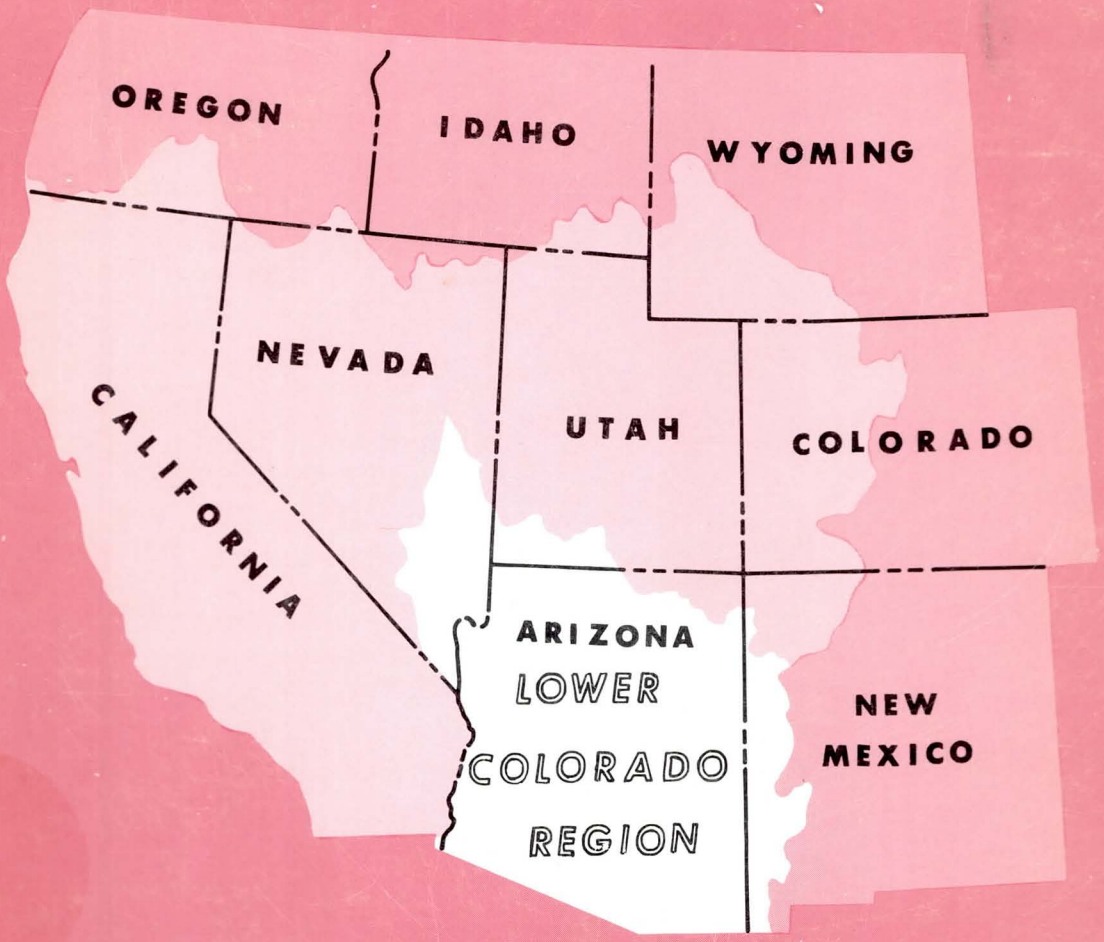
LOWER COLORADO REGION
Comprehensive Framework Study

APPENDIX I
HISTORY OF STUDY
APPENDIX II
THE REGION
JUNE 1971



PREPARED BY:

LOWER COLORADO REGION STATE – FEDERAL
INTERAGENCY GROUP FOR THE
PACIFIC SOUTHWEST INTERAGENCY COMMITTEE

LOWER COLORADO REGION – Appendix I History of Study, Appendix II The Region – Ju
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APPENDIXES TO THE MAIN REPORT

LOWER COLORADO REGION

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LOWER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

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This report of the Lower Colorado Region Framework Study State-Federal Interagency Group was prepared at field-level and presents a framework program for the development and management of the water and related land resources of the Lower Colorado Region. This report is subject to review by the interested Federal agencies at the departmental level, by the Governors of the affected States, and by the Water Resources Council prior to its transmittal to the President of the United States for his review and ultimate transmittal to the Congress for its consideration.

June 1971

This appendix prepared by the

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for the

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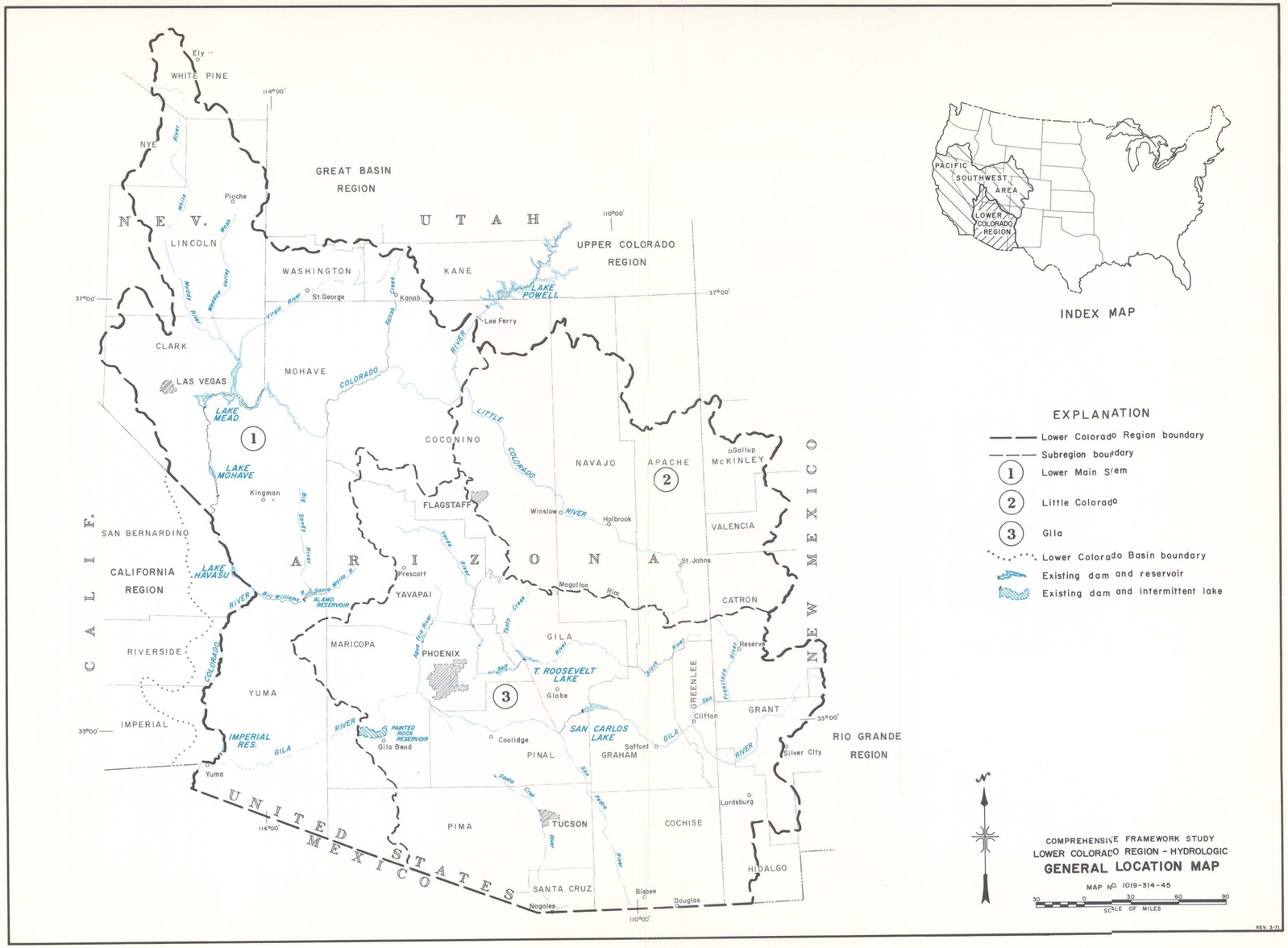

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- (2) Little Colorado
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- Lower Colorado Basin boundary
- Existing dam and reservoir
- Existing dam and intermittent lake

COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION - HYDROLOGIC

GENERAL LOCATION MAP

MAP NO. 1019-314-45

30 0 30 60 90
SCALE OF MILES

REV. 3-71

LOWER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY

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AUTHORIZATION

APPENDIX I - HISTORY OF STUDY

AUTHORIZATION, PURPOSE AND SCOPE

General Authorization

The Lower Colorado Region is one of 17 water resource regions in the conterminous United States, which are included in the program to provide comprehensive river basin plans for the development, use, and management of the water and related land resources of the Nation. This program stemmed from recommendations of the Senate Select Committee on National Water Resources and planning concepts are embodied in Senate Document No. 97, 87th Congress, Second Session. The overall program was presented by the President in the Fiscal Year 1963 budget. The Lower Colorado Region study was approved by Congress, and funds were provided to start this activity in Fiscal Year 1967.

The Water Resources Planning Act (P.L. 89-80, July 22, 1965) established the Water Resources Council. The President transferred the functions and committee organization of the Interagency Committee on Water Resources to the Water Resources Council on April 10, 1966. By letter of October 10, 1966, the Water Resources Council requested the Pacific Southwest Inter-Agency Committee (PSIAC) to take leadership and coordinate the comprehensive studies in the Pacific Southwest, including the Lower Colorado Region. PSIAC accepted this responsibility by letter of November 21, 1966. An organization meeting to begin the Lower Colorado Region study was held on February 8, 1967. The Department of the Interior was designated to be lead agency and the Bureau of Reclamation provides chairmanship of the Lower Colorado Region State-Federal Interagency Group and Staff.

The States of Arizona, California, New Mexico, Nevada, and Utah are participating with the various Federal agencies in this investigation.

Specific Authorizations

Specific Congressional authorities for Federal agencies' participation are as follows:

Department of Agriculture

Soil Conservation Service, Economic Research Service, and Forest Service--Section 6 of the Watershed Protection and Flood Prevention Act. (P.L. 83-566), 68 Stat. 666, 668, as amended.

Department of the Army

Corps of Engineers--Section 208 of Flood Control Act of 1965 (P.L. 89-298), 79 Stat. 1085 and 1086.

Department of Commerce

National Weather Service--Section 601 of the Economy Act of 1932, 47 Stat. 382, 417.

Economic Development Administration--Public Works and Economic Development Act of 1965. (P.L. 89-136).

Department of Health, Education, and Welfare

Public Health Service--Public Health Service Act (42 USC 241) as amended. Water Quality Act of 1965 (P.L. 89-234), 79 Stat. 903. Interdepartmental Agreement under Reorganization Plan No. 2 of 1966 (HEW-Interior) September 1, 1966. Clean Air Act (42 USC 1857-1857g). Solid Waste Disposal Act (40 USC 461).

Department of the Interior

Bureau of Land Management--Classification and Multiple Use Act of September 19, 1964, (P.L. 88-607), 78 Stat. 986. O&C Act of August 28, 1937, 50 Stat. 874. Taylor Grazing Act of June 28, 1934, 48 Stat. 1269, as amended. Public Land Administration Act of July 14, 1960, (P.L. 86-649), 74 Stat. 506.

Bureau of Indian Affairs--General Allotment Act of 1887, 24 Stat. 388, 390.

Bureau of Mines--Section 601 of the Economy Act of 1932, 47 Stat. 382, 417.

Bureau of Outdoor Recreation--The Act of May 28, 1963, 79 Stat. 49; (16 USC 460 et seq.).

Bureau of Reclamation--Federal Reclamation Laws, Act of June 17, 1902, 32 Stat. 388, and acts amendatory thereof or supplementary thereto.

Federal Water Pollution Control Administration (now called the Water Quality Office, Environmental Protection Agency)--The Federal Water Pollution Control Act of July 9, 1956, (P.L. 84-660), 70 Stat. 498, as amended, the Water Quality Act of 1965 (P.L. 89-234), 79 Stat. 903, and President's Reorganization Plan No. 2 of 1966, 30 Fed. Reg. 14483.

Fish and Wildlife Service--Fish and Wildlife Coordination Act, 48 Stat. 401, as amended; 16 USC 661 et seq.

Geological Survey--Section 601 of the Economy Act of 1932, 47 Stat. 382, 417.

National Park Service--Park, Parkway, and Recreation Area Study Act of June 23, 1960, 49 Stat. 1894; Antiquities Act of June 8, 1906, 34 Stat. 225; and Historic Sites Act of August 21, 1935, 49 Stat. 666.

Federal Power Commission

The Federal Power Act of June 10, 1920, 41 Stat. 1063, as amended, and various flood control and river and harbor acts substantially as stated in Section 4 of the Flood Control Act of 1938, 52 Stat. 1215, 1216.

Purpose of Study

In accordance with Senate Document No. 97, a principal objective in water resource planning "is to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs." To accomplish this in an expanding economy, the framework studies analyze past accomplishments and present and future requirements and compare them with the available water and related land resources to develop a program for the efficient satisfaction of projected demands.

The Water Resources Planning Act (P.L. 89-80, July 22, 1965) established the Water Resources Council. The purpose of this Act is "to provide for the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources through the establishment of a water resources council and river basin commissions, and by providing financial assistance to the states in order to increase state participation in such planning."

As stated in the Water Resources Council's "Guidelines for Framework Studies," October 1967, the regional reports will "provide projections of economic development, translation of such projections into demands for water and related land resource uses, hydrologic projections of water availability, both as to quantity and quality, and projections of related land resource availability, so as to outline the characteristics of projected water and related land resources problems and the general approaches that appear appropriate for their solution. Such framework studies would provide general guides to future water resource development. In addition to indicating which regions or subregions within them have water problems calling for prompt detailed planning efforts, as well as those where no such problems are current or looming, such studies will provide a substantial contribution of fact and analysis to subsequent detailed plan formulation."

To be most effective as guides for action programs and to serve as a sound base for a continuing planning process, framework studies

should be both broad in coverage and flexible in structure so that additional alternative courses of action may be examined, evaluated, and instituted as desirable or necessary. Development of the Lower Colorado Region framework program has been accomplished with these planning goals and reporting objectives in mind.

Scope of the Study

Investigations in the Lower Colorado Region cover parts of the States of Arizona, Nevada, New Mexico, and Utah.

The study covers the period from 1965 (base year) to the year 2020. In order to identify and stage early, intermediate, and late action programs, the study period was divided into three time frames: 1966-1980, 1981-2000, and 2001-2020.

This study deals with the water and related land resources of the Lower Colorado Region and embraces all significant problems and beneficial uses associated with these resources. Consideration was given to various aspects of problems related to supplies of water for municipal and industrial purposes, water quality control, flood control, irrigation, electric power production, mining and mineral processing, watershed management and treatment, land resources and use, outdoor recreation, and fish and wildlife. Environmental aspects such as natural beauty, cultural and historic values, rare species of flora and fauna, wildlife in general,and water and air quality goals are considered to be intregal parts of the fabric of an optimum framework program.

For the purpose of this study, the Lower Colorado Region was divided into three hydrologically delineated subregions; and to accommodate the socio-economic statistical analysis, the Region and subregions were extended to the closest fitting political boundaries. The latter delineations were designated the economic region and the economic subregions and projections for economic areas were adjusted to represent the hydrologic areas. Investigations were first conducted by subregions. These subregional studies were then consolidated to obtain the overall program for the Lower Colorado Region.

The study program consists of three basic elements:

1. Evaluation of present and projected needs for goods and services which place a demand on water and related land resources;

2. Evaluation of resources, including those in authorized and potential programs, which will become available to serve the demands; and

3. Formulation of a general Lower Colorado Region framework and development program to serve short- and long-term needs.

To fully utilize the capabilities of Federal and state agencies with expertise in all fields of planning, work groups were established to deal with each of the functional appendixes required. Generally, the chairmanship in each work group was vested with the agency having the most appropriate background related to the function. In all, 16 appendixes were developed, as listed on the front cover of this appendix.

Federal, state, and local agencies exchanged information and coordinated their work directly among themselves and in periodic joint meetings at field level to review findings and to exchange data and views.

Constraints

Early in the planning studies, existing legal and institutional situations were identified as constraints. As the studies proceeded, it was realized that legal and institutional changes in the future might be desirable or even required to effect certain elements of the program.

One important and immediate constraint is in Section 36 of the Water Resources Planning Act (P.L. 89-80) which prohibits the study of importing water from areas outside the designated boundaries of the Pacific Southwest Area.

The second most important constraint to this study is that: Projections of regional growth and development are generally constrained in accordance with national projections developed by the Departments of Commerce and Agriculture (Office of Business Economics and Economic Research Service). These projections were modified by the states of the Lower Colorado Region to reflect local conditions and trends.

In the course of this broad, comprehensive investigation, it was necessary to make additional general and specific assumptions to limit the number of possibilities of direction and magnitude of the various socio-economic projections. Among the major controlling assumptions and constraints are the following:

A. For the duration of the study period, there will be no catastrophic wars, no national political upheaval, no major economic depressions, or any other environmental changes that would upset the projected socio-economic trends.

