,034	226	3,086
Subtotal	3,885	15,764	4,009	2,946	26,604
Private Sector					
Individual, municipal, and county	14,816	7,765	14,478	2,303	39,362
Indian trust	-	752	-	-	752
Subtotal	14,816	8,517	14,478	2,303	40,114
TOTAL[2/]	18,701	24,281	18,487	5,249	66,718

Source: Colorado Year Book, 1962-1964, State Planning Division

1/ Boundaries of economic areas follow county lines nearest the actual major river basin boundaries

2/ There have been minor changes in ownership since 1964

uses constitute a highly complex land use situation. Present land use practices do not necessarily represent the sole or optimum use for which any particular area is suited. In fact, a land use that is considered desirable today may be recognized as an objectionable use tomorrow.

Much of the land in Colorado is used for the production of food and fiber. Rangelands, which are used for the production of livestock, are the most extensive of the food and fiber category. Large acreages are also used for cultivated agricultural crops, and many acres are in forests. Each of these, particularly the forests, are used for other purposes, including recreation, wildlife habitat, and municipal watersheds. According to the 1970 Agricultural Census, crops were harvested from 5.3 million acres in Colorado in 1969, of which 2.9 million were irrigated.

The lands in the State receiving the most intense use are the urban areas. Most of the urbanized lands are concentrated in the metropolitan areas of Denver, Pueblo, and Colorado Springs. Other types of land use that sometimes completely alter the character of the land are mining and transportation (road construction). The lands that receive the least use by mankind are the remote high and rugged forested mountain areas. These areas have been set aside primarily for recreational uses, and for the preservation of fish and wildlife, and for scenic, wilderness, and primitive area preservation. Table 4.2 shows the distribution of Colorado's land resources by primary uses.

Table 4.2--Estimated distribution of lands by use

(1,000 acres)

Primary use	Economic areas				
	Arkansas	Colorado	Missouri	Rio Grande	State
Inventory lands[1/]					
Cropland (total	3,832	1,106	6,279	569	11,786
Pasture	171	560	402	221	1,354
Range	9,787	3,501	6,761	1,242	21,291
Forest	1,783	3,687	1,098	395	6,963
Other land[2/]	279	366	294	73	1,012
Subtotal	15,852	9,220	14,834	2,500	42,406
Noninventory lands					
Federal-noncropland	2,520	14,829	2,960	2,687	22,996
Urban[3/]	265	153	566	47	1,031
Small water areas[4/]	11	16	21	4	52
Subtotal	2,796	14,998	3,547	2,738	24,079
TOTAL[5/]	18,648	24,218	18,381	5,238	66,485

Source: Colorado Conservation Needs Inventory, December 1969, Soil Conservation Service

1/ Includes agricultural lands and others such as forests used in the production of food and fiber

2/ Consists of land in farms not used to produce crops, such as farmsteads, farm roads, feed lots, ditch banks, and fence rows

3/ Consists of cities, villages, and other built-up areas of more than 10 acres, including industrial sites, railroad yards, cemetaries, airports, golf courses, shooting ranges, and institutional and public administrative sites. Strip mines, borrow pits and sand pits are not included

4/ Includes ponds and lakes of more than two acres and not more than 40 acres, and rivers and streams that are less than 1/8 mile wide.

5/ This total land area excludes all water areas of more than 40 acres and rivers wider than 1/8 mile

LAND CLASSIFICATION AND INVENTORY

Land classification or soil surveys cover only part of the State. The location of lands covered by surveys is shown on exhibit 4.2.

The earliest soil surveys were made in the late 1920's and early 1930's. Their purpose was for categorizing the soil types and their potentiality for producing food and fiber for human use and for livestock feed. The reports showing the results of these early surveys are out of print and are not readily available. Moreover, much of the information is out-of-date and no longer valid for present conditions.

Since the Soil Conservation Service (SCS) was created in 1935, that agency has pursued a continuing land classification program.

This program not only identifies soil types but also assesses the potential soil erosion hazards associated with the various classes of land and provides guidance for land use and cultural practices. Lands which possess little or no agricultural potential are classified for other potentialities, mainly timber production or recreation.

Considerable work has been done in recent years through Type I studies and the Colorado Conservation Needs Inventory to estimate the total amount of lands in the State that is suitable for various uses. Type I studies represent the initial phase of the National Water Resources Council's program for accomplishing comprehensive water resource development. They involve the collection of data and the preparation of an inventory of the water and related land resources. The Colorado Conservation Needs Inventory is a continuing program established by the Department of Agriculture as a part of the National Inventory of Soil and Water Conservation Needs. In Colorado, the program provides up-to-date information on land uses and conservation treatment needs on nonfederal lands through soil capability classes. Watershed project needs on both privately and publicly owned lands were also included in the 1969 inventory. Much of the work was done by surveying sample areas and deriving the total inventory by means of statistical projection, a method which does not actually locate the lands. An inventory of the lands as classified by the SCS is presented in table 4.3.

Recent soil surveys are, or soon will be, available for large parts of 18 counties out of the 42 counties in the combined Arkansas, Missouri, and Rio Grande Basins. A soil survey of a small area in the mountains which falls within the Missouri River Basin is also available.

Table 4.3--Land capability classification

(acres)

Capability classes	Explanation of capability classes	Economic areas				
		Arkansas	Colorado	Missouri	Rio Grande	State
I	Soils that have few limitations that restrict their use	1,318	14,199	282,785	-	298,302
II	Soils that have some limitations that reduce the choice of plants or require moderate conservation practices	559,324	116,539	1,754,945	-	2,430,808
III	Soils with severe limitations that reduce the choice of plants, require special conservation practices, or both.	1,656,751	496,155	3,290,412	447,932	5,891,250
IV	Soils with very severe limitations that restrict the choice of plants, require very careful management, or both.	3,855,968	1,442,377	2,341,163	225,216	7,894,724
V	Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.	20,291	84,501	140,031	50,071	294,894
VI	Soils with severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.	5,906,987	2,615,756	3,971,477	132,855	12,627,075
VII	Soils with very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.	3,624,612	3,993,503	2,698,323	1,581,497	11,897,935
VIII	Soils and land forms with limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to aesthetic purposes.	226,610	457,482	354,604	32,743	1,071,439
	Total	15,851,861	9,220,512	14,833,740	2,500,314	42,406,427

Source: Colorado - Conservation Needs Inventory by Colorado State Conservation Board
Colorado Association of Soil Conservation Districts, Soil Conservation Service - U.S. Department of Agriculture

NOTE: Lands administered by federal agencies, urban lands plus build-up areas of 10 acres or more, and all water areas were excluded.

Land classification surveys have also been made in Colorado by the Bureau of Reclamation. The lands surveyed are within both existing and potential irrigation projects. The purpose of a survey is to assess the suitability of the lands for irrigation development. The classification process involves five principal factors; that is, soils, topography, drainage, land development costs, and crop water requirements. Normally, the lands are delineated into classes 1, 2, 3, 4, and 6. Class 1 lands are highly suitable for irrigation development, class 2 lands moderately suitable, class 3 lands marginally suitable, class 4 lands are suitable for special purpose development (such as sprinkler irrigation and flood irrigation of hay meadows), and class 6 lands are unsuitable for irrigation.

The Bureau of Reclamation makes three principal grades of surveys, reconnaissance, semidetailed, and detailed. In reconnaissance surveys, it is a common practice to delineate only classes 1, 2, and 6. A land classification program for a potential project is usually conducted in two or three stages, the third or detailed classification being restricted to projects that are proposed for Congressional authorization. The results of the land classification surveys conducted by the Bureau of Reclamation are shown in table 4.4.

Table 4.4--Land classification of Bureau of Reclamation projects

Basin and project	Irrigable classes of land 1/ (acres) Class 1	Class 2	Class 3	Class 4	Total irrigable land (acres)	Non-irrigable land (acres)	Total lands classified (acres)	Type of survey	Status
Arkansas Basin									
Fryingpan-Arkansas	151,627	199,215	-	-	350,842	220,724	571,566	detail	under construction
Trinidad	1,155	12,570	5,992	-	19,717	40,680	60,397	detail	under construction
Colorado Basin									
Bostwick Park	40	3,649	2,421	-	6,110	33,386	39,496	detail	under construction
Basalt	-	3,200	4,320	-	7,520	49,040	56,560	detail	potential project
Battlement Mesa	-	3,150	6,320	-	9,470	40,604	50,074	detail	potential project
Bluestone	260	2,650	1,860	-	4,770	103,410	108,180	detail	potential project
Dallas Creek	-	2,570	4,780	-	7,350	140,113	147,463	detail	authorized project
Fruitland Mesa	-	7,915	10,759	-	18,674	36,656	55,330	detail	authorized project
Grand Mesa	4,840	16,570	6,860	-	28,270	79,730	108,000	detail	potential project
Grand Valley		no class breakdown			33,368	116,632	150,000	recon.	constructed
Lower Yampa			DATA NOT AVAILABLE				255,000	detail	potential project
Middle Park			DATA NOT AVAILABLE				76,000	recon.	potential project
Paonia	3,150	10,020	1,415	715	15,300	17,735	33,035	semidetail	constructed
Savery-Pot Hook	-	1,630	12,950	-	14,580	69,850	84,430	detail	authorized project
Silt	881	3,413	2,750	-	7,044	11,309	18,353	detail	constructed
Smith Fork	-	4,033	5,493	-	9,526	19,247	28,773	detail	constructed
Uncompahgre		no current data			67,794	59,768	127,562	detail	constructed
Upper Gunnison	-	-	-	-	-	208,170	208,170	detail	potential project
Upper Yampa			DATA NOT AVAILABLE				90,000	recon.	potential project
West Divide	4,980	14,280	20,660	-	39,920	103,911	143,831	detail	authorized project
Yellow Jacket	-	8,540	5,650	-	14,190	126,270	140,460	detail	potential project
Animas La Plata	5,412	55,108	8,030	-	65,550	52,358	117,908	semidetail	authorized
Dolores	1,750	30,360	36,010	-	68,120	97,080	165,200	detail	authorized
Florida	605	12,845	6,000	-	19,450	17,470	36,920	detail	constructed
Mancos 2/	-	-	-	-	28,000	-	28,000	recon.	constructed
San Miguel	3,310	28,750	6,690	-	38,950	50,779	89,729	semidetail	authorized
Missouri Basin									
Colorado-Big Thompson:									
Boulder Creek Supply	9,071	14,986	10,804	-	34,861	20,126	54,987	detail	constructed
South Platte Supply	5,603	30,605	9,201	-	45,409	18,268	63,677	detail	constructed
Pick-Sloan Missouri Basin:									
Narrows	81,755	99,022	44,973	-	225,750	194,817	420,567	detail	authorized
Mt. Evans	92,486	397,219	-	22,861	512,566	3,067,866	3,580,432	recon.	potential project
Rio Grande Basin									
Costilla	-	-	-	-	-		23,619	-	potential project
Conejos	11,460	32,990	17,830	23,870	86,150	30,050	116,200	-	
Rio Grande	60,970	96,850	47,450	37,290	242,560	266,610	509,170	detail	potential project

1/ Irrigable lands, as used in this report, are defined as lands that are suitable for sustained irrigated crop production but may or may not have irrigation service. Class 1 lands have high suitability for irrigation; Class 2 lands have moderate suitability; Class 3 lands have marginal suitability; Class 4 lands are irrigable lands with special problems that can be overcome.

2/ Lands classified only as irrigable or nonirrigable.

PART V

ECONOMIC BASE and PRESENT ECONOMIC CONDITIONS

PART V--ECONOMIC BASE AND PRESENT ECONOMIC CONDITIONS

A wide variety of natural resources, including the lands, minerals, vegetal cover, and climate, have enabled Coloradans to develop a diversified and complex economy. At present, Colorado is probably most widely known for its recreation facilities. Agriculture is practiced on a commercial scale in nearly all parts of the state, and fruits and vegetables are produced abundantly in a few areas. Lumbering is an important economic activity in some of the forested areas of the mountains. Mining is also of great importance as are manufacturing, personal services, and retail and wholesale trade. The major components of the gross state product and their estimated 1970 values are listed in the following tabulation:

Item	Million $	Percent
Manufacturing	1,967	49
Agriculture	1,175	29
Tourism	520	13
Mining and Minerals	381	9
Totals	4,043	100

Source: Colorado Commerce and Development Division

To relate economic conditions to water supplies, the State was divided into four economic areas that are essentially the same as the major drainage basins in the State, the difference being that the boundaries of the economic areas coincide with the nearest county lines rather than the actual basin boundaries. The economic boundaries are shown on exhibit 5.1.

The economic information presented in this report is based on the latest available data. The reader will recognize, however, that the data for each segment of the economy is not for the same year, the reason being that economic data are collected at 5- or 10-year intervals rather than annually. Thus, obtaining current data, or data for the same year for each segment is impossible.

AGRICULTURE

Land Use

In 1969, lands totaling nearly 36.7 million acres were included in Colorado farms and were used for agricultural purposes. These lands constitute approximately 55 percent of the total land area and are widely distributed over the state. In western Colorado, more than one-half of the agricultural land is used for grazing. The plains area which includes the major part of both the Arkansas and Missouri River Basins in Colorado has most of the cropland.

