TEXAS BOARD OF WATER ENGINEERS

A PLAN FOR MEETING THE 1980 WATER REQUIREMENTS OF TEXAS

Prepared under the direction of
John J. Vandertulip, Chief Engineer

For Submittal to the
Fifty-Seventh Legislature

May 1961

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May 31, 1961

Honorable Price Daniel
Governor of Texas
Austin, Texas

Honorable Ben Ramsey
Lieutenant Governor of Texas
Austin, Texas

Honorable James A. Turman
Speaker, House of Representatives
Austin, Texas

Gentlemen:

Transmitted herewith is a report entitled "A Plan for Meeting the 1980 Water Requirements of Texas."

Water is fundamental to sustaining our people and our economy. Additional development of our water resources will be essential to provide for a rapidly expanding population and an accompanying expansion of industrial capacity.

The plan presented herein provides a guide for orderly and economic development of the water resources of the State to meet the needs that can be estimated at this time with reasonable accuracy, and the projects suggested will be basic components of any plans devised to meet the water needs beyond 1980. The plan is not intended as a directive which would in any way limit any entity from considering or obtaining a supply from an alternate source.

This report reveals that through proper development, Texas has adequate water to meet its municipal and industrial needs in 1980 and sustain agriculture and other uses. Studies made during the preparation of this report indicate that continuous planning and increasingly comprehensive studies will be essential to bring about the development of the State's water resources necessary to meet its needs beyond the year 1980. Needs beyond 1980 can be met by proper and continuous planning for orderly development.

Respectfully submitted,

TEXAS BOARD OF WATER ENGINEERS

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TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (Cont'd)

ILLUSTRATIONS

Figures

Plates

ACKNOWLEDGEMENT

Valuable assistance and data used in this investigation were contributed by river authorities and conservation districts, by agencies of the Federal Government, by cities, water districts, and individuals. This plan could not have been prepared at this early date without the cooperation and planning work performed by the river authorities and conservation districts. All cooperation and assistance is gratefully acknowledged.

Special mention is made of the helpful cooperation of the following:

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Austin, Texas

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Fort Worth, Texas

City of Alice
Alice, Texas

Brazos River Authority
Waco, Texas

Central Colorado River Authority
Coleman, Texas

Colorado River Municipal Water District
Big Spring, Texas

Guadalupe-Blanco River Authority
Seguin, Texas

Jackson County Flood Control District
Edna, Texas

Lower Colorado River Authority
Austin, Texas

Lower Neches Valley Authority
Beaumont, Texas

Neches River Conservation District
Alto, Texas

Nueces River Conservation and Reclamation District
Corpus Christi, Texas

Refugio County Water Control and Improvement District No. 2
Refugio, Texas

Sabine River Authority
Orange, Texas

San Antonio River Authority
San Antonio, Texas

San Jacinto River Authority
Conroe, Texas

State Soil Conservation Board
Temple, Texas

Trinity River Authority
Fort Worth, Texas

Upper Colorado River Authority
Bronte, Texas

Upper Neches River Municipal Water Authority
Palestine, Texas

The United States Study Commission—Texas

Bureau of Reclamation, Department of the Interior

Corps of Engineers, Department of the Army

Federal Power Commission

Soil Conservation Service, Department of Agriculture

Geological Survey, Department of the Interior

Public Health Service, Department of Health, Education, and Welfare

SYNOPSIS

Texas, a state blessed with many natural resources over its vast area, has a variety of water problems. Inadequate facilities to meet increasing municipal and industrial water needs heads the list of these problems. Other important problems include (1) an unequal distribution by nature of water resources across the State, (2) floods and flood control, (3) the poor chemical quality of some surface and underground supplies, (4) determination of future agricultural needs for surface water, with respect to both location and amount, (5) sediment, and (6) the depletion of underground supplies in some areas. Details of many of these problems have been described in prior planning reports and are not repeated herein.

This report contains the following:

1. A description of the historical and present uses of both surface and ground waters by municipalities, industries, and irrigation.

2. A summary of the development of reservoirs constructed in Texas to conserve water and regulate floods, and of the increased use of underground water.

3. Estimates of the 1980 municipal and industrial water requirements of each area of the State.

4. A plan by which the 1980 municipal and industrial water needs could be served while providing for a continuation of all other existing rights and uses.

5. A summary of a program of additional coordinated studies to amplify portions of the plan.

This study demonstrates that Texas has water resources to meet the State's municipal and industrial needs of 1980. Properly developed new reservoir projects and an increased use of ground water can provide for the projected needs. With the developments contemplated for 1980 Texas will have water remaining in some areas for further additional development.

The plan contemplates the use of both surface and underground water to meet a projected 1980 annual demand totalling 6,547,500 acre-feet for municipalities and industries, while continuing to provide a water supply to other existing surface-water uses. This projected demand can be supplied utilizing a total of 1,300,400 acre-feet of ground water and a total of 5,247,100 acre-feet of surface water. Existing water rights have been recognized in the development of this plan.

At the present time, 14 major reservoirs are under construction in Texas. Portions of the yield of these 14 reservoirs will be put to use as soon as the reservoirs are operational, and the yield of 7 of these reservoirs will be utilized completely before 1980. Only small amounts of remaining yield will be available from the other 7 projects in 1980.

To meet the projected 1980 water requirements, this report envisions the need for 45 additional major reservoirs, plus enlargement of two existing reservoirs. Development of these 45 reservoir projects appears to be within the financial capability of the State and local interests, with Federal participation in projects containing flood control. These reservoirs will comprise both single and multipurpose projects.

Presently, 79 percent of the communities and municipalities in Texas obtain their water supplies from underground sources. This plan reflects continued use and some expanded development of ground water for municipal purposes. A state-wide program of reconnaissance ground-water investigations is in progress, together with detailed studies in some areas. Results of these studies may point out the potential availability of much larger ground-water supplies, or contrariwise, somewhat more limited ground-water supplies than shown herein.

CHAPTER I

THE STATE WATER PICTURE

INTRODUCTION

Nature within the past decade has inscribed upon the wide-spreading Texas landscape grim warnings of greater disasters to come if development of the State's water resources is neglected.

Texans have seen drought alternate with flood in a disheartening pattern of extremes. In many cases the same areas suffering from acute water shortages are later ravaged by floods, and the water so urgently needed for the economy of the State wastes to the Gulf, leaving grief and destruction in its wake. For much of the State, the period from 1950 to 1960 was either too dry or too wet, and below-normal spring and early summer rainfall in 1961 threatened a recurrence of the cycle.

The legendary vagaries of Texas weather, more amusing in folklore than actual experience, discourage any hope of relief through improvement in its natural behavior. If Texans cannot change the weather, they can at least, through sound, farsighted planning, conserve and develop water resources to supply their needs. That is the subject to which this report is addressed.

Despite the natural warnings so lately given, the most serious aspect of the State's water problem is the lack of continuing public awareness of its existence. It has been demonstrated that the people of Texas have not yet been aroused to the dire consequences of inaction or to the consequences of building projects which at best provide for only small increases in water needs.

In relation to long-term future needs in many areas, water is the least abundant of Texas' important natural resources; certainly it is the most indispensable. Only within recent years has Texas ceased to regard its water supply, like air, as something to be had merely for the taking.

Most of the water projects developed so far in Texas have been planned from a local viewpoint, to satisfy the then present and immediate local demands—and usually under financial limitations. A few noteworthy accomplishments have been achieved by local enterprise and private and public agencies; but unfortunately these do not embrace entire watersheds to allow full coordination of water supply and water demands. Despite the water-development projects completed in the past, Texas' water problems continue to grow in magnitude and complexity. The population of Texas has continued to increase at a phenomenal rate, with a corresponding acceleration in the construction of highways, schools, hospitals, and other public works. However, to supply its necessary water, Texas is relying for the most part on facilities which were designed to meet future needs as anticipated 15 to 20 years ago, and these were often underestimated. It is becoming increasingly apparent that orderless and unintegrated treatment of water problems, however natural and excusable it may have been under conditions of the past, should no longer be tolerated. An inventory of all water requirements in each basin and their interrelated aspects has been needed, so that the needs of entire basins may be satisfied as nearly as possible and surplus waters made available for areas of deficiency with the least expense—and without forestalling future developments. Such is the purpose of this statewide water plan.

The plan presented herein utilizes existing facilities as a foundation and provides for the orderly development of each river basin. The cost of additional conservation storage facilities proposed in the plan to satisfy the projected 1980 water demands is within the financial capabilities of the State, political subdivisions thereof, and local interests. Some of the multipurpose projects will require the financial participation of Federal agencies. This plan is not unyielding, for no fixed plan is possible, even to the year of 1980. To project area growth and amounts of water required beyond 1980 involves a multiplicity of uncertainties, especially in view of the pronounced effect that may result from increases and changes in population, land uses, and industrial locations.

It was the drought beginning in 1950 and extending through 1956 that awoke Texans to the real seriousness of the problem. By far, the majority of the people of the State, including industry and other water users, realistically felt the impact of a deficient water supply. That experience clearly demonstrated the need for planned development of the State's water resources. In response to this need, and under the leadership of Governor Daniel, the Texas Legislature in 1957, by House Joint Resolution 3, provided for the State Constitution to be amended to permit the State government to participate financially in development of water-resources projects. Also, by the 1957 Planning Act, the Legislature created the Texas Water Resources Planning Division within the Board of Water Engineers, and assigned to this division certain basic responsibilities of water-resources planning on a state-wide basis.

The Planning Act embodied broad statements of the following generally recognized fundamentals of water-resources planning: (1) determination of available water resources, (2) the extent to which these resources have been developed, (3) the uses for which these resources have been utilized, (4) a projection of probable future needs, and (5) planning for development of water resources to serve those projected needs. The text of the 1957 Act is contained as Appendix A to this report.

Sec. 3a(8) of the 1957 Act directs this agency:

"To prepare and submit to the Legislature a state-wide water report of the water resources of the State with a correlation and relationship of those resources and to make recommendations to the Legislature for the maximum development of the water resources of the State, and to furnish the same to all members of the Legislature and elected officers of the State without cost."

A progress report entitled "Texas Water Resources Planning at the End of the Year 1958," was submitted to the 56th Legislature. That report, dated December 1958, treated in broad outline the five principles enumerated above, and furnished the Legislature such recommendations as were considered timely and appropriate for implementation of further planning.

Governor Daniel met with the Board of Water Engineers on several occasions and on May 23, 1960, conferred with the Board, their Chief Engineer, and Chief Planning Engineer, and discussed with them the urgent need for State leadership in coordinating water planning in Texas. Many State, local, and Federal agencies are working on different aspects of the varied and complex water problems. The urgent need for preparation by the State of a state-wide plan to meet municipal and industrial water requirements was quite evident. It was determined that such a plan should be prepared by having the State coordinate the efforts of the various local interests, and that such coordination of effort by the State should be continuous to assure a sound and orderly program of water-resources development to meet the accelerating need for water.

At a June 15, 1960, meeting in Austin called by Governor Daniel, and attended by the Board of Water Engineers, its staff, representatives of river authorities and conservation districts, and consulting engineers, the Governor made two requests:

(1) That the Board prepare a planning report which would contain the projected municipal and industrial water requirements of the State for the year 1980, and the projects needed to meet those requirements and also provide for existing uses, including irrigation.

(2) That the river authorities and conservation districts prepare and furnish to the Board plans for their individual basins where none had been prepared or, where necessary, revise plans which had previously been developed.

This report has been prepared in accordance with the provisions of the Texas Water Planning Act of 1957. The plan presented covers the entire State and is in answer to the request of the Governor.

The preparation of this report involves an analysis of the use of water in Texas. Of this many-sided matter, two facets are significant here:

First: The economic aspect. The economic value of water for cities, towns, and industries is much greater than the economic value for other uses. Also, the financial ability of municipalities and industries for the development of water-supply projects is greater than that of other users.

Second: The legal aspect. Texas statutes set out the following order of priorities in the allotment and appropriation of the State's surface waters, subject to certain conditions and the public welfare as determined by the Board of Water Engineers:

1. Domestic and Municipal
2. Industrial
3. Irrigation
4. Mining
5. Hydroelectric power
6. Navigation
7. Recreation

The statutes provide that permits granted shall effect or permit maximum potential basin development without waste.

Furthermore, the Legislature provided that, beginning with 1931, water appropriated for any uses below Number 1 in the above list could be taken for domestic or municipal purposes by State permit, except along the Rio Grande, without the necessity of condemnation or paying therefor and provided no existing facilities of the original user are utilized. The full text of a 1931 statute relating to some of these matters is contained as Appendix B hereto.

Because of the economic and legal considerations, it seems clear that in some of the more arid sections of the State, the use of surface water for any of the uses in the priority list, below the first two, is at a disadvantage in competing for water subject to State appropriation. What is said here, of course, does not preclude the development of additional surface waters for other uses.

By law, domestic and municipal uses are classed as superior and coequal. The major portion of domestic uses is supplied through municipal water systems, and the remainder (the more rural part) is supplied from small wells and from streams in inappreciable amounts. In developing the plan, these more rural domestic uses have been fitted into the projection of a water supply to meet the 1980 requirements.

The plan presented in this report for meeting the municipal and industrial water needs in 1980 is concerned primarily with the development of surface water. Although large amounts of ground water are available in many parts of Texas, any planning for the orderly development of these underground supplies is limited by the fact that ground water has not been subjected to State control. The only legislative authority provided for local governmental regulation of beneficial use of ground water in Texas is that concerning the creation of underground water conservation districts (Article 7880-3c). Also, data is not available on ground-water resources of large areas of the State. However, state-wide reconnaissance studies are now underway by the Board of Water Engineers and the United States Geological Survey, in response to the 1957 Planning Act, to determine the amount and location of ground-water supplies; and all of these studies are to be completed by August 1963.

Detailed economic analysis are not contained in the report, but the projects suggested herein provide an economical means of meeting the water needs. Later and more detailed project planning in specific areas may indicate more economical solutions in individual instances. It has not been necessary to consider the questions of who shall design, construct, or operate the proposed facilities.

Water uses have increased greatly during the past 20 years. Projections of municipal and industrial water requirements for periods as long as 20 years into the future are subject to some variation during an era of major industrial expansion and rapid population changes. Projections of requirements beyond 20 years would be subject to even greater variation, and for this reason this report covers only the next two decades.

However, it should be clearly understood that the adoption of the 20-year period does not represent a short-sighted viewpoint of the Board with respect to the State's water problems. Full consideration has been given to long-range projections of water requirements, for 50 years or more, and the distribution of these requirements throughout the State. These long-range projections were considered in the formulation of this plan to the extent that all projects listed herein can be properly integrated in any long-range plan requiring the full development of the State's water resources. To go beyond these 20-year projections with state-wide project planning would not be prudent due to the speculative nature, both as to quantity and location, of projections of water needs that look forward 50 years or more. Water-resources planning must be a continuous process to be effective. Carefully developed plans must be periodically revised and extended in view of changes in water uses and future needs.

ORGANIZATION OF REPORT

This report is divided into three chapters. Chapter I is introductory and presents background material against which the balance of the report may be viewed. Also contained are various explanations as well as material relating to the State as a whole.

Chapter II is the main body of the report and contains a presentation of the following three subjects:

1. The present uses of water.
2. The requirements for water under what is expected to be the municipal and industrial conditions of 1980, but with weather conditions as they were during the recent great drought.
3. How such 1980 water requirements may

be met.

Chapter III outlines and briefly describes future studies which are necessary to complete some phases of planning, but which could not be completed for inclusion in this report.

Plate 24, the folded sheet following Appendix C, is a map of the state of Texas showing basins, coastal areas, and major reservoirs—a handy reference while the report is being read. Plate 25, the folded sheet following Plate 24, is a map of the State which will provide a helpful reference while reading portions of the report relating to ground water and locations of principal ground-water aquifers.

SOME PERTINENT CHARACTERISTICS OF TEXAS WATER RESOURCES

The terms "surface water" or "streamflow" as used herein mean the natural flow and underflow as well as the flood flow of streams, while the term "ground water" means all water from subsurface sources exclusive of river-channel underflow.

In Texas, streamflow is mostly subject to the vagaries of nature's rainfall. Plenitudes and droughts, each lasting anywhere from one or two years to ten or more years, are matters of general recent experience. Figure 1 at A shows, for a typical river basin, how greatly the volume of stream runoff differs during plenitudes and droughts, and how these periods each compare with the long-time average volume of runoff.

Precipitation is likewise the source of most ground water in Texas. However, plenitudes and droughts are not so immediately effective in increasing or decreasing the volume of ground water as they are the volume of streamflow. This time-lag effect is illustrated by the records of one of the large springs of Texas as depicted in Figure 1 at B.

It is also generally known that annual precipitation differs greatly across the State, being much heavier in the eastern than in the western sections. Figure 2 at A illustrates this variation. The large red numbers at the bottom of this graph show the approximate percentage of precipitation that becomes streamflow in each section of the State. The red numbers include the historic ground-water accretions to the streams.

Often, considerable distance separates the place where large quantities of water are needed for use and the place where the water is readily available in streams or reservoirs. Three aspects of this problem may be mentioned. The first is illustrated by Figure 2 at B, particularly the red line which shows the average depth of runoff occurring in selected sections of the State. It is shown that the greatest amount of water is in the eastern part of the State and along the upper coast and that the most meagerly supplied areas are in the west. The second is illustrated by Figure 3, which shows for three typical river basins, how different the relationship is between the following elements:

1. Long-time average annual volume of runoff.
2. Area of the drainage basin.
3. The 1960 population in the basin.

The third aspect may be illustrated by pointing out that the city of Dallas in the Trinity River Basin is now building a 40-mile pipeline and related facilities for bringing 112,000 acre-feet of water per year from Tawakoni Reservoir in the Sabine River Basin to serve municipal and industrial needs in Dallas. A further illustration is a 275-mile pipeline planned for bringing a firm yield of 103,000 acre-feet of water per year for municipal and industrial uses from the Sanford Reservoir on the Canadian River to 11 towns in the High Plains. This pipeline is to extend southward across the upper ends of the Red and Brazos River Basins in Texas to the town of Lamesa, 15 miles inside the Colorado River Basin. Thus, development of an area can continue and expand notwithstanding the necessity of transporting water for municipal purposes from available sources. More experience is needed in order to make reliable predictions with respect to the distance that water can be moved and still be considered economical for industrial and agricultural uses.

In Texas, as in most other places, there are differences, sometimes small, but usually great, between the times and amounts of natural streamflow and the water requirements of municipalities, industries, irrigators, and other users of water. Such differences are caused by periods of plentitudes and periods of drought. The differences between unregulated flows and actual water requirements last anywhere from a few days to a month, or may extend over several years. These differences arise because of the vagaries of weather while the water requirements of cities or industries are more uniform and continuing. Irrigation requirements are larger during times of deficient rainfall and therefore greater irrigation demands are made on drought-diminished water supplies.

The marked variations in rainfall and runoff across Texas have long been recognized. In

FIGURE 1

A COMPARISION OF PERIODS OF PLENITUDE AND DROUGHT WITH AVERAGE FLOW OF A REPRESENTATIVE RIVER AND SPRING

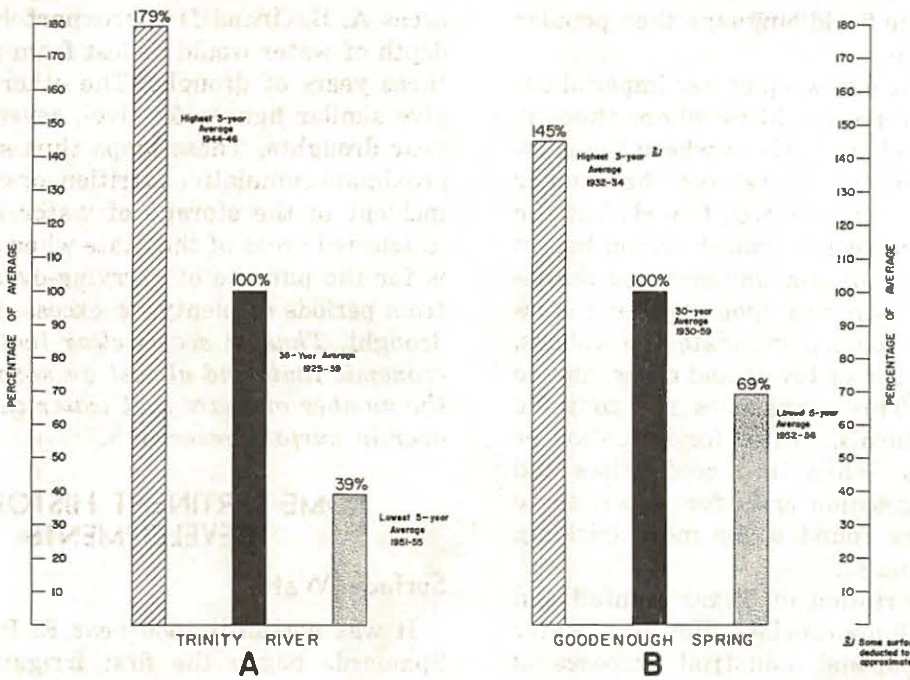
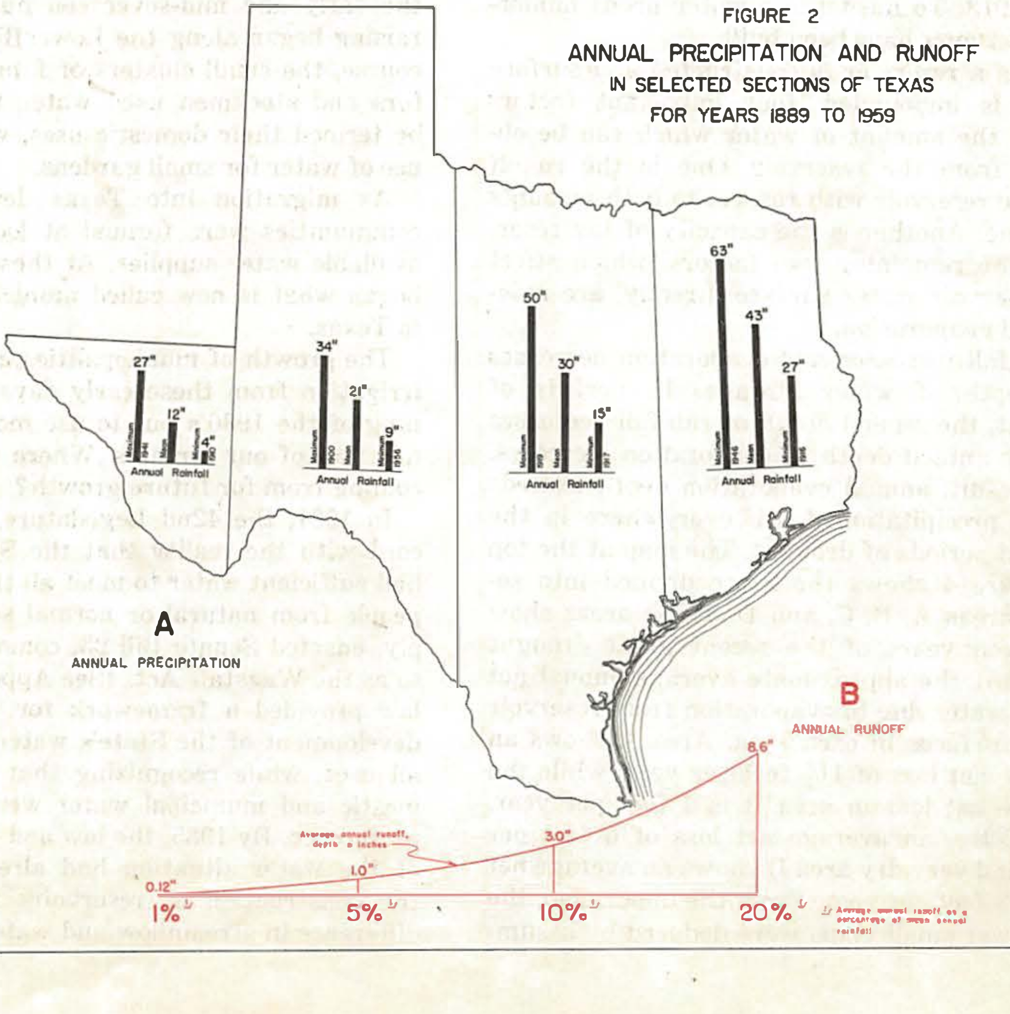


FIGURE 2

ANNUAL PRECIPITATION AND RUNOFF IN SELECTED SECTIONS OF TEXAS FOR YEARS 1889 TO 1959



1913, Representative D. W. Glasscock of Mission, one of the authors of the bill creating the Board of Water Engineers, expressed his recognition of these variations to the House of Representatives in the florid language then popular in legislative debate:

"In the magnificent sweep of her imperial domain Texas numbers localities where there is little or no rainfall, and others where the rainfall is so constant and excessive that rumor reports the inhabitants as web-footed; but the complaint common to her widest region lies in the alternation of super-abundance and scarcity. Her torrential streams upon recurring occasions burst their banks, inundate the valleys, threaten destruction of towns and cities, and do untold damage. This stage does not continue long enough to furnish water for irrigation or agricultural uses. When that need arises and the parching vegetation cries for water, these same streams are found to be mere trickling rills of fading promise."

This 1913 description of Texas rainfall and streamflow is still appropriate. However, water uses for municipal and industrial purposes as well as for agriculture have increased greatly since 1913. To meet these water needs numerous reservoirs have been built.

When a reservoir is constructed and surface runoff is impounded, four important factors govern the amount of water which can be obtained from the reservoir. One is the runoff into the reservoir with respect to both amounts and time. Another is the capacity of the reservoir. The remaining two factors, which affect the reservoir water surface directly, are *rainfall* and *evaporation.*

Rainfall increases and evaporation decreases the depth of water storage. In periods of drought, the annual depth of rainfall decreases and the annual depth of evaporation increases. As a result, annual evaporation depth exceeds annual precipitation depth everywhere in the State in periods of drought. The map at the top of Figure 4 shows the State divided into selected areas A, B, C, and D. These areas show for seven years of the recent great drought (1950-56) the approximate average annual net loss of water due to evaporation from reservoir water surfaces in each area. Area A shows an average net loss of 1½ feet per year, while the average net loss in area B is 4 feet per year. Area C has an average net loss of 6 feet per year; and very dry area D shows an average net loss of 8 feet per year. From the upper map, the four lower small maps were deduced by assuming that the same average drought conditions of precipitation and evaporation lasted respectively for three, five, seven, and nine years. The three-year small map shows for the selected areas A, B, C, and D approximately what total depth of water would be lost from reservoirs in three years of drought. The other small maps give similar figures for five-, seven-, and nine-year droughts. These maps thus show the approximate cumulative attrition, or cost in water, incident to the storage of water in reservoirs in selected areas of the State when such storage is for the purpose of carrying-over streamflow from periods of plenty, or excess, to periods of drought. *Thus, it seems clear that there is an economic limit and almost an absolute limit to the number of years that water can be carried over in surface reservoirs.*

SOME PERTINENT HISTORICAL DEVELOPMENTS

Surface Water

It was not until 1680 near El Paso that the Spaniards began the first irrigation by non-Indians in the area now included in Texas. In the early and mid-seventeen hundreds, stock-raising began along the Lower Rio Grande. Of course, the small clusters of families of irrigators and stockmen used water for what may be termed their domestic uses, which included use of water for small gardens.

As migration into Texas developed, small communities were formed at locations having available water supplies. At these communities began what is now called municipal water use in Texas.

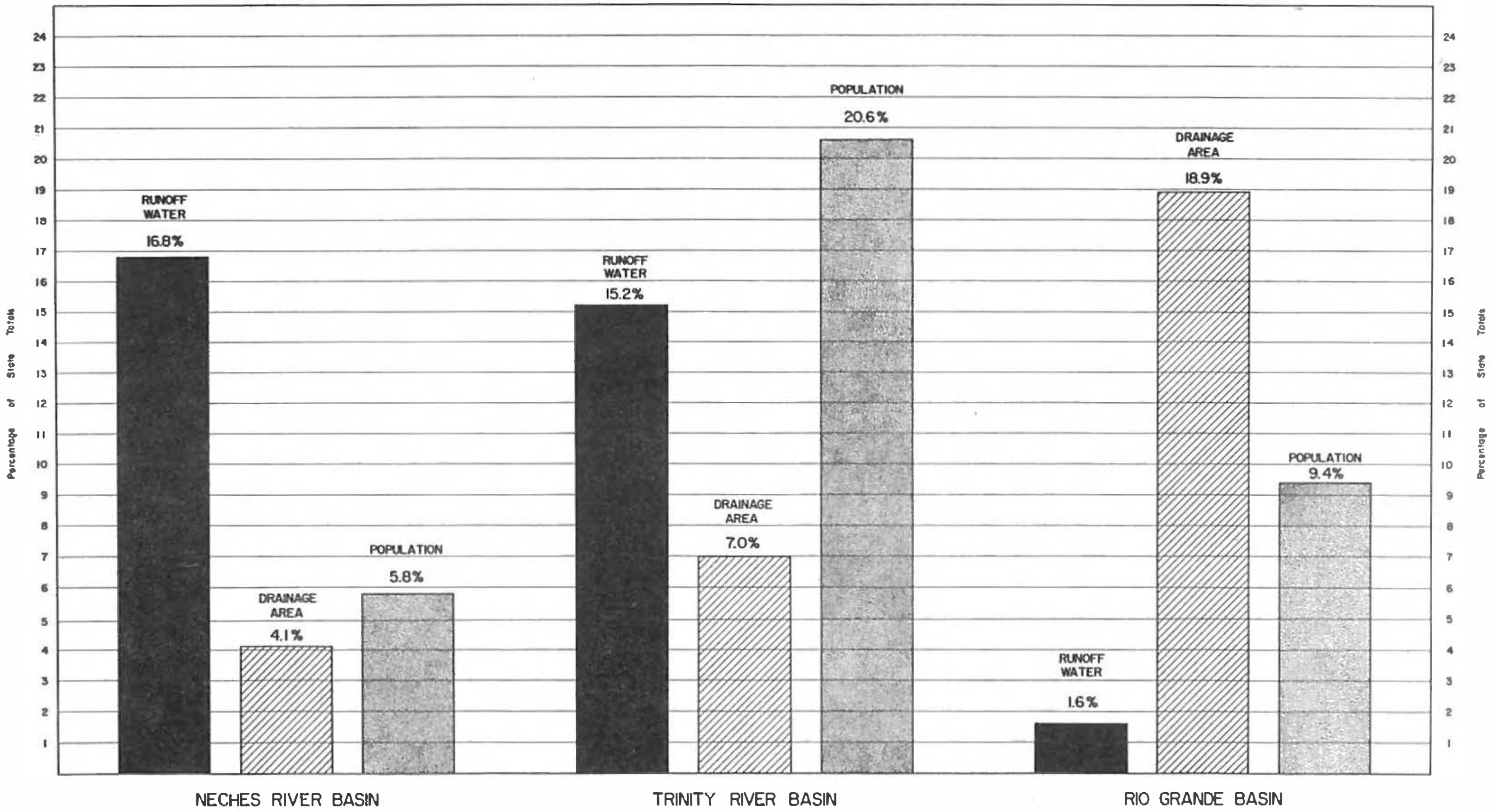
The growth of municipalities, industries, and irrigation from these early days to the beginning of the 1930's put to use most of the normal flow of our streams. Where was the water coming from for future growth?

In 1931, the 42nd Legislature, acting in accord with the reality that the State no longer had sufficient water to meet all the needs of its people from natural or normal sources of supply, enacted Senate Bill 93, commonly referred to as the Wagstaff Act. (See Appendix B.) This law provided a framework for the maximum development of the State's water resources for all uses, while recognizing that needs for domestic and municipal water were to be given preference. By 1935, the law and the necessities of the water situation had already prompted the construction of reservoirs to equate the difference in streamflow and water needs.

FIGURE 3

RUNOFF, DRAINAGE AREA AND POPULATION OF SELECTED RIVER BASINS IN TEXAS

as percentage of state total



In Texas, the Neches River basin has the most runoff water, the Trinity River basin has the most population and the Rio Grande basin has the most square miles of drainage area

At the beginning of 1935, Texas had 34 reservoirs with a combined conservation storage capacity of 1,830,000 acre-feet. By the end of 1941, the combined conservation storage capacity reached 4,900,000 acre-feet. At the end of 1946, when the recent great drought was just beginning over most of the State, conservation storage reached 5,950,000 acre-feet. In 1957, when the great drought had ended, the total conservation capacity was 10,600,000 acre-feet. By the end of 1960, this total reached 11,900,000 acre-feet. The above values include the United States' share of Falcon Reservoir and an assumed 50 percent of the Lake Texoma capacity. This combined conservation storage capacity may be divided into two general categories. The first includes those reservoirs in which the conservation capacity is primarily for consumptive uses by municipalities, industries, and irrigation. The second category includes those reservoirs whose purpose is generally considered non-consumptive, such as hydroelectric power, navigation, and recreation. The conservation capacity figures include unused sediment storage but do not include the storage below the bottom of the lowest outlet. Only those reservoirs with a capacity of 5,000 acre-feet or more have been considered in Figure 5, which is a graphical presentation of reservoir capacities described above.

While reservoirs constructed for conservation purposes afforded varying degrees of stream regulation, downstream developments of cities, industries, and farms in areas subject to flooding often required additional protection. In some instances, channel improvements and levees were constructed to provide such protection. For other areas, flood protection was provided by installing reservoirs with flood-control storage capacity specifically allocated therein. Many of these flood-control reservoirs also have storage capacities for conservation purposes. The flood-control storage in major reservoirs is depicted in red on Figure 5 for the period 1935 through 1960. The storage capacities thus depicted on Figure 5 do not include the capacity of flood-detention structures built by the United States Department of Agriculture. At the end of 1960, there were 457 such detention reservoirs in Texas with a combined flood capacity of 477,000 acre-feet. Also, 61 additional detention structures were under construction at that time. Although incidental flood regulation had been provided in one or more conservation reservoirs, only one small reservoir (Olmos Dam at San Antonio) had been constructed solely for flood regulation prior to 1940. During the 1940-50 period, Lake Travis, Lake Texoma, and Hords Creek, Barker, and Addicks Reservoirs were the only structures built with assigned storage capacities for flood-control functions. From 1951 through 1957, flood-control storage was provided in the following reservoirs: Whitney, Benbrook, Grapevine, San Angelo, Lavon, Falcon, Garza-Little Elm, Belton, Texarkana, and Lake O'the Pines. The total reservoir capacity for control of floods existing at the end of 1960 was 10,100,000 acre-feet. With the completion of the McGee Bend, Canyon, Waco, Navarro Mills, Proctor, and Twin Buttes Reservoirs, all now under construction, an additional 2,940,000 acre-feet of flood-control storage will be provided.

Ground Water

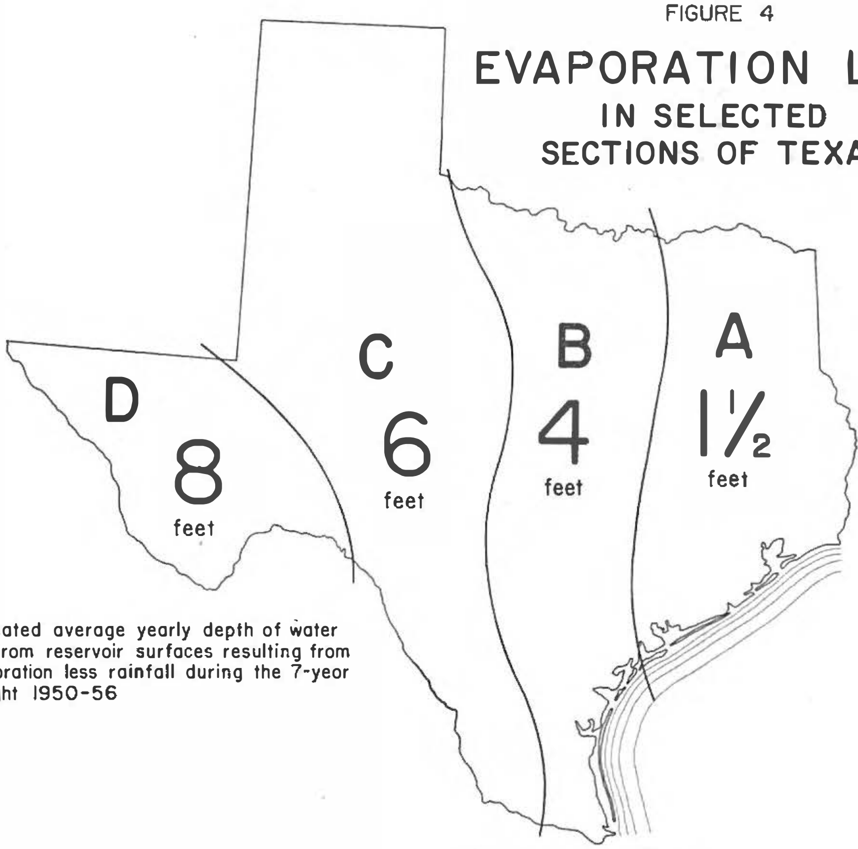
Ground Water has been used for domestic and stock-watering purposes since the time of the early settlers in Texas. Following the late 1800's, small centers of population sprang up away from streams and rivers which had supplied the first settlers with water. Shallow wells supplied domestic and stock uses, and limited agricultural needs. Not, however, until larger wells were developed and pumping equipment was improved did the significance of ground water become apparent as a factor in large scale municipal, industrial, and irrigation development. In 1930, only 41 percent of the State's population was in urban areas; whereas, in 1960, urban population was 75 percent of the total. New and expanding cities and industries, as well as large-scale development of irrigation, have increased uses of ground water in such representative areas as El Paso, the High Plains, the Winter Garden, San Antonio, and Houston.

In the El Paso area, the first well was drilled for municipal use in 1906. Average total pumpage of ground water in the El Paso area from 1936 through 1940 was about 19,000 acre-feet per year, and in 1959, pumpage had increased to about 87,000 acre-feet per year.

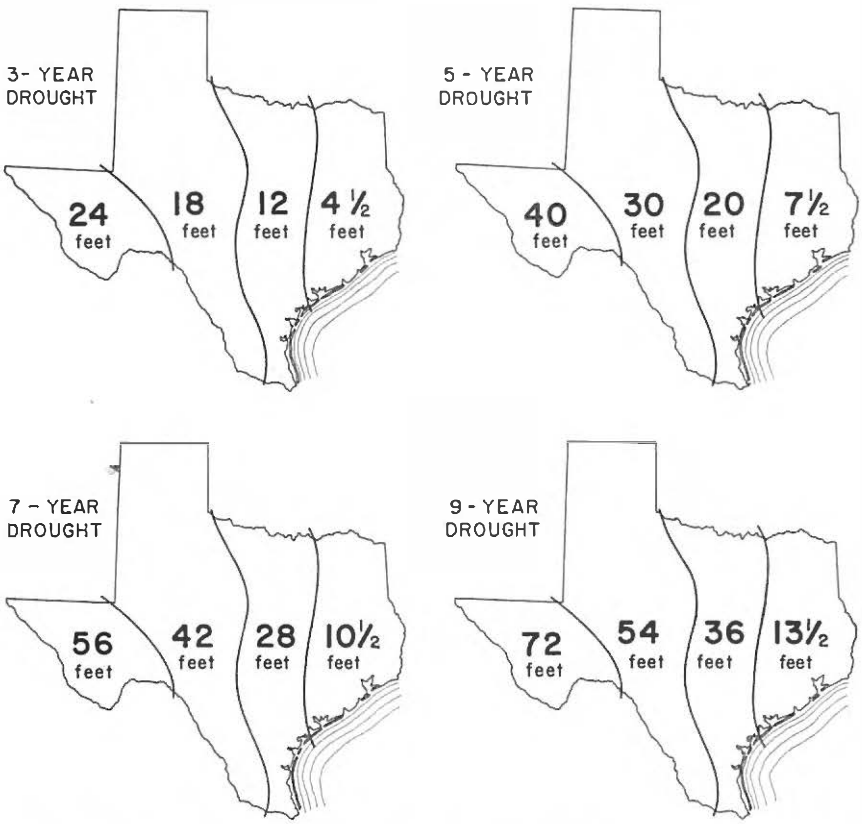
Irrigation with ground water began on the High Plains in 1911, but met with limited success until the early 1930's when a series of dry years, numerous economic considerations, and development of moderately priced pumping equipment made large-scale ground-water development feasible. Since 1935, when about 300 wells were in operation, irrigation with ground water in the High Plains area has increased steadily; and this pace was accelerated after

FIGURE 4

EVAPORATION LOSS
IN SELECTED SECTIONS OF TEXAS



Estimated average yearly depth of water lost from reservoir surfaces resulting from evaporation less rainfall during the 7-year drought 1950-56



Estimated depth of water lost from reservoir surfaces resulting from evaporation less rainfall during various lengths of drought.

1945 so that by January 1, 1949, there were approximately 10,500 irrigation wells in operation and 1,700,000 acres irrigated; and in 1959, there were about 47,000 wells supplying approximately 4,800,000 acres of irrigated land with about 6,600,000 acre-feet per year.

In the Winter Garden area, irrigation with ground water grew from 30 wells and 1,026 acres in 1905 to 403 wells and 27,000 acres irrigated in 1930, and then to 480 wells and 49,000 acres in 1949. Since 1949, there has been a leveling-out or small decrease in irrigated acreage in this area.

All municipal, industrial, and military water use in San Antonio is supplied by ground water. Most of this development is from the Edwards and associated limestones. The first irrigation well in this aquifer was completed in Bexar County about 1884. By 1907, there were 69 wells of which probably 25 supplied irrigation needs. Little further information is available on irrigation development in and around San Antonio until 1935, but from 1935 to 1956, irrigation development increased to 262 wells irrigating 30,000 acres in western Bexar, Medina, and Uvalde Counties. Total ground-water pumpage from the Edwards and associated limestones climbed from about 103,000 acre-feet per year in 1935 to about 234,000 acre-feet per year in 1959 in response to increased demands for water for all uses. About 111,000 acre-feet of this 1959 pumpage was for municipal and industrial use at San Antonio.

In 1906, the city of Houston purchased a water system which then included 45 flowing wells producing about 12,000 acre-feet per year. By 1935, pumpage for the city averaged about 27,000 acre-feet per year; and for the combined needs of municipalities, industry, and rice irrigation, ground-water use in the Houston area, most of Harris County and a small part of Waller and Fort Bend Counties, totaled about 70,000 acre-feet per year. By 1959, pumpage in this area had increased to about 319,000 acre-feet per year.

A large increase in the development and use of ground water in Texas occurred during the recent drought, as surface-water supplies were seriously depleted. Available data for the year 1957, following the record drought, show approximately 10,600,000 acre-feet of ground water pumped for municipal, industrial, and irrigation uses. Immediately following the drought, the annual rate of withdrawal of ground water in the State decreased somewhat, as more abundant rainfall increased the amount of water available from surface reservoirs and improved soil-moisture conditions in irrigated areas. However, the present annual rate of withdrawal is indicated to be near the 1957 level because of municipal, industrial, and irrigation growth that has occurred in recent years. Although the number of acres under irrigation has increased since 1957, improved farming practices and the occurrence of more precipitation which has been better distributed during the growing season for these years have generally decreased the amount of irrigation water used per acre.

Eight principal aquifers supply most of the ground water now used in Texas. Locations of these aquifers are shown on Plate 25. These, together with other locally important aquifers within each individual river basin, are discussed in Chapter II.

Irrigation

Figures on irrigation in Texas for the years 1939, 1949, and 1959 appear in Table I-A, with the figures for 1959 being the most reliable.

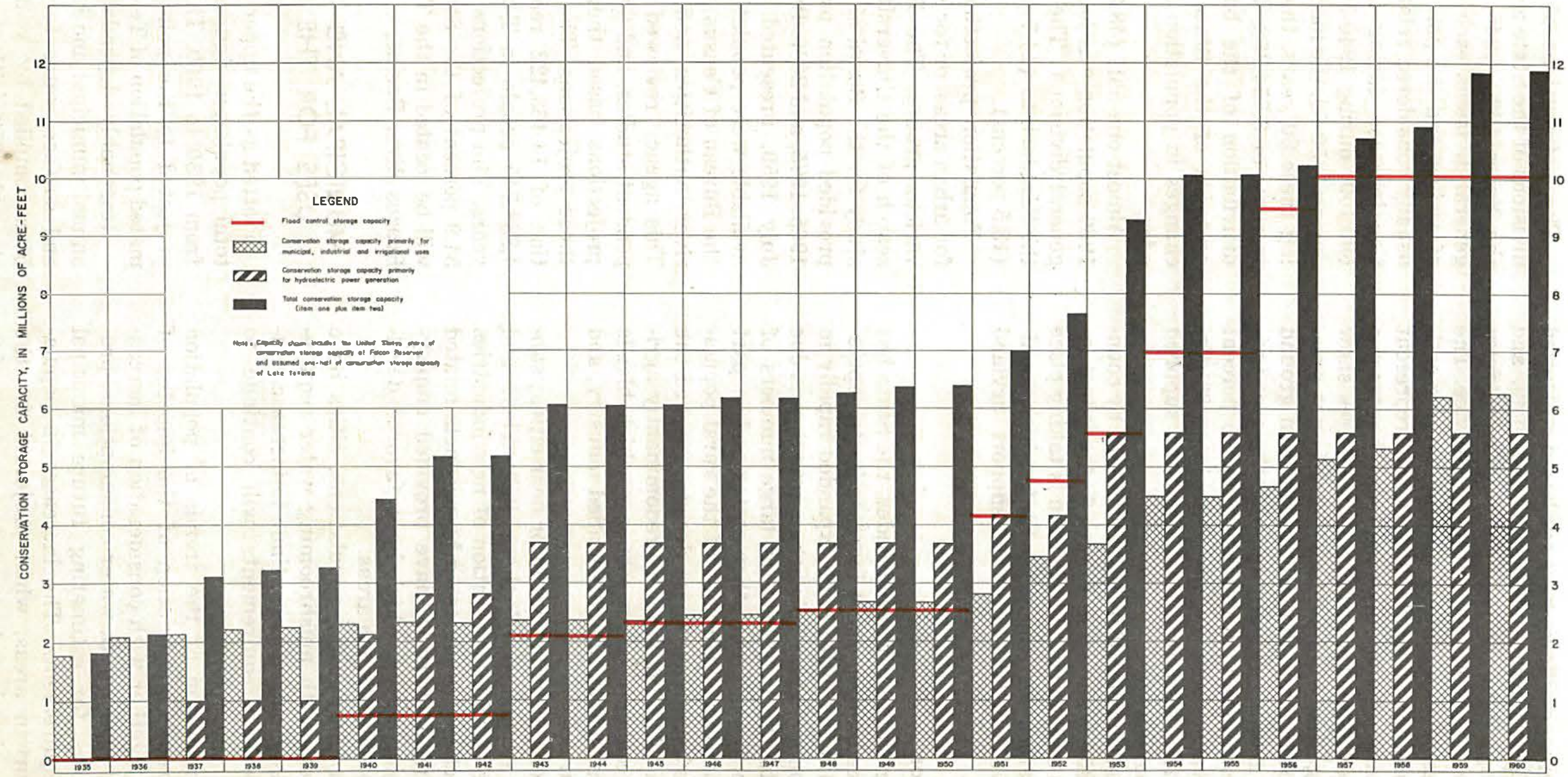
TABLE I-A. IRRIGATION IN TEXAS

Years	Area Farmed and Water Used					
	Surface Water		Ground Water		Total Irrigation	
	Acres	Acre-Feet	Acres	Acre-Feet	Acres	Acre-Feet
1939	778,200	2,389,100	267,000	427,200	1,045,200	2,816,200
1949	1,271,800	3,637,300	1,859,800	3,304,000	3,131,600	6,941,300
1959	1,225,700	3,373,300	5,914,800	9,350,200	7,140,500	12,723,500

FIGURE 5

FLOOD CONTROL STORAGE CAPACITY
AND
CONSERVATION STORAGE CAPACITY
OF
MAJOR RESERVOIRS
IN
TEXAS

By Years, Beginning 1935



The acreages shown here are based on United States Census figures for 1939 and 1949, and the acreage data for 1959 were obtained from the Texas Agricultural Extension Service. The quantities of water shown are engineering estimates based on all available data, and represent the amounts of water diverted from the streams or pumped from the ground. The figures show that irrigation from surface water is not presently growing, but that irrigation from ground water is growing rapidly. In 1939, the area irrigated from ground water was only 25 percent of the total acreage. Twenty years later, 83 percent of the total irrigated area was supplied from ground water.

The distribution of irrigated acreage by counties in 1959 is shown in Figure 6. A gradual increase in supplemental irrigation is taking place in the eastern portions of the State which usually receive rainfall ample to support dryland farming.

Population

During the past three decades, the State has experienced a 64 percent increase in its population, and many cities have expanded rapidly in population and area. This urban growth was due in part to the migration of large numbers of people to Texas from other states and in part to the shifting of portions of the rural population to urban areas. These decades marked the evolution of Texas from a predominantly agricultural economy to an economy which blends oil and gas production, diversified industry, and agriculture.

Locations of industries in or near cities; subsequent expansion of these industries; and often the location or creation of new industries with functions, products, or by-products related to existing industries, have provided employment opportunities which have favored development of large urban areas.

With rapidly rising populations, cities have had to cope with mushrooming water requirements. As populations continue to increase, municipal water requirements will continue to grow.

The projection of the trends of population and a proper appreciation of the impetus of growth, together with consideration of increases in daily per capita water consumptions, provide guides for estimating future municipal water requirements. The increases in population in urban areas, when projected for the next two decades, demonstrate an increasing need for water to meet municipal demands.

The distributions of historic populations by divisions of the State are shown in Table I-B for the Years 1930, 1940, 1950, and 1960. These general divisions each comprise the watershed of a river and the portions of the coastal plain usually considered related thereto. The population increase during the decade 1930-40 was 590,109; during 1940-50, it was 1,296,370; and during 1950-60, the increase was 1,868,483. During these 30 years, the State had a population increase of 3,754,962. Table I-B also shows the distribution of the basin population as percentages of the State total and the historic changes in population in each division by decades.

Almost one-half (48.5 percent) of the State's 1960 population was located within three of the general divisions: The Trinity (20.3 percent), the San Jacinto (14.7 percent), and the Brazos (13.5 percent).

Population projections for individual cities, for urban areas, or for zones have been made by various groups. The Bureau of Business Research of the University of Texas completed a study for the Board of Water Engineers which provided population projections for the years 1965, 1975, and 2000. Bulletin 5910, published in July 1959, presented these projections. Also available were population projections made by the Bureau of Census and some by the various river authorities and conservation districts. This agency reviewed these data, made independent studies, and developed 1980 population projections based thereon. Table I-B reflects these projections. The 1980 projected population of 14,463,422 represents an increase of 4,883,745 people in Texas during the next 20 years. The projections in Table I-B show that 51.9 percent of the State's population in 1980 will be located in the Trinity, San Jacinto, and Brazos River Basins.

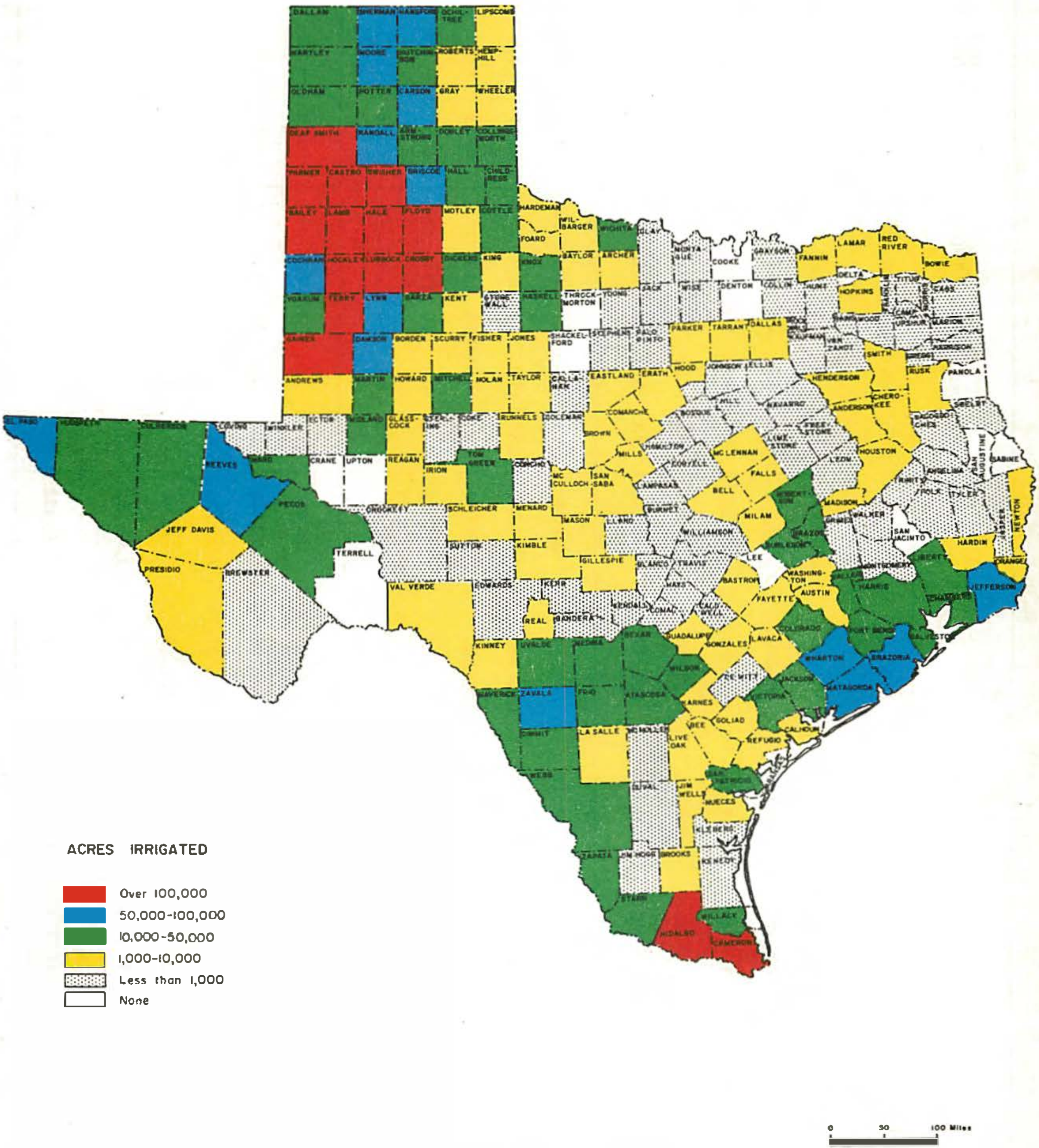
MUNICIPAL AND INDUSTRIAL WATER USES FOR THE PERIOD 1935-1959

Plotted as the upper line on Figure 7 are the total population figures for Texas by decades from 1930 to 1960. This plotted line has been projected to the point representing the estimated population of Texas in 1980.