B. No constraints are to be considered on the amount of goods, services, and resources required to support the projected levels of economic activity.

C. The following assumptions governed consideration of interregional transfers of water:

1. All existing diversions are to be recognized and the expected transfers of water included as a loss to the transferring-out region and available for use in the transferring-in region.

2. All actively authorized projects for interregional diversions are to be treated as in 1.

3. All water subject to distribution among regions in accordance with existing federally approved compacts or legal agreements is to be distributed in accordance with their provisions.

4. The ocean is considered available to the Lower Colorado Region and plans for its use as a water resource are included.

D. Assumptions concerning allocation of water among competing areas and uses are of paramount concern. The history of the West and western water law records the extreme sensitivity of the questions associated with allocation of water resources among competing areas and uses. In recognition of the foregoing, it was concluded that the following basic assumptions were necessary in Type I planning:

1. Water presently being beneficially used will not be diverted to supplement growing urban or industrial demands, except where urban or industrial growth occupies land on which water was previously beneficially used for another purpose, in which case it will be assumed that the water supply will be transferred with the land to the new use.

2. Allocation of newly developed water supplies will be predicated on the projected demands for commodities, services, and other purposes.

3. Available water allocated under compacts, agreements, or laws but not presently in beneficial use by the allottee will be available for future beneficial use of the allottee (state or other organizational unit). Each of the regions will rely on appropriate state laws for determination of priorities of use among competing areas and uses.

4. Plans will be made, if possible, for replacement of water presently being beneficially used but for which there is a legally established adverse claim, such as rights under area of origin, statutes and interstate compacts.

E. Consideration of water quality provides sufficient latitude to permit future growth and full development of water use in the Pacific Southwest, providing that the condition of the water does not reflect failure to apply all corrective measures which are technically possible and economically feasible. These water quality considerations do not inhibit application, in any way, of existing interstate compacts or court decrees or intrastate appropriation of water.

F. Projections of regional growth and development are generally constrained in this study in accordance with the national projections that were developed by the Departments of Commerce and Agriculture (Office of Business Economics and Economic Research Service) and supplied to the Region by the Water Resources Council. These projections were modified by the States of the Lower Colorado Region to reflect local conditions and trends.

G. The National Environmental Policy Act of 1969 (P.L. 91-190) establishes the policy of promoting efforts to prevent or minimize damage to the environment, enriching the understanding of the ecological systems and natural resources, and preserving important historic, cultural, and natural aspects of our national heritage. Generally, the philosophy of the Act has been pursued in developing the framework program.

The maintenance and/or enhancement of the environment of the Region extends into every segment of the framework study. In each of the functional segments of the study, environmental considerations have been on a comprehensive basis rather than on a single-purpose basis.

PREVIOUS STUDIES

PREVIOUS STUDIES

Following are descriptions of some of the previously completed comprehensive-type studies covering areas included in the Lower Colorado Region:

1. THE NATION"S WATER RESOURCES, The First National Assessment of the Water Resources Council, 1968.

This report describes the Nation's water and related land resources and their use and management problems.

2. WATER AND CHOICE IN THE COLORADO BASIN, An Example of Alternatives in Water Management, Committee on Water of the National Research Council, Publication 1689, National Academy of Sciences, Washington, D.C.

This report examines water problems and water management in the Colorado River Basin as a means of demonstrating the scientific, engineering, economic, and social perspectives that should qualify major water management decisions.

3. THE COLORADO RIVER, March 1946, U.S. Department of the Interior, Bureau of Reclamation.

The Colorado River is a comprehensive report on the development of the water resources of the Colorado River Basin in Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming.

The report included a description of the basin's resources, its needs and problems, and listed some 134 potential projects for the future development of the water resources within the natural drainage of the Colorado River.

4. UNITED WESTERN INVESTIGATION - Interim Report on Reconnaissance of California Section, December 1950, U.S. Department of the Interior, Bureau of Reclamation.

The United Western Reconnaissance covers the United States west of the Continential Divide and, with special objectives, extends consideration also to additional territory in Montana, Wyoming, Colorado, New Mexico, Texas, and the Republic of Mexico. The investigation is a study of the means of effecting improvement in the distribution and utilization of the water resources of the entire West.

The United Western report does not attempt to recommend the authorization or construction of any phase of the potential water storage or transfer development outlined.

5. REPORT ON WATER SUPPLY OF THE LOWER COLORADO RIVER - November 1953, U.S. Department of the Interior, Bureau of Reclamation.

This report was prepared to fill an urgent need for a comprehensive analysis of the water supply of the Lower Colorado River Basin. There has been a definite need for a determination, in more detail than presented in the Department of the Interior report "The Colorado River" (March 1946), of the average natural or virgin flows of the streams and the rates of use of water to serve as the basis for planning future developments for the maximum utilization of water supplies presently and ultimately available.

The report presented detailed analyses and estimates of historic streamflow at selected gaging stations and other key points; an estimate of average natural or virgin flow at the same stations and points; rates of consumptive use of crops, natural vegetation, and other water consuming items; estimates of channel and evaporation losses; and considerable other information on water supply and use in the Lower Colorado River Basin.

6. THE PACIFIC SOUTHWEST WATER PLAN, January 1964, U.S. Department of the Interior, Bureau of Reclamation.

The first Pacific Southwest Water Plan (PSWP) was published in August 1963. After comment by the states and Federal agencies, a revised plan was published in January 1964, providing for the creation of a development fund from revenues of certain hydropower projects, to be used in part to guarantee the annual availability of 7.5 million acre-feet of Colorado River water or its equivalent for consumptive use in California, Arizona, and Nevada, at costs to water users no greater than they would have been if this amount were available from natural streamflow.

The revised plan indicated that, on the basis of estimates of the rate at which the upper basin would develop uses for its apportioned share of Colorado River water, by the year 2030, in the absence of measures to increase lower basin water supplies, the amount of water available from the Colorado River at and below Hoover Dam for consumptive use by the lower basin states would decrease to 5,620,000 acre-feet annually. To make the difference between this amount and 7.5 million acre-feet, the plan provided for water salvage and related works to yield 680,000 acre-feet annually and for import of the remaining deficiency of 1,200,000 acre-feet.

7. THE LOWER COLORADO RIVER LAND USE PLAN, January 1964, U.S. Department of the Interior, A Report of the Lower Colorado River Land Use Advisory Committee.

This report and land use plan pertained to the area along the lower Colorado River from the southern boundary of the Lake Mead National

Recreation Area to the International Boundary with Mexico. It includes the study of the resources that extend back from the river on both sides for varying distances. It encompasses parts of the States of Arizona and California. Within Arizona, it contains lands in Mohave and Yuma Counties. In California, it involves some of the lands in San Bernardino, Riverside, and Imperial Counties. The river lands in Clark County, Nevada, are not currently a part of this study and plan.

The Land Use Plan is a general plan, with alternatives, for possible land uses along the lower Colorado River. The Land Use Plan does not embody a set of directives or definite commitments to be put into immediate operation. Instead, it is an outline of objectives for a long-range program of land use and zoning along the lower Colorado.

8. THE LOWER COLORADO RIVER BASIN PROJECT, 1965.

Negotiations among the southwestern states and with administration officials produced in 1965 a group of bills for consideration by Congress. From these bills came a proposal for the Lower Colorado River Basin Project (LCRBP). This proposal, a reduced version of the PSWP, included many of the key elements of that plan, namely, the Hualapai (Bridge) Canyon and Marble Canyon Projects, the Development Fund, the Central Arizona Project, the Dixie Project in Utah, and the Southern Nevada Water Project.

In 1967, partly because of objections, by conservationists to the Grand Canyon Dams; by the Administration to the overall cost of the project; and by the Pacific Northwest to the diversion study proposals; the Administration withdrew support for the Grand Canyon Dams and for the diversion study proposal.

The result: The Colorado River Basin Act (P.L. 90-537), which was signed into law on September 30, 1968, by President Lyndon B. Johnson, provided a program for the further comprehensive development of the water resources of the Colorado River Basin.

9. COOPERATIVE WATER RESOURCE INVENTORY - ARIZONA - 1965, U.S. Department of the Interior, Bureau of Reclamation.

This inventory of the water resources of Arizona was prepared by the Bureau of Reclamation under the terms of a cooperative contract with the Arizona Interstate Stream Commission. Its purpose is to provide a catalog of available factual data to serve as a guide for future water development planning in Arizona.

This inventory includes a description and discussion of the interstate stream systems located within the State of Arizona, together with tablular data and illustrative maps and charts. Data are included on climate, surface- and ground-water supplies and uses, water quality, agriculture, economic aspects of water use, and water using organizations.

10. LITTLE COLORADO RIVER, ARIZONA AND NEW MEXICO, January 1942, Corps of Engineers.

This report considers the Little Colorado River upstream of the Navajo Indian Reservation in Arizona. Local interests requested investigations for flood control, water conservation, water power, erosion control and domestic water supply. Those projects which had provisions for flood control were analyzed. This report recommended one levee project on the Little Colorado River.

11. REPORT ON SURVEY, FLOOD CONTROL, VIRGIN RIVER AND TRIBUTARIES IN NEVADA, ARIZONA, AND UTAH, June 1942, Corps of Engineers (not published).

The investigation considered 85 projects which included improvements for flood control, water conservation stream channelization, and various types of soil conservation and erosion control measures. Those projects which included provisions for flood control were analyzed on the basis of their estimated costs as compared with the benefits which they would provide. Two flood control basins were recommended.

12. INTERIM REPORT ON SURVEY, FLOOD CONTROL, GILA RIVER AND TRIBUTARIES ABOVE SALT RIVER, ARIZONA AND NEW MEXICO, December 1945, Corps of Engineers (not published).

The investigations were directed toward determination of plans of improvement that would combine flood control with other functions wherever practicable and toward coordination of the separate plans into a comprehensive project for the entire basin. Forty damsites in the study area were considered. The report recommended a three-part plan, inseparable, consisting of alteration of Safford Valley irrigation system, a multiple-purpose dam on the Gila River below San Pedro River, and a multiple-purpose dam on the San Pedro River with an aqueduct to transport municipal water.

Additional previous studies are listed in bibliographies included in some of the functional appendixes to this comprehensive framework study.

ACKNOWLEDGMENTS

ACKNOWLEDGMENTS

The preparation of the framework program for the Lower Colorado Region has been a joint effort of numerous Federal, state, and local agencies, including universities, municipalities, industries, and individuals whose cooperation is gratefully acknowledged. The number of these entities is so extensive that space does not permit acknowledgment here of each separate courtesy. Both published and unpublished data were utilized where available and sources of such basic data are quoted in bibliographies, in the narrative, or by footnote, in the Main Report and in some of the separate functional appendixes.

ORGANIZATION

ORGANIZATION AND COORDINATION

Water Resources Council

Members of the Water Resources Council are the Secretaries of the Interior; Agriculture; Army; Health, Education, and Welfare; Transportation; and the Chairman of the Federal Power Commission. Associate members are the Secretaries of Commerce and of Housing and Urban Development. The Attorney General of the United States and the Director, Office of Management and Budgets, are observers.

Pacific Southwest Inter-Agency Committee

Included in the transfer of regional organizations to the jurisdiction of the Water Resources Council was the Pacific Southwest Inter-Agency Committee (PSIAC), established in its present form in 1954. The Federal agencies participating are those represented at the Washington level as members and associate members of the Water Resources Council. Participating states are Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah and Wyoming. Under present rules, the Chairman of PSIAC is always a representative of a Federal agency.

By letter of October 10, 1966, the Water Resources Council requested the Pacific Southwest Inter-Agency Committee to take leadership and coordinate the Type I studies in the Pacific Southwest area which includes the California, Upper Colorado, Lower Colorado, and Great Basin Regions. By letter of November 21, 1966, the Pacific Southwest Inter-Agency Committee accepted this responsibility.

Coordinated Planning Subcommittee

The Pacific Southwest Inter-Agency Committee has several technical subcommittees, and in November of 1966 reactivated the Coordinated Planning Subcommittee which was given the responsibility for coordinating the four framework studies of the Pacific Southwest.

This subcommittee is directed to coordinate framework comprehensive river basin studies; to provide the basis for full and continuing exchange of views during a study; advise and assist all participating agencies in regard to objectives, work assignments, budgets, and schedules; assist in the resolution of study problems as they arise; review progress being made; and report to the Inter-Agency Committee periodically.

The Guidelines for Framework Studies, October 1967, published by the Water Resources Council, were distributed to all participants of the Comprehensive Type I Studies of the Pacific Southwest Area. As stated in the Foreword of the Guidelines, "The guidelines which follow are developed to obtain a reasonable degree of uniformity and consistency in the management and procedures followed in the regional framework

studies that make up a major segment of the present nationwide comprehensive basin study program. They will serve as a guide to the Member Agencies of the Water Resources Council and as suggestions to states in completing this study program within the coordinating means provided."

The Type I studies have been accomplished in accordance with the Water Resources Council's Guidelines, October 1967.

State-Federal Interagency Groups (SFIG)

The Coordinated Planning Subcommittee held its first work meeting concerning framework studies in Phoenix, Arizona, on January 5, 1967. It was agreed that under the guidance and coordination of the Coordinated Planning Subcommittee four State-Federal Interagency Groups (SFIG's) would be formed and that each group would be responsible for the completion of a regional study.

The Bureau of Reclamation, which was designated to assume the leadership of the SFIG for the Lower Colorado Region, appointed a staff. The SFIG established work groups to prepare the functional appendixes.

Money for Federal participation in the regional studies was included in the budget for Fiscal Year 1967 (beginning July 1, 1966).

The Water Resources Council originally recommended to the Bureau of the Budget that the four framework studies should be completed by June 30, 1972. In 1969, as a result of Congressional and Bureau of the Budget action, it was determined that the studies must be completed by June 30, 1971.

Coordination of Budgets

The Water Resources Council's Guidelines for Framework Studies, October 1967, provided for periodic review of work items, and the timing and magnitude of the input of each agency through interagency coordination of work and budgets.

Budgets were prepared at field level by the cooperating agencies and furnished to the Water Resources Council for review. The completed budgets, with supporting statements, were approved by the Water Resources Council and, when so approved, were essentially fixed as to total, except for general increases initiated by Congressional, Presidential or Bureau of the Budget action, such as Federal pay increases and other generally applicable items.

COOPERATING AGENCIES

COOPERATING AGENCIES AND WORK GROUPS

The Lower Colorado Region is one of four regions in the Pacific Southwest assigned to the Pacific Southwest Inter-Agency Committee by the Water Resources Council for comprehensive framework study. The study is a cooperative effort of the following state and Federal agencies whose representatives served on one or more work groups as listed on the following pages:

U.S. Department of Agriculture
- Soil Conservation Service
- Economic Research Service
- Forest Service
- Rural Electrification Administration

U.S. Department of the Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Mines
- Bureau of Outdoor Recreation
- Bureau of Reclamation
- Bureau of Sport Fisheries and Wildlife
- Geological Survey
- National Park Service

U.S. Department of the Army
- Corps of Engineers

U.S. Department of Labor

U.S. Department of Health, Education, and Welfare

U.S. Environmental Protection Agency
- Water Quality Office

U. S. Department of Commerce
- Business and Defense Services
- National Oceanic and Atmospheric Administration

U.S. Department of Housing and Urban Development

U.S. Federal Power Commission

U.S. International Boundary and Water Commission

State of Arizona
- Interstate Stream Commission
- Game and Fish Department
- Power Authority
- Department of Health
- State Land Department
- State Parks Board
- Flood Control District of Maricopa County
- Salt River Project
- University of Arizona
- Arizona State University

State of California
- Department of Water Resources
- Colorado River Board
- Department of Fish and Game
- Metropolitan Water District of Southern California

State of Nevada
- Colorado River Commission
- Department of Fish and Game
- Division of Water Resources

State of New Mexico
- Interstate Stream Commission
- Department of Game and Fish
- State Planning Office

State of Utah
- Division of Water Resources
- Geological and Mineralogical Survey
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- Division of Health
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Preparation of the Main Report is an assigned responsibility of the Lower Colorado Region Staff.

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SIGNIFICANT ACTIONS

CHRONOLOGY OF SIGNIFICANT ACTIONS

July 22, 1965

The Water Resources Act (P.L. 89-80) established the Water Resources Council.

April 10, 1966

The President transferred the functions and committee organization of the Interagency Committee on Water Resources to the Water Resources Council. This transfer included the Pacific Southwest Inter-Agency Committee.

October 10, 1966

By letter of this date the Water Resources Council requested that the Pacific Southwest Inter-Agency Committee (PSIAC) take leadership and coordinate the comprehensive studies in the Pacific Southwest, which include the Lower Colorado Region. PSIAC accepted the assignment by letter of November 21, 1966.

November 29, 1966

PSIAC met with the Water Resources Council to discuss accomplishment of Type I studies in the Pacific Southwest with the resulting assignment to do the work being given to the Coordinated Planning Subcommittee.

January 5, 1967

The Coordinated Planning Subcommittee held its first work meeting concerning the framework studies in Phoenix, Arizona. It was agreed that under the guidance and coordination of the Coordinated Planning Subcommittee, four State-Federal Interagency Groups (SFIG's) would be formed and that each group would be responsible for the completion of a regional study.

The Department of the Interior was designated lead agency for the Lower Colorado Region studies and the Bureau of Reclamation was designated the lead responsibility with the chairmanship for the State-Federal Interagency Group and the Staff.