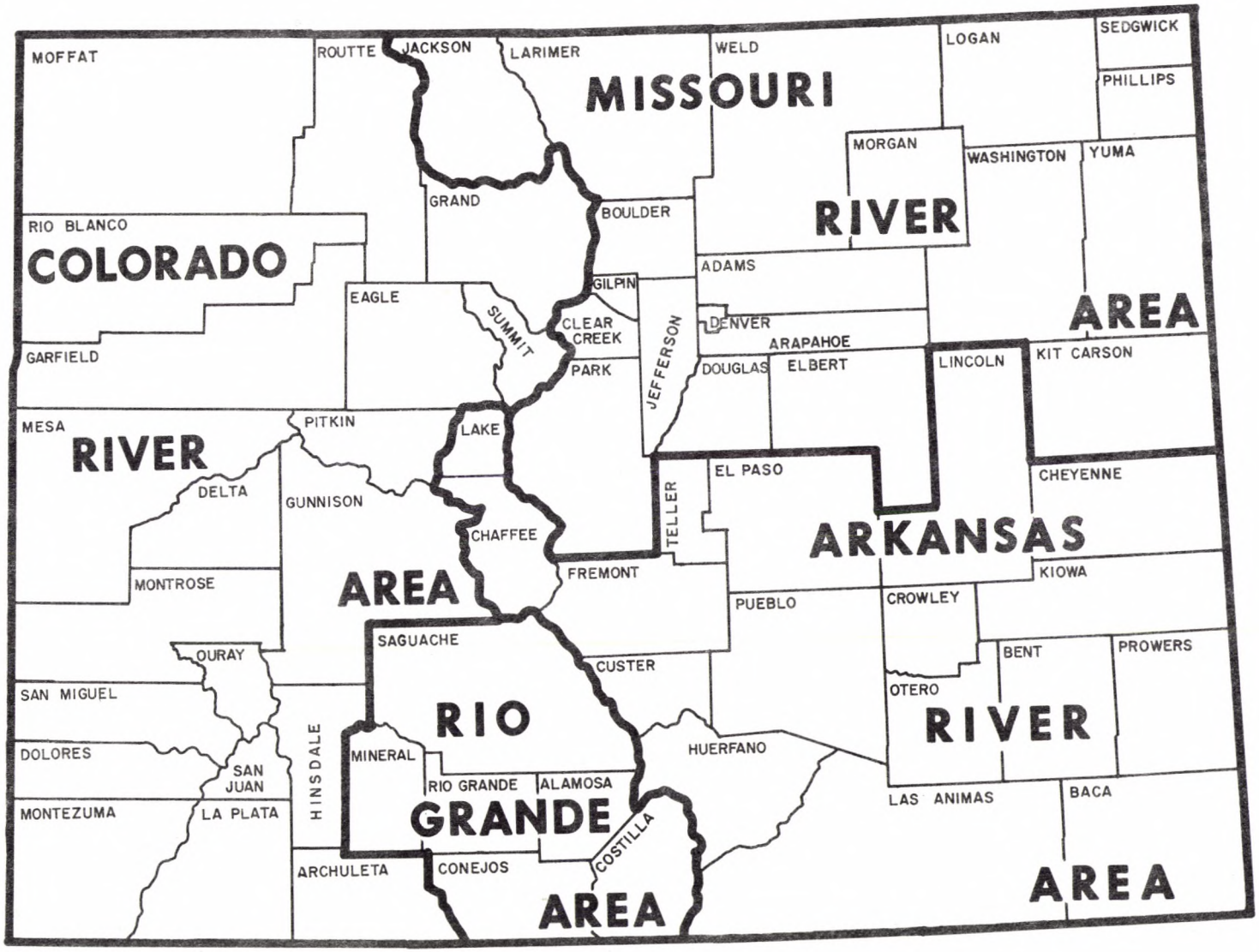
The most intensively cultivated lands are those that have been developed for irrigation. The irrigated lands constitute 27 percent of the cropland, and account for a large percentage of the crop production. Table 5.1 lists the agricultural lands in farms by use for each economic area. The land use data presented in this table was obtained from the U.S. Census of Agriculture and varies slightly from data presented previously in table 4.2 which was derived from data developed by the Soil Conservation Service.

Number, Size, and Types of Farms

The number of farms in Colorado has been declining for the past two decades. This experience is not peculiar to Colorado, but is in line with the nationwide movement of farm consolidation and the accompanying loss of farm population. The consolidation of farms in Colorado has taken place uniformly in each of the four economic areas. The decrease in the number of farms is shown in table 5.2. Table 5.3 shows the distribution of the farms by size.

Agricultural Production

Without irrigation, only a limited number of cultivated crops can be grown successfully in Colorado. Among the nonirrigated crops that are produced abundantly are winter wheat, rye, field beans, and grain sorghums. By using dryland practices and conservation measures, farmers have found these crops to be reliable where the growing season is adequate. Native grasses are also important to agriculture as they represent a major source of livestock feed.



ECONOMIC AREAS IN COLORADO

EXHIBIT 5.1

Table 5.1--Distribution of lands in farms according to use, 1969

(acres)

Land use	Economic areas				
	Arkansas	Colorado	Missouri	Rio Grande	State[1/]
Land in farms	13,733,700	7,386,147	13,740,065	1,814,292	36,697,132
Total cropland	3,217,085	1,207,839	5,871,603	474,490	10,773,310
Harvested cropland	1,343,372	729,558	2,861,641	329,637	5,265,721
Cropland used only for pasture or grazing	439,722	312,087	528,596	108,137	1,389,318
All other cropland[2/]	1,433,991	166,194	2,481,366	36,716	4,118,271
Woodland including woodland pasture	366,262	821,513	168,747	119,397	1,478,501
All other land[3/]	10,150,353	5,356,795	7,699,715	1,220,405	24,445,321
Irrigated land	487,863	752,254	1,192,384	456,173	2,894,984

Source: 1969 Census of Agriculture, Part 41, Volume 1, Sections 1 and 2, Colorado, U.S. Department of Commerce, Bureau of the Census.

1/ The State total is greater than the sum of the four economic areas because it includes acreages for some counties that were unavailable for the derivation of the acreages for the individual economic areas.

2/ Includes cropland used for soil improvement crops, crop failure, cultivated summer fallow, and idle cropland.

3/ Includes pastureland other than cropland and woodland pasture, rangeland, and land in house lots, barn lots, ponds, roads, wasteland, etc.

Table 5.2--Number and percentage distribution of farms, 1954-1969

Economic area	1954		1959		1964		1969	
	No.	%	No.	%	No.	%	No.	%
Arkansas Basin	9,813	24.1	7,974	23.9	7,122	23.9	6,552	23.5
Colorado Basin	10,121	24.8	8,096	24.2	7,446	25.0	6,373	22.8
Missouri Basin	18,449	45.3	15,520	46.5	13,665	45.9	13,586	48.6
Rio Grande Basin	2,366	5.8	1,800	5.4	1,565	5.2	1,412	5.1
State	40,749	100.0	33,390	100.0	29,798	100.0	27,950[1/]	100.0

Source: 1954, 1959, 1964, 1969 Census of Agriculture, Part 41, Volume 1, Sections 1 and 2, Colorado, U.S. Department of Commerce, Bureau of the Census.

1/ The State total is greater than the sum of the four economic areas because it includes farms from some counties that were unavailable for being counted with those of the individual economic areas.

Table 5.3--Number of farms by size, 1969

Size of farms (acres)	Economic areas				
	Arkansas	Colorado	Missouri	Rio Grande	State[1/]
Less than 10	404	443	1,066	63	1,981
10- 49	524	1,238	1,227	58	3,048
50- 69	96	291	287	24	699
70- 99	231	479	712	59	1,481
100- 139	168	339	496	64	1,067
140- 179	355	417	1,276	180	2,233
180- 219	176	251	446	58	931
220- 259	147	195	467	65	878
260- 499	863	700	2,081	375	4,021
500- 999	992	728	1,943	221	3,886
1000-1999	1,022	574	1,841	118	3,559
2000 and over	1,574	718	1,744	127	4,166

Source: 1969 Census of Agriculture, Part 41, Volume 1, Sections 1 and 2, Colorado, U.S. Department of Commerce, Bureau of the Census.

1/ The farms listed for the State are greater in number than the sum of those listed for the economic areas because the State listing includes farms from counties that were unavailable for counting with those of individual economic areas.

Lands in Colorado that receive irrigation service are used to produce a wide variety of crops. The irrigated crops represent a large portion of the agricultural production in Colorado. Crops usually grown under irrigation are corn, sugar beets, alfalfa, small grains, sorghums, fruits, and vegetables. The crops that can be grown without irrigation, including native grasses, are also grown on irrigated lands but to a lesser extent that those mentioned in the preceding sentence.

Crop production in Colorado for 1969 is shown in table 5.4. (following page)

Several kinds of livestock enterprises are associated with farm and ranch operations in Colorado. Cow-calf operations are the principal livestock enterprises throughout the agricultural areas. Raising sheep on rangelands is an important enterprise, and raising hogs and fattening cattle are important in areas where feed grains are produced abundantly. Table 5.5 shows the number of livestock sold in 1969, and table 5.6 shows the farm income and sales.

Table 5.5--Number of livestock sold, 1969

Livestock	Economic areas				
	Arkansas	Colorado	Missouri	Rio Grande	State[1/]
Cattle and calves	662,450	322,232	2,131,276	63,233	3,180,957
Hogs and pigs	103,358	39,441	268,500	23,281	434,580
Sheep and lambs	130,258	547,692	772,099	137,460	1,587,555
Horses and ponies	1,683	1,647	3,898	242	7,484
Chickens (3 mo. old or older)	212,018	28,763	495,467[2/]	31,266	1,129,191

Source: 1969 Census of Agriculture, Part 41, Volume 1, Sections 1 and 2, Colorado, U.S. Department of Commerce, Bureau of the Census.

1/ The livestock numbers listed for the State are greater than the sum of those listed for the individual economic areas because the State listing includes data from counties that were unavailable for including in the individual economic area listings.

2/ A large number of chickens in Adams County in the Missouri Basin was withheld to avoid disclosure of information for individual farms.

Table 5.4--Selected Colorado crop production, 1969

Crop	Unit	Economic areas				
		Arkansas	Colorado	Missouri	Rio Grande	State
Winter wheat						
Irrigated	bu	1,366,210	204,090	1,407,700	10,000	2,988,000
Nonirrigated	bu	10,667,700	2,803,050	28,334,250	-	41,805,000
Spring wheat						
Irrigated	bu	30,000	74,800	61,800	22,400	189,000
Nonirrigated	bu	162,620	220,050	146,330	-	529,000
Barley						
Irrigated	bu	272,300	1,237,150	2,913,250	4,411,300	8,834,000
Nonirrigated	bu	118,780	426,000	2,615,220	-	3,160,000
Sorghum for grain						
Irrigated	bu	5,804,900	135,000	358,100	-	6,298,000
Nonirrigated	bu	3,909,500	-	833,500	-	4,743,000
Oats						
Irrigated	bu	191,700	549,800	822,000	759,500	2,323,000
Nonirrigated	bu	90,200	139,000	1,353,800	-	1,583,000
Dry Beans						
Irrigated	cwt	67,640	161,500	1,136,060	800	1,366,000
Nonirrigated	cwt	43,125	490,000	9,875	-	543,000
Corn for grain						
Irrigated	bu	4,454,800	1,362,000	21,621,200	5,000	27,443,000
Nonirrigated	bu	74,350	3,000	414,650	-	492,000
Sugar Beets 1/	ton	179,400	259,800	2,784,800	-	3,224,000
Potatoes 1/	cwt	211,000	131,500	2,605,500	8,695,000	11,643,000
Corn Silage 1/	ton	592,880	242,400	3,084,820	6,900	3,927,000
Alfalfa	ton	461,650	520,860	962,990	199,500	2,145,000
Other hay	ton	187,110	450,210	401,480	137,200	1,176,000

Source: Colorado Agricultural Statistics, 1971

1/ Assumed to all be irrigated.

Table 5.6--Farm sales and income, 1969

(dollars)

Sales and income	Economic areas				
	Arkansas	Colorado	Missouri	Rio Grande	State [1]
Sales:					
Crops, including nursery products and hay	32,160,401	26,179,904	127,366,478	21,484,427	217,832,593
Forest products	130,399	184,454	23,618	5,862	374,836
Livestock, poultry, and their products	149,666,641	78,856,901	638,506,493	15,506,499	882,740,585
Total	181,957,441	105,221,259	765,896,589	36,996,788	1,100,948,014
Income:					
Customwork and other agricultural services	2,649,982	1,576,253	5,343,085	524,381	10,105,701
Recreational services	195,269	738,499	550,694	126,164	1,610,832
Government farm programs	15,149,994	3,460,682	24,634,533	526,986	43,772,240
Total	17,995,245	5,775,434	30,528,312	1,177,531	55,488,773

Source: 1969 Census of Agriculture, Part 41, Volume 1, Sections 1 and 2, Colorado, U.S. Department of Commerce, Bureau of the Census.

1/ The values listed for the State are greater than the sum for the individual economic areas because some county data was included in the State listing that was unavailable for the individual economic area.

MINERAL PRODUCTION

In 1970, 33 minerals were produced in Colorado on a commercial basis. To simplify the discussions on minerals, they were grouped into three categories, i.e., metallics, nonmetallics, and mineral fuels. The value of the minerals produced and the number of employees involved in their production are shown in table 5.7.

Table 5.7--Employment and value of mineral production by economic area, 1970

Economic area	Value of production (dollars)	Number of employees
Arkansas	134,940,036	4,330
Colorado	145,829,213	5,934
Missouri	85,279,004	4,175
Rio Grande	5,693,714	366
State	371,741,967	14,805

Source: A summary of Mineral Industrial Activities in Colorado 1970, Colorado Bureau of Mines

Metallics

The metallic resources are generally associated with the mountains and their peripheral outwash. In recent years, mining operations in the State have produced 15 metals in commercial quantities. Molybdenum is the leading metal being mined at the present time, the major molybdenum resources being the Climax and Urad deposits located in Lake and Clear Creek Counties, respectively. The Climax mine is the largest molybdenum mine in the United States. Colorado also leads the nation in the production of tin and vanadium. Table 5.8 lists the metals mined in Colorado in 1969 and 1970, and their values.

Table 5.8--Value of metallic production, 1969 and 1970

Metallics	(dollars) 1969	1970
Molybdenum	102,925,106	114,715,921
Vanadium	16,725,318	20,494,413
Uranium	17,260,081	15,246,708
Zinc	9,880,078	11,913,803
Tungsten	5,161,068	7,716,335
Lead	6,938,338	6,670,405
Silver	4,305,296	5,557,043
Copper	6,748,415	4,332,548
Gold	1,059,885	1,357,460
Iron	588,000	829,092
Cadmium	282,791	671,840
Tin	212,611	283,177
Pyrite	290,380	237,290
Beryllium	114,750	-
Miscellaneous metallics	289,645	133,050
Total metallic mineral production	172,781,762	190,159,085

Source: Summary of Mineral Industrial Activities in Colorado, 1970, Colorado Bureau of Mines

Nonmetallic Minerals

Nonmetallic minerals that are produced in quantity include a wide variety of substances used mainly in construction and industry. Some nonmetallics such as sand and gravel occur widely over the State. They are usually mined at locations near the point of demand because transportation costs are an important segment of the total production costs. The nonmetallics produced in the State in 1969 and 1970 and their values are listed in table 5.9.

Table 5.9--Value of nonmetallic production, 1969 and 1970

Nonmetallics	1969 (dollars)	1970 (dollars)
Sand and gravel	19,396,346	26,714,822
Cement	6,260,481	12,015,994
Limestone	3,755,580	4,198,107
Fluorspar	2,272,167	3,738,645
Stone	1,319,205	1,078,559
Clay	994,922	1,069,001
Dolomite	370,254	399,402
Volcanic Scoria	225,497	251,217
Gypsum	332,153	108,751
Peat	55,181	79,190
Perlite	73,400	38,944
Feldspar, Mica	5,779	11,982
Silica	72,267	-
Miscellaneous nonmetallics	18,012	4,120
Total nonmetallic mineral production	35,151,244	49,708,734

Source: Summary of Mineral Industrial Activities in Colorado 1970, Colorado Bureau of Mines

Mineral Fuels

Mineral fuels produced commercially in Colorado are coal, crude oil, and gas. Oil shale also occurs abundantly in Colorado, but at present, the demands for fuel are being met from the other types.