Reasonably dependable figures showing the annual municipal and industrial uses of ground and surface water for the entire State have been compiled by years for the period 1935 through 1959, with the degree of dependability progressively improving during this 25-year

FIGURE 6

DISTRIBUTION OF IRRIGATED ACRES IN TEXAS BY COUNTIES 1959 [1]



[1] Data obtained from Texas Agricultural Extension Service Irrigation Survey 1959

TABLE I-B. POPULATIONS OF TEXAS

Divisions	Division Totals					Percent of State Total					Percent Increase or Decrease for Years Compared			
	1930	1940	1950	1960	1980	1930	1940	1950	1960	1980	1930-40	1940-50	1950-60	1960-80
Canadian	104,049	123,537	175,624	252,969	376,615	1.8	1.9	2.3	2.6	2.6	+18.7	+42.2	+44.0	+48.9
Red	459,257	390,375	401,315	405,849	505,320	7.9	6.1	5.2	4.2	3.5	—15.0	+ 2.8	+ 1.1	+24.5
Sulphur	141,776	153,342	141,515	120,807	124,217	2.4	2.4	1.8	1.3	0.9	+ 8.2	— 7.7	—14.6	+ 2.8
Cypress	106,995	119,312	100,254	89,378	90,011	1.8	1.9	1.3	0.9	0.6	+11.5	—16.0	—10.8	+ 0.7
Sabine	237,277	318,066	297,415	302,777	366,125	4.1	5.0	3.9	3.2	2.5	+34.0	— 6.5	+ 1.8	+20.9
Neches	414,270	473,068	513,717	568,545	745,477	7.1	7.4	6.7	6.0	5.2	+14.2	+ 8.6	+10.7	+31.1
Trinity	1,045,820	1,150,686	1,444,871	1,944,569	3,068,830	18.0	17.9	18.7	20.3	21.2	+10.0	+25.6	+34.6	+57.8
San Jacinto	472,268	640,517	935,769	1,403,559	2,686,000	8.1	10.0	12.1	14.7	18.6	+35.6	+46.1	+50.0	+91.4
Brazos	1,065,095	1,072,584	1,154,958	1,296,188	1,749,305	18.3	16.7	15.0	13.5	12.1	+ 0.7	+ 7.7	+12.2	+35.0
Colorado	503,489	516,650	630,115	780,009	1,201,607	8.6	8.1	8.2	8.1	8.3	+ 2.6	+22.0	+23.8	+54.1
Lavaca	77,736	69,619	68,885	70,718	108,030	1.3	1.1	0.9	0.7	0.7	—10.4	— 1.1	+ 2.7	+52.8
Guadalupe	169,971	153,500	157,671	191,702	254,563	2.9	2.4	2.0	2.0	1.8	— 9.7	+ 2.7	+21.6	+32.8
San Antonio ...	341,059	426,165	581,898	765,767	1,153,930	5.9	6.6	7.5	8.0	8.0	+25.0	+36.5	+31.6	+50.7
Nueces	247,812	310,721	412,293	495,208	701,060	4.3	4.8	5.4	5.2	4.8	+25.4	+32.7	+20.1	+41.6
Rio Grande	437,841	496,682	694,894	891,632	1,332,332	7.5	7.7	9.0	9.3	9.2	+13.4	+39.9	+28.3	+49.4
Totals	5,824,715	6,414,824	7,711,194	9,579,677	14,463,422						10.1%	20.2%	24.2%	51.0%

period. These data include total municipal and industrial uses, with some reported large industrial diversion adjusted to reflect actual depletions. The total ground and surface water used in 1959 for these two purposes, as shown in Tables "A" of Chapter II, was 1,904,700 acre-feet, of which 47 percent or 894,400 acre-feet was ground water and 53 percent or 1,010,300 acre-feet was surface water. On the lower part of Figure 7 these past yearly use figures are plotted as circles with a generalized curve drawn through them.

WATER USES DURING 1959

Municipal, industrial, and irrigation water uses during 1959 are summarized below to provide a comparison of the amounts of surface and ground water used for these purposes. Detailed information on these uses by river basins is presented in Tables "A" of Chapter II.

WATER USE DURING 1959 IN TEXAS — ACRE-FEET

Use	Ground Water	Surface Water	Total
Municipal	555,800	578,800	1,134,600
Industrial	338,600	431,500	770,100
Irrigation	9,350,200	3,373,300	12,723,500
Total	10,244,600	4,383,600	14,628,200

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS IN 1980

The curve of municipal and industrial uses on Figure 7 has been extended to the year 1980 where it passes through the value 6,547,500 acre-feet which represents the 1980 water requirements. This 1980 value was checked by two additional separate approaches:

1. Compiling the estimates of the river authorities and districts and their engineers as submitted to the Board and adding to these estimates, this Board's estimates for areas of the State not covered.

2. By extending curves of population and per capita rates of use.

This value of 6,547,500 acre-feet is the total of requirements listed in all 23 of the Tables "B" in Chapter II. The report contemplates 1,300,400 acre-feet, or 20 percent of the total State requirement, will be supplied from ground water and 5,247,100 acre-feet, or 80 percent, from surface water, as shown in Table I-C.

THE PLAN

The objectives of a water plan are to determine the location and amount of future water needs and to show how these needs may be supplied. With an area as large as Texas, the planning factor most difficult to evaluate accurately is the future water requirement for each watershed division of the State. Thus, any plan prepared must be flexible to allow for later modification by the addition of new reservoir units depending upon the rate at which water needs develop. Each new reservoir must be studied in relation to the existing facilities and rights and other proposed projects in the basin. Therefore, water planning must be a continuous function that relates new developments in a given area to present and future water projects for that region and the State.

Preparation of the plan included (1) a review of all available information, (2) the making of numerous independent analyses and check studies, and (3) the interpetation of a mass of statistical data. In accomplishing these tasks, certain facts and conclusions important to water planning in the State become evident. To aid the reader in gaining a better understanding of the plan, some of these facts and conclusions are set forth below.

1. State-wide and urban population has increased greatly during the past two decades, with a correspondingly large increase in water usage.

2. As vividly demonstrated during the 1950-1956 drought, the water needs in many communities may at times exceed the supplies available from existing facilities. Dams have been built since the drought, and others are under construction to meet our present and immediate future needs. However, in many instances these new reservoirs will not be adequate to supply needs 20 years from now.

3. Industrial development generally brings increases in urban population. The addition of industries has been of great economic significance to the State and has increased the amounts of water put to beneficial use. The State has an excellent potential for a great many additional industries.

4. Water requirements will continue to increase during coming years as the State's population continues to grow, as additional industries locate in Texas, and as present industries

TABLE I-C. SUMMARY OF 1980 REQUIREMENTS

For Municipal and Industrial Water in Texas and Reservoir Yields to meet these Requirements, also Capacities and Surface Areas of all Reservoirs in this Program

(These are the totals for the State as shown for each river basin or coastal area in Chapter II)

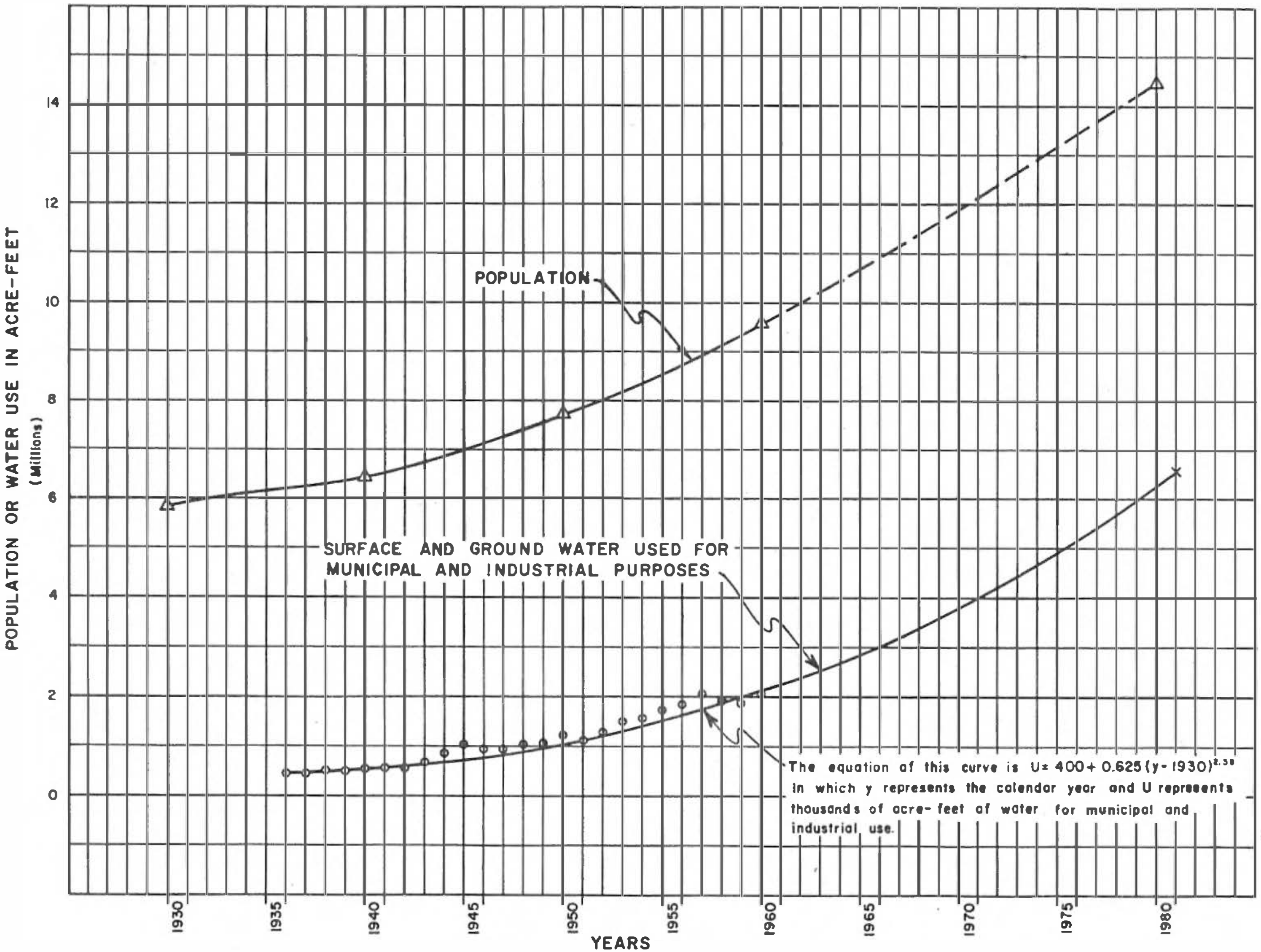
Totals From Tables in Chapter II	Item	Description	Percent	Acre-Feet
Tables "B"	1.	Total water required at the place of use to supply municipal and industrial uses in 1980	100	6,547,500
	2.	Ground-water portion of item 1	20	1,300,400
	3.	Surface-water portion of item 1	80	5,247,100
Tables "C"	4.	Total annual firm yield of all reservoirs in this program	100	9,417,500
	5.	Portion of item 4 needed at the reservoir or diversion point for municipal and industrial uses in 1980	57	5,340,400[1]
	6.	Portion of item 4 designated as yield remaining	43	4,077,100
Tables "C" and their Summaries	7.	Portion of item 6 remaining for municipal and industrial uses after 1980	31	1,263,900
	8.	Portion of item 6 for present or future uses other than municipal and industrial	69	2,813,200
Tables "D"	9.	Total Texas share of capacity of all reservoirs in this program	100	53,868,000
	10.	Portion of item 9 for conservation and sediment storage	67	36,322,000
	11.	Portion of item 9 for flood storage	33	17,546,000
	12.	Total surface area within Texas at top of conservation pools for all reservoirs in this program		1,505,700[2]

[1] This item includes 137,900 acre-feet of stream delivery losses and excludes 44,600 acre-feet of direct diversions and return flows. Thus adjusted, item 5 equals item 3.

[2] Expressed in acres.

FIGURE 7

CURVES SHOWING POPULATION AND MUNICIPAL AND INDUSTRIAL WATER USE FOR FIFTY YEARS IN TEXAS



expand existing facilities.

5. Unregulated streams do not have sufficient base flow to provide for these present and future needs, but existing, under-construction, and new reservoirs proposed herein can conserve flood flows and adequately provide water for all purposes.

6. Projections of future water requirements become increasingly speculative beyond a 20-year period in attempting to define locations and quantities of water needs.

7. Planning, to serve the future water requirements of the State, must provide for the development of water projects prior to the actual need for water, while maintaining the highest degree of flexibility to make the necessary adjustments for many future unknowns. Experience has shown that from 10 to 15 years elapse between the initial planning and the actual completion of construction of a reservoir project.

8. Development of large reservoir projects can often supply the needs of more than one community or area. Detailed planning and design of such projects by local and/or Federal agencies will require continued coordination at the State, local, and Federal levels of government. Such coordination will also be necessary for reservoir projects which may be planned and designed for purposes other than municipal and industrial water supplies.

9. Water supplies and reservoir sites are not often located at the point of use; therefore, consideration of alternate sources and of transporting water varying distances is required.

10. After building the projects to meet the 1980 water needs, additional water will be available to meet most needs further into the future.

To meet the projected 1980 municipal and industrial water requirements, the plan utilizes 73 existing reservoirs, 14 reservoirs now under construction, and includes 45 proposed new reservoirs and the enlargement of 2 existing reservoirs. These reservoirs have a total conservation capacity of 36,322,000 acre-feet plus 17,546,000 acre-feet of flood-control storage for a total of 53,868,000 acre-feet. The plan to meet future water requirements in each basin, while given in detail in Chapter II, is summarized below.

Canadian River Basin

While many cities in the Panhandle and High Plains will continue to obtain their supplies from ground water, the development of Sanford Reservoir on the Canadian River will supply part of the water needs of Amarillo, Borger, Pampa, Plainview, Levelland, Lubbock, Slaton, Brownfield, and Lamesa. The Sanford Reservoir, which will develop the full Texas allocation of conservation storage under the terms of the Canadian River Compact, is the only reservoir included for the Canadian River Basin. Most of the cities to be served from Sanford Reservoir are located in the upper portions of the Brazos and Colorado River Basins.

Red River Basin

Nine existing reservoirs in the Red River Basin will continue to supply parts of the water needs of municipalities in that basin. These existing reservoirs and the municipalities to be served include: Baylor Creek for Childress, Wichita and Kickapoo for Wichita Falls, Iowa Park for Iowa Park, Camp Creek for Electra, Farmers Creek for Nocona, Texoma for Sherman and Denison, Randall for Denison, and Crook for Paris. The existing Lake Pauline will continue to serve the West Texas Utility Company installation; and Brushy Creek Reservoir, the Texas Power and Light Company plant.

Five new reservoirs are proposed to meet additional water needs in the Red River Basin. Whitefish Creek Reservoir in Donley County is being planned for municipal, industrial, and irrigation uses. Both Clarendon and Wellington can be served from this reservoir. Existing facilities will not be adequate to meet the 1980 water needs of Wichita Falls and Henrietta. The Halsell and Ringgold reservoir sites on the Little Wichita River in Clay County have been studied in considerable detail, and one of these reservoirs will be needed in the immediate future. While either reservoir can provide supplies adequate to meet the 1980 water requirements, the plan presents both reservoirs as alternates. Buffalo Creek Reservoir in Wichita County is proposed to meet the needs of Iowa Park, together with the existing small Iowa Park Reservoir. Paris Reservoir on Sanders Creek in Lamar County is proposed to meet the water requirements of the Paris area. The Barkman Creek Reservoir in Bowie County is being planned to provide water for industrial purposes. This project also contemplates the diversion of water from the Red River to Barkman Creek Reservoir.

Ground water will continue to be important as a source of supply for numerous communities and some cities in the basin.

Sulphur River Basin

Three existing reservoirs in the Sulphur River Basin will provide for much of the 1980 water requirements in that basin. These are Whiteoak Bayou Reservoir for Sulphur Springs, Texarkana Reservoir for Texarkana, and River Crest Reservoir for the Texas Power and Light Company plant. Cooper Reservoir on South Sulphur River is proposed to serve Commerce, Cooper, and Sulphur Springs, and also to provide additional water to the North Texas Municipal Water District in the Trinity River Basin. Other needs in the Sulphur River Basin can be served from ground water.

Cypress Creek Basin

Five existing reservoirs in the Cypress Creek Basin will be adequate to meet projected needs of the area. Lake O'the Pines and Ellison Creek Reservoir will provide for the requirements of the Northeast Texas Municipal Water District and the Lone Star Steel Company at Daingerfield. Caddo Lake can provide for the needs of Marshall. Tankersly Creek and Hart Creek Reservoirs will serve the future requirements of Mount Pleasant. Ground water can provide for the remaining water requirements in the basin.

Sabine River Basin

Three existing reservoirs in the Sabine River Basin will provide for portions of the basin's future water requirements. Lake Tawakoni (Iron Bridge Dam) will provide for Greenville and can supply distributed smaller demands in the upper Sabine Basin. Water for Dallas and Terrell in the Trinity River Basin will also be pumped from this reservoir. The existing Lake Cherokee, together with the proposed Kilgore Reservoir in Smith County and the proposed Cherokee No. 2 Reservoir in Rusk County, will provide for the needs of Longview, Kilgore, and Gladewater, plus supplying a portion of the water needs of Henderson in the Neches River Basin. The existing Murvaul Reservoir will be adequate to meet the 1980 needs of the area it serves. Ground water use has been continued for a number of communities in the basin.

The largest project proposed for development in this basin is the Toledo Bend Reservoir on the state line reach of the Sabine River in Shelby, Sabine, and Newton Counties. Toledo Bend Reservoir is planned for municipal, industrial, irrigation, and hydroelectric power purposes. This project will be a joint venture by the states of Texas and Louisiana, and will provide firm water supplies to both states. The 1980 water needs of the lower Sabine River Basin in Texas can be served from Toledo Bend Reservoir.

Neches River Basin

The Neches River Basin has 5 existing reservoirs, 3 under-construction reservoirs, and 3 proposed reservoirs which are included in this plan to meet the 1980 water requirements.

The existing Gum Creek Reservoir in Cherokee County will continue to serve Jacksonville.

Water requirements of Tyler in 1980 can be met from the existing Lake Tyler, from Mud Creek Reservoir in Smith County on which construction has been initiated, and from Blackburn Crossing Reservoir, now under construction. Blackburn Crossing Reservoir on the Neches River can also supply Rusk and smaller communities in the Neches Basin and the Palestine area in the Trinity River Basin.

Flat Creek Reservoir in Henderson County is proposed to serve Athens in the Trinity River Basin.

The existing Striker Creek Reservoir and Lake Kurth, together with the proposed Ponta Reservoir on the Upper Angelina River, are referred to herein as the Ponta System. These three reservoirs would serve Lufkin, Nacogdoches, the Southland Paper Mills in Angelina County, and the distributed smaller uses in this area.

McGee Bend Dam on the Angelina River is under construction. This reservoir plus the existing Dam B and the proposed Salt Water Barrier on the Neches River above Beaumont are referred to herein as the McGee Bend System. This system can serve the municipal and industrial needs of Beaumont, Port Arthur, Groves, and the adjacent coastal area.

Ground water will continue to be used as a source of supply for numerous communities, cities, and some industries in the Neches River Basin.

Trinity River Basin

In the Trinity River Basin, water needs in 1980 for Tarrant County can be served by the Fort Worth Area System. This system includes the existing Lake Worth, Bridgeport, Eagle Mountain, Benbrook, and Arlington Reservoirs, and the under-construction Cedar Creek Reservoir in Henderson County. Weatherford's needs above those which can be obtained from the existing Weatherford Reservoir can be obtained from the Fort Worth Area System.

The Dallas Area System includes the existing Grapevine, Garza-Little Elm, and Lavon Reservoirs; the under-construction Forney Reservoir on East Fork; and the proposed Aubrey Reservoir on Elm Fork and the proposed Lavon Reservoir Enlargement. Aubrey Reservoir will provide for the conversion to conservation storage of a portion of the present flood-control storage in Garza-Little Elm Reservoir by transferring this flood-control storage upstream to Aubrey Reservoir. It is also proposed to provide additional conservation storage in Aubrey Reservoir. Aubrey and Garza-Little Elm Reservoirs are proposed to serve Dallas and Denton. Dallas will continue to obtain a portion of its water from Lavon Reservoir, and also will obtain water from the under-construction Forney Reservoir and the recently completed Lake Tawakoni on the Sabine River. Mountain Creek Reservoir will continue to be utilized to serve the Dallas Power and Light Company steam-electric plant installation.

To meet projected 1980 water needs of the North Texas Municipal Water District, it is proposed to enlarge Lavon Reservoir and to obtain some water from the proposed Cooper Reservoir in the Sulphur River Basin.

Terrell will supplement the yield of the existing Terrell Reservoir with water from Lake Tawakoni in the Sabine River Basin. Navarro Mills Reservoir, now under construction on Richland Creek in Navarro County, will supply the 1980 requirements of Corsicana. The existing Waxahachie Reservoir will serve the needs of Waxahachie. The proposed Bardwell Reservoir on Waxahachie Creek in Ellis County will meet the requirements of Ennis.

Conservation and regulation of the resources of the lower Trinity River will be accomplished by the construction of the proposed Livingston and Wallisville Reservoirs. Livingston Reservoir will provide the conservation storage, while releases from Livingston, plus flood inflows below this dam, will be regulated by Wallisville Reservoir, which will also act as a salt-water barrier. The system operation of these two reservoirs will supply industrial water to the Lower Trinity River Basin, the Houston industrial complex, and the adjacent coastal area.

Ground water will continue to be used to supply a portion of the water needs of the Trinity River Basin.

San Jacinto River Basin

Municipal water requirements of Houston will continue to be met in part from the existing Lake Houston and ground-water supplies. Additional municipal water supplies for Houston will require the construction of Honea Reservoir on the West Fork of the San Jacinto River in Montgomery County and Cleveland Reservoir on the East Fork of the San Jacinto River in San Jacinto County. Honea Reservoir will also supply Conroe, and Cleveland could obtain water from Cleveland Reservoir. Water from the San Jacinto River reservoirs could also be used to meet municipal needs of Baytown, and part of the requirements of Texas City and Galveston. Much of the 1980 industrial water requirements of the Houston industrial complex and adjacent areas will be met from the proposed Livingston and Wallisville Reservoirs in the Trinity River Basin.

Ground water will continue to supply part of the water needs of communities in the San Jacinto Basin and adjacent coastal areas.

Brazos River Basin

Twenty-nine reservoirs are contemplated to serve the 1980 water needs in the Brazos River Basin. These include 16 existing reservoirs, 4 reservoirs now under construction, and 9 proposed new reservoirs. Water supplies for Plainview, Levelland, Lubbock, and Slaton in the upper part of the basin will be met in part from Sanford Reservoir on the Canadian River, and Sweetwater will continue to obtain part of its supply from Oak Creek Reservoir in the Colorado River Basin. Ground water will continue to serve part of the 1980 water requirements of the basin.

The proposed White River Reservoir in Crosby County will serve Crosbyton, Ralls, Spur, and Post. Cities in the North Central Texas Municipal Water Authority could supply their water needs from the proposed Millers Creek Reservoir in Baylor County.

Sweetwater would obtain part of its supply from the existing Lake Sweetwater in the Brazos Basin and from Oak Creek Reservoir in the Colorado River Basin. Additional supplies for Sweetwater can be obtained from the proposed Seymour No. 2 Reservoir on the Double Mountain Fork of the Brazos River in Haskell and Stonewall Counties.

Abilene's 1980 needs can be supplied from the existing Fort Phantom Hill, Abilene, and Kirby Reservoirs; diversions from the Clear Fork into Fort Phantom Hill Reservoir; and the under-construction Hubbard Reservoir in Stephens County. This reservoir will also provide for Anson, Albany, and Breckenridge. Breckenridge can obtain part of its supply from the existing Lake Daniel.

Graham will continue to be served from the existing Salt Creek Reservoir.

Mineral Wells will obtain part of its needs from the existing Lake Mineral Wells. The proposed Keechi Reservoir in Palo Pinto County can provide additional water needed by Mineral Wells.

Waco will be supplied primarily by the under-construction Waco Reservoir. As the municipal demands exceed the yield of this reservoir, additional water may be obtained from the existing Possum Kingdom-Whitney Reservoir System.

Proctor Reservoir on the upper Leon River is now under construction in Comanche County with both conservation and flood-control storage to be provided. When completed, a portion of the flood-control storage in the existing Belton Reservoir will be converted to conservation storage. This reservoir system can provide for Stephenville, Cameron, Killeen, Fort Hood, Temple, and Belton, and can also serve a part of the requirements of the Freeport area. The existing Lake Leon will continue to supply part of the needs of the upper Leon River watershed.

Georgetown and Taylor can obtain their supplies from the proposed North San Gabriel Reservoir near Georgetown. This reservoir can also supply part of the Rockdale requirement not served from the existing Alcoa Reservoir.

The existing Lake Creek Reservoir will supply the Texas Power and Light Company plant, and Smithers Reservoir will supply the Houston Lighting and Power Company installation. The under-construction Bistone Reservoir on the upper Navasota River will supply Mexia.

Bryan and cities in that vicinity can be supplied from the proposed Millican Reservoir on the Navasota River.

Supplying the projected municipal and industrial water requirements of the basin from Bryan to Freeport will require a system operation of the existing Possum Kingdom and Whitney Reservoirs, coordinated with releases from the existing Belton Reservoir and the proposed Millican, Stillhouse Hollow, Somerville, and Allens Creek Reservoirs. The proposed Stillhouse Hollow Reservoir site is located on the Lampasas River in Bell County. Somerville Reservoir is planned for Yegua Creek at Somerville, and would also supply water requirements to cities in that area. The proposed Allens Creek Reservoir is an off-channel reservoir located in Austin County, and would have uncontrolled flood waters from the Brazos River diverted to it. The system operation of these reservoirs would also provide for a portion of the supply of the Texas City area, which is presently supplied from the Brazos River.

Colorado River Basin

Fifteen existing reservoirs will continue to supply a large part of the 1980 water requirements of the Colorado River Basin. The proposed Sanford Reservoir on the Canadian River will supply Brownfield and Lamesa in the Colorado River headwater area. One reservoir is now under construction, and four additional reservoirs are proposed in this basin. Ground water will continue to serve some of the requirements of the basin.

The Colorado River Municipal Water District cities of Odessa, Snyder, and Big Spring will be served by the existing Lake J. B. Thomas and the proposed Robert Lee Reservoir on the Colorado River in Coke County. Robert Lee Reservoir can also supply part of the requirements of Midland and Ballinger.

Colorado City municipal and surrounding area industrial uses will be supplied by the existing Lake Colorado City and Champion Creek Reservoir.

San Angelo will be supplied from a system of three reservoirs: the existing San Angelo and Nasworthy Reservoirs and the under-construction Twin Buttes Reservoir.

Coleman will continue to obtain part of its water supply from the existing Hords Creek Reservoir. The proposed Jim Ned Creek Reservoir in Coleman County is proposed to meet the projected 1980 water requirements.

Brownwood will continue to be supplied from the existing Brownwood Reservoir.

A reservoir is proposed on Brady Creek in McCulloch County to serve the needs of Brady.

The Lower Colorado River Authority system of six existing reservoirs, i.e., Buchanan, Inks, Granite Shoals, Marble Falls, Travis, and Austin, plus Town Lake at Austin, can supply Austin, Marble Falls, and Burnet. The operation of these reservoirs, coordinated with the proposed Columbus Bend Reservoir near Columbus, can supply the municipal and industrial needs of Columbus, Eagle Lake, Wharton, El Campo, Palacios, and Bay City.

Lavaca River Basin

The first reservoir to conserve the surface waters of the Lavaca River Basin is proposed at the Texana site on the Navidad River in Jackson County. Texana Reservoir can provide for Ganado, Edna, Port Lavaca, and the future industrial water needs of that portion of the coastal area. Other municipal needs in the basin can be supplied from ground-water sources.

Guadalupe River Basin

Canyon Reservoir, now under construction, will be the first major reservoir in the Guadalupe River Basin. This reservoir can provide water supplies for that portion of the basin between Canyon Dam and Gonzales. To provide for the large potential municipal and industrial water requirements from Victoria to the mouth and adjacent coastal area, it is proposed to construct the first stage of Cuero Reservoir on the Guadalupe River immediately above Cuero. An additional arm of the reservoir on Sandies Creek and a connecting channel can be added later. Ground water will continue to be used to supply part of the water needs of this basin.

The hydraulic interconnection of the Guadalupe, San Antonio, and Nueces River Basins by the Edwards Underground Reservoir suggests treatment of these three basins as a unit in developing total available supplies. However, any plan for meeting projected water requirements in the area must recognize the individuality of each river basin.

San Antonio River Basin

Ground-water supplies historically available to San Antonio are being depleted by irrigation pumping in Bexar, Medina, and Uvalde Counties. To meet its 1980 water requirements San Antonio will need to develop surface-water supplies. The plan suggests the construction of Cibolo Reservoir on Cibolo Creek in Wilson County, and Ecleto Reservoir on Ecleto Creek in Karnes County to supply part of the San Antonio requirement. Either of these reservoirs could be used to serve Karnes City and Kenedy. East Lake, an off-channel reservoir adjacent to the San Antonio River in Bexar County, is proposed to meet some of the 1980 water requirements for steam-electric power generation for San Antonio. A large reservoir is proposed at the Goliad site on the lower San Antonio River in Goliad County, which may supply industrial water to the Corpus Christi Bay industrial area and industrial and irrigation uses in the lower Guadalupe River Basin. Supplying a part of the San Antonio water needs from the Guadalupe River Basin may be possible within the framework considerations outlined in Chapter II.

Nueces River Basin

The water needs in the Nueces River Basin upstream from the existing Lake Corpus Christi will be supplied from ground water. To meet the projected future municipal water requirements of Corpus Christi and cities in the adjacent coastal area, it is proposed to enlarge Lake Corpus Christi, which was designed for enlargement, obtain industrial water from the proposed Goliad Reservoir on the San Antonio River, and construct five additional reservoirs. These reservoirs are Blanco Reservoir in Refugio County, Beeville Reservoir in Bee County, Woodsboro Reservoir in San Patricio and Refugio Counties, Alice Reservoir in Jim Wells County, and Kingsville Reservoir in Kleberg County.

Rio Grande Basin

Water requirements in the upper Rio Grande Basin will be served largely from ground water. El Paso will continue to obtain its supply from underground sources, although supplementing it from surface water. The construction of the proposed Amistad Dam, together with the existing Falcon Reservoir, can provide water supplies for cities along the Rio Grande and in the Lower Rio Grande Valley area.

Summary

The plan contained herein, and discussed by watershed units in Chapter II, provides for development of individual projects, and reservoir systems in a manner which permits flexibility. Each of these units will constitute a step toward optimum conservation and utilization of our water resources. As water requirements increase, new reservoir units will be added to serve the requirements.

Several projects being planned by local groups and/or a Federal agency primarily for irrigation and/or hydroelectric power generation as the initial purpose are contained in the report. Such projects have been included herein when the yield of these reservoirs also provided for part or all of the municipal and industrial water requirements in the general area of the project.

The total annual firm yield of all existing, under-construction, and proposed reservoirs included herein is 9,417,500 acre-feet of which 57 percent, or 5,340,400 acre-feet, will be required for municipal and industrial uses in 1980. Forty-three percent, or 4,077,100 acre-feet, is the yield remaining, as shown as item 6 in Table I-C. Of this 4,077,100 acre-feet, there is 1,263,900 acre-feet of reservoir yield which is for municipal and industrial use after 1980 and 2,813,200 acre-feet for other uses, including hydroelectric power. Hydroelectric power as an incidental use may be greater than indicated above by those amounts of water released through turbines and used downstream for municipal and industrial purposes. The remaining yield for municipal and industrial purposes after 1980 results in part from the development of projects in the years immediately preceding 1980, which will be designed to meet larger water requirements in later years.

Table I-C also shows that the total capacity of all reservoirs herein is 53,868,000 acre-feet, of which 67 percent, or 36,322,000 acre-feet, is for conservation storage; and 33 percent, or 17,546,000 acre-feet, is for flood-control storage. The surface area at top of conservation pools of all reservoirs included herein is 1,505,700 acres.

In reviewing the plan contained herein, consideration should be given to the important factors outlined in Chapter III.

CHAPTER II

RIVER BASINS AND COASTAL AREAS

GENERAL

Present uses of water, projected water requirements, and means of serving these needs are treated herein by units consisting of individual river basins and coastal areas. Divisions of river basins and coastal areas into zones have been made along topographic and hydrologic lines. Many of these zones include groups of major subdivisions which have been delineated. Work has been initiated to establish a continuing inventory of water resources, uses, and requirements for administrative and planning purposes using these major subdivisions as a base.

The State has been divided into 23 river basins or coastal areas, with the name of each river basin being the name of the main river which the basin topographically encloses and the name of each coastal area being the combined name of two main rivers between which the area lies with the name of the northernmost river first.

River basins are defined so as to include the large, sometimes flat areas in the high plains which lie at the head of some rivers, such as the Brazos, or the flat areas which form a midsection of such a river as the Canadian. Some of these flat areas are topographically bounded or defined only faintly. State boundary lines mark the limits of some of the river basins. Near the mouth of streams, basin definitions are based on low-flow conditions and the exclusion of deltas.

Coastal areas are defined so as to include the large, usually flat areas of coastal plain, peninsulas, and islands which lie adjacent to and between the main river basins.

Ground-water data included in this report is presented by river basins and coastal areas in order to integrate the information related to ground water within the framework of this report. It should be noted, however, that surface expressions of topography, such as river basin divides, are not reflected as hydraulic barriers in ground-water reservoirs which often extend laterally across the boundaries of several river basins. Development of ground-water supplies in a basin or defined zone within a basin may affect the availability of ground water from the same aquifer in adjoining basins or zones.

Progressing clockwise from the Panhandle, the names and numbers of the basins and coastal areas are:

1. Canadian River Basin
2. Red River Basin
3. Sulphur River Basin
4. Cypress Creek Basin
5. Sabine River Basin
6. Neches River Basin
7. Neches-Trinity Coastal Area
8. Trinity River Basin
9. Trinity-San Jacinto Coastal Area
10. San Jacinto River Basin
11. San Jacinto-Brazos Coastal Area
12. Brazos River Basin
13. Brazos-Colorado Coastal Area
14. Colorado River Basin
15. Colorado-Lavaca Coastal Area
16. Lavaca River Basin
17. Lavaca-Guadalupe Coastal Area
18. Guadalupe River Basin
19. San Antonio River Basin
20. San Antonio-Nueces Coastal Area
21. Nueces River Basin
22. Nueces-Rio Grande Coastal Area
23. Rio Grande Basin

Each of the 23 river basins and coastal areas is discussed in this chapter in the order given above, and these names and numbers will be used throughout this chapter. The method of treatment of the engineering and geologic facts for each basin or area are uniform and consist of the following: some brief text matter, a map, and four tables.

The text provides a concise, descriptive, and explanatory statement to unify and make clear the other material presented. This statement includes a general physical description of the river basin or coastal area, a discussion of ground water, a discussion of the plan for the basin, and pertinent hydrologic and chemical quality information.

To effect a concise presentation of material, the text discussion has been limited and use made of a series of four tables for each unit to present detailed data. Numbering of these tables and maps has been in accordance with the following pattern. Each river basin or coastal area was given a numerical designation, as shown at the beginning of this chapter. This same numerical designation is used to identify the map of that watershed. The numbers for the four tables of each unit have three symbols such as: II-2A. The Roman numeral is the chapter designation, the arabic numeral is the basin or area designation, and the letter following the arabic numeral distinguishes the table. The letter code used is

A—"Present Water Uses;"

B—"Municipal and Industrial Water Requirements and Sources of Supply for 1980;"

C—"1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports;" and

D—"Data for Reservoirs over 5,000 acre-feet."

The above listing gives actual table titles.

MATERIAL PRESENTED IN TABLES

Table A of each unit provides a summary of the present water uses by zones for municipal, industrial, and irrigation purposes. The figures shown for ground- and surface-water uses are based on annual user reports, supplemented by field information obtained by the Board's staff plus that obtained from cooperating agencies.

Table B of each unit contains the projected water requirements and sources of supply for 1980 and thus, constitutes a presentation of the proposed plan for each basin or coastal area. The means of meeting these projected requirements listed in the tables is not intended as a directive which would in any way limit any entity from considering or obtaining a supply from an alternate source. These tables show the possibilities of obtaining water from suggested sources which, if developed, will meet the municipal and industrial water needs of 1980 and lead to the further development of our State's water resources. The "Place of Use or User" column includes individual entities within a zone where separation of requirements is possible. The tables do not attempt to list every community or individual industry in each zone. Those entities not provided for in the specific informational detail of Tables B and C are included in the designation "Distributed" at the end of each zone listing. The amounts of water listed under sources of supply to be obtained from ground and surface water were predicted on one of several conditions: (1) the present source of water; (2) the continued availability of water from the present source; (3) the intent of local entities as expressed by filings of presentations and/or applications for water permits with this agency, or the previous granting of a water permit by the Board of Water Engineers; (4) the intent of local entities as expressed in reports received from river authorities, cities, and industries; (5) the sources of additional water available; or (6) availability of information on local areas. The surface reservoirs listed in Tables B are more fully explained in Tables C and D.

Table C of each unit provides a listing of the 1980 distribution of the firm yield of surface-water reservoirs and basin imports. A listing of the reservoir yield, the amount thereof used to meet 1980 needs, and the yield remaining for use after 1980 or for other uses prior to 1980 is presented. The total critical-period yield of a reservoir, except as specifically noted, is listed. The "Imports" column lists amounts of water transported into the area from another watershed. The name of the reservoir supplying the import and its basin location are shown in the first column. The amount of the import is listed in the third column, and the place of use of the import is shown in the fourth column. For example, in the Trinity River Basin, Table II-8C shows that Tawakoni Reservoir in the Sabine River Basin will supply 112,100 acre-feet of imported water for use in Dallas County. Amounts of use in the basin, from in-basin reservoirs or imports, are listed under "Basin Use." Amounts of water exported from this basin are listed under "Exports," with the destination shown under "Place of Use." The "Yield Remaining After 1980" is that portion of the yield not used for municipal and industrial purposes, although parts or all of these amounts of remaining yield may presently, or in the future, be available for other purposes. Data contained in this last column are a balance of total yield less than suggested for 1980 municipal and industrial uses.

Table D of each unit presents pertinent data for existing, under-construction, and proposed major reservoirs. Column headings for this table are self-explanatory. Conservation capacities listed in these tables include the sediment storage allowance.

HYDROLOGIC DATA

Pertinent hydrologic information is contained in the text for each basin and coastal area. These historic hydrologic data are based on the following periods of time: rainfall, average for years 1924 through 1956; runoff rates, average for years 1924 through 1956; and net evaporation rates, average for years 1940 through 1957. Reservoir yields shown are the 1980 condition firm yields without reserves at the end of the critical period.

A general appraisal of ground-water information now available on yields of water wells, ability of aquifers to transmit water, estimates of use and estimates of availability of ground water in relation to use is discussed in the text and is presented in tabular form in Appendix C for each basin and coastal area.

WATER RIGHTS AND EXISTING WATER USES

This plan recognizes all water permits, certified, filings, and other existing rights to the use of water. In the development of the reservoirs suggested for each basin, careful consideration was given to allowing sufficient water to provide for present surface-water irrigation. All data were reviewed which related to past and present uses of water. Reservoirs with storage allocations for irrigation and/or hydroelectric power were not changed to serve future municipal or industrial requirements, although this alternate may be considered in later years. The results set forth in Tables B and C reflect allowances for present surface-water irrigation.

MAPS

Following the text and tables for each basin or coastal area, is a map showing, among other things, the outline of that particular area and also its division into zones with the designations therefor. Reservoirs that are existing, currently under construction, or proposed as a part of this plan are shown on these maps. For the reader's convenience each of these maps bears as a plate number that idenification number listed in paragraph six of this chapter. A map of the State, Plate 24, folded in the back of the report shows the location of each basin and coastal area and also shows reservoirs or reservoir sites for all projects having a conservation capacity of 5,000 acre-feet or more.

CANADIAN RIVER BASIN

The area designated herein as the Canadian River Basin includes drainage areas of the South Canadian and North Canadian Rivers. Both streams head in New Mexico and flow into Oklahoma—the South Canadian River flowing across the Texas Panhandle north of Amarillo, and the North Canadian dipping a short distance into Texas in Sherman County. The map on Plate 1 shows the basin outline and the two zones into which it has been divided. This basin includes portions of the Great Plains and Central Texas geographical provinces. Sharply contrasting flat plains and rolling to rugged erosional breaks mark the topography of the basin.

Rainfall in this area averages about 20 inches per year. In contrast, the average net evaporation loss is about 55 inches per year.

The chemical quality of water in the Canadian River in Texas varied during the eleven years of record and averaged less than 500 ppm (parts per million) of total dissolved solids above the proposed Sanford Dam site. For the 1959 water year, the weighted average of total dissolved solids was 649 ppm for the Canadian River near Amarillo. Water from the Canadian River, when equated by Sanford Reservoir, will be generally suitable for municipal and most industrial purposes.

A reconnaissance ground-water study of the Canadian River Basin has been completed, and the results are presented in Texas Board of Water Engineers Bulletin 6016. Reasonably thorough, current information on ground-water conditions in the basin is available in a report on Carson County and the western half of Gray County. Because this is the only basin for which reconnaissance studies are complete, it is the only basin for which an estimate has been made of the quanitity of ground water available from the principal aquifers.

Large quantities of ground water are available from the Ogallala, the principal aquifer in the Canadian River Basin. Pumping is exceeding the rate of recharge, which is less than one inch annually. As a result, water in storage is slowly being depleted. The estimated quantity of water in storage in 1958 was a little more than 200 million acre-feet. Because well yields will decrease with the decline of water levels, probably not more than 150 million acre-feet of this stored water may be economically recoverable. Smaller quantities of ground water are found in Cretaceous, Jurassic, and Triassic aquifers underlying the Ogallala in the central and western part of the basin.

The area where the Ogallala yields fresh water in the Canadian River Basin is shown on Plate 25.

Ground water available from the Ogallala is chemically suitable for most uses. In general, the water is hard to very hard, contains less than 1,000 ppm total dissolved solids, and contains concentrations of silica that would be objectionable for some industrial boiler operations. Some of the water samples analyzed contain undesirable concentrations of fluoride for drinking purposes. The water from the Ogallala is suitable for irrigation.

The present uses of water for municipalities, industries, and irrigation are contained in Table II-1A, and total 582,630 acre-feet. As indicated in this table, all of this water has been obtained from underground sources.

The estimated 1980 municipal and industrial water requirements for this basin are 238,300 acre-feet per year. Tables II-1B and II-1C show how these needs may be met. Much of these future requirements will continue to be supplied from ground water.

One surface-water project is included for meeting water requirements. This is the Sanford Reservoir project on the Canadian River. Some water from this reservoir will also be diverted to river basins south of the Canadian River to serve municipal and industrial requirements in the upper Brazos and Colorado River Basins. Cities to be served by the Sanford Reservoir include Amarillo, Borger, Pampa, Plainview, Levelland, Lubbock, Seaton, Brownfield, and Lamesa.

The Canadian River Compact, between the states of New Mexico, Texas, and Oklahoma, contains provisions allowing development of specified amounts of conservation storage in Texas and New Mexico. The Sanford Reservoir provides for developing the conservation storage allocated to Texas under this compact.

TABLE II-1A. CANADIAN RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	2,180	0	2,180
Industrial	1,810	0	1,810
Irrigation	368,000	0	368,000
Total Zone A	**371,990**	**0**	**371,990**
Zone B			
Municipal	27,520	0	27,520
Industrial	44,920	0	44,920
Irrigation	138,200	0	138,200
Total Zone B	**210,640**	**0**	**210,640**
Basin Totals			
Municipal	29,700	0	29,700
Industrial	46,730	0	46,730
Irrigation	506,200	0	506,200
Total Canadian Basin	**582,630**	**0**	**582,630**

TABLE II-1B. CANADIAN RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Distributed	13,300	13,300	0	
Total Zone A	13,300	13,300	0	
Zone B				
Amarillo	53,800	15,600	38,200	Sanford
Borger	63,500	57,800	5,700	Sanford
Pampa	28,600	21,200	7,400	Sanford
Dalhart	1,500	1,500	0	
Dumas	16,200	16,200	0	
Distributed	61,400	61,400	0	
Total Zone B	225,000	173,700	51,300	
Total Canadian Basin	238,300	187,000	51,300	

Summary for Canadian Basin

Requirements supplied by:

Ground Water	187,000
Surface Water	51,300
Total requirements	238,300

TABLE II-1C. CANADIAN RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
No reservoirs in zone	0	0		0	0	0
Zone B						
Sanford	103,000		Amarillo	38,200		
			Borger	5,700		
			Pampa	7,400		
			Brazos Basin (BR), Zone A:			
			Plainview		3,800	
			Total Zone A, BR		3,800	
			Brazos Basin (BR), Zone C:			
			Levelland		2,900	
			Lubbock		38,200	
			Slaton		1,600	
			Distributed		800	
			Total Zone C, BR		43,500	
			Total BR (47,300)			
			Colorado Basin (CO), Zone A:			
			Brownfield		2,200	
			Lamesa		2,200	
			Total Zone A, CO		4,400	
Total Sanford	*103,000*	*0*		*51,300*	*51,700*	*0*
Total Zone B	**103,000**	**0**		**51,300**	**51,700**	**0**
Total Canadian Basin	**103,000**	**0**		**51,300**	**51,700**	**0**

Summary for Canadian Basin

Used in Canadian Basin		51,300
Exports to other basins:		
Brazos Basin	47,300	
Colorado Basin	4,400	
Total exports		51,700
Total yield		103,000

TABLE II-1D. CANADIAN RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
None								
Proposed								
Sanford	Canadian River	10 WNW Borger	Hutchinson	500,000	425,000	1,331,500[1]	103,000	16,800
Total Proposed				**500,000**	**425,000**	**1,331,500**	**103,000**	**16,800**
Total Canadian Basin				**500,000**	**425,000**	**1,331,500**	**103,000**	**16,800**

[1] Includes 406,500 acre-feet of sediment storage capacity.

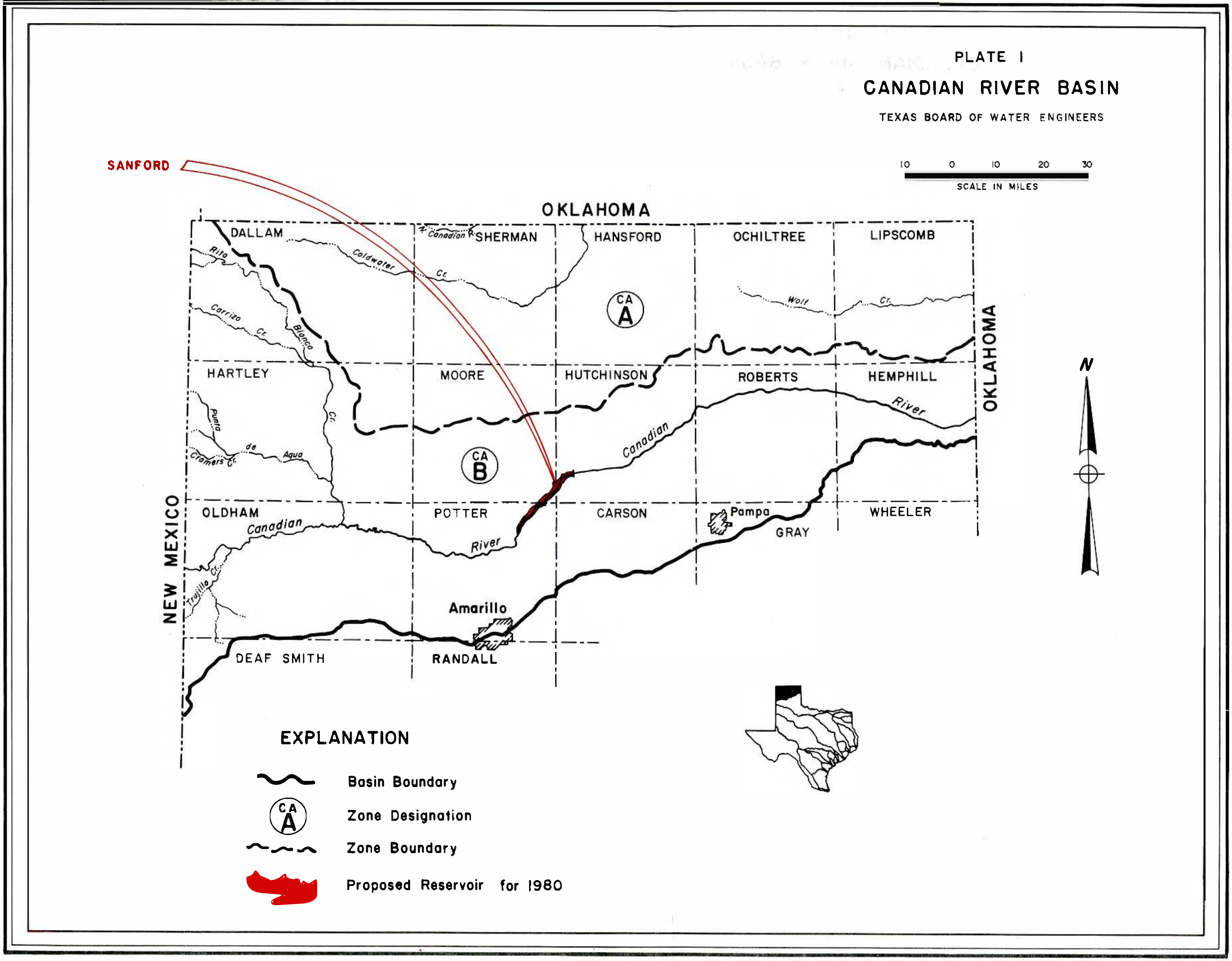


PLATE I
CANADIAN RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
SANFORD
OKLAHOMA
DALLAM
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
HARTLEY
MOORE
HUTCHINSON
ROBERTS
HEMPHILL
OLDHAM
POTTER
CARSON
GRAY
WHEELER
DEAF SMITH
RANDALL
NEW MEXICO
OKLAHOMA
Amarillo
Pampa
Canadian River
Canadian
River
N. Canadian R.
Coldwater Cr.
Wolf Cr.
Rita Blanca
Carrizo Cr.
Punta de Aqua
Cramers Cr.
Trujillo Cr.
Cr.
CA A
CA B
N
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Proposed Reservoir for 1980

RED RIVER BASIN

The Red River has its headwaters on the High Plains of Texas with an extreme western tip extending a few miles into New Mexico. Some of its northern tributaries drain eastward into Oklahoma before reaching the main stream. East of the Panhandle, the Red River forms the northern Texas boundary, with Oklahoma and Arkansas lying north of the river. A map of this basin showing its streams, its reservoirs, and its division into four zones is shown on Plate 2.

Throughout its length, the Red River successively drains portions of the Great Plains, Central Texas, and Gulf Coastal Plain geographical provinces. The principal Texas tributaries of the upper portion of the basin are the Pease, Wichita, and Little Wichita Rivers. Two major tributaries to the lower Red River are the Sulphur River and Cypress Creek, both of which join the Red River in Louisiana. The Texas portion of the watershed of each of the latter two streams has been treated as separate basins.

Rainfall on the headwaters of the Red River averages about 19 inches per year. It increases in an easterly direction and averages about 37 inches per year at Denison Dam and 47 inches per year at the eastern State boundary.

Surface runoff varies from practically nothing in the High Plains portion of this basin to an average of about 200 acre-feet per square mile per year in the middle basin to over 650 acre-feet per square mile in the lower basin near the Texas-Arkansas boundary.

The chemical quality of water in the Red River in Texas varies, with concentrations of more than 4,000 ppm (parts per million) total dissolved solids occurring in the upper reaches above the mouth of the Little Wichita River to less than 1,000 ppm below Lake Texoma. Of the principal tributaries, the water of the Pease and Wichita Rivers has concentrations of 3,000 ppm or greater; whereas, water of the Little Wichita River averaged less than 250 ppm. For the 1959 water year, the weighted average of dissolved solids was 1,640 ppm for the Red River near Gainesville, and was 1,100 ppm below Lake Texoma. The chemical quality of flood flows of the main stream is much better than the more highly mineralized base flows. Water from some tributaries above Denison Dam and from tributaries below this point is chemically suitable for municipal and most industrial uses.

The reconnaissance ground-water study for this basin is scheduled for completion in September 1962. More comprehensive studies have been made for the following areas in this basin: Hale County; Knox County; Grayson County; Odell Sandhill Area, Wilbarger County; and Gainesville Area, Cooke County.

The approximate extent of three of the principal aquifers—the Ogallala, the Seymour, and the Trinity sands—is shown on Plate 25. Other principal aquifers are the Blaine in parts of Collingsworth, Childress, Hardeman, Cottle, and King Counties and the Woodbine sands which yield fresh water in the eastern half of the area shown for Trinity sands in the basin.

Large quantities of ground water are pumped from the Ogallala, Blaine, and Seymour formations within the Red River Basin—principally for irrigation. Data available indicate that the present rate of pumpage from the Ogallala in this basin exceeds the rate of recharge. This also may be true for the Blaine and Seymour formations. Reconnaissance studies have not progressed to the point where reliable estimates of the quantity of water available from storage in these aquifers can be obtained. However, where pumpage exceeds recharge, the present rates of pumpage can not be maintained indefinitely.

The chemical quality of the ground-water supplies presently developed in the basin varies greatly. Generally, water obtained from the Ogallala, Seymour, Trinity, and Woodbine aquifers is suitable for municipal, irrigation, and most industrial uses, while water from the Blaine is used almost entirely for irrigation and is usually too highly mineralized for industrial and municipal supplies.

Present uses of water for municipalities, industries, and irrigation, as contained in Table II-2A, total 2,081,060 acre-feet. Of this total, 2,005,470 acre-feet was obtained from groundwater supplies; and 75,590 acre-feet, from surface-water sources. The estimated 1980 municipal and industrial water requirements for this basin total 215,800 acre-feet. The distribution of these requirements by zones and the means of serving the requirements are contained in Tables II-2B and II-2C. Existing and future reservoir facilities considered in serving these needs are shown in Table II-2D.

Nine existing reservoirs, five additional reservoirs, and continued use of ground water are proposed as means of meeting the 1980 municipal and industrial water requirements in the Red River Basin.

The existing Baylor Creek Reservoir will continue to supply Childress.

Whitefish Creek Reservoir in Donley County is planned principally for irrigation by the Greenbelt Municipal and Industrial Water Authority. This reservoir would provide water for Clarendon and Wellington.

Buffalo Creek Reservoir in Wichita County is proposed to meet the needs of Iowa Park, together with the existing small Iowa Park Reservoir.