February 8, 1967

Organization meeting held at Phoenix, Arizona. Resulting organization, the Lower Colorado Region State-Federal Interagency Group (LCRSFIG), to be responsible for accomplishing the studies. LCRSFIG Chairman and Staff were appointed and work groups were designated to accomplish the primary study elements for which appendixes will be required.

June 14, 1967

Plans of Study and Budget Estimates for the Type I studies were approved by the PSIAC for transmittal to the Water Resources Council.

July 13, 1967

LCRSFIG meeting at Phoenix, Arizona, adopted the official list of appendixes as recommended by the Coordinated Planning Subcommittee.

A Public Information Task Force was established and some members were designated.

July 29, 1967

Coordinated Planning Subcommittee meeting established the year 1965 as the Base Year as time of reference and projections to 1980, 2000, and 2020.

October 1967

The Water Resources Council issued Guidelines for Framework Studies.

February 6, 1969

The Water Resources Council informed PSIAC that Bureau of the Budget instructions required that Pacific Southwest Area studies were to be completed in 1971; one year short of the program submitted in April 1968.

October 14, 1969

As recommended by the State-Federal Interagency Group, a Reports Task Force was formed. The Department of the Interior, the Department of Agriculture, and the Department of the Army were represented in this task force. The purpose of the task force is to provide assistance to the Staff and the General Program and Alternatives Work Group with various review and report writing assignments. These assignments include the review of Appendixes II through XV; the assembly and writing of Appendix XVIII, General Program and Alternatives; and the writing of the Main Report.

PUBLIC INFORMATION ACTIVITIES

PUBLIC INFORMATION ACTIVITIES

July 13, 1967

At the Lower Colorado Region State-Federal Interagency Group meeting in Phoenix, Arizona, an Information Task Force was formed and the following operational guidelines were established:

1. The Information Task Force consists of one representative from each of the states and one from each of the funded Federal agencies.

2. All proposed press releases will be submitted to the Staff for consideration and recommendations to LCRSFIG for approval.

3. The Lower Colorado Region State-Federal Interagency Group recommends to the Coordinated Planning Subcommittee for consideration that all press releases of the four regions be exchanged among Staffs prior to release.

4. All proposed publications will be submitted to PSIAC for consideration and publication.

5. The chairman of the Lower Colorado Region Staff is to be an ex-officio member of the Information Task Force.

September 15, 1967

At the initial meeting of the Public Information Task Force, the Bureau of Reclamation was designated the chairmanship of the Task Force. A statement of purpose was adopted as was the "Information Plan" prepared by the Lower Colorado Region Staff. The latter plan provides a general guide for public information activities; defines the problem and the target public; outlines the methods to be used; delineates specific tasks of the Task Force and provides for coordination among affected agencies. The preparation of a public information brochure was assigned.

February 8, 1968

Press release "Lower Colorado River Basin Studies of Land and Water Resources Progressing"--This release, in the form of an annual report of progress, explained the purpose of the study and what was accomplished in the first year of the study.

June 7, 1968

The Chairman of the Public Information Task Force announced that the public information brochure "This Land - This Water - This West" will

be available for distribution in July 1968 and assigned responsibilities for distribution.

September 30, 1970

Press release announcing that the forthcoming Main Report would be available in December 1970.

October 7, 1970

The coordinator was designated for the preparation of a questions and answers brochure, first draft to be ready in December. The preparation of a slide lecture was assigned.

A summary pamphlet was scheduled to be prepared for liberal distribution.

January-February 1971

Preliminary field drafts of all required appendixes (except History of Study) and the Main Report were available from the Government Printing Office for field review distribution. Many complete sets were supplied to public and university libraries throughout the Pacific Southwest Area.

February 9, 1971

Five thousand copies of the Questions and Answers brochure were available for public distribution.

February 11, 1971

First semipublic presentation of the slide lecture featuring the comprehensive framework studies of the Lower Colorado Region was given in Phoenix, Arizona.

March 17, 1971

Five thousand copies of the Summary Report were available for public distribution.

March 22, 1971

Public announcement of the near completion of the Type I Comprehensive Framework Studies was made at a Governor's conference in Phoenix, Arizona.

LOWER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

APPENDIX II - THE REGION

DESCRIPTION

APPENDIX II - THE REGION

PURPOSE AND SCOPE

The purpose of this appendix is to provide a general description of the Lower Colorado Region study area oriented especially toward comprehensive framework planning of its water and related land resources. Basic objectives are to provide a summary of the physical features of the Region, a brief description of recent history, and to characterize the present population and economic structure. For the most part, this appendix deals with static phenomena and, of necessity, is general and descriptive in nature.

Primary considerations in achieving the stated purpose include: a discussion of the location and physical description of the Region and its size, in relation to the Nation; a description, location, and size of the subregions and a general statement of reasons for subregional breakdown; a brief treatment of the history of the study area; a general description of the development of, and the availability of, water, land, and mineral resources of the Region; and a discussion of the economic structure and characteristics of the present population.

RELATION TO OTHER PARTS OF THE REPORT

The data presented in this appendix are primarily a status report establishing the planning environment within which the comprehensive framework plan is developed by the functional appendixes for presentation in the Main Report.

DESCRIPTION

Location and Size

The Lower Colorado Region, as defined for purposes of this water resource study, occupies 141,137 square miles in the Pacific Southwest Area of the United States. The Region (shown on frontispiece) includes the Colorado River drainage area in the United States Downstream of Lee Ferry, Arizona, except that occurring in California. In addition, it includes several closed basins in Arizona, Nevada, and New Mexico, and some areas in southern Arizona and New Mexico that drain into Mexico. Area-wise, the Region represents about 4.8 percent of the contiguous United States. The Colorado River drainage area in California, shown as a dotted line, is included in the California Region.

The Region is bounded on the east by the Continental Divide in New Mexico, on the west by the State of California and a portion of southern Nevada, on the south by Mexico, and on the north by the hydrologic boundary separating the Upper and Lower Colorado River Basins set at Lee Ferry, Arizona, by the Colorado River Compact. These boundaries encompass most of the State of Arizona and parts of the States of Nevada, New Mexico, and Utah.

Subregions

Although the Region includes many hydrologic subbasins, it is naturally divided into three major drainage areas which have been designated as hydrologic subregions. These subregions provide a logical basis for water utilization analysis and planning. Economic subregions were selected using political subdivisions which most closely conformed to the hydrologic subregions. Most economic data are available only by political subdivisions, such as counties. All projections were adjusted to represent the hydrologic region and subregions.

For this study, the Lower Colorado Region study area has been divided into three subregions: Lower Main Stem, Little Colorado, and Gila.

The Lower Main Stem Subregion's 56,554 square miles of the western portion of the Region encompass western Arizona, a portion of southern Nevada, and the southwest corner of Utah. Major attractions are the Grand Canyon National Park, Hoover Dam, Lake Mead and other reclamation impoundments on the Lower Colorado River; the cool coniferous forests of the North and South Kaibab Forest areas; the broad expanses of grasslands and deserts; and the rich farmland and orange groves of the Lower Colorado River valley. The cities of St. George, Utah; Las Vegas, Nevada; and Yuma, Arizona, are located in the Subregion.

The Little Colorado Subregion contains 26,977 square miles and encompasses the Little Colorado River drainage basin extending from the Continental Divide in New Mexico to the Lower Main Stem Subregion boundary near Flagstaff, Arizona. The Little Colorado River drains into the Colorado River, 62 miles downstream from Lee Ferry, Arizona. The Subregion's mountainous areas are popular for both summer and winter recreational activities. Nearly one-half of the area in the Little Colorado Subregion is included within the boundaries of the Navajo and Hopi Indian reservations. Major cities of the Subregion are Gallup, New Mexico; and Flagstaff, Holbrook, and Winslow, Arizona.

The Gila Subregion encompasses 57,606 square miles of southeastern Arizona and southwestern New Mexico bordering Mexico on the south and the Continental Divide on the east. The climate of the Gila Subregion provides a major attraction for one of the most popular winter tourist areas in the United States, particularly in the Tucson and Phoenix metropolitan areas. The Cities of Phoenix and Tucson, Arizona; and Lordsburg, New Mexico, are located in this Subregion.

Table 1 contains a breakdown of areas within the Lower Colorado Region by subregion and state.

Climate

The Lower Colorado Region's climate varies widely as a result of the large differences in elevation, a considerable range in latitude, and the distribution of mountain ranges and highlands. (See Figure 1)

Mean annual temperatures range from 43.7 degrees at Alpine in the mountainous area of eastern Arizona to 72.4 degrees in the desert area of Gila Bend, Arizona. In the desert areas, temperatures in excess of 100 degrees are common during much of the summer. In the mountainous areas above 7,000 feet, normal summer daytime temperatures range in the 70's while winter temperatures below zero occur regularly. In parts of the White Mountains, temperatures sometimes drop to as low as 30 degrees below zero. Frost-free periods range from less than 60 days in the high mountains to nearly year-long in the desert valleys.

There are two distinct moisture sources. Winter precipitation is associated with moisture moving into the area from the Pacific Ocean, while the Gulf of Mexico is the source for much of the summer rainfall. About half the Region receives an average of less than 10 inches of precipitation per year, and a large part of the remainder receives less than 20 inches per year. In a few small areas, the average annual precipitation is more than 25 inches. The southwestern part of the Region is the most arid, and near Yuma some areas receive less than 5 inches of precipitation per year. The mountain ranges which are the headwaters of the Verde, Salt, Little Colorado, and Gila Rivers, are the areas of highest precipitation, and a few mountain peaks receive more than 30 inches of precipitation per year.

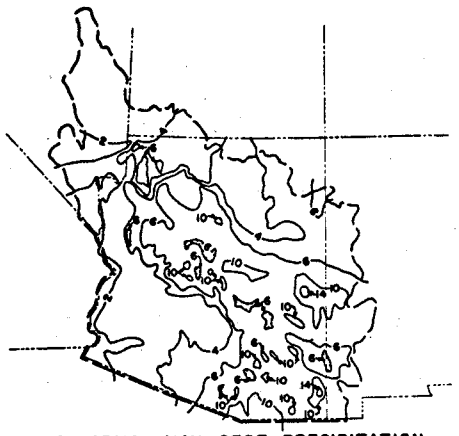
The combination of high temperatures and low humidity causes high rates of evaporation and transpiration resulting in the depletion of more than 95 percent of the precipitation before it can reach the streams or percolate to the ground-water reservoirs. In the alluvial valleys of the Basin and Range Lowlands province, where the need for water is greatest, precipitation is least and potential evapotranspiration is greatest. The gross annual evaporation rate ranges from 48 inches in the north to 86 inches along the Lower Main Stem of the Colorado River.

Streamflow is extremely variable. In the Basin and Range province few of the tributaries of the Lower Colorado River are perennial, except in the area bordering the Colorado Plateau province where base flow is provided by springs. Normally dry stream channels may periodically be filled bankfull as a result of torrential thundershowers. Prolonged periods of winter and early spring runoff occur infrequently. The ground water stored in the permeable alluvial aquifers in the Basin and Range province and in the consolidated sedimentary aquifer systems of the

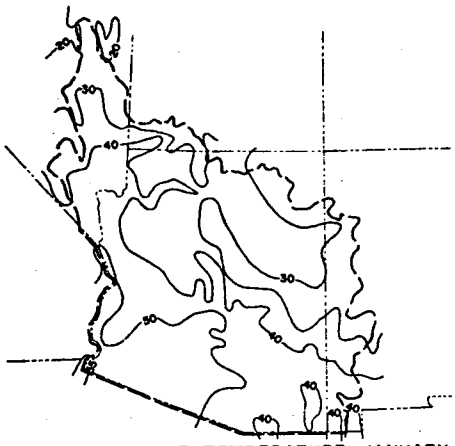
Table 1 - Total Area by State and Subregion
Lower Colorado Region, 1965
(Hydrologic Area)

Subregion			State				
No.	Name	Unit	Arizona	Nevada	New Mexico	Utah	Total
1	Lower Main Stem	Acres	22,882,000	11,078,000	--	2,234,000	36,194,000
		Sq. Miles	35,754	17,310	--	3,490	56,554
2	Little Colorado	Acres	13,867,000	--	3,398,000	--	17,265,000
		Sq. Miles	21,667	--	5,310	--	26,977
3	Gila	Acres	31,719,000	--	5,149,000	--	36,868,000
		Sq. Miles	49,561	--	8,045	--	57,606
TOTAL		Acres	68,468,000	11,078,000	8,547,000	2,234,000	90,327,000
		Sq. Miles	106,982	17,310	13,355	3,490	141,137

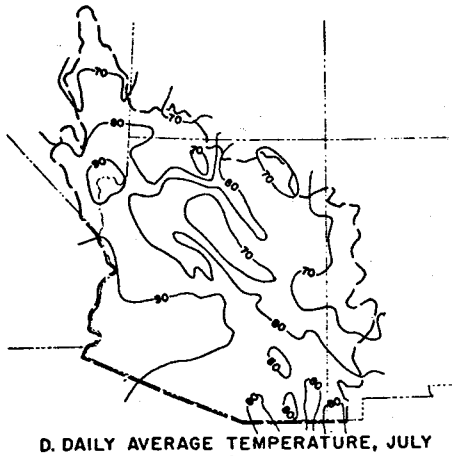
A. NORMAL ANNUAL PRECIPITATION (INCHES)



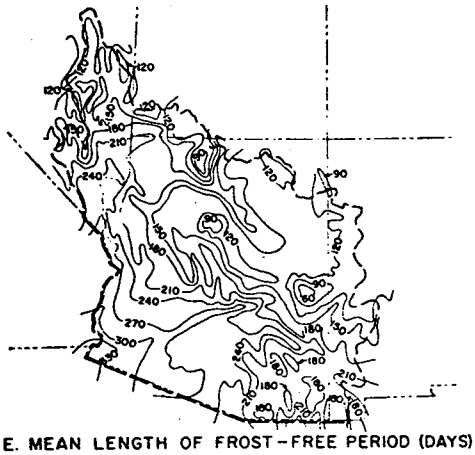
B. NORMAL MAY-SEPT. PRECIPITATION (INCHES)



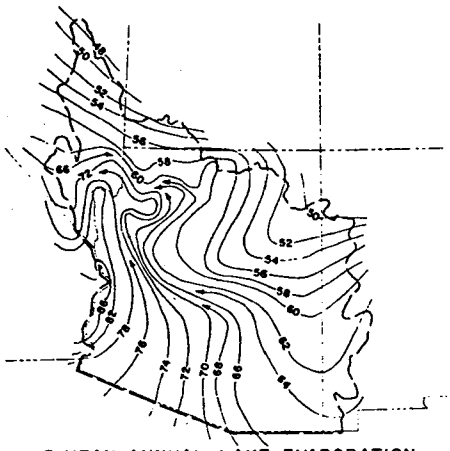
C. DAILY AVERAGE TEMPERATURE, JANUARY (°F)



D. DAILY AVERAGE TEMPERATURE, JULY (°F)



E. MEAN LENGTH OF FROST-FREE PERIOD (DAYS) BETWEEN LAST 32° F TEMPERATURE IN SPRING AND FIRST 32° F TEMPERATURE IN AUTUMN



F. MEAN ANNUAL LAKE EVAPORATION (INCHES)

FIGURE 1

COMPREHENSIVE FRAMEWORK STUDY
LOWER COLORADO REGION
CLIMATIC DATA

MAP NO. 1019-314-7

100 0 100 200 300
SCALE OF MILES

SEPTEMBER 1968

Colorado Plateau province represents an important portion of the Region's water supply. Recharge to the alluvial aquifer systes is limited by both climatic and geologic factors. The recharge is generally less than the ground-water pumpage, resulting in continuing depletion of the ground-water storage.

Land Forms and Topography

The Lower Colorado Region lies within two of the major physiographic provinces of the Southwest, the Basin and Range province and the Colorado Plateau province. The Region is a complex of plateaus, mountains, deserts, and plains, with elevations ranging from 100 feet above sea level near Yuma to 12,611 feet at the summit of Humphrey's Peak in the San Francisco Mountains north of Flagstaff.

The Basin and Range province occupies the southern and western portions of the Region and is characterized by mountain chains and alluviated valleys. Most of the province is within the drainage area of the Colorado River or its main tributary, the Gila River. In the mountain ranges, these streams and their tributaries have cut deep gorges. The part of the province bordering the Colorado Plateau, south of the Mogollon Rim, is a mountainous area with some small valleys. Many of the streams head in narrow canyons. In the southwestern part of the Region, however, the buttes and ranges are of generally small areal extent protruding above wide alluviated plains and valleys. The valleys consist of a series of interlocking basins partly filled by alluvium. The basin rims are formed by mountain ranges, which consist of all types of rocks--sedimentary, granitic, volcanic, and metamorphic--that usually have been subjected to recurrent faulting and tilting. As a result, many ranges consist of masses of rock that are strongly inclined, lying on end, or locally overturned. Differential erosion of these rocks has given the ranges an irregular appearance.