Thirty-eight of Colorado's 63 counties have some oil or gas production although one-half of the petroleum in the State is produced from the Rangely and Wilson Creek oilfields in Rio Blanco County. The remaining production in the State is scattered throughout the eastern flank of the Denver Basin in eastern Colorado. Production is exceeding discovery of new reserves. Extensive waterflooding is being practiced in most fields to extend their productive life. Proved reserves of petroleum are about 333 million barrels. The first two in a series of explosions aimed at stimulating natural gas production by nuclear fracturing of low-permeability gas zones are expected to increase the reserves of natural gas beyond the current 1,800 trillion cubic feet.

The estimated coal reserves of 82 to 370 billion tons are within 3,000 feet of the surface. Colorado has some of the highest quality low-sulfur coal in the west. This coal is widely distributed throughout the State with five major and three minor coal regions; the most important fields being in the western half of the State, with the exception of the Denver and Raton regions. About 40 percent of the State's production is metallurgical grade coal, and 45 percent utility coal. Strip mining has expanded to nearly half the State's production. Siting of electrical generating plants and coal gasification plants in proximity to these fields is likely. It is expected that the present 170 MW generating plant at Hayden will be expanded to 1,000 MW. Plants of similar size or larger are planned at Craig, Milner, Durango, and Nucla with water already reserved for these operations. Other coal fired powerplants have been proposed at Rangely and eastern slope locations. Proposed gasification plant locations based on these coal resources include Meeker, Palisade, Delta, Mt. Harris, Oak Creek, and Axial.

Colorado's oil shale reserves have been estimated at one trillion barrels of oil in shale of 25 gallons or more per ton, the major concentration of this resource in the United States. Many unknowns surround the eventual development of this resource. The Department of the Interior has announced a prototype oil shale leasing program to make available two tracts in Colorado (as well as two each in Utah and Wyoming) for commercial shale oil production. The Colorado tracts contain a potential of more than 86 billion barrels of oil. It is anticipated that two-thirds of this shale will be mined by surface mining methods.

The values of mineral fuels produced in Colorado in 1969 and 1970 are:

Mineral fuels	1969	1970
Crude oil	$ 84,882,759	$ 80,060,687
Gas sold	15,226,920	16,933,910
Other gas (all classes)	17,708,027	701,025
Coal	31,456,835	34,320,056
Total	$149,274,541	$132,015,678

Source: A Summary of Mineral Industrial Activities in Colorado 1970, Colorado Bureau of Mines

FOREST RESOURCES

Approximately 19,900,000 acres, representing nearly 30 percent of the State, are forest lands. Much of the forested area is within eleven national forests that lie wholly within, and one that lies partially within Colorado. These national forests average over a million acres each with a total of approximately 13,714,000 acres, or slightly over 20 percent of Colorado. These national forests are located in rugged areas, forming a broad belt that lies astride the Continental Divide with irregular spurs extending outward to the east and west.

Timber production in fiscal year 1970, as reported by the Colorado State Forest Service, totaled 315,626,000 board feet. Of this amount, state and private production accounted for eight percent.

The average wholesale value of finished lumber was $85.73 per thousand board feet. Average stumpage value was $13.71 per thousand board feet.

Estimated employment in the lumber and wood producing industry was 4,400 in fiscal year 1970.

MANUFACTURING

Historically, the number of manufacturing plants in the State has been gradually increasing. During the 5-year period, 1963-1967, the number of establishments increased from 2,453 to 2,461. Establishments that employed 20 or more people during 1967 numbered 664. The employees engaged in manufacturing in 1967 totaled 104,000 as compared to 93,700 in 1963, and the payroll of $730.5 million for 1967 was a 23 percent increase over that of 1963.

Value added by manufacturing in 1967 totaled over $1.5 billion while the value of shipments totaled over $3.2 billion. Cost of materials was $1.73 billion and expenditures for new capital was $99.6 million.

Much of Colorado's manufacturing is concentrated in the Denver area. In 1967, the manufacturing employees of the Denver Standard Statistical Area comprised 71 percent of the State total and they drew 76 percent of the total payroll. The manufacturing plants of the Denver SMSA accounted for 74 percent of the value added by manufacturing.

The largest group employed within a single manufacturing industry was the 18,700 employees engaged in processing food and kindred products. This group also had the highest payroll and contributed more to the value added than any other industry group. The second largest industry group was the 11,200 employees involved in the manufacture of nonelectrical machinery. This group's payroll for 1967 was $87.9 million. Table 5.10 shows the different aspects of manufacturing in 1967 by economic area.

Table 5.10--Manufacturing by economic area, 1967

Item	Arkansas	Colorado	Missouri	Rio Grande	State 1/
No. of establishments	379	238	1801	43	2461
Employment (1,000)	16.9	3.5	81.9	0.4	104.0
Payroll (million)	109.0	15.4	596.3	1.7	730.5
Value added (million)	206.5	32.6	1243.7	3.8	1509.2
Value of shipment (million)	398.2	67.1	2673.9	9.1	3226.6

Source: 1967 Census of Manufacturers, Colorado, U.S. Department of Commerce, Bureau of the Census

1/ Economic areas will not add up to the State total because of disclosure rules for protecting individual firms.

RECREATION

Early in its history, Colorado received wide recognition as a vacation land, being regarded as a summer resort by the people of both eastern and midwestern states. Through the years, many out-of-State people vacationed in Colorado, the main attractions in the early years being the mountain scenery, the cool summertime weather, and the abundant fish and wildlife. In the last decade, the quality and abundance of the winter snows for skiing has become an added attraction.

To preserve and supplement the natural elements, both the State and Federal Governments have set aside and developed areas for the enjoyment and convenience of vacationers. Among the most notable are the national parks and forests. Other popular recreation facilities include city parks and golf courses,

fishing and hunting areas developed by the State, and the recreation facilities developed in conjunction with irrigation and flood control reservoirs. Other important supplemental attractions are museums and art centers.

The fact that approximately 24,810,000 acres or 37 percent of the State is open to the public attests to the importance of outdoor recreation to the State's economy. Of the total lands open to the public 92.5 percent are in federal ownership and 7.5 percent in nonfederal ownership, i.e., state, county, municipal, school, and other lands.

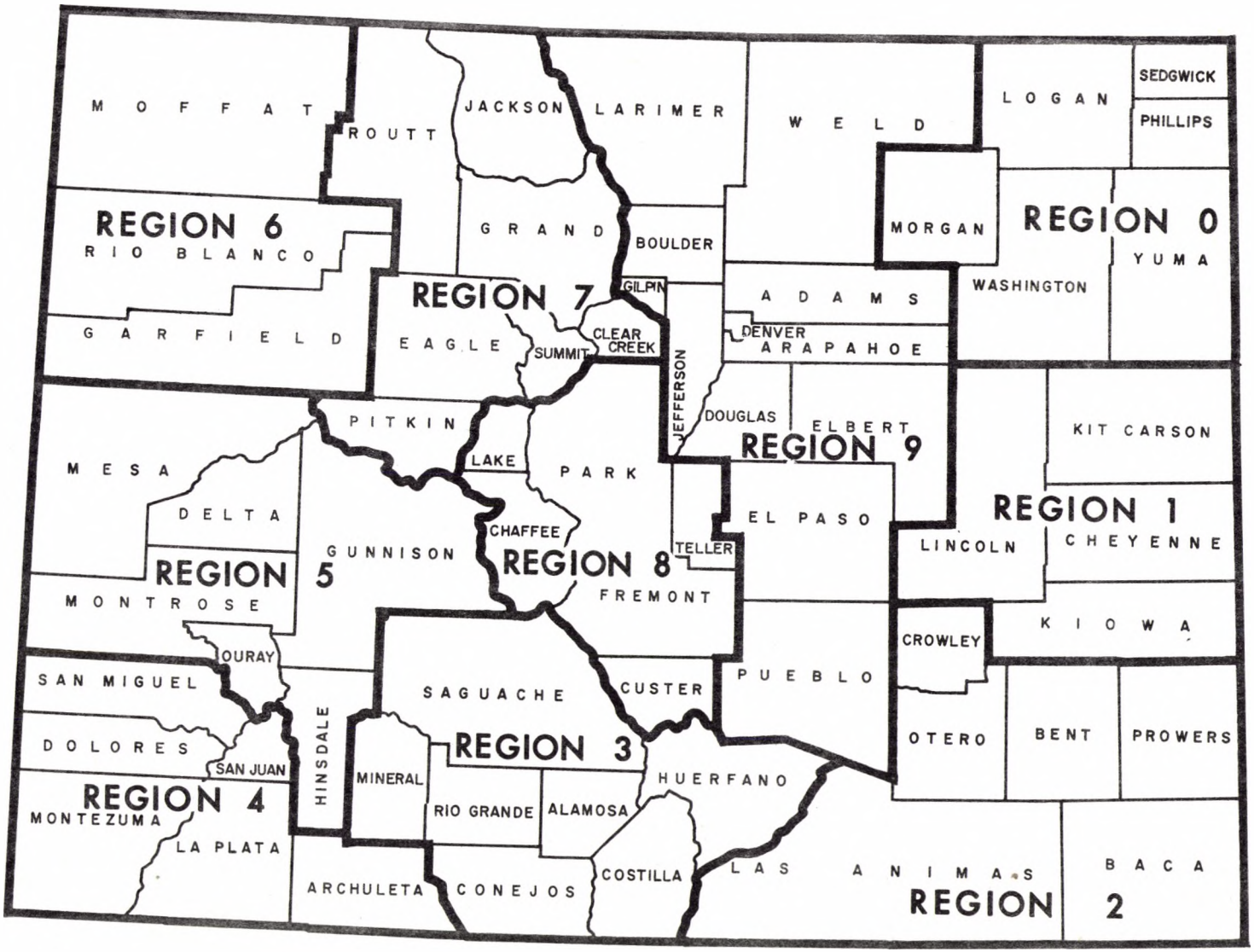
In the outdoor recreation sector, participation is significant in 34 separate activities. Eighteen of these activities have been appraised with respect to facilities (supply) as compared to demands (needs).

To simplify the problem of assessing the demands and needs, the State was divided into ten recreation regions as shown by exhibit 5.2. Both the demands and need for facilities were derived for each of the ten regions. In 1970, the estimated combined resident and nonresident demands amounted to 343 million activity days. In some regions, the existing facilities were more than adequate to meet its own demands. In region nine, however, there was an unsatisfied demand of 117 million activity days. Balancing the unsatisfied demands in region nine against the excess facilities in other regions gave a net unsatisfied demand of 95.1 million activity days in 1970 for the entire State. The unfilled demands are largely in the following activities: outdoor games, swimming, hiking, and picnicking. A summary of outdoor recreation conditions in 1970 is presented in tables 5.11 and 5.12.

Colorado's tourist industry generated approximately 49,500 jobs in 1968. This estimate does not include the jobs associated with supporting functions such as construction and government. The tourist industry primarily influences the jobs in the trade and service categories. Within these categories, eating and drinking places and lodging places are the main beneficiaries.

In 1968, the employees required to provide direct service to out-of-State tourists in major retail and service categories numbered 23,300, and the additional jobs created through indirect employment was 16,300. The number of employees required to service resident tourists was 10,000.

Expenditures by visitors in Colorado is an important and increasing contribution to the economy of the State. In 1970, the total expenditures of tourists in Colorado were estimated to be $520 million. Of this amount, more than $320 million was directly attributable to out-of-State tourists. The tourist



RECREATION REGIONS OF COLORADO

EXHIBIT 5.2

Table 5.11--Acreage and ownership of outdoor recreation resources, 1970

Region	Total acreage	Percent in land	Percent in water	Percent of total acreage in federal ownership
0	31,504	56.1	43.9	15.7
1	29,530	54.9	45.1	60.3
2	801,815	95.7	4.3	91.4
3	2,709,623	99.2	0.8	99.1
4	3,758,487	99.2	0.8	63.2
5	5,096,899	99.5	0.5	99.4
6	4,535,652	99.8	0.2	99.7
7	3,926,365	99.1	0.9	96.7
8	2,080,626	99.1	0.9	97.5
9	1,839,685	98.6	1.4	93.1
State	24,810,186	99.1	0.8	92.5

Source: 1970 Colorado Comprehensive Outdoor Recreation Plan

Table 5.12--Demand and needs of outdoor recreation activities, 1970

(thousands of activity days)

Region	Demand	Needs
0	13,000	5,078
1	4,000	1,320
2	13,000	5,918
3	11,000	2,837
4	9,000	1,774
5	16,000	3,910
6	6,000	620
7	12,000	1,951
8	14,000	2,660
9	245,000	116,964
State	343,000	95,100 1/

Source: 1970 Colorado Comprehensive Outdoor Recreation Plan

1/ Represents the balance between the needs and excess facilities

industry has other major impacts on the economy including investments in land, buildings, and other facilities which relate directly or indirectly to the tourist industry.

RETAIL TRADE

During 1967, there were 19,791 retail trade establishments in the State. As of mid-March, the employees plus the proprietors engaged in operating them numbered nearly 123,000. The total payroll for 1967 was $387.5 million, and the total sales amounted to $3.3 billion.

Eating and drinking places, with 3,790 establishments, constituted the largest retail group in the State. The second largest group was gasoline service stations. They numbered 2,845, and food stores with 1,970 establishments ranked third in number. The food stores had the highest sales, their total for 1967 being nearly $694 million. The sales of automotive dealers for the same year was $634 million. Retail trade sales in the State were up 24 percent from 1963. Table 5.13 shows the establishments, employees, and sales by economic areas.

WHOLESALE TRADE

Wholesale trade establishments numbered 3,713 in 1967. As of mid-March of 1967, 39,000 people, including paid employees and proprietors, were engaged in operating them. The payroll for the entire year amounted to $245 million while total sales were nearly $4.4 billion.

Merchant wholesalers constituted 62 percent of the establishments, and accounted for 41 percent of the sales. Wholesale trade sales for the State in 1967 were up 21 percent from 1963. Table 5.13 shows the establishments, employees, and sales by economic areas.

SELECTED SERVICES

Selected services consist of a wide variety of businesses. Represented in the group are: (1) hotels, motels, and trailer parks; (2) places of entertainment, such as cinemas and theaters; (3) personal services including medical

Table 5.13--Number of establishments, employees, and sales of noncommodity producing industries, 1967

Economic Area	Services			Wholesale trade			Retail trade		
	Establishments	Employees[1/]	Receipts ($1,000)	Establishments	Employees[1/]	Sales ($1,000)	Establishments	Employees[1/]	Sales ($1,000)
Arkansas	3,028	9,530	92,344	543	4,003	337,174	4,453	23,824	636,389
Colorado	1,921	6,114	51,593	326	1,956	139,179	2,415	11,539	287,147
Missouri	9,912	37,670	426,296	2,782	32,552	3,875,519	12,447	85,829	2,310,364
Rio Grande	242	464	4,356	68	523	28,547	471	1,787	46,272
State[2/]	15,103	55,919	575,205	3,713	39,114	4,385,769	19,791	122,979	3,280,672

Source: 1967 Census of Business, Services, Wholesale Trade, Retail Trade, U.S. Department of Commerce, Bureau of the Census.

1/ Includes proprietors

2/ The totals for the economic areas do not equal the state total because some figures were withheld to avoid disclosure of operations of individual reporting units.

and hospitalization; and (4) miscellaneous services such as automotive and appliance repair.