Other present reservoirs to serve 1980 water needs include Texoma for Sherman and Denison, Randall for Denison, Camp Creek for Electra, and Farmers Creek for Nocona. The existing Lake Pauline will continue to serve the West Texas Utility Company installation; and Brushy Creek Reservoir, the Texas Power and Light Company plant.

Questions relative to the ground-water sources of supply for Vernon and Burkburnett indicate the possibility of a future conversion from ground- to surface-water supplies. Separate small off-channel reservoirs are suggested herein as means of providing these supplies by selective diversion of acceptable quality water from Red River flood flows.

Paris Reservoir on Sanders Creek in Lamar County is proposed, together with the existing Lake Crook, to meet the needs of the Paris area.

Barkman Creek Reservoir in Bowie County is being planned to supply water for industrial purposes. This project also contemplates the diversion of water from the Red River to Barkman Creek Reservoir.

Projected 1980 water requirements of Wichita Falls cannot be met from existing Lake Kickapoo and Lake Wichita. Another reservoir on the Little Wichita River downstream from the present Lake Kickapoo will be required to meet the projected requirements. The Halsell and Ringgold sites have been investigated. A reservoir at the Halsell site with a capacity of 228,000 acre-feet will provide a yield of 43,000 acre-feet per year. The Ringgold site has been considered for two-stage development, with an initial capacity of 164,000 acre-feet and a second-stage total capacity of 433,000 acre-feet. The annual yield from the first stage would be 40,000 acre-feet, and that from the second-stage capacity would be 106,000 acre-feet. Either the Halsell Reservoir or the Ringgold Reservoir first stage would have a yield which, together with that from existing facilities, would meet the 1980 water requirements of Wichita Falls.

Ground water will continue to be important as a source of supply for numerous communities and some cities in the basin.

TABLE II-2A. RED RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	6,210	0	6,210
Industrial	1,510	0	1,510
Irrigation	1,811,920	10	1,811,930
Total Zone A	**1,819,640**	**10**	**1,819,650**
Zone B			
Municipal	6,630	400	7,030
Industrial	270	1,550	1,820
Irrigation	202,700	4,480	207,180
Total Zone B	**209,600**	**6,430**	**216,030**
Zone C			
Municipal	230	16,400	16,630
Industrial	10	1,520	1,530
Irrigation	1,150	37,780	38,930
Total Zone C	**1,390**	**55,700**	**57,090**
Zone D			
Municipal	4,750	5,710	10,460
Industrial	1,820	40	1,860
Irrigation	2,190	7,700	9,890
Total Zone D	**8,760**	**13,450**	**22,210**
Basin Totals			
Municipal	17,820	22,510	40,330
Industrial	3,610	3,110	6,720
Irrigation	2,017,960	49,970	2,067,930
Total Red Basin	2,039,390	75,590	2,114,980

TABLE II-2B. RED RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Canyon	1,500	1,500	0	
Clarendon	700	0	700	Whitefish Creek
Dimmitt	1,600	1,600	0	
Hereford	3,300	3,300	0	
Tulia	1,400	1,400	0	
Distributed	6,300	6,300	0	
Total Zone A	14,800	14,100	700	
Zone B				
Burkburnett	1,100	0	1,100	Off channel reservoir
Childress	1,800	900	900	Baylor Creek
Memphis	400	400	0	
Quanah	800	800	0	
Shamrock	1,000	1,000	0	
Vernon	2,800	0	2,800	Off channel reservoir
Wellington	600	0	600	Whitefish Creek
Distributed	15,500	15,500	0	
Total Zone B	24,000	18,600	5,400	
Zone C				
Archer City	1,000	0	1,000	Small existing reservoir plus direct diversion from South Fork Little Wichita River
Electra	1,500	0	1,500	Camp Creek
Henrietta	1,000	0	1,000	Halsell or Ringgold
Iowa Park	1,500	0	500	Iowa Park
			1,000	Buffalo Creek
West Texas Utilities Co.	2,000	0	2,000	Pauline

TABLE II-2B. RED RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Wichita Falls	45,000	0	17,000 2,000 26,000	Kickapoo Wichita Halsell or Ringgold
Distributed	8,000	8,000	0	
Total Zone C	**60,000**	**8,000**	**52,000**	
Zone D				
Bonham	2,000	2,000	0	
Denison	10,000	0	1,500 8,500	Randall Texoma
Sherman	12,000	2,000	10,000	Texoma
Nocona	500	0	500	Farmers Creek
Texas Power & Light Co.	10,000	0	10,000	Brushy Creek
Paris	23,600	0	4,000 19,600	Crook Paris
Anglo-Southern Paper Co.	55,000	0	55,000	Barkman Creek with selected diversions from Red River
Distributed	3,900	3,900	0	
Total Zone D	**117,000**	**7,900**	**109,100**	
Total Red Basin	**215,800**	**48,600**	**167,200**	

Summary for Red Basin

Requirements supplied by:

Ground Water	48,600
Surface Water	167,200
Total requirements	215,800

TABLE II-2C. RED RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at he beginning of this chap er)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
Whitefish Creek	25,000		Clarendon	700		
			Wellington, Zone B	600		
Total Whitefish	*25,000*	*0*		*1,300*	*0*	*23,700*[1]
Total Zone A	**25,000**	**0**		**1,300**	**0**	**23,700**
Zone B						
Baylor Creek	*2,200*		Childress	*900*		*1,300*
Total Zone B	**2,200**	**0**		**900**	**0**	**1,300**
Zone C						
Wichita	*2,000*		Wichita Falls	*2,000*	*0*	*0*
Kickapoo	*17,000*		Wichita Falls	*17,000*	*0*	*0*
Halsell or Ringgold	27,000[2]		Wichita Falls	26,000		
			Henrietta	1,000		
Total Halsell or Ringgold	*27,000*[2]	*0*		*27,000*	*0*	([2])
Iowa Park	*500*		Iowa Park	*500*	*0*	*0*
Buffalo Creek	*4,000*		Iowa Park	*1,000*	*0*	*3,000*
Camp Creek	*1,500*		Electra	*1,500*	*0*	*0*
Pauline	*2,000*		W. Texas Utilities Co.	*2,000*	*0*	*0*
Total Zone C	**54,000**	**0**		**51,000**	**0**	**3,000**
Zone D						
Farmers Creek	*2,000*		Nocona	*500*	*0*	*1,500*
Texoma	62,300[3]		Sherman	10,000		
			Denison	8,500		
Total Texoma	*62,300*	*0*		*18,500*	*0*	*43,800*
Brushy Creek	*10,000*		Tex. Power & Light Co.	*10,000*	*0*	*0*
Randall	*1,500*		Denison	*1,500*	*0*	*0*
Crook	*4,000*		Paris	*4,000*	*0*	*0*
Paris	*48,400*		Paris	*19,600*	*0*	*28,800*
Barkman Creek	*55,000*[4]		Anglo-Southern Paper Co.	*55,000*	*0*	*0*
Total Zone D	**183,200**	**0**		**109,100**	**0**	**74,100**
Total Red Basin	**264,400**	**0**		**162,300**	**0**	**102,100**

[1]Yield remaining for uses other than municipal and industrial.
[2]See Text.
[3]Storage authorized to be contracted for by nearby Texas cities.
[4]Includes 42,000 acre-feet of selected diversions from Red River.

Summary for Red Basin

Used in Red Basin		162,300
Yield remaining:		
Municipal and industrial uses after 1980	78,400	
Other present uses	23,700	
Total yield remaining		102,100
Total yield		264,400

TABLE II-2D. RED RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam: Reference (Miles)	Location of Dam: County	Capacity: Conservation (Acre-Feet)	Capacity: Flood (Acre-Feet)	Capacity: Total (Acre-Feet)	Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
Existing								
Bivins	Palo Duro Creek	7 NW Canyon	Randall	5,120	0	5,120	0	379
Baylor	Baylor Creek	10 NW Childress	Childress	9,220	0	9,220	2,200	610
Kemp	Wichita River	6 N Maybelle	Baylor	461,800	0	461,800	—	20,625
Lake Diversion	Wichita River	14 W Holliday	Archer	40,000	0	40,000	—	3,419
Santa Rosa	Beaver Creek	15 S Vernon	Wilbarger	11,570	0	11,570	—	1,500
Wichita	Holliday Creek	6 SW Wichita Falls	Wichita	14,000	0	14,000	2,000	2,200
Kickapoo	N. Fork Little Wichita River	10 NW Archer City	Archer	106,000	0	106,000	17,000	6,200
Farmers Creek	Farmers Creek	8 NE Nocona	Montague	25,400	0	25,400	2,000	1,470
Texoma	Red River	5 NNW Denison	Grayson	1,418,150[1]	1,347,000[1]	2,765,150[1]	62,300[2]	45,600[1]
Randall	Shawnee Creek	4 NW Denison	Grayson	5,400	0	5,400	1,500	172
Brushy Creek	Brushy Creek	3 N Savoy	Fannin	16,800	0	16,800	10,000	1,180
Crook	Pine Creek	5 N Paris	Lamar	9,960	0	9,960	4,000	1,226
Total Existing	....	....	....	**2,123,420**	**1,347,000**	**3,470,420**	**101,000**	84,581
Proposed								
Whitefish Creek	Salt Fork Red River	17 ENE Clarendon	Donley	100,500	0	100,500	25,000	3,450
Halsell	Little Wichita River	10 WSW Henrietta	Clay	228,000[4]	0	228,000[4]	43,000[5]	13,500[4]
Ringgold[3]	Little Wichita River	6 NW Ringgold	Clay	164,000[4]	0	164,000[4]	40,000[5]	10,700[4]
Buffalo Creek	N. Fork Buffalo Creek	5 NW Iowa Park	Wichita	20,200	0	20,200	4,000	1,810
Paris	Sanders Creek	14 N Paris	Lamar	98,860	0	98,860	48,400	—

TABLE II-2D. RED RIVER BASIN (Cont'd)

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Barkman Creek	Barkman Creek	9 NW Texarkana	Bowie	15,900	0	15,900	55,000[6]	1,500
Total Proposed				**235,460**	**0**	**235,460**	**159,400**	**6,760**
Total Red Basin				**2,358,880**	**1,347,000**	**3,705,880**	**260,400**	**91,341**

[1] Texas share shown. Total conservation, 2,836,300; total flood, 2,694,000; total capacity, 5,530,300; and total area, 91,200.
[2] Storage authorized to be contracted for by nearby Texas cities.
[3] First stage.
[4] Excluded from totals.
[5] Only 27,000 acre-feet included in the total of this column to meet the amount of municipal and industrial water required by 1980.
[6] Includes 42,000 acre-feet of selected diversions from Red River.

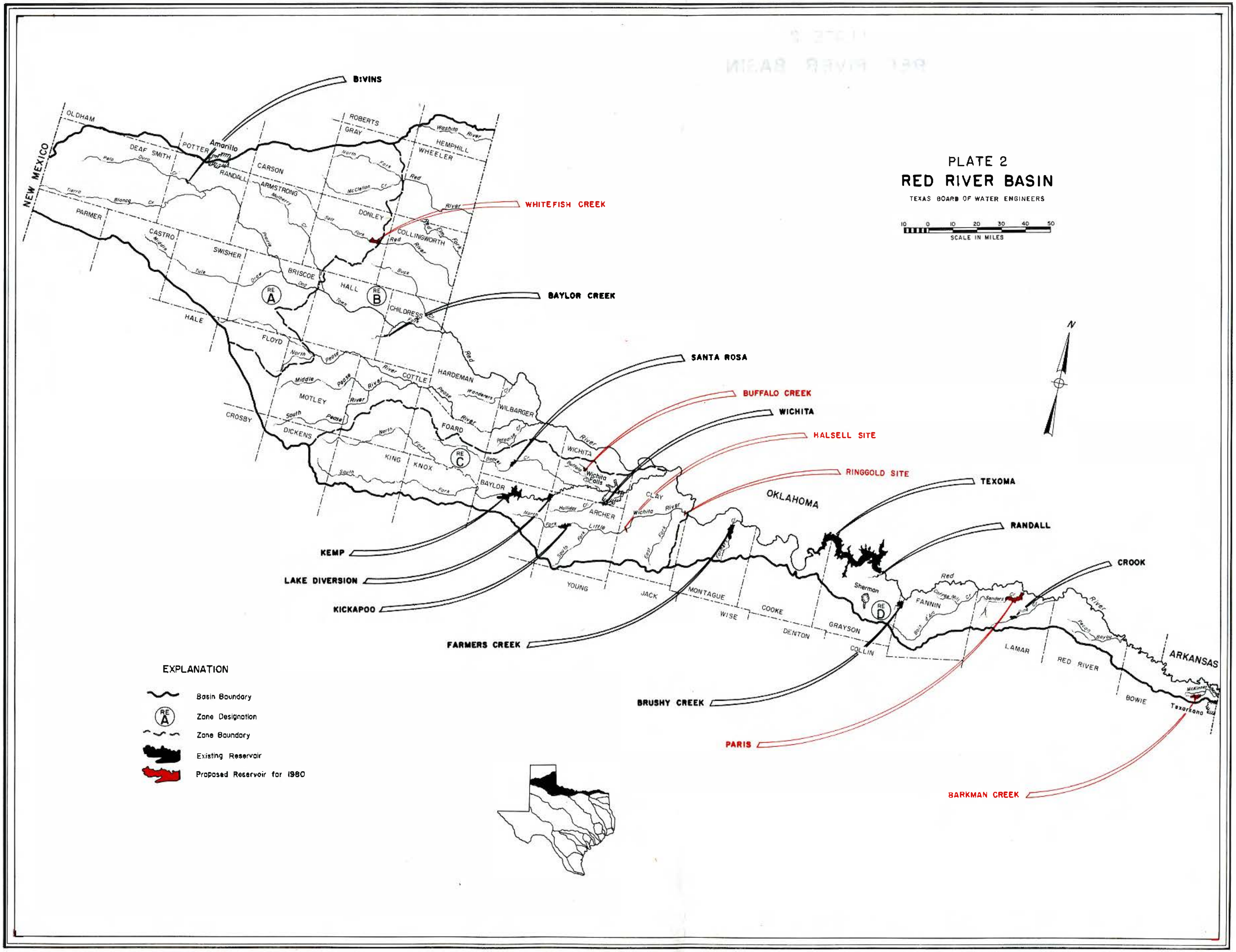


PLATE 2
RED RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
SCALE IN MILES
10 0 10 20 30 40 50
N
BIVINS
WHITEFISH CREEK
BAYLOR CREEK
SANTA ROSA
BUFFALO CREEK
WICHITA
HALSELL SITE
RINGGOLD SITE
TEXOMA
RANDALL
CROOK
KEMP
LAKE DIVERSION
KICKAPOO
FARMERS CREEK
BRUSHY CREEK
PARIS
BARKMAN CREEK
NEW MEXICO
OKLAHOMA
ARKANSAS
OLDHAM
POTTER
Amarillo
DEAF SMITH
RANDALL
CARSON
ROBERTS
GRAY
HEMPHILL
WHEELER
ARMSTRONG
DONLEY
COLLINGSWORTH
PARMER
CASTRO
SWISHER
BRISCOE
HALL
CHILDRESS
HALE
FLOYD
MOTLEY
COTTLE
HARDEMAN
WILBARGER
CROSBY
DICKENS
KING
KNOX
FOARD
WICHITA
BAYLOR
ARCHER
CLAY
YOUNG
JACK
MONTAGUE
WISE
COOKE
DENTON
GRAYSON
COLLIN
FANNIN
LAMAR
RED RIVER
BOWIE
Wichita Falls
Sherman
Texarkana
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Proposed Reservoir for 1980

SULPHUR RIVER BASIN

The Sulphur River Basin is shown on Plate 3. The river heads in, and drains a portion of, the extreme northeastern corner of Texas. It is a tributary to the Red River and joins that stream in Louisiana. All of this basin is located in the Gulf Coastal Plain geographical province.

Rainfall on the basin, ranges from an average annual value of 41 inches on the western headwater area to about 47 inches at the Texas-Arkansas boundary. In contrast, the annual net evaporation rates for the basin vary from an average of about 28 inches on the western headwaters to about 8 inches at Texarkana. The high rainfall in the basin produces runoff which varies from about 450 acre-feet per square mile per year in the upper watershed to over 650 acre-feet per square mile near the eastern State line.

Data of the chemical quality of the Sulphur River water indicates general suitability for municipal, industrial, and agricultural uses. For the 1959 water year, the weighted average of dissolved solids was 167 ppm (parts per million) for the South Sulphur River near Cooper.

The Sulphur River Basin ground-water reconnaissance study is scheduled for completion in September 1962.

Small quantities of fresh ground water are available in the Sulphur River Basin. The aquifers in the basin are only moderately extensive and productive. However, quantities of ground water adequate for small towns and industries are generally available in areas where the principal aquifers occur.

The two principal aquifers in the basin are the Nacatoch sand and the Carrizo-Wilcox sands. Plate 25 shows the extent of the Carrizo-Wilcox aquifer. Within the basin, the productive limits of the Nacatoch form a narrow strip extending from east-central Hunt County to southwestern Red River County. Although not considered a principal aquifer, the Blossom sand is of local importance in Lamar and Red River Counties.

Ground water available from the principal aquifers is chemically suitable for municipal and most industrial and irrigation uses.

Present water uses in the basin are small and are shown in Table II-3A to total 11,480 acre-feet. Of this total, 2,860 acre-feet was obtained from ground-water sources; and 8,620 acre-feet, from surface-water supplies.

Municipal and industrial water requirements for the basin are estimated to be 23,400 acre-feet in 1980. Of this total, 21,900 acre-feet may be supplied from surface water; and 1,500 acre-feet, from ground-water sources.

Three existing reservoirs in the Sulphur River Basin will provide for much of the 1980 water requirements in that basin. These are Whiteoak Bayou Reservoir for Sulphur Springs, Texarkana Reservoir for Texarkana, and River Crest Reservoir for the Texas Power and Light Company plant. Cooper Reservoir on the South Sulphur River is proposed to serve Commerce, Cooper, and Sulphur Springs. This single reservoir would have a yield in excess of the total 1980 requirements of the Sulphur River Basin. Development of Cooper Reservoir to the optimum capacity would provide an opportunity to supply water to meet the demands of areas to the south and west. This plan provides for water from Cooper Reservoir to serve a part of the future needs of the North Texas Municipal Water District in the Trinity River Basin. Smaller communities in the Sulphur River Basin will continue to be served from ground-water sources.

TABLE II-3A. SULPHUR RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	1,540	4,060	5,600
Industrial	170	2,060	2,230
Irrigation	1,150	2,500	3,650
Total Zone A	**2,860**	**8,620**	**11,480**
Total Sulphur Basin	**2,860**	**8,620**	**11,480**

TABLE II-3B. SULPHUR RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Commerce	1,500	0	1,500	Cooper
Cooper	900	0	900	Cooper
Sulphur Springs	2,500	0	500 2,000	Cooper White Oak Bayou
Texas Power & Light Co.	10,000	0	10,000	River Crest with selected diversions from Sulphur River
Texarkana	7,000	0	7,000	Texarkana
Distributed	1,500	1,500	0	
Total Zone A	23,400	1,500	21,900	
Total Sulphur Basin	23,400	1,500	21,900	

Summary for Sulphur Basin

Requirements supplied by:

Ground Water	1,500
Surface Water	21,900
Total requirements	23,400

TABLE II-3C. SULPHUR RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
Cooper	84,100		Commerce	1,500		
			Cooper	900		
			Sulphur Springs	500		
			Trinity Basin (TR), Zone A:			
			North Texas Municipal Water District		7,600	
			Total Zone A, TR.		7,600	
Total Cooper	*84,100*	*0*		*2,900*	*7,600*	*73,600*
White Oak Bayou	*2,000*		Sulphur Springs	*2,000*	*0*	*0*
River Crest (off channel)	*10,000*[1]		Tex. Power & Light Co.	*10,000*	*0*	*0*
Texarkana	*160,300*		Texarkana	*7,000*	*0*	*153,300*
Total Zone A	256,400	0		21,900	7,600	226,900
Total Sulphur Basin	256,400	0		21,900	7,600	226,900

[1] Selected diversions from Sulphur River.

Summary for Sulphur Basin

Used in Sulphur Basin	21,900
Exports to Trinity Basin	7,600
Yield remaining for municipal and industrial uses after 1980	226,900
Total yield	256,400

TABLE II-3D. SULPHUR RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
River Crest[1]	Sulphur River	7 SE Bogata	Red River	7,200	0	7,200	10,000[2]	560
Texarkana	Sulphur River	11 SW Texarkana	Bowie	145,000	2,509,000	2,654,000	160,300	20,000
Total Existing	....	....	....	**152,200**	**2,509,000**	**2,661,200**	**170,300**	**20,560**
Proposed								
Cooper	Sulphur River	5 SE Cooper	Delta-Hopkins	142,800	130,000	272,800	84,100	11,600
Total Proposed	....	....	....	**142,800**	**130,000**	**272,800**	**84,100**	**11,600**
Total Sulphur Basin	....	....	....	**295,000**	**2,639,000**	**2,934,000**	**254,400**	**32,160**

[1] Off channel to Sulphur River.
[2] Selected diversions from Sulphur River.

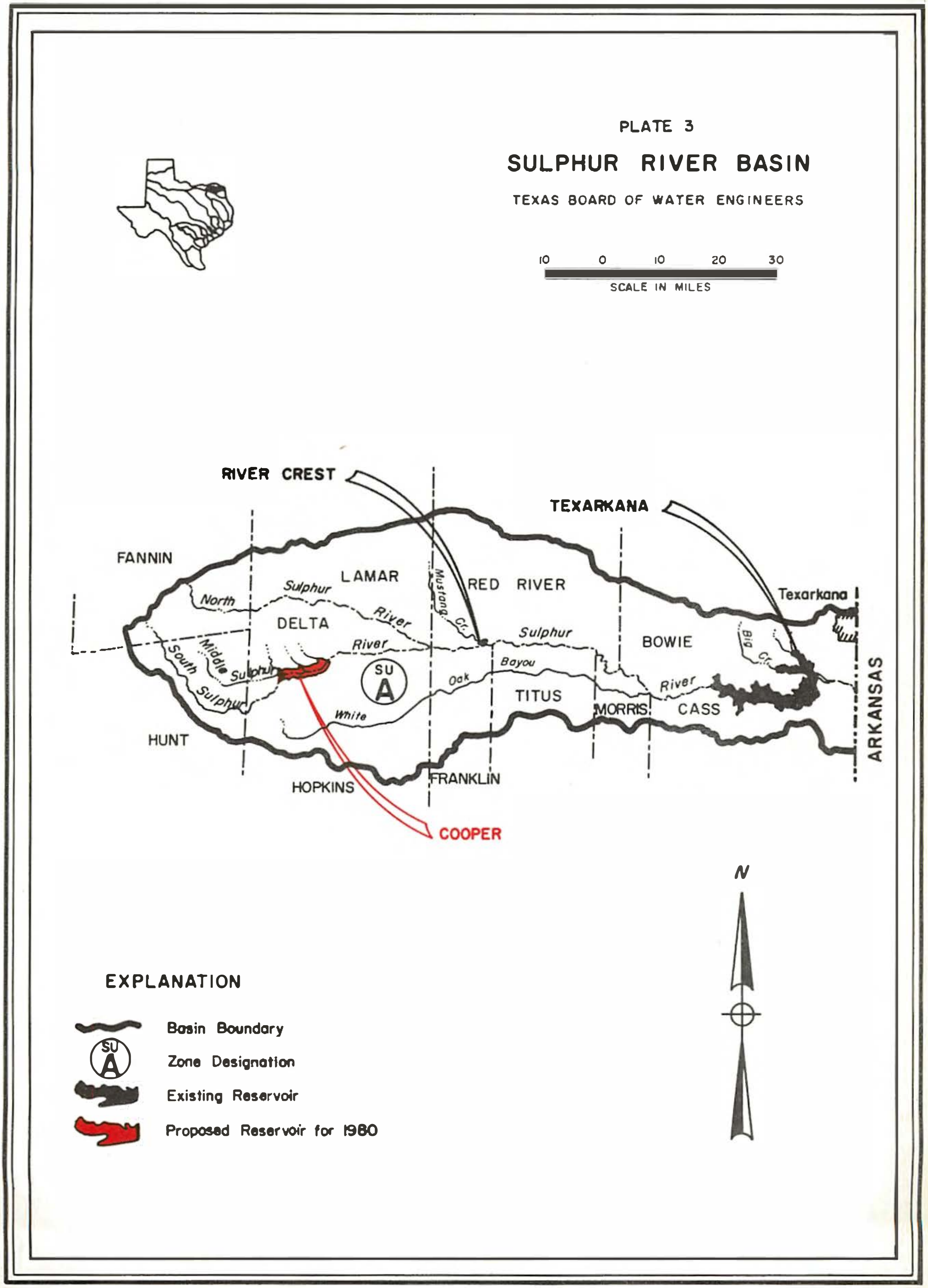


PLATE 3
SULPHUR RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
RIVER CREST
TEXARKANA
FANNIN
LAMAR
RED RIVER
North
Sulphur
River
DELTA
Mustang Cr.
Sulphur
Texarkana
BOWIE
Big Cr.
South
Middle
Sulphur
River
Bayou
SU A
Oak
River
White
TITUS
MORRIS
CASS
ARKANSAS
HUNT
HOPKINS
FRANKLIN
COOPER
N
EXPLANATION
Basin Boundary
Zone Designation
Existing Reservoir
Proposed Reservoir for 1980

CYPRESS CREEK BASIN

Cypress Creek drains a portion of northeastern Texas and is a tributary of the Red River which it joins in Louisiana. The Cypress Creek Basin is located wholly within the Gulf Coastal Plain geographical province. Its outline is shown on Plate 4.

Rainfall in this basin ranges from about an average of 42 inches in its headwaters to about 47 inches annually at the Texas-Louisiana boundary. Such rainfall produces correspondingly high average annual runoff rates, which vary from about 550 to over 650 acre-feet per square mile per year. Net evaporation rates range from an average of about 16 inches annually in the headwater reaches to about 6 inches annually at the State boundary.

The chemical quality of surface water in the Cypress Creek Basin in Texas, based on periodic sampling, is indicated to be such that the water is chemically suitable for municipal, agricultural, and most industrial uses.

The ground-water reconnaissance study for this basin will be completed in September 1962.

The Carrizo-Wilcox sands, the principal aquifer, occurs throughout the entire Cypress Creek Basin as shown on Plate 25. These sands comprise the only principal aquifer and now yield small quantities of water chiefly for municipal purposes. However, additional quantities are available, even though the Carrizo-Wilcox is not potentially as productive in the Cypress Creek Basin as it is in some other basins because of its relatively thin section of sands in the basin. The Queen City formation is an aquifer of minor importance in the basin.

The chemical quality of Carrizo-Wilcox water is only fair, but the water is generally suitable for irrigation, municipal, and some industrial uses.

The relatively small present municipal, industrial, and irrigation uses of water are listed in Table II-4A, and total only 38,330 acre-feet. Of this total, 3,950 acre-feet was supplied from ground-water sources; and 34,380 acre-feet, from surface water.

Municipal and industrial water requirements for 1980 for the basin are estimated to be 49,100 acre-feet. Of these requirements, about 2,100 acre-feet is indicated to be supplied from ground-water sources; and 47,000 acre-feet, from surface-water supplies.

Tables II-4B, II-4C, and II-4D outline how the 1980 municipal and industrial water requirements may be met in this basin. The 5 existing reservoirs in the Cypress Creek Basin will be adequate to meet projected needs of the area. Lake O'the Pines and Ellison Creek Reservoir will provide for the needs of the Northeast Texas Municipal Water District and Lone Star Steel Company at Daingerfield. Diversions from Cypress Creek at the head of Caddo Lake will continue to serve Marshall. Tankersly Creek and Hart Creek Reservoirs will serve Mount Pleasant. Ground water will provide for the remaining water requirements in the basin.

TABLE II-4A. CYPRESS CREEK BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	2,960	4,650	7,610
Industrial	690	28,460	29,150
Irrigation	300	1,270	1,570
Total Zone A	**3,950**	**34,380**	**38,330**
Total Cypress Basin	**3,950**	**34,380**	**38,330**

TABLE II-4B. CYPRESS CREEK BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Mount Pleasant	2,400	0	400	Hart Creek
			2,000	Tankersly Creek
Northeast Texas Municipal Water District	44,600	0	44,600	Lake O'the Pines
Distributed	2,100	2,100	0	
Total Zone A	49,100	2,100	47,000	
Total Cypress Basin	49,100	2,100	47,000	

Summary for Cypress Basin

Requirements supplied by:

Ground Water	2,100
Surface Water	47,000
Total requirements	49,100

TABLE II-4C. CYPRESS CREEK BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
Hart Creek	*400*		Mount Pleasant	*400*	*0*	*0*
Tankersly Creek	*2,200*		Mount Pleasant	*2,000*	*0*	*200*
Lake O'the Pines	*199,900*		Northeast Texas Municipal Water District	*44,600*	*0*	*155,300*
Caddo	35,000[1]		Sabine Basin (SB), Zone B:			
			Marshall	0	21,800	13,200
			Total Zone B, SB	0	21,800	13,200
Total Caddo	*35,000*[1]	*0*		*0*	*21,800*	*13,200*
Total Zone A	237,500	0		47,000	21,800	168,700
Total Cypress Basin	237,500	0		47,000	21,800	168,700

[1] Amount required to supply the city of Marshall's permits.

Summary for Cypress Basin

Used in Cypress Basin	47,000
Export to Sabine Basin	21,800
Yield remaining for municipal and industrial uses after 1980	168,700
Total yield	237,500

TABLE II-4D. CYPRESS CREEK BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

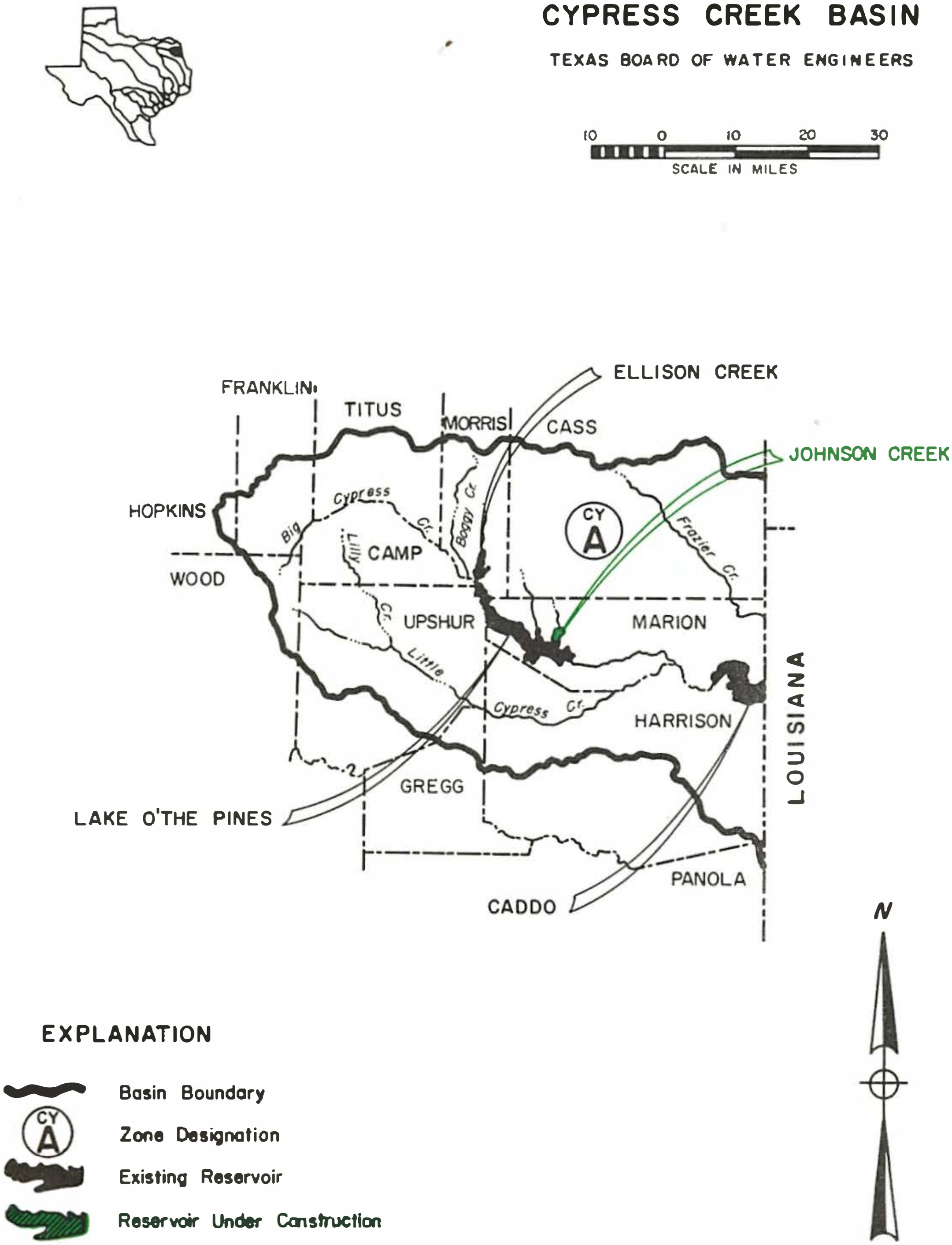
Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Ellison Creek	Ellison Creek	8 S Daingerfield	Morris	24,700	0	24,700	—	1,516
Lake O'the Pines	Cypress Creek	8 W Jefferson	Marion	254,900	587,200	842,100	199,900	20,000
Johnson Creek[1]	Johnson Creek	13 NW Jefferson	Marion	10,100	0	10,100	—	650
Caddo	Cypress Creek	29 NE Marshall	Marion-Harrison	58,000[2]	0	58,000	35,000[3]	11,000[2]
Total Existing				**347,700**	**587,200**	**934,900**	**234,900**	**33,166**
Proposed								
None								
Total Cypress Basin				**347,700**	**587,200**	**934,900**	**234,900**	**33,166**

[1] Under construction.
[2] Conservation capacity and surface area in Texas. Total conservation capacity 175,000 acre-feet, and total surface area at top of conservation pool 32,700 acres.
[3] Amount required to supply permit of City of Marshall.

PLATE 4

CYPRESS CREEK BASIN

TEXAS BOARD OF WATER ENGINEERS



SABINE RIVER BASIN

The Sabine River rises on the upper Gulf Coastal Plain north of Greenville and flows in a southeasterly direction to Logansport, Louisiana, and then south to the Gulf of Mexico. From a short distance above Logansport to the Gulf, the Sabine forms the state boundary between Texas and Louisiana. The Sabine River Basin, shown on Plate 5, has been divided into four zones.

Rainfall throughout the basin ranges from an average of about 39 inches annually in the headwaters to about 49 inches at Logansport to about 55 inches near its mouth. Correspondingly, the average annual net evaporation losses range from about 30 inches near the headwaters to about 4 inches near Logansport to about 4 inches near the mouth.

In this basin, large volumes of surface runoff occur, varying from an average of about 400 acre-feet per square mile in the upper reaches to about 650 acre-feet per square mile near Logansport to a high for the State of about 1,100 acre-feet per square mile in the lower reaches.

Surface water in the Sabine River Basin in Texas averages less than 200 ppm (parts per million) total dissolved solids; and the water is generally excellent for municipal, industrial, and agricultural uses. For the 1959 water year, the weighted average of dissolved solids was 188 ppm for the Sabine River near Tatum and 109 ppm near Ruliff.

A reconnaissance ground-water study of this basin will be completed in September 1962. More comprehensive ground-water studies have been made only in the Smith County area of the basin.

Large quantities of fresh ground water are available in the Sabine River Basin except in its upper reaches. The ground-water resources of the basin are essentially unused and have a large potential for additional development. The only part of the basin where moderate quantities are presently used is in, and near, the city of Orange. Uses of ground water in the basin are about four-fifths for municipal and industrial purposes and one-fifth for irrigation.

The Carrizo-Wilcox sands; the Miocene sands (Catahoula-Oakville-Lagarto); and the Coastal sands (Goliad-Willis-Lissie-Beaumont) are the principal aquifers in the basin. Because the Miocene sands and Coastal sands are lithologically similar and because wells draw water from both aquifers in parts of the area, they are treated here as a combined aquifer, referred to as the Miocene-Coastal sands. The approximate areas in which the Carrizo-Wilcox and the Miocene-Coastal sands yield fresh water are shown on Plate 25.

Minor aquifers, such as the Nacatoch and Queen City, are locally important and yield adequate quantities of water for domestic and stock supplies and in some instances supplies for small towns and industries.

The chemical quality of water from the principal aquifers in the basin ranges from excellent to poor; but generally, the water obtained in the areas shown on Plate 25 is suitable for irrigation, municipal, and most industrial uses.

Present uses of water in this basin, as listed in Table II-5A, total 232,800 acre-feet. Of this total, 32,710 acre-feet was pumped from underground supplies, and 200,090 acre-feet was derived from surface-water sources.

The 1980 municipal and industrial water requirements for this basin are estimated to be 307,900 acre-feet. Of this total, it is indicated that 9,900 acre-feet may be supplied from ground water; and 298,000 acre-feet, from surface-water sources.

Three existing and three proposed reservoirs will supply most of the future water needs of the basin. Lake Tawakoni (Iron Bridge Dam) will provide for Greenville and can supply distributed smaller demands in the upper Sabine Basin. Water for Dallas and Terrell in the Trinity River Basin will also be pumped from this reservoir. The existing Lake Cherokee, together with the proposed Kilgore Reservoir on Rabbit Creek in Smith County and the proposed Cherokee Reservoir No. 2 on Cherokee Bayou in Rusk County, will provide for the needs of Longview, Kilgore, and Gladewater, plus supplying a portion of the water needs of Henderson in the Neches River Basin. The existing Murvaul Reservoir will be adequate to meet the needs of the area it serves. Ground-water use will be continued for a number of communities in the basin.

The largest project proposed for development in this basin is the Toledo Bend Reservoir on the State line reach of the Sabine River in Shelby, Sabine, and Newton Counties. Toledo Bend Reservoir is planned for municipal, industrial, irrigation, and hydroelectric power purposes. This project will be a joint venture by the states of Texas and Louisiana and local interests, and will provide firm water supplies to both states. The future water needs of the lower Sabine River Basin in Texas can be served from Toledo Bend Reservoir.

Details of the water requirements, how they may be met, and existing and proposed reservoirs are contained in Tables II-5B, II-5C, and II-5D.

Other reservoirs considered in this basin for later development include Carthage, Stateline, Bon Weir, Lake Fork, Big Sandy, Rabbit, and Newton.

TABLE II-5A. SABINE RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	70	2,140	2,210
Industrial	0	0	0
Irrigation	70	410	480
Total Zone A	**140**	**2,550**	**2,690**
Zone B			
Municipal	3,300	5,840	9,140
Industrial	2,380	7,960	10,340
Irrigation	1,510	4,380	5,890
Total Zone B	**7,190**	**18,180**	**25,370**
Zone C			
Municipal	970	750	1,720
Industrial	0	0	0
Irrigation	170	50	220
Total Zone C	**1,140**	**800**	**1,940**
Zone D			
Municipal	4,340	1,060	5,400
Industrial	5,930	7,870	13,800
Irrigation	13,970	11,600	25,570
Total Zone D	**24,240**	**20,530**	**44,770**
Basin Totals			
Municipal	8,680	9,790	18,470
Industrial	8,310	15,830	24,140
Irrigation	15,720	16,440	32,160
Total Sabine Basin	32,710	42,060	74,770

TABLE II-5B. SABINE RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Greenville	13,000	0	13,000	Tawakoni
Distributed	6,000	500	5,500	Tawakoni
Total Zone A	19,000	500	18,500	
Zone B				
Longview, Gladewater, and Kilgore	49,100	0	18,000	Cherokee
			25,600	Cherokee No. 2
			5,500	Kilgore
Marshall	21,800	0	21,800	Import from Caddo in Zone A, Cypress Basin
Distributed	33,100	4,100	9,000	Tawakoni
			20,000	Murvaul
Total Zone B	104,000	4,100	99,900	
Zone C				
Distributed	8,700	1,000	7,700	Toledo Bend
Total Zone C	8,700	1,000	7,700	
Zone D				
Orange	159,400	0	159,400	Toledo Bend
Distributed	16,800	4,300	12,500	Toledo Bend
Total Zone D	176,200	4,300	171,900	
Total Sabine Basin	307,900	9,900	298,000	

Summary for Sabine Basin

Requirements supplied by:

Ground Water		9,900
Surface Water	276,200	
Import from Cypress Basin	21,800	
Total surface water		298,000
Total requirements		307,900

TABLE II-5C. SABINE RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
Tawakoni	224,200		Greenville	13,000		
			Distributed	5,500		
			Distributed, Zone B	9,000		
			Trinity Basin (TR), Zone A:			
			Dallas		112,100	
			Terrell		2,100	
			Total Zone A, TR		114,200	
Total Tawakoni	*224,200*	*0*		*27,500*	*114,200*	*82,500*
Total Zone A	**224,200**	**0**		**27,500**	**114,200**	**82,500**
Zone B						
Cherokee System: Kilgore, Cherokee, Cherokee No. 2	58,500		Longview, Kilgore, and Gladewater	49,100		
			Neches Basin (NE), Zone A:			
			Henderson		4,400	
			Total Zone A, NE		4,400	
Total Cherokee System	*58,500*	*0*		*49,100*	*4,400*	*5,000*
Murvaul	*29,000*	*0*	Distributed	*20,000*	*0*	*9,000*
Caddo in Cypress Basin	—	*21,800*	Marshall	*21,800*	—	—
Total Zone B	**87,500**	**21,800**		**90,900**	**4,400**	**14,000**
Zone C						
Toledo Bend (Texas share)	1,182,300		Distributed	7,700		
			Orange, Zone D	159,400		
			Distributed, Zone D	12,500		
Total Toledo Bend	*1,182,300*	*0*		*179,600*	*0*	*1,002,700*[1]
Total Zone C	**1,182,300**	**0**		**179,600**	**0**	**1,002,700**
Zone D						
No reservoirs in zone	0	0		0	0	0
Total Sabine Basin	**1,494,000**	**21,800**		**298,000**	**118,600**	**1,099,200**

[1] Yield remaining for municipal, industrial, and other uses.

Summary for Sabine Basin

Used in Sabine Basin		276,200
Exports to other basins:		
Trinity Basin	114,200	
Neches Basin	4,400	
Total exports		118,600
Yield remaining:		
Municipal and industrial uses after 1980	96,500	
Other present or future uses	1,002,700	
Total yield remaining		1,099,200
Total yield		1,494,000
Import from Cypress Basin		21,800

TABLE II-5D. SABINE RIVER BASIN

Data For Reservoirs Over 5000 Acre-Feet

(Tables bearing this general title are discussed at the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Tawakoni	Sabine River	9 NE Wills Point	Hunt	930,000	0	930,000	224,200	36,700
Gladewater	Glade Creek	2 NW Gladewater	Upshur	6,950	0	6,950	—	800
Cherokee	Cherokee Bayou	12 SE Longview	Gregg-Rusk	62,400	0	62,400	18,000	3,480
Murvaul	Murvaul Bayou	10 SW Carthage	Panola	45,840	0	45,840	29,000	3,820
Total Existing				**1,045,190**	**0**	**1,045,190**	**271,200**	**44,800**
Proposed								
Kilgore	Wilds Creek	6 WSW Kilgore	Rusk	16,270	0	16,270	5,500	817
Cherokee No. 2	Cherokee Bayou	12 NNE Henderson	Rusk	112,320	0	112,320	35,000	4,440
Toledo Bend	Sabine River	14 NE Burkeville	Newton	2,238,400[1]	0	2,238,400[1]	1,182,300[2]	90,800[1]
Total Proposed				**2,366,990**	**0**	**2,366,990**	**1,222,800**	**96,057**
Total Sabine Basin				**3,412,180**	**0**	**3,412,180**	**1,494,000**	**140,857**

[1]Texas share shown. Total capacity, 4,476,800 and total area, 181, 600.

[2]Texas share of total annual yield of 2,364,600 acre-feet.

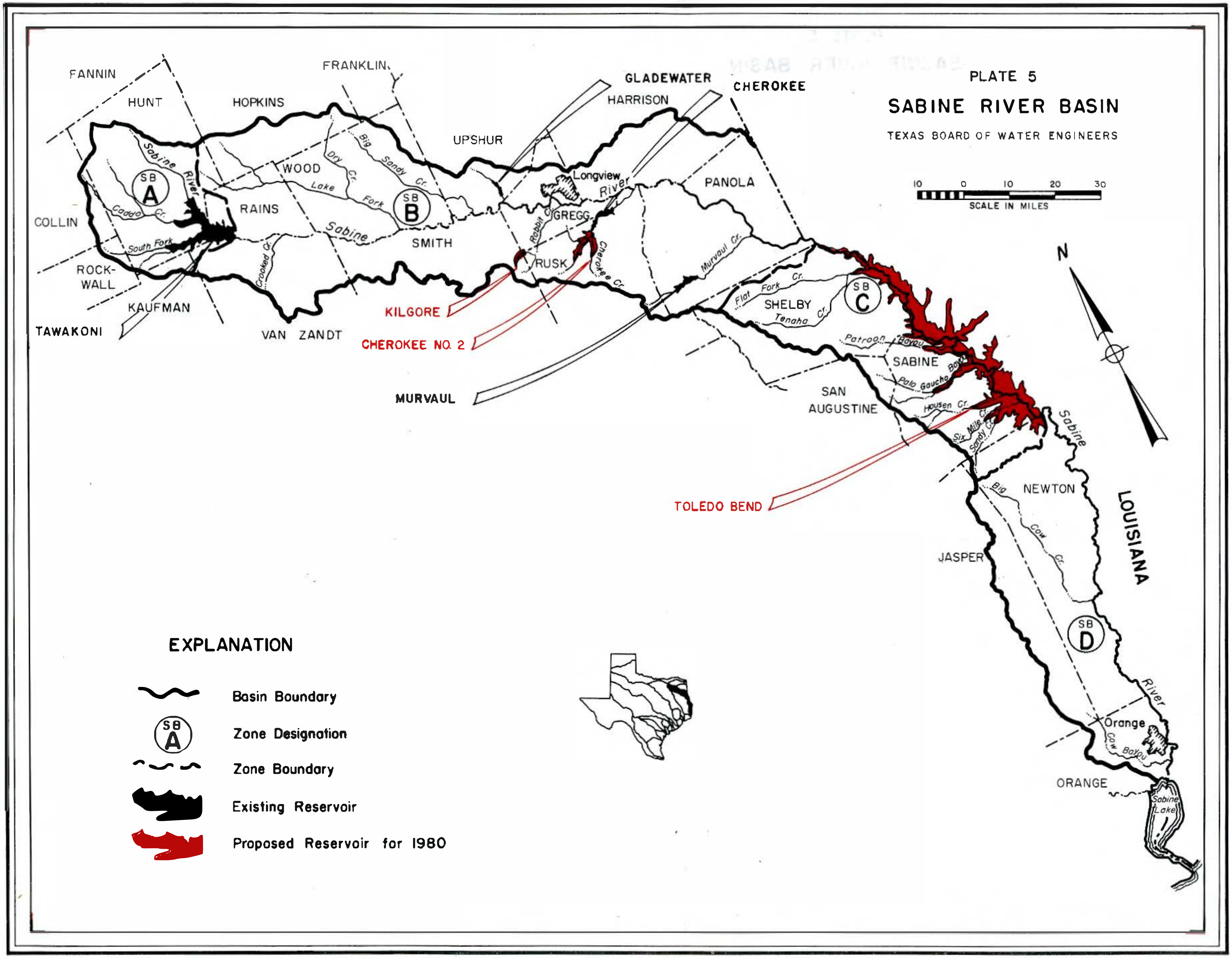


PLATE 5
SABINE RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
N
FANNIN
HUNT
HOPKINS
FRANKLIN
GLADEWATER
HARRISON
CHEROKEE
UPSHUR
WOOD
RAINS
COLLIN
ROCK-WALL
KAUFMAN
TAWAKONI
VAN ZANDT
SMITH
RUSK
GREGG
Longview
PANOLA
SHELBY
SABINE
SAN AUGUSTINE
NEWTON
JASPER
ORANGE
Orange
LOUISIANA
KILGORE
CHEROKEE NO. 2
MURVAUL
TOLEDO BEND
Sabine River
Caddo Cr.
South Fork
Lake Fork
Dry Cr.
Big Sandy Cr.
Sabine
Crooked Cr.
Rabbit Cr.
Cherokee Cr.
River
Murvaul Cr.
Flat Fork Cr.
Tenaha Cr.
Patroon Bayou
Palo Gaucho Bayou
Housen Cr.
Six Mile Cr.
Sandy Cr.
Big Cow Cr.
Cow Bayou
Sabine Lake
SB A
SB B
SB C
SB D
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Proposed Reservoir for 1980

NECHES RIVER BASIN

The Neches River rises on the upper portion of the Gulf Coastal Plain geographical province west of Tyler and follows a southerly course to empty into Sabine Lake below Beaumont. Plate 6 shows the basin divided into two zones. The principal tributary of the Neches River is the Angelina River, which drains the northeasterly portion of the watershed and which comprises about 35 percent of the basin area. Village Creek and Pine Island Bayou are the two large tributaries in the lower end of the basin.

Annual rainfall in the basin varies from an average of about 39 inches in the headwaters to about 47 inches in the middle portion to about 53 inches near the mouth. In contrast, the average annual net evaporation rates vary from about 22 inches near the headwaters to about 10 inches in the middle of the basin to about 4 inches near the mouth.

The Neches River Basin produces the largest volume of runoff of any river basin in Texas. Average annual runoff rates vary from about 450 acre-feet per square mile in the headwaters to about 950 acre-feet per square mile near the mouth.

Surface water in the Neches River Basin averages less than 250 ppm (parts per million) total dissolved solids and is generally excellent for municipal, industrial, and agricultural uses. For the 1959 water year, the weighted average of dissolved solids for the Angelina River (the principal tributary) near Lufkin was 111 ppm and for the Neches River near Evadale was 89 ppm.

The ground-water reconnaissance study for this basin will be completed in September 1962. In the Smith County area of the basin, more comprehensive studies have been completed.

Moderately large quantities of water of a chemical quality suitable for irrigation, municipal, and most industrial purposes are now being pumped from aquifers of this basin. Pumpage is concentrated in local areas; and as a whole, the ground-water resources of the basin are only partially developed.

The principal aquifers of the basin are the Carrizo-Wilcox sands, the Miocene sands (Catahoula-Oakville-Lagarto), and the Coastal sands (Goliad-Willis-Lissie-Beaumont). Because the Miocene and Coastal sands are lithologically similar and because wells draw water from both aquifers in parts of the area, they are discussed here as a combined aquifer referred to as the Miocene-Coastal sands. The areas where the principal aquifers yield fresh water are shown on Plate 25.

Approximately 70 percent of the pumpage from Carrizo-Wilcox sands is for industrial use and occurs in the vicinity of Lufkin. Most of the pumpage from Miocene-Coastal sands is for industrial purposes in the east-central part of Hardin County and an adjoining area of Jasper County and for irrigation in the southwest part of Hardin County.

Where the principal aquifers come to the surface, the material is generally quite permeable; and because of the abundant rainfall, recharge conditions are good.

Present uses of water in this basin total 284,400 acre-feet, of which 210,620 acre-feet is served from surface-water sources; and 73,780 acre-feet, from ground water. Pertinent information concerning present uses in the Neches Basin is listed by zones in Table II-6A.

Projected 1980 municipal and industrial water requirements by zones and places of use within the zones are set forth in Table II-6B, and total 469,100 acre-feet. Of this basin requirement, 393,800 acre-feet is indicated to be supplied from surface water; and 75,300 acre-feet, from ground-water sources. Pertinent details relative to the water requirements and means of serving these needs are contained in Table II-6C.

The plan for the Neches River Basin includes the use of 5 existing, 3 under-construction, and 3 proposed reservoirs, together with a continued use of ground water.

Water requirements of Tyler in 1980 can be met from the existing Lake Tyler, the reservoir on Mud Creek in Smith County, on which construction has been initiated, and from Blackburn Crossing Reservoir on the upper Neches River, which also is under construction. Blackburn Crossing Reservoir can also supply Rusk and smaller communities in the Neches Basin and the Palestine area in the Trinity River Basin.

The existing Gum Creek Reservoir will continue to serve the needs of Jacksonville.

Flat Creek Reservoir in Henderson County is proposed to serve Athens in the Trinity River Basin.

The existing Striker Creek Reservoir and Lake Kurth, an off-channel reservoir in Angelina County which has water diverted to it from the Angelina River, together with the proposed Ponta Reservoir are referred to herein as the Ponta System. These three reservoirs would serve Lufkin, Nacogdoches, the Southland Paper Mills in Angelina County, and the distributed smaller uses in this area. Southland Paper Mills will also continue to obtain a part of their water supply from existing ground-water facilities.

McGee Bend Reservoir on the Angelina River is under construction. This reservoir, the existing Dam B, and the proposed Salt Water Barrier are referred to herein as the McGee Bend System. This system can serve the municipal and industrial needs of Beaumont, Port Arthur, Groves, and the adjacent coastal area. Pertinent information on the reservoirs in the Neches River Basin is contained in Table II-6D.

One of the most important requirements in the development of the water resources of this basin is a salt-water barrier on the Neches River above Beaumont. Sea water intrudes up the river, and river flow required to keep the salt water away from the fresh-water intakes of the Lower Neches Valley Authority is about twice the average rate of use for the entire Beaumont-Port Arthur area. A salt-water barrier, with appropriate considerations for future extensions of navigation, will be needed in the reach of stream above the head of deep-water navigation and below the confluence of Pine Island Bayou. A site near Collier's Ferry appears promising. Such a structure could also provide a moderate amount of conservation storage capacity.

Other reservoirs have been proposed for the Neches River Basin. Projected water requirements for this basin indicate that the development of the Rockland Reservoir will not be needed in the immediate future. Henderson Reservoir near Henderson may be developed as an alternate to the use of water from Cherokee No. 2 Reservoir in the Sabine River Basin. Further long-range planning on this basin should give consideration to maximum upstream development by the provision of additional storage in Blackburn Crossing Reservoir.

