TEXAS WATER DEVELOPMENT BOARD

Water for Texas

Today and Tomorrow

– 1990 –

TEXAS WATER DEVELOPMENT BOARD

The People of the State of Texas

December 13, 1990

Transmitted herewith is the amended Texas Water Plan which was unanimously adopted by the Texas Water Development Board on December 13, 1990 as the official water plan for the State. Amendments to the Water Plan were last adopted in 1984. The 1990 Water Plan, entitled "Water for Texas, Today and Tomorrow," has been in preparation since 1987 and is the result of a planning process which included input from over 40 public meetings, an outside review committee, interviews with community and professional leaders, two draft plans circulated for comment, and an official public hearing.

The amended 50-year Plan is a summary document that presents current and prospective water uses, identifies water supplies, and estimates facility needs and costs. The Plan also describes water problems and opportunities, outlines significant environmental concerns and water issues, and offers program and policy recommendations.

The Plan approved by the Board includes both actions to be taken by the Texas Water Development Board and policy recommendations to local, State, and federal entities and the State Legislature to:

- implement programs and activities to address water demand and supply management issues and problems of inadequate water supplies in certain areas of the State,
- address problems associated with increased responsibility that local entities are experiencing for water supply, quality, and conservation; flood protection; and other issues through financial and technical assistance and efficient and consistent regulatory actions.
- maintain strong State involvement in protecting water quality,
- increase emphasis on protecting environmental values and uses of water,
- expand initiatives for flood protection and floodplain management at the State and local level,

Renewed and prospective population and economic growth and additional significant regulatory requirements will exert great pressures on the capabilities of local government to implement and finance new water-related facilities necessary to keep pace with growth and environmental, health, and public safety concerns. Actions are needed now to insure that Texas government is responsive to the needs of all of its citizens as our great State enters the 21st century.

Sincerely,

G.E. Kretzschmar
Executive Administrator

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WATER FOR TEXAS
TODAY AND TOMORROW

Sections 16.051 and 16.055 of the Texas Water Code direct the Executive Administrator of the Texas Water Development Board to prepare and maintain a comprehensive state water plan as a flexible guide for the orderly development and management of the State's water resources in order that sufficient water will be available at a reasonable cost to further the economic development of the entire State. In addition, the Board is directed to amend and modify the plan in response to experience and changed conditions.

Published and distributed
by the
Texas Water Development Board
P. O. Box 13231
Austin, Texas 78711-3231

Printed on Recycled Paper

December 1990
Document No. GP-5-1

WATER FOR TEXAS
TODAY AND TOMORROW

Table of Contents

(continued)

WATER FOR TEXAS
TODAY AND TOMORROW

Table of Contents

WATER FOR TEXAS
TODAY AND TOMORROW

List of Figures

List of Tables

WATER FOR TEXAS
TODAY AND TOMORROW

1 INTRODUCTION

Water is the most precious natural resource and basic economic commodity. It is distinct from other natural resources and has no substitute. Man and the environment, on which his existence depends, must have water to survive and prosper. Water interrelates with and affects almost every aspect of human and natural existence and, thus, becomes an extremely complex subject of planning and management.

How much water does Texas have? Is there enough for the people, the economy, and the environment? Will there be enough for future generations? Where are the supplies? Can they be made available for use at affordable costs? Will they be safe to drink and to use in other ways?

To address these fundamental questions, vast amounts of data must be gathered and evaluated and sound planning principles and assessment techniques must be applied. In turn, alternatives, conclusions, and recommendations must be coordinated with the State legislature; federal, state, and local agencies; and the general public.

State law directs the Executive Administrator of the Texas Water Development Board to prepare and maintain a comprehensive water plan for the orderly development and management of the State's water resources so that sufficient water will be available at a reasonable cost to further the economic development of the entire State. Because the management of water resources is a dynamic, changing process, the Board is directed to amend and modify the Water Plan as experience and changing conditions require. This document is the latest developmental blueprint in the Board's on-going water planning process.

PLAN GOALS AND OBJECTIVES

The primary objective of the Texas Water Plan is to provide a continuing comprehensive assessment of the current and future status of water-related resources within the State and to provide workable strategies that will guide State policy for the development, management, conservation, and protection of the State's water resources. The Water Plan also identifies and considers the public and private interests and institutions of the entire State, gives appropriate attention to environmental factors, and promotes economic welfare.

The 1990 Water Plan, as a flexible guide, identifies alternative approaches to manage water resources, makes recommendations for policy and program formulation and implementation, and gives public and private institutions direction to:

1. Provide for sufficient quantities of suitable quality water in a cost-effective manner in each area of the State as the population, economy, and environmental conditions of Texas change, taking into account improved water supply management, water use and reuse efficiencies, water conservation, and development of new sources of supply;

2. Protect the quality of both surface water and ground water in each area of the State and, where practical, improve water availability in both quality and quantity; and

3. Safeguard human life and property from flooding and flood damage, to the extent that such flood protection is economically and technically feasible.

While the Water Plan attempts to address the multitude of various water-related issues, it is not an all-inclusive representation of all State programs to protect and allocate water resources.

PLAN ORGANIZATION AND PLANNING TOOLS

The 1990 Texas Water Plan amendment, "Water for Texas, Today and Tomorrow" presents a summary report. Supporting materials are available in the Board's agency files. The introduction to the Plan provides an overview of the State's current and likely water resource situations and identifies key problem areas. Planning concepts, methodologies, and determinations used in the planning process are then discussed. Future water demands, supplies, and facility needs and costs are subsequently projected over a 50-year planning period for statewide, river basin, and regional study areas. Finally, the Plan outlines key policy and program issues and future action recommendations to provide the Legislature, state agencies, local governments, and the public with an array of tools to better manage water resources for the benefit of all of the State's citizens.

PERSPECTIVE ON PLANNING HISTORY

In 1957, after extremely damaging floods ended the 1950s drought, the Texas Water Development Board was created by legislative act, and Texas voters approved a constitutional amendment authorizing the Board to administer a $200 million Water Development Fund to help communities construct reliable water supplies. Also in 1957, statewide water planning was mandated when the Texas Water Planning Act (Acts 1957, 55th Leg., p. 1268, ch. 425, Section 3) was enacted. The authority to prepare a Water Plan is codified as Section 16.051 (Chapter 16, Subchapter C., Planning) of the Texas Water Code.

Although many proposals concerning the State's water resources were prepared between 1904, when voters first authorized the public development of water resources, and 1989, only three water plans have been officially adopted as State policy. The first two plans, which were adopted in 1961 and 1969, consisted of initial attempts to describe the State's water resources, to quantify future water needs, and to propose water supply projects to meet future demands. The interrelated nature of conventional water development proposals and non-water supply aspects of comprehensive water resources management, such as flood protection, hydropower generation, drainage, water quality, recreation, and fish and wildlife, was preliminarily recognized and incorporated into the 1969 Texas Water Plan.

The official adoption of the State's third water plan, Water for Texas - A Comprehensive Plan for the Future, in 1984 signaled a key departure from the earlier plans which relied almost exclusively on water supply development to meet future demands. The 1984 Plan proposed major new conservation, environmental, and ground-water protection initiatives and included long-term funding needs for water pollution control, in addition to conventional water supply projects. For the first time, the 1984 Plan presented a documented need for, and a justifiable approach to, developing the State's water resources.

The State's 1990 Water Plan further exemplifies the continuing evolution of water planning in Texas by building on the new directions established in 1984 and by emphasizing improved overall *management* of the State's existing and future water infrastructure systems. For water planning and management to be truly effective, the State Water Plan must be updated on a regular and predictable basis. The Board is committed to maintaining a continuing planning process to ensure that this objective is realized.

OVERVIEW OF THE STATE ECONOMY, WATER RESOURCES, AND PROBLEMS

The Texas Economy In the Decade of the 1980s

The State economy has historically been dependent on basic natural resources that have provided for the production of food, fiber, and energy. From this physical resource base, the State's economy has evolved into a major producer of the nation's goods and services. The movement of national firms into Texas in the last 20 years hastened the expansion and diversification of the State's economy, provided new employment opportunities, and generated additional revenues for state and local governments.

The escalation of energy prices and expansion of energy development in Texas during the 1970s and early 1980s provided the impetus for economic growth in Texas while the nation was experiencing a sharp downturn in economic activity. Expanding economic activity in Texas during this period resulted in a significant increase in the State's population. Between 1970 and 1980, Texas' population increased by three million people, with migration into the State accounting for an estimated 58 percent of the increase.

Beginning in late 1983 and continuing through 1986, the economic climate in Texas changed dramatically. The rapid expansion of the Texas economy was altered by international events, including the decline of crude oil prices, a corresponding decrease in energy development, escalation of the value of the U.S. dollar in foreign markets, and continued weakening of the profitability of the agricultural sector. These events adversely impacted the State's mining, construction, manufacturing, and agricultural sectors and indirectly affected real estate and finance.

Reduced economic activity also slowed the migration of people into the State and thus reduced future potential population levels and associated municipal water demands. During one phase of the economic expansion between 1980 and 1982, net migration added over 761,000 persons to the State population. By comparison, during two years of economic decline between 1984 and 1986, net migration contributed only 229,000 persons to the State's population.

Changes in the level of economic activity and demographic trends have had both direct and indirect effects upon the level of water use. Water use in manufacturing and agriculture directly mirrored the change in the economic conditions of the period. From 1980 to 1985, annual water use in the manufacturing sector declined about six percent or 92 thousand acre-feet (with some of the decline due to dry weather conditions early in the 1980s). Over the same period, annual water use for irrigation declined about 31 percent or 3.9 million acre-feet, primarily due to economic factors and governmental agricultural programs to reduce acreage.

By late 1987, the Texas economy began to recover from one of the worst downturns in the State's recent history. Leading the recovery were manufacturing sector growth and increased export volumes as the value of the U.S. dollar abroad began to decline. A more diversified economy, less dependent on the energy resources of the State and more closely approaching the national economy in employment distribution, had begun to emerge, although the current situation in the Middle East may have an, as yet, undetermined impact on the Texas economy.

Statewide Water Resources and Problems

Summary. In a number of areas of the State today, available yield in existing surface water or ground-water supplies will barely be sufficient to meet water demands during a critical drought period. Intense ground-water use for a variety of purposes around the State has significantly reduced aquifer levels and pumping yields in many areas, impacting ground-water quality and causing, in some locations, other undesirable effects such as land subsidence or severe reduction or cessation of springflow.

New surface water development has also become increasingly constrained by regulatory, and in some cases, physiographic limitations. Many favorable sites for reservoir projects are already developed, and the remaining sites must be addressed considering factors such as distance from demand centers, potential yields, costs, and higher environmental values. The efficient use of the available water through water conservation or reuse is essential to extend existing supplies limited by these factors.

Many problems affecting surface water and ground-water quality in Texas originate from stormwater runoff and wastewater discharges from agricultural and highly populated urban areas. In some areas, the quality of water supplies is affected by naturally occurring contaminants, such as chlorides or nitrates. Man's activities which reduce natural streamflows can also impact water quality. The continuing expansion of water quality regulations will require more costly and higher-level treatment of point source wastewater discharges, as well as increased educational efforts, demonstration of best management approaches and control techniques, and expanded technical and financial assistance to address nonpoint source pollution problems.

While stronger water quality standards, with resulting changes in wastewater effluent limitations, should improve the quality of raw water, new standards established under the federal Safe Drinking Water Act will affect an array of standards for quality and will impact all public water supply systems with higher costs of service. A large number of small community systems, many dependent on groundwater, will face formidable expenses to install new water treatment systems to meet current and forthcoming drinking water regulations, thus potentially placing increased demands on surface water availability.

In many cases, more non-traditional management practices, including water conservation, reuse, desalinization, watershed yield augmentation, reservoir operations optimization, and other methods can be employed to more efficiently use and extend available water supplies. These techniques are gaining increased attention and use as competing demands for water have heightened the difficulty and cost of providing new conventional water supplies.

The potential impact of upstream development on the availability and quality of water necessary for instream environmental needs and freshwater inflows to the bays and estuaries is a major concern to the State. Use of rivers and bays for navigation, commercial dredging, commercial/sport fishing, oil and gas production, maintenance and propagation of aquatic life, and diverse recreational activities is extensive and must be included in comprehensive water planning.

Serious flooding conditions, ranging from hurricane/tropical storm flooding of flat coastal areas along the Texas Gulf to high-velocity flash flooding in the narrow ravines and gorges of Central and West Texas to the lower velocity, but high volume riverine flooding in North Central, Northeast and East Texas, affect more than a quarter of the State. Flood protection can be costly, involve environmental impacts, and may provide direct relief to limited beneficiaries in an area, involve problems with funding, political decision-making, and infrastructure management. Non-structural flood control measures can, in many instances, be viable, cost-effective alternatives or complementary measures to costly structural flood control measures.

Ground-Water Resources and Use. More than 81 percent of Texas is underlain by nine major and 20 minor aquifers (Figures 1-1 and 1-2). These aquifers receive an average annual natural recharge of about 5.3 million acre-feet and contain about 3 billion to 4 billion acre-feet of usable quality water in storage, of which only a portion is recoverable using conventional water well technology.

As seen in Figure 1-3, more than 70 percent of the 6.4 million acre-feet of recent annual ground-water pumpage was for irrigated agriculture with municipal use accounting for about one-fifth of the total pumpage. Due to widespread availability and relatively low cost of supply, ground water accounts for about 63 percent of total water used for irrigation and about 45 percent of water used for municipal needs.

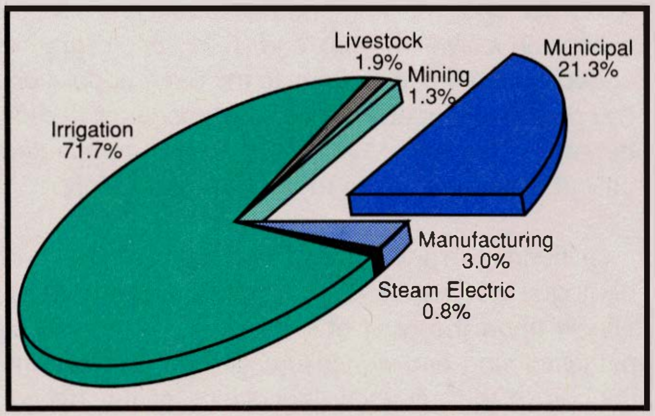


FIGURE 1-3
DISTRIBUTION OF TEXAS GROUND-WATER USE, 1987

FIGURE 1-1 MAJOR AQUIFERS OF TEXAS

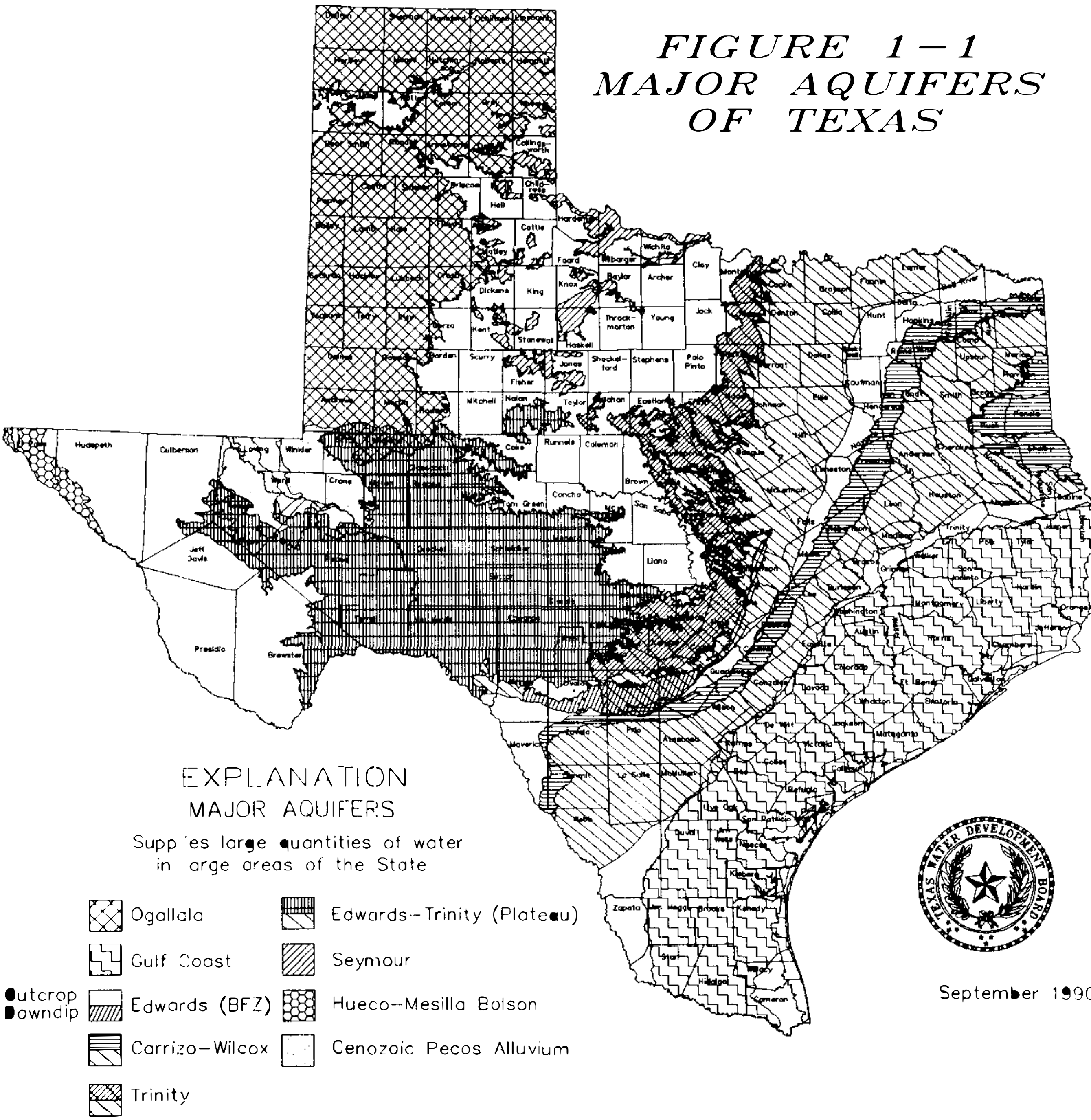
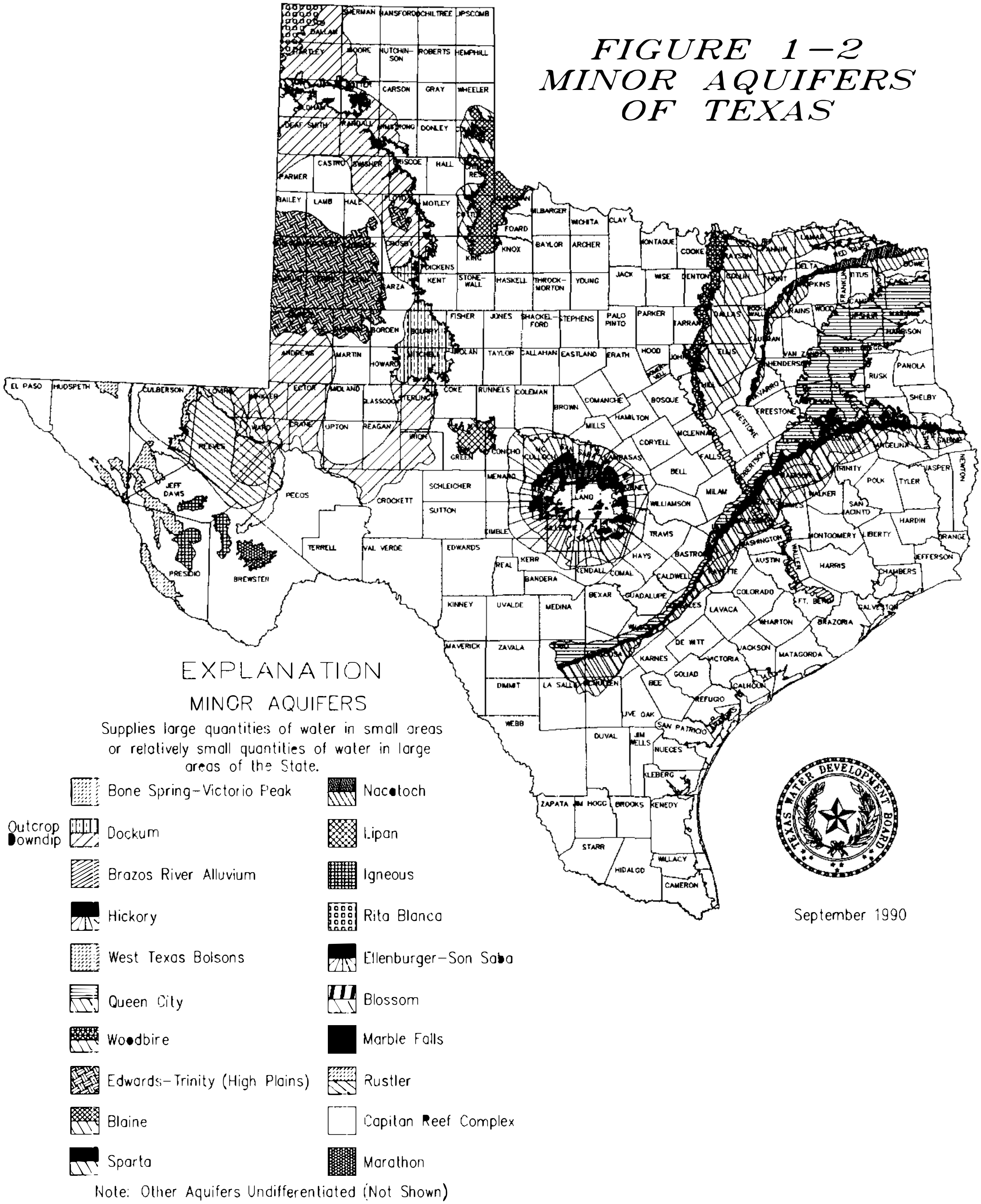