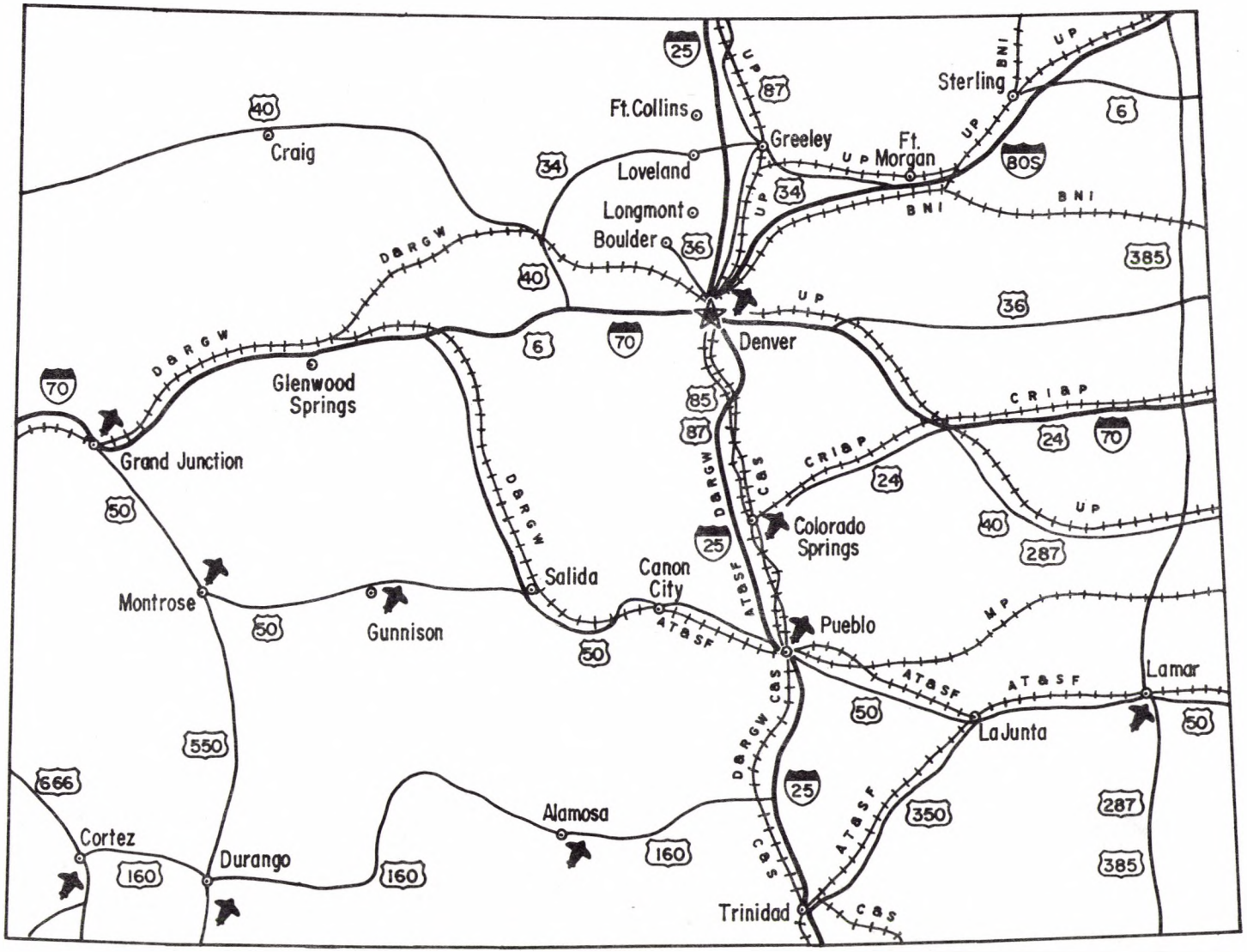
Selected service establishments numbered 15,103 in 1967. Their receipts for the year totaled more than $575 million. Paid employees, including the proprietors, as of mid-March totaled almost 56,000. The entire payroll for 1967 amounted to $165 million. Establishments that rendered personal services were the most numerous in this category. Their number in 1967 was 5,333. The miscellaneous business service category was second with 2,614 establishments. The receipts for selected services in 1967 were up 31 percent from 1963. Table 5.13 shows the establishments, employees, and receipts by economic areas.

TRANSPORTATION AND OTHER PUBLIC UTILITIES

Employment in transportation and other public utilities during mid-March 1969, totaled over 41,000. Taxable payrolls in the first quarter of 1969 amounted to $79.6 million. Total units reported were 1,428 with 42 percent of the units having 1 to 3 employees. The trucking and warehousing category had the highest employment, the highest payroll, and also more establishments than any other industry in this group. The communications category had almost as many employees and nearly the same payroll, but the number of establishments was significantly fewer. The transportation industry increased in all phases of activity from the previous year. Table 5.14 shows employees and payroll by economic areas. Colorado's major transportation systems are shown on exhibit 5.3.

FINANCE, INSURANCE, AND REAL ESTATE

Employment in this sector of the economy was almost 39,000 people in mid-March 1969. The taxable payroll for the first quarter of 1969 was nearly $59.4 million. The total reporting units totaled nearly 4,300 of which 65 percent hired from 1 to 3 employees. Insurance carriers with only nine percent of the reporting units had 26 percent of the total employment and 27 percent of the payroll. Banking ranked second in both employment and payroll while real estate led all other groups in number of units with 43 percent of the total. The finance, insurance, and real estate sector increased in all phases of activity from the previous year. Table 5.14 shows employees and payroll by economic areas.



Major Transportation Systems

.....Commercial Airports

EXHIBIT 5.3

Table 5.14--Number of employees and payroll for noncommodity producing industries, 1969

Economic area	Contract construction		Finance, insurance, and real estate		Transportation and other public utilities	
	Employees[1/] mid-March	Tax. payroll Jan.-Mar. ($1,000)	Employees[1/] mid-March	Tax. payroll Jan.-Mar. ($1,000)	Employees[1/] mid-March	Tax. payroll Jan.-Mar. ($1,000)
Arkansas	5,683	9,298	5,073	7,037	5,830	8,902
Colorado	2,258	3,665	1,883	2,396	2,823	4,356
Missouri	28,307	52,680	31,026	48,799	31,725	64,178
Rio Grande	179	188	182	222	497	747
State[2/]	37,157	67,454	38,765	59,381	41,272	79,618

Source: County Business Patterns 1969, Colorado, U.S. Department of Commerce, Bureau of the Census

1/ Excludes government employees, railroad employees, and self-employed persons.
2/ The totals for the economic areas will not add up to the State total because some figures were withheld to avoid disclosure of operations of individual reporting units.

CONTRACT CONSTRUCTION

People employed in contract construction in mid-March 1969 numbered over 37,000. The taxable payroll for the first quarter was $67.5 million. The number of units reporting totaled 4,011 of which 49 percent reported 1 to 3 employees. Special trade contractors comprised 63 percent of the reporting units. This group accounted for 52 percent of the employment and 50 percent of the payroll. Contract construction increased its activities from the previous year. Table 5.14 shows employees and payroll by economic areas.

GOVERNMENT

Government at the local and federal levels constitute an important sector of Colorado's economy. Total full-time equivalent employment for the local level in 1967 totaled 63,681 people of which 37,651, or 59 percent, were employed in education. The October payroll for local government employees amounted to over $32 million of which 63 percent was paid to employees in education.

General revenue, exclusive of interlocal revenue, was almost $657 million while direct general expenditures were $656.6 million. Local government in 1966-1967 had a general debt outstanding of almost $555 million of which 98 percent was long term.

In 1969, the number of federal employees in the State totaled approximately 44,000. The federal payroll for the first quarter in 1969 was almost $93 million. State government employment totaled over 25,000. Table 5.15 shows some selected items for local, State, and federal governments.

LABOR FORCE

Employment

The estimated average work force for Colorado in 1970 totaled 907,213 people of which over 874,000 were employed. Agriculture related employment accounted for six percent of the total employment.

Table 5.15--Selected elements of government employment

Item	Economic areas				
	Arkansas	Colorado	Missouri	Rio Grande	State 1/
Local government-1967:					
Full-time equiv. employment	13,691	7,075	41,611	1,304	63,681
In education	7,857	4,045	24,912	837	37,651
Oct. payroll ($1,000)	6,652	3,245	21,645	539	32,081
In education	4,204	2,067	13,664	376	20,300
Gen. Revenue excluding interlocal ($1,000) 1966-67	136,533	73,604	433,900	13,187	656,954
Direct gen. expenditure ($1,000) 1966-1967	143,170	75,932	424,518	13,263	656,566
State Government-1967:					
Full-time employees	4,746	1,387	18,837	320	25,265
Oct. payroll ($1,000)	-	-	-	-	16,097
In education	-	-	-	-	7,889
Federal Gov.-1969:					
No. of employees mid-March pay period	13,693	1,927	25,286	222	44,165
Total payroll-Jan.-Mar. ($1,000)	-	-	-	-	92,967

Source: 1967 Census of Governments, Colorado, Vol. 7, U.S. Dept. of Commerce, Bureau of the Census, and 1969 County Business Patterns, Colorado, U.S. Dept. of Commerce, Bureau of the Census

1/ Totals for economic areas in some instances do not equal the State total because some measurements were unavailable or excluded to avoid the disclosure of information concerning individual reporting units.

Much of the total employment in the State is within the Denver SMSA. In 1970, approximately 61 percent of the employed people worked within or had their headquarters within the Denver area. The employees of the combined Denver, Colorado Springs, and Pueblo SMSA's constituted 74 percent of the State total. Table 5.16 shows the annual average work force estimates by economic areas in 1970.

Unemployment

The estimated unemployment rate for Colorado in 1970 was 3.6 percent which was considerably less than the national average. Although the State in its entirety experiences a low unemployment rate, several counties had rates exceeding nine percent. These counties were Archuleta, Conejos, Costilla, Crowley, and Saguache. Costilla County, with 11.2 percent, had the highest unemployment rate in the State.

The U.S. Department of Labor in September 1972, classified the cities of Antonito (Conejos County), Blanco (Costilla County), Center (Saguache County), Ordway (Crowley County), Pagosa Springs (Archuleta County), and Walsenburg (Huerfano County) as being persistent unemployment areas. Eligible areas for assistance in September 1972, under Title 1 of the Public Works and Economic Development Act include: (1) Delta (Delta Co.), (2) Durango (La Plata Co), (3) Montrose (Montrose Co.), and (4) Walsenburg (Huerfano Co.).

Agricultural unemployment in the rural areas continues to be a problem because of seasonality.

Table 5.16--Average annual work force estimates, 1970

Description	Economic areas				
	Arkansas	Colorado	Missouri	Rio Grande	State
Total work force	162,499	76,180	654,329	14,304	907,312
Total employment	155,760	72,410	632,835	13,419	874,424
Nonag-employment	144,017	60,862	606,885	8,915	820,679
Agric. employment	11,743	11,638	25,950	4,504	53,835
Total unemployment	6,739	3,770	20,984	885	32,378
Percent unemployed	4.2	5.0	3.2	6.2	3.6

Source: State of Colorado, Division of Employment, Research and Analysis, July 1972

PERSONAL AND PER CAPITA INCOME

Estimated total personal income for Colorado in 1970 was $8,259 million while the per capita income was $3,766. This represents an increase of 9.1 and 4.5 percent respectively from 1969. Colorado's estimated per capita income in 1970 was $147 lower than the U.S. average.

TAX BASE

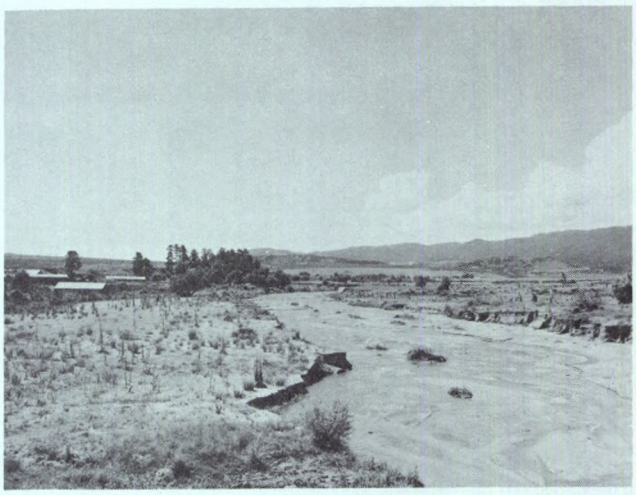
Colorado's total assessed valuation in 1970 amounted to $5.15 billion, an increase of 4.9 percent from 1969. Residential property accounted for 41 percent of the total, followed by commercial property with 26 percent. The balance of valuations is distributed between industrial, agricultural, oil or gas, mining or mineral, and State assessed properties. Table 5.17 shows valuations by classifications for economic areas in 1970.

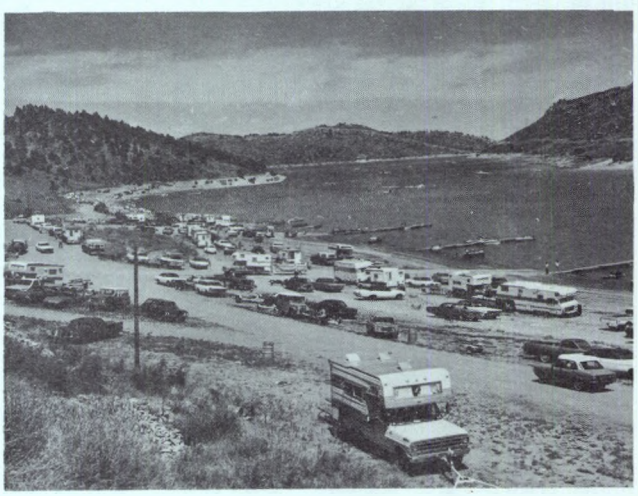
Table 5.17--Assessed valuations, 1970

Classification	Economic areas								State	
	Arkansas		Colorado		Missouri		Rio Grande			
	dollars	percent*	dollars	percent*	dollars	percent*	dollars	percent*	dollars	percent*
Residential	397,826,570	18.7	154,412,570	7.3	1,557,603,040	73.3	14,266,700	0.7	2,124,108,880	100
Commercial	212,484,360	16.2	107,395,960	8.2	981,359,570	74.7	11,911,800	0.9	1,313,151,690	100
Industrial	69,710,330	17.1	15,800,750	3.9	318,237,170	78.1	3,543,100	0.9	407,291,350	100
Agriculture	129,990,340	22.1	109,215,400	18.6	312,754,350	53.3	34,958,240	6.0	586,918,330	100
Oil or gas	5,537,570	5.9	56,765,440	60.3	31,748,410	33.8	-	-	94,051,420	100
Mining or mineral	46,640,080	51.4	26,129,440	28.8	16,209,380	17.9	1,768,900	1.9	90,747,800	100
State properties	106,047,390	20.0	84,137,490	15.9	325,670,740	61.6	13,145,600	2.5	529,001,220	100
total	968,236,640	18.8	553,857,050	10.8	3,543,582,660	68.9	79,594,340	1.5	5,145,270,690	100

Source: 59th Annual Report of the Colorado Tax Commission, 1970

* Percent of the State total





PART VI

CRITICAL ISSUES and PROBLEMS

PART VI--CRITICAL ISSUES AND PROBLEMS

This part of the report identifies and describes the critical issues and problems that are closely associated with present and future water utilization in Colorado. Also presented here are some options for resolving issues and problems, but no recommendations are made for courses of action.