TABLE II-6A. NECHES RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	9,950	8,550	18,500
Industrial	20,720	930	21,650
Irrigation	4,810	13,390	18,200
Total Zone A	35,480	22,870	58,350
Zone B			
Municipal	2,190	8,670	10,860
Industrial	24,100	6,850	30,950
Irrigation	12,010	58,240	70,250
Total Zone B	38,300	73,760	112,060
Basin Totals			
Municipal	12,140	17,220	29,360
Industrial	44,820	7,780	52,600
Irrigation	16,820	71,630	88,450
Total Neches Basin	73,780	96,630	170,410

TABLE II-6B. NECHES RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Henderson	4,400	0	4,400	Import from Cherokee System in Zone B, Sabine Basin
Jacksonville	2,100	0	2,100	Gum Creek
Tyler	32,300	0	15,000	Mud Creek
			11,100	Tyler
			6,200	Blackburn Crossing
Rusk	2,000	600	1,400	Blackburn Crossing
Lufkin	54,800	0	54,800	Ponta System
Nacogdoches	3,200	0	3,200	Ponta System
Southland Paper Mills	72,900	28,000	44,900	Ponta System
Distributed	72,400	20,400	33,000	Blackburn Crossing
			14,000	Ponta System
			5,000	McGee Bend System
Total Zone A	244,100	49,000	195,100	
Zone B				
Jasper	1,600	1,600	0	
Kountze	300	300	0	
Distributed	223,100	24,400	198,700	McGee Bend System
Total Zone B	225,000	26,300	198,700	
Total Neches Basin	469,100	75,300	393,800	

Summary for Neches Basin

Requirements supplied by:

Ground Water		75,300
Surface Water	389,400	
Import from Sabine Basin	4,400	
Total surface water		393,800
Total requirements		469,100

TABLE II-6C. NECHES RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zones A & B						
Cherokee System in Sabine Basin	—	*4,400*	Henderson	*4,400*	—	—
Gum Creek	*8,700*		Jacksonville	*2,100*	*0*	*6,600*
Tyler	*11,100*		Tyler	*11,100*	*0*	*0*
Mud Creek	*15,000*		Tyler	*15,000*	*0*	*0*
Blackburn Crossing	196,000		Tyler	6,200		
			Rusk	1,400		
			Distributed, Zone A	33,000		
			Trinity Basin (TR), Zone A:			
			Palestine		56,000	
			Total Zone A, TR		56,000	
Total Blackburn Crossing	*196,000*	*0*		*40,600*	*56,000*	*99,400*
Flat Creek	6,500		Trinity Basin (TR), Zone A:			
			Athens		1,800	
			Total Zone A, TR		1,800	4,700
Total Flat Creek	*6,500*			*0*	*1,800*	*4,700*
Ponta System			Lufkin	54,800		
Striker			Nacogdoches	3,200		
Ponta	339,700		Southland Paper Mills	44,900		
Kurth (off channel)			Distributed, Zone A	14,000		
Total Ponta System	*339,700*	*0*		*116,900*	*0*	*222,800*[1]
McGee Bend System			Distributed, Zone A	5,000		
McGee Bend			Distributed, Zone B	198,700		
Dam B, Zone B						
Salt Water Barrier Zone B	757,000		Neches-Trinity Coastal Area (NE-TR), Zone A:			
			Beaumont		89,900	
			Groves		3,100	
			Port Arthur		21,300	
			Distributed		160,700	
			Total Zone A, NE-TR		275,000	
Total McGee Bend System	*757,000*	*0*		*203,700*	*275,000*	*278,300*[1]
Total Zones A & B	**1,334,000**	**4,400**		**393,800**	**332,800**	**611,800**
Total Neches Basin	**1,334,000**	**4,400**		**393,800**	**332,800**	**611,800**

[1] Yield remaining for municipal, industrial, and other uses.

Summary for Neches Basin

Used in Neches Basin		389,400
Exports to other basins or coastal areas:		
Neches-Trinity Coastal Area	275,000	
Trinity Basin	57,800	
Total exports		332,800
Yield remaining:		
Municipal and industrial uses after 1980	110,700	
Other present or future uses	501,100	
Total yield remaining		611,800
Total yield		1,334,000
Import from Sabine Basin		4,400

TABLE II-6D. NECHES RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Blackburn Crossing[1]	Neches River	4 E Frankston	Anderson-Cherokee	407,000	0	407,000	196,000	25,500
Gum Creek	Gum Creek	5 SW Jacksonville	Cherokee	30,500	0	30,500	8,700	1,320
Tyler	Prairie Creek	12 SE Tyler	Smith	43,400	0	43,400	11,100	2,450
Mud Creek[1]	Mud Creek	13 SE Tyler	Smith	44,000	0	44,000	15,000	2,580
Striker	Striker Creek	18 SW Henderson	Rusk	26,700	0	26,700	20,600	2,400
Kurth	Angelina River (off channel)	8 N Lufkin	Angelina	16,200	0	16,200	19,100[2]	800
McGee Bend[1]	Angelina River	11 NNW Jasper	Jasper-Tyler	2,891,900	1,148,900	4,040,800	525,000	114,550
Dam B	Neches River	1 N Town Bluff	Jasper-Tyler	94,200	0	94,200	86,000	13,700
Total Existing				**3,553,900**	**1,148,900**	**4,702,800**	**881,500**	**163,300**
Proposed								
Flat Creek	Flat Creek	9 E Athens	Henderson	32,800	0	32,800	6,500	1,520
Ponta	Angelina River	11 E Rusk	Cherokee-Nacogdoches	810,000	0	810,000	300,000	37,235
Salt Water Barrier	Neches River	6 WNW Vidor	Orange-Jefferson	17,000	0	17,000	146,000	4,250
Total Proposed				**859,800**	**0**	**859,800**	**452,500**	**43,005**
Total Neches Basin				**4,413,700**	**1,148,900**	**5,562,600**	**1,334,000**	**206,305**

[1] Under construction.
[2] Permitted diversion from Angelina River.

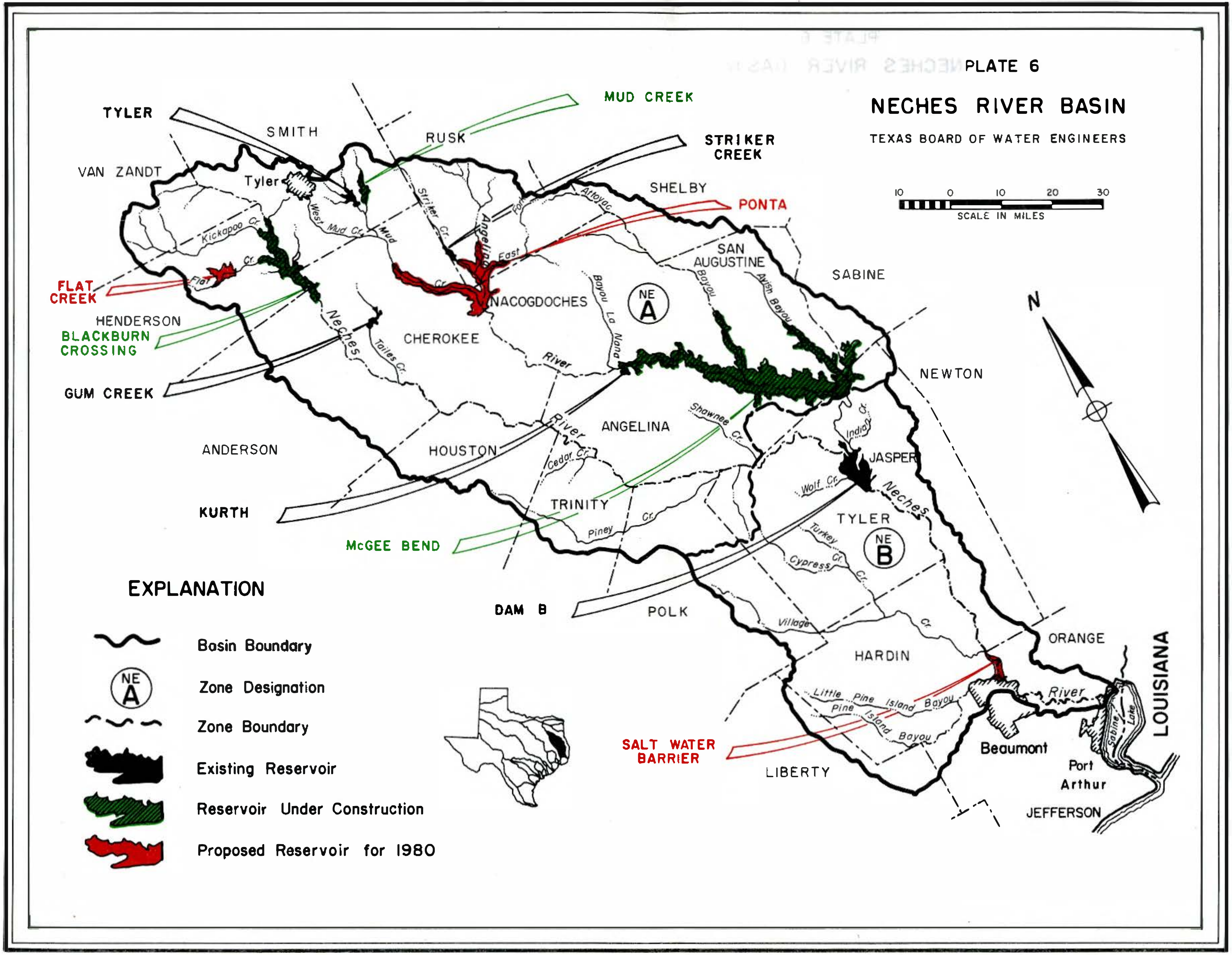


PLATE 6
NECHES RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
N
TYLER
MUD CREEK
STRIKER CREEK
PONTA
FLAT CREEK
BLACKBURN CROSSING
GUM CREEK
KURTH
McGEE BEND
DAM B
SALT WATER BARRIER
SMITH
VAN ZANDT
RUSK
SHELBY
SAN AUGUSTINE
SABINE
HENDERSON
CHEROKEE
NACOGDOCHES
NEWTON
ANDERSON
HOUSTON
ANGELINA
JASPER
TRINITY
TYLER
POLK
HARDIN
ORANGE
LIBERTY
JEFFERSON
LOUISIANA
Tyler
Beaumont
Port Arthur
Kickapoo Cr.
Flat Cr.
West Mud Cr.
Mud
Striker Cr.
Angelina
East Fork
Attoyac
Bayou La Nana
Ayish Bayou
Neches
Tailes Cr.
River
Shawnee Cr.
Cedar Cr.
Piney Cr.
Wolf Cr.
Indian Cr.
Turkey Cr.
Cypress Cr.
Village Cr.
Little Pine Island Bayou
Pine Island Bayou
Sabine Lake
NE A
NE B
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Reservoir Under Construction
Proposed Reservoir for 1980

NECHES-TRINITY COASTAL AREA

The Neches-Trinity Coastal Area, as shown on Plate 7, is located south of the Neches River Basin and east of the Trinity River Basin. This very flat area is a part of the Gulf Coastal Plain geographical province.

Rainfall occurs in large amounts and averages about 51 inches per year. This contrasts with the very low average annual net evaporation loss of about 6 inches. Average annual runoff rates range from 550 to 850 acre-feet per square mile.

Ground-water information for this and other upper coastal areas is discussed in a section immediately following this unit.

Present uses of water for municipalities, industries, and irrigation in this coastal area are listed in Table II-7A. Surface waters shown as being used in this area are diverted from both the Neches and Trinity Rivers.

The projected 1980 municipal and industrial water requirements for this coastal area totals 325,000 acre-feet. These amounts, as well as the possible means of supplying them by zones, are shown in Table II-7B. Details by zones of how the surface-water supplies may be provided are contained in Tables II-7C and II-7D. Information pertaining to the reservoirs to be utilized in serving these requirements is contained in the portion of the report describing the basin in which those reservoirs are located.

TABLE II-7A. NECHES-TRINITY COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	0	15,640	15,640
Industrial	840	98,350	99,190
Irrigation	1,980	236,700	238,680
Total Zone A	2,820	350,690	353,510
Zone B			
Municipal	140	0	140
Industrial	0	0	0
Irrigation	13,890	110,700	124,590
Total Zone B	14,030	110,700	124,730
Basin Totals			
Municipal	140	15,640	15,780
Industrial	840	98,350	99,190
Irrigation	15,870	347,400	363,270
Total Neches-Trinity Coastal Area	16,850	461,390	478,240

TABLE II-7B. NECHES-TRINITY COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Beaumont	89,900	0	89,900	Import from McGee Bend System in Zone A, Neches Basin
Groves	3,100	0	3,100	Import from McGee Bend System
Port Arthur	21,800	0	21,300	Import from McGee Bend System
Distributed	160,700	0	160,700	Import from McGee Bend System
Total Zone A	275,000	0	275,000	
Zone B				
Distributed	50,000	0	50,000	Import from Livingston System in Zones B and C, Trinity Basin
Total Zone B	50,000	0	50,000	
Total Neches-Trinity Coastal Area	325,000	0	325,000	

Summary for Neches-Trinity Coastal Area

Requirements supplied by:

Imports from other basins:

Neches Basin	275,000	
Trinity Basin	50,000	
Total imports		325,000
Total requirements		325,000

TABLE II-7C. NECHES-TRINITY COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution		Yield Remaining
Name	Yield		Place	Amount Used	
Zone A					
No reservoirs in zone	0	—		—	—
McGee Bend System in Neches Basin	—	*275,000*	Beaumont	89,900	
			Groves	3,100	
			Port Arthur	21,300	
			Distributed	160,700	
			Total McGee Bend System Import	*275,000*	—
Total Zone A	0	275,000		275,000	0
Zone B					
No reservoirs in zone	0	—		—	—
Livingston System in Trinity Basin	—	*50,000*	Distributed	*50,000*	—
Total Zone B	0	50,000		50,000	0
Total Neches-Trinity Coastal Area	0	325,000		325,000	0

Summary for Neches-Trinity Coastal Area

Imports from other basins:

Neches Basin	275,000
Trinity Basin	50,000
Total imports	325,000

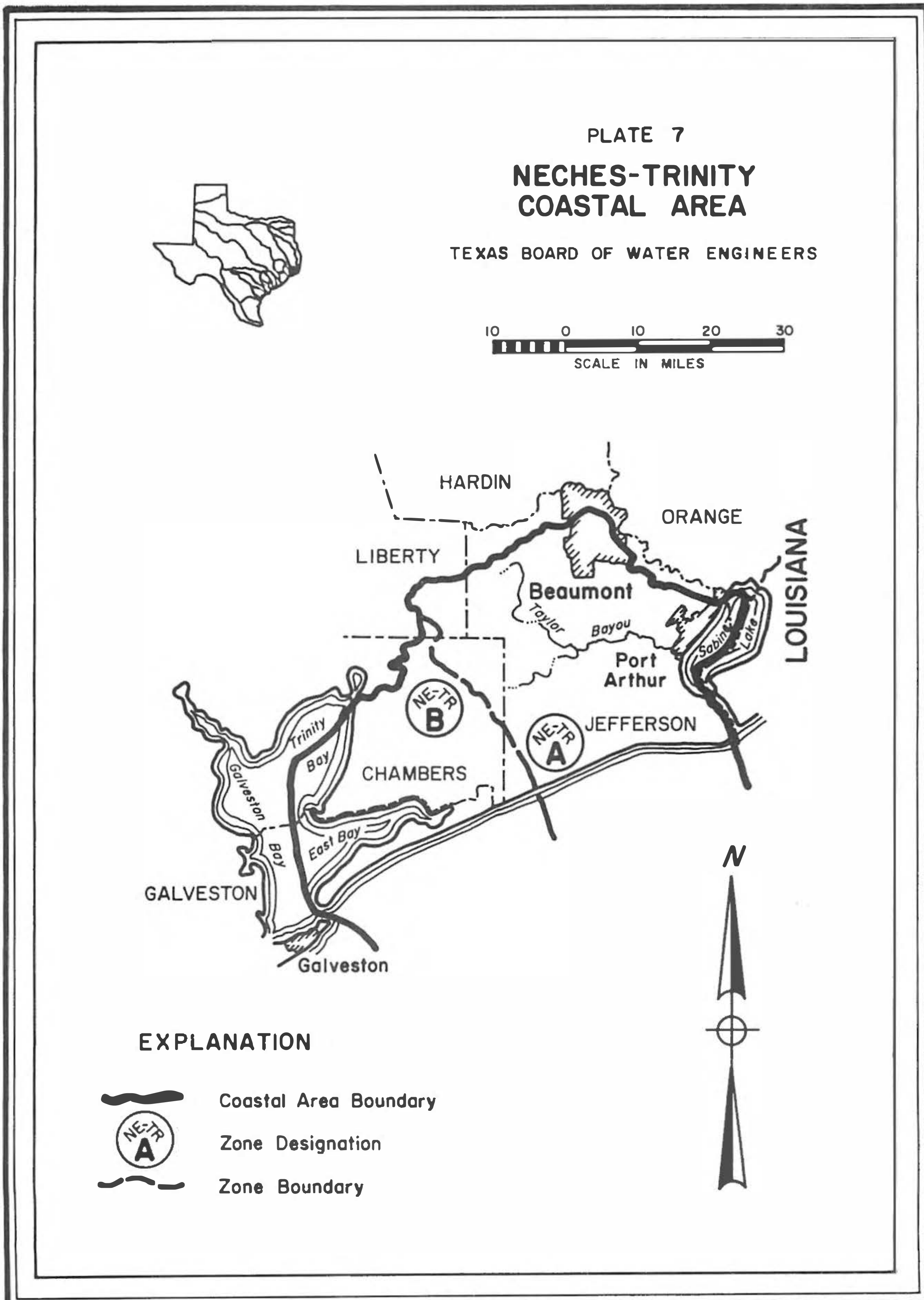


PLATE 7
NECHES-TRINITY
COASTAL AREA
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
HARDIN
ORANGE
LIBERTY
LOUISIANA
Beaumont
Taylor Bayou
Port Arthur
Sabine Lake
NE-TR B
NE-TR A
JEFFERSON
Trinity Bay
CHAMBERS
Galveston Bay
East Bay
GALVESTON
Galveston
N
EXPLANATION
Coastal Area Boundary
NE-TR A
Zone Designation
Zone Boundary

GROUND WATER OF UPPER COASTAL AREAS

To avoid repetition, there is combined here the discussion of ground water for the six coastal areas lying northeast of Victoria on the Guadalupe River. The names of these coastal areas and their unit numbers are

7. Neches-Trinity,
9. Trinity-San Jacinto,
11. San Jacinto-Brazos,
13. Brazos-Colorado,
15. Colorado-Lavaca,
17. Lavaca-Guadalupe.

The reconnaissance ground-water studies for the Upper Coastal Areas are scheduled for completion in September 1961. More comprehensive studies are available for the following counties in the Upper Coastal Areas: Brazoria, Calhoun, Chambers, Fort Bend, Galveston, Harris, and Victoria.

The principal aquifers in these coastal areas are the Miocene sands (Catahoula-Oakville-Lagarto) and the Coastal sands (Goliad-Willis-Lissie-Beaumont). Because the Miocene sands and the Coastal sands are lithologically similar and because wells draw water from both aquifers in parts of these areas, they are discussed as a combined aquifer referred to as the Miocene-Coastal sands. The locations of the area where the Miocene-Coastal sands yield fresh water are shown on Plate 25.

Very large quantities of ground water for these coastal areas are available from the principal aquifers, and an unknown quantity is potentially available from the Brazos River alluvium in a small area along the western edge of the San Jacinto-Brazos Coastal Area. Large withdrawals from the Miocene-Coastal sands are presently being made for municipal, industrial, and irrigation purposes throughout most of these Upper Coastal Areas.

The quality of water in the Miocene-Coastal sands is such that the water is generally good for most purposes in these coastal areas; however, it becomes brackish toward the Gulf. The encroachment of salt water in parts of the area near the coast is a factor to consider in planning future development.

The amount of recharge is not known, but the available recharge is considered to be large in relation to the present withdrawals from wells. The principal limiting factor to ground-water development is believed to be the ability of the sands to transmit water from areas of recharge to wells.

TRINITY RIVER BASIN

The Trinity River Basin, as shown on Plate 8, has been divided into three zones. The river heads northwest of Fort Worth in the Central Texas geographical province. The upper one-third of this watershed is located on the Osage Plains and Grand Prairie, while the remainder of the basin drains a portion of the Gulf Coastal Plain. Much of the upper part of the basin is composed of the tributary areas of the West Fork and Clear Fork above Fort Worth and the Elm Fork and East Fork north and east of Dallas. Important tributaries below Dallas are Cedar Creek and Richland Creek.

Rainfall in the basin varies widely from an average of about 26 inches annually in the headwaters of the West Fork to about 37 inches in the middle Trinity to 49 inches in the lower reach. Average annual net evaporation losses range from about 45 inches at Bridgeport Reservoir on the upper West Fork to about 25 inches at the confluence of Cedar Creek with the Trinity to about 10 inches near the mouth.

Surface runoff provides a large supply of water in this basin. Average annual runoff rates vary from about 100 acre-feet per square mile in the upper West Fork to about 350 acre-feet per square mile in the middle Trinity to about 600 acre-feet per square mile in the lower reach.

The chemical quality of water of the tributaries in the basin, ranges from excellent to good; and the water is suitable for municipal, agricultural, and most industrial uses. The main stream below Fort Worth and Dallas has a higher concentration of dissolved solids than the upper tributaries, but is suitable for agriculture and many industrial uses. The quality of the main-stream water improves gradually between Dallas and the mouth. For the 1959 water year, the weighted average of dissolved solids was 425 ppm (parts per million) for the Trinity River near Rosser (between Dallas and the mouth of Cedar Creek) and was 249 ppm at Romayor (State Highway 105 crossing, in Liberty County).

The reconnaissance ground-water study for this basin will be completed in September 1962. More detailed studies have been completed for the following areas: Chambers County; Leon County; Tarrant County; and the Gainesville Area, Cooke County.

The principal aquifers in the Trinity River Basin are the Trinity sands, the Woodbine sands, the Carrizo-Wilcox sands, the Sparta sands, the Miocene sands (Catahoula-Oakville-

Lagarto), and the Coastal sands (Goliad-Willis-Lissie-Beaumont). The Miocene sands and Coastal sands are discussed as a combined aquifer, because they are lithologically similar and because wells draw water from both aquifers in parts of the area. Large quantities of ground water are available from these aquifers and smaller quantities, adequate for domestic use and stock watering, and in some instances, supplies for small towns, industries, and irrigation are available for minor aquifers.

Plate 25 shows where the principal aquifers, with the exception of the Woodbine sands and Sparta sands, yield fresh water in this basin. The Woodbine yields fresh water in the eastern half of the area shown thereon for the Trinity sands of the basin, and the Sparta sands yield fresh water in approximately the southern third of the area shown for Carrizo-Wilcox sands in the basin.

The chemical quality of ground water available from the principal aquifers varies from aquifer to aquifer and within the same aquifer. Generally, the water obtained in the areas shown on Plate 25 is suitable for irrigation, municipal, and most industrial uses.

Present uses of water for municipalities, industries, and irrigation are listed by zones in Table II-8A, and total 442,840 acre-feet. Of this total, 339,050 acre-feet was obtained from surface water; and 103,790 acre-feet, from ground-water sources. Surface waters have been developed in this basin, particularly in its upper reaches, to meet municipal and industrial requirements of the river basin, which has the largest population in the State.

Projected 1980 municipal and industrial water requirements for this basin are indicated to be 866,500 acre-feet. Of this total, 792,300 acre-feet may be supplied from surface-water sources; and 74,200 acre-feet, from ground-water formations. The future municipal and industrial requirements and means of serving these requirements are shown in Table II-8B. Details pertaining to existing and proposed reservoirs in the basin are contained in the Tables II-8C and II-8D.

Water needs in 1980 in Tarrant County can be served by reservoirs referred to herein as the Fort Worth Area System. This system includes the existing Lake Worth and Bridgeport, Eagle Mountain, Benbrook, and Arlington Reservoirs, and also the under-construction Cedar Creek Reservoir in Henderson and Kaufman Counties. The continued use of some ground water in this area is also contemplated.

Weatherford's needs above those which can be obtained from the existing Weatherford Reservoir can be supplied from the Fort Worth Area System.

The Dallas Area System includes the existing Grapevine, Garza-Little Elm, and Lavon Reservoirs; the under-construction Forney Reservoir; and the proposed Aubrey Reservoir on Elm Fork as well as the proposed Lavon Reservoir Enlargement. Aubrey Reservoir will provide for: (1) the conversion to conservation storage of a portion of the present flood-control storage in Garza-Little Elm Reservoir, (2) the transfer of this flood-control storage upstream to Aubrey Reservoir, and (3) additional conservation storage in Aubrey Reservoir. Aubrey and Garza-Little Elm Reservoirs would be operated to serve both Dallas and Denton. The yield from the Grapevine Reservoir storage allocated to navigation has not been used to serve 1980 municipal and industrial needs. Dallas presently receives a small portion of its supply from Lavon Reservoir. This same amount has been continued in this plan. Dallas will also obtain water from the under-construction Forney Reservoir on East Fork and from the recently completed Lake Tawakoni on the Sabine River. The first-stage pipeline from Lake Tawakoni has been included in this plan. The existing Mountain Creek Reservoir will continue to be utilized to serve the Dallas Power and Light Company steam-electric plant installation.

The proposed Lavon Reservoir Enlargement will also serve to meet a portion of the projected 1980 water needs of the North Texas Municipal Water District. It is contemplated that the balance of these needs will be met by obtaining water from the proposed Cooper Reservoir in the Sulphur River Basin.

Terrell will supplement the yield of the existing Terrell Reservoir with water from Lake Tawakoni in the Sabine River Basin. Navarro Mills Reservoir, now under construction on Richland Creek in Navarro County, will supply the 1980 requirements of Corsicana. The existing Waxahachie Reservoir will serve the needs of Waxahachie. The proposed Bardwell Reservoir on Waxahachie Creek in Ellis County will meet the requirements of Ennis.

Athens will obtain its supply from the proposed Flat Creek Reservoir in the Neches River Basin.

The Palestine area will obtain water from the under-construction Blackburn Crossing Reservoir on the upper Neches River.

Conservation and regulation of the resources of the lower Trinity River will be accomplished by the construction of the proposed Livingston and Wallisville Reservoirs. Livingston reservoir will provide the conservation storage, while releases from Livingston, plus flood inflows below this dam, will be regulated by Wallisville Reservoir, which will also act as a salt-water barrier. The system operation of these two reservoirs will supply industrial water to the lower Trinity River Basin, the Houston industrial complex, and the adjacent coastal area industries.

Ground water will continue to be used to supply a portion of the water needs of the Trinity River Basin.

Other reservoirs considered for possible later development in this basin include Boyd Reservoir on the West Fork; Lakeview Reservoir on Mountain Creek; Tennessee Colony Reservoir on the Trinity River; Richland Creek Reservoir on Richland Creek; Tehuacana Reservoir on Tehuacana Creek; and a number of sites for reservoirs on tributaries to the Trinity River in the middle and lower reaches of the basin, as contained in the Trinity River Authority plan.

TABLE II-8A. TRINITY RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	27,820	241,900	269,720
Industrial	11,960	13,960	25,920
Irrigation	1,960	15,910	17,870
Total Zone A	**41,740**	**271,770**	**313,510**
Zone B			
Municipal	6,550	450	7,000
Industrial	19,890	1,060	20,950
Irrigation	8,240	14,790	23,030
Total Zone B	34,680	16,300	50,980
Zone C			
Municipal	730	0	730
Industrial	30	1,500	1,530
Irrigation	26,610	49,480	76,090
Total Zone C	27,370	50,980	78,350
Basin Totals			
Municipal	35,100	242,350	277,450
Industrial	31,880	16,520	48,400
Irrigation	36,810	80,180	116,990
Total Trinity Basin	103,790	339,050	442,840

TABLE II-8B. TRINITY RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Tarrant County	193,400	10,000	183,400	Fort Worth Area System
Weatherford	3,900	0	900	Weatherford
			3,000	Fort Worth Area System
Dallas County	382,000	0	269,900	Dallas Area System
			112,100	Import from Tawakoni in Zone A, Sabine Basin
Denton	10,500	0	10,500	Dallas Area System
North Texas Municipal Water District	72,100	0	64,500	Dallas Area System
			7,600	Import from Cooper in Zone A, Sulphur Basin
Terrell	2,900	0	800	Terrell
			2,100	Import from Tawakoni
Gainesville	4,300	4,300	0	
Burleson	1,200	1,200	0	
Corsicana	6,300	0	6,300	Navarro Mills
Waxahachie	3,700	100	3,600	Waxahachie
Ennis	2,500	0	2,500	Bardwell
Athens	1,800	0	1,800	Import from Flat Creek in Zone A, Neches Basin
Distributed	21,400	21,400	0	
Total Zone A	706,000	37,000	669,000	
Zone B				
Palestine	58,000	2,000	56,000	Import from Blackburn Crossing in Zone A, Neches Basin
Crockett	1,500	1,500	0	
Huntsville	2,800	2,800	0	

TABLE II-8B. TRINITY RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Distributed	53,700	26,400	27,300	Return flows from Zone A (Depending on where industries locate in Zone B, water can be obtained from ground water return flow, or reservoirs on Trinity tributaries)
Total Zone B	116,000	32,700	83,300	
Zone C				
Distributed	44,500	4,500	40,000	Livingston System
Total Zone C	44,500	4,500	40,000	
Total Trinity Basin	866,500	74,200	792,300	

Summary for Trinity Basin

Requirements supplied by:			
Ground Water			74,200
Surface Water:			
Major reservoirs	585,400		
Return flow	27,300		
Total Trinity surface water		612,700	
Imports from other basins:			
Sulphur Basin	7,600		
Sabine Basin	114,200		
Neches Basin	57,800		
Total imports		179,600	
Total surface water			792,300
Total requirements			866,500

TABLE II-8C. TRINITY RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
Fort Worth Area System						
Bridgeport }	238,100		Tarrant County	183,400		
Eagle Mountain }			Weatherford	3,000		
Lake Worth }						
Benbrook }						
Arlington }						
Cedar Creek }						
Total Fort Worth System	*238,100*	*0*		*186,400*	*0*	*51,700*[1]
Weatherford	*900*		Weatherford	*900*	*0*	*0*
Dallas Area System						
Grapevine }	386,800		Dallas County	269,900		
Aubrey }			Denton	10,500		
Garza-Little Elm }			N. Tex. Mun. Water Dist.	64,500		
Lavon (incl. enlargement) }						
Forney }						
Cooper in Sulphur Basin	—	7,600	N. Tex. Mun. Water Dist.	7,600		
Tawakoni in Sabine Basin	—	112,100	Dallas County	112,100		
Total Dallas System	*386,800*	*119,700*		*464,600*	*0*	*41,900*[1]
Terrell	*800*		Terrell	*800*		
Tawakoni in Sabine Basin	—	*2,100*	Terrell	*2,100*	—	—
Navarro Mills	*11,500*		Corsicana	*6,300*		*5,200*
Waxahachie	*3,600*		Waxahachie	*3,600*		*0*
Bardwell	*5,000*		Ennis	*2,500*		*2,500*
Flat Creek in Neches Basin	—	*1,800*	Athens	*1,800*	—	—
Total Zone A	**646,700**	**123,600**		**669,000**	**0**	**101,300**
Zones B & C						
Blackburn Crossing in Neches Basin	—	*56,000*	Palestine	*56,000*	—	—
Livingston System						
Livingston }	1,023,300		Distributed, Zone C	40,000		
Wallisville }						
			Neches-Trinity Coastal Area (NE-TR), Zone B:			
			Distributed		50,000	
			Total Zone B, NE-TR		50,000	
			Trinity-San Jacinto Coastal Area (TR-SJ), Zone A:			
			Baytown		68,000	
			Distributed		75,000	
			Total Zone A, TR-SJ		143,000	

TABLE II-8C. TRINITY BASIN (Cont'd)

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Export	
			San Jacinto Basin (SJ), Zone B:			
			Houston		869,000	
			Total Zone B, SJ....		369,000	
			San Jacinto-Brazos Coastal Area (SJ-BR), Zone A:			
			Texas City		122,300	
			La Marque		4,800	
			Galveston		11,100	
			Total Zone A, SJ-BR		138,200	
Total Livingston System ..	*1,023,300*	*0*	....	*40,000*	*700,200*	*283,100*[2]
Total Zones B & C	1,023,300	56,000	....	96,000	700,200	283,100
Total Trinity Basin ..	1,670,000	179,600	....	765,000	700,200	384,400

[1] Of this amount, 6,400 acre-feet from Benbrook Reservoir and 2,000 acre-feet from Grapevine Reservoir remain for present or future uses other than municipal and industrial.

[2] Yield remaining for municipal, industrial, and other uses.

Summary for Trinity Basin

Used in Trinity Basin		585,400
Exports to other basins or coastal areas:		
Neches-Trinity Coastal Area	50,000	
Trinity-San Jacinto Coastal Area	143,000	
San Jacinto Basin	369,000	
San Jacinto-Brazos Coastal Area	138,200	
Total exports		700,200
Yield remaining:		
Municipal and industrial uses after 1980	92,900	
Other present or future uses	291,500	
Total yield remaining		384,400
Total yield		1,670,000
Imports from other basins:		
Sulphur Basin	7,600	
Sabine Basin	114,200	
Neches Basin	57,800	
Total imports		179,600

TABLE II-8D. TRINITY RIVER BASIN
Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Amon Carter	Big Sandy Creek	6 S Bowie	Montague	19,900	0	19,900	700	1,540
Bridgeport	W. Fk. Trinity R.	2 W Bridgeport	Wise	270,900	([1])	270,900		10,400
Eagle Mountain	W. Fk. Trinity R.	14 NW Fort Worth	Tarrant	182,600	([2])	182,600	55,300	8,500
Lake Worth	W. Fk. Trinity R.	5 NW Fort Worth	Tarrant	33,700	0	33,700		3,270
Weatherford	Cl. Fk. Trinity R.	7 E Weatherford	Parker	19,600	0	19,600	900	1,280
Benbrook	Cl. Fk. Trinity R.	10 SW Fort Worth	Tarrant	88,250[3]	76,550[4]	164,800	6,400	3,770
Arlington	Village Creek	5 WSW Arlington	Tarrant	45,700	0	45,700	3,800	2,275
Mountain Creek	Mountain Creek	4 ESE Grand Prairie	Dallas	27,100	0	27,100	—	3,440
Garza-Little Elm	Elm Fk. Trinity R.	2 NE Lewisville	Denton	482,000	520,900	1,002,900	109,900	22,970
Grapevine	Denton Creek	2 NE Grapevine	Tarrant	188,500[5]	247,000	435,500	13,000	7,380
White Rock	White Rock Creek	Dallas	Dallas	12,300	0	12,300	—	1,095
Lavon	E. Fk. Trinity R.	4 NE Wylie	Collin	143,600	279,800	423,400	26,500	11,080
Forney[6]	E. Fk. Trinity R.	14 WNW Terrell	Kaufman	490,000	0	490,000	75,000	21,300
Waxahachie	S. Waxahachie Creek	4 S Waxahachie	Ellis	13,500	0	13,500	3,600	687
Halbert	Elm Creek	3 S Corsicana	Navarro	7,420	0	7,420	—	650
Navarro Mills[6]	Richland Creek	17 SW Corsicana	Navarro	63,300	148,900	212,200	11,500	5,070
Terrell	Muddy Cedar Creek	6 E Terrell	Kaufman	8,300	0	8,300	800	880
Cedar Creek[6]	Cedar Creek	3 NE Trinidad	Henderson	678,900	0	678,900	172,600	34,000
Anahuac	Turtle Bay	0.3 N Anahuac	Chambers	35,300	0	35,300	—	5,300
Total Existing				2,810,870	1,273,150	4,084,020	480,000	144,887

TABLE II-8D. TRINITY RIVER BASIN (Cont'd)

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Proposed								
Aubrey	Elm Fk. Trinity R.	11 NE Denton	Denton	650,000	238,000	888,000	113,200	24,700
Lavon (Enlargement)	E. Fk. Trinity R.	4 NE Wylie	Collin	203,600	4,800	208,400	49,200	6,960
Bardwell	Waxahachie Creek	6 SSW Ennis	Ellis	38,200	79,600	117,800	5,000	1,910
Livingston	Trinity River	9 SW Livingston	Polk-San Jacinto	1,750,000	0	1,750,000	1,023,300	71,400
Wallisville	Trinity River	7 NW Anahuac	Liberty	55,700	0	55,700		23,000
Total Proposed				2,697,500	322,400	3,019,900	1,190,700	127,970
Total Trinity Basin				5,508,370	1,595,550	7,103,920	1,670,700	272,857

[1] Has 534,500 acre-feet of flood retardation capacity.
[2] Has 458,000 acre-feet of flood retardation capacity.
[3] Allocated to navigation when required for that purpose.
[4] Has 93,800 acre-feet of additional flood retardation capacity.
[5] 25,000 acre-feet allocated to navigation when required for that purpose.
[6] Under construction.

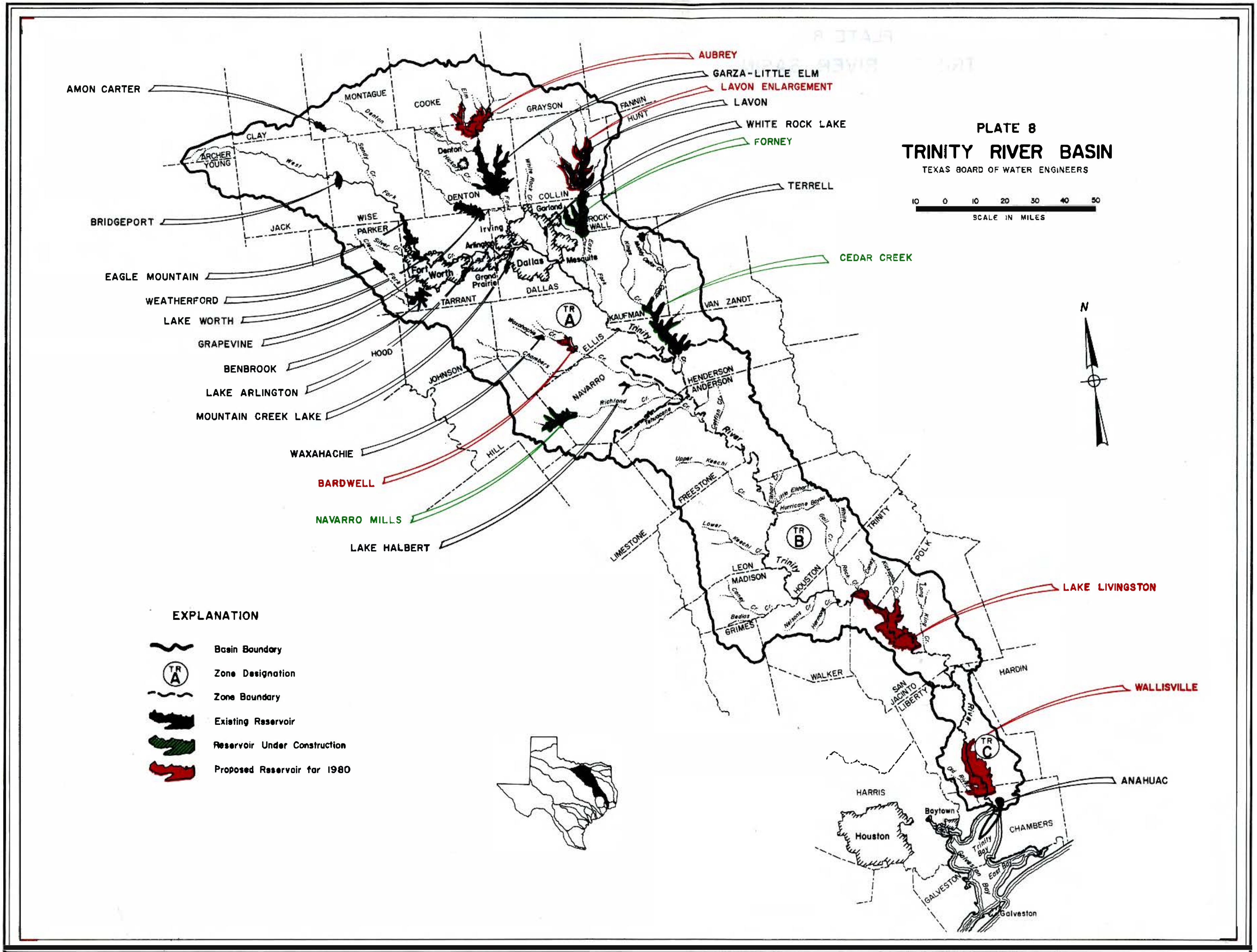


PLATE 8
TRINITY RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30 40 50
SCALE IN MILES
N
AUBREY
GARZA-LITTLE ELM
LAVON ENLARGEMENT
LAVON
WHITE ROCK LAKE
FORNEY
TERRELL
CEDAR CREEK
AMON CARTER
BRIDGEPORT
EAGLE MOUNTAIN
WEATHERFORD
LAKE WORTH
GRAPEVINE
BENBROOK
LAKE ARLINGTON
MOUNTAIN CREEK LAKE
WAXAHACHIE
BARDWELL
NAVARRO MILLS
LAKE HALBERT
LAKE LIVINGSTON
WALLISVILLE
ANAHUAC
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Reservoir Under Construction
Proposed Reservoir for 1980
MONTAGUE
COOKE
GRAYSON
FANNIN
HUNT
CLAY
ARCHER
YOUNG
DENTON
COLLIN
ROCK-WALL
JACK
WISE
PARKER
TARRANT
DALLAS
KAUFMAN
VAN ZANDT
HOOD
JOHNSON
ELLIS
NAVARRO
HENDERSON
ANDERSON
HILL
FREESTONE
LIMESTONE
LEON
MADISON
HOUSTON
TRINITY
POLK
GRIMES
WALKER
SAN JACINTO
LIBERTY
HARDIN
HARRIS
CHAMBERS
GALVESTON
Denton
Irving
Arlington
Garland
Mesquite
Fort Worth
Grand Prairie
Dallas
Houston
Baytown
Galveston
TR A
TR B
TR C
Trinity River
Trinity Bay
Galveston Bay
East Bay

TRINITY-SAN JACINTO COASTAL AREA

The small Trinity-San Jacinto Coastal Area is located between the Trinity and San Jacinto River Basins on the flat Gulf Coastal Plain. Rainfall on this area averages about 49 inches, in contrast to the average annual net evaporation loss of about 10 inches. Annual runoff rates average 550 acre-feet per square mile from this area. The location and boundaries of this coastal area are shown on Plate 9.

Present uses of water for municipalities, industries, and irrigation are listed in Table II-9A, and total 93,120 acre-feet. Of this total, 49,850 acre-feet was supplied by ground water, and 43,270 acre-feet was obtained from surface-water facilities.

Projected 1980 municipal and industrial water requirements for the one zone of this coastal area total 201,000 acre-feet. Of this total, 193,000 acre-feet is indicated to be served by surface-water supplies; and 8,000 acre-feet, from underground sources. Details of these requirements and how they may be supplied are contained in Tables II-9B, II-9C, and II-9D. No surface-water reservoirs are proposed for location in this zone. Information pertaining to resvoirs in other river basins which will supply the requirements for this area is shown in the portion of the report describing the river basin in which the reservoirs are located.

TABLE II-9A. TRINITY-SAN JACINTO COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	3,420	0	3,420
Industrial	17,830	24,670	42,500
Irrigation	28,600	43,270	71,870
Total Zone A	49,850	67,940	117,790
Total Trinity-San Jacinto Coastal Area	49,850	67,940	117,790

TABLE II-9B. TRINITY-SAN JACINTO COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Baytown	118,000	0	50,000	Import from Houston in Zone A, San Jacinto Basin
			68,000	Import from Livingston System in Zones B and C, Trinity Basin
Distributed	83,000	8,000	75,000	Import from Livingston System
Total Zone A	201,000	8,000	193,000	
Total Trinity-San Jacinto Coastal Area	201,000	8,000	193,000	

Summary for Trinity-San Jacinto Coastal Area

Requirements supplied by:		
Ground Water		8,000
Imports from other basins:		
Trinity Basin	143,000	
San Jacinto Basin	50,000	
Total imports		193,000
Total requirements		201,000

TABLE II-9C. TRINITY-SAN JACINTO COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution		Yield Remaining
Name	Yield		Place	Amount Used	
Zone A					
No reservoirs in zone	0	—		—	—
Livingston System in Trinity Basin	—	*143,000*	Baytown	68,000	
			Distributed	75,000	
			Total Livingston System import	*143,000*	—
Houston in San Jacinto Basin	—	*50,000*	Baytown	*50,000*	—
Total Zone A	0	193,000		193,000	0
Total Trinity-San Jacinto Coastal Area	0	193,000		193,000	0

Summary for Trinity-San Jacinto Coastal Area

Imports from other basins:

Trinity Basin	143,000	
San Jacinto Basin	50,000	
Total imports		193,000

TABLE II-9D. TRINITY-SAN JACINTO COASTAL AREA

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

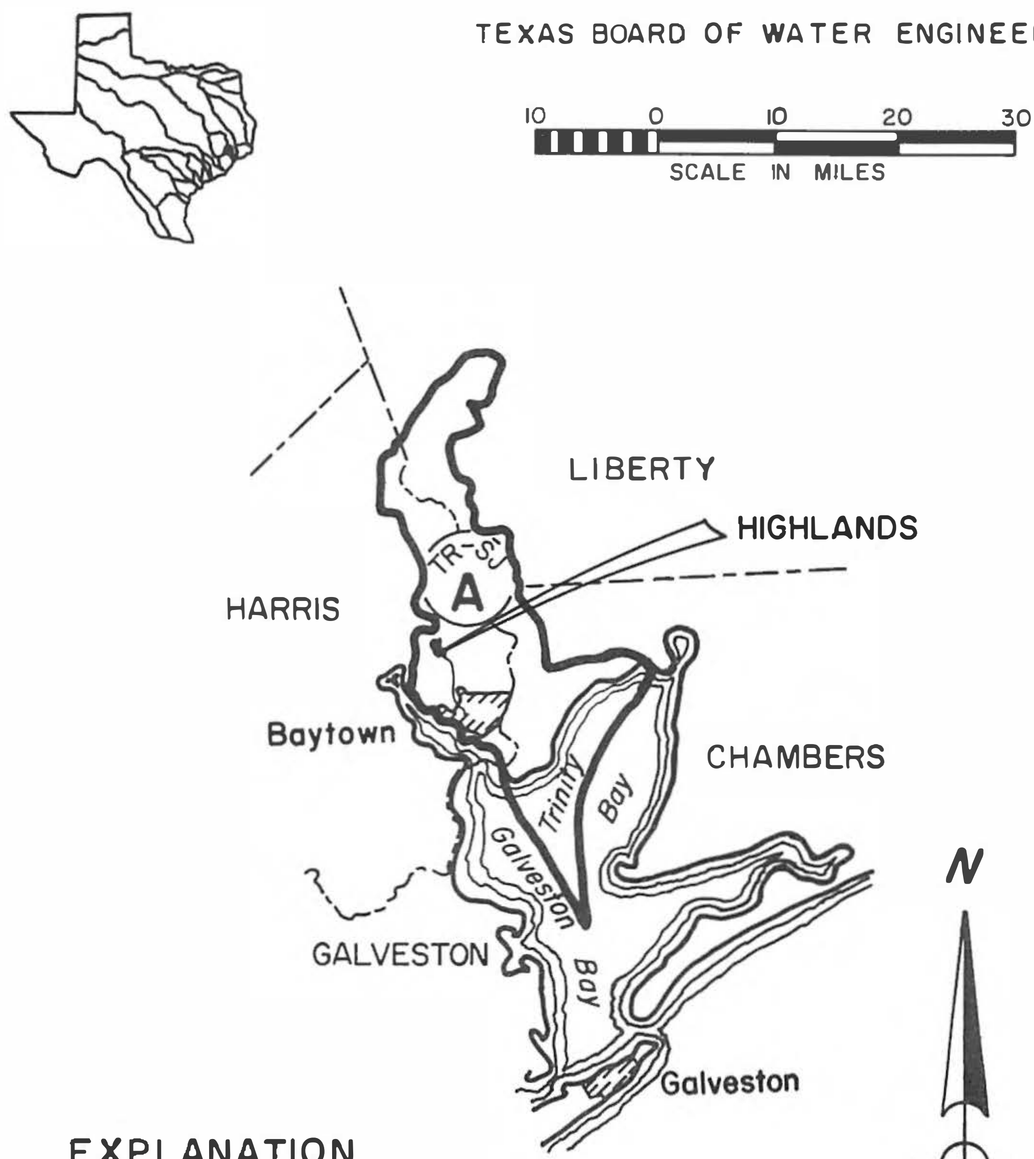
Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Highlands	Goose Creek (off channel)	2 ENE Highlands	Harris	5,600	0	5,600	([1])	1,407
Total Existing	....	....	....	**5,600**	**0**	**5,600**	**0**	**1,407**
Proposed								
None								
Total Trinity-San Jacinto Coastal Area ...	....	....	....	**5,600**	**0**	**5,600**	**0**	**1,407**

[1] Regulating water supply reservoir.

PLATE 9

TRINITY-SAN JACINTO COASTAL AREA

TEXAS BOARD OF WATER ENGINEERS



EXPLANATION

Coastal Area Boundary

Zone Designation

Existing Reservoir

SAN JACINTO RIVER BASIN

The San Jacinto River which drains a part of the Gulf Coastal Plain geographical province, has two main branches: West Fork and East Fork. This river basin has been divided into two zones and includes the city of Houston and all of Harris County. (See Plate 10.)

Rainfall on the basin varies from about 43 inches annually on the western side to an average of 50 inches on the eastern edge. Net evaporation rates range from an average of 18 inches to only 10 inches annually. Runoff rates increase from an average of 400 acre-feet per square mile annually on the west side to 550 acre-feet per square mile on the east side.

The surface water in the San Jacinto River Basin is of excellent chemical quality and suitable for municipal, industrial, and agricultural purposes.

In September 1961, the ground-water reconnaissance study for this basin will be completed. Somewhat more detailed information on ground water is available in completed studies for the following counties: Brazoria, Chambers, Fort Bend, Galveston, Harris, and Waller.

The principal aquifers in this basin are the Miocene sands (Catahoula-Oakville-Lagarto) and the Coastal sands (Goliad-Willis-Lissie-Beaumont). Because the Miocene sands and Coastal sands are lithologically similar and because wells draw water from both aquifers in parts of the area, they are treated as a unit in the table herewith. The areas where the principal aquifers yield fresh water are shown on Plate 25.

While pumpage from the Miocene sands in the northern part of the basin is small at the present time, large quantities of water are pumped from the Coastal sands in the southern part of the basin; and even larger quantities of ground water are available from the combined Miocene-Coastal aquifer. The greatest pumpage in the basin is for municipal and industrial purposes in the Houston-Pasadena area and for irrigation in the Katy area in western Harris, southeastern Waller, and northern Fort Bend Counties.

Generally, water in the Miocene-Coastal sands is of good quality. In the Houston-Pasadena area, the chloride content of the water increases downdip.

Problems of salt-water encroachment and land-surface subsidence, resulting from concentrated pumping of large amounts of ground water, are factors which must be considered in future uses of ground water in the Houston-Pasadena area.

Present uses of water for municipalities, industries, and irrigation in this basin are listed in Table II-10A, and total 483,470 acre-feet. Ground water has been used to supply 339,440 acre-feet of this total; and surface water, 144,030 acre-feet.

Projected 1980 municipal and industrial water requirements for this basin total 822,000 acre-feet. Of this total, 630,100 acre-feet is indicated to be supplied from surface-water sources; and 191,900 acre-feet, from underground supplies. Details of the requirements for each area of the basin are contained in Table II-10B.

Municipal water requirements will continue to be met in part from the existing Lake Houston and from ground-water supplies. Additional municipal water supplies for Houston will require construction of Honea Reservoir on the West Fork of the San Jacinto River in Montgomery County and Cleveland Reservoir on the East Fork of the San Jacinto River in San Jacinto County. Honea Reservoir can also supply Conroe, while Cleveland could obtain a supply from Cleveland Reservoir. Water from the San Jacinto River reservoirs could also be used to meet municipal needs of Baytown and part of the requirements of Texas City and Galveston. Much of the 1980 industrial water requirements of the Houston industrial complex and adjacent areas will be met from the proposed Livingston and Wallisville Reservoirs in the Trinity River Basin.

Ground water will continue to supply part of the water needs of communities in the San Jacinto River Basin.

Other reservoir sites in this basin considered for meeting future water requirements include Lower Lake Creek and Humble Reservoirs on West Fork.