FIGURE 1-2
MINOR AQUIFERS OF TEXAS



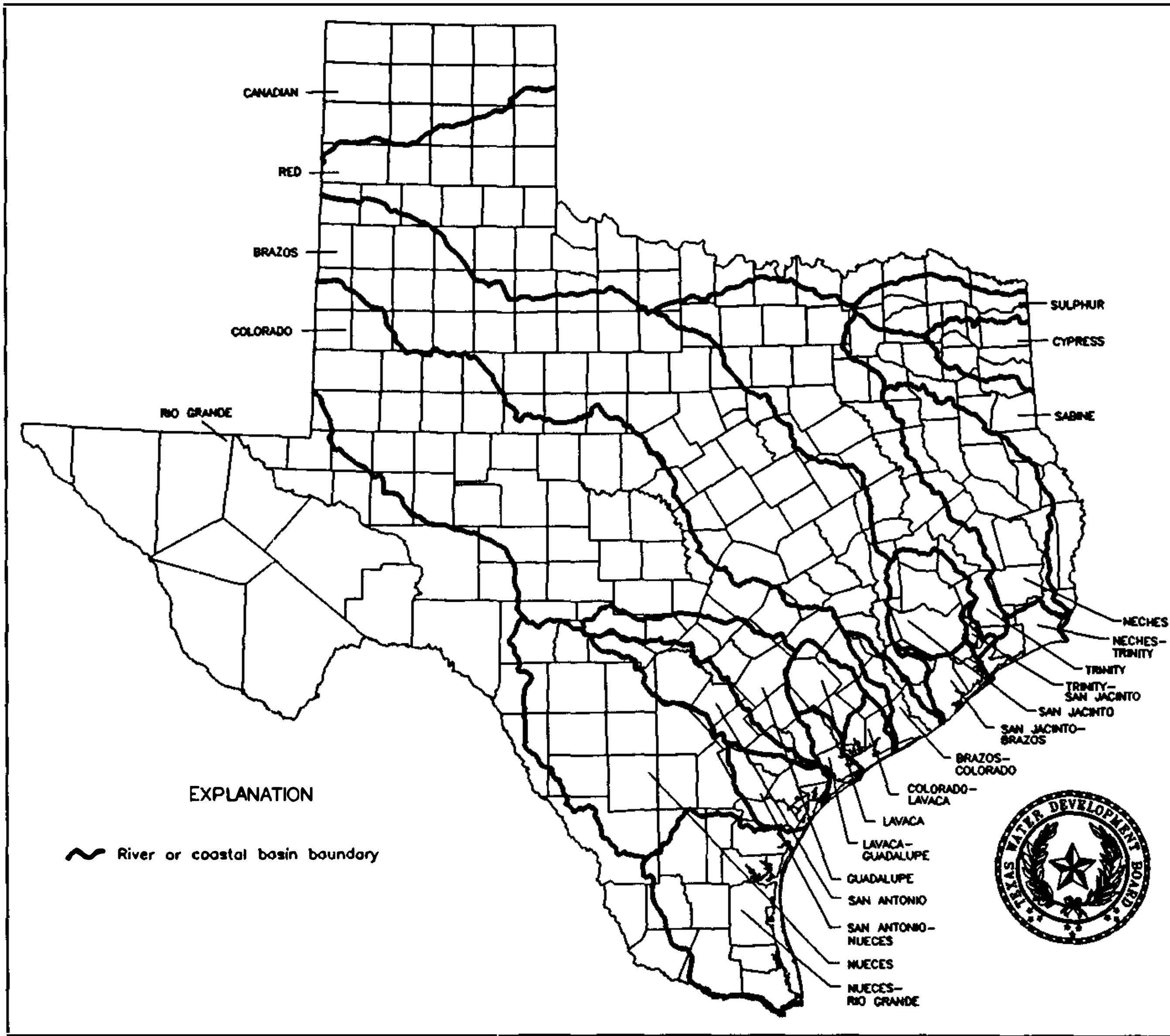


FIGURE 1-4
RIVER AND COASTAL BASINS IN TEXAS

In many areas, the quantity of ground water withdrawn has exceeded the natural recharge of aquifers, resulting in declining ground-water levels which can cause both supply and quality problems. Declining aquifer levels can also reduce springflows and result in reduced surface water supplies for uses by man and the environment. In the State of Texas, ground water is private property that may be conveyed with the sale of the land.

Surface Water Resources and Use. The State of Texas has 15 major river basins and eight coastal basins. The 23 river and coastal basins have approximately 3,700 streams and tributaries and 80,000 linear miles of streambed (see Figure 1-4). Physiographic and climatological features may vary dramatically from the headwaters to outlets into other rivers or at the Gulf of Mexico. For instance, long-term average annual precipitation contributing to rainfall runoff and surface water supplies varies dramatically across the State, ranging from 56 inches near Beaumont in East Texas to eight inches in far West Texas near El Paso.

Average annual runoff (streamflow) is about 49 million acre-feet, ranging from about 1,100 acre-feet per square mile at the Texas-Louisiana border to practically zero in parts of the Trans-Pecos Region of West Texas. Between 1940 and 1970, statewide runoff varied from an average 57 million acre-feet per year during the wettest period (1940-1950) to as little as 23 million acre-feet per year during the most severe recorded statewide drought of the early and mid-1950s.

There are currently 188 (38 federal and 150 non-federal) major reservoirs with 5,000 acre-feet or greater storage capacity in Texas. In addition, one federal and two non-federal reservoirs are currently under construction. The 191 major reservoirs have a total conservation storage capacity of about 37.1 million acre-feet. Storage capacity for flood protection totals about 17.9 million acre-feet in these reservoirs.

The dependable firm surface water supply (i.e., the uniform yield that can be withdrawn annually from total storage through extended drought periods, dependable run-of-the-river supplies, and dependable supplies in certain reservoirs that are operated in other than a firm yield mode) is about 11 million acre-feet or 30 percent of total conservation storage. Of the 11 million acre-feet of dependable supply from the State's major reservoirs and rivers, current withdrawals total about 6 million acre-feet or about 55 percent of the firm dependable surface water supply.

Approximately 83 percent of the remaining five million acre-feet of dependable surface water supply is committed through existing contractual agreements or reserved to meet future projected needs. However, over half of the remaining 17 percent of uncommitted supply is in the Sam Rayburn Reservoir.

Figure 1-5 indicates the distribution of surface water diversions for consumptive use in Texas in 1987. As seen, irrigated agriculture accounts for more than 40 percent of statewide surface water diversions. The amount and share of use of surface water for irrigation is noticeably less than ground-water use due to surface water's more distant location from agricultural demand centers and generally higher costs of supply. In addition to the diversions for consumptive uses, shown in Figure 1-5, the non-consumptive use of surface water plays a critical role in the biological productivity of instream and bay and estuarine environments.

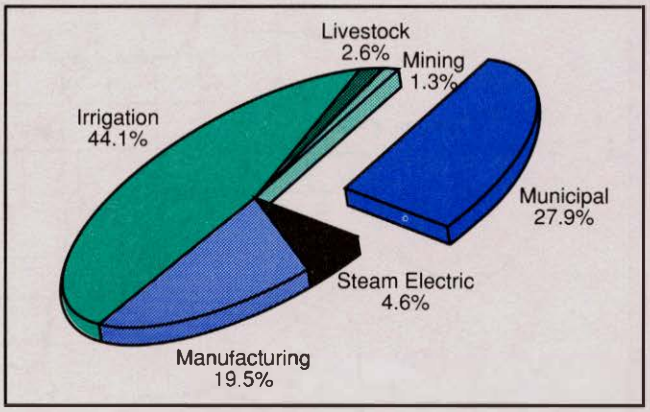


FIGURE 1-5
DISTRIBUTION OF TEXAS SURFACE WATER DIVERSIONS, 1987

Water Quality and Use Suitability. Water quality protection and enhancement are essential in various areas of the State with limited alternative water supplies. Both natural sources of contamination and pollution from human activities can impair surface water and ground-water quality.

In portions of Texas, surface and ground water passing through mineralized areas can increase the level of dissolved solids to the point that the water requires extensive treatment before it can be used as a drinking water source. Municipal and industrial discharges, rainfall runoff from agricultural and urban areas, accidental spills, and other land use activities can also significantly degrade surface water and ground-water supplies.

Surface Water Quality. The Texas Water Commission promulgates surface water quality standards identifying desirable uses of major streams in Texas and defining criteria to protect such uses. While conventional pollutants remain a concern, increasing attention is being devoted to the control of toxic pollutants and nonpoint sources of pollution associated with improper land management practices.

Based on the TWC's recent assessment in the State of Texas Water Quality Inventory of classified segments covered by the State's water quality standards, 84 percent of classified stream miles and 88 percent of the classified reservoirs in the State exhibit suitable water quality to support the major uses designated by the Texas Water Commission (i.e., public water supply, contact and non-contact recreation, aquifer protection, and aquatic habitat). Smaller waterbodies that are not classified segments and which are perennial or support perennial aquatic life uses are designated for contact recreation and at least limited quality aquatic life.

About 89 percent of the classified streams and 99 percent of the classified reservoirs meet the "swimmable" goal of the Clean Water Act. The "fishable" goal of the Act is achieved in more than 99 percent of the classified streams and reservoirs assessed. The causes of major reductions in water quality, ranked by number of river miles affected for rivers not fully supporting uses, include: pathogenic bacteria; salinity, total dissolved solids, and chlorides; and organic enrichment. Sources contributing to major reductions in river water quality, in order of magnitude, include: municipal point sources, natural sources, and urban runoff and storm sewers.

The most important causes of major degradation in reservoir water quality, ranked by acres affected for lakes not fully supporting uses, include: salinity, total dissolved solids, and chlorides; pathogenic bacteria; and siltation. Sources contributing to major reductions in reservoir quality, in order of magnitude, include: natural sources, municipal point sources, and agricultural activities.

Primarily on the Texas coast, state water and environmental resources and economic activity can also be adversely affected by occasional large and more frequent minor spills of oil, refined products, and chemicals.

Ground-water Quality. A 1989 report by the Texas Water Commission indicates that natural contamination probably affects the quality of more ground water in the State than all other sources of contamination combined. Salt water intrusion; other types of mineralization; and naturally occurring metals, nitrates, and radioactivity are important natural contaminants in some ground waters.

Man-induced ground-water contamination usually involves substances released on or slightly below land surface, although it can involve contamination at great depths. For the most part, this near-surface type of pollution is regionally confined to the most heavily populated and industrialized areas of Texas and to areas with wells associated with the oil and gas industry.

Improperly completed and abandoned wells are possibly of greatest concern. These wells allow direct access from the surface to ground-water aquifers or from one ground-water aquifer to another through vertical leakage. Most pesticides found in ground water are believed to have moved to aquifers through wells of this type. It is conservatively estimated that the State of Texas has at least 600,000 total water wells, of which about 150,000 are believed to be abandoned.

It is estimated that approximately 1,583,600 total oil and gas activity-related holes have been drilled within the State in the past 80 years. About 258,200 of those holes were for testing, service wells, and dry holes. The majority of these holes have not had the casing treated, and many of these may leak in the future. Additionally, improperly plugged abandoned wells and test holes are ready avenues for the upward migration of brine, as well as paths for other types of ground-water contamination, including oil and gas, drilling fluids, chemicals used in treating wells, other additives, and corrosion inhibitors. During 1986 alone, the Railroad Commission of Texas spent $3.8 million plugging 919 improperly abandoned wells.

Septic tanks, used for the disposal of human waste, have the potential to discharge large volumes of effluent directly to water-bearing units. If not properly sited, constructed and maintained, this waste disposal practice can become a localized threat to ground-water quality. More than one million older septic tanks are estimated to be scattered throughout the State.

Underground storage tanks are removed from easy visual inspection and often lie at depths that are continually saturated with ground water. Underground storage tanks are considered to be one of the principal contributing sources to man-made ground-water pollution. Statewide, about 154,000 tanks should ultimately be registered by the Texas Water Commission. It is now estimated that about 38,500 could eventually leak. Recent data indicates about 5,100 tanks had confirmed leaks, with the Commission receiving notice of confirmed leaking tanks at the rate of about 50 per month. Leaking tanks, which have contaminated ground water, are being repaired or removed, and their impacts are being actively mitigated.

Past disposal practices associated with municipal solid waste landfills have already resulted in, or will likely ultimately contribute significantly to, ground-water pollution. The U.S. Environmental Protection Agency is now in the process of developing new rules related to the construction and operation of municipal solid waste landfills.

Another source of concern over ground-water quality protection is that associated with the use of injection wells for disposal of industrial wastes and oil and gas brine. Currently, about five billion gallons of industrial wastewater are injected into subsurface reservoirs each year in Texas (approximately 60 percent of the industrial waste disposed of each year in the State by weight). However, there has never been a confirmed case of usable-quality ground water being contaminated by an industrial waste disposal well in Texas.

Some areas of high chloride (salinity) concentration in local ground-water supplies are coincident with significant oil and gas production and may be a result of oil field brine disposal activities, which typically include use of brine disposal wells, surface salt-water disposal pits or playa lakes, or historic dumping of salt water into surface drainageways. Potentially, ground water could be affected by oil and gas activities in 231 of the 254 counties within the State (TWC, 1989).

In some agricultural areas of the State, excessively high levels of nitrates and detected levels of pesticides in ground water are problems which require increasing attention and study. To address these problems, a statewide agricultural chemical ground-water strategy will be developed by the Texas Water Commission and others in the immediate future.

Environmental Concerns. Major areas of water-related environmental concern are freshwater inflows to bays and estuaries, instream flow needs, preservation of fish and wildlife habitats, and maintaining water quality. Of the many environmental concerns of Texans, none involve more public land, water, and wildlife than the need for freshwater inflow to the State's bays and estuaries.

There are seven major and at least three minor estuarine systems located along the 367 linear miles of Texas coastline on the Gulf of Mexico (see Figure 1-6). The 10 estuarine systems encompass about 1.5 million acres of open water bays, 1.1 million acres of adjacent wetland marshes, and 250,000 acres of submerged aquatic vegetation. Slightly more than 2,200 miles of Texas coastline abuts the edges of the 2.6 million acres of bays and estuaries.

Texas bays and estuaries provide resources that contribute to the economy in many ways, including a major navigation network, a natural method of waste treatment, and a vast resource base for minerals, seafoods, and recreational opportunities. Sport and commercial fishermen in Texas harvest an average of over 100 million pounds of coastal fish and shellfish per year, and when coupled with other recreational uses of these resources, yield a total annual direct and indirect impact on the State's economy estimated to exceed $2.6 billion.

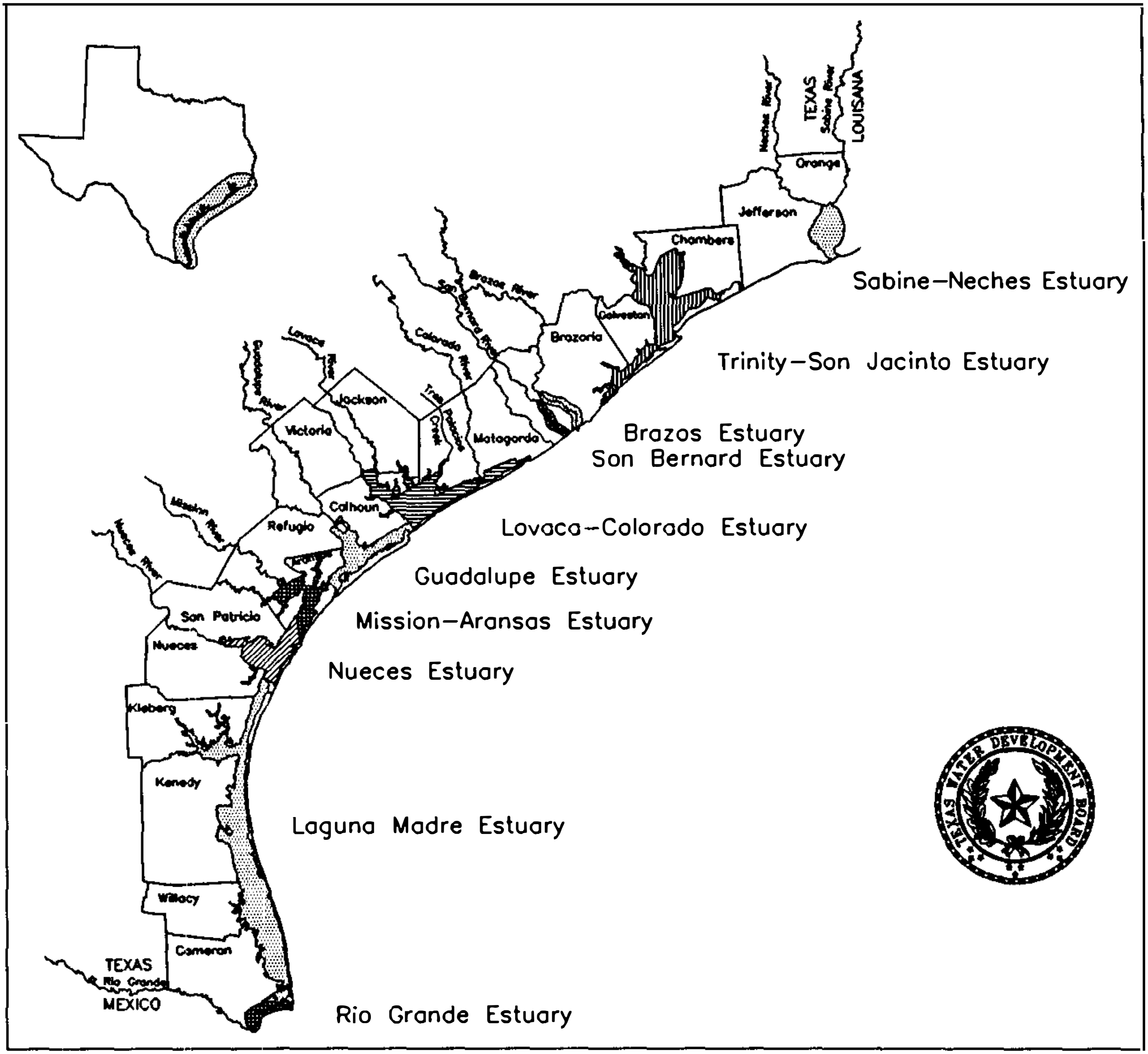


FIGURE 1-6
LOCATION OF TEXAS ESTUARIES

The State of Texas has an inventoried total of more than 3,700 streams and tributaries within the State's 15 major river basins, consisting of nearly 80,000 lineal miles of streambed. The Texas Parks and Wildlife Department estimated in 1989 that the total direct and indirect economic impact of inland fisheries and inland water-based recreation was $4.7 billion annually.