The Colorado Plateau province occupies the northern and north-eastern portions of the Region and is characterized by alternating cliffs and slopes formed as a result of variations in resistance to erosion. Ledges, cliffs, or rock benches formed of resistant beds of sandstone and limestone are separated by slopes, valleys, and badlands carved on the weaker intervening shaly strata. The whole province has similar rock formations of wide areal extent which are inclined slightly or are nearly horizontal. In areas adjacent to the Colorado River, canyon lands are developed extensively. In the area surrounding the canyon lands and in part of the upland adjoining the canyon rims, rock terraces form a series of platforms such as the Marble Platform, plateaus such as the Coconino Plateau, and high cliffs such as the Grand Wash Cliffs. In the southern part of the province beyond the belt of rock terraces and plateaus, the relief is rather subdued and broad slopes and low mesa-like features predominate.

Vegetal Cover and Related Categories

The Lower Colorado Region has a wide variation in "vegetative cover types and related categories." The forest types extend from the small alpine areas on top of Mt. Baldy in the White Mountains, the tip of Humphrey Peak in the San Francisco Peaks, and the crest of Charleston Mountain, Nevada; through the coniferous forest zones of spruce-fir, ponderosa pine, and the pinon-juniper and oak woodlands, and the chaparral types. The rangeland type extends from the forest type through the northern and southern desert shrubs, the northern and desert grasslands, down through a small area of true desert near the mouth of the Colorado River on the boundary between Mexico and Arizona. Scattered throughout the Region are areas of cultivated land, including irrigated pasture, with the largest blocks in the lower Gila and the southern half of the Lower Main Stem Subregions. More than 500,000 acres of the Region are developed as urban and industrial areas. More than 300,000 acres of the Region are occupied by water in the form of streams, lakes, impoundments, and reservoirs. The vegetative cover type is dependent upon the precipitation, topography, soil, and climate. In addition, each type is limited to rather specific ranges in elevation.

Geology

The Basin and Range province is characterized by isolated mountain blocks separated by broad alluvial-floored basins. The elevations of the mountain blocks are as much as 10,000 feet above mean sea level and usually are between 1,000 and 4,000 feet above the floors of the subjacent basins. The elevations of the basins range from 100 feet to as much as 5,000 feet. Most of the valleys in the Basin and Range country trend north to northwest. These alternating mountains and valleys were produced by large-scale faulting in which the mountain blocks were uplifted and the basins were depressed. Subsequent to and during faulting, the valleys were filled with alluvial material eroded from the mountain masses which are composed chiefly of granite, gneiss, schist, and quartzite. Many mountains are capped with volcanic rocks. Along some of the mountain fronts, the hard rocks have been planed by erosion to gentle slopes. A complete discussion of the complicated geologic events that occurred over a geologically long period of time resulting in the present relations of mountains to valleys is not warranted. A brief discussion of the major stages of erosion and sedimentation that formed the alluvial valleys will indicate the hydrologic importance of geologic history.

During Tertiary time, the large-scale movement along predominantly northwest-trending faults formed the general outlines of the Basin and Range structural pattern. It is probable that some movement on a smaller scale continues to the present time. In many valleys, the basement rocks are overlain by a coarse material of generally low permeability, which has eroded from the nearby highlands. Concurrent with this sedimentation, faulting occurred and volcanic eruptions deposited lavas. In some areas

the basin drainages were dammed forming lakes and playas in which fine-grained sediments were deposited. Subsequent erosion of the mountains caused thick alluvial fill to be deposited in the valleys. Volcanism continued intermittently and lavas, in some places, interbed with the alluvium.

The alluvium, which represents several stages of deposition under different environments, is the major deposit in the structural basins and consists of lenses of gravel, sand, clay, and silt in varying thicknesses. Locally it may be as much as 3,000 feet thick. In the fill in the central part of many of the valleys, considerable thicknesses of clay are common. Locally these clay beds contain lenses of gravel and sand. Sand and gravel are deposited along the larger streams and along the mountain fronts.

Channel deposits along the present drainages consist of mixtures of unconsolidated gravel, sand, and silt. These deposits include fill that underlies the flood plains of the present streams in the Basin and Range province. The alluvial fill is the major ground-water reservoir in the Basin and Range province. Recharge to the fill occurs near the mountain fronts and along the stream channels as seepage from the few perennial and many intermittent streams. Only occasionally do the main drainges carry water their full length for more than a few days.

The Colorado Plateau province is underlain by sedimentary rocks that overlie igneous and metamorphic basement rocks ranging in thickness from 1,000 to 10,000 feet. The sedimentary rocks are characterized by slight deformation, consisting of normal faulting and broad gentle folding. Part of the area is mantled by alluvial, eolian, and terrace deposits. Complex intertonguing and rapid facies changes are prevalent in the sedimentary rocks and are the principal controls on the ground-water movement. The movement of ground water in the sedimentary rocks is controlled by regional structure of the basins and upwarps. The main areas of recharge are on the highlands, on the upwarps, and along the structural divides. Movement of ground water is downdip from the highlands toward and paralleling the flow direction of the perennial streams.

The Colorado River became a through-flowing stream in late Cenozoic time. Downcutting by the river and its tributaries resulted in deep entrenchment of the entire system resulting in the spectacular canyons. Runoff from the plateaus in the Lower Colorado Region is to the Colorado, Little Colorado, and Virgin Rivers. The Colorado and Virgin Rivers are perennial; all the other streams are intermittent, except for short reaches; downstream from springs, such as Blue Spring near the mouth of the Little Colorado River; those in Havasu Canyon and near St. Johns, Arizona.

HISTORY

WUPATKI NATIONAL MONUMENT - Well preserved ruins of 12th century Indian pueblos. NPS

HISTORY

The Lower Colorado Region has provided a colorful chapter in American history. While containing some of America's most interesting archeological discoveries revealing early habitation, this Region was among the last to be settled by American pioneers.

Early Civilization

The Lower Colorado River Basin comprises most of the archeological unit commonly referred to as the Southwest. Native agriculture is one of the definitive characteristics of the area. But to the west, north, and east the adjacent areas were essentially nonagricultural.

Four major cultural subareas may be distinguished in the Southwest: the Hohokam of the desert of central and southern Arizona; the Mogollon in the mountainous areas of eastern Arizona and western New Mexico; the Anasazi of the high plateau region known as the Four Corners; and the Patayan, which centers in the Colorado River Valley in a desert environment. There was considerable interchange of cultural characteristics among the major subareas of the Lower Colorado River Basin in prehistoric times. The prehistoric cultures of the Southwest are ancestral to historic and modern Indian cultures of the area. For example, the Hopi of northern Arizona and the Zuni of west-central New Mexico still live on or near the townsites of their prehistoric ancestors.

Another apparent continuity between prehistoric and historic people is seen in the Patayan subarea where the Havasupai, Yavapai and Walapai continue to live in their ancestral homeland along the Colorado River. And in the desert region of southern Arizona, the relationships of the present-day Pima and Papago farmers to the prehistoric Hohokam is well established. Present evidence no more than suggests what happened to the prehistoric Mogollon people; some may have joined the Anasazi to the north, others may have joined the Hohokam.

The Southwestern cultural tradition had its roots in the food collecting pattern of western North America. This tradition began to the north around 7,000 B.C. and became established about 5,000 B.C. in the Southwest. About the beginning of the Christian era, a Southwestern culture clearly distinguishable from those of adjacent regions developed from this food collecting tradition. Cultivation of food plants and pottery making was introduced from Mexico, community populations gradually increased and a more sedentary pattern of living evolved.

The Hohokam flourished in the desert of south-central Arizona. Low, hot, and rarely rained upon, this country was entirely dependent upon

streams such as the Salt and Gila Rivers which arose in the mountains to the east. Irrigation farming was the subsistence base of the Hohokam culture and sometime between A.D. 500-900 these prehistoric people engineered a complex irrigation system along these major streams.

Like the Hohokam, the Mogollon culture developed from a food collecting base. But, overall, the Mogollon line of development seems less specialized than that of the Anasazi to the north and the Hohokam to the southwest. Despite their earlier beginnings in farming and ceramics, the Mogollon seems to have lost its leadership in Southwestern cultural development relatively early. Later in its history, the Mogollon culture was influenced by both the Anasazi and the Hohokam.

Although Anasazi cultural tradition is centered in the high plateau country of the Four Corners area, some development occurred in the Little Colorado River Valley of northern Arizona in prehistoric times. Modern Pueblo Indians and their ancestors have inhabited this general region since about the time of Christ, relying mainly upon natural runoff from springs and the heads of streams to water their crops.

Anasazi-culture Indians, living along the bottom lands of Muddy and Virgin Rivers and other perennial streams of the area as early as 500 A.D., were the first settlers in southern Nevada. Evidence at these sites indicates that these early settlers developed a primitive system of irrigated agriculture and that the settlements were abandoned about 1150 A.D.

When Father Kino visited the Southwest in 1700, he found a large population living in the valley of the Colorado River below the Grand Canyon. These were the Patayan people whose ancestors are the least well known in the Southwest. Their culture seems to be characterized by a great poverty of material remains, possibly because of a greater use of perishable materials which have not been preserved.

Discovery and Exploration

The deep canyons, obstructing cliffs, and desert wastes limited early exploration of the Lower Colorado Region. Friar Marcos de Niza was sent north in 1539 by the Viceroy of Mexico to investigate stories of a clothed people living in large towns. Though parts of the route are uncertain, he passed via the San Pedro River through southeastern Arizona and on to within a few miles of the Zuni Pueblo of Hawikuh in New Mexico. The following year Francisco Vasquez de Coronado led an expedition into this region, following essentially the route blazed by Friar Marcos. After a battle at Hawikuh, Coronado set up his temporary camp at this pueblo. One of his men discovered the Grand Canyon while in search of a water course to bring supplies north from the Gulf of California.

Antonio de Espeno, in 1583, and Marcos Farfan, in 1598, made brief exploratory trips to the vicinity of Jerome, Arizona, on the upper Verde

TUMACACORI NATIONAL MONUMENT - This old Spanish mission was established by Father Kino in about 1690.

River and were followed, in 1604 by Juan de Onate, Governor of New Mexico. Onate continued west, along the Bill Williams River, to the Colorado River and thence south to its mouth.

Father Eusebio Kino, a Spanish Jesuit priest working from a settlement that is now the town of Sonora, Mexico, explored and mapped much of the Gila River drainage area during the period from 1687 until his death in 1711. In the 1770's, Father Francisco Garces made several exploration trips down the Gila River and along the Colorado River south of the present City of Needles, California. Also during this decade, Bautista de Anza opened up the Gila River trail from the Presidio of Tubac and the present City of Tucson, Arizona, to California.

Many traders, trappers, and explorers entered the area after 1820. James Ohio Pattie, a fur trader, trapped along the Gila River and the Colorado River in the 1820's. Jedediah Smith, also a young fur trader, left Salt Lake City, Utah, and worked down the Virgin River and south along the Colorado River to the vicinity of Needles, California, in 1826, before turning west to coastal California. He reported that Indians in vicinity of the confluence of the Virgin and Colorado Rivers raised corn and pumpkins. In 1830 William Wolfskill, another fur trader, followed a generally similar route to California. John C. Fremont passed through the Las Vegas Valley-Virgin River-Muddy River area of southern Nevada in 1844 and noted the presence of Indians in the area. Felix Aubrey, in 1853, traveled from Zuni, New Mexico, across the lower reaches of the Colorado River to California. Army exploration, beginning with the United States occupation in 1846, continued throughout the territorial period until the Indians were settled on reservations in the 1880's. In 1869, Major John Wesley Powell explored the canyons of the Green and Colorado Rivers to the mouth of the Virgin River. He repeated his trip in 1871 when he officially applied the name "Grand Canyon" to that reach of the Colorado River.

Settlement

At the end of the war with Mexico, the treaty of Guadalupe-Hidalgo, signed in 1848, ceded to the United States most of the Region north of the Gila River. The Gadsden Purchase, in 1853, acquired from Mexico those lands south of the Gila River that are now included within the United States. Nevada obtained statehood in 1864, Utah in 1896, and New Mexico and Arizona in 1912. New Mexico was the 47th state admitted and Arizona the 48th.

Missionaries influenced early settlement in the Region. The first few settlements were built by Franciscans among the Hopi villages in the 1600's. Father Kino, a Spanish Jesuit priest, founded several of the first settlements subsequent to his many journeys through the southern portion of the Region beginning about 1687. He established a mission a few miles north of the present site of Nogales, Arizona, in 1701, which

became the first European-type structure in southern Arizona. Settlements founded by the Spaniards were confined primarily to the Santa Cruz Valley until after the opening of the American period. Tucson was the center of population during this era.

A town was first surveyed at Yuma in the lower Gila Valley about 1858 and at La Paz north of Ehrenberg, Arizona, in 1862. These were the first important developments to utilize the natural resources of the Lower Colorado River Valley. River traffic began with an attempt to supply Arizona City (Yuma) and Army posts in 1852, and soon several steamers plied the Colorado River delivering goods to points as far north as the present location of Hoover Dam. Their profitable operation ended, as did that of the Butterfield Stage Line, shortly after the transcontinental railroads spanned the valley at Yuma, Arizona, in 1877, and at Needles, California, in 1883.

The establishment of U.S. Army forts and the development of the new mines and freighting enterprises in the 1850's made possible the opening to settlement of central Arizona in the 1860's. Mormon settlements expanded south in the 1870's through the country bordering on the high mountains of eastern Arizona. In the 1880's, towns sprang up along the railroads as they expanded west through Arizona. Agricultural, livestock, and lumbering operations accelerated as demands increased.

In 1855, a Mormon mission of 30 families was placed at Las Vegas Springs (now Nevada) to establish a settlement at this important point on the route to California. In 1858, two missionaries to the Indians along the Muddy River reported that the Indians were growing corn, melons, pumpkins, and squash.

Preston and Lund, in the White River Valley of Nevada, were settled late in 1858. Although some livestock men settled at Ursine in the late 1850's, the discovery of the rich silver-lead-zinc mines at Pioche, in 1863, marked the real advent of settlement in the Meadow Valley area. Panaca was settled the following year. Since water to process the silver ores at Pioche was scarce, mills were constructed at Bullionville, near Panaca. Caliente was laid out in 1910 as a construction camp for the San Pedro, Los Angeles and Salt Lake Railway, which upon completion in 1905 provided access to markets in California and Utah. Overton, Nevada, was established late in 1869. Bunkerville, a short-lived experiment in socialism, was established on the Virgin River in 1877 and the experiment was dissolved in 1880. Mesquite was established across the Virgin and slightly upstream from Bunkerville in 1880. Until 1909, almost all of southern Nevada was in Lincoln County. Clark County, named afer W. A. Clark, builder of the San Pedro, Los Angeles and Salt Lake Railroad, was formed in 1909 and has since become the most significant economic entity in the State of Nevada.

Settlement along the Muddy River in the southern Nevada area was first attempted in 1865 when 250 families of Mormon pioneers established five

small communities. These were temporarily abandoned in 1871 but were reestablished in 1881. Agricultural development here soon expanded to the limit of the available artesian water supply.

Cattlemen were attracted to the expansive grazing areas of the Region, and a rapid expansion of the livestock industry resulted. The discovery of gold and silver deposits caused a temporary population influx during the period 1847 to 1860; but, during the Civil War, hostile Indians caused most mining settlements to be abandoned.

The Region's marked increase in growth rate began during World War II with the influx of air bases and defense plants. Afterward, the factors most influencing the continued growth rate have been the Nation's prosperity, the general westward migration, and the advent of air conditioning. During and after World War II, the Region had one of the highest growth rates in the Nation. In the twenty years prior to 1940, Arizona's population increased 50 percent; from 1940 to 1960, it increased 260 percent; and from 1960 to 1967, it is estimated that it increased an additional 25 percent. In 1940, Phoenix had a population of 65,414; and the 1967 population was estimated to be 519,000.

Population growth has been largely concentrated in the few major cities of the Region. In Arizona, Maricopa County, with its 1965 population of 875,000 centered in the Phoenix metropolitan area, contained 53 percent of the State's population. Pima County, with Tucson as the population center, contains 20 percent of Arizona's population. Las Vegas, the largest city in Nevada, is the population center of Clark County, which in 1966 contained 54 percent of the State's estimated 431,000 population.

DEVELOPMENT

DEVELOPMENT

Agriculture

Cropland production in the Lower Colorado Region is concentrated in the southern desert areas where there is a near all-year growing season and the climate is suited to a wide variety of crops. About 77 percent of the irrigated lands is in the Gila Subregion and most of the remainder is in the lower reaches of the Lower Main Stem Subregion. Irrigation is a necessity, hence, development occurs predominantly in the river valleys where water is available.

The Salt River Valley's fertile land and plentiful surface water were quickly recognized by the early settlers but, as the population increased and more land came under production, it became apparent that nature was not always dependable in providing an adequate water supply. A period of drought occurred during the years 1897 through 1899 and 75,000 acres were abandoned. In February of 1900, a flash flood destroyed all the diversion dams on the Salt River; and in the following month, wind and dust storms virtually completed the destruction of all agricultural developments and made the area almost uninhabitable. As a result, efforts were concentrated on obtaining Federal assistance to construct a dam on the Salt River and with the passage of the Reclamation Act of 1902, plans evolved for formation of the Salt River Valley Water Users' Association to serve 240,000 acres. In 1906, construction of Roosevelt Dam started; and, with its completion in 1911, a new era for central Arizona began.