TABLE II-10A. SAN JACINTO RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	1,890	0	1,890
Industrial	2,390	0	2,390
Irrigation	46,790	8,620	55,410
Total Zone A	51,070	8,620	59,690
Zone B			
Municipal	100,800	27,460	128,260
Industrial	96,340	59,290	155,630
Irrigation	91,230	23,990	115,220
Total Zone B	288,370	110,740	399,110
Basin Totals			
Municipal	102,690	27,460	130,150
Industrial	98,730	59,290	158,020
Irrigation	138,020	32,610	170,630
Total San Jacinto Basin	339,440	119,360	458,800

TABLE II-10B. SAN JACINTO RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Cleveland	1,400	0	1,400	Cleveland
Conroe	3,800	0	3,800	Honea
Distributed	16,800	12,800	2,000	Honea
			2,000	Cleveland
Total Zone A	**22,000**	**12,800**	**9,200**	
Zone B				
Houston	782,000	161,100	74,900	Honea
			61,100	Cleveland
			115,900	Houston
			369,000	Import from Livingston System in Zones B and C, Trinity Basin
Distributed	18,000	18,000	0	
Total Zone B	**800,000**	**179,100**	**620,900**	
Total San Jacinto Basin	**822,000**	**191,900**	**630,100**	

Summary for San Jacinto Basin

Requirements supplied by:

Ground Water		191,900
Surface Water	261,100	
Import from Trinity Basin	369,000	
Total surface water		630,100
Total requirements		822,000

TABLE II-10C. SAN JACINTO RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems: Name	Reservoirs or Reservoir Systems: Yield	Imports	Distribution: Place	Distribution: Amount: Basin Use	Distribution: Amount: Exports	Yield Remaining
Zone A						
Honea	94,200		Conroe	3,800		
			Distributed	2,000		
			Houston, Zone B	74,900		
Total Honea	*94,200*	*0*		*80,700*	*0*	*13,500*
Cleveland	64,500		Cleveland	1,400		
			Distributed	2,000		
			Houston, Zone B	61,100		
Total Cleveland	*64,500*	*0*		*64,500*	*0*	*0*
Houston	188,000		Houston, Zone B	115,900		
			Trinity-San Jacinto Coastal Area (TR-SJ), Zone A:			
			Baytown		50,000	
			Total Zone A, TR-SJ		50,000	
			San Jacinto-Brazos Coastal Area (SJ-BR), Zone A:			
			Texas City		11,100	
			Galveston		11,000	
			Total Zone A, SJ-BR		22,100	
Total Houston	*188,000*	*0*		*115,900*	*72,100*	*0*
Total Zone A	346,700	0		261,100	72,100	13,500
Zone B						
No reservoirs in zone	0	—		—	—	—
Livingston System in Trinity Basin	—	*369,000*	Houston	*369,000*	—	—
Total Zone B	0	369,000		369,000	0	0
Total San Jacinto Basin	346,700	369,000		630,100	72,100	13,500

Summary for San Jacinto Basin

Used in San Jacinto Basin		261,100
Exports to other basins or coastal areas:		
Trinity-San Jacinto Coastal Area	50,000	
San Jacinto-Brazos Coastal Area	22,100	
Total exports		72,100
Yield remaining for municipal and industrial uses after 1980		13,500
Total yield		346,700
Import from Trinity Basin		369,000

TABLE II-10D. SAN JACINTO RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Houston	San Jacinto River	4 N Sheldon	Harris	158,200	0	158,200	188,000	12,500
Total Existing				**158,200**	**0**	**158,200**	**188,000**	**12,500**
Proposed								
Honea	W. Fork San Jacinto River	6 WNW Conroe	Montgomery	488,000	0	488,000	94,200	24,900
Cleveland	E. Fork San Jacinto River	4 N Cleveland	San Jacinto	337,000	0	337,000	64,500	15,400
Total Proposed				**825,000**	**0**	**825,000**	**158,700**	**40,300**
Total San Jacinto Basin				**983,200**	**0**	**983,200**	**346,700**	**52,800**

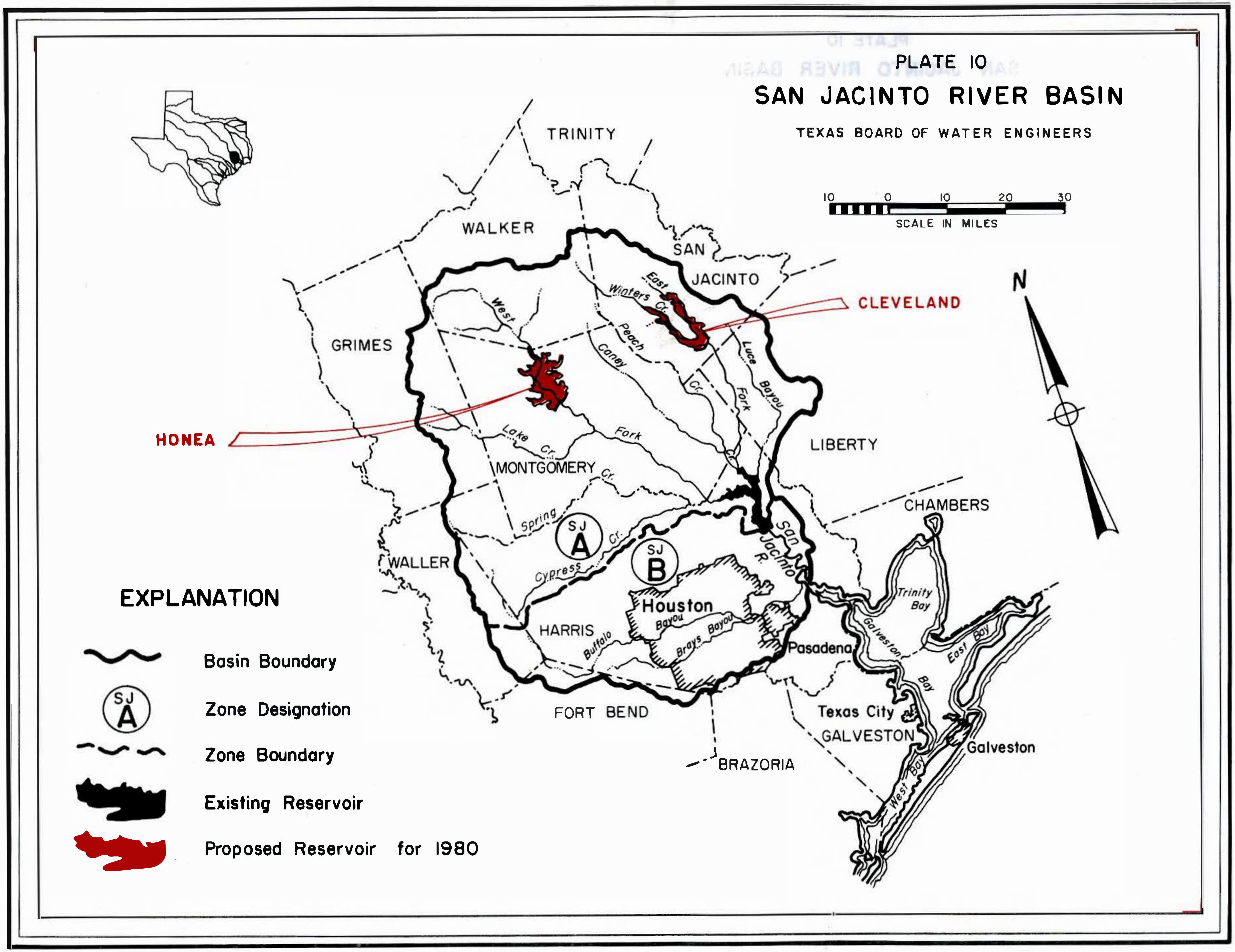


PLATE 10
SAN JACINTO RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
N
TRINITY
WALKER
SAN JACINTO
GRIMES
CLEVELAND
HONEA
LIBERTY
MONTGOMERY
CHAMBERS
WALLER
HARRIS
FORT BEND
BRAZORIA
GALVESTON
Houston
Pasadena
Texas City
Galveston
East Fork
Winters Cr.
West Fork
Peach Cr.
Caney Cr.
Luce Bayou
Lake Cr.
Spring Cr.
Cypress Cr.
Buffalo Bayou
Brays Bayou
San Jacinto R.
Trinity Bay
Galveston Bay
East Bay
West Bay
SJ A
SJ B
EXPLANATION
Basin Boundary
SJ A Zone Designation
Zone Boundary
Existing Reservoir
Proposed Reservoir for 1980

SAN JACINTO-BRAZOS COASTAL AREA

This flat portion of the Gulf Coastal Plain geographical province has been divided into two zones. (See Plate 11.) Rainfall on this area averages about 44 inches annually, and annual net evaporation rates average only 11 inches. Annual runoff averages about 450 acre-feet per square mile.

Present uses of water in this area for municipalities, industries, and irrigation are contained in Table II-11A, and total 243,060 acre-feet. Of this total, 175,910 acre-feet are supplied from surface-water sources; and 67,150 acre-feet, from underground supplies.

Projected 1980 municipal and industrial requirements for this coastal area total 238,400 acre-feet, of which 199,000 acre-feet are expected to be supplied from surface-water sources; and 39,400 acre-feet, from underground supplies. Details of the location of the places of use and sources of supply are listed in Tables II-11A, II-11B, and II-11C. As no major reservoirs exist in this coastal area, and none are proposed, pertinent information relative to the reservoirs which will supply water to this area is contained in the portions of this report describing the basins in which those reservoirs are located.

The projected water requirements of Texas City may be met by water from the Brazos River and from reservoirs in the San Jacinto and Trinity River Basins. A small amount of ground-water use in the Texas City area is continued.

Galveston's 1980 needs may be met by a continued and expanded use of ground water and by use of surface water from reservoirs in the San Jacinto and Trinity River Basins.

TABLE II-11A. SAN JACINTO-BRAZOS COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	20,340	0	20,340
Industrial	6,560	28,700	35,260
Irrigation	13,890	66,390	80,280
Total Zone A	40,790	95,090	135,880
Zone B			
Municipal	1,880	2,520	4,400
Industrial	970	2,600	3,570
Irrigation	23,510	104,400	127,910
Total Zone B	26,360	109,520	135,880
Coastal Area Totals			
Municipal	22,220	2,520	24,740
Industrial	7,530	31,300	38,830
Irrigation	37,400	170,790	208,190
Total San Jacinto-Brazos Coastal Area	67,150	204,610	271,760

TABLE II-11B. SAN JACINTO-BRAZOS COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Texas City	164,800	4,000	11,100	Import from Houston in Zone A, San Jacinto Basin
			27,400	Import from Brazos River Authority (BRA) System in **Zone H, Brazos** Basin
			122,300	Import from Livingston System in Zones B and C, Trinity Basin
La Marque	7,500	1,400	1,300	Import from BRA System
			4,800	Import from Livingston System
Galveston	51,100	29,000	11,000	Import from Houston
			11,100	Import from Livingston System
Total Zone A	223,400	34,400	189,000	
Zone B				
Distributed	15,000	5,000	10,000	Import from BRA System
Total Zone B	15,000	5,000	10,000	
Total San Jacinto-Brazos Coastal Area	238,400	39,400	199,000	

Summary for San Jacinto-Brazos Coastal Area

Requirements supplied by:

Ground Water		39,400
Imports from other basins:		
Trinity Basin	138,200	
San Jacinto Basin	22,100	
Brazos Basin	38,700	
Total imports		199,000
Total requirements		238,400

TABLE II-11C. SAN JACINTO-BRAZOS COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems: Name	Reservoirs or Reservoir Systems: Yield	Imports	Distribution: Place	Distribution: Amount Used	Yield Remaining
Zone A					
No reservoirs in zone	0	—		—	—
Livingston System in Trinity Basin	—	*138,200*	Texas City	122,300	
			La Marque	4,800	
			Galveston	11,100	
			Total Livingston System import	*138,200*	—
Houston in San Jacinto Basin	—	*22,100*	Texas City	11,100	
			Galveston	11,000	
			Total Houston import	*22,100*	—
Brazos River Authority System in Brazos Basin	—	*28,700*	Texas City	27,400	
			La Marque	1,300	
			Total BRA System import	*28,700*	—
Total Zone A	**0**	**189,000**		**189,000**	**0**
Zone B					
No reservoirs in zone	0	—		—	—
Brazos River Authority System in Brazos Basin	—	*10,000*	Distributed	*10,000*	—
Total Zone B	**0**	**10,000**		**10,000**	**0**
Total San Jacinto-Brazos Coastal Area	**0**	**199,000**		**199,000**	**0**

Summary for San Jacinto-Brazos Coastal Area

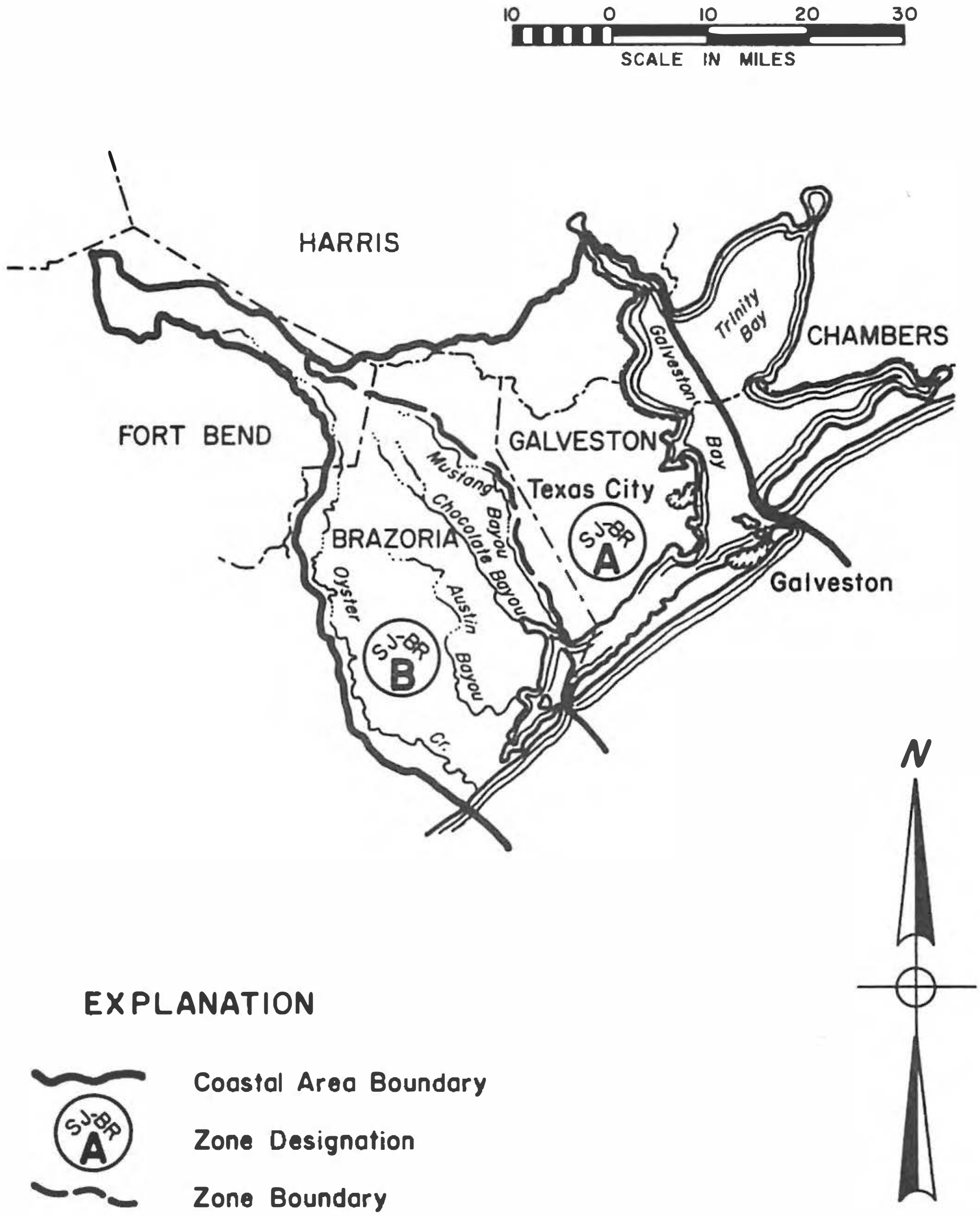
Imports from other basins:

Trinity Basin	138,200
San Jacinto Basin	22,100
Brazos Basin	38,700
Total imports	199,000

PLATE II

SAN JACINTO-BRAZOS COASTAL AREA

TEXAS BOARD OF WATER ENGINEERS



BRAZOS RIVER BASIN

The Brazos River rises on the High Plains in eastern New Mexico and takes a southeasterly course across Central Texas to empty into the Gulf of Mexico near Freeport. It drains, successively, portions of the Great Plains, Central Texas, and Gulf Coastal Plain geographical provinces. Principal streams in the portion of the basin above Possum Kingdom Dam are the Salt Fork, Double Mountain Fork, and Clear Fork. Important tributaries below Possum Kingdom Dam, in downstream order, are the Bosque River; the Little River (including its tributaries the Leon, Lampasas, and San Gabriel Rivers); Yegua Creek; and the Navasota River.

Rainfall varies across the basin from an average of 18 inches annually on the High Plains to about 32 inches near Waco to about 41 inches near the Coast. Annual net evaporation rates vary from an average of about 60 inches in the upper basin, to about 31 inches at Possum Kingdom Dam, to about 15 inches near the mouth.

Runoff varies throughout the basin with practically none occurring in the High Plains to an average of about 75 acre-feet per square mile above Possum Kingdom Dam to about 225 acre-feet per square mile in the reach of stream from Whitney Dam to the mouth of the Navasota River. It is in this reach of river below Whitney Dam that much of the runoff in this basin originates. The Brazos River Basin, divided into 16 zones, is shown on Plate 12.

The chemical quality of water in the Brazos River Basin varies through extreme ranges from very high values for some mineralized spring inflows in the upper basin to excellent quality water for tributaries in the lower basin. Good quality water can be obtained from many tributaries in the upper basin and from all significant tributaries in the lower basin. The main-stream Brazos River water quality progressively improves from the upper reaches to the mouth. For the 1959 water year, the weighted average of dissolved solids was 5,020 ppm (parts per million) or for the Salt Fork near Aspermont, 1,130 ppm, for the outflow from Possum Kingdom Reservoir, and 323 ppm at Richmond. Much of the water of this basin is suitable for municipal, agricultural, and many industrial uses.

The reconnaissance ground-water study for this basin will be completed in September 1962. More comprehensive studies have been completed for the following counties in the basin: Hale, Haskell, Knox, Lamb, Leon, and Waller.

The principal aquifers of the basin are the Ogallala formation, the alluvium (alluvial deposits along the Brazos River valley), the Seymour formation, the Trinity sands, the Carrizo-Wilcox sands, the Sparta sands, the Miocene sands (Catahoula-Oakville-Lagarto), and the Coastal sands (Goliad-Willis-Lissie-Beaumont). The Miocene sands and Coastal sands are discussed here as a combined aquifer referred to as the Miocene-Coastal sands because they are lithologically similar and because wells draw water from both aquifers in parts of the area.

With the exception of the Sparta sands, locations of the areas where the principal aquifers yield fresh water are shown on Plate 25. The Sparta sands yield fresh water in approximately the lower half of the area shown for the Carrizo-Wilcox aquifer. Large quantities of ground water are available in the basin from these principal aquifers. Some additional quantities of ground water, adequate for domestic and stock and in some cases supplies for small towns, industries, and minor irrigation, are available from minor aquifers that have limited areal extent and small potential for development. The Ogallala formation on the High Plains is the most important aquifer, yielding more than 90 percent of the ground water pumped in the basin. The alluvium and Seymour aquifers supply most of the remaining pumpage. Substantial additional development of ground water is possible in the Trinity, Carrizo-Wilcox, and Miocene-Coastal aquifers. Small quantities of additional ground water may be available from alluvium along the Brazos River.

Data available indicate that the present rate of pumpage from the Ogallala exceeds the rate of recharge. This may also be true for the Seymour. Reconnaissance ground-water studies have not progressed to the point where reliable estimates of the quantity of water available from storage in these aquifers can be obtained. However, where pumpage exceeds recharge, the present rates of pumpage cannot be maintained indefinitely.

The chemical quality of ground water in the principal aquifers in the basin is such that the water is generally suited for most purposes.

Uses of water by municipalities, industries, and irrigation in 1959 are listed by zones in Table II-12A. These uses total 4,354,660 acre-feet, of which 4,062,860 acre-feet was obtained from underground supplies; and 291,800 acre-feet, from surface-water facilities.

The projected 1980 industrial and municipal water requirements for this basin total 912,900 acre-feet, of which 100,800 acre-feet is indicated to be supplied from ground water; and 812,100 acre-feet, from surface-water sources. The location of the water requirements and possible means of meeting these water requirements are contained in Tables II-12A and II-12B.

In indicating means of meeting the 1980 water requirements of the basin, the use of the small output of the experimental, sea-water conversion plant at Freeport was not included.

Twenty-nine reservoirs are contemplated to serve the 1980 water needs in the Brazos River Basin. These include 16 existing reservoirs, 4 reservoirs now under construction, and 9 proposed new reservoirs. Water supplies for Plainview, Levelland, Lubbock, and Slaton, in the upper part of the basin, will be met in part from Sanford Reservoir on the Canadian River, while Sweetwater will continue to obtain part of its supply from Oak Creek Reservoir in the Colorado River Basin.

Ground water will continue to serve part of the 1980 water requirements of the basin.

The proposed White River Reservoir in Crosby County will serve Crosbyton, Ralls, Spur, and Post. Cities comprising the North Central Texas Municipal Water Authority could supply their water needs from the proposed Millers Creek Reservoir in Baylor County.

Sweetwater would obtain part of its supply from the existing Lake Sweetwater in the Brazos Basin and from Oak Creek Reservoir in the Colorado River Basin. Additional supplies for Sweetwater can be obtained from the proposed Seymour No. 2 Reservoir on the Double Mountain Fork of the Brazos River in Haskell and Stonewall Counties. The amount of water used by Sweetwater from the Double Mountain Fork and Colorado River Basin will be dependent upon a blending of these waters to obtain the most desirable combination of dissolved minerals. This may require some additional exchange of Colorado River and Double Mountain Fork water.

Abilene's 1980 needs can be supplied from the existing Fort Phantom Hill, Abilene, and Kirby Reservoirs; from diversions from the Clear Fork into Fort Phantom Hill Reservoir; and from the under-construction Hubbard Creek Reservoir in Stephens County. This reservoir will also provide for Anson, Albany, and Breckenridge. Breckenridge can obtain part of its supply from the existing Lake Daniel.

Graham will continue to be served from the existing Salt Creek Reservoir.

Mineral Wells will obtain part of its needs from the existing Lake Mineral Wells. The proposed Keechi Reservoir in Palo Pinto County can provide additional water needed by Mineral Wells.

Waco will be supplied primarily by the enlarged Waco Reservoir. The new Waco Dam, now under construction, is located immediately downstream from the existing Waco Dam. A part of the new Waco Reservoir will be the existing smaller Lake Waco. The project is referred to herein as Waco Enlargement. As the projected 1980 municipal and industrial requirements exceed the yield of this reservoir, additional water will be needed. This water may be obtained from the existing Possum Kingdom-Whitney Reservoir System.

Proctor Reservoir on the upper Leon River is now under construction in Comanche County. This reservoir will provide both conservation and flood-control storage. When Proctor Reservoir is completed, a portion of the flood-control storage in the existing Belton Reservoir will be converted to conservation storage. This two-reservoir system can provide for Stephenville, Cameron, Killeen, Fort Hood, Temple, and Belton, and also serve a part of the requirements of the Freeport area. The existing Lake Leon will continue to supply part of the needs of the upper Leon River watershed.

Georgetown and Taylor can obtain their supplies from the proposed North San Gabriel Reservoir near Georgetown. This reservoir can also supply that part of the Rockdale requirement not served from the existing Alcoa Reservoir.

The existing Lake Creek Reservoir will supply the Texas Power and Light Company plant while Smithers Reservoir will supply the Houston Lighting and Power Company installation. The under-construction Bistone Reservoir on the upper Navasota River will supply Mexia.

Bryan and cities in that vicinity can be supplied from the proposed Millican Reservoir on the Navasota River.

Supplying the projected municipal and industrial water requirements of the basin from Bryan to Freeport will require a system operation of the existing Possum Kingdom and Whitney Reservoirs, coordinated with releases from the existing Belton Reservoir and the proposed Millican, Stillhouse Hollow, Somerville, and Allens Creek Reservoirs. The proposed Stillhouse Hollow Reservoir site is located on the Lampasas River in Bell County. Somerville Reservoir is planned for Yegua Creek at Somerville and would also supply water requirements to cities in that area. The proposed Allens Creek Reservoir, an off-channel reservoir to be located in Austin County, would divert uncontrolled flood waters from the Brazos River. The system operation of these reservoirs would also provide for a portion of the supply of the Texas City area, which is presently supplied from the Brazos River.

Further detailed analysis of a system operation coordinating releases from Possum Kingdom and Whitney Dams with releases from reservoirs on the lower tributaries to determine the best method of obtaining the optimum quality of water along the lower reach of the Brazos River will be necessary.

Other reservoirs considered in planning for possible development in this basin are South Bend Reservoir above Possum Kingdom Dam; Turkey Creek, Inspiration Point, High Tower, De Cordova Bend, and Bee Mountain Reservoirs, between the existing Possum Kingdom Dam and Whitney Reservoir; and Aquilla, South San Gabriel, Laneport, and Wayland Crossing Reservoirs on tributary streams.

The five reservoirs between Possum Kingdom Dam and Whitney Reservoir have been investigated for the purpose of hydroelectric power generation. Investigations of these reservoirs, at present, include consideration for initial construction and use for the purpose of hydroelectri power generation, with possible future conversion of the power storage to water-supply storage as water requirements increase. One or more of these five dams may be constructed prior to 1980.

The North San Gabriel Reservoir is being studied by the Corps of Engineers in conjunction with their authorized Laneport Reservoir further downstream on the San Gabriel River. Both reservoirs, as proposed, include conservation and flood-control storage. The phasing of construction of the North San Gabriel and Laneport Reservoirs will require further consideration.

TABLE II-12A. BRAZOS RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	5,660	0	5,660
Industrial	530	0	530
Irrigation	1,655,000	0	1,655,000
Total Zone A	1,661,190	0	1,661,190
Zone B			
Municipal	1,070	70	1,140
Industrial	0	0	0
Irrigation	201,500	0	201,500
Total Zone B	202,570	70	202,640
Zone C			
Municipal	27,410	0	27,410
Industrial	6,330	0	6,330
Irrigation	1,864,000	0	1,864,000
Total Zone C	1,897,740	0	1,897,740
Zone D			
Municipal	800	10	810
Industrial	0	0	0
Irrigation	9,660	0	9.660
Total Zone D	10,460	10	10,470
Zone E			
Municipal	1,150	220	1,370
Industrial	110	0	110
Irrigation	68,920	0	68,920
Total Zone E	70,180	220	70,400
Zone F			
Municipal	430	16,090	16,520
Industrial	1,270	950	2,220
Irrigation	5,980	2,080	8,060
Total Zone F	7,680	19,120	26,800

TABLE II-12A. BRAZOS RIVER BASIN (Cont'd)

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone G			
Municipal	630	4,070	4,700
Industrial	0	1,830	1,830
Irrigation	4,900	940	5,840
Total Zone G	5,530	6,840	12,370
Zone H			
Municipal	780	4,020	4,800
Industrial	30	20	50
Irrigation	170	8,110	8,280
Total Zone H	980	12,150	13,130
Zone I			
Municipal	2,640	0	2,640
Industrial	0	0	0
Irrigation	2,620	2,200	4,820
Total Zone I	5,260	2,200	7,460
Zone J			
Municipal	3,430	0	3,430
Industrial	100	0	100
Irrigation	2,790	4.530	7.320
Total Zone J	6,320	4,530	10,850
Zone K			
Municipal	1,700	5,300	7,000
Industrial	50	290	340
Irrigation	5,560	3,830	9,390
Total Zone K	7,310	9,420	16,730
Zone L			
Municipal	4,100	5,210	9,310
Industrial	20	30	50
Irrigation	550	5,480	6,030
Total Zone L	4,670	10,720	15,390

TABLE II-12A. BRAZOS RIVER BASIN (Cont'd)

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone M			
Municipal	7,970	15,320	23,290
Industrial	2,000	7,540	9,540
Irrigation	87,260	29,820	117,080
Total Zone M	97,230	52,680	149,910
Zone N			
Municipal	1,120	0	1,120
Industrial	0	0	0
Irrigation	610	210	820
Total Zone N	1,730	210	1,940
Zone O			
Municipal	640	520	1,160
Industrial	0	0	0
Irrigation	2,880	1,540	4,420
Total Zone O	3,520	2,060	5,580
Zone P			
Municipal	5,480	4,260	9,740
Industrial	9,290	86,600	95,890
Irrigation	65,720	55,720	121,440
Total Zone P	80,490	146,580	227,070
Basin Totals			
Municipal	65,010	55,090	120,100
Industrial	19,730	97,260	116,990
Irrigation	3,978,120	114,460	4,092,580
Total Brazos Basin	4,062,860	266,810	4,329,670

TABLE II-12B. BRAZOS RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require- ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Plainview	7,200	3,400	3,800	Import from Sanford in Zone B, Canadian Basin
Distributed	9,800	9,800	0	
Total Zone A	17,000	13,200	3,800	
Zone B				
Crosbyton	600	0	600	White River
Ralls	500	0	500	White River
Spur	400	0	400	White River
Distributed	7,400	7,400	0	
Total Zone B	8,900	7,400	1,500	
Zone C				
Levelland	3,500	600	2,900	Import from Sanford
Littlefield	2,500	2,500	0	
Lubbock	51,000	12,800	38,200	Import from Sanford
Slaton	2,300	700	1,600	Import from Sanford
Distributed	2,700	1,900	800	Import from Sanford
Total Zone C	62,000	18,500	43,500	
Zone D				
Post	1,300	0	1,300	White River
Distributed	10,700	8,700	2,000	Seymour No. 2
Total Zone D	12,000	8,700	3,300	
Zone E				
Munday	700	0	700	Millers Creek
Seymour	1,100	0	1,100	Millers Creek
Distributed	1,900	900	1,000	Millers Creek
Total Zone E	3,700	900	2,800	

TABLE II-12B. BRAZOS RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone F				
Abilene	33,000	0	21,000	Fort Phantom Hill System
			12,000	Hubbard Creek
Sweetwater	25,000	0	5,000	Import from Oak Creek in Zone C, Colorado Basin
			2,500	Sweetwater
			17,500	Seymour No. 2
Distributed	2,000	1,000	1,000	Hubbard Creek
Total Zone F	60,000	1,000	59,000	
Zone G				
Albany	700	0	700	Hubbard Creek
Anson	700	0	700	Hubbard Creek
Breckenridge	1,700	0	1,000	Daniel
			700	Hubbard Creek
Cisco	2,400	0	2,400	Cisco
Haskell	1,100	0	1,100	Millers Creek
Stamford	1,500	0	1,500	Stamford
Distributed	4,300	1,300	500	Cisco
			500	Stamford
			2,000	Seymour No. 2
Total Zone G	12,400	1,300	11,100	
Zone H				
Graham	2,100	0	2,100	Salt Creek
Mineral Wells	4,400	0	1,000	Mineral Wells
			3,400	Keechi
Distributed	5,500	1,000	1,100	Salt Creek
			3,400	Keechi
Total Zone H	12,000	1,000	11,000	

TABLE II-12B. BRAZOS RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone I				
McGregor	3,600	3,600	0	
Stephenville	2,900	0	2,900	Belton System
Distributed	3,500	1,500	2,000	Belton System
Total Zone I	**10,000**	**5,100**	**4,900**	
Zone J				
Cleburne	4,100	4,100	0	
Hillsboro	2,200	2,200	0	
Distributed	3,500	3,500	0	
Total Zone J	**9,800**	**9,800**	**0**	
Zone K				
Distributed	9,800	1,200	1,900 6,700	Leon Belton System
Total Zone K	**9,800**	**1,200**	**8,600**	
Zone L				
Belton	4,400	1,400	3,000	Belton System
Cameron	1,300	0	1,300	Belton System
Georgetown	2,000	0	2,000	North San Gabriel
Killeen	5,300	0	5,300	Belton System
Fort Hood	12,000	0	12,000	Belton System
Lampasas	1,500	1,500	0	
Taylor	2,800	0	2,800	North San Gabriel
Temple	10,800	0	10,800	Belton System
Distributed	2,700	2,700	0	
Total Zone L	**42,800**	**5,600**	**37,200**	

TABLE II-12B. BRAZOS RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone M				
Marlin	2,000	0	2,000	Brazos River Authority (BRA) System
Waco	96,000	0	62,000 34,000	Waco BRA System
Texas Power & Light Co.	10,000	0	10,000	Lake Creek (off channel) with selected diversions from Brazos River
Distributed	2,000	2,000	0	
Total Zone M	110,000	2,000	108,000	
Zone N				
Rockdale	19,400	1,400	13,000 5,000	North San Gabriel Alcoa (off channel) with selected diversions from Little River
Distributed	7,500	1,500	6,000	Somerville
Total Zone N	26,900	2,900	24,000	
Zone O				
Bryan	18,000	4,000	14,000	Millican
Mexia	1,400	0	1,400	Bistone
Distributed	1,600	1,600	0	
Total Zone O	21,000	5,600	15,400	
Zone P				
Brenham	1,500	1,500	0	
Freeport	400,000	2,000	82,800 19,900 31,900 29,100 165,000 69,300	BRA System Belton System Stillhouse Hollow Somerville Millican Allens Creek (off channel) with selected diversions from Brazos River from existing facilities

TABLE II-12B. BRAZOS RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Navasota	1,100	0	1,100	Millican
Rosenberg	4,000	4,000	0	
West Columbia	1,200	1,200	0	
Houston Lighting & Power Co.	8,000	0	8,000	Smithers
Distributed	78,800	6,800	72,000	Millican
Total Zone P	494,600	15,500	479,100	
Total Brazos Basin	912,900	99,700	813,200	

Summary for Brazos Basin

Requirements supplied by:

Ground Water			99,700
Surface Water		760,900	
Imports from other basins:			
Canadian Basin	47,300		
Colorado Basin	5,000		
Total imports		52,300	
Total surface water			813,200
Total requirements			912,900

TABLE II-12C. BRAZOS RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
No reservoirs in zone	0	—		—	—	—
Sanford in Canadian Basin	—	*3,800*	Plainview	*3,800*	—	—
Total Zone A	0	3,800		3,800	0	0
Zone B						
White River	4,000		Crosbyton	600		
			Ralls	500		
			Spur	400		
			Post, Zone D	1,300		
Total White River	*4,000*	*0*		*2,800*	*0*	*1,200*
Total Zone B	4,000	0		2,800	0	1,200
Zone C						
No reservoirs in zone	0	—		—	—	—
Sanford in Canadian Basin	—	*43,500*	Levelland	2,900		
			Lubbock	38,200		
			Slaton	1,600		
			Distributed	800		
			Total Sanford Import	*43,500*	—	—
Total Zone C	0	43,500		43,500	0	0
Zone D						
Seymour No. 2	33,000		Distributed	2,000		
			Sweetwater, Zone F	17,500		
			Distributed, Zone G	2,000		
Total Seymour No. 2	*33,000*	*0*		*21,500*	*0*	*11,500*
Total Zone D	33,000	0		21,500	0	11,500
Zone E						
Millers Creek	6,000		Munday	700		
			Seymour	1,100		
			Distributed	1,000		
			Haskell, Zone G	1,100		
Total Millers Creek	*6,000*	*0*		*3,900*	*0*	*2,100*
Total Zone E	6,000	0		3,900	0	2,100
Zone F						
Sweetwater	*2,500*		Sweetwater	*2,500*	*0*	*0*
Oak Creek in Colorado Basin	—	*5,000*	Sweetwater	*5,000*	—	—
Abilene System: Fort Phantom Hill, Abilene, Kirby	*21,000*		Abilene	*21,000*	*0*	*0*
Total Zone F	23,500	5,000		28,500	0	0
Zone G						
Stamford	2,000		Stamford	1,500		
			Distributed	500		
Total Stamford	*2,000*	*0*		*2,000*	*0*	*0*

TABLE II-12C. BRAZOS RIVER BASIN (Cont'd)

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Cisco	2,900		Cisco	2,400		
			Distributed	500		
Total Cisco	*2,900*	*0*		*2,900*	*0*	*0*
Hubbard Creek	30,400		Abilene, Zone F	12,000		
			Albany	700		
			Anson	700		
			Breckenridge	700		
			Distributed, Zone F	1,000		
Total Hubbard Creek	*30,400*	*0*		*15,100*	*0*	*15,300*
Daniel	*1,000*		Breckenridge	*1,000*	*0*	*0*
Total Zone G	36,300	0		21,000	0	15,300
Zone H						
Salt Creek	7,000		Graham	2,100		
			Distributed	1,100		
Total Salt Creek	*7,000*	*0*		*3,200*	*0*	*3,800*
Keechi	6,800		Mineral Wells	3,400		
			Distributed	3,400		
Total Keechi	*6,800*	*0*		*6,800*	*0*	*0*
Mineral Wells	*1,000*	*0*	Mineral Wells	*1,000*	*0*	*0*
Brazos River Authority (BRA) System						
Possum Kingdom } Whitney, Zone J }	332,000		Marlin, Zone M	2,000		
			Waco, Zone M	34,000		
			Freeport, Zone P	82,800		
			Stream delivery loss, Zone P	44,500		
			San Jacinto-Brazos Coastal Area (SJ-BR), Zone A:			
			Texas City		27,400	
			La Marque		1,300	
			Stream delivery loss		23,300	
			Total Zone A, SJ-BR		52,000	
			San Jacinto-Brazos Coastal Area (SJ-BR), Zone B:			
			Distributed		10,000	
			Stream delivery loss		6,700	
			Total Zone B, SJ-BR		16,700	
			Total SJ-BR (68,700)			
Total BRA System	*332,000*	*0*		*163,300*	*68,700*	*100,000*[1]
Total Zone H	346,800	0		174,300	68,700	103,800
Zone I						
Waco (Enlarged)	*62,000*		Waco, Zone M	*62,000*	*0*	*0*
Total Zone I	62,000	0		62,000	0	0

TABLE II-12C. BRAZOS RIVER BASIN (Cont'd)

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems: Name	Yield	Imports	Distribution: Place	Amount: Basin Use	Amount: Exports	Yield Remaining
Zone J						
Whitney (See Zone H)	—	—		—	—	—
Zone K						
Leon	*1,900*		Distributed	*1,900*	*0*	*0*
Belton System						
Proctor, Belton	123,000		Distributed	6,700		
			Stephenville, Zone I	2,900		
			Distributed, Zone I	2,000		
			Cameron, Zone L	1,300		
			Killeen, Zone L	5,300		
			Fort Hood, Zone L	12,000		
			Temple, Zone L	10,800		
			Belton, Zone L	3,000		
			Freeport, Zone P	19,900		
			Stream delivery loss, Zone P	8,500		
Total Belton System	*123,000*	*0*		*72,400*	*0*	*50,600*[2]
Total Zone K	**124,900**	**0**		**74,300**	**0**	**50,600**
Zone L						
North San Gabriel	19,800		Georgetown	2,000		
			Taylor	2,800		
			Rockdale, Zone N	13,000		
Total North San Gabriel	*19,800*	*0*		*17,800*	*0*	*2,000*
Stillhouse Hollow	60,500		Freeport, Zone P	31,900		
			Stream delivery loss, Zone P	13,600		
Total Stillhouse Hollow	*60,500*	*0*		*45,500*	*0*	*15,000*
Total Zone L	**80,300**	**0**		**63,300**	**0**	**17,000**
Zone M						
Lake Creek (off channel)	*10,000*[3]		Texas Power & Light Co.	*10,000*	*0*	*0*
Total Zone M	**10,000**[3]	**0**		**10,000**	**0**	**0**
Zone N						
Alcoa (off channel)	*5,000*[4]		Rockdale	*5,000*	*0*	*0*
Somerville	47,300[4]		Distributed, Zone N	6,000		
			Freeport, Zone P	29,100		
			Stream delivery loss, Zone P	5,200		
Total Somerville	*47,300*	*0*		*40,300*	*0*	*7,000*
Total Zone N	**52,300**	**0**		**45,300**	**0**	**7,000**
Zone O						
Bistone	*1,600*		Mexia	*1,400*	*0*	*200*
Millican	292,000	0	Bryan	14,000		
			Freeport, Zone P	165,000		
			Stream delivery loss, Zone P	29,200		
			Distributed, Zone P	72,000		
Total Millican	*292,000*	*0*		*280,200*	*0*	*11,800*
Total Zone O	**293,600**	**0**		**281,600**	**0**	**12,000**

TABLE II-12C. BRAZOS RIVER BASIN (Cont'd)

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone P						
William Harris & Brazoria	—[5]	—	....	—	—	—
Allens Creek (off channel)	188,000[3]		Freeport	69,300		
			Stream delivery loss	6,900		
Total Allens Creek	*188,000*	*0*	....	*76,200*	*0*	*111,800*
Smithers	*8,000*[6]		Houston Lighting and Power Co.	*8,000*	*0*	*0*
Total Zone P	**196,000**	**0**	....	**84,200**	**0**	**111,800**
Total Brazos Basin	**1,268,700**	**52,300**	....	**920,000**	**68,700**	**332,300**

[1] Yield remaining for municipal, industrial, and other uses.
[2] Of this amount, 15,000 acre-feet from Belton Reservoir remain for present or future uses other than municipal and industrial.
[3] Selected diversions from Brazos River.
[4] Selected diversions from Little River.
[5] Annual yield included with yield of BRA System.
[6] Selected diversions from Brazos River from existing facilities.

Summary for Brazos Basin

Used in Brazos Basin		867,700
Export to San Jacinto-Brazos Coastal Area		68,700
Yield remaining:		
Municipal and industrial uses after 1980	217,300	
Other present or future uses	115,000	
Total yield remaining		332,300
Total yield		1,268,700
Imports from other basins:		
Canadian Basin	47,300	
Colorado Basin	5,000	
Total imports		52,300

TABLE II-12D. BRAZOS RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Buffalo	Dbl. Mtn. Fk. Brazos River	9 SE Lubbock	Lubbock	5,360	0	5,360	—	225
Sweetwater	Bitter Creek	6 SE Sweetwater	Nolan	11,900	0	11,900	2,500	630
Abilene	Big Elm Creek	6 NW Tuscola	Taylor	9,790	0	9,790		640
Kirby	Cedar Creek	5 S Abilene	Taylor	7,620	0	7,620	21,000	740
Fort Phantom Hill	Big Elm Creek	5 S Nugent	Jones	74,310	0	74,310		4,250
Stamford	Paint Creek	12 SE Haskell	Haskell	60,000	0	60,000	2,000	5,125
Cisco	Sandy Creek	3 N Cisco	Eastland	31,250	0	31,250	2,900	1,050
Hubbard Creek[1]	Hubbard Creek	6 NW Breckenridge	Stephens	320,000	0	320,000	30,400	12,800
Daniel	Gonzales Creek	8 S Breckenridge	Stephens	11,000	0	11,000	1,000	980
Salt Creek	Salt Creek	2 NW Graham	Young	52,500	0	52,500	7,000	2,550
Possum Kingdom	Brazos River	11 SW Graford	Palo Pinto	724,700	0	724,700	332,000	19,800
Mineral Wells	Rock Creek	15 WNW Weatherford	Parker	9,030	0	9,030	1,000	630
Whitney	Brazos River	7 SW Whitney	Hill-Bosque	387,000	1,630,500	2,017,500	([2])	15,800
Waco[1]	Bosque River	4 W Waco	McLennan	179,000	553,300	732,300	62,000	7,260
Lake Creek	Manos Creek (off channel)	4 WSW Riesel	McLennan	8,400	0	8,400	10,000	550
Leon	Leon River	8 S Ranger	Eastland	27,290	0	27,290	1,900	1,590
Proctor[1]	Leon River	9 NE Comanche	Comanche	64,100	310,100	374,200	11,600	4,610
Belton	Leon River	4 NW Belton	Bell	457,600	640,000	1,097,600	111,400	12,300
Alcoa	Sandy Creek (off channel)	6 SW Rockdale	Milam	10,500	0	10,500	5,000	700
Bistone[1]	Navasota River	7 SW Mexia	Limestone	10,000	0	10,000	1,600	1,200

TABLE II-12D. BRAZOS RIVER BASIN (Cont'd)

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Smithers	Dry Creek	10 SE Richmond	Fort Bend	18,000	0	18,000	8,000	2,140
William Harris	Brazos River (off channel)	7 NW Angleton	Brazoria	12,000	0	12,000	(2)	1,660
Manor-Eagle Nest	Trib. to Varners Creek	5 N West Columbia	Brazoria	18,000	0	18,000	—	4,300
Brazoria	Brazos River (off channel)	1 NE Brazoria	Brazoria	21,970	0	21,970	(2)	1,860
Total Existing				**2,531,320**	**3,133,900**	**5,665,220**	**611,300**	**103,390**
Proposed								
White River	White River	17 SE Crosbyton	Crosby	38,200	0	38,200	4,000	1,810
Seymour No. 2	Dbl. Mtn. Fk. Brazos River	16 NW Haskell	Haskell	261,000	59,000	320,000	33,000	10,000
Millers Creek	Millers Creek	13 SW Seymour	Baylor-Throckmorton	25,000	0	25,000	6,000	1,850
Keechi Creek	Keechi Creek	8 S Mineral Wells	Palo Pinto	47,100	0	47,100	6,800	2,350
Stillhouse Hollow	Lampasas River	4 SW Belton	Bell	239,800	389,900	629,700	60,500	6,430
N. San Gabriel	N. San Gabriel R.	3 W Georgetown	Williamson	133,700	87,900	221,600	19,800	3,240
Somerville	Yegua Creek	3 SW Somerville	Burleson-Washington	169,800	337,700	507,500	47,300	11,460
Millican	Navasota River	2 N Navasota	Grimes-Brazos	2,400,000	770,000	3,170,000	292,000	85,000
Allens Creek	Allens Creek (off channel)	10 SE Sealy	Austin	575,000	0	575,000	188,000	14,400
Total Proposed				**3,889,600**	**1,644,500**	**5,534,100**	**657,400**	**136,540**
Total Brazos Basin				**6,420,920**	**4,778,440**	**11,199,320**	**1,268,700**	**239,930**

[1] Under construction.
[2] Annual yield included with yield of Possum Kingdom.

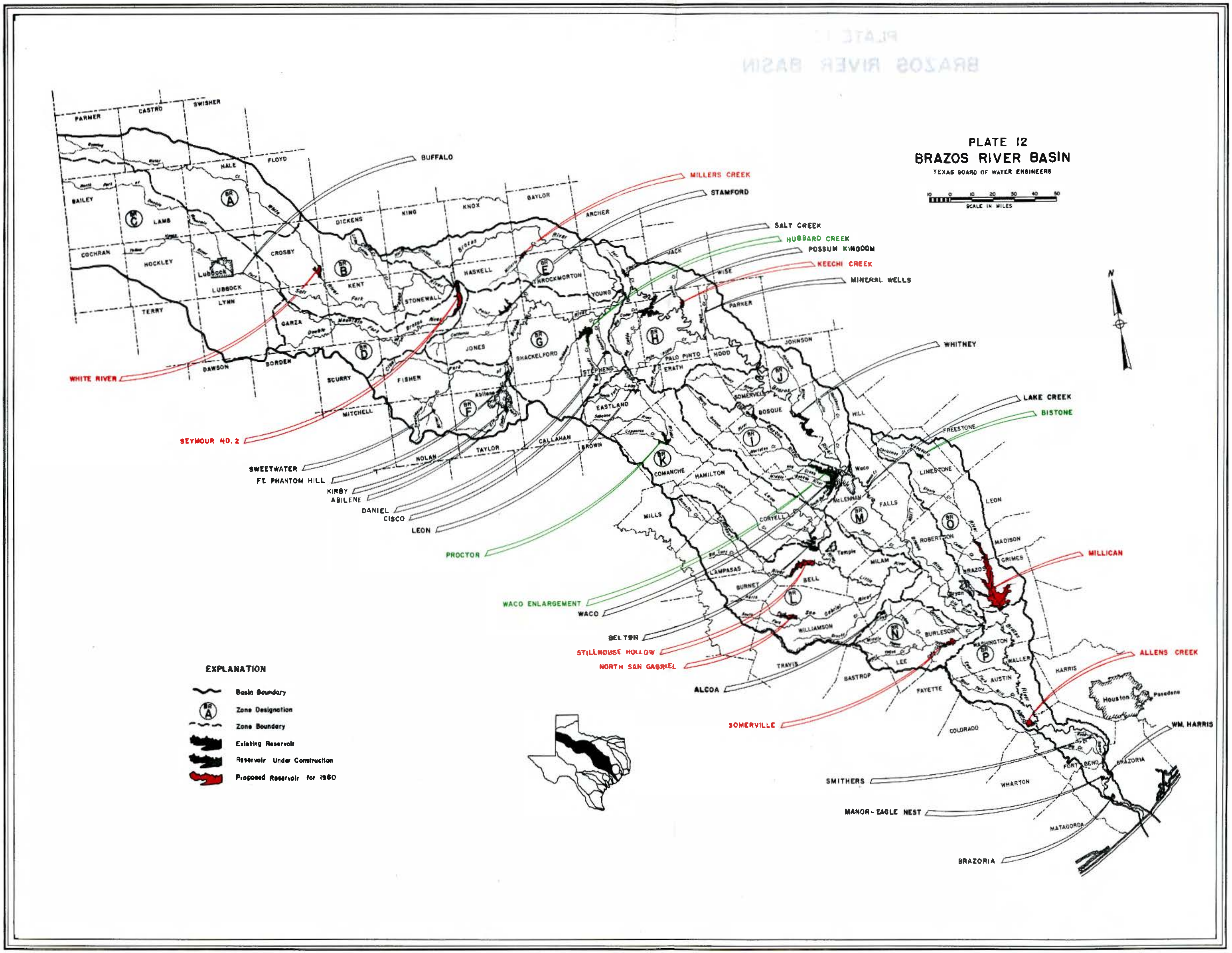


PLATE 12
BRAZOS RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
SCALE IN MILES
10 0 10 20 30 40 50
N
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Reservoir Under Construction
Proposed Reservoir for 1960
BUFFALO
MILLERS CREEK
STAMFORD
SALT CREEK
HUBBARD CREEK
POSSUM KINGDOM
KEECHI CREEK
MINERAL WELLS
WHITNEY
LAKE CREEK
BISTONE
MILLICAN
ALLENS CREEK
WM. HARRIS
SMITHERS
MANOR - EAGLE NEST
BRAZORIA
SOMERVILLE
ALCOA
NORTH SAN GABRIEL
STILLHOUSE HOLLOW
BELTON
WACO
WACO ENLARGEMENT
PROCTOR
LEON
CISCO
DANIEL
ABILENE
KIRBY
FT. PHANTOM HILL
SWEETWATER
SEYMOUR NO. 2
WHITE RIVER
PARMER
CASTRO
SWISHER
BAILEY
LAMB
HALE
FLOYD
COCHRAN
HOCKLEY
LUBBOCK
CROSBY
DICKENS
KING
KNOX
BAYLOR
ARCHER
TERRY
LYNN
GARZA
KENT
STONEWALL
HASKELL
THROCKMORTON
YOUNG
JACK
WISE
DAWSON
BORDEN
SCURRY
FISHER
JONES
SHACKELFORD
STEPHENS
PALO PINTO
PARKER
HOOD
JOHNSON
ERATH
SOMERVELL
BOSQUE
HILL
MITCHELL
NOLAN
TAYLOR
CALLAHAN
EASTLAND
BROWN
COMANCHE
HAMILTON
MILLS
CORYELL
McLENNAN
Waco
FALLS
LIMESTONE
FREESTONE
LEON
ROBERTSON
MADISON
GRIMES
BRAZOS
Bryan
LAMPASAS
BURNET
BELL
Temple
MILAM
WILLIAMSON
TRAVIS
BASTROP
LEE
BURLESON
WASHINGTON
WALLER
AUSTIN
FAYETTE
COLORADO
HARRIS
Houston
Pasadena
FORT BEND
WHARTON
MATAGORDA
BRAZORIA
Lubbock

BRAZOS-COLORADO COASTAL AREA

This coastal area is located between the Brazos and Colorado Rivers and includes the drainage area of the San Bernard River. This portion of the Gulf Coastal Plain geographical province has an average rainfall of about 41 inches per year and an average annual net evaporation loss of about 14 inches per year. Runoff averages about 350 acre-feet per square mile annually in this area. The location and boundaries of this area are shown on Plate 13.

The chemical quality of water in the San Bernard River is indicated by periodic sampling to be good; and the water is suitable for municipal, agricultural, and many industrial uses.

The uses of water in this area in 1959 for municipalities, industries, and irrigation are shown in Table II-13A to total 366,880 acre-feet. Of this total, 135,190 acre-feet was obtained from ground-water sources; and the remaining 150,990 acre-feet was supplied from surface-water facilities.

Projected 1980 municipal and industrial water requirements for this area total 86,800 acre-feet. Of this total, 10,800 acre-feet is indicated as being supplied from ground-water sources; and 76,000 acre-feet, from surface-water sources. Details of the location of these requirements and how they may be met are contained in Tables II-13B and II-13C. As this coastal area does not have any existing or proposed surface reservoirs, information pertaining to reservoirs which will supply the surface water to this area is contained in the portions of this report describing the river basin in which those reservoirs are located.

TABLE II-13A. BRAZOS-COLORADO COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	1,080	0	1.080
Industrial	4,010	2,990	7,000
Irrigation	130,100	148,000	278,100
Total Zone A	**135,190**	**150,990**	**286,180**
Total Brazos-Colorado Coastal Area	**135,190**	**150,990**	**286,180**

TABLE II-13B. BRAZOS-COLORADO COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Brazoria	800	800	0	
Bay City	76,000	0	76,000	Import from Lower Colorado River Authority System in Zone J, Colorado Basin
Distributed	10,000	10,000	0	
Total Zone A	86,800	10,800	76,000	
Total Brazos-Colorado Coastal Area	86,800	10,800	76,000	

Summary for Brazos-Colorado Coastal Area

Requirements supplied by:

Ground Water	10,800
Import from Colorado Basin	76,000
Total requirements	86,800

TABLE II-13C. BRAZOS-COLORADO COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution		Yield Remaining
Name	Yield		Place	Amount Used	
Zone A					
No reservoirs in zone	0	—	....	—	—
Lower Colorado River Authority System in Colorado Basin	—	*76,000*	Bay City	*76,000*	—
Total Zone A	0	76,000	....	76,000	0
Total Brazos-Colorado Coastal Area	0	76,000	....	76,000	0

Summary for Brazos-Colorado Coastal Area

Import from Colorado Basin 76,000

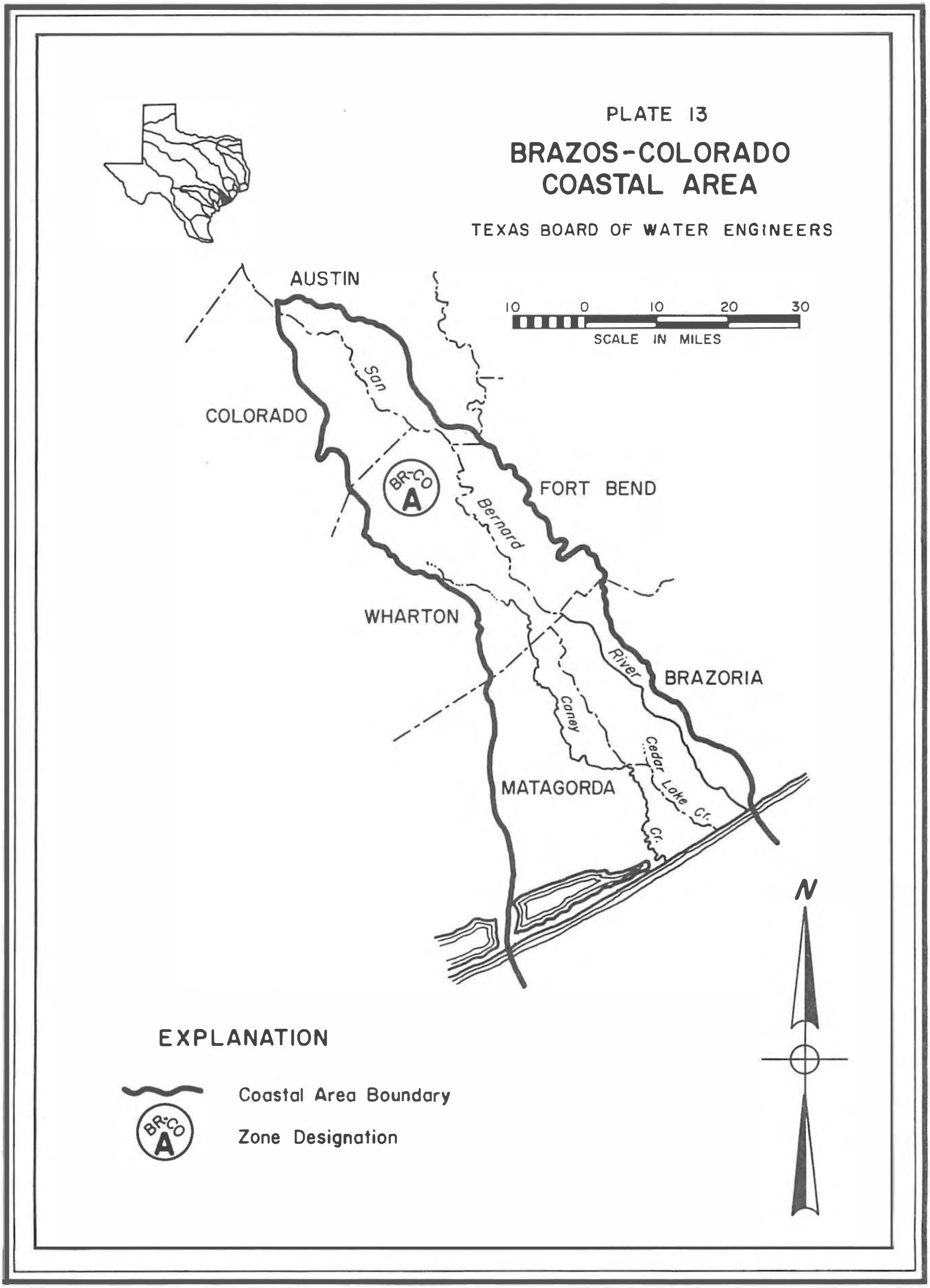


PLATE 13
BRAZOS-COLORADO
COASTAL AREA
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
AUSTIN
COLORADO
FORT BEND
WHARTON
BRAZORIA
MATAGORDA
San
Bernard
River
Caney
Cedar Lake Cr.
Cr.
BR-CO A
N
EXPLANATION
Coastal Area Boundary
Zone Designation

COLORADO RIVER BASIN

The Colorado River Basin, as shown on Plate 14, has been divided into 12 zones. This basin extends from the headwaters area in southeastern New Mexico, across the South High Plains, through Central Texas, to the Gulf of Mexico. The basin drains, in downstream order, portions of the Great Plains, Central Texas, and Gulf Coastal Plain geographical provinces.