Federal and state law now requires the TWC and TPWD to consider the effect that the issuance of a permit to store, take, or divert water from a river or stream might have on existing instream uses, water quality of the river, and the existing fish and wildlife habitat. In addition, the permit applicant may be required to take reasonable actions to mitigate any adverse impacts on fish and wildlife habitats.

Another major environmental issue encompasses the effects of various types of water development activities on local riparian (riverbank) communities, floodplain environments, and any associated bottomland hardwood forests. Federal and other programs to acquire these sensitive habitats may also conflict with potential water development proposals.

Because the assessment of large project impacts is time consuming and expensive, especially when model development is required for complex environmental issues such as inflows to bays and estuaries or the instream flow needs of fish, the role of advance planning and coordination of mitigation and its cost implications for future water development projects is essential.

Flood Protection. Given the diverse climatological, physiographic, and socioeconomic features of Texas, the State experiences a wide array of flooding conditions of varying cause, frequency and severity. Major flooding and erosion damage can occur in urban and rural floodplain areas from coastal, riverine and overland flooding. Flooding can also be caused by the failure of protective measures, ocean shoreline retreat, land subsidence, and by fluctuating reservoir levels along lake shores. An acceleration of the current trend of a relative rise in the sea level along the Texas Gulf Coast could significantly increase coastal and adjacent riverine flooding. Damage can result from sudden flash flooding or be the result of more predictable, gradual rising and receding waters.

Flood protection is needed for both structural and non-structural control measures. In addition to more traditional and typically expensive structural methods of flood damage control, the implementation and enforcement of floodplain zoning restrictions, including the encouragement of greenbelt parks and other low-intensity land uses in floodprone areas and drainages, can be very cost-effective in many cases. Implementation of methods to reduce the rate of rainfall runoff through structural and non-structural means can also reduce the severity of flooding events.

Based on the U.S. Soil Conservation Service's (SCS) findings in 1984, Texas has the greatest acreage of rural floodplain land (slightly more than 20 million acres) of the 48 contiguous states. According to 1985 data for all states from the Federal Emergency Management Agency (FEMA), Texas also has the greatest acreage (18.3 million acres) classified as floodplain land in identified floodprone communities.

In 1987, Texas had the third largest number of flood insurance policies in effect (225,275) and the second highest amount of flood insurance coverage ($15.3 billion) of all states. From 1978 through 1987, Texas had the second highest number of flood insurance claims paid (55,862) and the greatest dollar amount paid for claims ($575.6 million) in the U.S. with many of these claims representing repetitive losses for property in chronic floodprone areas. For instance, the structural value of households at risk in the 100-year floodplain of communities in Texas alone totals over $101 billion (NFIP, 1988).

Summary. Texas faces a wide array of water resources concerns that range from pressing issues to longer-term considerations. The Water Plan is the State's primary macro-level planning tool for assessing the overall current condition and the potential future condition of Texas' water-related resources. The Plan delineates areas with problems and needs, and identifies opportunities for action that will help guide the formation and implementation of effective State and local water policies and programs for the future development and conservation of Texas' water resources.

The following sections of the Water Plan report describe the various planning concepts and methods used in developing the Board's forecasts of future water-related needs; an array of potential management actions, facility requirements, and related expenditures to address those needs; and various policy issues and recommendations for Legislative and State agency consideration.

2 PLANNING CONCEPTS

Sound planning practice requires that legal, physical, environmental, and economic factors, as well as data sources, modeling techniques, and procedures be addressed in the planning and reporting process.

REGULATORY CONSIDERATIONS

Jurisdiction and Authorities

As distinct from some states, management responsibilities of Texas water resources are dispersed among a number of entities of federal, state, and local governments. Responsibility for the initiation of planning, design, funding, construction, and daily operation and maintenance of public water and wastewater facilities commonly rests with over 4,500 local entities, including municipalities, regional and smaller special districts, and investor-owned and non-profit utility corporations. This diverse array of jurisdictions and authorities is beneficial, in some instances, to the efficient planning and use of the State's water resources and detrimental in other cases.

Intergovernmental Relationships

Successful implementation of the recommendations in the Texas Water Plan can only occur through the collaborative efforts of the electorate, private interests, local government officials, State agencies, the Texas Legislature, and the federal government. The failure of any one party to fulfill its responsibility will impede the activities of all others. A primary cornerstone of the Water Plan is recognizing the appropriate roles of federal, state, and local government and pursuing deliberate actions to promote intergovernmental cooperation and integrated planning within the limits of each governmental level's proper role.

Since the early 1970s, the State's role in water management has increased, and the federal role in water planning and financing has diminished. Nowhere is this more apparent than in the financing of new water, wastewater, and flood protection/drainage facilities.

As shown in the Figure 2-1 below, federal funds expended for new water-related facilities in Texas between 1978 and 1989 declined from 40 percent to 17 percent of total State infrastructure spending for water, wastewater, and flood protection/drainage projects, while the State's share of financial assistance increased from slightly less than five percent to over 10 percent. This statewide infrastructure spending relates the levels of public market (local), federal, and state capital facility financing from 1978 through 1989 and includes water, wastewater, and flood protection capital-related spending from issuance of bonds and federal and state cost sharing. It should be clearly noted that the preponderance of the infrastructure financing in Texas is borne by local governments.

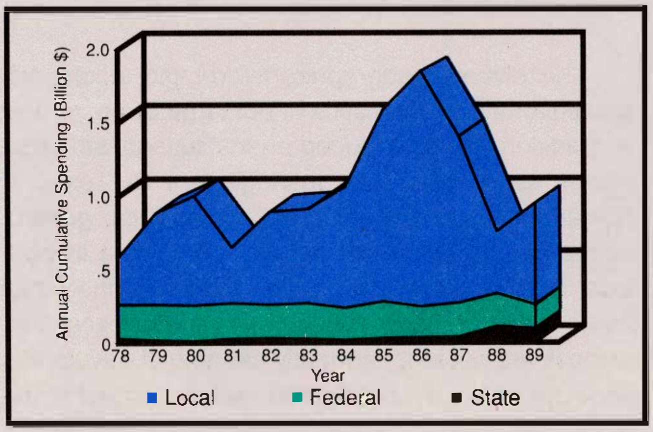


FIGURE 2-1
HISTORICAL SPENDING FOR PUBLICLY-FINANCED WATER, WASTEWATER, AND FLOOD PROTECTION PROJECTS IN TEXAS, 1978-1989

Passage of the federal Tax Reform Act of 1986 has severely limited the State's ability to finance new infrastructure even though Texas voters had approved expanded State financing authority in 1985. The impacts of the Tax Reform Act and the State's economic downturn on water-related facility investment are evident in the levels of water-related infrastructure spending shown above in years 1986 through 1988.

A second area of federal activity that has limited State initiative, i.e. federal involvement in water management, is illustrated by the Federal Energy Regulatory Commission's (FERC) refusal as a part of hydropower licensing to accept and use official state water plans that do not meet FERC-established requirements. Also, the U.S. Supreme Court has allowed FERC to preempt state's water rights.

Most coordination and cooperation between the State agencies with water management responsibility occurs informally rather than through established agreements. This fragmented arrangement has developed, in part, because of contradictory or conflicting statutory assignments; the proliferation of narrow, special-purpose water legislation; and the lack of a clearly articulated strategy for integrating water policy goals and processes with other important State objectives.

The diverse geographic, hydrologic, economic, and cultural characteristics of our large State, as well as tradition, have produced an institutional structure where water resources management in Texas is primarily a local responsibility. While local governments should and does actively participate in both local and broader-scale water planning, individual levels of government, whether federal, state, regional, or local, are not independently capable of developing and executing a coordinated water policy for the State. As State and local planning processes continue to evolve and improve, the Water Plan should provide an ideal mechanism for identifying and reporting on public and private roles that will foster beneficial cooperation and help result in the emergence of a broadly supported comprehensive and consistent water management program for the State.

Water Rights

Texas' legislature and courts have determined that the State of Texas owns, in trust for every citizen, all surface water in defined water courses in the State. Since the 1967 Water Rights Adjudication Act, anyone desiring to reserve permission to use the State's water must apply in writing to the Texas Water Commission. A regular permit for the right to use surface water may be granted by the Commission only if a beneficial use of water is contemplated, existing surface water rights are not impaired, unappropriated water is available, water conservation is practiced, and the surface water right is not detrimental to public welfare. Existing Texas law does not establish a similar permitted use system for ground water in the State.

Surface water rights information must be considered in all water planning to safeguard previously approved Certificates of Adjudication and permits to use surface water. In formulating the amended Water Plan, the following tenets have been recognized:

- The Plan will not interfere with vested surface water rights under existing adjudicated certificates, water rights permits, or international or interstate compacts;
- For planning purposes, intrabasin needs for all beneficial purposes within the foreseeable 50-year planning period that can be met with supplies that are economically and technically feasible to develop will have priority over exportation for out-of-basin needs;
- Surface water temporarily surplus to intrabasin requirements and existing rights will be conserved and exported to meet out-of-basin requirements only under a valid permit and contractual agreement;
- Surface water rights for any new project will be obtained by fully complying with the rules and procedures of the Texas Water Commission.
- the type of use recognized under a permit may be changed through amendment of the permit at some future time as water needs change.

A projection of increased ground-water management was also incorporated into the Water Plan forecasts. In problem areas, future ground-water supply availability was limited to the "perennial yield" or the annual recharge quantity of the aquifer supply. In areas where withdrawals from the aquifer in excess of the annual recharge were not expected to cause deleterious side-effects (such as subsidence, cessation of springflow, or harm to other aquifer users or the aquifer), "mining" of aquifer supplies was used.

Environmental Regulations

Applicable major federal and state regulations were considered for new water supply projects in the Water Plan, including regulations related to protection of water quality, threatened and endangered species and critical habitats, and sites of historical importance. Assessment of the physical features and environmental resources of alternative major project sites in the updated Water Plan was conducted on a "reconnaissance-level" basis.

The results of additional interagency field investigations of potential reservoirs sites are planned for consideration and inclusion in the next update of the Water Plan. Once specific projects are considered for implementation, additional environmental studies must be performed to provide the detailed site-specific data needed to allow the adequate assessment and consideration of full environmental impacts of the proposed projects.

PLANNING CONCEPTS

Planning Horizon and Study Areas

To comply with Section 16.052 of the Texas Water Code, the planning horizon or study period for the amended Water Plan is designated as the 50-year period, 1990 to 2040, with forecasts developed for each ten-year increment within the overall study period. This provision of the Water Code stipulates that, except on a temporary basis, no plan shall be prepared which contemplates the removal of surface water from a river basin of origin if the water will be required to meet the reasonably foreseeable water requirements within the basin of origin during the 50-year period.

In accordance with Section 16.051 of the Texas Water Code, each basin has been designated as a separate planning area for the purpose of calculating in-basin supplies and demands over the designated 50-year planning horizon. In addition to these legal directives, the amended Water Plan also uses eight geographic regions of the State to facilitate presentation of regional and local information.

The Board is currently undertaking the formulation of new regional study area boundary definitions and associated data development which will better reflect the physiographic, climatological, geohydrologic, economic, and other factors affecting the particular water supplies, uses, needs, institutions, and appropriate management techniques for the different parts of the State. It is anticipated that these new regional delineations will form the primary basis for the presentation of data and evaluation for the 1992 Water Plan update with more detailed information presented for individual cities, towns, and larger utility districts. Supplemental information will be also presented at a resource-unit level for each river basin and aquifer.

Demand Forecasting

For this Water Plan update, population and water use projections were developed for two alternative growth scenarios representing high and low series water demand forecasts. These growth-related alternative water demand forecasts were then assessed for without- and with-conservation scenarios.

Population projections were developed using a cohort-survival model that projects births and deaths and net migration. The high series forecast reflects the higher levels of migration experienced during the rapid economic expansion over the last twenty-year period, and the low series forecast reflects lower levels of migration experienced on the average during the previous thirty-year period.

Municipal (residential and commercial) water use requirements were based on projected population and per capita water use. Data reported by suppliers of municipal and commercial water provided the necessary information to compute historical per capita water use for Texas counties and major cities. Per capita water use for the high series forecast considers the highest recorded per capita water use for each supplier and represents demands during periods of below average rainfall conditions. The low series forecast reflects per capita water use representative of average rainfall conditions.

Projections for implementation of municipal water conservation techniques were made for the Board's "with conservation" scenarios. In these scenarios, the implementation of water efficient programs and practices is projected to reduce municipal per capita water use by 2-1/2 percent by the year 1990, 7-1/2 percent by 2000, 12-1/2 percent by 2010, and 15 percent savings by the year 2020.

Manufacturing water use was estimated using national and statewide growth outlooks developed for each industrial category in the State, historical water use, known facility expansions or construction, the industrial base of each county, and potential savings through recirculation and improved water use technology. Based on the different sets of potential growth patterns, high and low series of future manufacturing water use were developed for each industry.

Steam-electric power generation future water needs are based upon forecasts of power demands, fuel sources used for generation, cooling technology, and plans for expanding power generating capacity identified by the industry. The high and low series are based upon high and low series projected population and industrial growth reflected in future residential, industrial, and other power demands.

Mining water requirements were based on water use coefficients. These coefficients are representative of each type of mining operation in the State, historical national and state trends in mineral production, and reflects substitutions of mineral fuels for energy production.

Irrigated agriculture water requirements depend on the acreage currently in irrigated production, the current water usage per acre, water costs, and the availability of water supplies. Projections of irrigation water needs reflect quantities of water associated with typical Texas irrigated farming operations, including regional water supplies and cropping patterns.

Given the dramatic and continuing decline in irrigated acreage (between 1985 and 1989 irrigated acreage fell by about 670,000 acres) due to varying levels of demand for farm products, federal farm programs, increasing scarcity and higher cost of water, and other farm economic variables, high and low series irrigation water use projections were developed based on varying determinations of irrigated acreages.

Farmland irrigated in 1985 totaled 6.75 million acres. In the year 2040, the low case forecast predicts 4.71 million acres in irrigated production while the high case forecast reflects 5.82 million irrigated acres. A projection of 20 percent increased water use efficiency per acre, resulting from adoption of improved management and water conservation procedures, was made for both projection scenarios. Water conservation by agriculture can provide significant savings in water use and extend the use of limited ground-water supplies in problem areas.

Livestock water use rates for the different classes of livestock were developed using animal nutrition data to determine daily water requirements and livestock census information. Water use rates and forecasts of livestock production provided the basis for estimating future livestock watering needs.

Coordination of the Board's preliminary population and water demand projections was conducted with the public in each regional planning area of the State with the help of the 24 regional Councils of Governments of Texas. This provided substantial opportunities for municipalities, utilities, and citizens to provide comment on the forecasts. Local comments were reviewed, and the projections were modified where appropriate.

Supply Forecasting

The allocation of future water demands to available supplies was first analyzed at the city and county levels. Water supplies used included existing or under-construction reservoirs, locally available ground water, and projected municipal and industrial return flows. When these supplies were not sufficient, the best source which could be developed to provide additional supplies was identified considering potential availability and sponsorship and likely cost of supplies, and those new sources of water were allocated to those demand centers needing additional future supplies.

Ground Water. The estimate of the ground-water supply capability of each area of the State was based on the determination that some form of ground-water management program would be instituted in each area of the State where it was prudent to do so. In areas where natural recharge of the aquifer is significant and in some areas where it is currently believed that ground water can be "mined" from storage without causing harm to the aquifer or users, ground-water supplies were allocated on a "safe-yield" basis. In parts of West Texas and in the High Plains, where natural recharge to aquifers is negligible and ground-water "mining" or withdrawals in excess of natural recharge is necessary and practical, ground water was presumed to be "mined" at a decreasing annual rate according to the hydrologic capabilities of the aquifers.

Both existing and projected ground-water supplies were utilized in many cases in conjunction with surface water supplies and facilities, particularly where such coordinated operation of water supply facilities would be expected to lower the cost of providing adequate water supplies.

The Board, in coordination with ground-water districts and other local ground-water interests, is initiating efforts to update its information related to ground water in storage, natural rates of recharge, and appropriate best management techniques for use in the Board's on-going state water planning process.

Surface Water. Water availability from all major existing or under-construction reservoirs was calculated based on either the defined firm annual yield (which is the maximum quantity of water that can be withdrawn from a reservoir each year, on a dependable basis, during a repetition of the most critical drought of record) or the supplies that could be developed under the operating mode of the supply source during drought conditions. For reservoirs without an adequate sedimentation pool, firm yield or available supply was adjusted downward over time as the specific case warranted.

The volume of surface water supplies projected to be available for beneficial use includes the firm annual yield of reservoirs, direct runoff of rainfall, and springflow during the worst year of the critical drought. The available supply from a reservoir that was used in the analysis was the smaller of the calculated yield or the water rights issued for the reservoir. Return flows, defined as discharges into rivers and streams from municipal and industrial wastewater treatment plants and industrial recirculation facilities, were also used as surface water supply sources, where appropriate.

Provisions of international and interstate water compacts, water supply contracts and surface water permits issued by the Texas Water Commission were reviewed and used as guides for allocating supplies to demands. It was predicted that contract owners would act as regional water suppliers. The provisions of existing permits establishing specific limits for specific types of use (i.e., municipal, industrial, irrigation, etc.) were not rigidly followed since such limits could be changed in the future through permit amendments. This planning consideration allowed unused water to be made available to those in need.

Facility Needs Methodology

Various types of water, wastewater, and flood protection needs for the State were estimated, using a variety of methods and sources of data (see following inset). Statewide, regional, and county water-related facility needs estimates are presented in the following Sections of the Plan, categorized broadly as follows:

Category	Sources of Data
Major Reservoirs, Chloride Control, and Water Conveyance Projects	A, B, F
Individual Water System Facilities	D, F
Wastewater System Facilities	C
Identified Flood Protection Facilities	E

Estimates were prepared to achieve a level of accuracy adequate for long range water resource planning at the state level, using data sources and methods shown in the inset, and are not generally intended to accurately reflect costs for individual utility needs. A process to define statewide water facility requirements by working with individual utilities to develop local and regional needs is underway.

Key to Data Sources

A. Update previous estimates with cost indices.
B. Planning level cost estimates using average cost curves and approximate quantities and routes.
C. Existing estimates from the wastewater needs survey.
D. Average costs derived from computer analysis of over 2,400 publicly owned water system inventories, future projected populations and deficiencies.
E. Cost estimates for flood control projects from Corps of Engineers and TWDB-sponsored studies.
F. Capital improvement plans of individual larger utilities.

Facility Planning Major Assumptions

1. Current wastewater discharge permit limits, stream standards and waste load evaluations.
2. Texas Department of Health design standards for water systems.
3. Implementation of approved regional planning studies, and capital improvement programs.
4. Texas Water Development Board high series population projections
5. Conservation will reduce municipal per capita water use 15 percent by 2020

As examples of the final products of this program, facility plan summaries for two selected communities are included in Appendix A of this report. The Board prepared the plans after meeting with individual utility operators. Data from these plans will be entered into a database which will be available for future revisions of the Water Plan. Technical assistance will be provided to eligible local utilities to help identify opportunities for cost savings through regionalization, new technologies and program measures, and improved management techniques. This interaction will provide information on the ability of local utilities to finance needed programs and produce better estimates of the magnitude of unmet funding needs. The Board can then more accurately forecast the need for assistance from the Water Development, Water Assistance, and State Revolving Loan Funds.

Reconciling Water Demands and Supplies

In addition to various legal and regulatory constraints, planning techniques, and standard methods, attention was also given to assorted water demand and supply management techniques to use water more effectively, as outlined below.

Water Conservation

Water conservation will play a key role in the future of water management in Texas. The more efficient use of water is essential if Texans are to have adequate, clean, and affordable water in the future. The total dependable yield of the State's conventional ground and surface water resources is currently about 16 million acre feet per year. Even if all identified potential reservoir sites are built, this yield can be increased by only an additional four to five million acre feet per year. This means that Texas' conventional fresh water supplies are already 75 to 80 percent developed.