POPULATION IMBALANCE

As mentioned in Part II, the population of Colorado in 1970 was 2,207,259, an increase of 25.8 percent over 1960. As may be expected, however, population changes did not occur uniformly among the different regions of the State. In fact, some counties actually lost population--the losses being experienced largely from the rural sector.

Population growth rate and imbalance are the foremost independent variables related to social well being of a given area. In evaluating the impact of population growth rates in an area, consideration must be given to both natural increase (births over deaths) and migration. In general, areas with a heavy influx of people are economically viable areas; whereas, areas which tend to export people, especially the young, are usually either economically depressed or are borderline cases.

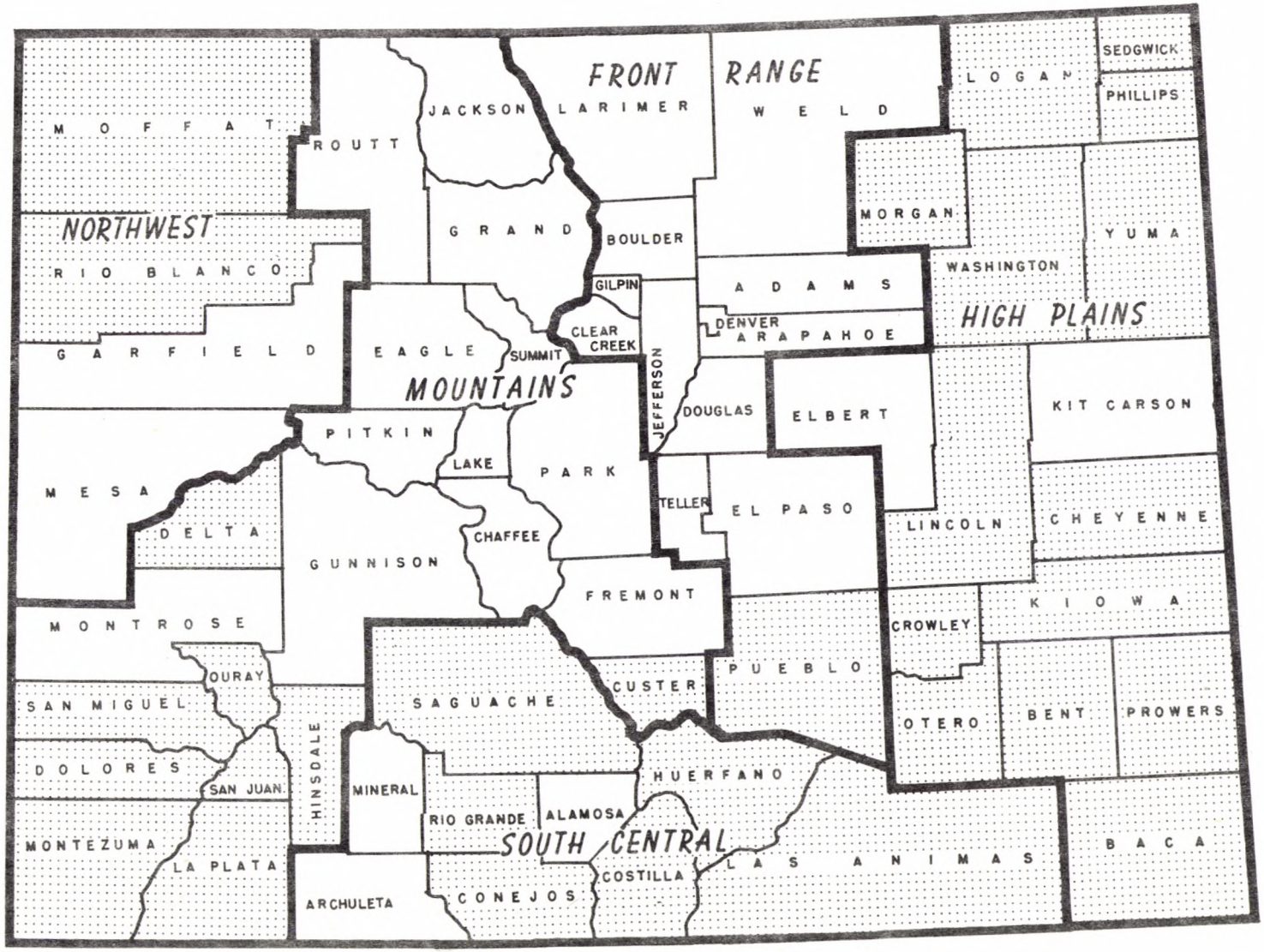
For reporting on this subject, the State was subdivided into five regions which demonstrate similar dominant characteristics and problems. These regions are shown on exhibit 6.1 which also indicates the counties that gained or lost population during the 1960 to 1970 period. Tables 6.1 and 6.2 show the vital statistics and population changes by geographical regions.

Table 6.1--Vital statistics by State planning region (1960-1970)

Region	Births	Deaths	Net natural growth
Front Range	313,317	119,615	193,702
Mountains	28,644	14,570	14,074
High Plains	26,620	14,015	12,606
Northwest	13,941	7,196	6,645
South Central	14,190	7,118	7,072
State	396,712	162,614	234,098

Table 6.2--Regional and county population (1960 and 1970)

Region and county	Total population			Urban population			Rural population		
	1960	1970	% change	1960	1970	% change	1960	1970	% change
High Plains:									
Baca	6,310	5,674	-10.1	0	0	0	6,310	5,674	-10.1
Bent	7,419	6,493	-12.5	3,402	3,148	-7.5	4,017	3,345	-16.7
Cheyenne	2,789	2,396	-14.1	0	0	0	2,789	2,396	-14.1
Crowley	3,978	3,086	-22.4	0	0	0	3,978	3,086	-22.4
Elbert	3,708	3,903	5.3	0	0	0	3,708	3,903	5.3
Kiowa	2,425	2,029	-16.3	0	0	0	2,425	2,029	-16.3
Kit Carson	6,957	7,530	8.2	0	2,828	0	6,957	4,702	-32.4
Lincoln	5,310	4,836	-8.9	0	0	0	5,310	4,836	-8.9
Logan	20,302	18,852	-7.1	10,751	10,636	-1.1	9,551	8,216	-14.0
Morgan	21,192	20,105	-5.1	11,000	10,971	-.3	10,192	9,134	-10.4
Otero	24,128	23,523	-2.5	12,955	12,797	-1.2	11,173	10,726	-4.0
Phillips	4,440	4,131	-7.0	0	0	0	4,440	4,131	-7.0
Powers	13,296	13,258	-.3	7,369	7,797	5.8	5,927	5,461	-7.9
Sedgewick	4,242	3,405	-19.7	0	0	0	4,242	3,405	-19.7
Washington	6,625	5,550	-16.2	0	0	0	6,625	5,550	-16.1
Yuma	8,912	8,544	-4.1	0	0	0	8,912	8,544	-4.1
Subtotal	142,033	133,315	-6.14	45,477	48,177	5.94	96,556	85,138	-11.83
Front Range:									
Adams	120,296	185,789	54.4	105,922	173,893	64.2	14,374	11,896	-17.2
Arapahoe	113,426	162,142	42.9	103,941	158,058	52.1	9,485	4,084	-56.9
Boulder	74,254	131,889	77.6	56,354	102,602	82.1	17,900	29,287	63.6
Clear Creek	2,793	4,819	72.5	0	0	0	2,793	4,819	72.5
Denver	493,887	514,678	4.2	493,887	514,678	4.2	0	0	0
Douglas	4,816	8,407	74.6	0	0	0	4,816	8,407	74.6
El Paso	143,742	235,972	64.2	109,237	208,281	90.7	34,505	27,691	-19.7
Gilpin	685	1,272	85.7	0	0	0	685	1,272	85.7
Jefferson	127,520	233,031	82.7	106,929	208,991	95.4	20,591	24,040	16.8
Larimer	53,343	89,900	68.5	34,761	59,557	71.3	18,582	30,343	63.3
Pueblo	118,707	118,238	-.4	103,336	103,300	-.03	15,371	14,938	-2.8
Teller	2,495	3,316	32.9	0	0	0	2,495	3,316	32.9
Weld	72,344	89,297	23.4	26,314	41,472	57.6	46,030	47,825	3.9
Subtotal	1,328,308	1,778,750	33.91	1,140,681	1,570,832	37.71	187,627	207,918	10.81
Mountains:									
Chaffee	8,298	10,162	22.5	4,560	4,355	-4.5	3,738	5,807	55.4
Custer	1,305	1,120	-14.2	0	0	0	1,305	1,120	-14.2
Delta	15,602	15,286	-2.0	3,832	3,694	-3.6	11,770	11,592	-1.5
Eagle	4,677	7,498	60.3	0	0	0	4,677	7,498	60.3
Fremont	20,196	21,942	8.6	11,794	15,036	27.5	8,402	6,906	-17.8
Grand	3,557	4,107	15.5	0	0	0	3,557	4,107	15.5
Gunnison	5,477	7,578	38.4	3,477	4,613	32.7	2,000	2,965	48.3
Jackson	1,758	1,811	3.0	0	0	0	1,758	1,811	3.0
Hinsdale	208	202	-2.9	0	0	0	208	202	-2.9
Lake	7,101	8,282	16.6	4,008	4,314	7.6	3,093	3,968	28.3
LaPlata	19,225	19,199	-.1	10,530	10,333	-1.9	8,695	8,866	2.0
Montezuma	14,024	12,952	-7.6	6,764	6,032	-10.8	7,260	6,920	-4.7
Montrose	18,286	18,366	.4	5,044	6,496	28.8	13,242	11,870	-10.4
Ouray	1,601	1,546	-3.4	0	0	0	1,601	1,546	-3.4
Park	1,822	2,185	19.9	0	0	0	1,822	2,185	19.9
Pitkin	2,381	6,185	159.9	0	0	0	2,381	6,185	159.9
Routt	5,900	6,592	11.7	0	0	0	5,900	6,592	11.7
San Juan	849	831	-2.1	0	0	0	849	831	-2.1
San Miguel	2,944	1,949	-33.8	0	0	0	2,944	1,949	-33.8
Summit	2,073	2,665	28.6	0	0	0	2,073	2,665	28.6
Dolores	2,196	1,641	-25.3	0	0	0	2,196	1,641	-25.3
Subtotal	139,480	152,099	9.05	50,009	54,873	9.73	89,471	97,226	8.67
Northwest:									
Garfield	12,017	14,821	23.3	3,637	4,106	12.9	8,380	10,715	27.9
Mesa	50,715	54,374	7.2	23,650	25,994	9.9	27,065	28,380	4.9
Moffat	7,061	6,525	-7.6	3,984	4,205	5.5	3,077	2,320	-24.6
Rio Blanco	5,150	4,842	-6.0	0	0	0	5,150	4,842	-6.0
Subtotal	74,943	80,562	7.5	31,271	34,305	9.7	43,672	46,257	5.92
South Central:									
Alamosa	10,000	11,422	14.2	6,205	6,985	12.6	3,795	4,437	16.9
Archuleta	2,629	2,733	4.0	0	0	0	2,629	2,733	4.0
Conejos	8,428	7,846	-6.9	0	0	0	8,428	7,846	-6.9
Costilla	4,219	3,091	-26.7	0	0	0	4,219	3,091	-26.7
Huerfano	7,867	6,590	-16.2	5,071	4,329	-14.6	2,796	2,261	-19.1
Las Animas	19,983	15,744	-21.2	10,691	9,901	-7.4	9,292	5,843	-37.1
Mineral	424	786	85.4	0	0	0	424	786	85.4
Rio Grande	11,160	10,494	-6.0	3,385	3,909	15.5	7,775	6,585	-15.3
Saguache	4,473	3,827	-14.4	0	0	0	4,473	3,827	-14.4
Subtotal	69,183	62,533	-9.61	25,352	25,124	-.9	43,831	37,409	-14.65
TOTAL	1,753,947	2,207,259	25.8	1,292,790	1,733,311	34.1	461,157	473,948	2.8



COLORADO

GEOGRAPHICAL REGIONS AND POPULATION CHANGES

Population Gain

Population Loss

EXHIBIT 6.1

Colorado's population has doubled in the past 30 years, increasing from slightly more than 1 million in 1940 to 2.2 million in 1970. Colorado, although not overpopulated, is faced with a population imbalance problem inasmuch as 80.4 percent of the people live within the Front Range Region. Much of the Front Range's population growth (67 percent) is the result of inmigration. Most of this growth occurred in the urban areas, the urban population increasing by nearly 38 percent from 1960 to 1970. The rural population in the Front Range Region increased by about 11 percent during the same period. Over 50 percent of Colorado's population resides in the Denver SMSA which encompasses Adams, Arapahoe, Boulder, Denver, and Jefferson Counties. It has been estimated that from 90 to 95 percent of the State's growth in the last 50 years has occurred in this area.

The population of the Mountain and Northwest regions grew by 9.1 percent and 7.5 percent, respectively. This growth was accounted for by natural increase since there was a net outmigration from these regions equal to 12 percent of the net growth. The urban population in both regions increased by about 10 percent. The rural population increased by about 6 percent for the Northwest Region and 9 percent for the Mountain Region. About 10 percent of the State's population resides in these counties.

The population declined by 6.1 percent in the High Plains Region and by 9.6 percent in the South Central Region. Only about 20 percent of the natural population increase remained in these regions. Although the High Plains and South Central regions lost in total population, the urban population of the High Plains actually increased by about 6 percent. The urban population in the South Central Region experienced no significant change. The greatest population losses occurred in the rural areas, the South Central Region losing about 15 percent of its rural population and the High Plains about 12 percent. These two regions account for about 9 percent of the State's total population.

Until very recently, population growth was encouraged in Colorado and the policies of State and local governments were directed toward this goal. However, for the vast rural areas of the State--the eastern plains, the San Luis Valley, and the majority of the western slope counties not only has growth failed to materialize but a major export of these rural communities has been its young people.

Urbanization

The Denver metropolitan area is the only large population complex in the State. This large complex attracts the bulk of the new economic and population inflow from out-of-State, and even attracts enterprises and population from the rural areas within the State. The trend of this complex incorporating a larger and larger proportion of the State's total population represents a process which tends to feed on itself and become self-generating; newcomers are attracted to the opportunities in the complex; industry is attracted to the labor pool and services; finance and services are attracted to the source of industry and people; rural Coloradans are attracted to the job opportunities; developers are attracted to the opportunities for land value appreciation; new governmental jurisdictions come into being alongside existing ones; new schools, roads, services and natural resources--land and water--are required to provide for the needs of increased population and industry base. Once started the process tends to become irreversible.