Rainfall on this basin varies from an average of 16 inches on the High Plains portion, to about 31 inches at Mansfield Dam, to about 39 inches annually on the lower reach near the Coast. In contrast to this rainfall, the average net evaporation rates vary from about 65 inches annually in the upper reach, to about 37 inches at Mansfield Dam, to about 22 inches at Columbus.

Runoff rates in the semi-arid upper portion of the basin vary from practically nothing on the High Plains, to about 75 acre-feet per square mile annually in the drainage above Buchanan Dam, to about 250 acre-feet per square mile in the reach of stream from Austin to the mouth.

The chemical quality of surface water in the Colorado River varies through extreme ranges, with more than 4,000 ppm (parts per million) total dissolved solids occurring above Colorado City, to an average of less than 500 ppm at San Saba, to an average of less than 250 ppm below the 6 Highland Lakes. For the 1959 water year, the weighted average of dissolved solids was 4,990 ppm for the Colorado River at Ira (State Highway 350 crossing, Scurry County); 249 ppm at Austin; and 231 ppm at Wharton. The water of the upper basin, most tributaries, and the basin below Buchanan Dam is chemically suitable for municipal, industrial, and agricultural uses. The water in parts of the middle reach of the Colorado River contains undesirable chloride concentrations.

In September 1962, the reconnaissance ground-water study for this basin will be completed. Somewhat more detailed studies have been completed for the following counties in the basin: Crane, Edwards, Hays, McCulloch, Real, and Winkler.

The principal aquifers of the basin are the Ogallala formation, Triassic sands which include the Santa Rosa sandstone, the Edwards-Trinity (Edwards limestone and Trinity sands), the Carrizo-Wilcox sands, the Miocene sands (Catahoula-Oakville-Lagarto), and the Coastal sands (Goliad-Willis-Lissie-Beaumont). The Miocene sands and Coastal sands are discussed here as a combined aquifer referred to as the Miocene-Coastal sands because they are similar lithologically and because wells draw water from both aquifers in parts of the area.

Locations in the basin where the principal aquifers yield fresh water are shown on Plate 25. The Triassic aquifer, considered to be significant within the river basin, is located in parts of the Mitchell, Nolan, and Scurry Counties.

Large quantities of ground water are available from the principal aquifers in the basin. Smaller quantities, available from several minor aquifers, are adequate for supplying small towns, minor irrigation, domestic and stock uses; and all are important to the areas they serve. Some of the minor aquifers in the basin are the Edwards limestone (fault zone), the Hickory sandstone in the central part of the basin; alluvial deposits of local extent throughout the basin; and the Mt. Selman and Sparta sands in the lower portion of the basin.

The chemical quality of ground water in the principal aquifers is such that the water is generally acceptable for municipal, most industrial, and irrigation purposes.

Data available indicate that the present rate of pumpage from the Ogallala exceeds the rate of recharge. Reconnaissance studies have not progressed to the point where reliable estimates of the quantity of water available from storage in the aquifer within the Colorado River Basin can be obtained. However, where pumpage exceeds recharge, the present rate of pumpage cannot be maintained indefinitely.

Present uses of water in each of these zones during 1959 for municipalities, industries, and irrigation is shown in Table II-14A to total 1,065,340 acre-feet. Of this total, 859,130 acre-feet was obtained from underground sources; and the remaining 206,210 acre-feet, from surface-water supplies.

The projected 1980 municipal and industrial water requirements for this basin total 378,300 acre-feet. As shown in Tables II-14B and II-14C, this total requirement may be supplied by using 66,100 acre-feet of ground water and 311,300 acre-feet of surface water.

Fifteen existing reservoirs will continue to supply a large part of the 1980 water requirements of the Colorado River Basin. The proposed Sanford Reservoir on the Canadian River will supply Brownfield and Lamesa in the Colorado River headwater area. One reservoir is under construction, and four additional reservoirs are proposed in this basin. Ground water will continue to serve some of the requirements of the basin.

The Colorado River Municipal Water District cities of Odessa, Snyder, and Big Spring will be served by the existing Lake J. B. Thomas and the proposed Robert Lee Reservoir on the Colorado River in Coke County. Robert Lee Reservoir can also supply part of the requirements of Midland and Ballinger.

Colorado City and surrounding area industrial uses will be supplied by the existing Lake Colorado City and Champion Creek Reservoir.

San Angelo will be served from a system of three reservoirs which include the existing San Angelo and Nasworthy Reservoirs and the under-construction Twin Buttes Reservoir.

Coleman will continue to obtain part of its water supply from the existing Hords Creek Reservoir. The proposed Jim Ned Creek Reservoir in Coleman County is proposed to meet the projected 1980 water requirements.

Brownwood will continue to be supplied from the existing Brownwood Reservoir. A reservoir is proposed on Brady Creek in McCulloch County to serve the needs of Brady.

The Lower Colorado River Authority System of six existing reservoirs, i.e., Buchanan, Inks, Granite Shoals, Marble Falls, Travis, and Austin, plus Town Lake at Austin, can supply Austin, Marble Falls, and Burnet. The operation of these reservoirs, coordinated with the proposed Columbus Bend Reservoir near Columbus, can supply the municipal and industrial needs of Columbus, Eagle Lake, Wharton, El Campo, Palacios, Bay City, and adjacent coastal areas.

Ground water will continue to serve a portion of the water requirements of the basin.

Detailed information concerning the location and pertinent features of the proposed reservoirs, together with data for existing and under-construction reservoirs, is contained in Table II-14D.

Other reservoirs investigated and considered for future development include Stacy Reservoir on the Colorado River, San Saba Reservoir on the San Saba River, Llano Reservoir on the Llano River, Rodway Reservoir on the Pedernales River, and La Grange Reservoir on the Colorado River.

TABLE II-14A. COLORADO RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	21,910	15,690	37,600
Industrial	10,810	0	10,810
Irrigation	662,300	0	662,300
Total Zone A	695,020	15,690	710,710
Zone B			
Municipal	180	1,710	1,890
Industrial	530	3,770	4,300
Irrigation	32,580	840	33,420
Total Zone B	33,290	6,320	39,610
Zone C			
Municipal	0	0	0
Industrial	0	0	0
Irrigation	3,230	4,080	7,310
Total Zone C	3,230	4,080	7,310
Zone D			
Municipal	680	0	680
Industrial	280	0	280
Irrigation	25,810	12,430	38,240
Total Zone D	26,770	12,430	39,200
Zone E			
Municipal	390	0	390
Industrial	0	0	0
Irrigation	12,850	4,950	17,800
Total Zone E	13,240	4,950	18,190

TABLE II-14A. COLORADO RIVER BASIN (Cont'd)

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone F			
Municipal	740	870	1,610
Industrial	10	80	90
Irrigation	2,220	7,600	9,820
Total Zone F	2,970	8,550	11,520
Zone G			
Municipal	370	12,510	12,880
Industrial	470	670	1,140
Irrigation	2,340	37,910	40,250
Total Zone G	3,180	51,090	54,270
Zone H			
Municipal	250	0	250
Industrial	0	0	0
Irrigation	1,280	8,590	9,870
Total Zone H	1,530	8,590	10,120
Zone I			
Municipal	1,970	20	1,990
Industrial	0	0	0
Irrigation	14,780	14,110	28,890
Total Zone I	16,750	14,130	30,880
Zone J			
Municipal	2,080	30,590	32,670
Industrial	10	0	10
Irrigation	16,060	5,330	21,390
Total Zone J	18,150	35,920	54,070

TABLE II-14A. COLORADO RIVER BASIN (Cont'd)

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone K			
Municipal	2,300	0	2,300
Industrial	280	0	280
Irrigation	1,850	9,060	10,910
Total Zone K	**4,430**	**9,060**	**13,490**
Zone L			
Municipal	1,930	0	1,930
Industrial	0	0	0
Irrigation	38,640	31,690	70,330
Total Zone L	**40,570**	**31,690**	**72,260**
Basin Totals			
Municipal	32,800	61,390	94,190
Industrial	12,390	4,520	16,910
Irrigation	813,940	136,590	950,530
Total Colorado Basin	**859,130**	**202,500**	**1,061,630**

TABLE II-14B. COLORADO RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Andrews	4,500	4,500	0	
Brownfield	3,600	1,400	2,200	Import from Sanford in Zone B, Canadian Basin
Lamesa	4,200	2,000	2,200	Import from Sanford
Midland	27,100	6,400	14,000	Robert Lee
			6,700	Return flow
Odessa	36,500	12,700	7,200	J. B. Thomas
			12,000	Robert Lee
			4,600	Return flow
Snyder	6,800	0	6,800	J. B. Thomas
Stanton	600	600	0	
Distributed	37,700	37,700	0	
Total Zone A	121,000	65,300	55,700	
Zone B				
Big Spring	26,000	0	10,000	J. B. Thomas
			16,000	Robert Lee
Colorado City	3,400	0	2,000	Colorado City
			1,400	Champion Creek
Distributed	600	600	0	
Total Zone B	30,000	600	29,400	
Zone C				
Distributed	2,000	2,000	0	
Total Zone C	2,000	2,000	0	
Zone D				
Distributed	3,800	3,800	0	
Total Zone D	3,800	3,800	0	
Zone E				
Distributed	1,800	1,800	0	
Total Zone E	1,800	1,800	0	

TABLE II-14B. COLORADO RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone F				
Coleman	1,700	0	800 900	Hords Creek Jim Ned Creek
Distributed	600	600	0	
Total Zone F	**2,300**	**600**	**1,700**	
Zone G				
Ballinger	1,900	0	1,900	Robert Lee
Brownwood	6,700	0	6,700	Brownwood
San Angelo	25,000	0	25,000	San Angelo System
Distributed	15,700	2,300	4,000 5,000 4,400	San Angelo System Brownwood Robert Lee
Total Zone G	**49,300**	**2,300**	**47,000**	
Zone H				
Distributed	1,200	1,200	0	
Total Zone H	**1,200**	**1,200**	**0**	
Zone I				
Brady	3,000	500	2,500	Brady
Distributed	1,700	1,700	0	
Total Zone I	**4,700**	**2,200**	**2,500**	
Zone J				
Austin	89,000	0	89,000	Lower Colorado River Authority (LCRA) System
Burnet	1,500	0	1,500	LCRA System
Marble Falls	3,500	0	3,500	LCRA System
Distributed	10,900	2,000	8,200 700	LCRA System Diversions from small channel reservoirs
Total Zone J	**104,900**	**2,000**	**102,900**	

TABLE II-14B. COLORADO RIVER BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone K				
Columbus	7,200	0	7,200	LCRA System
Distributed	7,800	3,000	4,800	LCRA System
Total Zone K	15,000	3,000	12,000	
Zone L				
Eagle Lake	7,000	0	7,000	LCRA System
Wharton	34,000	0	34,000	LCRA System
Distributed	39,000	19,000	20,000	LCRA System
Total Zone L	80,000	19,000	61,000	
Total Colorado Basin	416,000	103,800	312,200	

Summary for Colorado Basin

Requirements supplied by:

Ground Water			103,800
Surface Water:			
Major reservoirs	295,800		
Small reservoirs	700		
Return flow	11,300		
Total Colorado surface water		307,800	
Import from Canadian Basin		4,400	
Total surface water			312,200
Total requirements			416,000

TABLE II-14C. COLORADO RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
J. B. Thomas	24,000		Odessa	7,200		
			Snyder	6,800		
			Big Spring, Zone B	10,000		
Total J. B. Thomas	*24,000*	*0*		*24,000*	*0*	*0*
Sanford in Canadian Basin	—	*4,400*	Brownfield	2,200	—	—
			Lamesa	2,200	—	—
			Total Sanford Import	*4,400*		
Total Zone A	24,000	4,400		28,400	0	0
Zone B						
Colorado City	*3,000*		Colorado City	*2,000*	*0*	*1,000*
Champion Creek	*5,000*		Colorado City	*1,400*	*0*	*3,600*
Robert Lee	50,000		Big Spring	16,000		
			Odessa, Zone A	12,000		
			Midland, Zone A	14,000		
			Ballinger, Zone G	1,900		
			Distributed, Zone G	4,400		
Total Robert Lee	*50,000*	*0*		*48,300*	*0*	*1,700*
Total Zone B	58,000	0		51,700	0	6,300
Zone C						
Oak Creek	5,000		Brazos Basin (BR), Zone F:			
			Sweetwater		5,000	
			Total Zone F, BR		5,000	
Total Oak Creek	*5,000*	*0*		*0*	*5,000*	*0*
Total Zone C	5,000	0		0	5,000	0
Zone D						
San Angelo System						
Twin Buttes / Nasworthy, Zone G / San Angelo, Zone E	49,000		San Angelo, Zone G	25,000		
			Distributed, Zone G	4,000		
Total San Angelo System	*49,000*	*0*		*29,000*	*0*	*20,000*[1]
Total Zone D	49,000	0		29,000	0	20,000
Zone E						
San Angelo (See Zone D)	—	—		—	—	—
Zone F						
Hords Creek	*900*		Coleman	*800*	*0*	*100*
Jim Ned Creek	*10,100*		Coleman	*900*	*0*	*9,200*
Brownwood	16,000		Brownwood, Zone G	6,700		
			Distributed, Zone G	5,000		
Total Brownwood	*16,000*	*0*		*11,700*	*0*	*4,300*[1]
Total Zone F	27,000	0		13,400	0	13,600

TABLE II-14C. COLORADO RIVER BASIN (Cont'd)

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone G						
Nasworthy (See Zone D)	—	—		—	—	—
Zone H						
No reservoirs in zone	0	0		0	0	0
Zone I						
Brady	*2,500*	*0*	Brady	*2,500*	*0*	*0*
Total Zone I	2,500	0		2,500	0	0
Zone J						
Lower Colorado River Authority (LCRA) System						
Buchanan, Inks, Granite Shoals, Marble Falls, Travis, Austin, Town Lake, Columbus Bend, Zone K	546,000		Burnet	1,500		
			Marble Falls	3,500		
			Austin	89,000		
			Distributed	8,200		
			Columbus, Zone K	7,200		
			Distributed, Zone K	4,800		
			Eagle Lake, Zone L	7,000		
			Wharton, Zone L	34,000		
			Distributed, Zone L	20,000		
			Colorado-Lavaca Coastal Area (CO-LA), Zone A:			
			El Campo		47,000	
			Palacios		3,000	
			Distributed		7,000	
			Total Zone A, CO-LA		57,000	
			Brazos-Colorado Coastal Area (BR-CO), Zone B:			
			Bay City		76,000	
			Total Zone B, BR-CO		76,000	
Total LCRA System	*546,000*	*0*		*175,200*	*133,000*	*237,800*[1]
Total Zone J	546,000	0		175,200	133,000	237,800

TABLE II-14C. COLORADO RIVER BASIN (Cont'd)

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining[1]
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone K						
Columbus Bend (See Zone J)	—	—		—	—	—
Zone L						
No reservoirs in zone	0	0		0	0	0
Total Colorado Basin	**711,500**	**4,400**		**300,200**	**138,000**	**277,700**

[1] Yield remaining for municipal, industrial, and other uses.

Summary for Colorado Basin

Used in Colorado Basin		295,800
Exports to other basins or coastal areas:		
Brazos Basin	5,000	
Brazos-Colorado Coastal Area	76,000	
Colorado-Lavaca Coastal Area	57,000	
Total exports		138,000
Yield remaining:		
Municipal and industrial uses after 1980	103,600	
Other present uses	174,100	
Total yield remaining		277,700
Total yield		711,500
Import from Canadian Basin		4,400

TABLE II-14D. COLORADO RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
J. B. Thomas	Colorado River	16 SW Snyder	Scurry-Borden	204,000	0	204,000	24,000	7,820
Colorado City	Morgan Creek	6 SW Colorado City	Mitchell	31,800	0	31,800	3,000	1,850
Champion Creek	Champion Creek	7 S Colorado City	Mitchell	41,700	0	41,700	5,000	1,560
Oak Creek	Oak Creek	5 SE Blackwell	Coke	39,360	0	39,360	5,000	2,375
Twin Buttes[1]	South Concho River	8 SW San Angelo	Tom Green	170,000	430,000	600,000		9,150
Nasworthy	South Concho River	6 SW San Angelo	Tom Green	12,390	0	12,390	49,000	1,330
San Angelo	North Concho River	3 NW San Angelo	Tom Green	119,200	277,200	396,400		5,440
Hords Creek	Hords Creek	6 N Valera	Coleman	8,640	0[2]	8,640	900	510
Brownwood	Pecan Bayou	8 N Brownwood	Brown	137,300	0	137,300	16,000	7,580
Buchanan	Colorado River	11 W Burnet	Burnet-Llano	992,000	0	992,000		23,200
Inks	Colorado River	9 WSW Burnet	Burnet-Llano	17,000	0	17,000		830
Granite Shoals	Colorado River	4 WSW Marble Falls	Burnet-Llano	145,200	0	145,200		6,400
Marble Falls	Colorado River	0.7 S Marble Falls	Burnet-Llano	8,760	0	8,760	362,000	780
Travis	Colorado River	13 NW Austin	Travis	1,172,000	778,000	1,950,000		18,930
Lake Austin	Colorado River	3 NW Austin	Travis	21,000	0	21,000		1,830
Town Lake	Colorado River	3 SE Austin	Travis	3,520	0	3,520		420
Eagle Lake (Natural)	Caney Creek	2 S Eagle Lake	Colorado	9,600	0	9,600	—	1,200
Total Existing	.....	.....	.....	3,133,470	1,485,200	4,618,670	464,900	91,205
Proposed								
Robert Lee	Colorado River	6 W Robert Lee	Coke	346,000	0	346,000	50,000	16,000

TABLE II-14D. COLORADO RIVER BASIN (Cont'd)

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Jim Ned Creek	Jim Ned Creek	14 N Coleman	Coleman	40,000	24,000	64,000	10,100	2,700
Brady	Brady Creek	3 W Brady	McCulloch	30,000	0	30,000	2,500	1,950
Columbus Bend	Colorado River	2 WNW Columbus	Colorado	235,000	0	235,000	184,000	18,650
Total Proposed				651,000	24,000	675,000	246,600	39,300
Total Colorado Basin				3,784,470	1,509,200	5,293,670	711,500	130,505

[1] Under construction.

[2] Has 16,670 acre-feet of flood retardation capacity.

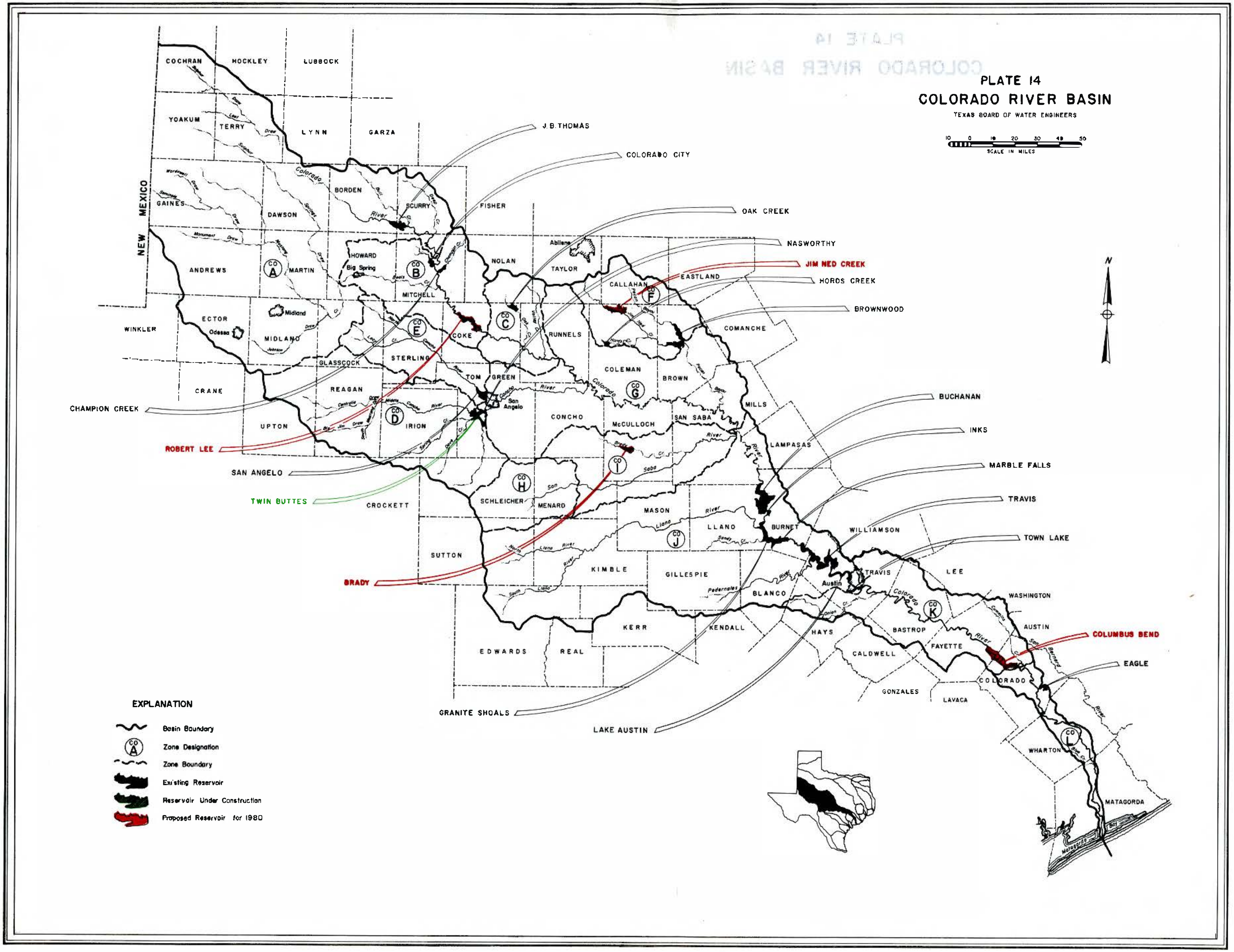


PLATE 14
COLORADO RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
SCALE IN MILES
J.B. THOMAS
COLORADO CITY
OAK CREEK
NASWORTHY
JIM NED CREEK
HORDS CREEK
BROWNWOOD
CHAMPION CREEK
ROBERT LEE
SAN ANGELO
TWIN BUTTES
BRADY
BUCHANAN
INKS
MARBLE FALLS
TRAVIS
TOWN LAKE
COLUMBUS BEND
EAGLE
GRANITE SHOALS
LAKE AUSTIN
NEW MEXICO
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Reservoir Under Construction
Proposed Reservoir for 1980

132

COLORADO-LAVACA COASTAL AREA

This portion of the Gulf Coastal Plain is located between the Colorado and Lavaca River watersheds. This area has been divided into two zones. (See Plate 15.)

Rainfall on the area averages about 37 inches annually as compared to the average annual net evaporation loss of about 18 inches. Annual runoff rates average about 300 acre-feet per square mile.

Uses of water for municipalities, industries, and irrigation in 1959 in this area are listed for each zone in Table II-15A. Of the total use of 127,290 acre-feet, 70,200 acre-feet was obtained from ground-water supplies; and 57,090 acre-feet, from surface-water facilities.

Projected 1980 municipal and industrial water requirements for this area total 69,900 acre-feet, of which 5,500 acre-feet is indicated to be supplied from ground-water sources; and 64,400 acre-feet, from surface-water supplies. Details of the location of these water requirements and the sources of supply for them are contained in Tables II-15B and II-15C. As no surface reservoirs exist in this area, and none are planned to meet the 1980 requirements, details pertaining to reservoirs to serve the surface-water requirements are contained in portions of this report describing the basins in which those reservoirs are located.

TABLE II-15A. COLORADO-LAVACA COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	720	0	720
Industrial	70	0	70
Irrigation	40,600	49,600	90,200
Total Zone A	41,390	49,600	90,990
Zone B			
Municipal	1,000	0	1,000
Industrial	260	0	260
Irrigation	27,550	7,490	35,040
Total Zone B	28,810	7,490	36,300
Coastal Area Totals			
Municipal	1,720	0	1,720
Industrial	330	0	330
Irrigation	68,150	57,090	125,240
Total Colorado-Lavaca Coastal Area	70,200	57,090	127,290

TABLE II-15B. COLORADO-LAVACA COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Source of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
El Campo	47,000	0	47,000	Import from Lower Colorado River Authority (LCRA) System in Zone J, Colorado Basin
Palacios	3,500	500	3,000	Import from LCRA System
Distributed	12,000	5,000	7,000	Import from LCRA System
Total Zone A	62,500	5,500	57,000	
Zone B				
Distributed	7,400	0	7,400	Import from Texana in Zone A, Lavaca Basin
Total Zone B	7,400	0	7,400	
Total Colorado-Lavaca Coastal Area	69,900	5,500	64,400	

Summary for Colorado-Lavaca Coastal Area

Requirements supplied by:

Ground Water		5,500
Imports from other basins:		
Colorado Basin	57,000	
Lavaca Basin	7,400	
Total imports		64,400
Total requirements		69,900

TABLE II-15C. COLORADO-LAVACA COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution		Yield Remaining
Name	Yield		Place	Amount Used	
Zone A					
No reservoirs in zone	0	—		—	—
Lower Colorado River Authority (LCRA) System in Colorado Basin	—	*57,000*	El Campo	47,000	
			Palacios	3,000	
			Distributed	7,000	
			Total LCRA System import	*57,000*	—
Total Zone A	0	57,000		57,000	0
Zone B					
No reservoirs in zone	0	—		—	—
Texana in Lavaca Basin	—	*7,400*	Distributed	*7,400*	—
Total Zone B	0	7,400		7,400	0
Total Colorado-Lavaca Coastal Area	0	64,400		64,400	0

Summary for Colorado-Lavaca Coastal Area

Imports from other basins:

Colorado Basin	57,000
Lavaca Basin	7,400
Total imports	64,400

PLATE 15

COLORADO - LAVACA COASTAL AREA

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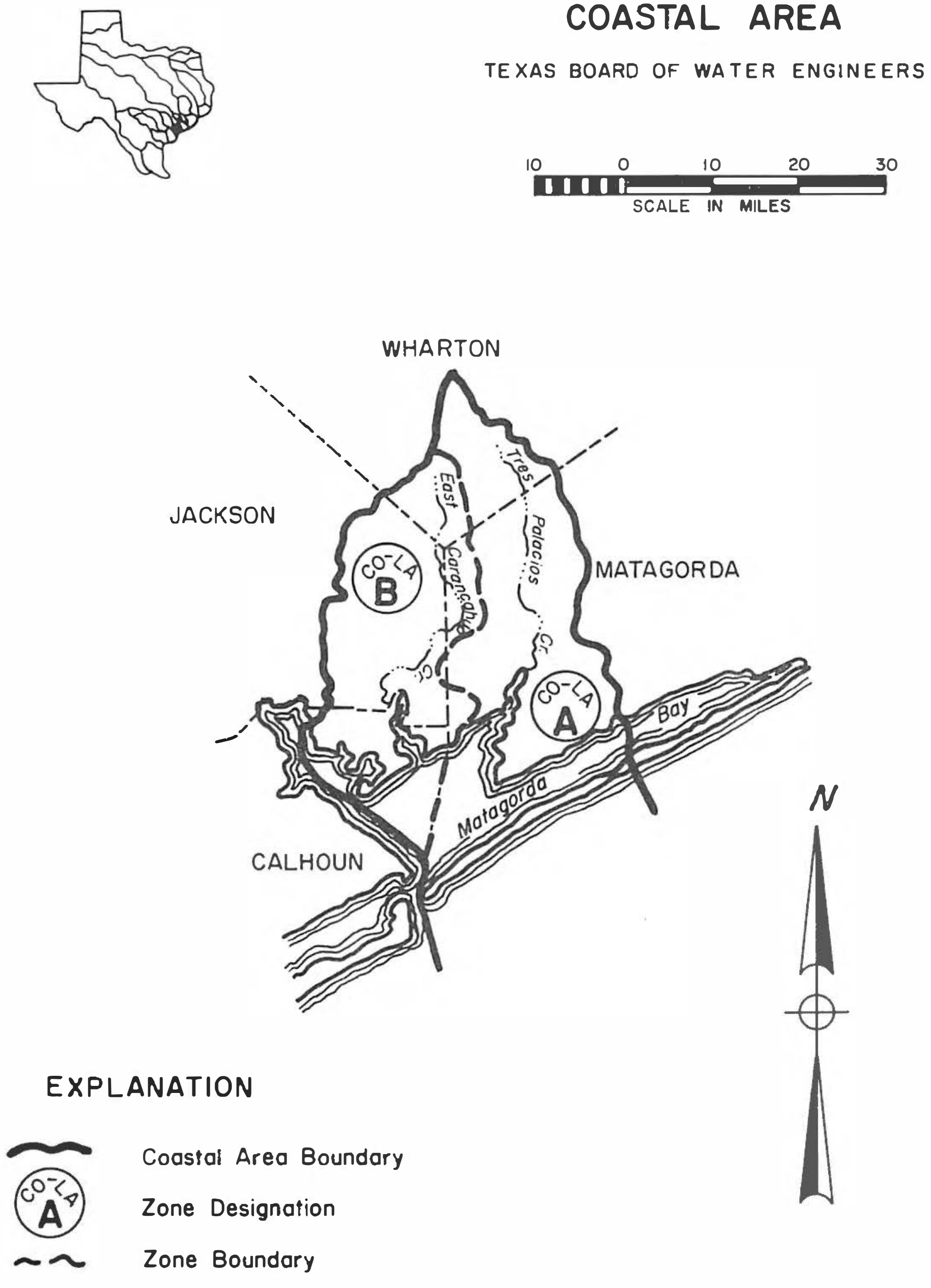

LAVACA RIVER BASIN

The Lavaca River Basin is located wholly on the Gulf Coastal Plain. It is composed of watersheds of two streams; namely, the Lavaca and Navidad Rivers. The location and extent of this basin is shown on Plate 16.

Rainfall on this basin averages about 37 inches annually, and net evaporation rates range from about 26 inches annually on the inland portion to about 20 inches near the Coast. Runoff rates average about 225 acre-feet per square mile.

The surface water in the Lavaca and Navidad Rivers is indicated, by periodic sampling, to be of a chemical quality suitable for municipal, agricultural, and most industrial uses.

The Lavaca River Basin ground-water reconnaissance study will be completed in September 1961. More comprehensive ground-water studies have been completed for Calhoun and Victoria Counties.

The principal aquifers in the Lavaca Basin are the Miocene sands (Catahoula-Oakville-Lagarto) and the Coastal sands (Goliad-Willis-Lissie-Beaumont). Because the Miocene sands and Coastal sands are lithologically similar and because wells draw water from both aquifers in parts of the area, they are treated here as a combined aquifer referred to as Miocene-Coastal sands. The location of the areas where these aquifers yield fresh water in the basin are shown on Plate 25. Moderate quantities of water, adequate for municipal and domestic supplies, are pumped from the Miocene sands, and large quantities for irrigation in the southeastern half of the basin are supplied from the Coastal sands.

The Coastal sands yield water of variable quality; however, the water generally is suitable for irrigation, municipal, and some industrial uses.

Uses of water for municipalities, industries, and irrigation in 1959 are listed in Table II-16A, and total 281,630 acre-feet. Of this total, 209,540 acre-feet was obtained from ground-water sources; and 72,090 acre-feet, from surface-water facilities. There are no major existing reservoirs in this basin.

The 1980 projected municipal and industrial water requirements for this basin total 17,200 acre-feet, of which 15,200 acre-feet is indicated to be supplied from ground-water sources; and 2,000 acre-feet, from surface-water supplies.

The first reservoir to conserve the surface waters of the Lavaca River Basin is proposed at the Texana site on the Navidad River in Jackson County. Texana Reservoir can provide for Ganado, Edna, Port Lavaca, and the future industrial water needs of that portion of the coastal area. Other municipal needs in the basin can be supplied from ground-water sources.

Details of the location of these requirements and how they may be supplied, together with pertinent details of the proposed Texana Reservoir, are contained in Tables II-14A, II-14B, and II-14C.

TABLE II-16A. LAVACA RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	2,820	0	2,820
Industrial	620	0	620
Irrigation	206,100	72,090	278,190
Total Zone A	209,540	72,090	281,630
Total Lavaca Basin	209,540	72,090	281,630

TABLE II-16B. LAVACA RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Yoakum	2,400	2,400	0	
Schulenburg	1,000	1,000	0	
Ganado	500	0	500	Texana
Edna	1,500	0	1,500	Texana
Distributed	11,800	11,800	0	
Total Zone A	17,200	15,200	2,000	
Total Lavaca Basin	17,200	15,200	2,000	

Summary for Lavaca Basin

Requirements supplied by:

Ground Water	15,200
Surface Water	2,000
Total requirements	17,200

TABLE II-16C. LAVACA RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
Texana	72,500		Ganado	500		
			Edna	1,500		
			Colorado-Lavaca Coastal Area (CO-LA), Zone B:			
			Distributed		7,400	
			Total Zone B, CO-LA		7,400	
			Lavaca-Guadalupe Coastal Area (LA-GU), Zone A:			
			Port Lavaca		39,700	
			Total Zone A, LA-GU		39,700	
Total Texana	*72,500*	*0*		*2,000*	*47,100*	*23,400*
Total Zone A	**72,500**	**0**		**2,000**	**47,100**	**23,400**
Total Lavaca Basin	**72,500**	**0**		**2,000**	**47,100**	**23,400**

Summary for Lavaca Basin

Used in Lavaca Basin 2,000

Exports to other basins or coastal areas:

Colorado-Lavaca Coastal Area 7,400
Lavaca-Guadalupe Coastal Area 39,700

Total exports 47,100

Yield remaining for municipal and industrial uses after 1980 23,400

Total yield 72,500

TABLE II-16D. LAVACA RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
None								
Proposed								
Texana	Navidad River	8 SE Edna	Jackson	120,000	0	120,000	72,500	6,250
Total Proposed	....	....	....	120,000	0	120,000	72,500	6,250
Total Lavaca Basin.....	....	....	....	120,000	0	120,000	72,500	6,250

PLATE 16

LAVACA RIVER BASIN

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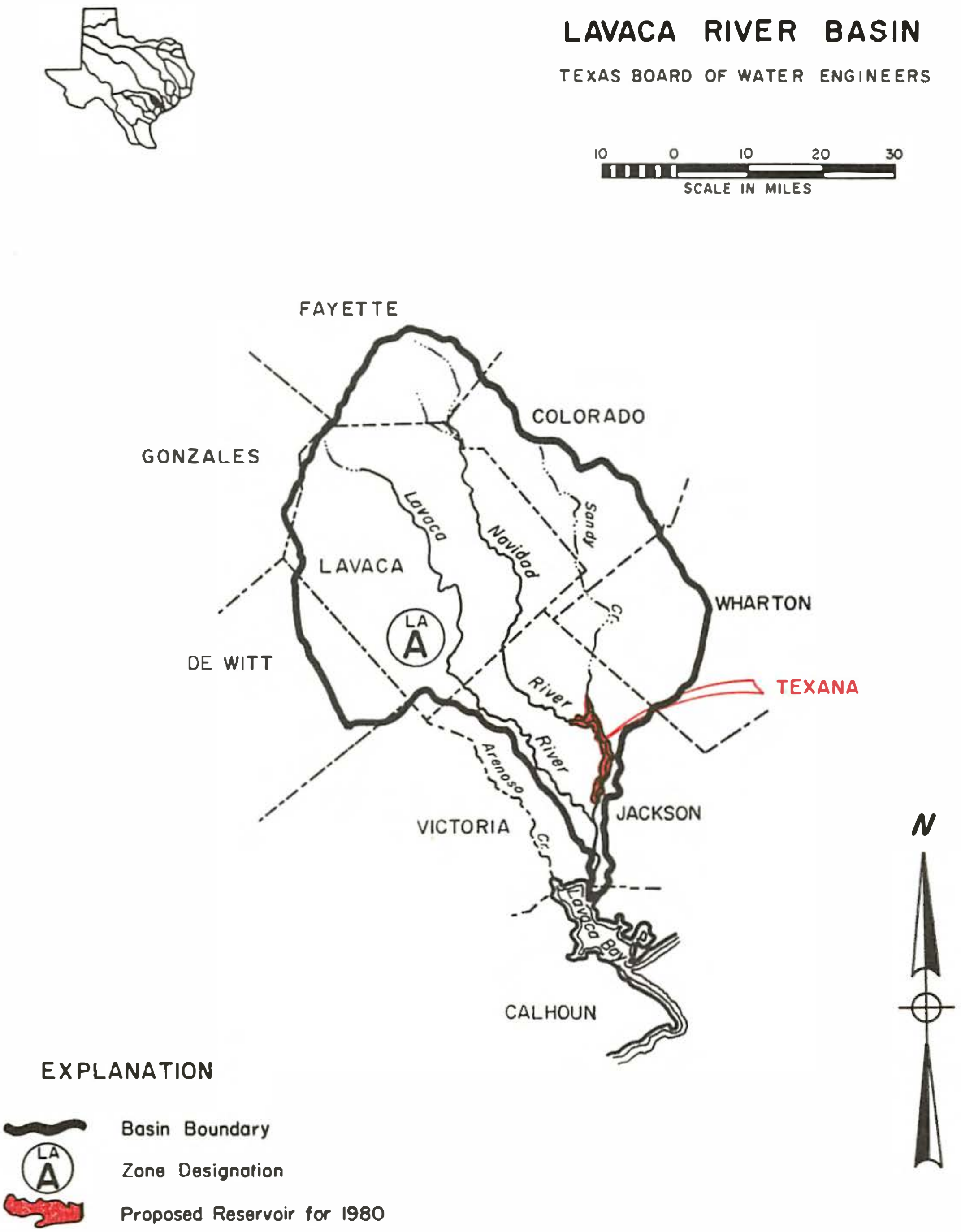


LAVACA-GUADALUPE COASTAL AREA

This area, located between the Lavaca and Guadalupe River watersheds, is located wholly on the Gulf Coastal Plain. Its location and boundaries are shown on Plate 17.

Rainfall on this area averages about 35 inches annually; the net evaporation rates for the area average about 22 inches annually. Annual runoff rates average about 200 acre-feet per square mile.

Uses of water for municipalities, industries, and irrigation in 1959 in this area are shown in Table II-17A to total 68,980 acre-feet. Of this total, 44,630 acre-feet was served from ground-water supplies; and 24,350 acre-feet, from surface-water sources.

The projected 1980 municipal and industrial water requirements for this area total 104,700 acre-feet. These requirements may be met by use of 15,000 acre-feet of ground water and 89,700 acre-feet of surface water. The location of these requirements and possible means of serving them are shown in Tables II-17B and II-17C.

No reservoirs are contemplated in this coastal area to meet the surface-water requirements. Details pertaining to reservoirs in adjacent areas to supply the surface-water requirements are shown in the tables contained in the portions of this report describing the basins in which those reservoirs are located. One reservoir considered for future development in this area is located on Garcitas Creek.

TABLE II-17A. LAVACA-GUADALUPE COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	780	0	780
Industrial	10	20	30
Irrigation	41,750	11,120	52,870
Total Zone A	**42,540**	**11,140**	**53,680**
Zone B			
Municipal	90	0	90
Industrial	0	2,370	2,370
Irrigation	2,000	13,210	15,210
Total Zone B	**2,090**	**15,580**	**17,670**
Coastal Area Totals			
Municipal	870	0	870
Industrial	10	2,390	2,400
Irrigation	43,750	24,330	68,080
Total Lavaca-Guadalupe Coastal Area	**44,630**	**26,720**	**71,350**

TABLE II-17B. LAVACA-GUADALUPE COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Port Lavaca	39,700	0	39,700	Import from Texana in Zone A, Lavaca Basin
Distributed	2,000	2,000	0	
Total Zone A	41,700	2,000	39,700	
Zone B				
Distributed	63,000	13,000	50,000	Import from Cuero I in Zone C, Guadalupe Basin
Total Zone B	63,000	13,000	50,000	
Total Lavaca-Guadalupe Coastal Area	104,700	15,000	89,700	

Summary for Lavaca-Guadalupe Coastal Area

Requirements supplied by:		
Ground Water		15,000
Imports from other basins:		
Lavaca Basin	39,700	
Guadalupe Basin	50,000	
Total imports		89,700
Total requirements		104,700

TABLE II-17C. LAVACA-GUADALUPE COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution		Yield Remaining
Name	Yield		Place	Amount Used	
Zone A					
No reservoirs in zone	0	—	....	—	—
Texana in Lavaca Basin	—	*39,700*	Port Lavaca	*39,700*	—
Total Zone A	**0**	**39,700**	....	**39,700**	**0**
Zone B					
No reservoirs in zone	0	—	....	—	—
Cuero I in Guadalupe Basin	—	*50,000*	Distributed	*50,000*	—
Total Zone B	**0**	**50,000**	....	**50,000**	**0**
Total Lavaca-Guadalupe Coastal Area	**0**	**89,700**	....	**89,700**	**0**

Summary for Lavaca-Guadalupe Coastal Area

Imports from other basins:

Lavaca Basin	39,700	
Guadalupe Basin	50,000	
Total imports		89,700

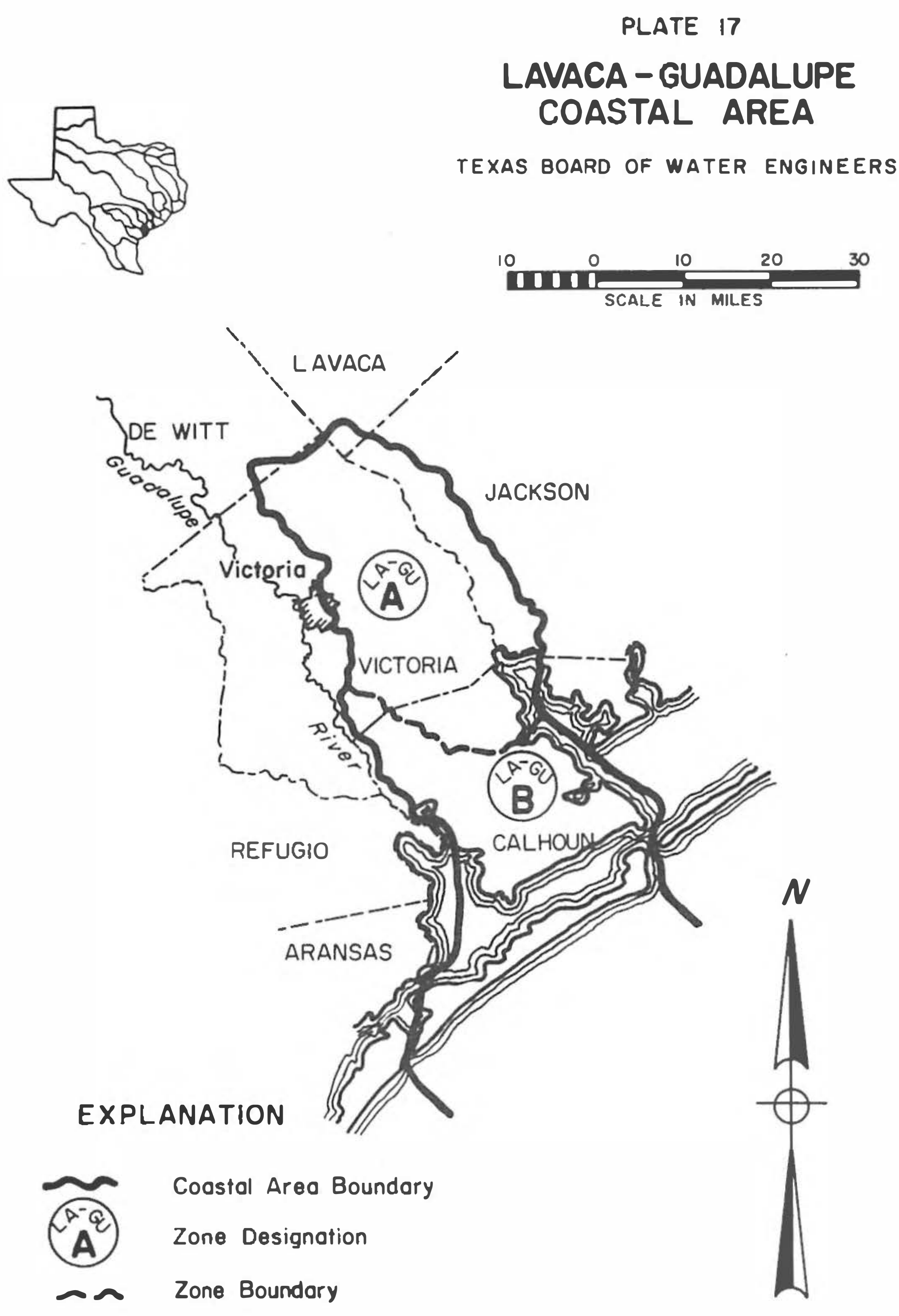


PLATE 17
LAVACA - GUADALUPE
COASTAL AREA
TEXAS BOARD OF WATER ENGINEERS
10
0
10
20
30
SCALE IN MILES
LAVACA
DE WITT
Guadalupe
JACKSON
Victoria
LA-GU
A
VICTORIA
River
LA-GU
B
CALHOUN
REFUGIO
ARANSAS
N
EXPLANATION
Coastal Area Boundary
LA-GU
A
Zone Designation
Zone Boundary

GUADALUPE RIVER BASIN

The Guadalupe River rises on the Edwards Plateau and follows a general southeasterly course across the Gulf Coastal Plain to empty into the Gulf of Mexico below Victoria. The San Marcos River, its principal tributary, has its headwaters on the Edwards Plateau and also drains a portion of the Gulf Coastal Plain. The location and extent of this basin is shown on Plate 18.

Rainfall on the watershed, ranges from an average of 26 inches annually in the upper headwater area of the Guadalupe River, to about 32 inches at Gonzales, to about 34 inches at the mouth. Average net evaporation rates vary from about 48 inches annually in the headwater area in Kerr County, to about 30 inches at Gonzales, to about 24 inches at the mouth.

Surface runoff varies from an average of about 100 acre-feet per square mile annually in the headwaters to an average of about 150 acre-feet per square mile from Canyon Dam to the mouth. In addition, the streamflow in the Guadalupe Basin is increased by discharges from the Comal, San Marcos, and Hueco Springs.

The chemical quality of the surface water in the Guadalupe River Basin is generally such that the water is suitable for municipal, agricultural, and most industrial uses. For the 1959 water year, the weighted average of dissolved solids of the Guadalupe River at Victoria was 303 ppm (parts per million).

In the Guadalupe River Basin, the reconnaissance ground-water study will be completed in August 1963. Somewhat more detailed studies have been made in the following counties in the basin: Calhoun, Comal, Goliad, Guadalupe, Hays, Karnes, Victoria, and Wilson.

The principal aquifers of the Guadalupe Basin are the Edwards-Trinity (Edwards limestone and Trinity sands) and Edwards limestone (fault zone) in the northern portion; the Carrizo-Wilcox sands in the central portion; and the Miocene sands (Catahoula-Oakville-Lagarto) and Coastal sands (Goliad-Willis-Lissie-Beaumont) in the southern portion. Since the Miocene sands and Coastal sands are lithologically similar and since wells in parts of the basin draw water from both aquifers, they are discussed as a combined aquifer referred to as the Miocene-Coastal sands. Areas in which the principal aquifers yield usable water are shown on Plate 25.

Substantial amounts of water drain from the Edwards-Trinity to form the base flow of perennial streams which supply much of the recharge to the Edwards limestone (fault zone). Thus, pumpage from the Edwards-Trinity reduces the quantity of water draining from it and indirectly reduces the quantity of water potentially available from the Edwards limestone (fault zone). Because the Edwards limestone (fault zone) has an exceptionally high transmissibility, pumpage from it in one basin, in many cases, diverts water that otherwise would move across basin boundaries to points of discharge through wells or springs. Because of these conditions, the quantity of water potentially available for development from the Edwards limestone (fault zone) in any one basin is dependent in part on the quantity of water pumped from the Edwards-Trinity in that basin and from both the Edwards-Trinity and Edwards limestone (fault zone) in adjacent basins.

Moderate quantities of water are available from the Carrizo-Wilcox sands, and large to moderate quantities are available from the Miocene-Coastal sands.

The chemical quality of ground water in the northern portion of the basin is such that the water is generally suitable for most purposes. Water obtained from the Carrizo-Wilcox sands ranges in quality from fair to good. Water from the Miocene-Coastal sands is of excellent quality in the most northerly area of its occurrence. Water in these sands, however, generally becomes poorer in quality in a coastward direction, and large-scale pumpage near the coast probably will cause problems of salt-water encroachment.

Uses of water by municipalities, industries, and irrigation in the Guadalupe River Basin in 1959 are listed in Table II-18A, and total 72,680 acre-feet. Of this total, 21,740 acre-feet was obtained from ground-water sources; and 50,940 acre-feet, from surface-water facilities. No major surface-water reservoirs exist in the basin, although a number of small, channel dams have been constructed in the headwater area and between New Braunfels and Cuero. These latter structures were installed and have been used for the generation of hydroelectric power.

Projected 1980 municipal and industrial water requirements for this basin total 133,700 acre-feet. Of this total, 32,800 acre-feet may be supplied from ground water; and 100.900 acre-feet. from surface-water facilities. Details of the location of these requirements and how they may be supplied are contained in Tables II-18B and II-18C.

Canyon Reservoir, now under construction, will be the first major reservoir in the Guadalupe River Basin. This reservoir can provide water supplies for that portion of the basin between Canyon Dam and Gonzales. To provide for the large potential municipal and industrial water requirements from Victoria to the mouth and adjacent coastal area, it is proposed to construct the first stage of Cuero Reservoir (Cuero I). The first-stage reservoir, on the Guadalupe River immediately above Cuero, has been proposed to meet 1980 water requirements, with an additional arm of the reservoir on Sandies Creek and a connecting channel to be added later. Ground water will continue to be used to supply part of the water needs of this basin.

Details relative to Canyon Reservoir and the proposed Cuero Reservoir (first stage) and the Salt Water Barrier are contained in Table II-18D.

Other reservoirs considered for future development in this basin include: the second stage of Cuero Reservoir (by adding a dam on Sandies Creek and a connecting channel between the Guadalupe and Sandies Reservoirs), Cloptin Crossing Reservoir on the Blanco River, Dam No. 7 on the Guadalupe River, Lockhart Reservoir on Plum Creek, and Confluence Reservoir on the Guadalupe River.

The Edwards limestone (fault zone) hydraulically connects three river basins: the Guadalupe, the San Antonio, and the Nueces. (See map, Plate 25.) The San Antonio River joins the Guadalupe River a short distance upstream from San Antonio Bay. The three basins have a number of similarities with respect to topography, geology, and hydrology. The hydraulic interconnections of the basins suggest the treatment of these three basins as a unit in developing means of meeting projected water requirements for the immediate future, while also continuing to recognize the individuality of each river basin.

As described later herein in the discussion of the San Antonio Basin, the present underground source of supply available to the city of San Antonio is being reduced by an increase in irrigation pumping west of that city. In order to meet the 1980 municipal and industrial water requirements of San Antonio, it appears to be necessary to import water from areas lying to the east. Furthermore, imported water appears to be necessary to meet the 1980 industrial water requirements of the Corpus Christi Bay area.

Construction of a large reservoir on the lower San Antonio River at the Goliad site will effectively develop the water supply of the San Antonio River Basin. However, a significant portion of the inflows to this reservoir will be treated sewage effluent, and the reservoir outflow will not be desirable for municipal purposes; but it will be of a quality suitable for most industrial and irrigation uses. The proximity of the Goliad Reservoir site to the industrial and irrigation areas af the lower Guadalupe River suggests the possibility of the cooperative development of facilities in the Guadalupe River Basin to supply a portion of the municipal requirements of San Antonio and the replacement of an equivalent amount of water to serve industrial and irrigation needs in the Calhoun-Refugio County reach of the Guadalupe River. The development of the Goliad Reservoir may also be coordinated with meeting the industrial water requirements of the Corpus Christi Bay area.

The development described above would be a means of meeting a portion of the San Antonio water requirements for a reasonable period of time. Supplying a part of the San Antonio requirements from the Guadalupe River Basin may be possible within a cooperative endeavor which would give consideration to: (1) recognition that the Guadalupe River Basin is not a basin of surplus water on a long-range basis; (2) recognition of interim needs below the confluence of the Guadalupe and San Antonio Rivers and the permanent needs of the Guadalupe River Basin above the confluence; and (3) provisions that any transfers from the Guadalupe River to San Antonio will be replaced from the San Antonio River when needed in the lower reaches of the Guadalupe.