Additional storage and irrigation facilities were constructed to serve various irrigation projects. Major irrigation diversion facilities and projects are discussed in the Irrigation and Drainage Appendix X. The greatly accelerated migration of people to the Southwest reached epic proportions after World War II. The surface water became increasingly inadequate and wells were drilled in increasing numbers. The once plentiful ground water began to be withdrawn much faster than nature could replace it and the water levels began to decline rapidly.

Early irrigation along the Colorado River was limited to lands that could be reached by surface diversion and these were subjected to frequent destructive floods. The United States first attempted to reclaim the arid lands on the Colorado River Indian Reservation in 1867. Later, the Yuma and Gila Projects were constructed. Intermittent floods and erratic water supply hampered development from time to time. The completion of Hoover Dam and its appurtenant works in 1935 made it possible to control and utilize the waters of the Colorado River, and did much to increase the Lower Colorado Region's economic contribution to the Nation.

Irrigated citrus groves - central Arizona. USBR

Harvesting cotton, one of the major sources of agricultural income in the Lower Colorado Region. USBR

Anaconda's Twin Buttes "open pit" copper mine near Tucson, Arizona. BM

Excluding double-cropped acreage, there were 1,160,000 acres irrigated in 1965. Of this amount, the Gila Subregion contained 895,000 irrigated acres and 28,000 acres were in the Little Colorado Subregion. Most of the remaining irrigated area, 237,000 acres, were contained in Yuma County, Arizona, along the Colorado River in the Lower Main Stem Subregion.

Major sources of income in the Lower Colorado Region are cotton, feeder livestock, vegetables, citrus, and melons. In 1965, Arizona ranked fifth among the states in cotton production and cotton accounted for 39 percent of the State's gross crop value. The second most valuable crop in the Region was vegetables, followed by hay and feed grains. Irrigated agriculture in the desert area of Arizona is an important supplier of the Nation's winter vegetables. The livestock industry provides a sizable share of the agricultural income and efforts toward restoration of rangeland promise a continuance of the industry. The high plateaus and forested areas provide range for summer grazing. In some of the northern parts of the Region, livestock accounts for the bulk of the agricultural income. Large feeder operations have developed in the central and southern part of the Region where alfalfa and feed grains are grown throughout the year, and where yields greatly exceed the national average. Livestock and associated products accounted for over 40 percent of the Region's agricultural products gross value in 1965.

Lands suitable for irrigated agriculture within the Region are plentiful, totaling some 36.2 million acres. Water is the present limiting resource on agricultural production because irrigation is a necessity for the growth of crops in nearly all parts of the Region.

Mining

Significant gold and silver strikes were made in the Region in the 1870's. These strikes led to booms, with their attendant influx of people. There was no orderly development, no scientific method of locating ore deposits, nor was any attempt made to establish this major resource as the basis for a stable industry.

Large scale copper production began in the Region in the middle 1880's. By 1888, the Arizona yield was valued at $5 million; and, by 1910, Arizona was producing $38 million worth of copper annually. In 1965, the value of Arizona's copper production was $433 million. Arizona has maintained its position as the Nation's leading copper producing state every year since 1910 and for the past several years has produced more than 50 percent of the Nation's supply. The major portion of the copper production is from the Gila Subregion. The value of copper presently produced annually accounts for about 85 percent of the total annual value of all minerals produced in the Region.

Mining and mineral resources are of vital importance to the Lower Colorado Region. Development is now based on sound planning and utilization

of modern scientific knowledge and methods. Continued expansion of the copper industry has been made possible largely as the result of improvements in equipment, making profitable the moving and processing of large quantities of low-grade ore from open-pit mines. Ores mined today typically run as low as 15 pounds of copper to each ton of rock, a proportion which was previously considered unprofitable to process.

Power

The first franchise to provide electric service in the Lower Colorado Region was from the City of Phoenix in 1886, and electric service was instituted in 1888. Mesquite wood was used to fire the boilers of a steam generating plant providing a capacity of 50 kilowatts.

In 1892, the Yuma Water and Light Company was formed, and in 1895, the Prescott Electric Company was organized.

The first Federal power development in the Region was completed in 1911 with the installation of five 1,080 kilowatt hydroelectric units in Roosevelt Dam on the Salt River. The Salt River Project later assumed operation of these facilities and constructed additional dams and hydroelectric facilities on the Salt and Verde Rivers. To serve increasing power requirements, the Salt River Project later added thermal generating facilities.

In 1965, the total electric utility generating capacity installed and under construction in the Region was 4,310,863 kilowatts. This included 15 hydroelectric plants having total installed capacity of 1,655,000 kilowatts, 17 steam-electric plants having 2,534,668 kilowatts of total installed capacity, and 16 internal-combustion electric plants having 121,195 kilowatts of installed capacity.

Hoover Dam is one of the world's largest hydroelectric installations with a commercial generating capacity of 1,340,000 kilowatts. Commercial generation first began in 1936 and the last unit went on the line in 1961. Energy is sold to both public and private agencies. Hoover Dam's primary purpose is to provide storage capacity for the regulation of the erratic flows of the Colorado River. The regulation of riverflows made possible the construction of Davis and Parker Dams downstream with accompanying hydroelectric facilities. The Davis Dam Power Plant has a capacity of 225,000 kilowatts. The Parker Dam Power Plant, located in California, has a capacity of 120,000 kilowatts.

The Parker-Davis Project was authorized by an act of Congress in 1954 to consolidate the Davis Dam Power Project and the Parker Dam Power Project. The Parker-Davis Project, with headquarters in Phoenix, Arizona, includes a transmission system serving power market areas in southern California and Arizona and interconnecting Parker, Davis, and Hoover Power Plants.

The major privately owned utilities serving the Region are the Arizona Public Service Company, with an installed (or under construction) capacity of 803,933 kilowatts 1/; Tucson Gas and Electric with an installed (or under construction) capacity of 609,036 kilowatts; and the Nevada Power Company with an installed (or under construction) capacity of 528,467 kilowatts.

The Salt River Project, serving the central Arizona area in the vicinity of Phoenix, is the largest non-Federal publicly owned power facility with installed (or under construction) capacity of 608,162 kilowatts. Hydroelectric and thermal-electric power resources existing (or under construction) in 1965 are presented in Appendix XIV, Electric Power.

Construction of the Pacific Northwest-Pacific Southwest Intertie which would provide for interchange of electric power between the power systems of the Columbia-North Pacific Region and the power systems of the Pacific Southwest Area, has been progressively delayed by budget limitations. It is expected that the feasibility of the Intertie will be reexamined about 1974. Intertie facilities would include an 824-mile-long, 750,000-volt direct current transmission line from the Celilo Substation near The Dalles, Oregon, to the Mead Substation in the vicinity of Hoover Dam. This interconnection would have a capability of 1,300 megawatts.

Western Energy Supply and Transmission (WEST) Associates was organized in 1964 and its membership now includes 23 utilities, 12 private and 11 public, in a nine-state area. The large power facilities needed to supply economically the rapidly expanding powerloads will be developed through joint planning, construction, and operation of generating and transmission facilities. A large thermal plant, with two 750,000 kilowatt units, is under construction by certain members of WEST in northwestern New Mexico. Although this plant is within the hydrologic boundaries of the Upper Colorado Region, its output will be used in the systems of its owners located in California, Arizona, New Mexico, and Texas. Another power plant with two 750,000 kilowatt units is being constructed on the Colorado River at the southern tip of Nevada. It will be owned by Southern California Edison Company, Los Angeles Department of Water and Power, Nevada Power Company, and Salt River Project.

Manufacturing

In the last two decades, the economy of the Lower Colorado Region has experienced a significant transition from an agricultural-mining base to a manufacturing-service base. In Arizona, the manufacturing income for 1965 was $1.10 billion, compared to a combined income of the agriculture and mining sectors of $1.09 billion. In contrast, the 1955 manufacturing income was only one-half that of agriculture-mining.

1/ Includes jointly owned Yuma-Axis plant of 75,000 kilowatts.

Growth in the manufacturing sector has been one of the major factors in the overall economic growth of the Region. Output increased 300 percent between 1955 and 1965. In terms of percentage growth in manufacturing employment, Arizona led all other states for the 1957-1965 period with a 106 percent gain.

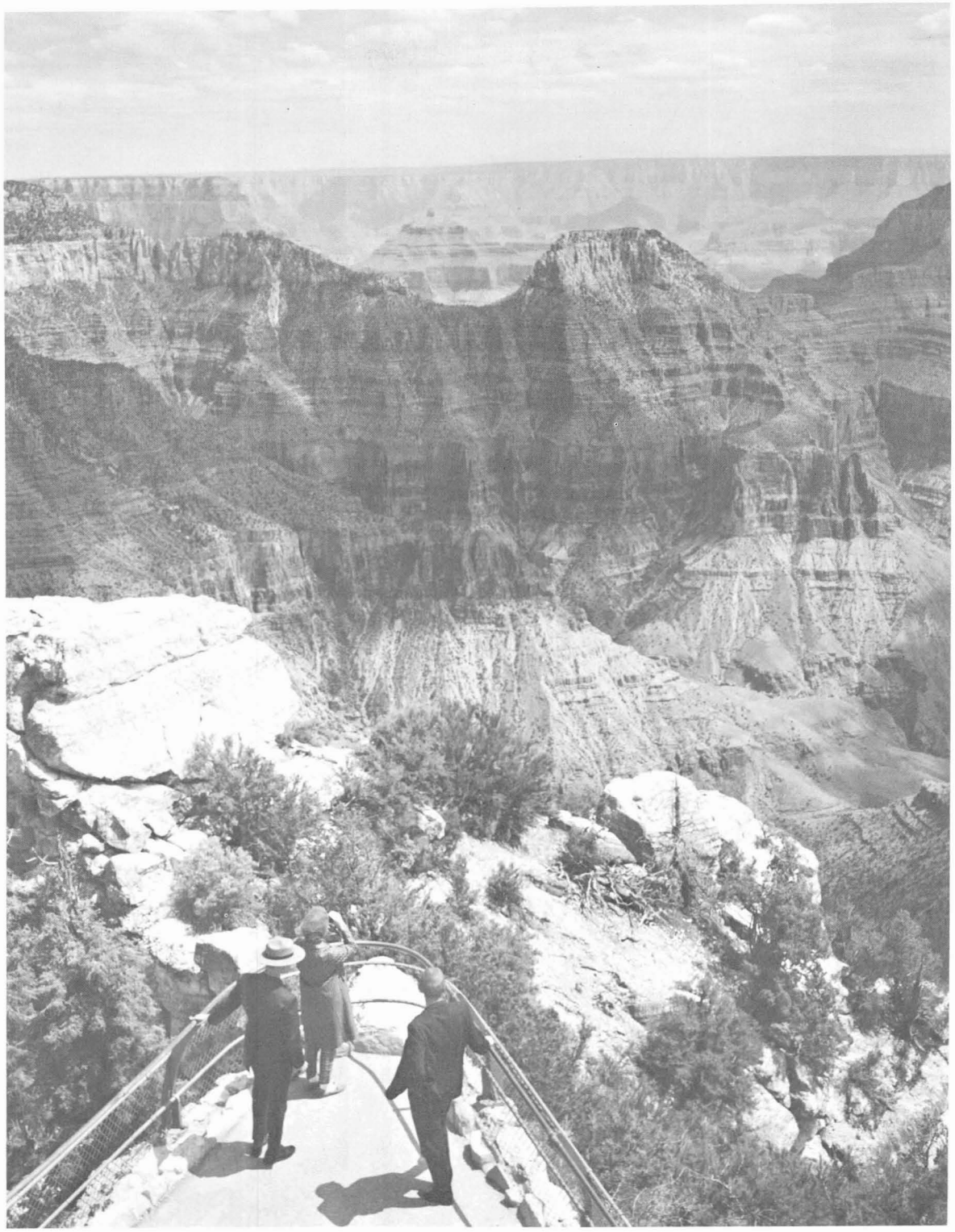
The most spectacular manufacturing growth has been in high-value compact goods, such as electronic components. These goods are able to absorb the locational penalty of transporation charges, which many goods manufactured in the area are assessed. Important manufacturing categories in the Region are electrical equipment, aircraft and parts, primary metal industries, food and kindred products, printing and publishing, and chemicals.

Regional growth in manufacturing output is expected to continue. As the magnitude of the sector increases, rates of percentage growth will become more moderate, but absolute amounts should increase. While electronics should retain its importance, other industries will grow as markets mature within the Region.

Tourism

Tourism has contributed an increasingly important segment to the economy of the Lower Colorado Region in recent years. In Arizona, the tourism and travel expenditures increased from $290 million in 1960 to $420 million in 1965. In Las Vegas, Nevada, over 13,000,000 visitors spent $350 million during 1965. Seven airlines brought 1,700,000 visitors to the city in 1964 and 4,100,000 during 1970. Tourist connected industries, hotels, casinos, amusement, and recreational facilities make up the largest employment category in Nevada and largely account for Nevada ranking first nationally in the rate of growth of nonagricultural employment, with a gain of 85 percent during the period of 1955 to 1965. Arizona ranks second in this category with an 82 percent gain during the period of 1955 to 1965; but the growth is more diversified into manufacturing, tourist-connected industries, and other service industries.

Probably the most significant offerings to the tourists of the Lower Colorado Region are climate and recreational opportunities. The climate ranges from hot desert to cold highlands and allows the tourist to choose from a wide variety. Recreational opportunities range from the lavish entertainment of Las Vegas hotels and casinos to such widespread year-round outdoor activities as camping, golfing, boating, hunting and fishing. Arizona has more national parks and monuments than any other state, and variety here ranges from the physical majesty of Grand Canyon to the spirit-like tie with a vanished society that is embodied in the Casa Grande and many other Indian ruins. Arizona and Nevada share the Lake Mead National Recreation Area. In 1965, over 6 million people visited Lake Mead.



View from north rim of the Grand Canyon. NPS

Hotel-Casino-Golf complex, Las Vegas, Nevada, a major tourist attraction of the Lower Colorado Region. Las Vegas News Bureau

The Gila Wilderness Area of New Mexico was the first area in the United States to be designated for Wilderness Management and is one of the largest. About 0.8 million acres of land in the Lower Colorado Region, ranging from desert to alpine, have been designated for Wilderness Management. The Lower Colorado Region is endowed with one of the largest varieties of wildlife of any similar area in the United States. Wildlife includes game birds, waterfowl, songbirds, many species of fish and reptiles and others; some of which are found only in this Region and Mexico.

The traveler may choose among the many types of accommodations available in the Region--from the plush resort hotels to rustic mountain cabins or from excellently developed campgrounds to "roughing it" in the vast uninhabited desert and mountain areas. The abundant natural base is being complemented continually by new development, and local promotion is helping to attract increasing numbers of tourists to the area. It appears that tourism will remain a major source of regional income.

Transportation

The development of transportation facilities has always been important to the Region's economy. One of the early east-west routes across the Region was the Butterfield Trail, established to carry the overland mail from St. Louis, Missouri, to California. With the advent of the Civil War, the stageline was discontinued. After the war was over, a trail approximating the old stage route brought thousands of people from the East across the Region and on to California. The Atlantic and Pacific Railroad crossed the Region in 1883 from Albuquerque, New Mexico, to California.

East and west railroad transportation in the Region is presently provided by the Atchison, Topeka, and Santa Fe Railway and in the extreme southern part by the main line of the Southern Pacific Railroad, with branch lines serving the major mining and agricultural areas. The main line of the Union Pacific Railroad, connecting Salt Lake City and Los Angeles, crosses the Region in a north and south direction through Nevada. Interstate railroad freight amounts to more than 25 million tons annually, of which about one-third originates from within the Region and had an estimated value of $104 million.

East-west highways include Interstate 40 (U.S. 66) in the north; Interstate 10 (U.S. 60 and 70) in the central part of the Region; and Interstates 8 and 10 (U.S. 80) across the southern part of the Region. North-south highways include Interstate 15 (U.S. 91), extending from Salt Lake City through the Region to Los Angeles, and Interstates 17 and 19 (U.S. 89) from Salt Lake City to southern Arizona. Transcontinental air, truck, and buslines serve the major population centers. In 1965 in the State of Arizona, there were in excess of 5,000 miles of highways and total vehicle miles traveled by all motor vehicles was more than 12.6 million. The total number of freight carriers in Arizona exceeded 66,000 and provided revenue in excess of $138.7 million.

Transportation-Interstate Highway Interchange, Phoenix, Arizona. Arizona Highway Dept.

Due to the excellent climatic condition, the Region supports some of the heaviest air traffic to be found anywhere. Since 1948, Phoenix Sky Harbor Airport has ranked among the top ten in the Nation in air traffic movements. In 1965, the total number of passengers arriving and departing in Phoenix, Tucson, and Las Vegas combined, exceeded 4 million. Air freight tonnage for Phoenix and Tucson increased 189 percent during the period 1951 to 1962.

Timber Industry

Timber and timber products have played an important part in the development of the Lower Colorado Region, dating back to the early mineral and farming development periods. The first lumber was produced in 1856 in the Santa Rita Mountains south of Tucson, Arizona. The first sawmill in the Region was believed to have been built in 1864 near Prescott, Arizona, to supply lumber for the mines and mining camps.

Mineral discoveries and mining development in southeastern Arizona resulted in development of the timber industries of this area during the 1870's and 1880's. Similar mineral discoveries in the Silver City area of New Mexico resulted in the development of a timber industry in western New Mexico.