Colorado citizens are becoming increasingly concerned over the problems connected with the growth of the Front Range area. Aside from the water problems, to be discussed later, the physical, social, and cultural problems may become unmanageable if positive steps are not taken now to decelerate or reverse the trend.

There is growing concern that the continued urbanization in the Front Range area will have far more drastic impact in the foreseeable future than that which has occurred during the last decade. If present trends are allowed to continue, the Front Range area will experience the following:

1. Increased air, noise, water, and land pollution.

2. More congested highways with practically no alternative forms of transportation.

3. Legal isolation of governments within a total functional area with all the attendant problems of racial and economic separation.

4. A continuing spread of urban activity in all directions, necessitating increased dependence on the automobile; higher infrastructure costs; a greater consumption of materials, fuels, water, and open space land; and increased economic and social costs for goods and services.

Rural Problems

In many ways, the rural area of Colorado is becoming a land of lost opportunity. In fact, the economic and social problems that drive citizens to the cities prevent rural governments from significantly improving the situation.

Population declined in 32 of Colorado's 63 counties between 1950 and 1970. These population losses have resulted directly from declining employment, generally in agriculture and in coal mining. Most of the counties with declining employment opportunities had specialized economies, highly dependent on either agriculture or coal mining or a combination of both.

All of the counties with declining total populations experienced substantial decreases in population supported by agriculture. This situation is in evidence even though agricultural production has increased. In such areas, agricultural productivity has increased although fewer workers are required.

A similar trend has occurred in coal mining operations. The U.S. Department of Labor estimates that output per man-hour in 1970 was roughly three times the 1950 level. So, although the State's coal production was up 25 percent, the employment dropped substantially.

The population decline in specialized rural counties is likely to continue, except in counties with major resort developments. The communities that are supported largely by mining and ranching rarely compare favorably with those with significant manufacturing, clerical operations, and other businesses. As the communities decline, they lose pace in health, education, and transportation services, and other amenities, and become even less attractive for new activities.

Therefore, the conventional decisions of the market place seldom bring new economic activity into these areas. They have limited labor pools and their isolation dictates expensive access to markets or subassemblies for manufacturing. The institutions of State and local governments have not been designed to help these communities deal with either population decline or rapid growth. Typical problems associated with the population imbalance include the following:

1. Water allocation: In order to increase the economic opportunities of rural towns, agricultural water is often the only source for municipal and industrial supply. As in the case of the Front Range area, mining activities and tourism require additional water, and transfer of water rights are usually acquired to obtain it. This transfer, or conversion, decreases and degrades the agricultural and rural water supplies.

2. Land use: The State now lacks future-oriented, integrated and implemented planning or Statewide zoning to help local governments enforce good land use policy.

3. Centralization: State offices, located in the heart of the single metropolitan center, inhibit dispersion of population or services.

4. Development: Tourism, recreation, and urbanization create land speculation (often followed by despoilation) for both prime agricultural land and undeveloped forest and mountain land. Inflated prices enable the owners to realize more profit by selling their land for development than they can by retaining it as open space or for agricultural purposes. Furthermore, as farmers or ranchers retire, their land is unavailable to other farmers and ranchers because agriculture cannot compete with other interests.

5. Lack of expertise: Rural areas often cannot afford the professional help necessary to compete with metropolitan areas in attracting industries and obtaining federal grants. Dedicated local citizens, short of time, and lacking proper training, must compete with full-time professionals in the cities.

Impact of Urbanization on Water Resources

Extensive urbanization within the Front Range area has required the commitment of many resources to this particular region at the possible detriment to the rest of the State. It has caused a substantial change in the use of the State's water and land resources. Many irrigation water rights have been converted to M&I use and, as a result, considerable amounts of irrigated land have been removed from agricultural production. These shifts have resulted in a steady decline in the importance of agriculture which has been a mainstay in the State's economy.

Most of the shift away from agriculture has occurred in the Front Range area where much of the State's prime irrigated agricultural land is situated. Although the full implication of this trend is uncertain, it is clear that the limited surface water supplies it will be difficult to support both an agricultural economy and a large urban population.

The Front Range area meets most of its water demands from the South Platte and Arkansas Rivers. For many years, supplies from these sources have been insufficient to meet the growing demands. In more recent years, Denver and other Front Range cities have been diverting a substantial part of their water supplies from the western slope. Diversion of this water through the Continental Divide comes at great expense.

The more people that concentrate in the Front Range area, the greater will be the need to divert additional Colorado River Basin water from the western slope. Additional transmountain diversion facilities will be more complex and constructed at a much greater cost than the present facilities. More importantly, however, additional diversions to accommodate growth in the Front Range area represents foregone opportunities for growth on the western slope where the water originates, inasmuch as the quantity of water in Colorado is finite for the foreseeable future.

A further consequence of water diversions from western slope streams relates to Colorado River salinity. Future diversions may intensify the salinity problem by removing high quality water. Studies being conducted under the Colorado Water Quality Improvement Program will determine the impact of irrigation diversion point sources and transmountain diversions.

Studies Completed and Need for Policy

As the pressures to resolve the Statewide water and related land resource problems have increased, so has the number of commissions and committees. Over the past few years, Colorado has established a Land Use Commission, an Environmental Commission, a Population Growth Advisory Council and a Rural Development Commission. In addition, the Interim Legislative Committee on Balanced Population has been active during 1972 and 1973. All of these groups have studied the growth problems in Colorado and have made predictions concerning the growth that can be expected in the future. It now seems that State officials have the information to determine the direction that growth should take, and the public support to move in that direction. However, a State policy for channeling or controlling growth has yet to be implemented.

Public concern is deepening as the State growth pattern seems headed on an irreversible course toward urban concentration and rural decline. It is time now to decide what the future growth and development of Colorado should be and embark upon the action programs that will lead to the realization of desired goals and objectives.

MUNICIPAL, INDUSTRIAL, AND RURAL DOMESTIC WATER

Some of the most disturbing water supply issues in Colorado are those concerning the conversion and allocation of larger quantities of water to municipal and industrial use. The issues stem mainly from the impact that regulation and diversion of water has on the natural flow of streams. At present, the water used for municipal, industrial, and rural domestic purposes represents about 4.8 percent of the total available supply. Thus, on a Statewide basis, the issues seem to be based on factors other than the actual quantity of water involved.

Municipal Water

In this discussion, municipal water refers to that which is used in residential areas and business districts of cities and towns with populations of 2,500 people or more. Some municipal water is used by light industries but no distinction is made between that and the remainder of the municipal supplies.

In the past, much of the increased demands for municipal water have been met through the transfer of irrigation water rights to municipal use. Such changes have been possible because the latter commands a higher price.

In Colorado, many municipalities are facing critical problems in meeting their water demands. Their problems include inadequate quantities, distribution facilities, and substandard water quality. In general, the municipalities with inadequate supplies are those experiencing consistent growth. The municipalities that are experiencing only water quality problems are usually those with little or no growth.

Cities and towns known to have water supply problems that must be resolved in the near term time frame are listed in table 6.3.

Table 6.3--Cities and towns with short term water supply problems[1/]

City or town	1970 population	Population trend	Type of problem
Aspen	2,439	rapid growth*	quality
Austin	1,163	rapid growth*	quantity
Basalt	419	rapid growth	quantity
Boulder	66,870	rapid growth	quantity
Brighton	8,309	rapid growth	quantity & quality
Carbondale	726	rapid growth	quantity
Craig	4,205	slow growth	quantity & quality
Cortez	6,032	rapid growth*	quantity
Delta	3,694	slow growth	quantity
Denver SMSA**	1,227,529	rapid growth	quantity
Durango	10,333	rapid growth*	quantity
Fort Collins	43,337	rapid growth	quantity
Fort Lupton	2,489	slow growth	quantity & quality
Fort Morgan	7,594	slow growth	quantity & quality
Glenwood Springs	4,106	rapid growth	quantity
Greeley	38,902	rapid growth	quantity
Gunnison	4,613	rapid growth	quantity
La Junta	7,938	slow decline	quantity & quality
Lamar	7,797	slow growth	quantity & quality
Las Animas	3,148	slow decline	quantity & quality
Meeker	1,597	rapid growth	quantity
Montrose	6,496	rapid growth	quantity & quality
Rocky Ford	4,859	slow decline	quantity & quality
Trinidad	9,901	slow decline	quantity
Walsenburg	4,329	slow decline	quantity

1/ Some problems are related to inadequate facilities

* Growth is occurring outside the city limits

** Includes Boulder County

The options currently available for resolving municipal water supply problems are few. In the past, the long range approach has invariably been to obtain additional supplies, although some municipalities have resorted to water rationing for short periods. Other methods of resolving the problems have been suggested, such as growth limitation, water conservation, and water recycling. However, these methods are difficult to implement or, like water rationing, are socially unacceptable at this time. Thus, the current practice is to resolve near term water supply problems by increasing the available supplies.

Additional supplies may be obtained by one or more methods such as: (1) conversion of irrigation water rights to municipal use, (2) construction of additional regulating reservoirs and conveyance systems, (3) further development of ground water, (4) weather modification, (5) water importation, and (6) desalting plants to purify brackish or saline water.

Industrial Water

Projected industrial activities in Colorado indicate that additional water will need to be allocated to industrial use. Such action would have significant effects on management of the State's total water supply, including transmountain diversions and meeting downstream commitments required by interstate compacts. Therefore, the issue is recognized as having Statewide significance. Moreover, the issue is critical because the uncommitted water resources for supplying these anticipated needs are small, and are being diminished rapidly by being developed for other uses.

Some of the future industrial needs will be met from municipal systems. These requirements have been given coverage in the previous section "Municipal Water." The discussions in this section are limited mainly to heavy users of industrial water with systems that are separate from municipal systems. At present, the industries that use large quantities of water include sugar beet processing plants, canning factories, slaughter houses, the steel industry, and thermal electric powerplants.

The impending increase in industrial water needs are linked primarily to the combined effects of growing demands for energy and the dwindling domestic petroleum resources. In the future, if the anticipated energy demands are to be met, fuels other than petroleum must be the source.

The current outlook is that part of the future energy demands will be supplied from the vast coal beds and oil shale formations in western Colorado. The earliest expansion of energy development is expected to be through accelerated use of the coal resources to provide fuel for thermal powerplants. Plans have already been made for expanding the coal-fired plants at Hayden, Colorado, and in northwestern New Mexico. A new 700-megawatt powerplant has been proposed for a site 3-1/2 miles southwest of Craig, Colorado. Reliable water supplies will be needed for plant cooling and for supplying the domestic needs of the associated workers and their families.

The coal liquification and coal gasification industries in Colorado have yet to become a reality. However, the current outlook is promising in view of our diminishing petroleum reserves and the strong demands for both liquid and gaseous fuels. The expectation that coal conversion will become commercially attractive in the near future leaves little doubt that either liquification or gasification plants could be in operation within the near term time period. A minimum gasification plant would be a 2-unit installation with each unit having a daily capacity of 250 million cubic feet. Such a plant would require 30,000 acre-feet of water per year.

The potential installations for extracting oil from the vast shale formations in western Colorado are also ill-defined at this time. So far, only small-scale operations of an experimental nature have been conducted. Initiation of large-scale operations depend upon factors that have a bearing on the present energy crisis, such as construction progress on the Alaskan Oil Pipeline and developments in marketing foreign oil. Important also is the outcome of an oil shale leasing program and the availability of capital. One prediction is that large-scale production (300,000 barrels per day) will be a reality by year 1981.[1/]

The exact location of the initial plant has not been determined. Two promising sites are on privately-owned land in the Roan and Parachute Creek areas and a third is in the Piceance Creek area on public lands.

The water requirement estimates for oil shale developments have ranged from 7,000 to 21,000 acre-feet per year for every 100,000 barrel-per-day production.

1/ A projection made in the draft environmental statement for the proposed prototype oil shale leasing program.

Several problems are associated with the development of additional water for industrial use. One problem to resolve is the preservation of uncommitted supplies until such a time as they are needed.

A major problem stems from the requirements of the Supreme Court decisions and interstate compacts involving the four major river systems: the Arkansas, the Colorado, the Platte, and the Rio Grande. The combined average annual flow of these four river systems is 16,000,000 acre-feet. Colorado is entitled to deplete these flows by about 8,000,000 acre-feet per year, which, in view of the increasing needs of a growing population, are insufficient to maintain Colorado's agricultural base[2/] and to satisfy current and expanding municipal, industrial, and rural domestic needs.

A large share of the water filings for diversions from the Colorado River system for industrial purposes are junior to other rights, and thus would not provide a reliable water supply because the rights cannot be exercised during low flow periods.

Reliable sources of water for industrial use in western Colorado can be obtained or developed by employing one or more of the following options:

1. Develop a part of the remaining unused water supplies allocated to Colorado by the Colorado River Compact for industrial use in lieu of committing the entire unused supply for future production of food and fiber or other uses.

2. Control the influx of industry by the assessment of fees or taxes for firms locating in water-short areas.

3. Curtail or limit transmountain diversions.

4. Purchasing a portion of the supply from Green Mountain and Ruedi Reservoirs.

5. Transfer irrigation water rights to industrial use.

6. Construct reservoirs to store and regulate flood waters and surplus winter flows.

7. Develop ground water supplies.

8. Weather modification.

2/ The agricultural base is a general term denoting the same proportion of economic value to the State gross product.

The options for resolving industrial water supply problems east of the mountains are the same as those listed under municipal water except for water rationing. Usually, water rationing cannot be resorted to in solving industrial water supply problems.

Rural Domestic Water

For this report, rural domestic water consists of supplies used by towns and communities with populations less than 2,500 people and by farm families. The towns and communities within the Southern Ute and Ute Mountain Indian Reservations are included in this category. The quantity of water used by a particular entity is small. Collectively, however, the amount is significant and because the water supply is vital to each entity, due consideration should be given to the rural domestic supplies. In areas where ground water is adequate, wells are usually constructed to obtain the rural domestic supplies.

Because the number of systems is large and scattered, a complete picture of the total problem is difficult to obtain. At this time, it must be assumed that a complete accounting of all problems is yet to be made. In many instances, farm families and small towns must resort to their own resourcefulness to design, construct, and repair their systems. Moreover, they must accept the responsibility of identifying their own water quality problems.

The present and potential problems include inadequate quantities, sub-standard quality and inadequate economic base to finance water supply and sewage disposal systems. Instances have been reported of communities having to rely upon wells with 4 gal/min capacity to furnish potable water to over 200 people. Moreover, the quality of some supplies are much below the standards set by the Public Health Service--the total dissolved solids being the most common type of water quality shortcoming.