TABLE II-18A. GUADALUPE RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	1,780	90	1,870
Industrial	0	0	0
Irrigation	1,040	1,840	2,880
Total Zone A	**2,820**	**1,930**	**4,750**
Zone B			
Municipal	3,400	80	3,480
Industrial	0	0	0
Irrigation	1,030	3,820	4,850
Total Zone B	**4,430**	**3,900**	**8,330**
Zone C			
Municipal	8,420	2,800	11,220
Industrial	400	150	550
Irrigation	3,140	8,670	11,810
Total Zone C	**11,960**	**11,620**	**23,580**
Zone D			
Municipal	0	0	0
Industrial	0	870	870
Irrigation	2,530	5,750	8 280
Total Zone D	**2,530**	**6,620**	**9,150**
Basin Totals			
Municipal	13,600	2,970	16,570
Industrial	400	1,020	1,420
Irrigation	7,740	20,080	27,820
Total Guadalupe Basin	**21,740**	**24070**	**45,810**

TABLE II-18B. GUADALUPE RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Kerrville	3,300	3,300	0	
Distributed	1,000	0	1,000	Diversions from small channel reservoirs
Total Zone A	**4,300**	**3,300**	**1,000**	
Zone B				
Lockhart	1,900	1,900	0	
San Marcos	4,400	4,400	0	
Distributed	5,900	4,000	1,900	Return flows
Total Zone B	**12,200**	**10,300**	**1,900**	
Zone C				
New Braunfels	13,200	13,200	0	
Seguin	4,000	0	4,000	Canyon
Gonzales	1,800	0	1,800	Canyon
Cuero	4,200	0	4,200	Cuero I
Distributed	4,000	1,000	1,000 2,000	Cuero I Canyon
Total Zone C	**27,200**	**14,200**	**13,000**	
Zone D				
Victoria	18,100	4,100	14,000	Cuero I
Distributed	71,900	900	71,000	Cuero I
Total Zone D	**90,000**	**5,000**	**85,000**	
Total Guadalupe Basin	**133,700**	**32,800**	**100,900**	

Summary for Guadalupe Basin

Requirements supplied by:

Ground Water		32,800
Surface Water:		
Major reservoirs	98,000	
Small reservoirs	1,000	
Return flow	1,900	
Total surface water		100,900
Total requirements		133,700

TABLE II-18C. GUADALUPE RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
Canyon	96,100		Seguin, Zone C	4,000		
			Gonzales, Zone C	1,800		
			Distributed, Zone C	2,000		
			Channel loss	2,500		
Total Canyon	*96,100*	*0*		*10,300*	*0*	*85,800*
Total Zone A	**96,100**	**0**		**10,300**	**0**	**85,800**
Zone B						
No reservoirs in zone	0	0		0	0	0
Zone C						
Cuero I	218,200		Cuero	4,200		
			Distributed	1,000		
			Victoria, Zone D	14,000		
			Distributed, Zone D	71,000		
			Lavaca-Guadalupe Coastal Area (LA-GU), Zone B:			
			Distributed		50,000	
			Total Zone B, LA-GU		50,000	
			San Antonio-Nueces Coastal Area (SA-NU), Zone A:			
			Distributed		8,000	
			Total Zone A, SA-NU		8,000	
Total Cuero I	*218,200*	*0*		*90,200*	*58,000*	*70,000*[1]
Total Zone C	**218,200**	**0**		**90,200**	**58,000**	**70,000**
Zone D						
No reservoirs in zone	0	0		0	0	0
Total Guadalupe Basin	**314,300**	**0**		**100,500**	**58,000**	**155,800**

[1] Yield remaining for municipal, industrial, and other uses.

Summary for Guadalupe Basin

Used in Guadalupe Basin		100,500
Exports to other basins or coastal areas:		
Lavaca-Guadalupe Coastal Area	50,000	
San Antonio-Nueces Coastal Area	8,000	
Total exports		58,000
Yield remaining:		
Municipal and industrial uses after 1980	85,800	
Other present or future uses	70,000	
Total yield remaining		155,800
Total yield		314,300

TABLE II-18D. GUADALUPE RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Canyon[1]	Guadalupe River	12 NNW New Braunfels	Comal	394,500	346,400	740,900	96,100	12,890
Dunlap[2]	Guadalupe River	9 NW Seguin	Guadalupe	3,600	0	3,600	—	406
McQueeney[2]	Guadalupe River	5 WNW Seguin	Guadalupe	5,000	0	5,000	—	396
H-4[2]	Guadalupe River	10 W Gonzales	Gonzales	5,400	0	5,400	—	800
Total Existing				408,500	346,400	754,900	96,100	14,492
Proposed								
Cuero I	Guadalupe River	8 N Cuero	DeWitt	1,094,000	715,000	1,809,000	218,200	53,375
Salt Water Barrier	Guadalupe River	4 N Tivoli	Calhoun-Refugio	6,000	0	6,000	—	2,700
Total Proposed				1,100,000	715,000	1,815,000	218,200	56,075
Total Guadalupe Basin				1,508,500	1,061,400	2,569,900	314,300	70,567

[1] Under construction.

[2] Existing power dam.

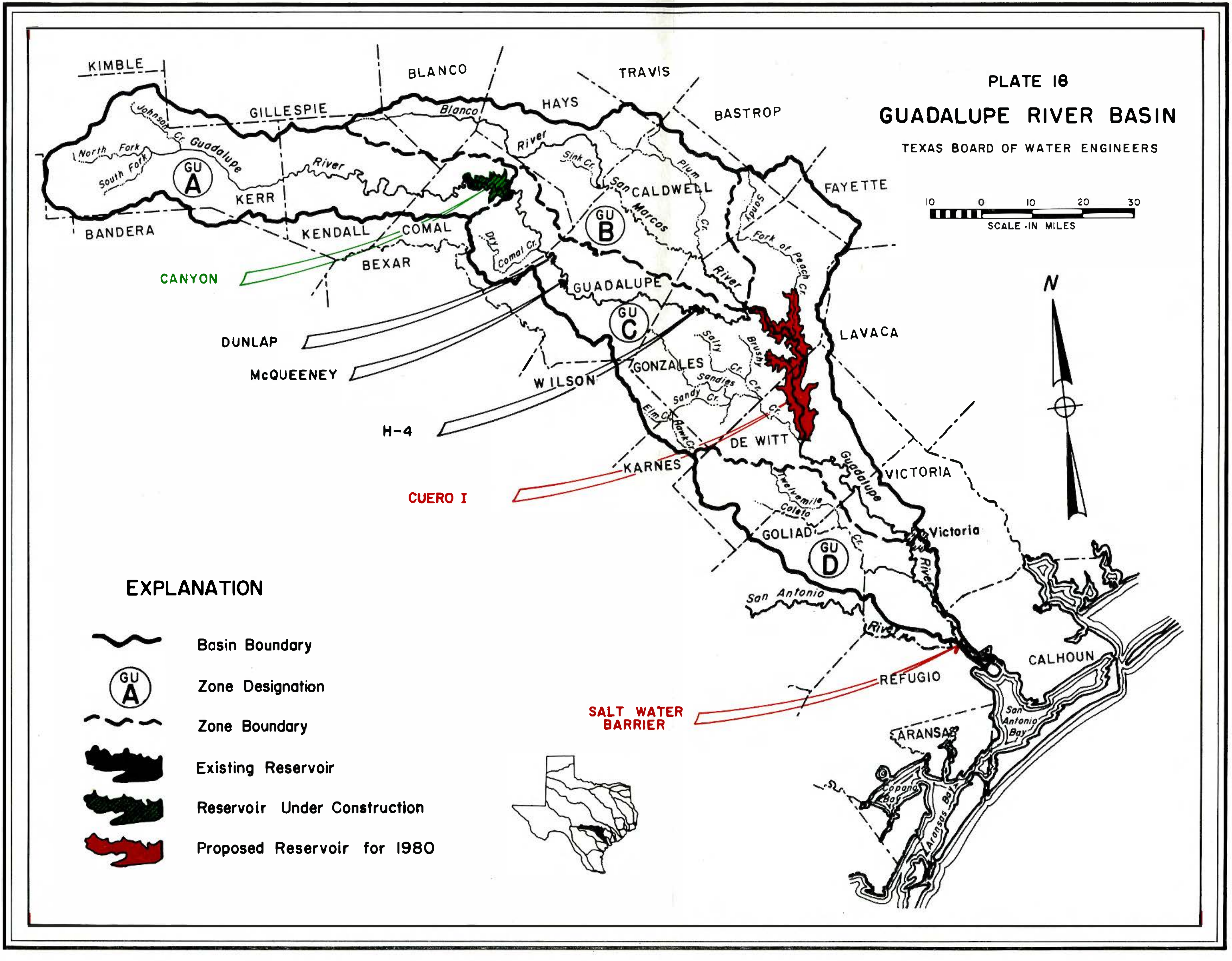


PLATE 18
GUADALUPE RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
N
KIMBLE
BLANCO
TRAVIS
GILLESPIE
HAYS
BASTROP
KERR
BANDERA
KENDALL
COMAL
BEXAR
CALDWELL
FAYETTE
GUADALUPE
GONZALES
WILSON
LAVACA
DE WITT
KARNES
VICTORIA
GOLIAD
REFUGIO
CALHOUN
ARANSAS
Victoria
North Fork
South Fork
Johnson Cr.
Guadalupe
River
Blanco
River
Sink Cr.
San Marcos
River
Plum
Cr.
Sandy
Fork of Peach Cr.
Dry
Comal Cr.
Salty
Brushy
Cr.
Sandies
Sandy
Cr.
Elm Cr.
Hawk Cr.
Guadalupe
Twelvemile
Coleto
Cr.
River
San Antonio
River
San Antonio Bay
Copano Bay
Aransas Bay
GU A
GU B
GU C
GU D
CANYON
DUNLAP
McQUEENEY
H-4
CUERO I
SALT WATER BARRIER
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Reservoir Under Construction
Proposed Reservoir for 1980

151

SAN ANTONIO RIVER BASIN

The San Antonio River Basin heads on the Edwards Plateau and flows in a southeasterly direction across the Gulf Coastal Plain to empty into the Guadalupe River a short distance upstream from San Antonio Bay. The two largest tributaries of the San Antonio River are Medina River and Cibolo Creek. This basin has been divided into three zones. (See Plate 19.)

Rainfall on this watershed varies from an average of 27 inches annually in the upper Medina River watershed to about 34 inches near its confluence with the Guadalupe River. Net evaporation losses range from an average of about 48 inches annually in the headwater reaches to about 25 inches near the mouth.

With the exception of those portions of the watershed which contribute substantial amounts of water to recharging underground formations, runoff rates in this basin average about 100 acre-feet per square mile annually.

The chemical quality of the surface water in the San Antonio River Basin varies, with the water of tributaries being generally suitable for municipal, agricultural, and most industrial purposes. The San Antonio River immediately below San Antonio has higher concentrations of dissolved minerals. Water of the San Antonio River is presently suitable for agricultural and many industrial uses. For the 1959 water year, the weighted average of dissolved solids was 457 ppm (parts per million) for the San Antonio River at Goliad.

The reconnaissance ground-water study in the San Antonio River Basin will be completed in August 1963. More comprehensive studies have been made in the following counties in the basin: Bandera, Bexar, Comal, Goliad, Guadalupe, Karnes, Medina, and Wilson.

The principal aquifers in the San Antonio Basin are the Edwards-Trinity (Edwards limestone and Trinity sands), the Edwards limestone (fault zone), the Carrizo-Wilcox sands, the Miocene sands (Catahoula-Oakville-Lagarto), and the Coastal sands (Goliad-Willis-Lissie-Beaumont). Because the Miocene sands and Coastal sands are lithologically similar and because wells draw water from both aquifers in parts of the area, they are discussed as a combined aquifer referred to as the Miocene-Coastal sands. The approximate locations of the areas from which fresh water can be produced from the principal aquifers are outlined on Plate 25.

Pumpage of water from the Edwards-Trinity and from the Edwards limestone (fault zone) in any one basin where both aquifers occur has a direct bearing on the quantity of additional water available for development from the Edwards limestone (fault zone) in the same basin and in adjacent basins. The interrelationship of pumpage and its effect on the potential availability of additional water from the Edwards limestone (fault zone) aquifer is discussed at greater length hereinbelow and also under the Guadalupe Basin.

The present large pumpage of ground water in the basin is for municipal, industrial, and irrigation purposes. Greatest pumpage occurs at San Antonio and in the area immediately west of San Antonio. With the exception of the Edwards limestone, additional large quantities of water are available for increased development in the basin. Smaller supplies of water are available from minor aquifers in the south-central portion of the basin.

Ground water obtained from the principal aquifers in most areas of the basin is of fair to good chemical quality and is suitable for most uses.

Uses of water for municipalities, industries, and irrigation in 1959 in this basin are listed in Table II-19A and total 198,980 acre-feet. The major portion of these uses, 168,830 acre-feet, was supplied from ground-water sources, with the remaining 30,150 acre-feet obtained from surface-water supplies. The principal source of this ground water was the Edwards limestone.

Projected 1980 municipal and industrial water requirements for this basin total 298,500 acre-feet, of which 106,300 acre-feet is indicated to be supplied from ground water; and 192,200 acre-feet, from surface-water supplies. Information pertaining to the amount and distribution of these requirements and sources of supply is contained in Tables II-19B and II-19C.

The San Antonio metropolitan area presently obtains its water from the Edwards limestone (fault zone). A unit of this underground formation extends from the West Nueces River in Kinney County, across Uvalde, Medina, Bexar, Comal, and Hays Counties, to the vicinity of Kyle. Several large springs discharge water from this limestone formation into the Nueces, San Antonio, and Guadalupe River Basins. Pumping of water from the Edwards limestone (fault zone) for irrigation in Bexar, Medina, Uvalde, and Kinney Counties has increased significantly during the past decade. In the years just preceding 1956, a combination of a severe drought with reduced recharge to the reservoir, discharge from the springs, and increased pumping reduced the water stored in the underground reservoir to such a level that Comal Springs ceased to flow in the summer of 1956. While the quality of the Edwards limestone (fault zone) water is very good, water of very poor quality occurs in a line generally along the southern edge of the underground reservoir. As water levels declined, preceding the summer of 1956, a shifting of this "good water-bad water" line seems to have occurred. Subsequently, with the large amounts of recharge into the formation during 1957-1958, the "good water-bad water" line apparently returned to its previous position. Insufficient data are available to show in detail how the movement of the "good water-bad water" line changed with water levels in the Edwards formation. However, assuming that future water levels will not be drawn lower than those which occurred in 1956 and also projecting the increased irrigation pumping in Bexar, Medina, Uvalde, and Kinney Counties, it appears that only about 75,000 to 100,000 acre-feet of water will remain available to the city of San Antonio annually from the Edwards limestone (fault zone) under 1980 conditions. It is thus expected that, in order to meet the 1980 municipal and industrial water requirements, it will be necessary for San Antonio to obtain surface-water supplies.

Three reservoirs are proposed for development in this basin to meet as much as feasible of the 1980 metropolitan requirements of San Antonio and towns coastward to Kenedy. These include the Cibolo Creek Reservoir in Wilson County and the Ecleto Creek Reservoir in Karnes County for municipal purposes, and the East Lake off-channel reservoir which would divert water from the San Antonio River and serve a portion of the steam-electric power generation requirements of the Bexar County area. Either Cibolo or Ecleto Reservoir could be utilized to meet the municipal and industrial requirements of Kenedy and Karnes City. The remainder of the San Antonio surface-water requirements may be met by importation of water from the east.

A large reservoir can be developed on the lower San Antonio River at the Goliad site to serve industrial water requirements in that area and possibly in the lower Guadalupe and Corpus Christi Bay areas. A discussion of the interrelation of the Guadalupe, San Antonio, and Nueces River Basins and a possible cooperative solution for serving the immediate water needs of San Antonio is contained in the Guadalupe River Basin portion of this report.

Pertinent details relative to the proposed reservoirs in this river basin are contained in Table II-19D.

TABLE II-19A. SAN ANTONIO RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	3,900	0	3,900
Industrial	0	0	0
Irrigation	24,730	10,440	35,170
Total Zone A	**28,630**	**10,440**	**39,070**
Zone B			
Municipal	103,600	0	103,600
Industrial	15,770	0	15,770
Irrigation	7,200	3,390	10,590
Total Zone B	**126,570**	**3,390**	**129,960**
Zone C			
Municipal	4,680	0	4,680
Industrial	350	0	350
Irrigation	8,600	16,320	24,920
Total Zone C	13,630	16,320	29,950
Basin Totals			
Municipal	112,180	0	112,180
Industrial	16,120	0	16,120
Irrigation	40,530	30,150	70,680
Total San Antonio Basin	168,830	30,150	198,980

TABLE II-19B. SAN ANTONIO RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Distributed	22,000	22,000	0	
Total Zone A	22,000	22,000	0	
Zone B				
San Antonio	263,000	75,000[1]	12,000	East Lake
			4,000	Ecleto
			34,000	Cibolo
			138,000[1]	Import from other basins[1]
Distributed	3,000	3,000	0	
Total Zone B	266,000	78,000	188,000	
Zone C				
Kenedy and Karnes City	4,200	0	4,200	Ecleto
Distributed	6,300	6,300	0	
Total Zone C	10,500	6, 300	4,200	
Total San Antonio Basin	298,500	106,300	192,200	

[1]See text in Chapter I.

Summary for San Antonio Basin

Requirements supplied by:		
Ground Water		106,300
Surface Water	54,200	
Imports from other basins[1]	138,000	
Total surface water		192,200
Total requirements		298,500

TABLE II-19C. SAN ANTONIO RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
No reservoirs in zone	0	0		0	0	0
Zone B						
East Lake	*12,000*		San Antonio	*138,000*[1]	—	—
Imports	—	*138,000*[1]	San Antonio	*138,000*[1]	—	—
Total Zone B	12,000	138,000		150,000	0	0
Zone C						
Cibolo	*34,000*		San Antonio	*34,000*	*0*	*0*
Ecleto	11,000		Kenedy-Karnes City	4,200		
			San Antonio, Zone B	4,000		
Total Ecleto	*11,000*	*0*		*8,200*	*0*	*2,800*
Goliad	224,500		San Antonio-Nueces Coastal Area (SA-NU), Zone C:			
			Sinton		3,000	
			Portland		3,000	
			Ingleside		9,000	
			Aransas Pass		5,000	
			Rockport		2,000	
			Total Zone C, SA-NU		22,000	
			Nueces-Rio Grande Coastal Area (NU-RG), Zone A:			
			Corpus Christi		25,000	
			Robstown-San Pedro		5,000	
			Driscoll		500	
			Bishop		5,000	
			Kingsville		8,500	
			Total Zone A, NU-RG		44,000	
Total Goliad	*224,500*	*0*		*0*	*66,000*	*158,500*[2]
Total Zone C	269,500	0		42,200	66,000	161,300
Total San Antonio Basin	281,500	138,000		192,200	66,000	161,300

[1] See text in Chapter I.
[2] Of this amount 35,000 acre-feet remain for present or future uses other than municipal and industrial.

Summary for San Antonio Basin

Used in San Antonio Basin		54,200
Exports to other basins or coastal areas:		
San Antonio-Nueces Coastal Area	22,000	
Nueces-Rio Grande Coastal Area	44,000	
Total exports		66,000
Yield remaining:		
Municipal and industrial uses after 1980	126,300	
Other present or future uses	35,000	
Total yield remaining		161,300
Total yield		281,500
Imports from other basins		138,000

TABLE II-19D. SAN ANTONIO RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Medina	Medina River	7 NNW Rio Medina	Medina	249,200	0	249,200	—	5,575
Total Existing	....	....	....	249,200	0	249,200	—	5,575
Proposed								
East Lake	Arroyo Seco	15 SE San Antonio	Bexar	26,500	0	26,500	12,000[1]	1,350
Cibolo	Cibolo Creek	13 ESE Floresville	Wilson	200,000	222,000	422,000	34,000	7,200
Ecleto	Ecleto Creek	5 NW Runge	Karnes	80,000	0	80,000	11,000	5,100
Goliad	San Antonio River	3 WSW Goliad	Goliad	997,600	702,000	1,699,600	224,500[2]	39,000
Total Proposed	....	....	....	1,304,100	924,000	2,228,100	281,500	52,650
Total San Antonio Basin	....	....	....	1,553,300	924,000	2,477,300	281,500	58,225

[1] Selected diversion from San Antonio River.
[2] Includes return flows.

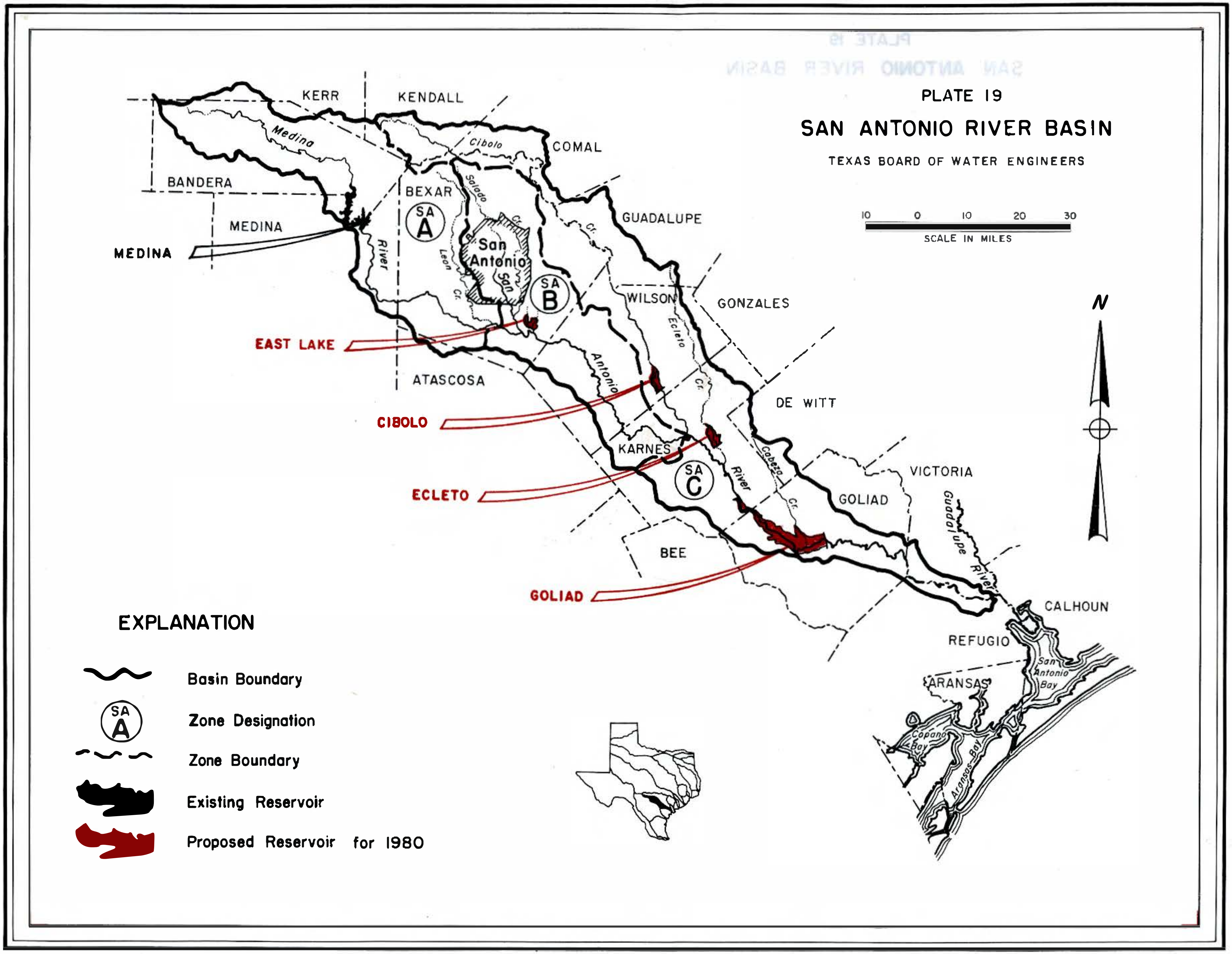


PLATE 19
SAN ANTONIO RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
N
KERR
KENDALL
COMAL
BANDERA
BEXAR
MEDINA
GUADALUPE
WILSON
GONZALES
ATASCOSA
DE WITT
KARNES
VICTORIA
GOLIAD
BEE
CALHOUN
REFUGIO
ARANSAS
Medina
Cibolo
Salado
Cr.
River
Leon
San Antonio
SA A
SA B
SA C
Ecleto
Antonio
River
Cabeza
Guadalupe River
San Antonio Bay
Copano Bay
Aransas Bay
MEDINA
EAST LAKE
CIBOLO
ECLETO
GOLIAD
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Proposed Reservoir for 1980

157

SAN ANTONIO-NUECES COASTAL AREA

This portion of the Gulf Coastal Plain geographical province is located between the San Antonio and Nueces River Basins and includes the Mission River watershed. This area has been divided into three zones. (See Plate 20.)

Rainfall here varies from an average of about 28 inches annually on the west side to about 33 inches annually on the east side. Net evaporation rates range from about 35 inches at the headwaters of the Mission River to about 25 inches at the Coast. Surface runoff rates average about 75 acre-feet per square mile annually.

The chemical quality of water of the several streams in this coastal area varies, with the base flows of some tributaries containing undesirable concentrations of dissolved minerals. The flood flows of streams in this area generally are of good quality. The regulation of flows by reservoirs in this area will provide water generally suitable for municipal, agricultural, and most industrial uses.

Uses of water by municipalities, industries, and irrigation in this area in 1959 are listed in Table II-20A, and total 22,440 acre-feet. Most of this water, 22,220 acre-feet, was derived from ground-water sources, with the remaining 220 acre-feet obtained from surface-water supplies. There are no major surface-water reservoirs in this area.

Projected 1980 municipal and industrial water requirements for this area total 93,500 acre-feet, of which 12,700 acre-feet is indicated to be supplied from ground-water sources; and 80,800 acre-feet, from surface-water sources. Three proposed reservoirs will be needed in this area to meet a portion of the surface-water requirements. These three reservoirs are Beeville Reservoir on Medio Creek, Blanco Reservoir on Blanco Creek, and Woodsboro Reservoir on the Aransas River. In addition, part of the industrial water requirement of this area would be served from Goliad Reservoir on the lower San Antonio River, and some municipal water obtained from Lake Corpus Christi. Pertinent information relative to the requirements of this area and sources of supply are listed in Tables II-20B and II-20C. Information on the three proposed reservoirs is contained in Table II-20D.

TABLE II-20A. SAN ANTONIO-NUECES COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	40	0	40
Industrial	0	0	0
Irrigation	0	0	0
Total Zone A	**40**	**0**	**40**
Zone B			
Municipal	810	0	810
Industrial	690	0	690
Irrigation	20	220	240
Total Zone B	**1,520**	**220**	**1,740**
Zone C			
Municipal	2,190	1,300	3,490
Industrial	610	9,000	9,610
Irrigation	17,860	0	17,860
Total Zone C	**20,660**	**10,300**	**30,960**
Coastal Area Totals			
Municipal	3,040	1,300	4,340
Industrial	1,300	9,000	10,300
Irrigation	17,880	220	18,100
Total San Antonio-Nueces Coastal Area	**22,220**	**10,520**	**32,740**

TABLE II-20B. SAN ANTONIO-NUECES COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Distributed	10,000	2,000	8,000	Import from Cuero I in Zone C, Guadalupe Basin
Total Zone A	**10,000**	**2,000**	**8,000**	
Zone B				
Refugio	3,200	1,000	2,200	Blanco
Distributed	5,800	5,800	0	
Total Zone B	**9,000**	**6,800**	**2,200**	
Zone C				
Beeville	3,500	0	3,500	Beeville
Sinton	4,000	0	1,000 3,000	Woodsboro Import from Goliad in Zone C, San Antonio Basin
Taft	3,400	900	2,500	Woodsboro
Odem	4,600	0	4,600	Import from Corpus Christi in Zone B, Nueces Basin
Gregory	26,000	0	26,000	Import from Corpus Christi
Portland	5,400	0	2,400 3,000	Import from Corpus Christi Import from Goliad
Ingleside	11,600	0	2,600 9,000	Import from Corpus Christi Import from Goliad
Aransas Pass	10,000	0	5,000 5,000	Import from Goliad Import from Corpus Christi
Port Aransas	1,000	0	1,000	Import from Corpus Christi
Rockport	2,500	500	2,000	Import from Goliad
Distributed	2,500	2,500	0	
Total Zone C	**74,500**	**3,900**	**70,600**	
Total San Antonio-Nueces Coastal Area	**93,500**	**12,700**	**80,800**	

Summary for San Antonio-Nueces Coastal Area

Requirements supplied by:			
Ground Water			12,700
Surface Water		9,200	
Imports from other basins:			
Guadalupe Basin	8,000		
San Antonio Basin	22,000		
Nueces Basin	41,600		
Total imports		71,600	
Total surface water			80,800
Total requirements			93,500

TABLE II-20C. SAN ANTONIO-NUECES COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems: Name	Yield	Imports	Distribution: Place	Amount Used	Yield Remaining
Zone A					
No reservoirs in zone	0	—		—	—
Cuero I in Guadalupe Basin	—	*8,000*	Distributed	*8,000*	—
Total Zone A	0	8,000		8,000	0
Zone B					
Blanco	*7,400*		Refugio	*2,200*	*5,200*
Beeville	*7,200*		Beeville, Zone C	*3,500*	*3,700*
Total Zone B	14,600	0		5,700	8,900
Zone C					
Woodsboro	7,400		Sinton	1,000	
			Taft	2,500	
Total Woodsboro	*7,400*	*0*		*3,500*	*3,900*
Goliad in San Antonio Basin	—	*22,000*	Sinton	3,000	
			Portland	3,000	
			Ingleside	9,000	
			Aransas Pass	5,000	
			Rockport	2,000	
			Total Goliad import	*22,000*	—
Corpus Christi in Nueces Basin	—	*41,600*	Odem	4,600	
			Gregory	26,000	
			Portland	2,400	
			Ingleside	2,600	
			Aransas Pass	5,000	
			Port Aransas	1,000	
			Total Corpus Christi import	*41,600*	—
Total Zone C	7,400	63,600		67,100	3,900
Total San Antonio-Nueces Coastal Area	22,000	71,600		80,800	12,800

Summary for San Antonio-Nueces Coastal Area

Used in San Antonio-Nueces Coastal Area		9,200
Yield remaining for municipal and industrial uses after 1980		12,800
Total yield		22,000
Imports from other basins:		
Guadalupe Basin	8,000	
San Antonio Basin	22,000	
Nueces Basin	41,600	
Total imports		71,600

TABLE II-20D. SAN ANTONIO-NUECES COASTAL AREA

Data For Reservoirs Over 5,000 Acre-Feet

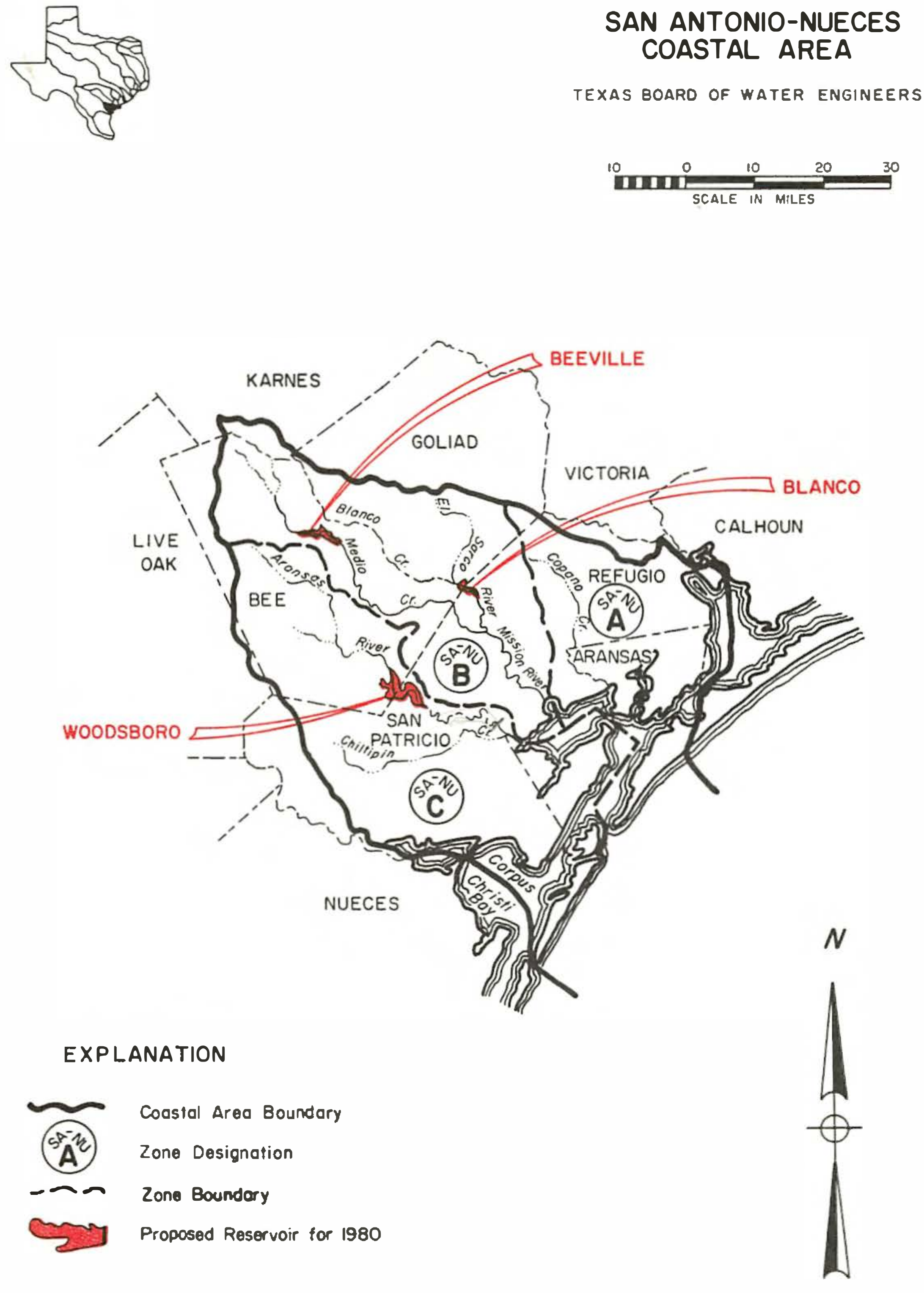
(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
None								
Proposed								
Beeville	Medio Creek	8 NE Beeville	Bee	70,700	0	70,700	7,200	3,500
Blanco	Blanco Creek	7 NW Refugio	Refugio	59,200	0	59,200	7,400	4,600
Woodsboro	Aransas River	15 SW Refugio	Refugio-San Patricio	62,500	0	62,500	7,400	5,000
Total Proposed				192,400	0	192,400	22,000	13,100
Total San Antonio-Nueces Coastal Area				192,400	0	192,400	22,000	13,100

PLATE 20

SAN ANTONIO-NUECES COASTAL AREA

TEXAS BOARD OF WATER ENGINEERS



GROUND WATER OF LOWER COASTAL AREAS

To avoid repetition, there is combined here the discussion of ground water for two coastal areas lying south of the San Antonio River. These coastal areas and their unit numbers are

20. San Antonio-Nueces and
22. Nueces-Rio Grande.

The reconnaissance ground-water study in the Lower Coastal Areas will be completed in September 1961. More comprehensive studies have been made in the following counties: Cameron, Goliad, Hidalgo, Karnes, Live Oak, and Starr.

The principal aquifers in these coastal areas are the alluvium; the Miocene sands (Catahoula-Oakville-Lagarto); and the Coastal sands (Goliad-Willis-Lissie-Beaumont). Because the Miocene sands and Coastal sands are similar lithologically and because wells draw water from both aquifers in parts of the area, they are discussed as a combined aquifer referred to as the Miocene-Coastal sands. The locations where these aquifers yield fresh water are shown on Plate 25.

Adequate supplies of ground water are generally available in the area to supply most small municipal, industrial, and ranch needs. The quantity of fresh water available from the Miocene-Coastal sands in the Lower Coastal Areas is much less than is available in the Upper Coastal Areas because of wide variations in sand thickness, generally lower transmissibilities, and reduced rainfall for recharge. Intensive irrigation is supported in the Rio Grande Valley area by the combined use of ground and surface water, and in local parts of these Lower Coastal Areas by ground water alone. Most of the ground water pumped in the Rio Grande Valley area is for irrigation. Leakage from canals and ditches carrying surface water and downward percolation of applied irrigation water furnishes much of the recharge to aquifers in this area. Additional quantities of recharge are supplied by precipitation and infiltration of streamflow.

Water in the Miocene-Coastal sands generally is poorer in chemical quality than water available from this aquifer in the Upper Coastal Areas, although it is generally suitable for most purposes.

NUECES RIVER BASIN

The Nueces River Basin rises on the Edwards Plateau and flows in a southerly direction onto the Gulf Coastal Plain near Uvalde. It follows a southerly course to Carrizo Springs and thence an easterly and southeasterly course to empty into Corpus Christi Bay. Its principal tributaries are the Frio and Atascosa Rivers. This basin has been divided into two zones. (See Plate 21.) It should be noted that the basin, as defined, does not include Corpus Christi, which lies in the Nueces-Rio Grande Coastal Area just south of this basin line.

Rainfall on the basin ranges from an average of 22 inches annually on the headwaters to about 28 inches at the mouth. Across the center of the basin, the rainfall ranges from an average of 20 inches on the western edge to about 26 inches on the eastern side. Net evaporation rates range from about 60 inches in the headwaters and western edge of the basin to about 30 inches at the mouth.

Average runoff rates vary from very little along the western edge to about 50 acre-feet per square mile in the headwaters and through the central and eastern portions of the basin.

The chemical quality of the surface water in the Nueces River Basin varies from the headwaters to the mouth. Generally, the water of the main stream and major tributaries is suitable for municipal, industrial, and agricultural uses. The water of the basin above Uvalde is of excellent quality. Small mineral contributions gradually occur downstream from Uvalde, but these are not objectionable. The outflow from Lake Corpus Christi is low in dissolved minerals as indicated by the 1959 water year records, which show the weighted average total dissolved solids was 274 parts per million.

The reconnaissance ground-water study in the Nueces River Basin will be completed in August 1963. Somewhat more detailed studies have been made in the following counties in the basin: Bandera, Bexar, Dimmit, Edwards, Karnes, Kinney, Live Oak, Medina, Real, Uvalde, and Wilson.

Large quantities of ground water are available from the Edwards limestone (fault zone) and the Carrizo-Wilcox sands. Lesser quantities are available from the Edwards-Trinity (Edwards limestone and Trinity sands); the Miocene sands (Catahoula-Oakville-Lagarto), and the Coastal sands (Goliad-Willis-Lissie-Beaumont). Because the Miocene sands and Coastal sands are lithologically similar and because wells in the basin draw water from both sands, they are discussed here as a combined aquifer referred to as the Miocene-Coastal sands. The location of the areas where these principal aquifers yield fresh water in the basin are shown on Plate 25. After periods of heavy rainfall, relatively large amounts of water also are available from the Leona gravel along the Leona and Nueces Rivers in Dimmit and Zavala Counties, but it is not included as a principal aquifer in the table herewith. Water suitable for irrigation, stock, and domestic use, and in some areas, for small communities is available in small quantities from minor aquifers in the Nueces Basin.

Pumpage of water from the Edwards-Trinity and from the Edwards limestone (fault zone) in any one basin where both aquifers occur has a direct bearing on the quantity of additional water available for development from the Edwards limestone (fault zone) in the same basin and in adjacent basins. The interrelationship of pumpage and its effect on the potential availability of additional water from the Edwards limestone (fault zone) aquifer is discussed at greater length herein under the Guadalupe and San Antonio Basins.

The water obtained from the Edwards-Trinity, Edwards limestone (fault zone), and Carrizo-Wilcox sands is generally of a uniform chemical quality suitable for most uses. However, it becomes more highly mineralized downdip. Generally, water obtained from the other prinicpal aquifers is moderately to highly mineralized but is suitable for stock, domestic, irrigation, and some industrial uses and in some instances, for small municipal supplies.

Present uses of water in this basin in 1959 are listed in Table II-21A, and total 422,550 acre-feet. Of this total, 292,630 acre-feet was supplied from ground-water sources; and the remaining 129,920 acre-feet, from surface-water supplies. The only major surface reservoir in this basin is Lake Corpus Christi.

Projected municipal and industrial water requirements in this basin total 34,900 acre-feet. These water requirements are indicated to be supplied from ground-water sources.

The location of the water requirements and means of serving these requirements are contained in Tables II-21B and II-21C.

To meet the water requirements of Corpus Christi, which is located in the coastal area adjacent to the Nueces River Basin, it is proposed to enlarge Lake Corpus Christi (the present dam was designed for future enlargement).

Pertinent reservoir information on the enlargement of Lake Corpus Christi is contained in Table II-21D. Several additional reservoirs have been proposed for this basin primarily for irrigation and include the following reservoirs listed in the Nueces River master plan developed by the Nueces River Conservation and Reclamation District: Concan, Cotulla, Fowlerton, Sabinal, Tom Nunn Hill, and Whitsett. Of these reservoirs, the Concan and Sabinal Reservoirs will be given future consideration for use to supplement the recharge to the Edwards limestone (fault zone).

TABLE II-21A. NUECES RIVER BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	7,770	280	8.050
Industrial	2,150	0	2.150
Irrigation	271,700	74,260	345,960
Total Zone A	281,620	74,540	356,160
Zone B			
Municipal	1,030	1,050	2,080
Industrial	0	0	0
Irrigation	9,980	3,190	13,170
Total Zone B	11,010	4,240	15,250
Basin Totals			
Municipal	8,800	1,330	10,130
Industrial	2,150	0	2,150
Irrigation	281,680	77,450	359,130
Total Nueces Basin	292,630	78,780	371,410

TABLE II-21B. NUECES RIVER BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Requirements	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Carrizo Springs	3,600	3,600	0	
Crystal City	3,100	3,100	0	
Cotulla	1,500	1,500	0	
Hondo	1,800	1,800	0	
Uvalde	4,500	4,500	0	
Distributed	15,500	15,500	0	
Total Zone A	30,000	30,000	0	
Zone B				
Mathis	1,300	1,300	0	
Distributed	3,600	3,600	0	
Total Zone B	4,900	4,900	0	
Total Nueces Basin	34,900	34,900	0	

Summary for Nueces Basin

Requirements supplied by:

Ground Water 34,900

TABLE II-21C. NUECES RIVER BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution			Yield Remaining
			Place	Amount		
Name	Yield			Basin Use	Exports	
Zone A						
No reservoirs in zone	**0**	**0**		**0**	**0**	**0**
Zone B						
Corpus Christi	**212,000**		San Antonio-Nueces Coastal Area (SA-NU), Zone C:			
			Odem		4,600	
			Gregory		26,000	
			Portland		2,400	
			Ingleside		2,600	
			Aransas Pass		5,000	
			Port Aransas		1,000	
			Total Zone C, SA-NU		41,600	
			Nueces-Rio Grande Coastal Area (NU-RG), Zone A:			
			Agua Dulce		800	
			Alice		8,000	
			Corpus Christi		102,000	
			Robstown-San Pedro		14,400	
			Total Zone A, NU-RG		125,200	
Total Corpus Christi	*212,000*	*0*		*0*	*166,800*	*45,200*
Total Zone B	212,000	0		0	166,800	45,200
Total Nueces Basin	**212,000**	**0**		**0**	**166,800**	**45,200**

Summary for Nueces Basin

Exports to other basins or coastal areas:

San Antonio-Nueces Coastal Area	41,600	
Nueces-Rio Grande Coastal Area	125,200	
Total exports		166,800
Yield remaining for municipal and industrial uses after 1980		45,200
Total yield		212,000

TABLE II-21D. NUECES RIVER BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Corpus Christi	Nueces River	4 SW Mathis	San Patricio-Jim Wells	302,100	0	302,100[1]	118,800	22,050
Total Existing				302,100	0	302,100	118,800	22,050
Proposed								
Corpus Christi (Enlargement)	Nueces River	4 SW Mathis	San Patricio-Jim Wells	297,900	0	297,900	93,200	12,850
Total Proposed				297,900	0	297,900	93,200	12,850
Total Nueces Basin				600,000	0	600,000	212,000	34,900

[1] At the present time the operating capacity is 185,900 acre-feet.

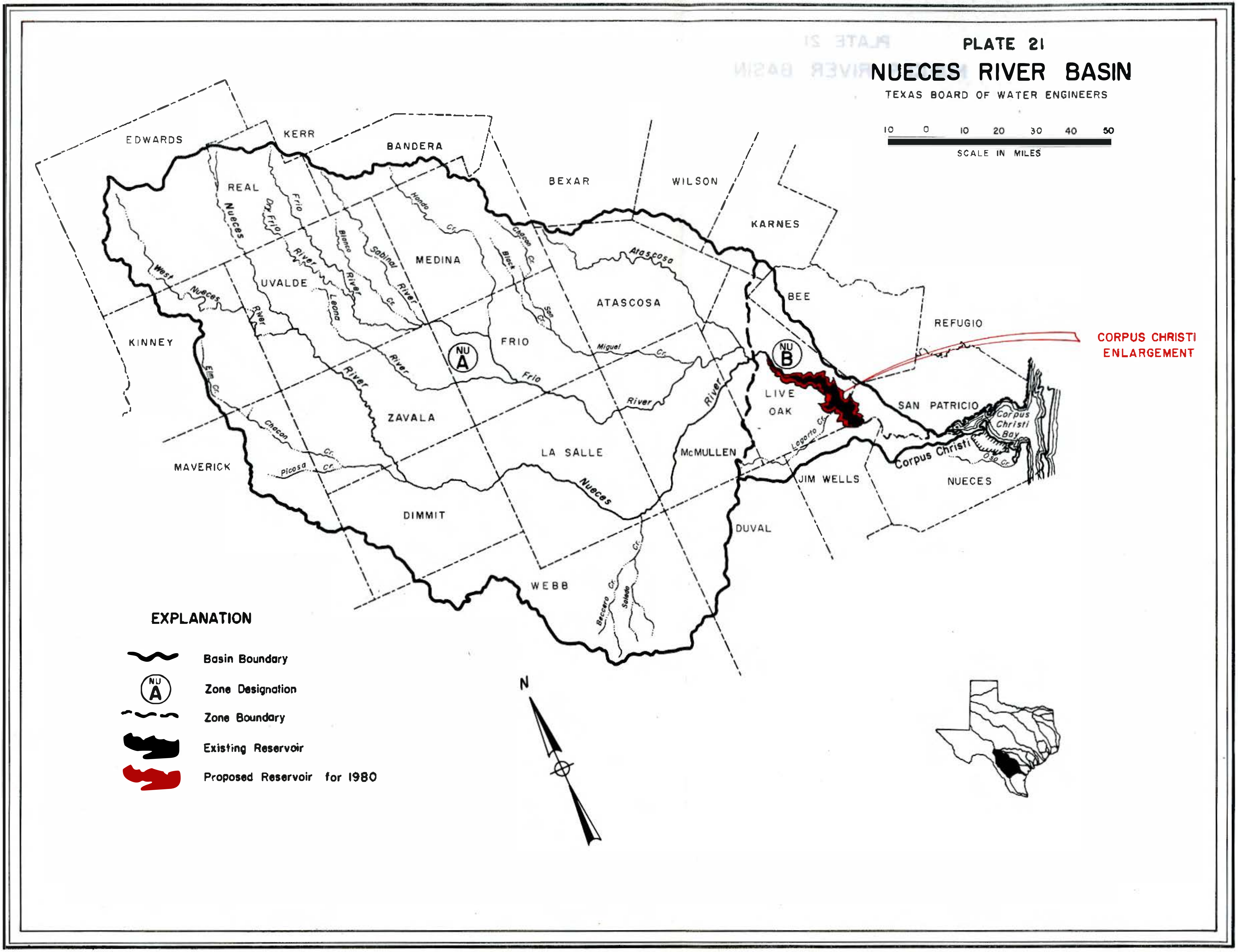


PLATE 21
NUECES RIVER BASIN
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30 40 50
SCALE IN MILES
EDWARDS
KERR
BANDERA
BEXAR
WILSON
KARNES
REAL
MEDINA
UVALDE
ATASCOSA
BEE
REFUGIO
KINNEY
FRIO
LIVE OAK
SAN PATRICIO
ZAVALA
LA SALLE
McMULLEN
MAVERICK
JIM WELLS
NUECES
DIMMIT
DUVAL
WEBB
CORPUS CHRISTI ENLARGEMENT
Corpus Christi Bay
Corpus Christi
NU A
NU B
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Proposed Reservoir for 1980
N

169

NUECES-RIO GRANDE COASTAL AREA

This portion of the Gulf Coastal Plain is bounded on the north by the Nueces River Basin and on the west and south by the Rio Grande Basin. Its location and extent are shown on Plate 22. This area has been divided into three zones and includes Corpus Christi on the northeast and lower Rio Grande Valley on the southern end.

Rainfall varies from an average of about 21 inches annually on the westerly inland section to about 28 inches along the Coast. Average net evaporation rates range from about 60 inches on the westerly inland portion to about 32 inches annually along the coast. Runoff rates average about 50 acre-feet per square mile.

Uses of water in this area during 1959 are listed in Table II-22A, and total 1,357,340 acre-feet. Ground water supplied 253,200 acre-feet of this use while surface-water facilities served the remaining 1,104,140 acre-feet.

Projected 1980 municipal and industrial water requirements in this area total 431,600 acre-feet, of which 58,600 acre-feet is indicated to be supplied from ground water; and 373,000 acre-feet, from surface-water sources. The locations and amounts of these requirements and sources of supply are shown in Tables II-22B and II-22C. In order to meet these projected requirements, use was made of water from the enlarged Lake Corpus Christi, from the Rio Grande, from two proposed reservoirs at Alice and Kingsville, and from industrial water from Goliad Reservoir. Details of these existing and proposed reservoirs are contained in Table II-22D. For discussions of Goliad Reservoir, please refer to the Guadalupe and San Antonio River Basin portions of this chapter.

TABLE II-22A. NUECES-RIO GRANDE COASTAL AREA

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	7,340	17,900	25,240
Industrial	4,230	22,940	27,170
Irrigation	10,500	7,320	17,820
Total Zone A	22,070	48,160	70,230
Zone B			
Municipal	1,860	0	1,860
Industrial	0	0	0
Irrigation	4,270	3,710	7,980
Total Zone B	6,130	3,710	9,840
Zone C			
Municipal	3,450	65,620	69,070
Industrial	790	3,090	3,880
Irrigation	225,000	1,089,000	1,314,000
Total Zone C	229,240	1,157,710	1,386,950
Coastal Area Totals			
Municipal	12,650	83,520	96,170
Industrial	5,020	26,030	31,050
Irrigation	239,770	1,100,030	1,339,800
Total Nueces-Rio Grande Coastal Area	257,440	1,209,580	1,467,020

TABLE II-22B. NUECES-RIO GRANDE COASTAL AREA

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
Agua Dulce	1,100	300	800	Import from Corpus Christi in Zone B, Nueces Basin
Alice	20,500	6,000	8,000 6,500	Import from Corpus Christi Alice
San Diego	1,000	0	1,000	Alice
Corpus Christi	127,000	0	102,000 25,000	Import from Corpus Christi Import from Goliad in Zone C, San Antonio Basin
Robstown-San Pedro	19,400	0	14,400 5,000	Import from Corpus Christi Import from Goliad
Driscoll	1,000	500	500	Import from Goliad
Bishop	11,800	6,800	5,000	Import from Goliad
Kingsville	23,300	7,300	7,500 8,500	Kingsville Import from Goliad
Distributed	12,900	12,900	0	
Total Zone A	**218,000**	**33,800**	**184,200**	
Zone B				
Falfurrias	7,400	7,400	0	
Hebbronville	800	800	0	
Distributed	7,900	7,900	0	
Total Zone B	**16,100**	**16,100**	**0**	
Zone C				
Brownsville	14,500	0	14,500	Import from Falcon in Zone G, Rio Grande Basin
Donna	4,700	0	4,700	Import from Falcon
Edinburg	4,400	0	4,400	Import from Falcon

TABLE II-22B. NUECES-RIO GRANDE COASTAL AREA (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Harlingen	12,000	0	12,000	Import from Falcon
McAllen	10,500	0	10,500	Import from Falcon
Mercedes	3,100	0	3,100	Import from Falcon
Mission	5,200	0	5,200	Import from Falcon
Pharr	3,200	0	3,200	Import from Falcon
Raymondville	3,400	0	3,400	Import from Falcon
San Benito	4,400	0	4,400	Import from Falcon
Weslaco	3,400	0	3,400	Import from Falcon
Distributed	128,700	8,700	120,000	Import from Falcon
Total Zone C	**197,500**	**8,700**	**188,800**	
Total Nueces-Rio Grande Coastal Area	**431,600**	**58,600**	**373,000**	

Summary for Nueces-Rio Grande Coastal Area

Requirements supplied by:

Ground Water			58,600
Surface Water		15,000	
Imports from other basins:			
San Antonio Basin	44,000		
Nueces Basin	125,200		
Rio Grande Basin	188,800		
Total imports		358,000	
Total surface water			373,000
Total requirements			431,600

TABLE II-22C. NUECES-RIO GRANDE COASTAL AREA

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems		Imports	Distribution		Yield Remaining
Name	Yield		Place	Amount Used	
Zone A					
Alice	8,000		Alice	6,500	
			San Diego	1,000	
Total Alice	*8,000*	*0*		*7,500*	*500*
Kingsville	*8,000*		Kingsville	*7,500*	*500*
Goliad in San Antonio Basin	—	*44,000*	Corpus Christi	25,000	
			Robstown-San Pedro	5,000	
			Driscoll	500	
			Bishop	5,000	
			Kingsville	8,500	
			Total Goliad import	*44,000*	—
Corpus Christi in Nueces Basin	—	*125,200*	Agua Dulce	800	
			Alice	8,000	
			Corpus Christi	102,000	
			Robstown-San Pedro	14,400	
			Total Corpus Christi import	*125,200*	—
Total Zone A	16,000	169,200		184,200	1,000
Zone B					
No reservoirs in zone	0	0		0	0
Zone C					
No reservoirs in zone	0	—		—	—
Falcon in Rio Grande Basin	—	*188,800*	Brownsville	14,500	
			Donna	4,700	
			Edinburg	4,400	
			Harlingen	12,000	
			McAllen	10,500	
			Mercedes	3,100	
			Mission	5,200	
			Pharr	3,200	
			Raymondville	3,400	
			San Benito	4,400	
			Weslaco	3,400	
			Distributed	120,000	
			Total Falcon import	*188,800*	—
Total Zone C	0	188,800		188,800	0
Total Nueces-Rio Grande Coastal Area	16,000	358,000		373,000	1,000

Summary for Nueces-Rio Grande Coastal Area

Used in Nueces-Rio Grande Coastal Area		15,000
Yield remaining for municipal and industrial uses after 1980		1,000
Total yield		16,000
Imports from other basins:		
San Antonio Basin	44,000	
Nueces Basin	125,200	
Rio Grande Basin	188,800	
Total imports		358,000

TABLE II-22D. NUECES-RIO GRANDE COASTAL AREA

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beg nning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
Tranquitas	Tranquitas Creek	5 NW Kingsville	Kleberg	6,000	0	6,000	—	400
Monte Alto	Rio Grande (off channel)	4 NNE Monte-Alto	Hidalgo	25,000	0	25,000	—	2,370
Valley Acres	N. Floodway (off channel)	7 NNE Mercedes	Hidalgo	7,800	0	7,800	—	906
Loma Alta[1]	Resaca del Rancho Viejo (off channel)	8 NE Brownsville	Cameron	26,500	0	26,500	—	—
Total Existing				65,300	0	65,300	—	3,676
Proposed								
Alice	San Fernando Creek	3 NNE Alice	Jim Wells	23,000	0	23,000	8,000	3,340
Kingsville	San Fernando Creek	7 SE Kingsville	Kleberg	23,100	0	23,100	8,000	2,390
Total Proposed				46,100	0	46,100	16,000	5,730
Total Nueces-Rio Grande Coastal Area				111,400	0	111,400	16,000	9,406

[1] Under construction.