With limited future water supplies and a growing State population and economy, it is essential, as a part of prudent planning, to estimate the potential savings that are possible through reasonable water conservation practices and to conservatively incorporate these savings into the State's projected water use and facility needs assessment. However, water conservation must first be defined as to the context used in the Plan, that is, *the more efficient use of water*, not the rationing or limiting of water use as is sometimes required during droughts. Examples of water conservation practices would include the use of water-efficient irrigation equipment and practices on farms, the use of water-saving plumbing fixtures in the home, and the detection and repair of leaks in a water conveyance system such as a pipeline or canal. By contrast, water rationing, such as restricting the time or day when one can water their lawn, is an emergency demand management technique and not a conservation technique.

Currently, the three major categories of water use in Texas are farm irrigation, municipal, and manufacturing. All three major water demand sectors offer substantial opportunities for improving water use efficiencies.

Agricultural Irrigation. The potential benefit of water conservation is most dramatically demonstrated in farm irrigation. While canal lining and other improvements to agricultural water transmission systems (which in some cases now lose one-third to one-half of water pumped due to leaks, seepage, and evapotranspiration) can avoid substantial water loss, the biggest water savings in the agricultural sector in the foreseeable future will be achieved through the application of five major on-farm irrigation water conservation practices.

These five practices include: (1) Low Energy Precision Application (LEPA) sprinklers, (2) surge flow furrow irrigation valves, (3) drip irrigation , (4) soil moisture measurement, and (5) the use of on farm, underground water distribution pipelines. Each of these is described in more detail below.

- Low Energy Precision Application Sprinklers: Low Energy Precision Application (LEPA) sprinkler systems would improve on farm water use by 20 to 25 percent at cost effective rates. Unlike conventional high pressure spray sprinkler systems, a LEPA system conserves water by distributing the water at low pressure directly to the furrow through drop tubes. Conversion of existing center pivot systems costs about $5,000 to $7,000 per system with a savings payback period of three to five years, while installation of a LEPA system to replace a current furrow system would cost about $40,000 to $60,000 per quarter section (130 acres) with a savings payback of five to seven years. As much as 2.0 million acres in Texas that now uses conventional systems could be converted to LEPA systems. Farm operators and underground water conservation districts in the High Plains and other areas of Texas have demonstrated this technology with great success, in part with financial assistance from the State of Texas. Provision of State financial assistance in the form of low interest loans to promote agricultural water conservation has been hampered in recent years by provisions of the federal Tax Reform Act of 1986 which removed the tax-exempt bonding status from the State-backed bonds supporting this program.

- Surge Flow Irrigation Systems. Surge flow systems control the flow of water in a furrow irrigation system with a valve so that the water travels down the furrow in surges. This technique can reduce tail-water runoff and more evenly distribute water in the furrow so that water is not wasted. Improvements in water use efficiency of 15 to 20 percent are commonly achievable with this technique. Surge systems cost about $1,500 per unit which will serve 80 to 100 acres. A pay back period of one to three years is common with this system.

- Drip Irrigation. Drip irrigation conserves water by applying water directly to individual plants through flexible tubing equipped with built-in or attached emitters, thus controlling runoff and evaporation. Drip irrigation is limited in application but where applicable, it can reduce water use by 20 to 30 percent. Currently, over 40,000 acres are irrigated with drip systems. Installation costs can exceed $1,000 per acre.

- Soil Moisture Measurement. The scheduling of when to irrigate can be greatly improved through the use of a multitude of instruments that are available on the market. Soil moisture measurement, which is one of the most simple and least expensive water conservation techniques, could be used on over five million acres currently under irrigation. This technique often has a one year pay-back period.

- Underground Pipelines. Many farms are still served by on- and off-farm earthen canals. These can loose much of their water through seepage and evaporation. The installation of underground pipelines can reduce this loss by 20 to 30 percent, and have a pay back of five to seven years depending of the location of the system and the cost of the water. Underground pipelines currently serve about 4.8 million acres, but could be installed on much of the remaining 1.3 million acres.

Critical to the successful implementation of agricultural conservation efforts will be the education and technology transfer programs necessary to convey the potential benefits, costs, financing alternatives, operational techniques and performance, etc. to the State's farm community. The Texas Agricultural Extension Service, the Texas State Soil and Water Conservation Board and soil and water conservation districts, the U.S. Department of Agriculture, U.S. Soil Conservation Service, the Texas Water Development Board, and many of the underground water conservation districts, river authorities, and others have active education and outreach programs to promote agricultural water conservation practices. Continued and expanded funding of these agency efforts, as well as provision of viable financing assistance to farmers in purchasing this equipment, is key to achieving significant water conservation savings possible in the irrigated agriculture sector.

In the agricultural farm irrigation sector, the Board's water demand forecasting evaluations were developed separately for each irrigation area in the state, based on regional irrigation practices, conditions, and levels of possible conservation activities. As a result of reduced irrigated acreage and an increase in water use efficiency per acre, annual water use for irrigation (which was 12.7 million acre-feet in 1980) is predicted to decrease to between 6.2 and 7.6 million acre-feet by the year 2000 and to between 5.0 and 6.7 million acre-feet by 2040.

Perhaps as much as 500,000 acre-feet per year of additional water savings are also possible through canal lining and other improvements to agricultural water transmission systems. In some cases, these losses account for one-third to one-half of water pumped due to leaks, seepage, and evapotranspiration.

Municipal. Water uses for municipal (residential, commercial, and institutional) and manufacturing purposes are the most rapidly growing and costly demands being placed on the State's limited water resources. Municipal and manufacturing uses, in many cases, not only strain limited supplies, but require the building and operation of expensive water and wastewater facilities.

Urban and rural municipal water use currently averages 165 gallons per person per day. However, a significant portion of this water is often lost in transmission and distribution. A recent study found that the average utility in Texas cannot account for 15 to 20 percent of the water it treats and distributes. It is estimated that about one-half of this loss is from leaks in distribution systems. Yet with proper water auditing techniques and modern electronic leak detection equipment, many Texas utilities have reduced unaccounted-for water to between five and ten percent.

Utility customers also often waste much water. In Texas, the *extra* water used in seasonal hot weather (primarily for landscape irrigation) averages about one-quarter of total volume of annual municipal water use. However, some researchers estimate that as much as one-half of outdoor watering use is not needed to maintain a healthy, well-kept lawn, but instead is wasted through over-watering or improper watering practices. Utilizing proper landscape management techniques and/or use of low water-using landscaping plants (Xeriscaping) can dramatically improve water use efficiencies in outdoor urban water uses.

Inside the home, about three-quarters of all water use occurs in the bathroom. In office buildings, schools, and public buildings, toilet flushing is also the predominant water use. Yet there are toilets available today that use 1.6 gallons of water per flush, as compared to the 3.5 to 8.0 gallons per flush toilets in common use in the State of Texas today.

If 1.6 gallon flush toilets were in universal use in Texas today, statewide water savings would be almost 200 million gallons per day for which utility customers pay some $200 million per year in water and wastewater bills. If low-flush toilet standards were put into effect in the near future, it would take about 40 years to replace most existing toilets, but it could save as much as 300 million gallons of water per day by that time. Further, lowering showerhead flow rates to 2.5 gallons per minute, (instead of the current standard of three to eight gallons per minute) would significantly reduce water and energy use and wastewater discharge.

In the municipal water demand projections, water use efficiencies were incorporated into the Board's forecasts by estimating a percent reduction in per capita water use. In this context, it is essential to note that the projected reduction in per capita water use is in no way intended to be used to set mandatory targets or regulatory limits for utilities. Instead, a numerical percentage reduction in water use was developed only because of the need to quantify water use efficiency considerations in the municipal water demand forecasts.

As summarized in the inset box, the Board considered several methodological and impact factors in the development of its municipal per capita water use forecasts, including historical trends in per capita water use for municipalities; potential effectiveness of water conservation practices on a regional basis; existing local water use patterns and previous conservation efforts; potential effects of reduced per capita water use on utility finances; and potential effects of conservation on future major water supply and other water-related facility needs.

Tenets of Board Conservation Planning Forecasts

- ★ Evaluate potential conservation measures based on implementable, workable, and cost-effective technologies and programs.
- ★ Identify reasonably achievable water conservation savings goals to be used in the municipal, manufacturing, and irrigation water use forecasts.
- ★ Promote conservation practices and programs to acheive savings rather than numerical regulatory targets for utilities.

★ Historical Trends. Following World War II, state-wide average municipal per capita water use increased from about 100 gallons per capita per day (gpcd) to levels slightly above 182 gpcd by the mid-1970s. Subsequent to then, average per capita use in the State had leveled out and actually begun to decline. For example, per capita use in Texas municipalities in 1978 averaged about 178 gpcd. By 1987, average statewide municipal per capita consumption had fallen to about 170 gpcd, exhibiting a general declining trend over the ten-year period, as illustrated in Figure 2-2.

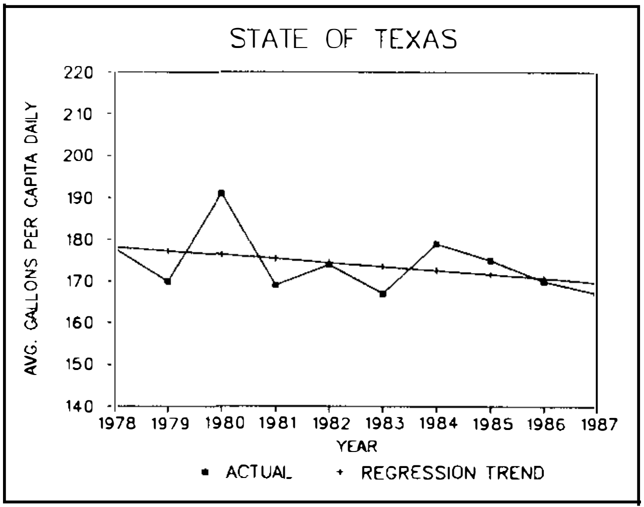


FIGURE 2-2
TRENDS IN MUNICIPAL PER CAPITA WATER USE
STATE OF TEXAS, 1978-1987

★ Regional Variations. The potential for municipal water conservation to reduce per capita water use was examined for each of the eight planning region of the state. Since outdoor water use varies significantly from one region of the State to another, ten years of monthly municipal water use data for each city in Texas of 1,000 population or more were analyzed to determine what percent of annual municipal use was above winter use rates.

Seasonal (hot weather) water use was calculated as that amount of water in excess of what would be used in a year if low winter consumption occurred year-around. For the period from 1976 to 1985, average seasonal use varied form 5 percent or less in far East Texas to 40 percent of total annual use in some areas of far West Texas. In developing the estimates of savings due to water conservation, it was estimated that seasonal water use would be reduced by 10 to 15 percent. For indoor water use, it was estimated that new advanced plumbing fixtures standards and water saving appliances would reduce per capita water use by 24 gallons per person per day by the year 2020. This includes the projection that 90 percent of existing toilets (water closets) will be replaced and all new toilets will meet the 1.6 gallon per flush standard by 2020 and that all showerheads and faucet aerators would meet similar standards. It was also projected that per capita water use would be reduced by another 5 to 6 percent on the average by other means including water audits and leak repair programs of distribution systems, changes in water use habits, and non-plumbing related commercial and institutional conservation practices.

Table 2-1 indicates an estimated 20 to 22 percent reduction in municipal per capita water use is possible in all eight planning regions of the state. It is also important to note that these projected savings are based on the highest municipal per capita water use figures for each region recorded by the Board for the period from 1976 through 1985.

TABLE 2-1
POTENTIAL REDUCTION IN PER CAPITA WATER
USE DUE TO WATER CONSERVATION

Geographic Region	High Case Per Capita Water Use in Gallons Daily (a)	Potential Percent Reduction in High Case Per Capita Water Use Due to Water Conservation Practices by Year 2020			
		Plumbing (b)	Outside Home (c)	Other (d)	Total
High Plains & Trans-Pecos	201	11.9%	4.5%	5.4%	21.8%
West Central Texas	194	12.4%	4.1%	5.2%	21.7%
North Texas	195	12.3%	3.6%	5.2%	21.1%
Northeast Texas	181	13.2%	3.1%	5.4%	21.7%
Southeast Texas/Upper Gulf	177	13.5%	1.8%	5.6%	20.9%
South Texas/Lower Gulf	195	12.3%	3.8%	5.0%	21.1%
South Central Texas	211	11.4%	3.9%	5.3%	20.6%
Upper Rio Grande/Far West Tx.	196	12.2%	4.7%	5.4%	22.3%
State of Texas	191	12.6%	3.2%	5.4%	21.2%

(a). Highest regional per capita water use figure recorded for the period from 1976 through 1987.
(b). Considers use of advanced plumbing fixtures and appliances in future construction and in replacement of existing fixtures and appliances.
(c). These figures reflect a 10 percent to 15 percent reduction in outdoor water use. Some experts place this figure at 20-30 percent.
(d). Includes reduction in distribution system leak loss and other commercial and institutional water conser ation practices not affected by improved plumbing standards.

★ Consideration of Local Conditions and Past Municipal Conservation Activities. The consideration of variations in local water use patterns and previous water conservation practices is important in developing a viable forecast of what reasonable levels of future conservation are possible. When developing the municipal water use projections, the Board utilized the highest recorded per capita water use value for each individual municipality for the period from 1976 through 1985. This is reflected in Table 2-1 on a regional basis.

The reason for using the recent historical high municipal per capita water use rate for each individual utility was three-fold. First, the use of each municipal entity's highest per capita use rate during this period allowed for regional or local variations due to changing climatic conditions and water use patterns and considered each individual utility's high-level water use during hot, dry weather conditions. Secondly, the highest per capita statistic used for many Texas municipalities in the Board's forecasts was from 1980 and was prior to the implementation of any significant, effective municipal conservation programs by Texas cities. Third, by using the period between 1976 and 1985 before *any* utility in the State had passed new water conserving plumbing fixtures standards (including the 1.6 gallon per flush toilet), it reflects per capita use prior to the institution of major multi-component water conservation programs in Texas.

Thus, the Board's selected forecasting technique for modeling potential future conservation savings, in effect, allows credit for local variations in water use patterns as well as municipal water conservation programs that have been previously implemented.

★ Financial and Other Considerations. Another important aspect that was considered in developing the Board's municipal water conservation forecasts is the potential financial effects upon the utility and its customers. Financial benefits of an effective municipal water conservation include: in both the near- and long-term, the ability to reduce utility and home operating expenses through energy and materials savings as a result of reduction in treating, pumping, and heating volumes of water and wastewater; and over the long-term, the ability to reduce, defer, or eliminate significant new capital expenditures for facility capacity.

A concern voiced over municipal water conservation measures is the potential for financial impact upon utility revenues from possible sudden, reduced utility (volume) sales when the fixed costs of the utility have to be met regardless of sales. Phasing-in or staging conservation programs and practices (so that the utility customer base increases at a faster rate than does the effects of reduced per customer usage) will likely address those concerns. The implementation of water-saving plumbing fixtures standards, which account for up to 80 percent of the phased-in municipal savings identified in this Plan, would take some 30 years or more to have full effect. Most other conservation measures would also take time to have full effect.

The population of the State of Texas is projected to double in the next 50 years, and the number of water and wastewater utility customers will, in all likelihood, grow faster than the effect that any new conservation program might have in reducing utility sales. This customer base growth would tend to offset any potential reduction in utility revenue, and when coupled with near-term reduction in operating costs and lessened capital spending in the longer-term, the most likely consequence of effective water conservation programs will be reduced customer utility bills for water, sewer, and energy services.

The benefits of the type of water conservation measures discussed here are multi-fold. As stated at the beginning of this section, an important and obvious benefit is the conservation of the state's limited and precious water supplies for future use by both man and the environment. Another key benefit of water conservation is that the number of environmentally sensitive major reservoirs and other large water projects to be built is reduced or deferred while the State's full water needs are met through better demand management. Still another, and often overlooked benefit, is the impact that municipal water conservation will have on the volumes of wastewater that must be treated and the corresponding need to build expensive wastewater treatment facilities.

The types of measures being discussed do not involve the use of rationing or other methods which could potentially reduce the standard of living. If using water more efficiently will save Texans money, water, and energy, and also help preserve the natural environment, it is very likely to improve our overall standard of living.

★ Forecasting and Sensitivity Analysis Considerations. Based on the previous factors, water conservation would achieve a statewide reduction in high per capita municipal water use of approximately 21 percent (see Table 2-1). Reductions as high as 30 percent are possible given the proper time and conditions for the types of measures discussed. A conservative modeling approach, that per capita water use would be reduced by 15 percent by the year 2020, was used to incorporate water conservation into the water use projections developed for this Water Plan.

This methodology is flexible in giving credit for existing conservation efforts and for variations in the effectiveness of future programs. Because the calculated differences in percent savings for the eight planning regions varied by no more than 5 percent from the State average (see Table 2-1), the 15 percent savings was held constant for all regions, but was not assumed to be fully implemented until 2020. Hence, for the projections of municipal per capita use, a uniform reduction in per capita use of 2 1/2 percent by 1990, 7 1/2 percent by 2000, 12 1/2 percent by 2010, and 15 percent by 2020 were used for all areas of the State. In evaluating regulatory or loan applications, the climatological, physiographic, and socioeconomic characteristics of the area in which the utility is located should be taken into account.

The impact of just a 15 percent reduction in municipal per capita water use is dramatic. By 2000, with only a 7-1/2 percent reduction, approximately 100,000 acre-feet per year would be saved, but with the increase in population and the achievement of the full 15 percent reduction in per capita by 2020, the savings grow dramatically to over 1.1 million acre-feet by 2040.

A set of demand projections and facilities needs forecasts, based on no new municipal conservation savings were also developed to use as a sensitivity analysis comparison to the recommended 15 percent savings scenario to help determine what effect realized conservation savings would have on the State's future infrastructure costs, and to provide planning flexibility in identifying any additional new reservoirs if the Board's "with conservation" demand projections are actually exceeded by Texas municipalities, as these projects can take from 10 to 30 years or more to implement (see Figure 3-9 and Table 3-1 for a comparison of the alternative forecasts).

Manufacturing. In response to the high costs to treat wastewater, rising water and energy costs, and other environmental considerations, many industries use water more efficiently today than they did even a decade ago. However, the potential exists to increase water use efficiency in the industrial sector even more. Specific areas where additional savings are possible include:

- Process modification or substitution
- Cooling water conservation including:
  - use of saline water or treated wastewater,
  - air cooling,
  - using recirculating cooling systems, and
  - proper cooling system operation to increase cycles of concentration.

- Steam and hot water conservation including:
  * substituting direct fired heaters and electric heat for steam and hot water,
  * energy conservation,
  * waste heat recovery,
  * modern process control, and
  * good maintenance.

In addition, conservation practices common to the residential/commercial sectors are often applicable in industry, and the Board's forecast of manufacturing water use also included consideration of these as well. Increased water use efficiency is projected to reduce manufacturing water use some 400,000 acre-feet per year lower by the year 2040 than would be the case in the Board's without conservation forecast.

Thus, the more efficient use of water through water conservation can have a significant, very positive, role to play in the future management of the state's precious water resources. However, the conservation programs and techniques discussed in this Plan, as well as other methods such as conservation-oriented utility rate structures, must be put into effective practice if the full magnitude of these benefits are to be realized.

Water Reuse

Reuse of treated effluent also holds significant potential for meeting future water needs. Texas utilities and manufacturers currently discharge about 2.5 million acre-feet per year, and are projected to increase these discharges to more than 3.8 million acre-feet by 2040. Currently, only about four to five percent of treated municipal effluent and less than one percent of industrial effluent is reused for various purposes, including industrial water supply, landscape and agricultural irrigation, direct recharge of drinking water aquifers, and aesthetic and environmental uses. In the context used by the Board, reuse is defined as the utilization of effluent water prior to discharge into a stream or river and is separately defined from that of use of return flows that have already been discharged a receiving waterbody.

The opportunities for reuse are extensive. Even with modest, conventional reuse practices, another 300,000 acre-feet of effluent could be reused by 2020, and reuse could exceed 1.4 million acre-feet per year by 2040 under the Board's most optimistic predictions. In several urban areas in Texas, water reuse was incorporated as a partial means of meeting area water needs in the 50-year planning period. This resulted in approximately 560,000 acre-feet per year of reuse by 2040. As with most all actions, there are corresponding potential effects that must be considered. Extensive reuse and consumption of water during reuse could remove water from Texas water bodies that were previously present as return flows. Case-by-case consideration should be given to the effects of substantial reuse on downstream water rights and environmental needs. In the situation of environmental water needs, it may be the case that reuse, although reducing return flows, may benefit the downstream environment by not drawing on higher quality water supplies still in the river or stream.