Rural areas known to have serious water supply problems include many in the Arkansas River Basin downstream from Pueblo, the Colorado River and Roaring Forks River valleys upstream from Glenwood Springs, the North Fork of the Gunnison River Valley, Grand Mesa, and the south slopes of Grand Mesa, the communities surrounding Cortez, the town of Ignacio and other tribal communities located within the Southern Ute Indian Reservation, and the rural areas within the Denver Basin along the Colorado Front Range.[3/]

3/ The Denver Basin is a ground water basin about 5,550 square miles in area stretching from Greeley to Colorado Springs and Denver to Limon.

The options available for resolving the domestic water supply problems are:

1. Let each entity assume full responsibility for resolving its own water supply problems through the private enterprise sector.

2. In areas where the water supply is a key factor in economic and population growth, federal or state support could be provided on a cost-sharing basis to develop adequate water supplies.

3. Government assistance to assess the economic and environmental consequences of developing alternative conventional water supplies or desalting plants to meet present and future requirements.

4. Rural water treatment and distribution associations could be formed to serve domestic users in critical water supply areas.

5. Regional multipurpose and multiobjective water supply and distribution systems could be built to serve rural domestic needs as well as others.

IRRIGATION

Since the early days of Colorado's history, agriculture has played a dominant role in her development. However, as population has grown and cities have expanded along the front range, the general consensus is that the importance of agriculture has declined. In recent national ratings, development of new water supplies for irrigation was ranked well down the list in terms of priority. This low priority may be due largely to the high productivity of American agriculture and past surpluses, but recent world food shortages indicate a need for some reconsideration on our priorities.

Even today agricultural production and related activities, such as food, fiber, and livestock processing, still constitute a substantial share of the State's total economy. In 1970, for example, cash receipts from farm marketing totaled almost $1.2 billion.

Much of the productivity of agriculture in Colorado stems from its supply of irrigation water. In fact, of the estimated water depletions of 5.3 million acre-feet per year in Colorado, about 4.2 million goes to irrigated agriculture. For the entire State, the irrigation depletions represent 79 percent of the total, and is even higher (90 percent) if the Rio Grande Basin is excluded. In comparison, only 0.25 million acre-feet, or 4.8 percent, is depleted for municipal and industrial use.

In the marketplace, irrigated agriculture is able to pay substantially less for water than can be paid by some of the other productive uses, such as municipal and industrial development. In the past, this situation has resulted in many irrigation water rights being converted or transferred to other uses, and in the future, the ultimate result is likely to be a significant decline in overall irrigated acreage and in livestock production from irrigated hay and pastureland. This decline will occur more rapidly if cities have prescriptive rights to the water they need for expanding populations. A definite need exists to determine, adopt, and implement a water use policy that will direct Colorado's future development on the basis of criteria other than the ability to pay.

Some water use issues or problems that relate to specific areas deserve special mention. For instance, in some cities along the South Platte River, especially near the Front Range, the municipal and industrial water supply is becoming critical and in the absence of other alternatives, agricultural water rights have been purchased. There is a danger here that the basic agricultural economy will be destroyed. In the Arkansas Basin, shortages and rationing of M&I water supply have already occurred even though irrigation water rights have been converted to M&I use. In the Colorado River Basin, potential mineral development, especially in connection with oil shale development, offers substantial threats to agricultural water use.

Through programs to rehabilitate existing private irrigation systems, there is much opportunity to increase the efficiency of use of limited water supplies. However, the careful redesigning of systems that is necessary is often beyond the financial capability of the private companies. Similarly, onfarm irrigation efficiency can also be greatly improved, but the essential equipment and structural changes can be costly, and widespread adoption of new practices cannot be accomplished on short notice.

In the southeastern portion of the State, there are numerous localized ground water aquifers which have been mined in the past and yet, which may offer opportunities to recharge. This is not a program that an individual can undertake for private benefit, but one which requires public investment in order to be practicable. This same principle holds true for managing the snowmelt

and heavy summer rainfall which runs off the land without full utilization. Storage reservoirs could control the majority of this water and provide opportunity for the release of downstream appropriations to increase the usable supply of Colorado water. However, the realization of these opportunities nearly always requires public investment rather than private.

FLOOD PROBLEMS

Flood problems in many instances are the result of man's injudicious use of river flood plains. During the development of our country, settlements were usually located in river valleys near watercourses, primarily for reasons of water supply and transportation. Though this nearness is currently less important due to man's ability to transport water economically over long distances, he still displays an affinity for water and tends to construct his homes and cities adjacent to streams and lakes. This practice, whether brought about by the practical need for water, a sewage outlet, or merely aesthetics, is costly.

The 1969 Conservation Needs Inventory of Colorado indicated that Statewide, about 1,492,000 acres are subject to flooding and sediment damage. Because much of this land is nearly level, fertile and close to water, it contains a disproportionate amount of the lands devoted to intensive agriculture, and a similarly disproportionate share of man's developments. Urban areas occupy about 18,000 acres of the total flood-prone areas.

Although flood problems exist Statewide, some areas have been cited as particularly troublesome. One of the most frequently mentioned are areas within the Arkansas River Basin. Here, Fountain Creek from Colorado Springs to Pueblo has a multidimensional problem of flood control and municipal and industrial water supply shortages. The need for sewage and waste water treatment also exists.

Local flood protection works are needed at Florence, Portland, Pueblo, and La Junta, and improvements are needed on the Arkansas River from Brewster to Florence. Lamar is also a problem area. General floodwater and environmental problems have been observed on the Arkansas River and its tributaries from Canon City eastward to the State line.

The entire Upper Colorado Basin is considered to warrant flood control studies. The flooding caused by ice jams near the towns of Gunnison, Steamboat Springs, and Rangely affects primarily agricultural land, but urban development

in this area is accelerating, and little opportunity for single purpose flood water storage appears to be possible. Heavy reliance must be placed in this area on nonstructural management.

Severe flood damage has been experienced along the South Platte River in the vicinity of Denver. Chatfield Dam, currently being constructed by the Corps of Engineers, will eliminate much of the flooding originating in the foothills and the mountainous part of the basin. Additional flood protection may be provided in the future by means of water resource developments designed primarily to eliminate irrigation and M&I water shortages. Bijou Creek near Wiggins frequently experiences exceptionally large discharges.

Flood control needs on the Rio Grande and its tributaries were recognized over 30 years ago, but corrective measures have not been undertaken due to problems of interstate water indebtedness.

For the most part, governmental programs to reduce flood damages generally attempt to retard streamflows above the damage areas and release them slowly or channel them swiftly through the area in designed and well protected channels. This type of program is useful where the flood plain has already been developed and the risk of damages must be alleviated in some way.

Unfortunately, many of the better locations for flood retarding dams along our major rivers have already been preempted and the alternatives for structural control such as channel improvement are becoming increasingly costly. Moreover, the environmental problems caused by some installations would outweigh the benefits achieved by them.

In rural areas, furnishing flood protection involves an additional problem. Flood damages, though substantial to individual landowners, are often of low dollar value on a per acre basis, a situation that jeopardizes the feasibility of many potential control measures. Where very high valued crops are involved, it may be possible to construct small watershed floodwater retarding reservoirs, but even here, the damages to cropland may not offset the cost of structural control. A system of onfarm land treatment measures designed to check and slow runoff may offer greater opportunity for feasible flood control than other structural methods.

Another course of action preferable to structural methods are land use measures to determine the types of uses that are consistent with the degree of flood hazard expected and to discourage or prevent any nonconforming uses. As

mentioned previously, this is difficult since the flood plains are already some of our most intensively used lands. In addition, short run development costs tend to be significantly lower on the flood plains and unless strictly regulated, development will generally occur there rather than in nearby rolling but flood-free areas.

EROSION AND SEDIMENTATION

Closely related to flood problems, but treated separately, is the problem of erosion and sedimentation. Erosion is closely related to peak flows and the formation of gullies are accelerated during the high flow periods. Serious problems including gully formation, streambank and roadside erosion, and the washing away of valuable topsoil can also occur without damaging floodflows.

Although intensive rains cause tributaries to swell and erode, sedimentation of varying degrees is in progress even under normal streamflow conditions. Normal flows cause deposition of sediment in irrigation distribution systems, thereby reducing canal capacities and increasing operation and maintenance costs. Aggradation of the river channel in the vicinity of irrigation diversion dams requires annual maintenance to keep the structures operative.

The Soil Conservation Service's 1969 Conservation Needs Inventory shows 8,412,000 acres of private land affected by erosion. A majority of this land is in the Colorado River drainage and the unstable condition is due to exploitation and improper land use.

Serious sediment problems, which are associated mainly with floods, occur in the Arkansas River Basin downstream from Pueblo. Sediment reduces the capacity of John Martin Reservoir about 6,000 acre-feet annually. The 100-year sediment volume for the Pueblo Reservoir will occupy about 103,000 acre-feet of costly storage. The 75-year sediment volume is estimated at 39,000 acre-feet for the Trinidad Reservoir, a project being constructed by the Corps of Engineers on the Purgatoire River.

Floodflows from Bijou Creek, a tributary on the South Platte River, carry high sediment loads and cause the usual damage to irrigation facilities. Accelerated erosion is also occurring on the Mancos River within the Ute Mountain Indian Reservation, and on other streams within the Southern Ute Indian Reservation. The erosion is degrading the quality of the water and the scenic beauty of the area, and reducing the value of the streams as recreation resources.

Potential erosion problems also exist in the areas where strip mining of coal beds and oil shale resources has started. Reestablishing the vegetative cover to stabilize the disturbed materials is a major problem associated with strip mining operations.

ENERGY AND MINERAL DEVELOPMENT

Energy requirements in Colorado as well as other parts of the United States are becoming more and more difficult to satisfy. Projections of future electric power needs for the State of Colorado have been made to determine the probable effect on the State economy and on use of its natural resources, such as fuel, and to develop estimates of future needs for cooling water. Electric energy consumption is related primarily to population and to use for development of natural resources. Further, development of available natural resources imposes increased electric energy demands for industrial, commercial, and agricultural customers. Thus, the availability of economical electric energy is a key element in the economy of the State and, in turn, the power industry is directly affected by the economic climate. The available generation capacity and power loads anticipated in Colorado for selected years are shown in table 6.4.

To ensure that adequate generating capacity is available to meet the load requirements, the following items should be considered in establishing and adopting future energy policies for the State:

1. Maximize the thermodynamic efficiency of energy in power sources.

2. Encourage energy conservation.

3. Minimize undesirable effluents and waste resulting from fuel extraction and power production.

4. Encourage development of fast breeder nuclear reactors as power sources.

5. Encourage development of hydroelectric power where possible.

6. Encourage the use of insewerable waste for power production.

7. Encourage the development of low polluting fuels.

Table 6.4 --Present and projected Colorado power loads and generating capacity[1/]

Item	1970	1980	1990
		Megawatts	
Generation capacity			
Thermal plants	2,066[2/]	4,295	4,995
Hydro plants	789	928	1,066
Total	2,855	5,223	6,061
Less 13% for system reserves	371	679	788
Capacity for meeting load	2,484	4,544	5,273
Load (peak demand)	2,130	4,230	8,030
Area surplus or deficit (-)	354	314	-2,757
		Millions of kWh	
Total energy load	11,500	23,400	45,300

1/ Power Supply Area 32 (Colorado plus a small part of northwestern New Mexico)

2/ Federal Power Commission report "The Future of Power in the West Region, 1970-1980-1990" June 1969, Tables 5-1 to 5-5, and Table 6

Criteria 7 is extremely important because two distinct water problems are of growing concern in fuels management - water quality and water temperature. Questions of quality relate to individual energy sources; thermal problems however are common to use of all fuel commodities.

In the future, energy commodities, notably natural gas, will encounter supply limitations; other energy commodities will be disqualified from some markets because of environmental degradation possibilities. To the extent that these factors materialize, requirements will have to be filled by other energy commodities. Oil shale is one of the nation's untapped abundant energy resources.

The richest United States oil shale deposits are located in the Rocky Mountain area of the country and represent billions of barrels of oil. Development of this resource has not been undertaken in the past because accessible supplies of oil and gas have been available at a lower cost. However, the nation's future energy needs are so large that it is anticipated that conventional domestic oil and gas deposits will be supplemented by synthetic fuels derived from oil shale and other convertible fossil fuel sources within the next decade.

LAND USE PLANNING

The rapid conversion of land to new uses without regard to its capabilities to support the conversion is resulting in the degradation of some aspects of our environment, giving rise to a need for local and State land use planning and control. The extent of this need is widespread and adequate policies must be established and controls put into effect as quickly as possible.

Throughout the State, many areas now being developed for residential and industrial uses are unsuitable for such use for the following reasons:

1. Shortage of onsite water supplies.

2. Adverse effects on decreed water rights by proposed change of use.

3. Soils or geologic conditions inappropriate to onlot sewage disposal systems in areas lacking central sewage collection and treatment systems or for which such systems might not be feasible.

4. Flood, slide, fire, or avalanche hazards.

5. Extreme weather conditions.

6. Pockets where thermal inversion could cause severe air pollution if intensive development were to occur.

7. Insufficient land use controls which fail to recognize the multiuse potentials of areas based on access, drainage, soils, vistas, resources, and where agricultural uses could be combined with open space functions in a suitable economic manner.

Status of Land Development

The Colorado Land Use Commission in its February 1972 Progress Report to the State Legislature called attention to the current land developments in Colorado. The Commission's report revealed the following:

1. As of February 1972, there were 229 known large-scale subdivisions being planned, platted, and sold in the State. These subdivisions cover more than 800,000 acres of land.

2. It was estimated that another 400-500 subdivisions of less than 500 acres were also being platted and sold, bringing the total land documented as being subdivided to over 1,000,000 acres.

3. Collectively, all lands involved in sales activities, such as recorded plats, expansion of existing subdivisions, and areas under option for development were estimated to total 1.5 to 2 million acres.

The potential impact of such large subdivisions is tremendous. Realization of the developments proposed by the subdividers of these areas would greatly increase the population and the associated resource demands.

Land Use Plan

In response to its legislative mandate, the Colorado Land Use Commission prepared an Interim Land Use Plan for the State in February 1973, with the final report completed in December 1973. In its final report the Commission:

1. Identified five regions, consisting of groups of counties which demonstrate similar dominant characteristics and problems, that often have more in common with regions in adjacent states than they do with each other.

2. Identified four areas which are inseparable from land-use planning - environment, economics and population, natural resources, and social concerns.

3. Defined goals and targets for each of the areas, working in consultation with various interest groups throughout the State.

4. Established general policies to guide the land-use program.

5. Developed programs in each of the four broad areas, for each of the five regions, and for the State as a whole.

6. Recommended legislation, organizational mechanisms, and implementation actions are needed to carry out the Commission's land-use program.

Legislative Action - 1973 Legislature

Stemming from recommendations and proposals contained in the Interim Land Use Plan, legislation was introduced and was considered by the 1973 Legislature. The two main bills were derived from a compilation of proposals suggested by the Land Use Commission, the Rural Development Commission, the Interim Legislative Committee on Balanced Population and other groups that have been studying the State's growth problems.

The stronger of the proposed bills provided for a degree of regulation of use of agricultural lands and declared the 13-county Front Range area as an area of Statewide concern and made its growth subject to regulation by a State Commission.