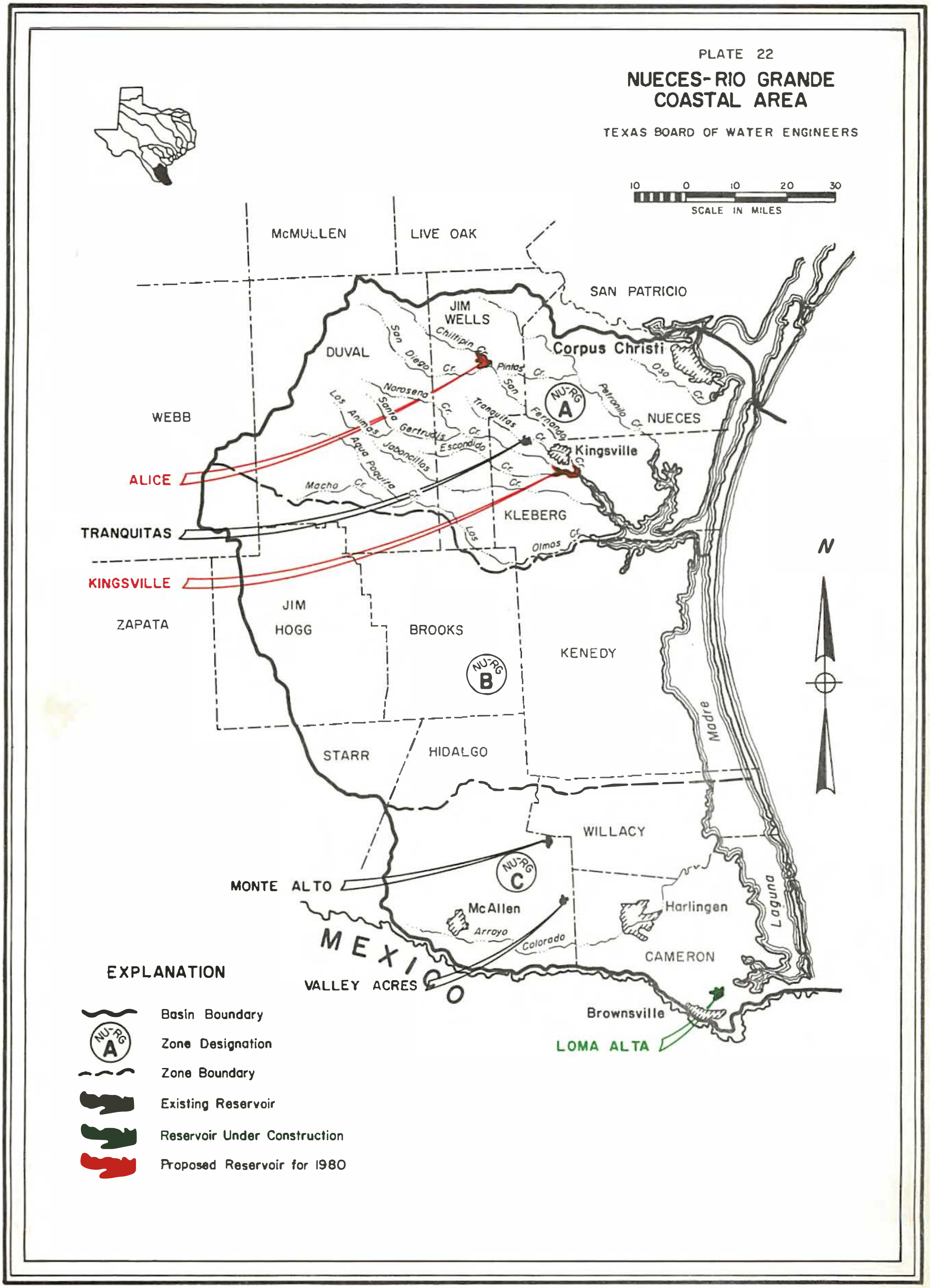


PLATE 22
NUECES-RIO GRANDE COASTAL AREA
TEXAS BOARD OF WATER ENGINEERS
10 0 10 20 30
SCALE IN MILES
McMULLEN
LIVE OAK
SAN PATRICIO
JIM WELLS
DUVAL
WEBB
Corpus Christi
NUECES
Kingsville
KLEBERG
ALICE
TRANQUITAS
KINGSVILLE
ZAPATA
JIM HOGG
BROOKS
KENEDY
STARR
HIDALGO
WILLACY
MONTE ALTO
McAllen
Harlingen
CAMERON
MEXICO
VALLEY ACRES
Brownsville
LOMA ALTA
Madre
Laguna
N
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Reservoir Under Construction
Proposed Reservoir for 1980

RIO GRANDE BASIN

The Rio Grande rises in southern Colorado, flows in a southerly direction across New Mexico, and enters Texas at El Paso. From El Paso to its mouth, a distance of about 1,250 miles, the river forms the international boundary between the United States and Mexico. Since the Rio Grande is an interstate and international river, its flow is allocated under one compact between the states of Colorado, New Mexico, and Texas, as well as two treaties between the United States and Mexico. Between El Paso and Brownsville, the basin includes, successively, portions of the Trans-Pecos Texas, Central Texas, and the Gulf Coastal Plain geographical provinces. The basin has two large tributaries in Texas: the Pecos and Devils Rivers; and three important tributaries enter from Mexico: Rio Conchos, Rio Salado, and Rio San Juan. The Texas portion of the basin, as shown on Plate 23, is quite broad above the mouth of the Devils River; while below that point, it tapers down to a narrow area bordering the river. In the broad portion, there are two large closed basins. This is the largest river basin in Texas.

The Pecos River where it joins the Rio Grande, and the Rio Grande in the reach from the Pecos to Falcon Reservoir have experienced the largest known peak flood flows of any rivers in Texas.

Rainfall varies from an average of about 8 inches annually at El Paso, to about 14 inches at the mouth of the Pecos River, to about 26 inches in the lower valley. Net evaporation rates average from about 90 inches annually in the Big Bend country, to about 70 inches at the mouth of the Pecos, to about 35 inches at Brownsville. Runoff rates range from about zero in portions of the upper basin to about 50 acre-feet per square mile annually in the lower part of the basin.

The water of the Rio Grande in Texas is of a chemical quality generally suitable for municipal, agricultural, and most industrial purposes. Undesirable concentrations of dissolved minerals occur in the main-stream reach from the lower El Paso valley to Presidio, and also occur on the Pecos River from Red Bluff Reservoir to Sheffield. The high concentration of minerals in the water of the Pecos River throughout the Red Bluff Water Power Control District requires irrigated lands to have good drainage to prevent the accumulation of undesirable salts. The Pecos River water above Sheffield is not suitable for municipal purposes. Accretions of good quality ground water to the Pecos River below Sheffield greatly improve the chemical quality of the water reaching the Rio Grande. Water below Falcon Dam is of good quality, with some gradual increases in mineral concentrations occurring downstream. At times of low releases from Falcon Reservoir and small diversions from the river, the mineral concentrations in the Rio Grande become deleterious. Available data indicate the sources of these salts to be principally drains from Mexico. For the 1959 water year, the weighted average of total dissolved solids was 5,140 ppm (parts per million) for the Pecos River below Red Bluff Dam near Orla. In the Rio Grande, for the calendar year 1959, the weighted average of total dissolved solids was 809 ppm at El Paso; 1,728 ppm at Fort Quitman at the lower end of the El Paso Valley; 434 ppm below Falcon Dam; and 647 ppm passing Anzalduas Dam.

In the Rio Grande Basin, the reconnaissance ground-water study will be completed in September 1962. More comprehensive studies have been made in the following areas in the basin: Cameron County; Crane County; Dimmit County; Edwards County; El Paso County; Hidalgo County; Hudspeth County; Kinney County; Marathon Area, Brewster County; Marfa Area, Presidio County; Pecos County; Reeves County; Starr County; and Winkler County.

Relatively large quantities of water are available in local areas of the Rio Grande Basin from alluvium (alluvial deposits including Trinity sands where they are in contact with alluvium in the Pecos County area) and from the Edwards-Trinity (Edwards limestone and Trinity sands). Locations of these two aquifers are shown on Plate 25. Smaller quantities of water significant in supplying domestic, stock, and municipal needs are available from the Santa Rosa formation in Winkler and Reeves Counties, the Bone Spring limestone in Hudspeth County, and parts of the San Andres and Capitan aquifers. Limited supplies of ground water occur in river alluvium from El Paso to Starr County, but these supplies are only locally important.

The alluvium in the Rio Grande Basin receives large amounts of recharge in local areas. However, data available indicate that the present rate of pumpage from the alluvium throughout the basin as a whole exceeds the rate of recharge. Where pumpage exceeds recharge, the present rates of pumpage cannot be maintained indefinitely.

The large pumpage of ground water for municipal and industrial purposes is concentrated mainly in the El Paso area, where 62,000 acre-feet was pumped in 1959 for these purposes. Of this amount, 31,000 acre-feet was pumped from alluvial deposits in the Hueco Bolson. The Hueco Bolson, the source of most of the good quality ground water available for future use, receives approximately 15,000 acre-feet of recharge per year and has in storage about 7,200,000 acre-feet of recoverable water of good quality.

The quality of ground water in the Rio Grande basin ranges within wide limits. The water is generally of good quality in the alluvium in parts of the Trans-Pecos and El Paso areas. However, local problems are encountered in developing supplies from the alluvium as highly mineralized water moves into areas of heavy pumpage. With local exception, water from the other aquifers in the basin is more highly mineralized; but, because of favorable soil characteristics, it is suited for irrigation, and most of the water pumped is used for that purpose.

Uses of water in this basin during 1959 by municipalities, industries, and irrigation are listed in Table II-23A, and total 1,661,280 acre-feet. Ground water supplied 792,050 acre-feet of this total; and surface water, the remaining 689,230 acre-feet. Major surface-water reservoirs in the area are Falcon International Reservoir on the Rio Grande, Red Bluff Reservoir on the Pecos River, and Lake Walk and Devils Lake on the Devils River. Water from Falcon and Red Bluff Reservoirs are used primarily for irrigation, while the two Devils River reservoirs are used for hydroelectric power generation; and the releases from these reservoirs subsequently enter the Rio Grande. The Devils River reservoirs will both be submerged by the Amistad Dam.

Projected 1980 municipal and industrial water requirements for this basin total 191,300 acre-feet. This requirement is expected to be supplied by 167,200 acre-feet of ground water and by 24,100 acre-feet of surface water.

Municipal and industrial water needs in the upper Rio Grande Basin will be served largely from ground water. El Paso will continue to obtain its supply from underground sources although supplementing it from surface water. A new international reservoir at the Amistad Site, 12 miles above Del Rio, is planned for construction by the International Boundary and Water Commission prior to 1980 and has been included herein. The construction of the proposed Amistad Dam, together with the existing Falcon Reservoir, can provide water supplies for cities along the Rio Grande and in the Lower Rio Grande Valley area.

TABLE II-23A. RIO GRANDE BASIN

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone A			
Municipal	45,120	15,820	60,940
Industrial	4,890	0	4,890
Irrigation	106,500	349,800	456,300
Total Zone A	**156,510**	**365,620**	**522,130**
Zone B			
Municipal	1,670	0	1,670
Industrial	0	0	0
Irrigation	22,360	7,770	30,130
Total Zone B	**24,030**	**7,770**	**31,800**
Zone C			
Municipal	170	0	170
Industrial	650	0	650
Irrigation	138,700	13,520	152,220
Total Zone C	**139,520**	**13,520**	**153,040**
Zone D			
Municipal	5,570	0	5,570
Industrial	7,370	0	7,370
Irrigation	1,530	860	2,390
Total Zone D	**14,470**	**860**	**15,330**
Zone E			
Municipal	7,340	150	7,490
Industrial	2,020	20	2.040
Irrigation	376,900	59,350	436,250
Total Zone E	**386,260**	**59,520**	**445,780**

TABLE II-23A. RIO GRANDE BASIN (Cont'd)

Water Uses During 1959

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Zones and Uses	Ground Water	Surface Water	Total
Zone F			
Municipal	440	0	440
Industrial	170	0	170
Irrigation	4,000	840	4,840
Total Zone F	**4,610**	**840**	**5,450**
Zone G			
Municipal	4,490	10,300	14,790
Industrial	0	740	740
Irrigation	11,780	122,100	133,880
Total Zone G	**16,270**	**133,140**	**149,410**
Zone H			
Municipal	0	730	730
Industrial	270	130	400
Irrigation	45,870	222,500	268,370
Total Zone H	**46,140**	**223,360**	**269,500**
Basin Totals			
Municipal	64,800	27,000	91,800
Industrial	15,370	890	16,260
Irrigation	707,640	776,740	1,484,380
Total Rio Grande Basin	**787,810**	**804,630**	**1,592,440**

TABLE II-23B. RIO GRANDE BASIN

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone A				
El Paso	**113,000**	**113,000**	0	
Distributed	3,000	3,000	0	
Total Zone A	**116,000**	**116,000**	**0**	
Zone B				
Distributed	4,400	4,400	0	
Total Zone B	**4,400**	**4,400**	**0**	
Zone C				
Distributed	1,300	1,300	0	
Total Zone C	**1,300**	**1,300**	**0**	
Zone D				
Kermit	4,400	4,400	0	
Monahans	6,800	6,800	0	
Distributed	11,000	11,000	0	
Total Zone D	**22,200**	**22,200**	**0**	
Zone E				
Alpine	2,300	2,300	0	
Pecos	4,400	4,400	0	
Fort Stockton	2,300	2,300	0	
Distributed	8,000	8,000	0	
Total Zone E	**17,000**	**17,000**	**0**	
Zone F				
Distributed	1,400	1,400	0	
Total Zone F	**1,400**	**1,400**	**0**	

TABLE II-23B. RIO GRANDE BASIN (Cont'd)

Municipal and Industrial Water Requirements and Sources of Supply for 1980

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Place of Use or User	1980 Require-ments	Sources of Supply		
		Ground Water	Surface Water	Surface Reservoirs and Remarks
Zone G				
Del Rio	6,200	3,200	3,000	Amistad
Eagle Pass	3,100	0	3,100	Amistad
Laredo	16,000	0	16,000	Amistad
Distributed	1,200	1,200	0	
Total Zone G	26,500	4,400	22,100	
Zone H				
Rio Grande City	2,000	0	2,000	Falcon
Distributed	500	500	0	
Total Zone H	2,500	500	2,000	
Total Rio Grande Basin	191,300	167,200	24,100	

Summary for Rio Grande Basin

Requirements supplied by:

Ground Water	167,200
Surface Water	24,100
Total requirements	191,300

TABLE II-23C. RIO GRANDE BASIN

1980 Distribution of the Firm Yield of Surface Water Reservoirs and Basin Imports

Units: Acre-Feet Per Year

(Tables bearing this general title are discussed at the beginning of this chapter)

Reservoirs or Reservoir Systems: Name	Yield	Imports	Distribution: Place	Amount: Basin Use	Amount: Exports	Yield Remaining
Zone A						
No reservoirs in zone	0	0		0	0	0
Zone B						
No reservoirs in zone	0	0		0	0	0
Zone C						
No reservoirs in zone	0	0		0	0	0
Zone D						
No reservoirs in zone	0	0		0	0	0
Zone E						
No reservoirs in zone	0	0		0	0	0
Zone F						
No reservoirs in zone	0	0		0	0	0
Zone G						
Amistad	81,000		Del Rio	3,000		
			Eagle Pass	3,100		
			Laredo	16,000		
Total Amistad	*81,000*	*0*		*22,100*	*0*	*58,900*[1]
Falcon	732,000		Rio Grande City, Zone H	2,000		
			Nueces-Rio Grande Coastal Area (NU-RG), Zone C:			
			Brownsville		14,500	
			Donna		4,700	
			Edinburg		4,400	
			Harlingen		12,000	
			McAllen		10,500	
			Mercedes		3,100	
			Mission		5,200	
			Pharr		3,200	
			Raymondville		3,400	
			San Benito		4,400	
			Weslaco		3,400	
			Distributed		120,000	
			Total Zone C, NU-RG		188,800	
Total Falcon	*732,000*	*0*		*2,000*	*188,800*	*541,200*[1]
Total Zone G	813,000	0		24,100	188,800	600,100
Zone H						
No reservoirs in zone	0	0		0	0	0
Total Rio Grande Basin	813,000	0		24,100	188,800	600,100

[1] Yield remaining for uses other than municipal and industrial.

Summary for Rio Grande Basin

Used in Rio Grande Basin	24,100
Export to Nueces-Rio Grande Coastal Area	188,800
Yield remaining for present uses other than municipal and industrial	600,100
Total yield	813,000

TABLE II-23D. RIO GRANDE BASIN

Data For Reservoirs Over 5,000 Acre-Feet

(Tables bearing this general title are discussed in the beginning of this chapter)

Name of Reservoir	Stream	Location of Dam		Capacity			Yield (Acre-Feet Per Year)	Area Top Cons. Pool (Acres)
		Reference (Miles)	County	Conservation (Acre-Feet)	Flood (Acre-Feet)	Total (Acre-Feet)		
Existing								
San Estaban	Alamito Creek	10 S Marfa	Presidio	18,800	0	18,800	—	762
Red Bluff	Pecos River	5 N Orla	Loving-Reeves	307,000	0	307,000	—	11,700
Balmorhea	Sandia Creek	3 SE Balmorhea	Reeves	6,400	0	6,400	—	573
Devils	Devils River	16 NNW Del Rio	Val Verde	11,700	0	11,700	—	406
Walk	Devils River	11 NNW Del Rio	Val Verde	5,400	0	5,400	—	380
Casa Blanca	Chacon Creek	2 NE Laredo	Webb	25,200	0	25,200	—	1,950
Falcon	Rio Grande	14 NW Roma	Starr	1,430,100[1]	532,600[1]	1,962,700[1]	732,000[2]	36,100[1]
Total Existing				1,804,600	532,600	2,337,200	732,000	51,871
Proposed								
Amistad	Rio Grande	9 NW Del Rio	Val Verde	1,995,000[3]	997,600[3]	2,992,600[3]	81,000[4]	43,215[3]
Total Proposed				1,995,000	997,600	2,992,600	81,000	43,215
Total Rio Grande Basin				3,799,600	1,530,200	5,329,800	813,000	95,086

[1] United States share shown. Total conservation, 2,440,500; total flood, 908,800; total capacity, 3,349,300; and total area, 78,500.
[2] United States share shown.
[3] United States share shown. Total conservation, 3,550,000; total flood, 1,775,000; total capacity, 5,325,000; and total area, 67,000.
[4] United States share shown. Total yield, 144,000 acre-feet.

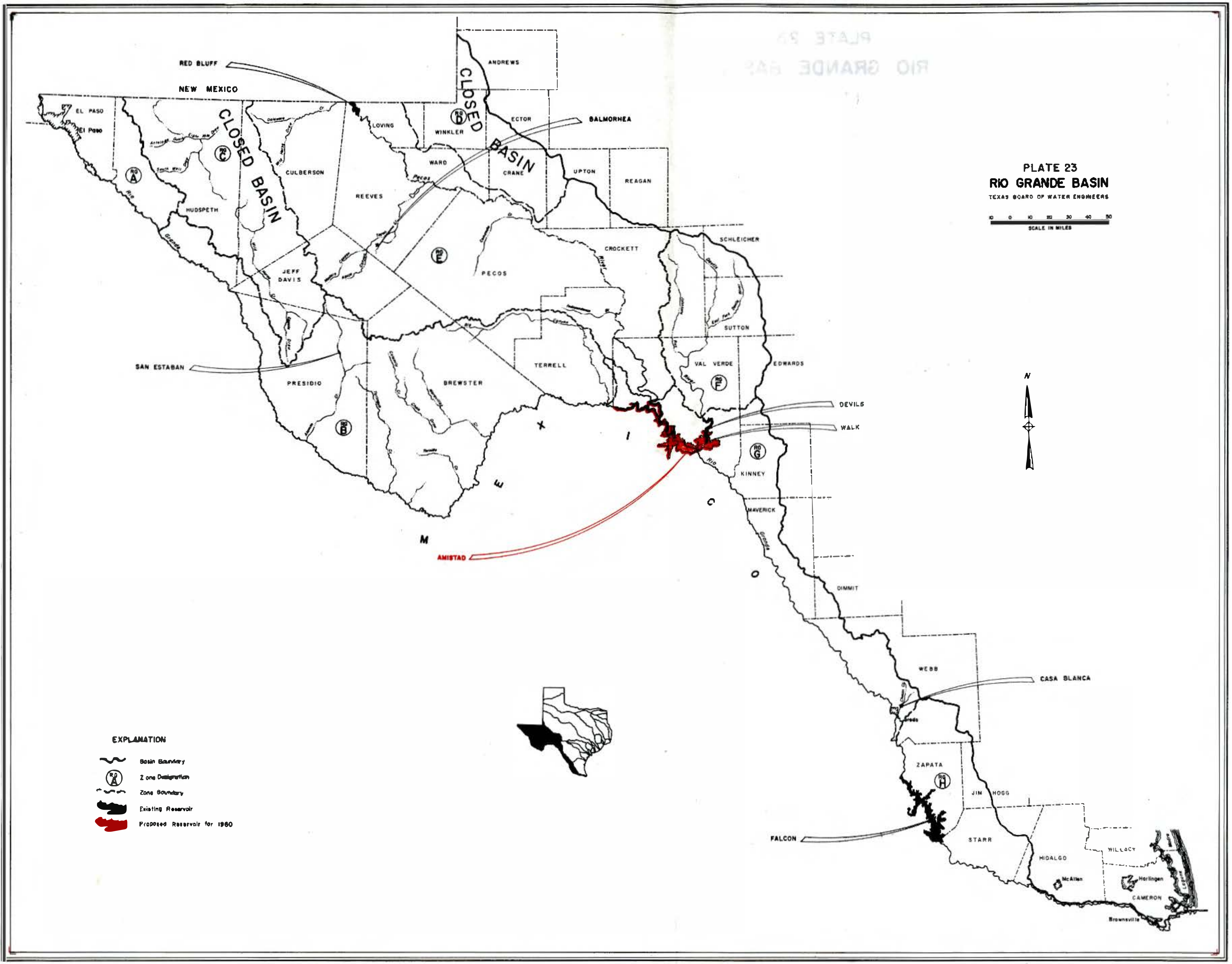


PLATE 23
RIO GRANDE BASIN
TEXAS BOARD OF WATER ENGINEERS
SCALE IN MILES
N
RED BLUFF
NEW MEXICO
CLOSED BASIN
CLOSED BASIN
EL PASO
El Paso
HUDSPETH
CULBERSON
JEFF DAVIS
PRESIDIO
BREWSTER
REEVES
LOVING
WINKLER
WARD
ANDREWS
ECTOR
CRANE
UPTON
REAGAN
PECOS
CROCKETT
TERRELL
SCHLEICHER
SUTTON
VAL VERDE
EDWARDS
KINNEY
MAVERICK
DIMMIT
WEBB
ZAPATA
JIM HOGG
STARR
HIDALGO
WILLACY
CAMERON
McAllen
Harlingen
Brownsville
BALMORHEA
SAN ESTABAN
DEVILS
WALK
AMISTAD
CASA BLANCA
FALCON
M E X I C O
EXPLANATION
Basin Boundary
Zone Designation
Zone Boundary
Existing Reservoir
Proposed Reservoir for 1980

CHAPTER III

FUTURE UNDERTAKINGS

This report provides a basic, workable plan. As all phases of water-resources development are not covered herein, it is expected that the plan presented will be adjusted.

The actual growth of cities and locations of new industries will differ from the predictions made in this investigation. Therefore, the program for water uses, water projects, and water quality must be a continuous and expanding study. This applies to domestic, municipal, industrial, and irrigation, as well as mining, hydroelectric power, navigation, and recreation uses; and it applies to both surface and ground water, as well as to flood-control storage and recharge projects. New projects must be measured by their relationship to their immediate area, to the basin in which they are located, and to the State as a whole.

Additional considerations in later developing a comprehensive long-range plan include the following items:

1. Supplying the State's water requirements at a future time, more distant than 1980, can be accomplished by coordinated planning with local interests for the maximum development of the surface-water resources of each area, together with the greatest feasible use of underground waters.

As heretofore described, the largest part of the surface-water resources of the State occur in the eastern basins. As needs for water in the basins of the central and westerly sections of the State approach the amount of water which can be developed in those basins, water will have to be brought in from areas further to the north or east.

Needs for additional water to be imported into areas of the central and western basins or coastal areas with future deficiencies will not occur simultaneously. Thus, the actual planning and development of trans-basin diversion facilities from areas of surplus will most likely occur by stages from one basin to another. The State has the primary responsibility for coordinating the planning of this stage development with numerous local entities, in order to provide an overall integration of water-transporting units, which shall not, however, necessarily be continuous. Diversions of water from one basin to another will have to be considered within the framework of the future planning, which will also provide for: the then existing and future needs of the exporting basins; the maximum development of reservoirs in each basin; and trans-basin diversions as far upstream as practicable.

2. In determining maximum development of a reservoir site, consideration will be given to the following, with reference to an individual project or to a project for inclusion in a system operation, as circumstances dictate:

(a) topography of the site including developments within the site

(b) yield vs. capacity characteristics of the site or system

(c) cost vs. yield characteristics of the site or system

(d) the length of time for filling of the reservoir or system and frequency of periods during which filling is possible.

Some reservoir capacities suggested herein are based on preliminary information, and may require future revisions after completion of more detailed study.

3. Increased return flows from municipalities and industries may deleteriously affect the quality of streamflow so as to require a change in the source of water supply from those developments shown herein. This quality factor may result in water derived from developments shown herein being used in the future temporarily for dilution of return flows, or being used for irrigation or industrial purposes rather than for the municipal and domestic purposes planned herein. This is true even though the trend in Texas is toward a higher degree of treatment for both municipal and industrial wastes and a re-use of this water, rather than the use of impounded fresh waters for dilution or as a means of waste disposal. Many municipalities, to avoid dumping of waste in streams, are selling sewage for use in industry and to irrigate crops not destined for human consumption. Industry has studied and is using on a limited basis a system of injecting wastes to highly mineralized subsurface strata. The latter practice is prevalent

in the oil industry, and the Railroad Commission now requires producers in many Texas oil fields to re-inject salt water produced with oil.

Continuous consideration must be given to means of maintaining and improving the quality of our streams. Although there are some streams in Texas with excess water available for dilution to abate pollution, Article 4444 of Revised Civil Statutes of Texas and Article 698b of the Penal Code strike at the source of the problem by forbidding the discharge of pollutants into any watercourse or public body of water. Thus, man-made pollution is prohibited by law. Enforcement agencies active in this field comprise the Water Pollution Advisory Council whose members represent State Health Department, Board of Water Engineers, Game and Fish Commission, Railroad Commission and Attorney General.

To the extent that natural pollution can be treated successfully by artificial means, such should be done. Studies are now under way in Texas to locate sources of natural pollution and to devise means of abatement.

The policy of Texas is that use of water for pollution abatement by dilution should be avoided wherever possible and used only as a stopgap measure until the cause of the pollution can be eliminated.

The developments recommended in this report will need to be examined in the light of quality factors at times of actual development in the future.

4. Speaking generally for the State, reservoirs to fully serve present and future needs for flood control have been and some are now being built without sufficient conservation storage to serve the future domestic, municipal, industrial, and agricultural water needs. Conservation storage in these instances usually was limited by the financial ability of local interests and the State. In some places, an unwise competition between flood-control storage and conservation storage for the best and least expensive reservoir sites has resulted. In such competitive situations, either conservation storage must be given the superior position or regulatory arrangements must be provided for converting existing flood-control storage to conservation storage and providing other flood-control storage where necessary. In accomplishing further flood control, more study must be devoted to the use of levees and flood plain regulation, in lieu of flood control reservoirs. Reservoirs without flood-control storage listed herein may have such storage added during the preparation of detailed plans for these projects.

5. The possible conversion of existing hydroelectric power storage to conservation storage, necessitating the substitution of thermal power facilities, must be studied. Hydroelectric power must remain only incidental to other uses for which there are no such convenient substitutes.

6. The inclusion of projects herein does not constitute or imply the automatic granting of water permits therefor or serve as the approval required under statutory procedures set forth in Article 7472e. The Board will scrutinize applications for permits or review Federal agency reports on proposed projects de novo and completely, based upon procedures which have been established for consideration of each project.

7. Nuclear fallout during a national emergency could contaminate exposed surface-water reservoirs. The development of underground supplies for such emergencies needs further consideration by this agency and every municipality in Texas.

8. Some areas of the state have large quantities of both surface and ground waters. Studies are required of the amounts of ground water which can be used during critical periods to supplement the yields of surface reservoirs, thus allowing a greater diversion of water from surface reservoirs during average and above-average runoff periods.

9. Technological improvements may provide alternate sources of supply or increase existing supplies. Re-use of municipal return flows and conversion of industrial processes to methods using less water will require additional consideration as will evaporation retardation and demineralization of inland brackish waters and sea water.

In areas where evaporation dissipates great quantities of water, there is the possibility of reducing some of these losses by applying monomolecular chemical films to the water surfaces, but many problems have yet to be worked out before the theoretical savings indicated by laboratory methods can be approximated. A research program is being carried on in this field at the present time. The possibility of using this method of reducing water losses from small impoundments, such as farm and ranch stock tanks and other small bodies of water appears feasible. The work is now in the field phase of investigation and is being conducted jointly by the Board of Water Engineers and the Texas A & M Research Foundation in consultation with the Southwest Evaporation Research

Council.

There are a few areas in the State where desalinization would be economically feasible, but the areas are limited. A desalinization research investigation should be carried forward in order that the lowest possible cost and the most practical methods may be developed for use in areas where the conventional methods of developing new supplies are not applicable because of great distances to be traversed or because of lack of acceptable supply at any cost. It is entirely possible that the present methods and procedures used in desalinization may produce water at costs acceptable to certain industries and towns that have no other supplies, but if costs are to remain near $1.00 per 1000 gallons without considering debt service and other costs which are normally included where private capital is used, much research is yet to be accomplished. This research should be supported by very accurate cost figures, because it is in this field that the main concern is now centered.

10. Increased consumptive losses of water by non-beneficial vegetation has occurred along the upper Rio Grande and Pecos River. Similar vegetation (notably salt cedar) has been noted in the upper portions of the Red, Brazos, and Colorado River Basins. Expansion of these phreatophyte areas may result in significant decreases in water supplies as well as creating potential flood problems. A periodic review of problem areas may indicate the feasibility of water salvage projects through eradication procedures in areas of greatest infestation.

11. The greatest use of water in Texas at present is for irrigation. During 1959 about 83 percent of the irrigated area was served from ground-water supplies. Continuation of irrigation by ground water at the present rate in some areas may not be possible on an indefinite basis when full consideration is given to water availablity and economics. Other areas with an abundant supply of ground water may experience an increase in irrigation. Agricultural research historically has provided both mechanical and chemical means of increasing crop yields. Further advancement in these fields of research can be anticipated. The future additional use of surface water for irrigation will require a comprehensive appraisal of the needs for additional agricultural products; regulatory controls of these crops, if any; water supplies; and project economics.

12. A detailed accounting of the State's water resources is not included in this report. In order to provide a proper accounting, this agency has initiated a complex inventory program to determine: (1) the quantity of the water resources which occur in each distinct regional area of the State; (2) the amount of water used in each such area; and (3) the quality of the water and its suitability for various uses. As a part of this state-wide program, the Board has delineated the river basins and coastal areas of the State as shown in this report. In turn, these units have been divided into major subdivisions along hydrologic lines. The present dividing lines between zones used herein coincide with lines delineating such major subdivisions, but the zones generally include several such subdivisions. This inventory was initiated in accordance with the "Tentative Standards for River Basin Water Planning" issued by the Board in July 1960.

The major subdivisions, named and numbered in a pre-selected manner, provide a frame of reference for the entire State. On this frame, by means of punched cards, in computing machine language, will be recorded the multitudinous facts for each major subdivision including such data as: Rainfall, streamflow, evaporation, diversions, return flow, channel losses and/or gains, water quality, reservoir locations and characteristics, water requirements, and water rights—appropriative and other.

From these cards the electronic computers can be programmed to compile or compute in various combinations the data and obtain answers pertinent to many studies of the State's water resources which are now needed, but impossible to make because of the time and expense involved.

This program will provide for efficient handling of such matters as:

(a) Inventory of data on all phases of water resources for each distinct area of the State.

(b) Hydrologic studies for planning or administrative purposes by this agency.

(c) Making data available for use by all agencies and individuals.

(d) The protection of existing water rights.

(e) The projection of area resource possibilities.

13. The continuation and completion of the program of reconnaissance and detailed ground-water studies outlined in this agency's December 1958 Planning Report to the Fifty-Sixth Legislature will be needed to provide more reliable specific information on the quantity and quality of ground-water resources available for all uses.

14. Development of detailed project design and economic and legal considerations for projects listed herein remain. These items can be accomplished by the coordinated efforts of the State with local and Federal agencies.

IMPLEMENTING THE PLAN

Projections of future water requirements have been made and a plan for meeting these anticipated needs outlined. This plan will not provide a single drop of additional water for future needs unless a concerted effort is made by all interested groups to bring into being the needed facilities.

Water facilities cost money; and a major share of this cost will have to be borne by the cities, industries, and other groups who will use water that is developed. As local groups will have an ultimate financial responsibility in providing these facilities, it is logical that they also be expected to carry out detailed planning, design, and financial studies for these projects and to obtain advice on related legal questions.

Some of the projects contained herein will serve several functions in addition to providing water for municipal and industrial uses. These functions include flood control, navigation, and irrigation. In developing some of these projects, it may be desirable and necessary to consult with appropriate agencies of the Federal Government.

Financial participation in projects by the State, through the Texas Water Development Board, may be desired by local groups. In the event the constitutional amendment to provide the proper conservation storage in proposed reservoirs (H.J.R. 46) is approved by the people of Texas in November 1962, the financial, planning, and development participation by the State in reservoirs proposed in this plan will of necessity be given more detailed consideration.

The State has an interest in the proper development of each project which will conserve and put to beneficial use a part of its water resources. Recognition of existing water rights and the coordinating of water planning to provide for these existing rights is the responsibility of the State. Consideration must also be given to the interrelation of all projects, existing and proposed, in each river basin.

With many local groups, and numerous Federal agencies concerned with various aspects of water, orderly development of the water resources of each area can be accomplished only by the continued and intensified coordination, with and through the Board of Water Engineers, of all water planning activities by all local, State, and Federal agencies, at all stages of endeavor from inception to completion. Project planning should not be initiated without prior consultation with the Board. Through this coordinated effort, and with the assistance provided by this agency, project planning can be accelerated, and projects constructed to meet the water needs.

APPENDIX A

WATER PLANNING ACT OF 1957

[The principal parts of the Act are quoted herein from Senate Bill No. 1, Chapter 11, General and Special Laws of Texas, 1957, 55th Legislature, First Called Session.]

Be it enacted by the Legislature of the State of Texas:

NAME OF ACT

Section 1. This Act shall be known as "The Texas Water Planning Act of 1957."

DEFINITIONS

Sec. 2. As used in this Act, the following words and terms shall have the following meanings, unless the context shall indicate another or different meaning or intent:

(a) "Board" means the Board of Water Engineers.

(b) "Planning Division" or "Division" means the Texas Water Resources Planning Division of the State Board of Water Engineers, as created and constituted by this Act.

(c) "Public Agency" means and includes any agency of the United States, State of Texas or political subdivision of the State.

(d) "Conservation Storage" means that portion or part of a reservoir created by a dam or other works of improvement in which water may be impounded or stored for conservation, development, and beneficial use in accordance with law.

CREATION OF WATER PLANNING DIVISION

Sec. 3. The State Board of Water Engineers is hereby authorized and directed to establish within the Board a division to be known as the Texas Water Resources Planning Division.

Sec. 3(a). The Planning Division shall be under the supervision and direction of the State Board of Water Engineers, and its functions shall be:

(1) To develop and inventory as to quantity, quality, and location of all surface water resources of the State.

(2) To analyze topographic maps and other data appropriate for the determination of the development of available surface supplies for meeting present and foreseeable needs.

(3) To prepare an inventory of information as to available underground water disclosed by geologic and hydrologic investigation of underground reservoirs.

(4) To enter into contracts with federal, state and local political subdivisions and agencies including the State Soil Conservation Board and any other persons, firm or corporation for topographic mapping, joint investigation and research in the field of water and soil resource planning.

(5) To enter into contracts and agreements with any public agency to carry out a joint program of topographic and geologic mapping of the watersheds of this state and to expend funds specifically appropriated to the State Board of Water Engineers for this purpose.

(6) To prepare a present and continuing inventory of the available water resources of the state.

(7) To make studies of probable additional beneficial use for surface, ground and underground waters.

(8) To prepare and submit to the Legislature a state wide water report of the water resources of the state with a correlation and relationship of these resources and to make recommendations to the Legislature for the maximum development of the water resources of the state, and to furnish the same to all members of the Legislature and elected officers of the state without cost.

ACCUMULATION OF DATA AND COOPERATION OF AGENCIES

Sec. 3(b) The Planning Division shall have access to all public records pertaining to the purposes of this section, and all state public agencies are hereby directed to cooperate with and to furnish to said Division copies of all data collected by any such agencies. The Planning Division is hereby directed to bring together the studies heretofore and hereafter made by the Board, the Texas Water Resources Committee, the University of Texas Bureau of

Business Research, the Texas Society of Professional Engineers, the University of Texas, the A. & M. College System of Texas, the State Soil Conservation Board, the Public Health Authorities, the United States Geological Survey, the United States Soil Conservation Service, the United States Army Corps of Engineers, the United States Bureau of Reclamation, the International Boundary and Water Commission, the Canadian, Pecos, Rio Grande, and Sabine Compact Commissions, the several river authorities, ground water conservation districts and other political subdivisions, and any and all other agencies having information or having studied the subject of water resources policy and conservation, and to relate and correlate such information with such additional data and information as the Division may collect and assemble on its own behalf.

The State Soil Conservation Board is authorized to appoint a representative to advise and work with the Planning Division; the State Soil Conservation Board is hereby authorized to use any funds heretofore appropriated for use during the current biennium ending August 31, 1959, for the purpose of paying the salary, travel expenses and other expenses of the representatives appointed by the Soil Conservation Board.

DISTRIBUTION AND PUBLICATION OF INFORMATION

Sec. 3(c) All records, reports, data and information in the files of the Planning Division shall be open to public inspection and shall be made available and supplied in printed form to all interested persons, firms, corporations, political subdivisions and public agencies. The State Board of Water Engineers is authorized to charge and collect reasonable fees of all interested parties, to cover the costs of the publication and distribution of such information.

SALARIES AND OTHER EXPENSES: METHOD OF FINANCING

Sec. 4. (a) The Planning Engineer shall receive a salary to be determined by the Legislature. The Board is authorized to employ a Planning Engineer, and such assistant planning engineers and such professional and clerical employees as may be authorized for the performance of the duties herein imposed upon the Planning Division. The Legislature, hereafter in General Departmental Appropriations Acts, shall make the necessary appropriation to pay wages, salaries, and other expenses of the Planning Division.

" ....

(balance of this section is omitted as being applicable only to the 1957 biennium)

...."

" ....

(b) (portion of this section omitted as being applicable only to the 1957 biennium)

...."

In addition to any funds made available by the Legislature, the Board is authorized to contract for, receive or accept money or services from anyone, or from any agency, political subdivision, or other legal entity, provided, however, that the same shall not be, become, held or considered as a debt or enforceable obligation against the State of Texas, and may then use such money to carry into effect the duties required by this Section. The money thus obtained shall be deposited by the Board in the State Treasury as a special fund and said money may be used by the Planning Division for any of its purposes, including wages, salaries, and other expenses.

(c) No person shall be appointed Planning Engineer who has not resided in the State of Texas for at least five years of the 10 years last preceding his appointment.

(d) No person shall be appointed as Planning Engineer, Assistant Engineer, or Chief Engineer of any section authorized by this Act who is not a registered Professional Engineer under the laws of the State of Texas.

AUTHORITY TO ACQUIRE CONSERVATION STORAGE

Sec. 5. (a) When the Board finds it necessary, in the conservation of the water resources of the State, the Board is authorized and empowered to negotiate with the United States, or any agency of the United States, for the development and acquisition of conservation storage in reservoirs constructed by the United States, or any agency thereof, and may enter into preliminary agreements therefor; provided, however, any such action shall not abrogate, modify, implement, supplement, designate or in anywise effect rights in and to such water, or in anywise affect existing or vested rights of any kind or character.

(b) The Board shall, at the next succeeding session of the Legislature, whether general or special, report in writing to the Governor, the Lieutenant Governor, and the Speaker of the House, with sufficient copies for all members of the Legislature, the status of all such negotiations, and furnish copies of all such preliminary agreements made by the Board and the United States, or any agency thereof.

(c) No such preliminary agreement shall be binding upon the State of Texas or the Board of Water Engineers, or have any effect, unless such agreement is thereafter specially approved by the Legislature.

SEVERABILITY CLAUSE

Sec. 6. The provisions of this Act are severable. If any section, provision or part whatsoever of this Act should be held to be void as in violation of the Constitution, it shall not affect the validity of the remaining portions thereof, and it is hereby declared to be the legislative intent that this Act would have been passed as to the remaining portions hereof, regardless of the invalidity of any part.

EMERGENCY CLAUSE

Sec. 7. The fact that conservation and development of water resources is of such paramount importance to the State of Texas; the pressing need for the state to acquire conservation storage in order to conserve, develop, and beneficially use the water resources of Texas that otherwise would be wasted; the dependency of future economic growth on the enactment of this legislation; and the importance of this Act to the public welfare of the State of Texas, create an emergency and an imperative public necessity that the Constitutional Rule requiring bills to be read on three several days in each House be suspended; and said Rule is hereby suspended, and this Act shall be in effect from and after its passage, and it is so enacted.

Passed the Senate, October 31, 1957, by a viva voce vote; November 11, 1957, Senate refused to concur in House amendments and requested appointment of Conference Committee; November 11, 1957, House granted request of Senate; November 12, 1957, Senate adopted Conference Report: Yeas 29, Nays 2; passed the House, November 8, 1957, with amendments: Yeas 120, Nays 0; November 11, 1957, House granted request of Senate for appointment of Conference Committee; November 12, 1957, House adopted Conference Report: Yeas 132, Nays 7.

Approved Dec. 2, 1957.

Effective Dec. 2, 1957.

APPENDIX B

APPROPRIATIONS OF PUBLIC WATERS AND PRIORITIES OF USES

[The Act, introduced by Senator R. M. Wagstaff and commonly referred to as The Wagstaff Act, is quoted herein from Senate Bill No. 93, Chapter 128, General Laws of Texas, 1931, 42nd Legislature, Regular Session.]

Be it enacted by the Legislature of the State of Texas:

SECTION 1. Article 7471 of the Revised Civil Statutes of the State of Texas of 1925, is hereby amended and as amended shall hereafter read as follows:

"Article 7471. In the conservation and utilization of water declared the property of the State, the public welfare requires not only the recognition of uses beneficial to the public well being, but requires as a constructive public policy, a declaration of priorities in the allottment and appropriation thereof; and it is hereby declared to be the public policy of the State and essential to the public welfare and for the benefit of the people that in the allottment and appropriation of the waters defined in Article 7467, of the Revised Civil Statutes of Texas of 1925, preference and priority be given to the following uses in the order named, to-wit:

1. Domestic and Municipal uses, including water for sustaining human life and the life of domestic animals.
2. Water to be used in processes designed to convert materials of a lower order of value into forms having greater usability and commercial value, and to include water necessary for the development of electric power by means other than hydro-electric.
3. Irrigation.
4. Mining and recovery of minerals.
5. Hydro-electric power.
6. Navigation.
7. Recreation and pleasure."

SEC. 2. Article 7472 of the Revised Civil Statutes of the State of Texas of 1925 is hereby amended so as to hereafter read as follows:

"Article 7472. As between appropriators, the first in time is the first in right, provided, however, that all appropriations or allottments of water hereafter made for hydro-electric power, irrigation, manufacturing, mining, navigation, or any other purposes than domestic or municipal purposes, shall be granted subject to the right of any city, town or municipality of this State to make further appropriations of said water thereafter without the necessity of condemnation or paying therefor, for domestic and municipal purposes as herein defined in paragraph numbered "1" of Art. 7471 as herein amended any law to the contrary notwithstanding.

SEC. 3. The right to take waters necessary for domestic and municipal supply purposes is primary and fundamental, and the right to recover from other uses, waters essential to such purposes shall be paramount and unquestioned in the policy of the State, and in the manner Constitutional and Statutory authority provide. All political sub-divisions of the State, and Constitutional Governmental Agencies exercising delegated Legislative powers, are recognized to have the Right of Eminent Domain, to be exercised as permitted by Law for uses domestic and municipal and manufacturing, for authorized purposes, including the irrigation of lands for all requirements of agricultural employment.

SEC. 4. In the administration of laws provided for the maximum judicious employment of the State waters in the public interest, it shall be the duty of the State Board of Water Engineers, or other administrative agency designated for the service by the State, to conserve this natural resource in the greatest practicable measure for the public welfare; and recognizing the Statutory precedent established for granting the privilege to take and utilize the waters of the State for uses recognized and authorized, it shall be the duty of the State Board of Water Engineers or other agency of the State designated for the purpose to observe the rule that as between applicants for rights to use the waters of the State, preference be given not only in the order of preferential uses declared, but that preference also be given those applications the purposes for which contemplate and will effectuate the maximum utilization of waters and are designated and calculated to prevent the escape of waters without contribution to a beneficial public service.

SEC. 5. It shall be the purpose and policy of the State and of the enactments in accord therewith, in effecting the greatest beneficial utilization of waters of the State, to cause to be made all surveys essential to disclose the measure and potential availability of the water resources of the State to uses recognized; and to ascertain from necessary investigation the character of the principal requirements of the distinct regional division of the watershed areas of the State for the uses herein authorized, to the end that distribution of the right to take and use the waters of the State may be the more equitably administered in the public interest, and privileges granted for the uses recognized may be economically co-ordinated, achieving the maximum of public value from this resource; and recognizing alike the distinct regional necessities for water control and conservation, and for control of harmful floods.

SEC. 6. The provisions of Section 2 of this Act shall not apply to any stream which constitutes or defines the International border or boundary between the United States of America and the Republic of Mexico.

SEC. 7. Any law or laws or part or parts thereof in conflict with the express provisions or the express purposes of this Act shall be held of no force or effect and shall be in all things held to have been repealed.

SEC. 8. If any part or parts of this Act shall be held in contravention of the Constitution, such ineffective part or parts thereof shall not be held to affect other parts in such provisions.

SEC. 9. Whereas, the conservation, control, storing preservation and distribution of the ordinary flow, underflow, storm and flood waters of the rivers and streams in Texas for State, municipal, domestic, irrigation and manufacturing and processing purposes is recognized as a public right and a public duty, essential to the development of the State, municipalities and all sections of Texas; and, whereas, the waters of the ordinary flow, underflow, storm and flood waters of every river or natural stream, canyon, ravine or water-shed within the State of Texas, are declared by Law and recognized by the people as the property of the State and are held by the State in trust for the public welfare, to be allotted and appropriated in such manner as will benefit the greatest number of people and result in the greatest benefit to all the people of the State; and, whereas, it is the public policy of the State and for the benefit of the greatest number of people that in the appropriation of waters as herein defined, the appropriation of water for domestic and municipal uses shall be and remain superior to the rights of the State to appropriate the same for all other purposes; and, whereas, the importance of protecting the rights of the people in the appropriation of the waters as defined herein and for the purposes as herein defined, create an emergency and an imperative public necessity that the Constitutional Rule requiring bills to be read on three several days in each House be suspended and said Rule is hereby suspended and this Act shall take effect and be in force from and after its passage, and it is so enacted.

Approved May 18, 1931.

Effective May 18, 1931.

[NOTE.—S. B. No. 38 passed the Senate by a vote of 30 yeas, 0 nays; passed the House by a vote of 105 yeas, 7 nays.]

APPENDIX C

TABULATIONS OF GROUND-WATER INFORMATION

The following ground-water tabulations present information on yields of existing wells, ability of the aquifers to transmit water, water use, and estimates of additional ground water potentially available for development on a long term basis.

The ratings given in column four of the tabulation to express the ability of the aquifers to transmit water reflect the following general order of determined or expected coefficients of transmissibility: Low—less than 10,000 gpd/ft (the number of gallons per day that will move through a vertical strip of the aquifer one foot wide when the hydraulic gradient is 100 percent); Medium—10,000 to 40,000 gpd/ft; High—over 40,000 gpd/ft. In column six the ratings used for expressing the estimated quantity of additional water available are related to the use given in column five and reflect the general order of estimates as follows: Few—less than three times greater; several—from three to seven times greater; many—more than seven times greater.

CANADIAN RIVER BASIN

Principal Aquifer	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1958	Estimated Additional Water Available In Relation To 1958 Use
Ogallala	700	1,225	Medium to High	523,800	Subject to depletion[1]

[1]Rate of use exceeds ate of recharge. Water available from storage in the aquifer to supply the overdraft is estimated to be 150,000,000 ac e-feet.

RED RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Ogallala	550	1,100	Medium	2,217,300	Subject to depletion[1]
Blaine	400	1,500	Medium	57,000	Subject to depletion[1]
Seymour (includes river alluvium)	300	1,300	Medium	67,200	Subject to depletion[1]
Trinity	325	720	Low	3,200	Few to several times greater
Woodbine	175	740	Low	1,600	Few times greater

[1]Rate of use from Ogallala exceeds rate of recharge. This also may be true for Blaine and Seymour.

SULPHUR RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Nacatoch	225	400	Low	900	A few times greater
Carrizo-Wilcox	60	128	Low	1,300	A few times greater

CYPRESS CREEK BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1958	Estimated Additional Water Available In Relation To 1958 Use
Carrizo-Wilcox	300	1,100	Low	4,400	A few times greater

SABINE RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Carrizo-Wilcox	275	730	Low to Medium	4,000	Several times greater
Miocene-Coastal sands	1,800	3,500	High	23,600	Several to many times greater

NECHES RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Carrizo-Wilcox	450	1,340	Medium	28,900	Few to several times greater
Miocene-Coastal sands	1,600	4,530	High	37,400	Few to several times greater

UPPER COASTAL AREAS

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Neches-Trinity Area					
Miocene-Coastal sands	250	1,500	Medium	14,400	A few times greater
Trinity-San Jacinto Area					
Miocene-Coastal sands	1,900	3,400	High	41,300	A few times greater
San Jacinto-Brazos Area					
Miocene-Coastal sands	1,500	3,200	High	71,300	A few times greater
Brazos-Colorado Area					
Miocene-Coastal sands	1,500	3,100	High	84,000	A few times greater
Colorado-Lavaca Area					
Miocene-Coastal sands	1,500	3,500	High	51,400	A few times greater
Lavaca-Guadalupe Area					
Miocene-Coastal sands	1,200	3,000	High	37,500	A few times greater

TRINITY RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Trinity:	430	2,200	Medium		
Dallas-Ft. Worth Area				31,100	No additional water
Outside Dallas-Ft. Worth Area				22,600	A few times greater
Woodbine	120	600	Low	8,100	A few times greater
Carrizo-Wilcox	500	1,650	Medium	7,000	Several times greater
Sparta	400	510	Low to Medium	700	Several times greater
Miocene-Coastal sands	1,500	3,400	High	17,200	A few times greater

SAN JACINTO RIVER BASIN

Principal Aquifer	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Miocene-Coastal sands	1,800	2,900	High	293,000	A few times greater

BRAZOS RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Ogallala	550	1,000	Medium	3,935,800	Subject to depletion[1]
Alluvium and Seymour	450	1,370	High	189,800	Subject to depletion[1]
Trinity	200	2,100	Low to Medium	23,200	A few times greater
Carrizo-Wilcox	300	1,000	Medium	4,500	A few to several times greater
Sparta	325	500	Low to Medium	4,000	A few times greater
Miocene-Coastal sands	1,500	3,400	High	31,200	Several times greater

[1]Rate of use from Ogallala exceeds rate of recharge. This also may be true for Alluvium and Seymour.

COLORADO RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Ogallala	400	1,200	Medium to High	692,600	Subject to depletion[1]
Triassic sands	175	800	Low to Medium	35,100	A few times greater
Edwards-Trinity	250	1,000	Medium (or low to high)	32,600	A few times greater
Carrizo-Wilcox	375	900	Medium	1,100	A few to several times greater
Miocene-Coastal sands	1,500	3,400	High	39,400	A few times greater

[1]Rate of use exceeds rate of recharge.

LAVACA RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Miocene-Coastal sands	1,000	2,900	High	152,400	A few times greater

GUADALUPE RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Edwards-Trinity	400	1,000	Medium	2,500	A few times greater
Edwards (fault zone)	1,500	2,300	High	8,200	Many times greater
Carrizo-Wilcox	500	1,000	Medium to High	1,600	Several times greater
Miocene-Coastal sands	500	1,500	High	3,000	Many times greater

SAN ANTONIO RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Edwards-Trinity	400	1,300	Medium	900	A few times greater
Edwards (fault zone)	1,500	19,000	High	170,000	See text discussion
Carrizo-Wilcox	900	1,800	High	2,000	Several to many times greater
Miocene-Coastal sands	800	2,000	Medium to High	3,100	Many times greater

LOWER COASTAL AREAS

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
San Antonio-Nueces Area Miocene-Coastal sands	500	3,000	Medium	15,200	A few times greater
Nueces-Rio Grande Area Miocene-Coastal sands	275	1,000	Low to Medium	22,300	A few times greater
Alluvium (Rio Grande Valley)	500	2,730	Medium to High	216,500	A few times greater

NUECES RIVER BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Edwards-Trinity	80	100	Low to Medium	100	A few times greater
Edwards (fault zone)	900	1,200	High	30,100	Several times greater
Carrizo-Wilcox	700	1,200	Medium to High	206,000	A few times greater
Miocene-Coastal sands	500	1,800	Low to Medium	15,200	A few times greater

RIO GRANDE BASIN

Principal Aquifers	Yield of Large Capacity Wells Gallons Per Minute		Ability to Transmit Water	Use and Availability Acre-Feet Per Year	
	Average	Maximum		Use in 1957	Estimated Additional Water Available In Relation To 1957 Use
Alluvium	1,000	3,000	High	854,000	Subject to depletion[1]
Bone Spring	900	3,000	Locally High	94,000	No additional water
San Andres-Capitan Reef	1,000	2,000	High	10,000	Few times greater
Santa Rosa	300	1,800	Locally Medium	12,400	Few times greater
Edwards-Trinity	400	4,000	Locally High	169,100	Few times greater

[1]With local exceptions, rate of use exceeds rate of recharge.