In the early 1880's a sawmill was constructed in Kyle Canyon on Mt. Charleston to supply lumber for ranches being developed in Las Vegas and Pahrump Valleys in southern Nevada. After the Las Vegas-Tonopah Railroad was completed, lumber was hauled from Mt. Charleston to the railroad for shipment to and use in Las Vegas, Beatty, and Tonopah.

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In the 1880's, the Army constructed a sawmill at the present Roberts Ranch (near McNary, Arizona) on the Ft. Apache Reservation to supply lumber for the construction of Army posts. In 1916, a mill was constructed at McNary with an annual capacity of about 2 million board feet. Present annual capacity of the McNary mill is approximately 75 million board feet, with about 20 million being harvested from reservation lands.

Timber and sawmill industries were developed in the vicinity of Flagstaff, Arizona, to supply railroad ties and bridge timbers to the Atlantic and Pacific Railroad in the early 1880's.

Timber harvesting in the forests of the Lower Colorado Region has been of economic importance for more than 100 years. In 1899, there were 14 sawmills in the Region, with a combined annual production of

about 40 million board feet of lumber. During the early years of development, a large volume of timber was used for house logs, fuel wood, fence posts, poles, mine props, and other round wood products. The number of sawmills reached the peak in 1946, with 71 mills cutting about 350 million board feet of lumber. In 1961, a pulp and paper mill at Snowflake, Arizona, went into production and, together with a small pulp mill at Flagstaff, utilized 150 thousand cords of pulp wood in 1965. By 1965, the number of sawmills had declined to 31, but production had increased to 475 million board feet.

Livestock Industry

The Spaniards introduced the first horses, sheep, and cattle into what is now the Lower Colorado Region in 1539 and 1540 when Coronado explored the area. He brought with him, 1,000 horses, 500 cattle, and 500 sheep. The Spanish missions became the livestock centers during the 16th and 17th centuries. Beginning about 1700, large cattle companies began intensive use of the grazing lands of the Lower Colorado Region. In the early 1800's, small herds of livestock were operated by miners and small farmers supplying meat and other foodstuffs to the mining camps.

Between 1870 and 1880, following the Civil War, livestock operations expanded and by 1890 more than three million head of cattle were estimated to have been grazing on the area now included in the Lower Colorado Region. This apparent overgrazing and the drought of 1891 and 1894 resulted in the reduction of an estimated 75 to 80 percent of the herds through mortality and movement out of the Region.

Between 1914 and 1920, cattle numbers increased, reaching a peak in about 1920, when more than two million cattle were utilizing the forage from the Lower Colorado Region range and forest lands. This far exceeded the carrying capacity of the Region and by 1930, the number had fallen to about 912,000. By 1935, the number of livestock on the Lower Colorado Region forest and range lands had increased to about 1,137,000 head of cattle and with minor variations remained at this level through 1965.

By 1940, the livestock feeding operations in the Region had increased to about 50,000 head of cattle at any one time and a total of 90,000 head were fed during the 1940 calendar year. On January 1, 1950, 59,500 head of cattle were in feedlots in the Region, and approximately 104,000 head of cattle were marketed during the 1950 calendar year. On January 1, 1965, the number of livestock in the feedlots in the Region had increased to about 360,000 head. About 630,000 head of cattle were marketed from the regional feedlots in 1965.

Water and Watershed Management

Water and management of the watershed lands of the Lower Colorado Region, and the headwaters of the Colorado River, have been one of the

most important factors in the development of the Region. The grazing lands of the Region were overgrazed during the period from 1860 to 1900 and again from 1914 to about 1920, resulting in loss of top soil, gully and sheet erosion, and accompanying rapid runoff, siltation of streambeds, and downstream flooding. The National Forests were created shortly after 1900, resulting in some control in the livestock use of some of the mountain lands. The Forest and Range Experiment Stations first began research work at "Wagon Wheel Gap" in Colorado in 1917 to determine the potential for increasing water yield through resource management of forest lands. In 1923, the Summit Plots near Roosevelt Lake were established to evaluate the effect of grazing on water yield.

Beginning in the 1930's, Federal land managing agencies have carried on active programs in watershed management, on forest and range lands, to control erosion and sediment yield, and prevent or minimize downstream floods. Numerous programs to manage forest and rangelands and resources, to increase water quantity, and to improve water quality for downstream uses have been carried on by several Federal and state agencies and by private and semiprivate organizations.

POPULATION CHARACTERISTICS

POPULATION CHARACTERISTICS

Growth

Population of the Lower Colorado Region was estimated at 1,877,000 in 1965 (based on economic subregional boundaries), an increase of more than 222 percent over the 1940 population. During the period 1955 to 1965, Nevada and Arizona ranked first and second, respectively, in the national population growth rate.

The Region's population growth rate increased rapidly during the period starting with World War II, with an increase of 49 percent from 1940 to 1950; 73 percent from 1950 to 1960; and it is estimated, 25 percent from 1960 to 1965. This compares to a national rate of 14 percent and 18 percent,respectively, for the two decades (see Table 2).

Distribution

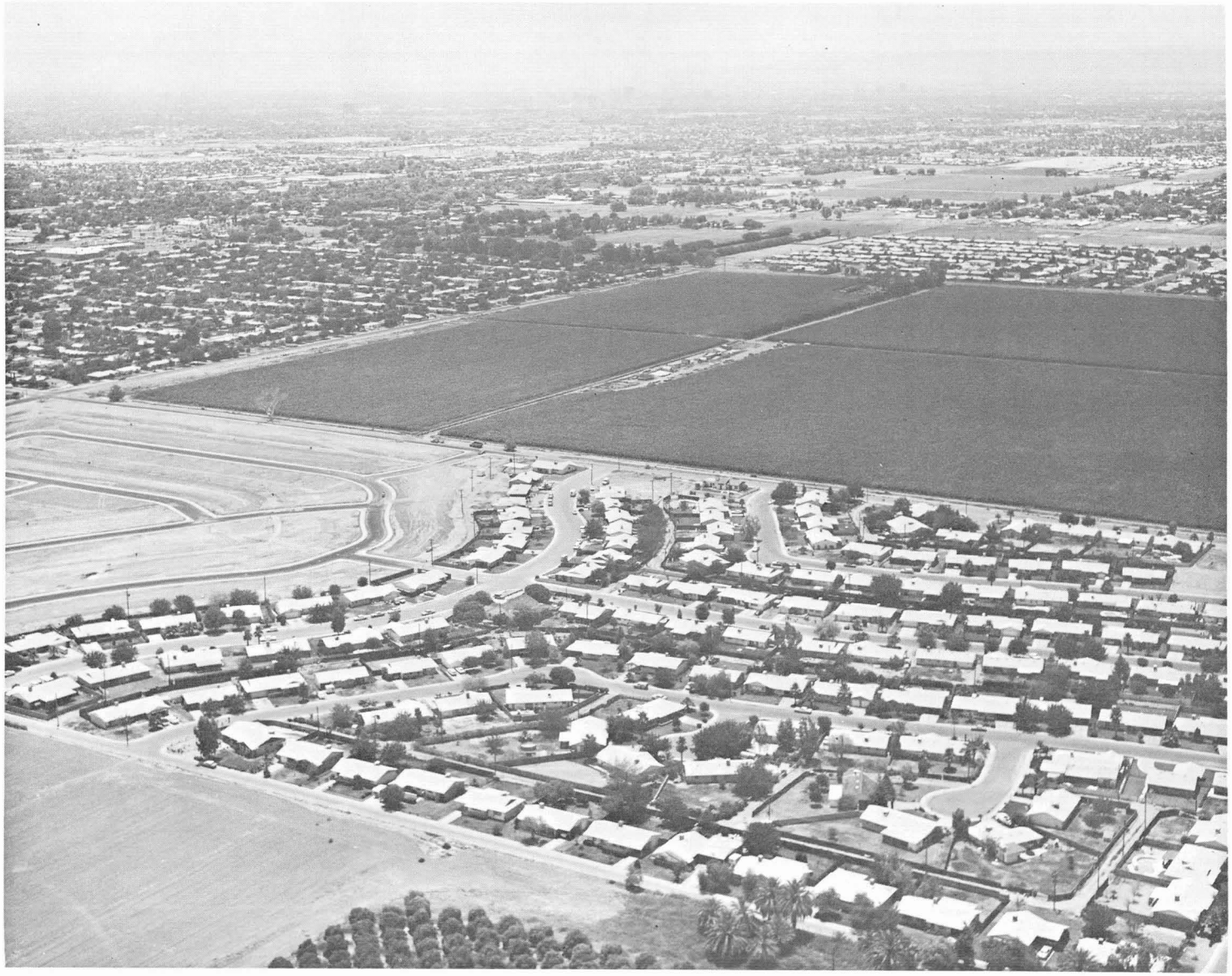
The Gila Subregion includes the major part of the population of the Lower Colorado Region. In 1965, 75 percent of the population was in that Subregion, 18 percent in the Lower Main Stem Subregion, and 7 percent in the Little Colorado Subregion (see Table 3). The proportion in the Lower Main Stem Subregion increased from 13 to 18 percent in the period from 1940 to 1965, while the proportion in the Little Colorado Subregion declined from 13 to 7 percent. The proportion in the Gila Subregion remained relatively stable, the proportion in 1940 being 74.3 percent compared with 75 percent in 1965.

Urbanization

In 1965, 80 percent of the Region's population lived in urban areas of 2,500 inhabitants or more, compared with 72 percent for the Nation. (see Table 4). The situation was similar in the Gila and Lower Main Stem Subregions, where 84 and 78 percent, respectively, of the population live in urban areas. However, in the Little Colorado Subregion only 36 percent of the population lived in urban areas, and the remaining 64 percent was classified in the rural group.

Age

The average age of the Lower Colorado Region population is lower than that of the Nation. In 1959, 40 percent of the Region's population was under 18 years of age, compared with 36 percent for the Nation. In the Region, only 6.7 percent were 65 years and over in age, compared with 9.3 percent for the Nation. These facts are somewhat surprising in view of the Lower Colorado Region's reputation of being a retirement area. It indicates that the Lower Colorado Region also is considered a desirable place to raise a family. All three subregions show a larger proportion



Urbanization of agricultural lands - Phoenix, Arizona. USBR

Table 2
Population and Increase by Decade - Years 1940-1960*; 1965**
Lower Colorado Region and United States

Area	Population, U.S. Census Year 1940	1950	1960	1965	Change 1940 to: 1950	1950 to: 1960	1940 to: 1960	1940 to 1965
	Thousands				Percent			
United States	131,669	150,697	178,464	--	14	18	36	--
Lower Colorado Region	582.4	869.3	1,505.5	1,877.0	49	73	160	220
Subregions:								
1. Lower Main Stem	76.5	122.4	235.6	345.2	60	92	210	350
2. Little Colorado	73.0	84.7	105.6	125.0	16	25	44	71
3. Gila	432.9	662.2	1,164.3	1,406.8	53	76	170	220

Source: * Census of Population 1940, 1950, and 1960.

** Estimate.

Table 3
Population Distribution by Subregion
Lower Colorado Region

Area	U.S. Census Years 1940	1950	1960	1965 1/
	----------Percent----------			
Lower Colorado Region	100.0	100.0	100.0	100.0
Subregions:				
1. Lower Main Stem	13.1	14.1	15.7	18.4
2. Little Colorado	12.6	9.7	7.0	6.6
3. Gila	74.3	76.2	77.3	75.0

1/ 1965 population estimated.

Table 4
Urban and Rural Population, 1965
Lower Colorado Region and United States

Area	Urban 1/ Thousands	Urban 1/ Percent	Rural Thousands	Rural Percent
Unites States	140,400.0	72.0	54,600.0	28.0
Lower Colorado Region	1,501.6	80.0	375.4	20.0
Subregions:				
1. Lower Main Stem	269.3	78	75.9	22
2. Little Colorado	45.0	36	80.0	64
3. Gila	1,181.7	84	225.1	16

1/ The urban population comprised all persons living in (a) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns, and (b) the densely settled urban finge, whether incorporated, or urbanized areas.

of the population under 18 years of age than does the Nation. The Little Colorado Subregion, with its 60 percent Indian population, shows 50 percent of its population in this group, while only 4.3 percent are 65 years old and over.

Cultural and Social Patterns

Racial Composition

The population group classified as White in the 1960 Census constituted 89 percent of the population in the Lower Colorado Region. Indians comprised about 7 percent, Negroes about 3.6 percent, and all other races about 0.4 percent (see Table 5. The Region was similar to the Nation in that the White group comprised about the same proportion of the population in both instances. However, the Indian population is much larger, relatively, in the Lower Colorado Region--7 percent versus 0.3 percent for the Nation. The Negro population was relatively smaller in the Lower Colorado Region than in the Nation.

Considerable variation was evident within the Region in the racial composition of the population. The White group comprised about 94 percent of the population in the Gila Subregion and about 87 percent in the Lower Main Stem. However, it dropped to about 38 percent in the Little Colorado Subregion. In contrast, the Indian population comprised more than 2 percent of the population in the Gila Subregion and slightly over 6 percent in the Lower Main Stem Subregion, while in the Little Colorado Subregion it comprised about 60 percent of the total population.

Education

The population of the Lower Colorado Region 25 years old and over had completed about the same median number of years of schooling as the comparable group in the Nation (see Table 6). The proportion of the population with no schooling was larger in the Lower Colorado Region than in the Nation. In constrast, in the Region, a larger proportion of the population 25 years old and over had completed high school and 4 years of college than in the national average.

Significant differences were evident within the Region in years of schooling completed. The predominantly Indian population of the Little Colorado Subregion had completed an average of only 7.4 years of school compared with 10.3 and 11.2 in the other two subregions. The proportion completing none or only 1-7 years of schooling was also relatively high in the Little Colorado Subregion. In the other two subregions, the Gila was relatively high in the proportion of the population 25 years old and over that had completed only 8 years or less of elementary schooling. However, it was also relatively high in the proportion that had completed 4 years or more of college.

Table 5
Racial Distribution - 1960
Lower Colorado Region and United States

Area	White	Negro	Indian	Other 1/	Total
	Percent				
United States	88.7	10.6	.3	.4	100.0
Lower Colorado Region	89.0	3.6	7.0	.4	100.0
Subregions:					
1. Lower Main Stem	87.3	5.9	6.3	.5	100.0
2. Little Colorado	38.2	1.8	59.8	.2	100.0
3. Gila	93.8	3.4	2.3	.5	100.0

1/ Includes persons of Mexican birth or ancestry.

Table 6
Distribution of Population of Age 25 Years and Older - By Years of School Completed, Lower Colorado Region and United States - 1960 Census

Unit: Percent

Area	Number 1/	Elem. School			High School		College		
		None	1-7 yr	8 yr	1-3 yr	4 yr	1-3 yr	4 yr	Total
United States	10.6	2.3	19.9	17.5	19.2	24.6	8.8	7.7	100.0
Lower Colorado Region	10.2	4.1	16.4	14.4	19.2	25.7	11.4	8.8	100.0
Subregions:									
1. Lower Main Stem	11.2	3.1	13.0	13.2	22.0	29.3	12.0	7.4	100.0
2. Little Colorado	7.4	27.0	19.7	10.5	15.1	16.3	5.8	5.6	100.0
3. Gila	10.3	2.7	16.9	14.9	18.8	25.7	11.7	9.3	100.0

1/ A simple average of the median years completed for male and female.

Employment

In 1965, 675,700 people were employed in the Lower Colorado Region, which comprised 36 percent of the population (see Table 7). This percentage is a little below the estimated 38.0 percent national employment rate. The employment distribution by industry in 1965 was: agriculture 5.8 percent; mining, 2.6 percent; manufacturing, 14.6 percent; trade, 18.6 percent; services, 26.3 percent; transporation, 3.1 percent; contract construction, 8.3 percent; utilities, 3.0 percent; rentals, 4.7 percent; and other employment, including forestry, government, and miscellaneous, about 13 percent.

Of the states in the Lower Colorado Region, during the period from 1955 to 1965, Arizona ranked first nationally in the growth of manufacturing employment; while, in the growth of nonagricultural employment, Nevada ranked first, Arizona was second, and New Mexico was fourth.

The Little Colorado Subregion, with its predominantly Indian population, is unique in that only 27 percent of the population are employed. This low percentage is partially due to the relatively large proportion of the population that is under 18 years of age and to the lower level of education. The proportion of the population that is employed in the Gila Subregion is also below that of the Lower Main Stem Subregion.

Table 7
EMPLOYMENT AND THE PARTICIPATION RATE 1940-1965
Lower Colorado Region

Area	Employment 1/			Participation Rate 2/		
	1940	1950	1965	1940	1950	1965
Region	175.9	288.5	675.7	30.2	32.9	36.0
Lower Main Stem	24.7	46.5	134.8	32.3	38.0	39.0
Little Colorado	23.7	25.3	33.7	32.5	29.8	27.0
Gila	127.5	216.7	507.2	29.5	32.7	36.0

1/ Total employment, including the Armed Forces (1,000).
2/ Percent of population.

Income

The states of the Lower Colorado Region also ranked high nationally during the 1955 to 1965 period in the rate of growth of personal income.

Nevada ranked first, with a 139 percent gain; Arizona was third, with a 125 percent gain; and New Mexico was sixth, with a 94 percent gain.