The other bill provided for fewer State controls and more power centered in 12 regional areas.

After giving consideration to a number of compromise measures, the 1973 Legislature adjourned without passing any land use measures.

OUTDOOR RECREATION

The importance of outdoor recreation and the types of activities involved are presented in Part V--Economic Base and Present Economic Conditions. The information presented there will not be repeated here.

Even though outdoor recreation is of great importance in Colorado, it is not without its problems and shortcomings. Some of these are as follows:

1. Existing recreation facilities within easy reach of population centers, especially Denver, are inadequate for meeting the demands.

2. Outdoor recreation has not been developed to its full potential even though the demands are not being met. Many reservoirs developed for irrigation and M&I water are without recreation facilities and are closed to recreation use. Moreover, many flood plain areas that experience frequent flooding could be managed to good advantage for recreation use, and recreation opportunities could be increased if measures were taken to prevent severe dewatering of many streams in the State.

3. Conflict of interests exists among groups in the use of resources, particularly water, for economic use versus recreation use. For example, some recreation enthusiasts advocate retaining water in reservoirs for recreation that were developed for and financed by other uses, such as irrigation, M&I water supplies, and hydroelectric power.

4. Lack of interest or the inability of State agencies and local entities to administer and accept the responsibility of cost-sharing proposed recreation developments.

5. Vandalism inflicted by users of public recreation facilities is beyond belief and is a major problem in the maintenance and administration of recreation facilities.

6. The heavy use of facilities such as picnic and camping grounds located within or adjacent to natural settings has an adverse effect on ecological balance of the area.

7. Weak funding in the last 6 to 7 years for recreation facilities for federal agencies with land management responsibilities. Consequently, the Forest Service, National Park Service, and Bureau of Land Management in recent years have been carrying out only minimal construction and rehabilitation recreation programs.

8. Unused site withdrawals for defunct reclamation and power projects. The withdrawals are no longer needed and difficulties have been experienced in including them in wild or scenic river or wilderness-type areas.

WATER QUALITY CONTROL

Among the stated national goals of the Federal Water Pollution Control Act Amendments of 1972 are:

1. Elimination of the discharge of pollutants into the navigable waters by 1985.

2. Wherever attainable in the interim, achievement of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water by July 1, 1983.

As a step toward the implementation of standards, classifications, and regulations aimed at the achievement of these goals in Colorado, the State, in November 1973, held public hearings on the following proposals among others:

1. Proposed Water Quality Standards for Colorado.

2. Proposed Classification of Interstate and Intrastate Waters in Colorado by River Basins.

3. Proposed Regulations for the State Discharge Permit System.

While Colorado has previously had standards, classifications, and regulations for the control of water pollution, these new revised and expanded proposals considerably enlarge the scope of the water quality problem. Only two broad classifications, "A" and "B", are proposed for all waters, with specific exceptions. Both classes of water "would be suitable for ALL PURPOSES" except that "A" includes "primary contact recreation" while "B" does not. Two subclassifications under each main class provide for cold and warm water fisheries.

As a measure of the impact of the new proposals: In the field of municipal waste water it has been estimated that Colorado has come close to provision of secondary treatment for 100 percent of the populace; in light of the new standards it is anticipated that as many as 90 percent of the wastewater treatment plants in the State will no longer be capable of providing adequate treatment. This is especially true in those mountain areas where the limited water supply is of very high quality and rapid growth is being experienced to accommodate tourists and provide "second homes."

A substantial reduction in pollution attributable to industrial wastes, particularly in the South Platte and Upper Arkansas River Basins has been achieved in recent years through inplant recycling, irrigation with waste water, connection to treatment facilities, etc. The implementation and vigorous enforcement of the proposed State Discharge Permit System (the Colorado responsibility under the National Pollutant Discharge Elimination System, NPDES) will no doubt result in further reduction, and hopefully ultimate elimination, of pollution problems from these sources.

Sediment has been described as one of the more serious pollutants in the nation's waterways. All of Colorado's streams carry sediment due to natural causes or as the result of man's activity. Erosion as a natural process has been shaping the earth's surface since time began. Man cannot halt this process, but, through long term conservation practices, and control of construction and other short term endeavors can reduce the deleterious effects of his own activities. Under the new proposals discharge permits will be required for construction related discharges and the conditions of these permits will result in the use of more and more sophisticated treatment equipment to meet the stringent standards on turbidity.

Under the NPDES separate storm sewers are exempted from the requirement for discharge permits. This runoff usually occurs from urban areas and can contain significant amounts of pollutants washed from roofs, streets, and lawns, or from the air but in very dilute form. The degree of dilution and the fact that storm flows are quite erratic in occurrence, duration and time of concentration all make treatment a difficult problem. Several studies are underway throughout the country on possible solutions.

The State acknowledges the existence in many river basins of salinity problems which are, at least in part, due to irrigation return flows. It proposes to continue gathering background data and to support efforts at salinity reduction through improved irrigation management practices, granting that present technology does not permit economical treatment of point source return flows. The discharge permit system does require permits for point source discharges of irrigation return flows though at this time it is not certain as to what conditions will be contained in such permits.

Mining wastes, along with all other industrial waste water discharges, are subject to regulation under the permit system. The situation is complicated by the difficulty in determining responsibility in the cases of many long abandoned workings. However, problem areas are localized and readily identifiable, and much research effort is being devoted to solutions for this problem.

The problem of runoff from feedlots to the waters of the State, especially the South Platte River, has been serious in the past. However, compliance with State Department of Health rules and guidelines has largely brought the situation under control. Proposed new regulations and inclusion of such facilities under the discharge permit system provide the means for essentially eliminating the problem.

While the previously referenced standards, classifications, and regulations are not specifically directed at the quality of ground water they may have much to do with protecting and improving that quality. This is especially true where the aquifers are valley fills which are recharged from surface streams, hence the quality of the surface water is reflected in the quality of the ground water. Other State guidelines and regulations are aimed at protection of ground water from contamination by seepage from sanitary land fills, seepage from waste treatment lagoons, waste water injection wells, improper leaching field construction, etc.

The language of the "Federal Water Pollution Control Act Amendments of 1972" occasionally contains phrases such as "wherever attainable" and "best practicable control technology currently available" which might lead to the assumption that there is some degree of uncertainty regarding capability to attain the goals of the act in the specified time frame. The act also establishes a National Study Commission "which shall make a full and complete investigation and study of all of the technological aspects of achieving, and all aspects of the total economic, social, and environmental effects of achieving or not achieving, the effluent limitations and goals set forth for 1983 in section 301(b)(2) of this act." Appointments to the Commission were completed in the fall of 1973 and their report to Congress is due in the fall of 1975.

FISH AND WILDLIFE PRESERVATION

Maintaining sufficient high quality water in streams, lakes, and reservoirs for the preservation of fish and wildlife is an old and recurring problem in Colorado. Every form of water use conflicts in some degree with the use of water for fish and wildlife. The problem, through the years, has been aggravated by shortcomings of the Colorado water laws which until 1972 required that streamflows be diverted from their natural course in order to be put to beneficial use. This concept, in effect, attached little if any value to fish and wildlife habitat and was the basic water use principle that led to the destruction of many quality fisheries and wildlife habitat in Colorado.

It is well known that population growth and the associated water use and waste disposal requirements are resulting in greater demands for water. Additional supplies are needed for M&I purposes. Greater demands for food and fiber are generating additional needs for irrigation, and the energy shortage virtually dictates that additional water be allocated for developing our fuel resources. Each additional use encroaches further upon the natural streamflows and threatens further degradation of the aquatic environment of many streams and lakes throughout the State. Furthermore, the speculative land development activities in many instances have seriously degraded the water resources and destroyed the natural environment by accelerating erosion to intolerable rates.

Projected demands for recreation associated with fish and wildlife indicate that additional water could be allocated to instream use. There are some 14,000 miles of trout streams remaining in the State. Fishing demands increase about 10 percent annually, while the stream-miles available for fishing decrease.

Part of the fishing and hunting demands could be satisfied by opening to public use the reservoirs that are now closed for various reasons.

The Colorado Division of Wildlife is inventorying the streams in Colorado that support a stream fishery or have a fishery potential. This agency has also made tentative recommendations for minimum flows required to support an acceptable fishery. In the future, these recommendations will be revised whenever additional data indicate a change is desirable.

In addition to maintaining adequate streamflows, another requirement for an acceptable aquatic environment is that the riparian vegetation cannot be removed or substantially disturbed. Some of the proposed water resource developments in the State would upset the ecological balance of some stream channels. For example, construction of the Closed Basin Division of the San Luis Valley Project would involve the modification of about 12 miles of the Rio Grande channel of which about 6 miles would be within the Alamosa National Wildlife Refuge. This proposed construction may also change the ecology in part of the Great Sand Dune National Monument by lowering the water table.

The development of the coal and oil shale resources in northwestern Colorado could destroy vast areas of wildlife habitat and some important fisheries. The potential oil shale development would alter aminimum of 50,000 acres of land. Much of it is winter deer range which is critical to the maintenance of the current deer population of the area.

WILDERNESS-TYPE AND SPECIAL USE AREAS

Both federal and State agencies are interested in expanding the wilderness systems, and are making studies to that end. Other interests in Colorado, including some conservationists as well as commerical and speculative interests, are opposed to or are skeptical of the desirability of the expansion program. Some contend that a wilderness designation of any area simply calls attention to its attractiveness, causing hordes of visitors to swarm to the area and degrading or destroying the attributes which the wilderness status was intended to protect. Other groups are interested in the areas for the available water supplies on other development potentialities, such as commercial recreation sites, summer homes, grazing rights, timber production, or mining. The use of the streams

and the lands for such purposes is not compatible with the concept of preserving them in their present state.

Wilderness-Type Areas

Studies began in the early 1920's for selection of wildlands within national forests to be protected in their natural state. The first wilderness was designated as such in 1924 under Authority of the 1897 Organic Act. From then on, other portions of national forests have been set aside for such protection. The early wilderness areas and several others which have been established in recent years are now administered directly or indirectly under the authority of the Wilderness Act of 1964. The wilderness-type areas in Colorado are extensive and they include an important aspect of our natural heritage. The wilderness-type areas within Colorado are listed in table 6.5.

In addition, in 1971, the Chief of the Forest Service directed that a service-wide study be made of roadless areas that might possibly qualify for inclusion in the wilderness system. As a result of these studies, 41 areas, ranging from 444 to 100,374 acres, were selected for further investigations concerning their qualifications. The average size of the 41 areas is nearly 25,000 acres. Each of these will receive the same protection as the existing classified areas under the mandate that no form of development or disruptive intrusion by man will be permitted pending the outcome of the ongoing investigations.

Wild, Scenic, and Recreational Rivers

To date, no streams or sections of streams in Colorado have been given protection under the Wild and Scenic Rivers Act (Public Law 90-542). Therefore, some federal agencies, particularly the Bureau of Outdoor Recreation, and some State agencies are pressing for action that would lead to the protection of some streams or sections of streams under this act. In all, the interested agencies have identified all or parts of 91 streams in Colorado, involving more than 3,400 stream miles, as having characteristics that warrant their protection from further regimen or development, although complete agreement on such matters is lacking.

Table 6.5--Restricted and special use areas in national forests

Class and name	Forest	Gross acres	Net acres	Authorization	Date
Wilderness areas:					
Maroon Bells - Snowmass	White River	71,329	71,065	P. L. 88-577	9/3/64
Mt. Zirkel	Routt	72,472	72,472	P. L. 88-577	9/3/64
La Garita	Gunnison	24,322	24,322	P. L. 88-577	9/3/64
La Garita	Rio Grande	24,164	24,164	P. L. 88-577	9/3/64
Rawah	Roosevelt	27,464	26,674	P. L. 88-577	9/3/64
West Elk	Gunnison	61,412	61,412	P. L. 88-577	9/3/64
Subtotal		281,109	280,109		
Primitive areas:					
Flat Tops	Routt	2,549	2,549	L-20	3/5/32
Flat Tops	White River	99,575	99,575	L-20	3/5/32
Gore Range - Eagles Nest	Arapahoe	36,203	36,164	U-3	12/3/41
Gore Range - Eagles Nest	White River	25,922	25,778	U-3	12/3/41
San Juan	San Juan	227,399	226,656	L-20	10/1/32
Uncompahgre	Uncompahgre	69,253	53,252	L-20	3/28/32
Upper Rio Grande	Rio Grande	58,014	58,014	L-20	3/5/32
Wilson Mountains	San Juan	9,600	9,600	L-20	10/1/32
Wilson Mountains	Uncompahgre	17,747	17,747	L-20	10/1/32
Subtotal		546,262	529,335		
Scenic areas:					
Abyss Lake	Pike	5,880	5,880	U-3	1/11/56
Lost Creek	Pike	15,120	14,800	U-3	5/2/63
Bristlecone Pine	Pike	150	150	U-3	5/31/67
Subtotal		21,150	20,830		
Natural areas (research):					
Gothic	Gunnison	1,050	1,050	U-4	7/1/59
Hurricane Canyon	Pike	520	520	L-20	7/3/31
Mt. Goliath	Arapahoe	160	160	U-4	3/11/57
Narraguinnep	San Juan	1,928	1,928	U-4	5/15/62
Saddle Mountain	Pike	500	500	U-4	3/6/51
Subtotal		4,158	4,158		
Research areas:					
Black Mesa	Gunnison	4,799	4,258	U-4	2/8/63
Frasier	Arapahoe	23,000	23,000	L-20	8/26/37
Fremont	Pike	240	240	U-4	4/12/56
Manitou	Pike	16,460	14,400	L-20	4/14/56
Redfeather	Roosevelt	2,285	2,285	U-4	2/2/68
Subtotal		46,784	44,183		
TOTAL		899,463	878,615		

WATER FOR TOMORROW--COLORADO'S CHALLENGE

The preceding discussions present the critical water related issues and problems which concern Colorado's citizenry and which could dramatically influence water resource management and development in the future. By presenting these issues and problems, it is hoped that more of Colorado's citizens can participate effectively with their leaders in formulating the broad policies and guidelines for future management and development of water resources in Colorado. Some of the questions which can be drawn from today's critical issues and problems (as presented in Part VI) are as follows:

1. Should there be a State policy on future population growth?

2. Should future urban growth be restricted? Directed? or Curtailed?

3. Should strict land use policies be adopted and enforced?

4. Should there be a moratorium instituted on transbasin water diversions?

5. Should State financing and support for water resource development be continued and expanded?

6. Should the State adopt policies to revitalize rural Colorado?

7. Should present acreage of irrigated agriculture be maintained and prime agricultural land protected, together with incentives to promote agriculture and open space utilization?

8. Should State water management policies be coordinated with land use planning, natural resource management, population policies, and environmental policies?

9. Should a State Wild River System be established?

10. Should stricter and more effective water quality control measures be enacted?

Again, these questions are only presented to stimulate thinking among the concerned citizens of Colorado and do not represent definite recommendations or conclusions concerning future courses of action.

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