Water Quality Protection and Enhancement

Various scenarios regarding water quality were considered and, where feasible at this time, incorporated into water availability and supply allocations. Chloride removal and salt water barrier projects were projected to be completed as soon as possible on the upper Canadian, Brazos, and Red rivers and lower Trinity and Neches rivers, respectively. Projected wastewater treatment volumes, effluent, and stream water quality were considered from the Board's wastewater needs survey, and various TWC stream segment reports. While not considered explicitly, the Board recognizes the value of riverine and coastal wetlands processes in improving water quality.

A detailed assessment of the effects of the Safe Drinking Water Act on supply availability was not performed. However, ground-water sources with iron, fluoride, and radon levels exceeding Safe Drinking Water Act requirements were shifted to surface water sources in areas where surface water is an alternative. A more comprehensive examination of contaminants in supply sources and technical and economic feasibility of removal of these contaminants should be completed prior to the next update of the Water Plan.

Water Supply Yield Enhancement

Artificially recharging aquifers can increase the supply of usable ground water in some areas. Although State rules must be met, this water supply has proven to be feasible, as shown by the City of El Paso's innovative project to store treated effluent in the Hueco Bolson geologic formation. On-going studies are examining the feasibility of aquifer recharge on the High Plains through the use of playa lakes. The capture and retention of flood waters or use of any excess water in storage could also provide water supplies for aquifer recharge. The capture and retention of rainfall in the soil profile through grading and terracing of fields, as well as the use of pits and ditches cut into porous soil profile, can also be used to recharge aquifers and enhance streamflow quality.

Additional quantities of fresh water may be obtained from aquifers that are only partially saturated. Capillary water is water which occurs between the water table and land surface, but which cannot flow into a well under gravitational force alone due to capillary action. Previous studies indicate that the quantity of capillary water in storage in the dewatered section of wet sand/gravel zones of the Ogallala Formation is almost equal to the quantity of ground water which can be removed by gravity drainage. Preliminary secondary recovery tests, using air injection to overcome the capillary force, appears to be promising, although additional studies are needed.

Coordinated reservoir operations can increase yields by reducing surface evaporation, capturing flood flows normally lost as spills, or reducing streambank losses. Although changes may be needed in water rights permits, reservoir system operations can be managed, as evidenced by the Amistad-Falcon Reservoirs systems operation on the Rio Grande.

Efforts to artificially induce or increase precipitation with the use of silver iodide, dry ice, and other means may have potential to increase water supplies in the drier areas of the State. A cloud-seeding project conducted during the 1970s-1980s has been reported by the CRMWD as producing increases in precipitation in the project area compared to neighboring areas in the same years. There is considerable debate over the effectiveness of this technique, and additional research and cost studies are required to appropriately consider weather modification as a viable method of increasing water supplies.

Selective removal of high water use weeds and brush may often provide water for more beneficial purposes. Studies by the Soil Conservation Service and the Texas Agricultural Experiment Station provide preliminary results on techniques and possible water savings. The proposed Statewide Brush Control Plan, to be conducted by the Texas State Soil and Water Conservation Board, would provide a structured means for implementation of feasible approaches for watershed yield enhancement. The TSSWCB has been given authority to provide cost-assistance to landowners for brush management programs, but lack the resources for significant implementation.

Finally, many of the options available for water supply yield enhancement raise questions of potential environmental impact. Reduction of stream flows, changes in weather patterns, and removal of terrestrial habitat might adversely affect environmental values, while protection of springflows, increases in available water for man and the environment, and potential increases in terrestrial habitat with selective brush control might enhance certain environmental values.

Desalinization

The potential for desalting to provide an alternative source of water is significant. Brackish and more highly saline water resources are distributed over wide areas of Texas (see Figures IV-5 through IV-7, Volume 2, 1984 Texas Water Plan). Brackish ground water, containing 1,500-5,000 milligrams per liter (mg/l) of total dissolved solids (TDS), underlie much of the Texas coast, a band east of the Balcones Fault in Central and North Texas, areas around the Llano uplift in Central Texas, and significant areas of the High Plains, Cross Plains and Trans-Pecos areas. Brackish surface water also occurs in the upper Rio Grande, Pecos, Colorado, Brazos, Red, and Canadian basins.

The major desalting techniques used in Texas today are distillation, reverse osmosis (RO), electrodialysis (ED), electrodialysis reversal (EDR), and ion exchange. The membrane processes (RO, ED, and EDR) are expected to be the most rapidly growing and economical future desalt processes. Membranes are very thin films capable of selectively separating suspended materials and organisms and/or dissolved salts and minerals from water. The RO process can be used for feedwaters containing up to 45,000 mg/l TDS, whereas the ED and EDR processes are typically used for feedwater containing 10,000 mg/l TDS or less. Distillation is generally only cost-effective for water containing more than 35,000 mg/l TDS.

Disposal of concentrated brine from these processes is an important consideration. Methods employed range from evaporation ponds, disposal wells, injection for secondary oil recovery, salt gradient solar ponds, recovery of marketable by-products, and discharge to surface streams. The methods must be designed on a site-specific basis and may be a combination of approaches, depending upon local conditions and brine quality. Current unit membrane desalting equipment capital costs (installed) in Texas for *brackish* water systems (raw water with less than 5,000 mg/l of dissolved salts) in the 1 to 10 million gallon per day range are $0.60 to $1.25 per gallon per day of product.

The operations and maintenance costs for desalinization plants of this size normally range from $0.50 to $1.50 per 1,000 gallons of product water. Therefore, total production costs for brackish water membrane systems typically range from $1.00 to $2.50 per 1,000 gallons, assuming no blending and a 90 percent load factor. By contrast, *sea water* desalting by RO typically ranges from about $4.00 to $8.00 per 1,000 gallons. The use of low-pressure membrane softening, split treatment, blending, and energy recovery devices can significantly lower costs in those cases where it is deemed acceptable for the specific application.

Conjunctive Use

In areas where surface or ground-water quality is sufficiently poor and substandard for treatment and potable use, it may be possible to mix those poorer quality supplies with higher quality water from alternate sources to a blended quality level that provides for economic treatment and use, thus increasing the overall availability of usable water supply and avoiding the development of new and costly supply sources. The Colorado River Municipal Water District, in the upper Colorado River Basin, is one of several Texas utilities with an active conjunctive use program, utilizing higher quality ground water for mixing with surface water with high dissolved solids content. Conjunctive use may also provide for more suitable quality feedwaters for desalinization processes as well.

Conjunctive use can also increase water supply availability. Supplies in reservoirs are subject to evaporation, and river flows are dependent on recent rainfall. Ground water does not evaporate as does water in a lake, and is not as dependent on recent rainfall. Conjunctive use programs can involve using surface supplies as much as possible and using ground-water supplies to meet peak demands and when surface water is not available. The Upper Guadalupe Authority is studying storing treated surface water in the ground until it is needed. This would extend surface supplies without the employment of existing surface water treatment facilities.

Water Supply Facility Development

In assessing future supply needs, several considerations were made: in areas that were supplied by ground water, it was determined that once a demand center exceeded one-half of the entity's pumping capacity, the center would need to develop additional supplies; if ground water was available county-wide, then the demand center would remain on ground water; if ground water was limited, it was predicted that water users with centralized systems will move to surface water if available or developable; and areas that had water quality problems or declining water tables were moved to surface water when available.

Demand centers that were on surface water or had contracts for surface water remained on surface water or were shifted to surface water until the availability, contract, or permitted limits were exceeded. Once supply from a source was exceeded, additional surface water, ground-water or reuse were proposed. In considering new reservoir projects, consideration was given to project regionalization, project cost, environmental concerns, delivery cost, inter-basin transfer constraints, and public acceptance of the project. In areas that are under a regulated reduction in ground-water use, demand centers were assigned to the most likely surface water supply that could be developed in the mandatory time frame.

The Board is unable to evaluate every alternative. For some areas, it is expected that another solution exists that will solve the immediate need. Most often, these would be smaller "local" surface water or ground-water projects that would likely only provide short-term relief. Because of the relatively high cost of water from new reservoirs, agricultural water demand was limited to available ground-water supplies or continued use of lower-cost existing surface water supplies. In some cases, projected agricultural water use exceed available supplies and are shown as a shortage, i.e. while farm demand for water would be present (based on the farm economics modeled in the Board's forecasts), sufficient low-cost water supplies to meet that demand would not available.

Water Supply Transfer and Importation

Assessments of future water needs were not limited to nearby supplies or inter-basin transfer of supplies available within Texas. Both in-state and out-of-state supplies were considered, where currently feasible, for import to water deficit areas. Also, where Texas supplies could supplement other states' water needs, those needs were also considered.

Environmental Uses

Few Texans are aware of the vital ecological need for freshwater inflows to coastal bays and estuaries, including transport of sediments, nutrients, and food materials; dilution of Gulf marine waters to form brackish waters in the bays that allows the inhabiting organisms to survive, grow, and reproduce; and periodic estuarine flushing that stimulates the cycling of essential nutrients, dilutes or removes pollutants, and eliminates many predators, parasites, bacteria, and viruses harmful to estuarine populations.

In response to statutory directives for studies on the effects of freshwater inflows, a comprehensive data base and methodology for determining freshwater inflow needs of the bays and estuaries has been developed. Further, as required by statute, five percent of the firm annual yield of any new reservoir projected to be constructed with State financial participation within 200 river miles of the coast was appropriated to Texas Parks and Wildlife Department for releases to protect bay, estuary, and instream uses. Future updates of the Water Plan should include data pertinent to the amounts and timing of freshwater inflows to Texas bays and estuaries. An interagency study on this topic is nearing completion.

Another major area of environmental concern is the provision of adequate instream flows to meet needs of non-consumptive instream uses. Instream uses refers to the use of flowing waters and includes consumptive uses such as livestock watering and non-consumptive uses such as hydroelectric power generation, recreation, and fish and wildlife uses which do not require removal or diversion of water from the river. These uses represent the recognition of the value of the instream presence of flowing waters. Requirements for consideration of effects of new State water permits on streamflow have brought a national controversy to Texas concerning which method is used to determine the amount of flowing water needed to maintain the habitat. The existing federal technique is referred to as the Instream Flow Incremental Methodology (IFIM) and was developed by the U.S. Fish and Wildlife Service in swift coldwater Rocky Mountain trout streams.

However, there is disagreement about whether this method can be appropriately extended to the slow, meandering warmwater streams of Texas and other southern states. Consequently, widely ranging interpretations of IFIM results are causing considerable confusion with regard to permit recommendations. An analytical technique for instream flow assessment in Texas must be specifically applicable to low-gradient, warmwater streams and flexible enough to use in each of the State's ecologically diverse river basins. Board staff have developed a simplified desk-top method for evaluation of streamflow needs. This new method was used in making the Board's preliminary estimates of the instream flow needs associated with future reservoirs recommended in the Water Plan. In addition, the Board's staff are currently developing a sophisticated modeling technique for determining the availability of aquatic habitats for fish and wildlife under various streamflow conditions. This model may also become a valuable addition to methods presently available for determining instream flow needs.

The Board recognizes that these preliminary flow need estimates cannot substitute for site-specific field studies which will be necessary for the detailed permitting of future reservoirs. Nevertheless, the Board's preliminary needs assessment suggest that instream flow releases would range from 5 to 25 percent of firm annual yield of the recommended new reservoir projects. Many of the new reservoirs evaluated have instream releases that amount to about 5 to 8 percent of firm annual yield. Although the Board's new approach to instream flow needs has not been accepted by all affected agencies, it can be a useful planning tool for making preliminary estimates.

Preparation of a drought contingency plan and an reservoir operation optimization are recommended for each proposed reservoir in the Plan. This involves selecting target levels of instream flows for both normal and drought conditions, and using an optimization model to switch from a high reservoir level operating rule to the low flow alternative based on an analysis of the reservoir's probability of going dry during a critical drought period. In practice, this type of reservoir operation provides greater instream flows overall than a simple allocation of a certain reserved percentage of a new reservoir's firm yield supply.

The Texas Parks and Wildlife Department, at its option, may be a party in water permit hearings on applications to store, take, or divert State water. In making its final decision on a permit application, the Texas Water Commission is directed by statute to consider all information presented, including that given by the Department and the Board. In addition, the Commission's staff may also participate in developing flow recommendations to protect environmental resources. As more knowledge about the needs of the living aquatic systems is gained, the nature and specificity of flow recommendations will continue to evolve. Similarly, when streamflows diminish, the importance of reservoir releases will increase.

A third area of major environmental concern related to water development involves the potential impacts on wetland and riparian habitats, as well as the impact of preservation upon water development. Most of the existing mitigation assessment procedures used to determine compensation for environmental resource losses due to the water project construction have been established through broadly based wildlife habitat categorizations set up to meet the national goals of federal agencies. However, national goals are not always identical or responsive to the specific goals and needs of the individual states. Some state-specific methods may be more appropriate, although state and federal agencies should work together to try to reach consensus on common approaches to impact assessment and the determination of mitigation requirements.

For example, the Texas Parks and Wildlife Department has developed a useful procedure, the Wildlife Habitat Appraisal Procedure (WHAP), to allow a holistic evaluation of wildlife habitats in particular tracts of land, but it was not designed to evaluate habitat quality in relation to individually affected wildlife species. When individual species are of paramount importance, the Habitat Evaluation Procedure (HEP), developed by the U.S. Fish and Wildlife Service, is widely recognized and as one of the most useful species-specific assessment technique. Information from the WHAP, the Board's regional planning grant studies, the Board's bay and estuary inflow and instream flow assessment studies, surveys for archeological sites, records on the occurrence of any threatened or endangered species, and other data have been used to make recommendations concerning the environmental soundness of potential reservoir and other facility projects and potential mitigation requirements. Where specific studies of potential reservoir sites have been conducted, information on potential mitigation requirements were evaluated and, in some cases, updated. A review of the U.S. Fish and Wildlife Service's bottomland hardwoods acquisition program in Texas was also made concerning potential conflicts with possible water supply development and possible methods of coordinating objectives for environmental preservation and meeting public water supply needs in the future.

Where no detailed site-specific environmental studies were available, an estimate of 14 percent of project cost was allocated for potential mitigation requirements. This cost estimate only includes allowables for capital and land-related expenses. Additionally, an annuity that would provide for the operation and maintenance expenses associated with mitigation lands might also be included upfront in permit decisions as a "first cost" of future projects.

Other Non-consumptive Water Uses

Water provides a means by which some activities can occur without noticeably altering the quantity of water. Navigation, recreation, and hydroelectric power generation are classified as non-consumptive uses of water resources. Navigation in Texas is concentrated along the Gulf Coast, with the Gulf Intracoastal Waterway being the main transportation artery for waterborne commerce. The waterway connects Texas' 12 deep-water port channels to other Gulf and Atlantic Coast ports. Currently, inland navigation only exists on the most downstream reaches of the Sabine, Neches, Trinity, Brazos, and Colorado Rivers in Texas and the Red River in Arkansas and Louisiana. However, little water is required to be released from reservoirs to maintain adequate navigation depths. Normal streamflow plus reservoir releases for other purposes are expected to satisfy these navigation demands. Other plans for inland navigation have been formulated, but development is not envisioned during the 50-year planning period.

Water-related recreation activities are major consumers of leisure time for Texas residents and visitors. Reservoirs, rivers, and bay and gulf waters provide for fishing, boating, swimming, skiing, and other associated outdoor recreation activities. Recreational demands on the State's surface water resources are expected to be satisfied by existing and future surface water development, continued enhancement of river and stream water quality for recreation and other purposes, and sufficient releases from reservoirs to maintain the recreational and environmental resources of the State. No new demands were placed on water supplies for recreation purposes.

Currently, hydroelectric power generation accounts for less than one percent of the total power generation in Texas. Although water is not consumed in hydroelectric operations, large volumes of water are required for generation. Currently, between 10 to 20 million acre-feet of water annually passes through hydroelectric turbines in Texas. Water requirements for satisfying these needs are expected to be met from existing permitted hydroelectric uses and as a by-product of releases for other purposes. No specific allowance was made for new hydroelectric facilities in determining the firm yields of new reservoirs, although sufficient supplies of water for new generation could also likely be met as a by-product of reservoir releases for other purposes.

3 PLANS TO MEET WATER RESOURCES NEEDS

As charged by Section 16.051 of the Texas Water Code, the Water Plan should provide for the "orderly development and management of water resources in order that sufficient water will be available at a reasonable cost to further the economic development of the entire State."

To meet this directive, the Board has evaluated alternative future scenarios of water use requirements, surface and ground-water supply availability, and potential major facility needs and costs arising from identified infrastructure deficiencies for water, wastewater, and flood protection facilities . The Board's study efforts originated at the local level of analysis, examining individual municipal and rural utility conditions, and then proceeded to the study of river basin, regional, and statewide levels of investigation.

PROJECTED STATEWIDE WATER DEMANDS, SUPPLIES, AND FACILITY NEEDS

The quantity of water used for a variety of purposes by various regions and urban/rural areas of the State of Texas is highly dependent on the demographic, economic, climatological, and water availability features. These factors distinguish each city and region from one another, and when combined provides a summation and overview of the State's total water use and supply.

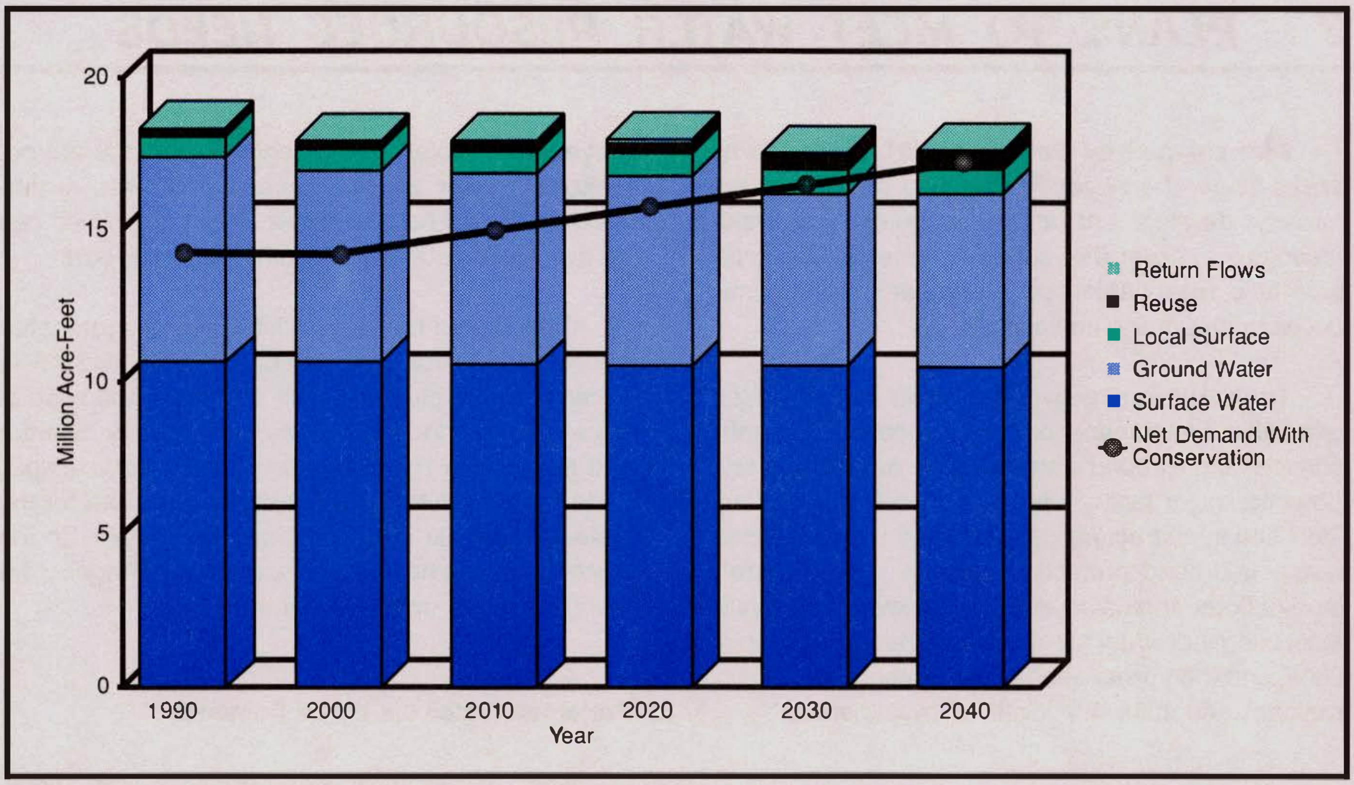
Figure 3-1 presents the projected statewide water demand and supply forecast for the 50-year planning period, 1990 to 2040. With increasing water demand, additional water supplies will be necessary to meet projected water needs. With the potential conservation savings forecast in the Plan and the provision of new surface water supply projects, limited reallocation of existing surface water storage, additional groundwater pumping in selected localized areas, and wastewater reuse and return flow projects, future State water supplies would be sufficient to meet the projected overall water needs of the State in the next 50 years. If projected conservation savings are not realized, further supply sources and other water-related facilities beyond those already identified can be developed, but at significant additional costs.