As shown by Table 8, personal income per capita (wages, salaries, profits, and other income) in the Lower Colorado Region, in terms of 1958 dollars, increased from $1,117 in 1940 to $2,292 in 1965, about 90 percent of the national average.

The level of per capita income in the Little Colorado Subregion is only 45.7 percent of the regional average. This low per capita income appears to be due entirely to unemployment in the Subregion. Personal per capita income in both the Lower Main Stem Subregion and Gila Subregion is above that of the Lower Colorado Region average.

Table 8
PERSONAL INCOME PER CAPITA 1940-1965 1/
Lower Colorado Region

Area	Dollars			Per Capita Relative - United States = 1.00		
	1940	1950	1965	1940	1950	1965
Region	1,117	1,638	2,292	.859	.907	.901
Lower Main Stem	1,372	2,052	2,593	1.055	1.137	1.019
Little Colorado	796	985	1,049	.612	.546	.412
Gila	1,126	1,644	2,329	.866	.917	.915

1/ Source: Appendix IV, Economic Base and Projections.

WATER RESOURCES AND UTILIZATION

WATER RESOURCES AND UTILIZATION

Water Sources

There are three sources of water supply presently available for use in the Lower Colorado Region. These sources are: (1) a portion of Colorado River flows delivered at Lee Ferry, (2) local runoff originating within the Region's boundaries, and (3) local ground water.

The erratic flows of the uncontrolled Colorado River created many problems for the early irrigators. In 1905, the river deserted its course to the Gulf of California and created the Salton Sea. The river was finally returned to its course in 1907. These problems and others finally led to the Colorado River Compact of November 24, 1922, dividing the flow by Upper and Lower Basins, and the Boulder Canyon Project Act (December 21, 1928) which, among other things, authorized the construction of Hoover Dam and the All-American Canal. Hoover Dam storage began in 1935 and brought the first control to the Colorado River. Since then, various other surface-water control works have been built providing flood control, electrical power, and reregulation for benefit of downstream irrigators and Mexican Treaty commitments. Notable works include Imperial, Palo Verde, Headgate Rock, Davis, Parker, and Senator Wash Dams. Senator Wash Dam, an offstream storage reservoir, has provided additional regulation of flows arriving at Imperial Dam since January 31, 1966. Additional flood control is provided by Alamo Dam which was completed in 1968 on the Bill Williams River.

The average annual natural undepleted flow of the Colorado River as it enters the Lower Colorado Region is estimated at 15.09 million acre-feet for the 60-year period 1906-65. From here, the river gains an average of about 1 million acre-feet of water during its journey through the canyons to Hoover Dam. As the river continues tis course toward the Gulf of California, through the thirsty desert reaches, it loses more than the million acre-feet gained in the reaches above Lake Mead. Including the contribution of the Gila River near the Mexican border, the Colorado River's average annual undepleted flow at the International Boundary is about 15.94 million acre-feet.

The Colorado River of today is almost completely controlled by the Upper Colorado River Basin storage projects and Lake Mead, having a combined capacity of about 60 million acre-feet. The release of water from Glen Canyon Dam, 17 miles upstream from Lee Ferry, the Compact Point of measurement, is dependent on many variables. However, Article IIId of the Colorado River Compact provides that the river at Lee Ferry will not be depleted below an aggregate of 75 million acre-feet for any period of 10 consecutive years.

Flows originating in the Upper Colorado Regiln and released through Glen Canyon Dam constitute a major source of supply to the Lower Colorado Region. If Colorado River mainstem water is available at Lee Ferry in sufficient quantity to satisfy 7.5 million acre-feet of annual consumptive use in the three Lower Colorado River Basin States, Arizona, Nevada, and California are apportioned 2.8, 0.3, and 4.4 million acre-feet, respectively. In addition, the Mexican Treaty of 1944 provides for delivery of 1.5 million acre-feet of water annually to Mexico.

Local Water Resources

Approximately 100 million acre-feet of precipitation fall each year upon the Region. Of this, only 3 million acre-feet reach the streams or ground-water reservoirs for downstream use.

There is a wide variation in annual runoff within the Region. In the desert areas, where runoff is directly dependent on rainfall, the bulk of the flow, if any, occurs during the summer--July through September. Above the major surface-storage reservoirs, peak monthly runoff results from snowmelt and generally occurs during the March-June period.

The distribution by subregion of average annual runoff (undepleted flow) is estimated as follows:

	Millions of Acre-Feet
Subregion 1 (Lower Main Stem)	0.90
Subregion 2 (Little Colorado)	0.42
Subregion 3 (Gila)	1.80
Lower Colorado Region	3.12

Subregion 1, Lower Main Stem--The principal tributaries of the Colorado River, within the Lower Main Stem Subregion are the Virgin, Muddy, and Bill Williams Rivers, and Kanab, Bright Angel, and Havasu Creeks. The average annual undepleted water supply contributed to the Colorado River by these smaller tributaries is estimated as about 0.90 million acre-feet. Tributary development is not intensive and most of this water supply is consumed along the main stream. The water control features of the Colorado River have been previously discussed.

Subregion 2, Little Colorado--Under the natural environment, the Little Colorado River contributed an average of about 0.42 million acre-feet annually (1914-65) to the Colorado River. More than 30 percent of this supply is from springs near the mouth, known collectively as Blue Spring. The undepleted flow at the gaging station near Cameron,

below all water supply development, is estimated to average 0.29 million acre-feet. The principal tributaries of the Little Colorado River are Silver, Chevelon, and Clear Creeks and Canyon Diablo, all draining from the south and east. Principal tributaries from the north and west are Carrizo, Leroux, Dinnebito, and Moenkopi Washes and the Zuni and Puerco Rivers. Most of the development in the Little Colorado Subregion is at and above Winslow, Arizona. Major reservoirs include Lyman Reservoir near St. Johns; Daggs Reservoir on Silver Creek; and Lakeside, Lone Pine, and Fools Hollow Reservoirs on Show Low Creek. Transbasin diversions to the Salt River drainage area (Gila Subregion) are made from Lake Show Low and Blue Ridge Reservoirs. These diversions are used, by exchange, for mining purposes in the vicinity of Morenci, Arizona.

Subregion 3, Gila--The average annual runoff of the Gila River, under the natural environment, is estimated as 1.3 million acre-feet at the site of Painted Rock Dam. The average annual runoff in the upstream reaches of the river is about 1.8 million acre-feet. Channel losses through the desert reduce the flow considerably. Under present conditions, the normal riverflow is fully utilized before leaving the central Arizona area, thereby avoiding formerly large channel losses.

Almost 90 percent of the estimated local water supply originates from the Salt and Gila Rivers above Kelvin, Arizona. In addition to the Salt River, which produces over 60 percent of the water supply, the chief tributaries of the Gila River are the San Franisco, San Carlos, San Pedro, Santa Cruz, and Agua Fria Rivers. Eight major reservoirs having a combined usable storage capacity of 3.2 million acre-feet almost completely control the flows entering central Arizona. Six of these reservoirs are located on the Salt River or its major tributary, the Verde River. Perhaps the most notable is Roosevelt Lake with a storage capacity of about 1.4 million acre-feet. Completed in 1911, Roosevelt Dam was one of the first projects begun under the National Reclamation Act of 1902. The other Salt River reservoirs are Apache Lake, Canyon Lake, and Saguaro Lake; and on the Verde River are Horseshoe and Bartlett Reservoirs. San Carlos Reservoir, with a storage capacity of about 1.0 million acre-feet impounded by Coolidge Dam, was completed in 1928 and controls the available water supply originating in the upper reaches of the Gila River. Waddell Dam, on the Agua Fria River, was completed in 1927 and provides a reservoir with a storage capacity of about 0.16 million acre-feet. Notable flood control reservoirs in the Gila Subregion are Whitlow Ranch Reservoir on Queen Creek, and Painted Rock Dam at the Subregion outflow point on the Gila River. Painted Rock Reservoir provides protection to the intensively developed irrigated lands along the lower Gila River and the Colorado River below the mouth of the Gila River. Developments above the major reservoirs are limited to small diversion dams that divert surface flows and to ground-water development.

Ground Water

The history of water development in the Lower Colorado Region is one of meager surface-water supplies being supplemented by ground-water resources. As the ground-water development intensified, water levels declined. The exploitation of this resource brought with it a multitude of problems, some of which were economic and some physical. Land subsidence and degradation of water quality have occurred in some areas as a result of excessive pumpage from ground-water reservoirs. Historically, annual ground-water pumpage in the Lower Colorado Region has increased from less than 1 million acre-feet in the early 1930's to 3 million acre-feet following World War II, and to about 5 million acre-feet at the present time. Overdraft, the amount of water by which the net annual pumping draft exceeds the perennial yields of the ground-water basins, is presently estimated at about 2.5 million acre-feet, most of which occurs in central Arizona.

The areas of the greatest water demand, the desert lowlands of central Arizona and the Las Vegas Valley in Nevada, must rely substantially on ground-water resources. In these areas, ground-water levels are declining as much as 20 feet annually. The results of this continued mining of ground water have already been felt in some areas. In addition to land subsidence and poorer water quality, once productive lands are being retired as wells go dry or as pumping costs rise to the point of no economic gain. Until the introduction of another source of water or, in some cases, the economic means to better utilize the present sources, ground water overdraft remains as the only alternative to supply demands for water.

Water Utilization

The major utilization of water within the Lower Colorado Region is for agricultural, municipal, and industrial purposes. At the present time, about 94 percent of the total Lower Colorado Region water withdrawal is used for irrigated agriculture and 6 percent for municipal and industrial uses. Minor quantities of water are used for cooling in thermal power generation, mining, rural domestic needs, and for livestock. Other uses which are primarily nonconsuming are hydroelectric power, recreation, and fish and wildlife.

Although most of the 1.2 million acres of irrigated land has a near adequate water supply at the present time, its adequacy is dependent on mining of ground water. As the ground-water levels decline, pumping costs increase, quality deteriorates, and wells in the shallow aquifers go dry. In the areas above the major storage reservoirs, the water supply is generally dependent on streamflow and summer and late-season shortages frequently occur. The average annual withdrawal of water for irrigation is estimated as nearly 6 acre-feet per acre, of which crops consume about 3.3 acre-feet per acre. The remaining withdrawal

is either consumed by nonbeneficial uses associated with irrigation, returned to the streams, or is a recharge to ground water. There is essentially no outflow from the Region excepting some return flows occurring near the regional boundary in the vicinity of Yuma, Arizona. Total system spills in 1965 were estimated at 0.65 million acre-feet.

One of the major consuming uses of water in the Lower Colorado Region is water-surface evaporation. The high rate of evaporation produces an estimated annual lake evaporation loss of more than 1.4 million acre-feet. About 85 percent of this loss occurs from the major reservoirs on the Colorado River. These losses are a part of the price paid for the control and orderly use of water for onsite and downstream purposes.

Water Quality

Regionally, mineral water quality as expressed by total dissolved solids (TDS) concentrations, is generally poor in contrast to that in many other parts of the Nation. With few exceptions, most surface and ground-water supplies have mineral concentrations exeeding 500 milligrams per liter (mg/l), and many exceed 1,000 mg/l.

Surface Water

The Colorado River, the major surface water source, enters the Region having a mean TDS concentration of 588 mg/l at Lee Ferry, Arizona, and increases to 838 mg/l at Imperial Dam according to data for 1941-1966, modified to 1966 conditions of development. Sodium in this supply varies from about 28 percent at Lee Ferry to about 51 percent at Imperial Dam. Boron concentrations of 0.4 mg/l, the critical level for citrus crops, have been observed at Imperial Dam. Colorado River water has a total hardness, expressed as calcium carbonate, varying from about 332 mg/l at Lee Ferry to about 700 mg/l at Yuma, Arizona.

The second major surface-water source, the Gila River system, rises within the Region. In the mountainous reaches of this system, water quality is generally good, with TDS concentrations less than 500 mg/l. However, in the middle reaches below points of major diversions, water quality generally deteriorates to a range of 500 to 1,000 mg/l TDS concentration.

This pattern of increasing TDS in a downstream direction is largely due to the concentration of dissolved solids by the consumptive uses of water. This effect continues into the lower reaches of some streams, until successive uses have consumed the entire streamflow. This situation is observed on the Gila River, downstream from Phoenix, where highly saline flows, the source of which is municipal waste water and irrigation return flows, are diverted to leave a completely dry streambed between Gillespie Dam and Painted Rock Dam, a distance of 60 miles.

Fluoride concentrations in parts of the Little Colorado and Gila Rivers often reach 3 to 4 mg/l, levels far in excess of the recommended maximum limits of approximately 1 mg/l set forth for drinking water supplies in the Public Health Service Drinking Water Standards. The majority of the water is considered deficient in fluorides, from the standpoint of prevention of dental cavities.

Biological quality, characterized by nutrients, dissolved oxygen, and bacterial concentrations, is considered reasonably good, except for some local problems. The presence of nutrients from manmade sources has caused excessive algal growths in localized areas of Lake Mead. In isolated cases, bacterial concentrations have exceeded desirable levels.

Sediment concentrations in the Region range from very high to moderate. The areas of greatest sediment yield are located in northern Arizona and southwestern Utah where sediment concentrations as great as 700,000 ppm have been measured and 500,000 ppm observations are not unusual. On Basin and Range Lowlands, the yields are moderate, with concentrations in adjacent streams averaging about 20,000 ppm. The annual average sediment yield in most areas stays within moderate bounds due to the infrequent occurrence of heavy rainfall. The area between Imperial Dam and Laguna Dam serves as a depository for sediment removed from the Colorado River water by a major California user. More than 500,000 tons of sediment are removed annually in this area.

Ground Water

The mineral quality of ground water ranges from excellent for all purposes to unsuitable for most purposes. Ground water in the alluvial deposits of the Basin and Range province, for example, contains from less than 100 to more than 100,000 mg/l of TDS concentrations. Ground water from most of these basins, however, contains TDS concentrations of less than 1,000 mg/l. The dissolved solids content of water in the Colorado Plateau ranges from 90 to more than 60,000 mg/l. A wide area in the Colorado Plateau contains water having between 1,000 and 3,000 mg/l TDS. Ground water generally contains less than 1,000 mg/l of TDS, but several springs located yield highly saline water. Concentrations of dissolved solids vary not only areally, but also with depth. As a result, the concentrations of TDS for a given well may change abruptly with depths, as will the ionic makeup.

The ground water ranges from soft to very hard; from less than 60 mg/l to more than 180 mg/l of calcium carbonate ($CaCO_3$). The concentrations of minor constituents such as iron, magnesium, and silica vary considerably throughout the Region; but, except for fluoride and nitrate, the concentrations are not objectionable for most uses. Though concentrations of nitrate are generally small in water from drilled wells, water from dug wells in northern Arizona may contain more than 45 mg/l of nitrate, the maximum allowable limit recommended for drinking water supplies.

More than 4 mg/l of fluoride is common in ground waters of northern Arizona. Water from many wells in the Basin and Range province contains in excess of 2 mg/l of fluoride. Fluoride content in excess of the amount recommended by the U.S. Public Health Service Drinking Water Standards is found in waters in many areas of the Lower Colorado Region.

LAND RESOURCES AND USE

LAND RESOURCES AND USE

General

The Lower Colorado Region encompasses nearly 90 million acres of land area. In 1965, 1.8 million acres (2 percent) were classified as cropland, 57.6 million acres (64 percent) were rangeland, 29.9 million acres (33 percent) were forest and woodland, 0.5 million acres (0.6 percent) were urban and built-up, and a small acreage (76,000 acres) was classified as miscellaneous lands.

Numerous resources, uses, and activities exist on all classes of land. These are as varied as the climate, topography, vegetation, and pattern of land ownership and administration. Land management plans and programs are designed to attain maximum benefits from the land.

Percentage-wise, land ownership in 1965 was distributed approximately as follows: About 18 percent of the total land was in private ownership, 18 percent Indian Trust, 12 percent state and municipal, with 52 percent remaining in Federal ownership. Of the total federally owned land, 32 percent was administered by the Department of Agriculture, 59 percent by the Department of the Interior, and 9 percent by the Department of Defense. See Table 9 for detailed information on land ownership and administration for the Region.