Care should be taken in interpreting aggregated statewide statistics, while statewide totals may reflect either water surplus or deficit situations, the case at the regional or local level may be markedly different and masked by the statewide trends. For example, while sufficient future supplies were identified for the state as a whole and for almost every entity in the State during the next 50 years, unmet shortages were identified in the upper Rio Grande Basin.

Projected Statewide Water Demands

While recent historical trends of the 1980s, described in Section 1, have indicated either absolute decline or noticeable reductions in the growth rate of major Texas water use sectors, total water use requirements in Texas are projected to increase over the 50-year planning horizon, but to a level less than previous Water Plan forecasts. Because of better information on declining trends in the amount of irrigated acreage and irrigation water use, lowered base population and economic levels and lowered growth rates actually realized in the 1980s, the Board's most recent water use projections reflect less growth in future water requirements than those projections made in the 1984 Water Plan.

Figure 3-2 illustrates the 1984 Plan's statewide water use forecast and the 1990 Plan's most recent statewide projections. The primary factors underlying the difference in the demand projections of the two plans include: (1) a significant reduction in the 1990 Plan's water use forecasts for irrigated agriculture reflective of actual trends experienced in the 1980s, and (2) a lower population and economic base in the 1990 Plan as a result of the significant economic decline experienced in the mid- and later 1980s.



Item	1990	2000	2010	2020	2030	2040
Projected Population (millions)	17.562	20.987	24.498	28.363	32.790	35.621
Projected High Case Demand (With Conservation)						
Municipal	3.719	4.208	4.629	5.190	5.985	6.491
Manufacturing	1.620	1.977	2.340	2.695	3.049	3.438
Steam Electric	0.457	0.628	0.747	0.901	1.022	1.098
Mining	0.215	0.198	0.245	0.292	0.340	0.355
Irrigation	8.501	7.301	7.086	6.864	6.645	6.557
Livestock	0.292	0.322	0.332	0.332	0.332	0.332
Total Demands	14.804	14.645	15.379	16.274	17.372	18.270
Irrigation Shortage	0.559	0.419	0.371	0.421	0.713	0.887
Net Demands	14.245	14.226	15.008	15.853	16.659	17.383
Projected Supplies						
Surface Water	10.715	10.676	10.609	10.579	10.551	10.512
Ground-water	6.702	6.280	6.254	6.205	5.653	5.698
Local Surface Water	0.666	0.716	0.718	0.746	0.789	0.803
Reuse	0.175	0.204	0.270	0.331	0.439	0.519
Return Flows	0.084	0.086	0.095	0.106	0.106	0.111
New Surface Water	0.145	0.497	0.800	0.863	1.207	1.372
Total Supplies	18.487	18.458	18.747	18.830	18.744	19.015
Net Surface Supplies	4.241	4.232	3.739	2.977	2.085	01.632

FIGURE 3-1
PROJECTED STATEWIDE WATER DEMAND AND SUPPLY, 1990-2040
(million acre-feet)

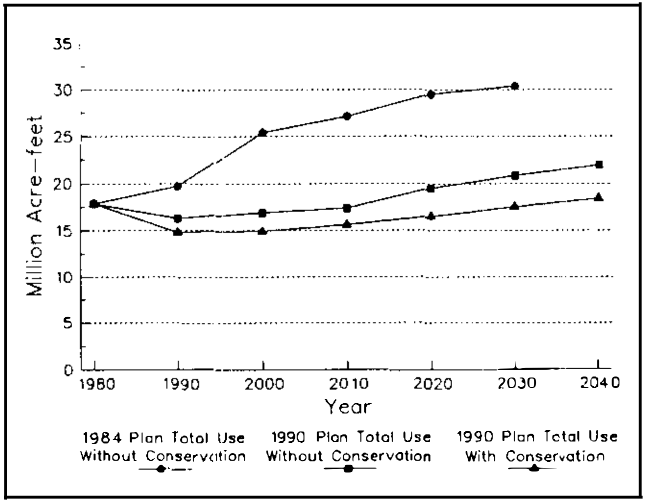


FIGURE 3-2
COMPARISON OF PROJECTED STATEWIDE WATER DEMANDS OF RECENT WATER PLANS

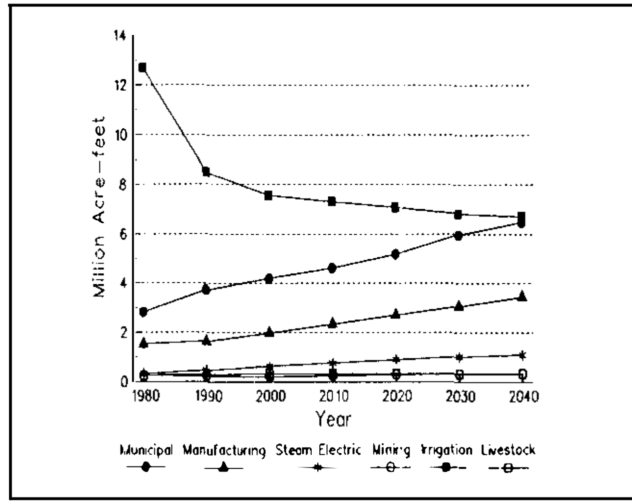


FIGURE 3-3
COMPONENTS OF PROJECTED STATEWIDE WATER DEMAND HIGH CASE - WITH CONSERVATION, 1990-2040

As discussed below, three major future water use scenarios were evaluated:

(1) a high series forecast with a high population growth rate, high per capita water use reflective of below-average rainfall, no municipal conservation savings, high manufacturing growth rate, and high forecast of irrigated farm acreage with conservation practices;

(2) a high series forecast with phased-in conservation for municipal water use that would attain a 15 percent savings by 2020, more aggressive conservation and reuse practices by manufacturing, and a high forecast of irrigated farm acreage with conservation practices; and

(3) a low series forecast of lower population and economic growth rates, per capita use projections reflective of average rainfall conditions, and a low projection of irrigated farm acreage with conservation practices.

The Board's high series forecast with conservation savings was used as the primary scenario in the Water Plan, although the high series without conservation was also assessed to add flexibility to the Plan and for purposes of examining the potential effects of expanded water conservation.

Components of the total statewide demand for Scenario 2 are shown in Figure 3-3. Irrigation, municipal, and manufacturing water demand make up the majority of current and projected State water use. For many years, water used for irrigation has been the largest use of water in Texas, although in recent years, water use for this purpose has exhibited a steady declining trend due to reduction in irrigated acreage and more efficient use of water.

While water use for irrigated agriculture is projected to continue to decline over time, the Board forecasts that the State population will about double in the next 50 years with the result that urban (municipal and manufacturing) water use, even with conservation practices in place, will become the dominant water use in the State by the end of the planning period. Over time, these types of additional urban water demands would most likely be met through the development of new surface water supplies.

As shown in Figure 3-4, the high series forecast predicts the State economy will exhibit steady long-term growth and that the population would increase from an estimated 17.6 million people in 1990 to over 35.6 million persons by 2040, a 50-year increase of 103 percent or a compound average annual increase of 1.4 percent.

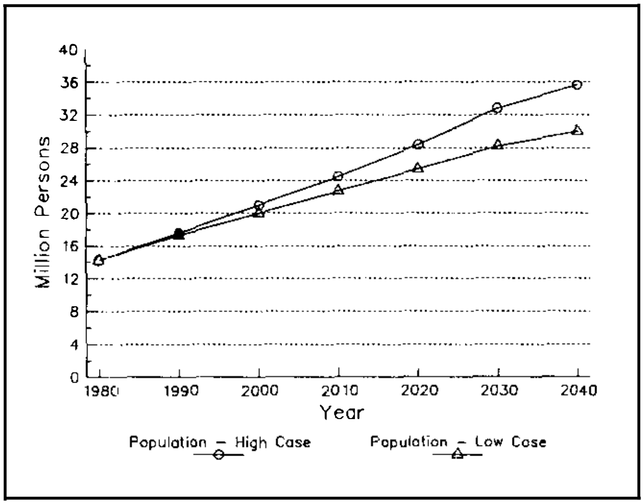


FIGURE 3-4
PROJECTED TEXAS POPULATION, 1990-2040

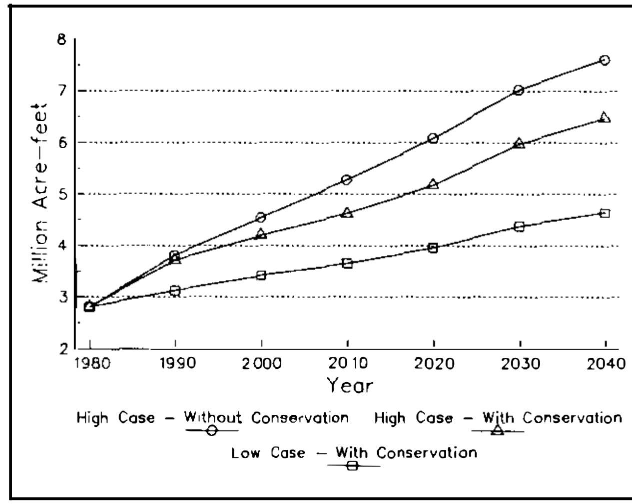


FIGURE 3-5
PROJECTED TEXAS MUNICIPAL
WATER USE REQUIREMENTS, 1990-2040

The Board's low series forecast predicts that the State population would increase from an estimated 17.3 million residents in 1990 to a level of about 30 million people by 2040, an increase of about 73 percent over the 50 year period or a compound average increase of 1.1 percent per year.

Using the alternative forecasts of population, high and average municipal per capita water use, and consideration of potential conservation practices, the Board made alternative projections of municipal water requirements for the State (shown in Figure 3-5). Projected municipal water use would increase from about 4.6 million acre-feet per year (low case, with conservation) to 7.6 million acre-feet per year (high case, without conservation) by 2040, an increase of 75 to 100 percent over current levels.

The difference in the Board's two high-case municipal water use projections, due to conservation savings, is estimated at over 1.1 million acre-feet annually by 2040. This potential savings is roughly equivalent to 80 percent of the total volume of new surface water supply projected to be needed in the next 50 years, even with conservation. Without conservation, the amount of new surface water supplies needed during the next 50 years would almost double beyond that needed with effective conservation measures in place.

As shown in Figure 3-6, under high case growth conditions manufacturing water use in the State of Texas is projected to increase by over 115 percent to 3.4 million acre-feet annually by the end of the 50-year planning period. Under lower growth rate predictions, State manufacturing water requirements would increase to about 2.5 million acre-feet per year by the year 2040 or an overall increase of 56 percent over estimated 1990 levels of 1.6 acre-feet per year.

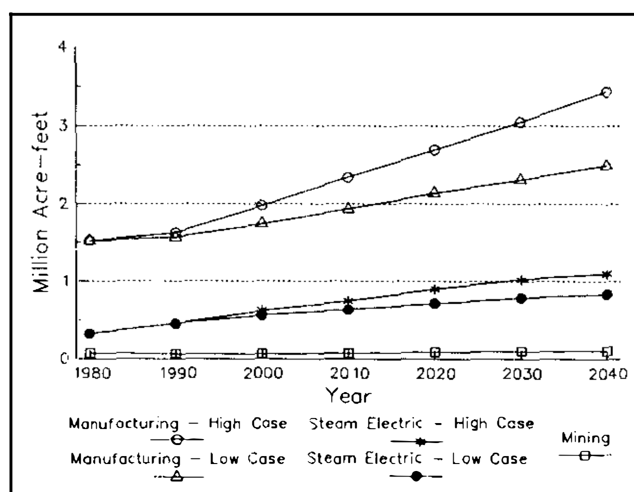


FIGURE 3-6
PROJECTED TEXAS INDUSTRIAL
WATER USE REQUIREMENTS, 1990-2040

New Board projections of potential steam electric power generation water use are also slightly reduced over levels previously forecast in the 1984 Plan. Water use for steam electric power generation is projected to increase over time, reflective of alternative demographic/economic growth rates assumed for municipal (residential and commercial) and manufacturing sectors. By the year 2040, annual water demand for steam electric power generation under the Board's high case forecast should increase to over one million acre-feet per year or 139 percent greater than that estimated to be used in 1990.

Water demand for mining (primarily oil and gas extraction and lignite surface mining) is expected to decline slightly until about the year 2000 as sagging prices for Texas oil and gas production stabilize and demand for oil and gas energy resources rebound to a period of moderate, but relatively stable growth in overall production. Water use by mining in 2040 is projected to total about 330,000 acre-feet per year or about 53 percent higher than the 1990 estimated use, although the Board's forecast does not reflect the recent uncertainties in the Middle East and how that may affect the oil and gas industry in Texas.

While irrigation water use has historically comprised the largest portion of statewide water use, irrigation water use peaked in the early 1980s. By about the year 2010, Texas municipal and industrial water requirements are projected to about equal the declining irrigation water requirements.

The recent historical and projected declines in irrigation's portion of the statewide water budget (see Figure 3-7) are reflective of the substantial reduction in water requirements from water conservation and increased use efficiencies, projected to total 1.6 million acre-feet in savings annually by 2020 and increasing to 1.7 million acre-feet by the year 2040. Statewide irrigation demand under the high case forecast is projected to decrease from 8 million acre-feet per year currently to about 6.7 million acre-feet annually by 2040, a decrease of about 16 percent from estimated 1990 levels (see Figure 3-7). The Board's year 2040 low case irrigation use forecast reflects a reduction of about 37 percent below estimated 1990 demand.

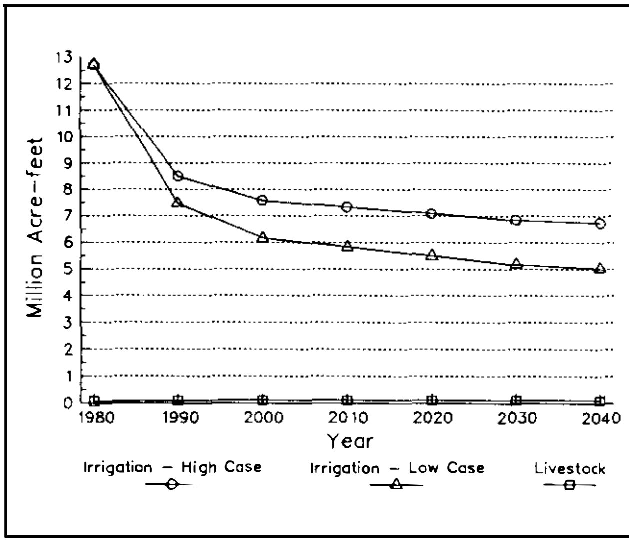


FIGURE 3-7
PROJECTED TEXAS AGRICULTURAL
WATER USE REQUIREMENTS, 1990-2040

Water use for livestock watering is expected to remain relatively stable over the 50-year planning period (projected 15 percent increase to about 330,000 acre-feet per year by 2040) and remain a relatively minor share of overall statewide water use.

Projected Statewide Water Supplies

As reflected in Figure 3-1, future annual water supplies of over 19 million acre-feet would be required by the year 2040 to meet the high case water demands if projected conservation savings are obtained. Of the total statewide supply needed by the year 2040 for the with-conservation case, about 17 million acre-feet or 90 percent would come from existing regional surface water, local surface water, and ground-water supplies with an additional 2 million acre-feet or 10 percent of total needed supplies coming from new surface water reservoirs, reuse, or use of return flows.

New surface water reservoirs would account for about 1.4 million acre-feet, while expanded water reuse and use of return flows would provide about 630,000 acre-feet of the year 2040 total supplies. Ground-water use is projected to decline statewide,

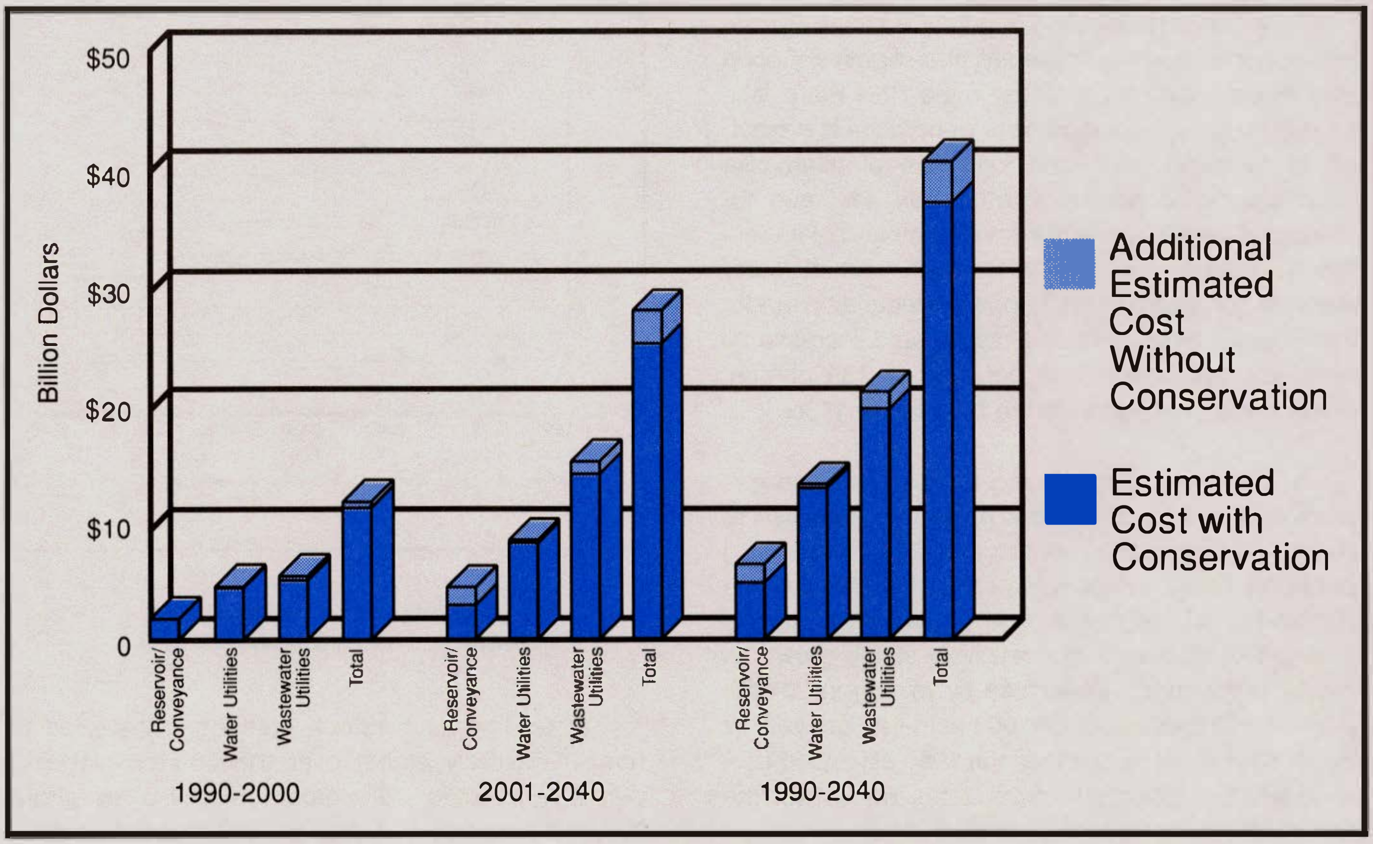


FIGURE 3-8
DISTRIBUTION OF PROJECTED STATEWIDE COSTS FOR WATER AND WASTEWATER FACILITIES

although additional ground water supplies will continue to be developed in localized areas such as portions of East Texas.

In projecting available water supplies, various uncertainties exist concerning the ultimate availability and amounts of certain types of supply such as ground water, reuse, and use of return flows. While it is likely that there will be additional quantities of these particular types of resources beyond those shown in Figure 3-1, the Board was cautious in its forecasts of what might be available for future use.

Therefore while the net remaining surface water supplies in the year 2040, as a percent of total surface water capacity, is approximately 13 percent, there can be additional future supplies developed from other new surface water supply projects, and potentially from ground water, reuse, and return flow sources as well. Additional conservation savings, beyond those projected by the Board, would help extend whatever available supplies exist.

If the Board's projected water conservation savings cannot be realized by the year 2040 then, in addition to the total water supplies referenced previously, another 747,000 acre-feet of supplies would be required from six additional new surface water reservoirs, ground-water usage would rise by about 740,000 acre-feet, and reuse and the use of return flows would increase by another 93,000 acre-feet in this situation.

Projected Statewide Facility Needs and Costs

As indicated in Figure 3-8 and Table 3-1, the Board projects that if its projected water conservation savings are realized, new water and wastewater facilities in Texas in the next 50 years are expected to cost a minimum of $37 billion dollars. Over one-quarter of these expenditures would need to be incurred in the 1990s.

Should the Board's projected water conservation savings not be obtained by Texas municipalities, it is estimated that roughly a ten percent increase (+$3.4 billion) in water and wastewater facilities costs, above the with-conservation forecasts, would be realized. Under this scenario, the expected costs of meeting minimum water and wastewater infrastructure requirements for the State of Texas in the next 50 years would total over $40.5 billion.

FACILITY TYPE	1990-2000	2001-2040	1990-2040
RESERVOIRS/CONVEYANCES			
With Conservation	$1.854	$2.944	$4.798
Without Conservation	$1.854	$3.174	$6.370
WATER UTILITIES			
With Conservation	$4.606	$8.239	$12.845
Without Conservation	$4.712	$8.503	$13.215
WASTEWATER UTILITIES			
With Conservation	$5.220	$14.300	$19.521
Without Conservation	$5.612	$15.373	$20.985
TOTAL			
With Conservation	$11.680	$25.483	$37.163
Without Conservation	$12.178	$28.392	$40.570
DIFFERENCE DUE TO CONSERVATION	$0.498	$2.909	$3.406

TABLE 3-1
DISTRIBUTION OF PROJECTED STATEWIDE COSTS FOR PUBLIC WATER AND WASTEWATER IMPROVEMENTS, 1990-2040 (billion $)

Spending for wastewater facility improvements is projected to place the largest demand upon statewide water-related public infrastructure financing over the next 50 years. About 53 percent of identified facility needs are attributable to wastewater improvements, while 47 percent are estimated for water improvements.

Overall, the estimated costs for new reservoirs and cross-country conveyances that provide for water supply account for only about $4.8 billion or 13 percent of the cost of total identified water and wastewater infrastructure needs. Other utility infrastructure such as water treatment, storage, pumping, transmission, and wastewater treatment, pumping, and collection (i.e., typical municipal facilities) is projected to total over $32 billion or 87 percent of the State's total $37 billion in identified water and wastewater facility needs.

In addition to these requirements, about $1.9 billion in flood protection needs have been identified from various studies completed by the U.S. Army Corps of Engineers, Board-sponsored, and other federal and local studies. These costs do not represent total statewide needs, but are simply costs identified by the studies available to the Board. A more comprehensive evaluation of flood protection needs should be available for the next Water Plan update. In addition, an evaluation of alternative methods of minimizing damage from flooding, including careful consideration of uses of floodplain property and programs to control rainfall runoff rates, should be included in future updates.

In general, the Board's cost estimates are based on minimum standards of the Texas Department of Health, current Texas Water Commission wastewater permit limits, and generally accepted engineering standards. Accordingly, these cost estimates should be considered as minimum amounts.

Further significant costs will be incurred by utilities for activities including: flood protection needs resulting from further studies; pending Safe Drinking Water Act regulations; stormwater treatment; non-point source pollution controls; stricter wastewater discharge regulations; rehabilitation of existing facilities; and fire protection needs of individual communities. Additional data on the expected costs of these actions will be included in future Plan updates as they are finalized and quantified.

While it is not possible to characterize the specific situations of each of the State's 2,400+ utilities, it is recognized that water quality issues are important to, and have significant impact upon, the needs for facilities and their costs. Levels of treatment vary depending on individual stream segment standards and can significantly affect the cost of wastewater treatment, as well as the cost of treating water for potable uses further downstream.

The Texas Water Commission is the State agency responsible for setting water quality standards. Needs for wastewater facilities and their costs were based on the latest available information on water quality requirements for each permitted utility.

The geographic distribution of the projected costs for water, wastewater, and identified flood protection facilities, respectively, are shown in Figures 3-9 through 3-11. Costs were assigned to the counties of identified need rather than by project location. The magnitude of identified future infrastructure costs for water, wastewater, and even flood protection generally corresponds to the population density of the region.

Large metropolitan areas are projected to have the greatest population growth, facility needs, costs, and financing requirements. Even given the large majority of infrastructure needs and costs identified for larger urbanized areas, this does not minimize the importance, or the financial impact, of meeting the water-related facility needs facing the smaller urban and rural areas.

Indeed, areas of lesser population and lesser land development densities may have the greatest need for State planning and financial assistance due to lack of technical staff, attractive or feasible financing alternatives, minimal economies of scale and high unit costs, or absence of viable institutional organizations.

Major Water Supply Projects. From the Board's analysis of projected water demands, existing supplies and facilities of individual utilities, and an assessment of projected regional-level water demands and supplies, supply deficits of surface and ground water were projected in various portions of the State of Texas.

The Board examined a variety of supply and demand management and development alternatives that could address these potential water supply shortages, including both structural and non-structural measures. In considering structural methods, the Board has identified an array of different types of new supply projects that could economically address these deficits.

Overall, 14 new major surface water supply reservoirs are projected to be needed in the 50-year planning horizon if the Board's projected water conservation savings are attained (see Table 3-2 top and Figure 3-12 top). The need for these recommended projects are discussed in more detail in the following portions of this Section.

To provide for better planning flexibility, a series of six alternative or back-up reservoir projects (see Table 3-2 bottom and Figure 3-12 bottom) were also identified as being needed should the Board's projected water conservation savings not be attained. These projects would also be needed should the Board's high-case forecast of economic growth be too low, or if some of the recommended water supply projects prove to be infeasible for engineering, environmental, economic, regulatory, or other reasons.

Various other potential reservoir sites that have been previously studied by various federal, state, and local entities are also considered as alternative sources of new surface water supply (see Figure 3-13). One or more of these alternative reservoir sites may be developed to meet identified needs should it ultimately be determined that a recommended or prime alternative supply project is infeasible.

Additionally, some of these supply projects will be developed to help meet the water needs of Texas beyond the Board's 50-year planning horizon.

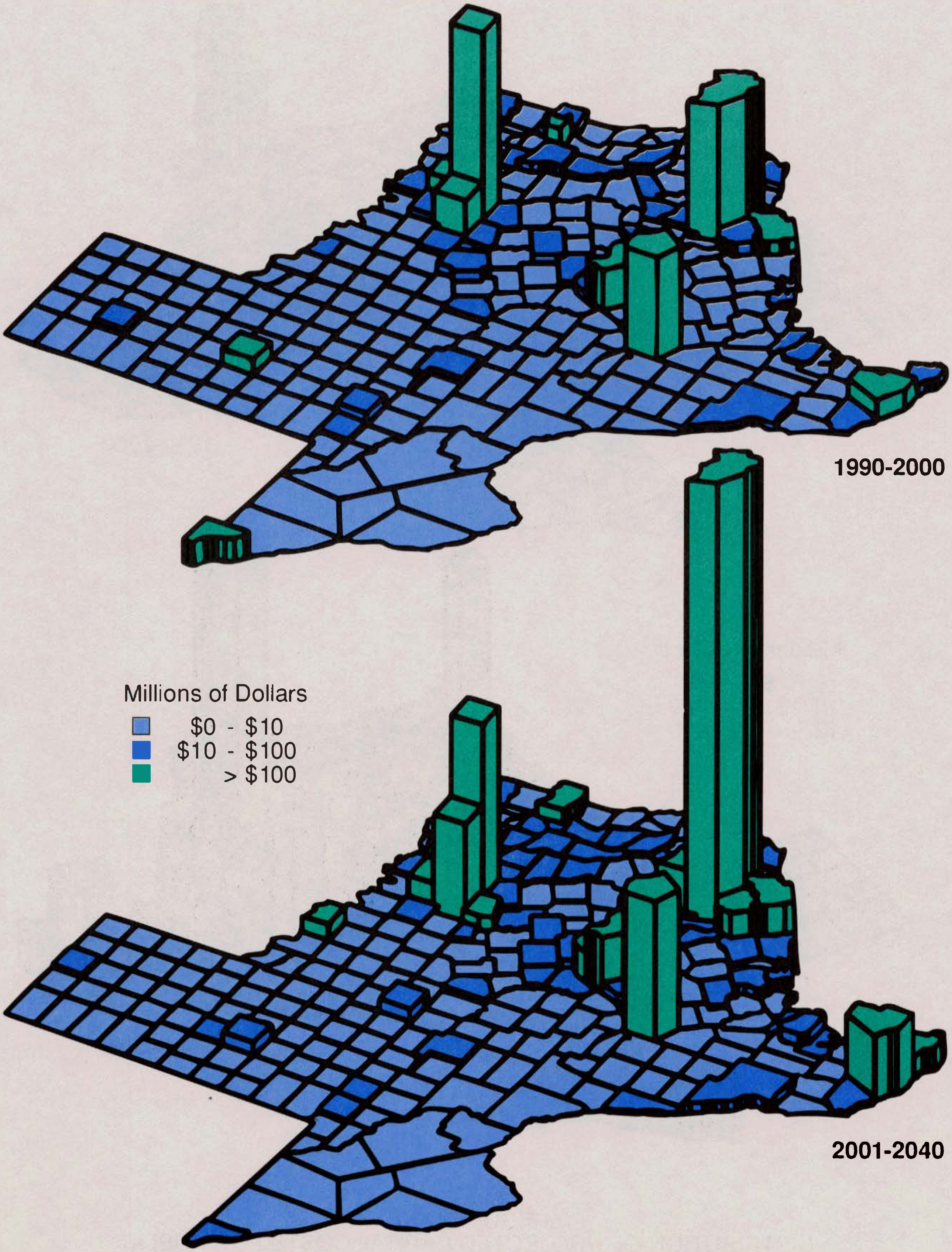


FIGURE 3-9
DISTRIBUTION OF PROJECTED CAPITAL COSTS
FOR PUBLIC WATER FACILITIES NEEDS,
1990-2000 AND 2001-2040

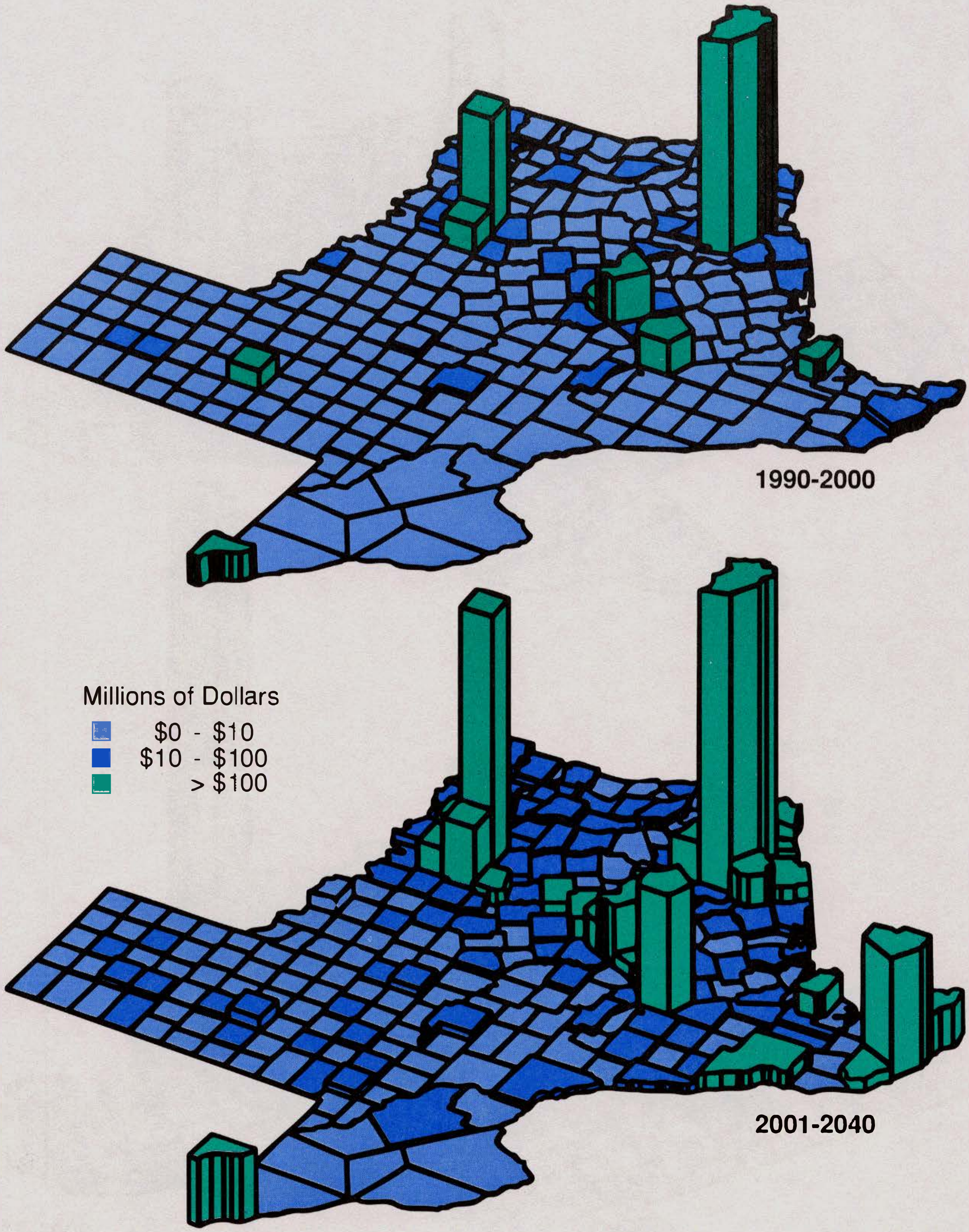
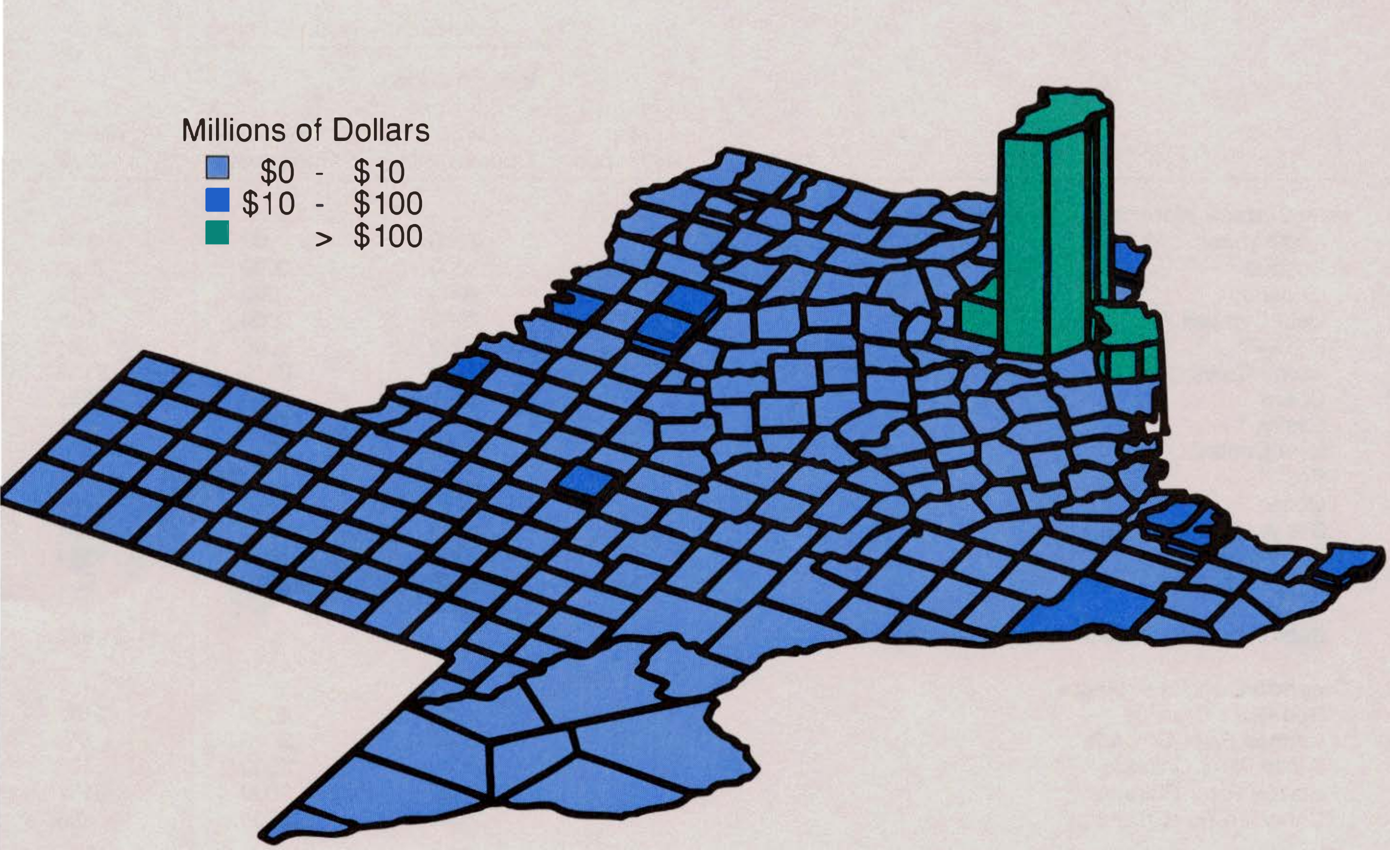


FIGURE 3-10
DISTRIBUTION OF PROJECTED CAPITAL COSTS FOR PUBLIC WASTEWATER FACILITIES NEEDS, 1990-2000 AND 2001-2040



Note: This figure is not intended to reflect comprehensive statewide needs for flood protection. It shows only projected costs identified by U.S. Army Corps of Engineers and TWDB studies, conducted to date, which have Benefit/Cost ratios greater than one.