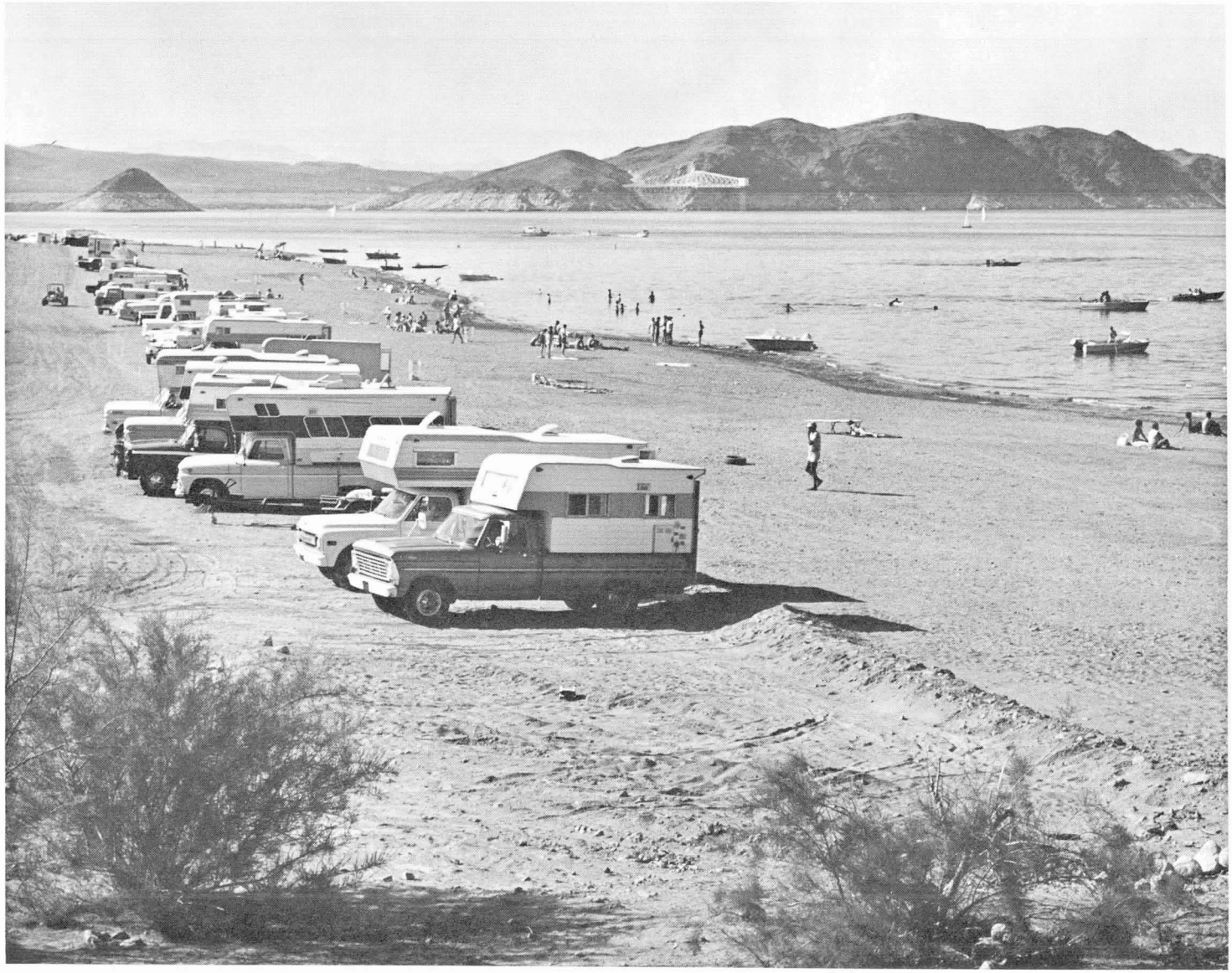
Recreation, Fish, and Wildlife

A wide variety of outdoor recreation opportunities is found within the Region. This Region is unique in that it has desert environment for enjoyment in the winter and cool mountains for summer use. These same mountainous areas provide excellent opportunities for the development of winter sports areas. Practically all lands in the Region have something of interest to the recreationist. Areas most valuable for recreation are generally those with some special attraction, such as rivers, streams, lakes or reservoirs; or areas of unusual archeological, historical, botanical, scenic, or geological values.

Wildernesses and primitive areas range from the desert beauty of the Superstition Mountains, to the primeval timber lands in the Gila Wilderness Area, to the alpine areas of the Mt. Baldy Primitive Area.

Recreation and tourism have grown into a multimillion dollar industry in the Region. The outdoor recreation opportunities provided by the forest, mountain, desert and water areas have been an important factor in this expanding industry.

The land and water areas in the Region provide homes for more than 750 species of resident and migratory wildlife, including some that are



Recreational activities at Special Events Beach, Lake Mead. USBR

Table 9
Land Ownership and Administration - 1965
Lower Colorado Region Summary

Unit: 1,000 Acres

Land Ownership and Administration	State of Arizona	State of Nevada	State of Utah	State of New Mexico	Total
Federal Lands					
Department of Agriculture					
Forest Service	11,525	336	289	2,825	14,975
Department of the Interior					
Bureau of Land Management	11,943	8,123	1,115	1,506	22,687
Bureau of Sport Fisheries & Wildlife	772	932	0	0	1,704
National Park Service	2,344	441	139	0	2,924
Other (Bureau of Reclamation)	364	54	0	0	418
Department of Defense	3,544	526	0	13	4,083
Other	86	14	0	0	100
Subtotal Federal Lands	(30,578)	(10,426)	(1,543)	(4,344)	(46,891)
State-owned Lands	9,308	39	137	1,092	10,576
Other Public Lands	25	0	0	0	25
Subtotal Non-Federal Public Lands	(9,333)	(39)	(137)	(1,092)	(10,601)
Privately-owned Lands					
Individual or Corporate	13,037	473	554	2,020	16,084
Indian Trust Lands	15,319	5	0	1,088	16,412
Subtotal Private Lands	(28,356)	(478)	(554)	(3,108)	(32,496)
Total	68,267	10,943	2,234	8,544	89,988

Note: Only land areas, water areas are not included.

found no other place in the world. Big game species found in the Region include mule and white-tail deer, elk, antelope, black bear, javelina, and big horn sheep. Wild turkey is also considered as big game. Common species of small game and fur bearers include squirrel, beaver, muskrat, skunk, fox, and rabbit. Game birds providing hunting in the Region include Gamble's, Mearn's, and scaled quail; bandtail pigeons; mourning and white-winged dove; blue and sage grouse; chukar and pheasant.

Several species of predatory animals, nongame animals, and birds are hunted as varmints in the Region and, in this report, sport hunting for these species is considered as small game hunting. Included in this category are mountain lions, bobcats, coyotes, jack rabbits, prairie dogs, various types of ground squirrels, and ravens.

A number of species of waterfowl winter in the desert wetlands of the Region, and a small number nest in the mountainous marshlands during the summer months.

Many impoundments in the Region are not permanent pools, thus, are not classed as fish habitat. The fishing waters of the Region consist of about 2,500 miles (about 10,200 acres) of streams and about 240,000 acres of lakes that provide over 4 million man-days of fishing annually. There are about 2,000 acres of cold water streams and over 7,000 acres of cold water lakes. The 233,000 acres of lakes and reservoirs and 8,000 acres of streams in the warmer portions of the Region provide about 3 million man-days of warm water fishing annually. The use and enjoyment of these resources by hunters, sight-seers and fishermen have expanded in recent years and have widespread cultural, social, and economic significance.

Cultivated Lands

The Region's irrigated cropland area contains about 1.8 million acres. The availability of suitable irrigation water, in terms of both quantity and quality, has been the major determining factor in the location and amount of irrigated land. This is especially true in the desert area where the nearly year-long growing season makes this area ideal for irrigated crop production. With the exception of the desert areas, irrigated farming has developed primarily along major streams where soils are productive, have uniform slopes, and where suitable water is available.

Yields of many irrigated crops are high in comparison to other regions of the United States. The Region had the highest yields for barley, sorghum, and American-Egyptian cotton and ranked second in yield per acre for all cotton and alfalfa hay.

The Region is also important in the production of citrus and vegetables. For certain periods during the year, the Region and southern California produce most of the Nation's supply of such crops as lettuce, cauliflower, carrots, broccoli, onions, and melons.

There were 31,000 acres of nonirrigated cropland in the Region in 1965. This cropland is located on gently to moderately sloping lands at above 4,000 feet elevation and has annual precipitation averaging 16 inches or more. A general survey indicated that about 1.6 million acres of land are suitable for nonirrigated crop production in the Region.

Livestock Grazing

The range resource contributes substantially to livestock production, long one of the major industries, within the Region. In 1965, about 1.1 million animals utilized forage from about 76 million acres (about 67 percent from grass and shrub lands and about 33 percent from forest and woodlands). The area used for grazing in 1965 produced about 7.9 million animal unit months (AUMs) on forest land, and rangeland and about 0.6 million AUMs on cultivated land.

Two broad types of rangeland are used for grazing: ephemeral and perennial. The ephemeral rangeland (about 16 million acres) is in the desert below the elevation of 3,000 feet. The average annual precipitation is less than 8 inches; however, precipitation varies widely from year to year. Large volumes of annual grasses and forbs, which provide good livestock forage, are produced during above-normal spring and summer rains. Distribution of water for livestock is a major problem.

The perennial-type rangeland (about 35 million acres) provides a more dependable, perennial-type forage. More precipitation at higher elevations increases forage quantity and quality in these areas above 3,000 feet elevation. The highest producing rangeland, on a per acre basis, is the grassland area in the southeast portion of the Region.

Forest land areas used for range-type grazing, consist of about 25 million acres. These types include chaparral, pinon-juniper, oak-woodland, and coniferous forests; they are generally in higher precipitation zones and provide a stable forage resource.

About 0.7 million acres of cropland and less than 40 thousand acres of irrigated pasture are grazed.

Timber Production

The commercial timberlands of the Region cover 5.5 million acres and are of economic importance. Of this amount, 69 percent is on national forest, 23 percent is on Indian reservations, 1 percent is owned by states and counties, 5 percent is owned by farmers and ranchers, and 2 percent is owned by timber companies and other private operators.

Commercial timberlands within the Region contain about 33 billion board feet of saw timber comprised of ponderosa pine 1/ (91 percent),

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1/ The Region contains the largest single block of ponderosa pine in the United States.

Douglas fir (4.5 percent), spruce-fir (2.5 percent), and other species (2 percent). In addition, there are about 7.5 billion cubic feet of growing stock suitable for paper pulp, poles, fuel, and other forest products.

In 1965, there were 475 million board feet of saw timber and 150,000 cords of pulp wood harvested from the commercial timberlands of the Lower Colorado Region. The allowable annual cut under sustained yield management is approximately 500 million board feet of saw timber and 450,000 cords of pulp wood.

The publicly owned, and most of the privately owned, commercial timberlands are managed under the principle of multiple use and produce a sustained yield of timber and other forest products and services. These timber producing lands are the highest water yielding lands of the Region. There are opportunities for increasing water quality and quantity from these lands. The commercial forest lands provide some of the better livestock ranges. They provide important habitat for wildlife and cold water fisheries. The commercial forest areas are popular for recreation, and their natural beauty has important scenic value. How these forest lands are managed and used will affect not only future timber yields but also the availability of all other wildland products and services.

Military and Related Uses

Lands within the Region that are used for military and related purposes consist of 3.6 million acres in Arizona, 0.5 million acres in Nevada, and 0.02 million acres in New Mexico. A small percentage of these lands is in areas suitable for urban expansion and/or surrounded by intensively used agricultural land. The majority of these lands is barren desert or semiarid mountainous terrain.

Urban and Industrial

Urban and industrial developments occupy approximately 513,000 acres of land in the Region. Individual developments range in size from Phoenix's 158,000 acres to small unincorporated towns of less than a square mile. In general, these lands are not compatible with other uses; with the exception of recreation use. The larger urban developments have recreation areas reserved within their boundaries.

Mineral Production

Although low grade mineral deposits occur over large areas, a very small percentage of the Region's lands were actually used for mineral production in 1965. While small in size (75,000 acres) these lands are intensively used. Their economic importance is great; their compatibility with other uses is small; and they are, almost entirely, in private

ownership. The value of minerals produced is discussed in the "Mineral Resources" chapter of this appendix.

Transportation and Utilities

Demands for additional land for transportation and utilities have kept pace with the rapid regional growth. In 1965, approximately 660,000 acres of land were used for transporation and utilities. Land used for roads, railroads, and airports is generally excluded from other land uses, but telephone, canal, electric power, and pipeline rights-of-way often modify existing uses and may produce benefits not previously present. Detrimental effects may be produced in some areas.

MINERAL RESOURCES

MINERAL RESOURCES

Commercial production of minerals in the Region since World War II has included 42 different mineral commodities. As elsewhere in the West, gold and silver were the early attractions and are still produced, but one metal--copper--now dominates the mining industry.

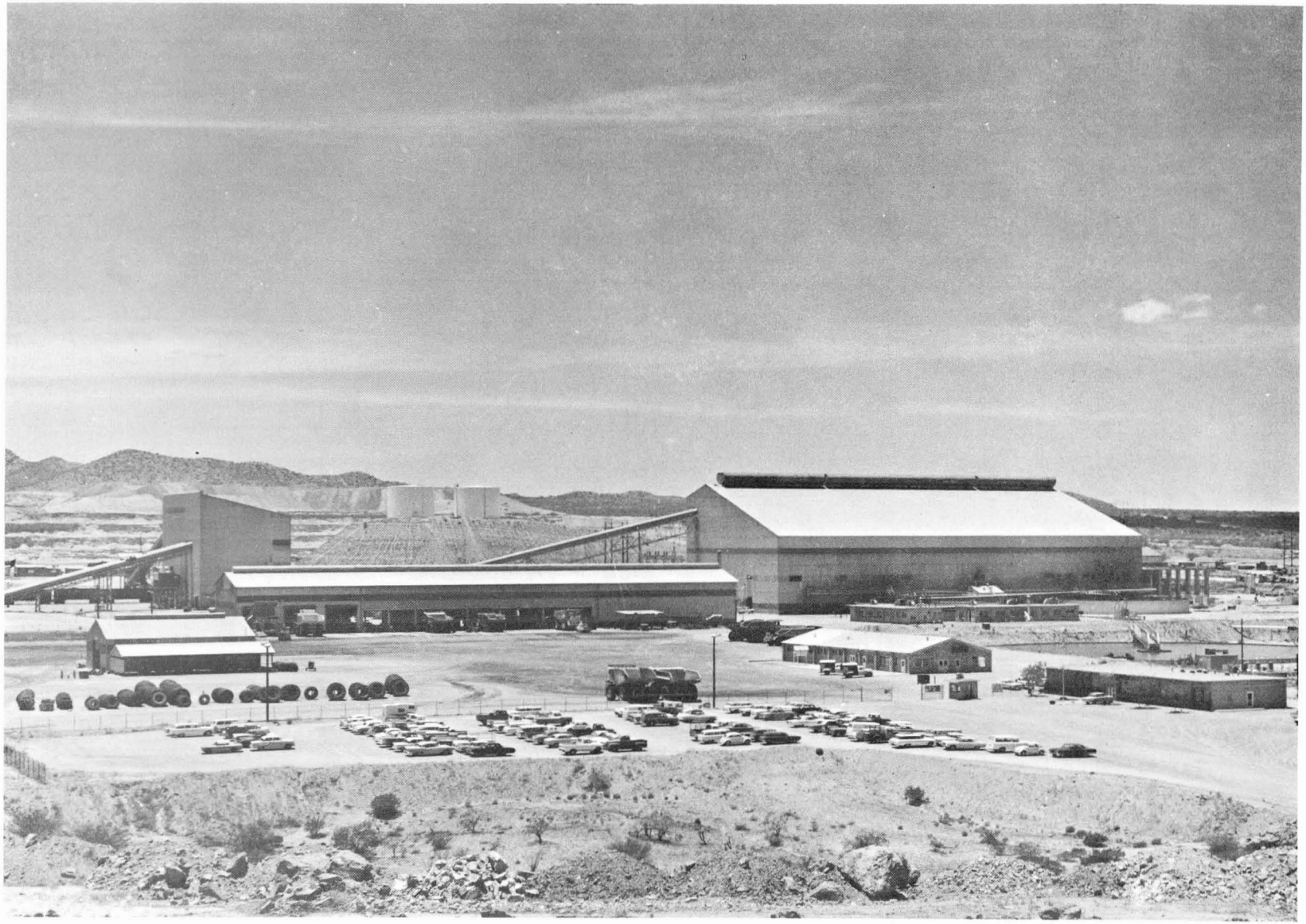
The mineral resources that occur in sufficient volume or value that exploitation is or could become feasible are: Mineral Fuels: uranium, coal, crude oil, natural gas, and helium; Metallic Minerals: copper, molybdenum, gold, silver, lead zinc, iron, manganese, and vanadium; and Nonmetallic Minerals: bentonite, borates, halite, gypsum, potash, sand and gravel, stone and pumice.

Table 10 shows the value of the major mineral commodities produced in the Region in 1965 and their relationship to the total national output for the individual commodity.

Table 10
Important Mineral Commodities Produced and Relation to
Total National Output - 1965
Lower Colorado Region

Commodity	Value of Production ($1,000,000)	Percent of Total U.S. Production
Uranium Ore	34.3	40.9
Copper	567.8	59.3
Gold	5.4	9.1
Molybdenum	17.3	14.3
Silver	8.5	16.5
Zinc	17.5	9.8
Pumice	1.5	22.8
Sand and Gravel	22.6	2.4

The Lower Colorado Economic Region leads the Nation in producing copper and uranium. Furthermore, the Region is second only to the



Copper Production - Mission Unit of American Smelting and Refining Company, Pima County, Arizona. BM

Upper Colorado Region in molybdenum output, second to the Columbia North Pacific Region in silver output, and third to the Missouri and Great Basin Regions in gold production.

Cement, sand, and gravel production is closely related to the extraordinary growth and development of the Region, particularly in its urban centers. A multitude of other construction minerals--lime, gypsum, stone, pumice, perlite, diatomite, etc.--together with a number of commodities produced in small quantities, such as mercury, mica, salt, and asbestos, all contribute to the mineral commodity mix of the Region.

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