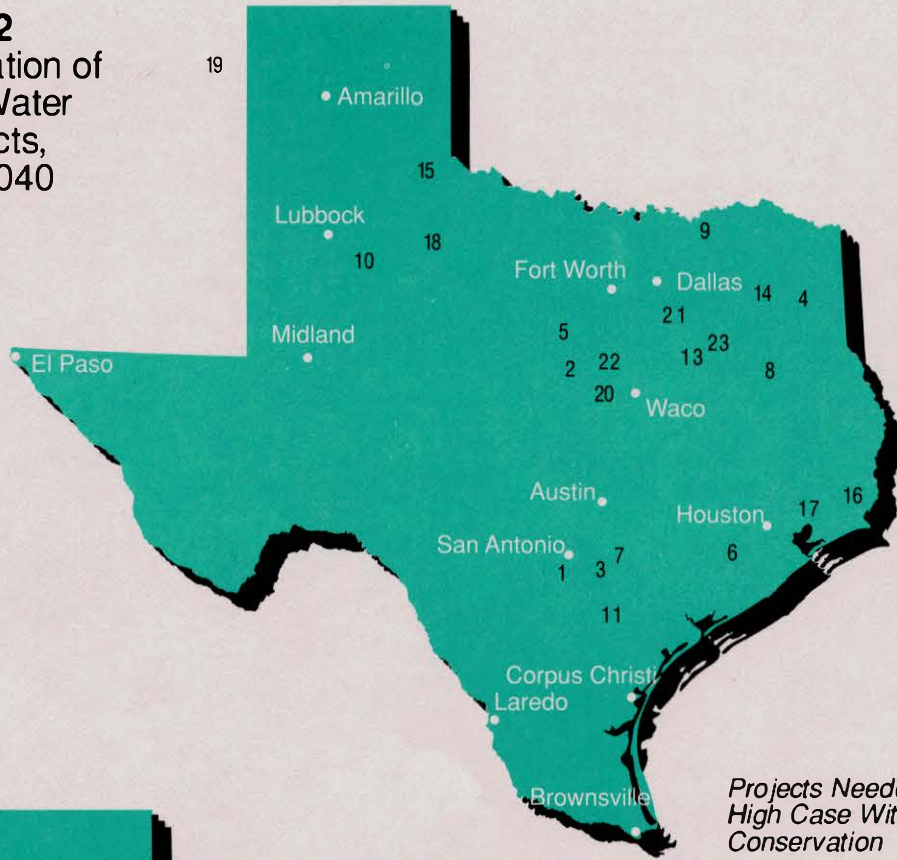
FIGURE 3-11
DISTRIBUTION OF PROJECTED CAPITAL COSTS
FOR CURRENTLY-IDENTIFIED FLOOD PROTECTION FACILITIES NEEDS

Table 3-2
Conceptual Location, Cost, and Timing of Need of
Future Major Water Supply Projects, 2000-2040

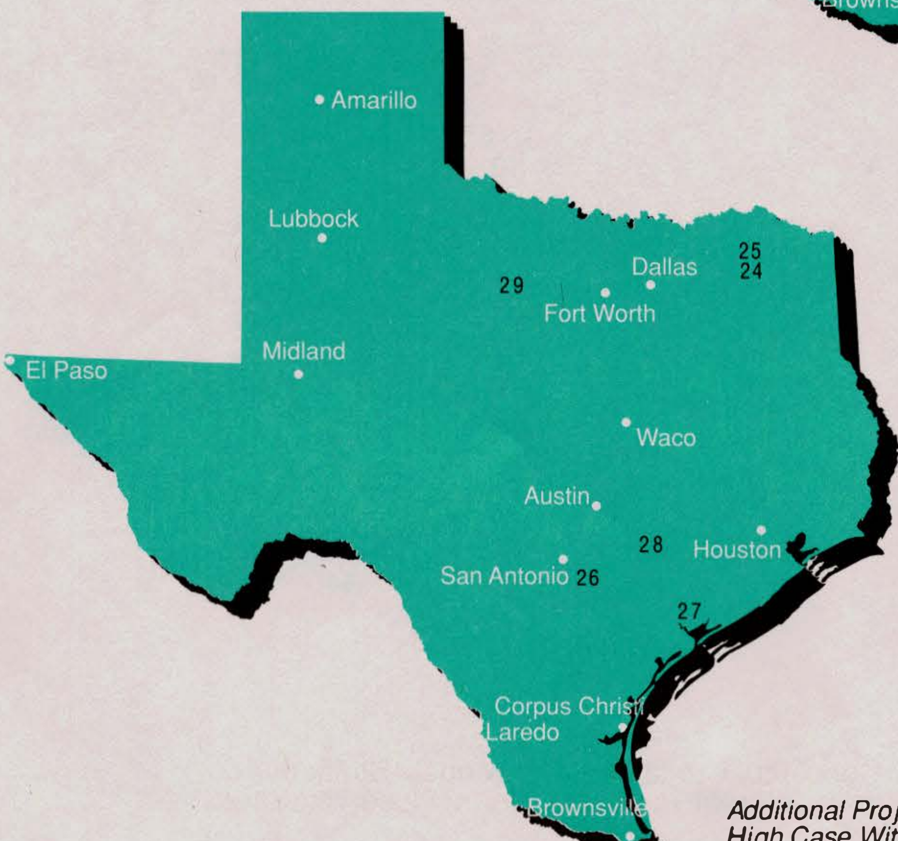
Project	Fig. 3-12 Map Reference	Date Supply Needed By: Recommended High Case With Conservation	Date Supply Needed By: High Case Without Conservation	Cost, million 1990$
New Surface Water Reservoirs				
Applewhite *	1	2000	2000	$93
Bosque	2	2000	2000	$56
Lindenau	3	2000	2000	$315
Little Cypress *	4	2000	2000	$88
Paluxy *	5	2000	2000	$61
Allens Creek	6	2010	2010	$158
Cuero	7	2010	2000	$346
Eastex *	8	2010	2000	$91
New Bonham	9	2030	2020	$70
Post *	10	2030	2020	$28
Goliad	11	2030	2020	$296
Site A Channel Dam	12	2030	2020	$28
Tehuacana	13	2030	2030	$113
Big Sandy	14	2040	2040	$84
Subtotal - New Surface Water Reservoirs				$1,827
Chloride Control Projects				
Red River Chloride	15	2000	2000	$162
Neches River Chloride	16	2000	2000	$45
Trinity River Chloride	17	2000	2000	$30
Brazos River Chloride	18	2000	2000	$157
Canadian River Chloride	19	2000	2000	$3
Subtotal - Chloride Control				$397
Reallocation/Modification Projects				
Waco Reallocation	20	2000	2000	$19
Bardwell Reallocation	21	2010	2000	$9
Whitney Reallocation	22	2020	2010	$105
Trinity River Diversion	23	2020	2010	$34
Subtotal - Reallocation/Modification				$167
Prime Alternative/Back-up Surface Reservoir Sites				
Parkhouse I	24		2030	$60
Parkhouse II	25		2040	$59
Cibolo	26		2040	$226
Palmetto Bend II *	27		2040	$91
Shaws Bend	28		2040	$257
South Bend	29		2040	$208
Subtotal - Prime Alternative/Back-up Sites				$901
Total - All Projects				$2,391 to $3,292

* State permit for water rights issued by Texas Water Commission.

Figure 3-12
Conceptual Location of Future Major Water Supply Projects, Years 2000-2040



Projects Needed: High Case With Conservation



Additional Projects Needed: High Case Without Conservation

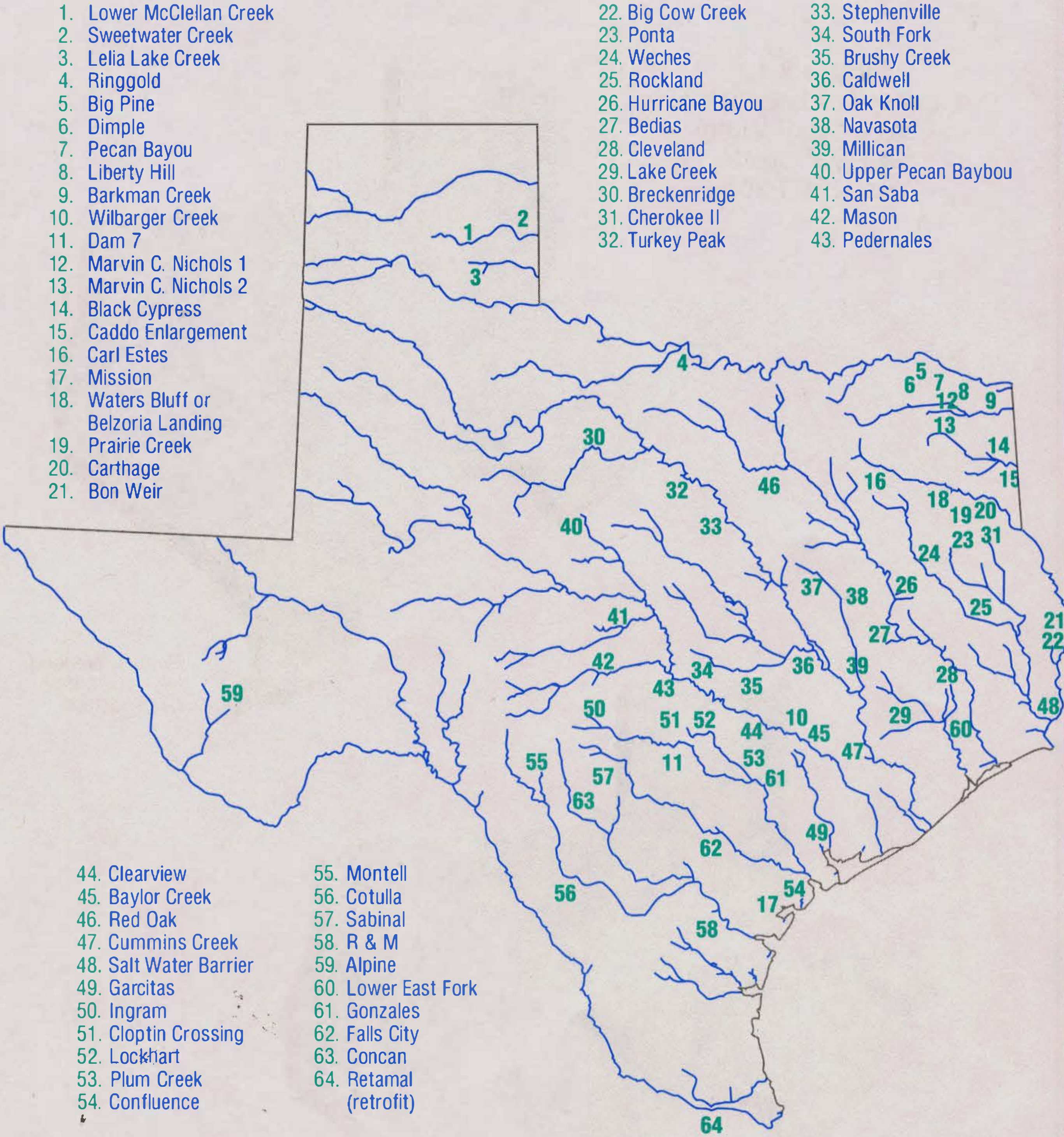


Figure 3-13
Conceptual Location of Previously-Studied
(Potential Alternative or Long-Term) Reservoir Sites

In addition to the construction of new surface water supply reservoirs, the Board also examined other alternatives for providing future water supply and is recommending several new projects that would increase or improve existing, available surface water supplies.

Because of high chloride (salinity) levels in various riverine waters due to passage over certain geologic formations, man-made brine contamination, or sea water intrusion, the Board is recommending five chloride control projects to improve water quality and/or reduce costs of treatment to potable water standards. A brine injection project is recommended to reduce the salinity of Canadian River water in Texas (see Table 3-2 and Figure 3-12). In the upper Red and Brazos river basins, small impoundment reservoirs are proposed to retain and evaporate saline waters and lessen the effects on downstream water quality.

Salt water barrier projects are also proposed for the lower Neches and Trinity river basins to minimize the impacts of sea water intrusion on higher quality riverine supplies. Further surface water supplies could also be made available by the reallocation and/or modification of total reservoir storage in Federal projects to increase the amount of water storage allocated to water supply storage. The Board recommends reallocations for the existing Bardwell, Whitney, and Waco reservoir projects. The Corps of Engineers has also been requested to perform a reallocation study for Lake O' The Pines in northeast Texas.

The Board, in addition, recommends a major diversion project that would move water from the Trinity River into the existing Richland-Chambers and Cedar Creek reservoirs. This would increase the yield of those existing water supply sources and defer additional new major supply projects until later in time.

Major Water Conveyance Projects. In many cases, major water conveyance pipelines and other facilities would be needed to transport surface water supplies from both new and existing reservoirs to the general locations of the major water demand centers. In some instances, proposed new reservoirs would provide releases upriver of the water demand center(s), and much of the conveyance costs can be avoided.

Where needed, the major water conveyance systems recommended by the Board are referenced by conceptual location, timing of need, and potential cost in Table 3-3 and Figure 3-14.

Comment. While many of these various new water supply reservoir, chloride control, reallocation/modification, and conveyance system projects would serve the future water needs of Texas' larger cities, many of the cities or districts receiving water from these facilities also provide wholesale water service to smaller communities and districts. In several cases, these water supply projects would provide direct service for smaller towns and utilities.

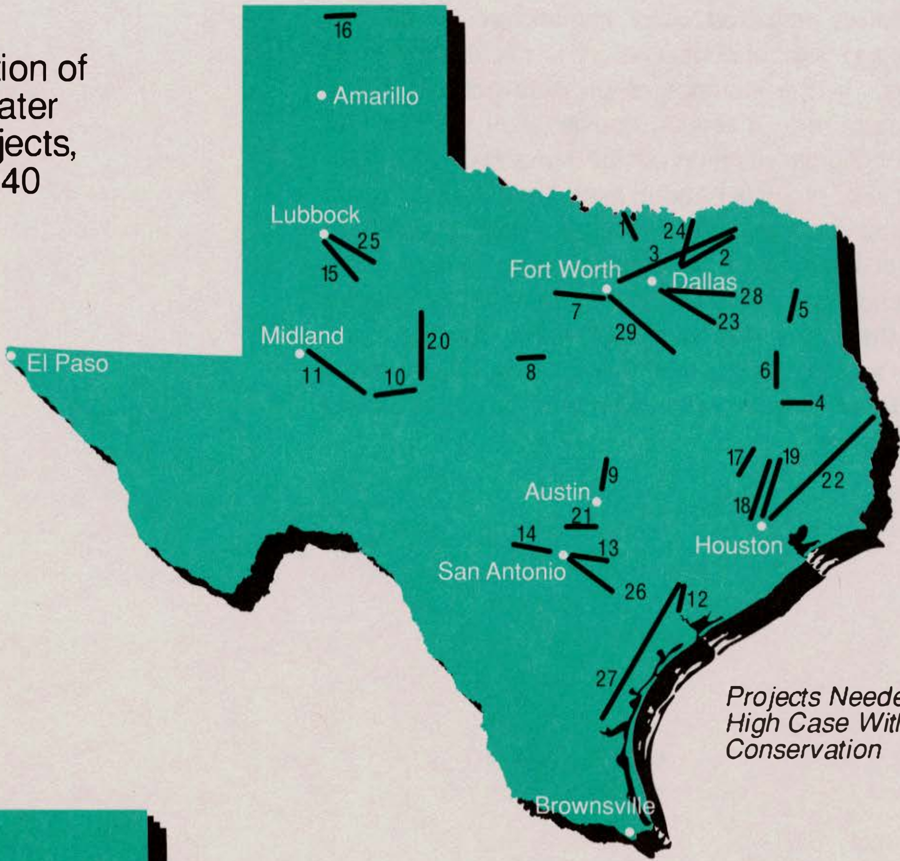
The Board's list of recommended and prime alternative water supply projects, alternative/long-term reservoir sites, and conveyance systems, identified in Figures 3-12 and 3-13, should be used not only to help identify potential facilities which are needed to meet water supply needs, but also as a land management planning tool as well. All governmental agencies and the private sector should refer to this siting information in considering the potential implications that other future development, land use practices, or regulatory decisions might have on potential water supply project development or operational feasibility.

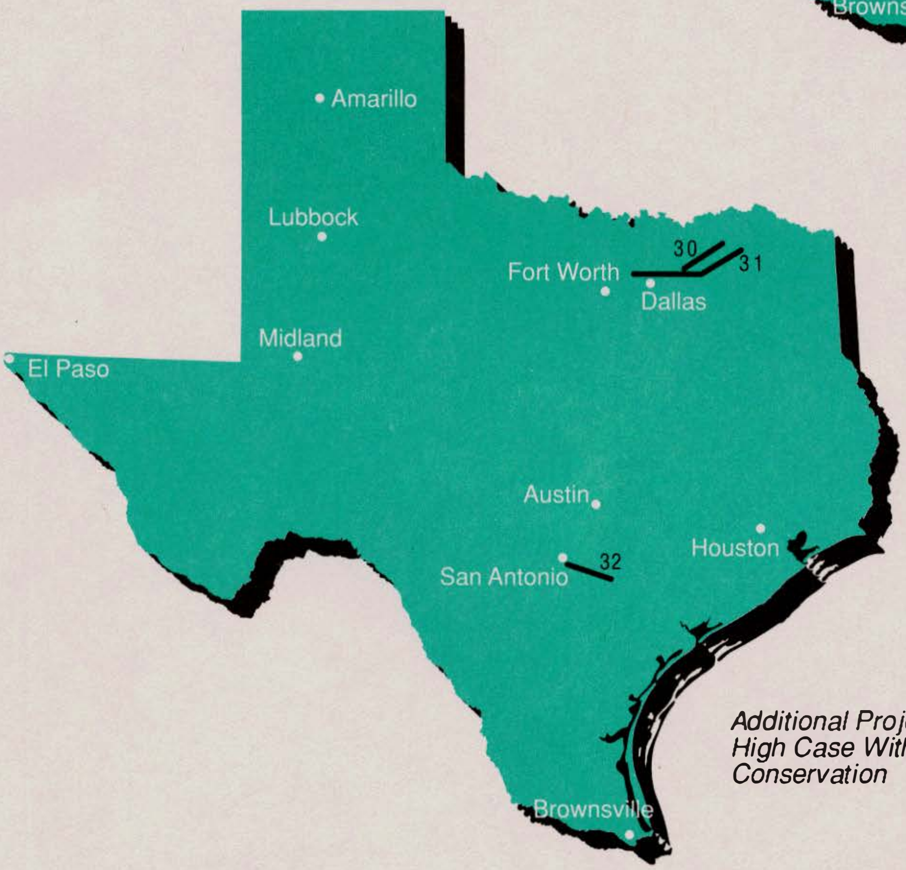
The timing of project need, referenced in Tables 3-2 and 3-3, indicates when *operation* of these new facilities would be required in actually providing water supplies. It can take anywhere from 10 to 30 years to complete development on a new surface water supply project from the initiation of the planning to the commencement of operations. In many instances, the near-term timing of a recommended project reflects that it is needed to avoid continued mining of groundwater supplies.

Table 3-3
Conceptual Location, Cost, and Timing of Need of
Future Major Water Conveyance Projects, 2000-2040

Project Origin/Destination	Fig. 3-14 Map Reference	Date Supply Needed By: Recommended High Case With Conservation	Date Supply Needed By: High Case Without Conservation	Cost, million 1990$
New Major Water Conveyance Facilities				
Moss Reservoir to Gainesville	1	2000	2000	$4
Cooper Reservoir to Lake Lavon	2	2000	2000	$70
Cooper Reservoir to Irving	3	2000	2000	$54
Sam Rayburn Reservoir to Lufkin	4	2000	2000	$44
Little Cypress Reservoir to Kilgore/Longview	5	2000	2000	$38
Eastex Reservoir to Customers	6	2000	2000	$27
Benbrook Reservoir to Weatherford	7	2000	2000	$23
Paluxy Reservoir to Stephenville	8	2000	2000	$26
Stillhouse Hollow Reservoir to Round Rock	9	2000	2000	$19
O.H. Ivie Reservoir to San Angelo	10	2000	2000	$32
San Angelo to Midland (O.H. Ivie water)	11	2000	2000	$75
Texana Reservoir to Point Comfort	12	2000	2000	$19
Lindenau/Cuero Reservoirs to San Antonio	13	2000	2000	$174
Medina Reservoir to San Antonio	14	2000	2000	$45
Alan Henry Reservoir to Lubbock	15	2000	2000	$84
Palo Duro Reservoir to Gruver	16	2010	2010	$25
Livingston Reservoir to Conroe	17	2010	2010	$75
Livingston Reservoir to Houston	18	2010	2010	$84
Livingston Reservoir to Houston	19	2010	2010	$50
O.H. Ivie to Abilene	20	2010	2010	$45
Canyon Reservoir to San Marcos	21	2010	2000	$23
Toledo Bend Reservoir to Houston	22	2020	2020	$399
Palestine Reservoir to Dallas	23	2020	2000	$215
New Bonham Reservoir to Lake Lavon	24	2030	2020	$37
Post Reservoir to Lubbock	25	2030	2020	$42
Goliad Reservoir to San Antonio	26	2030	2020	$159
Texana Reservoir to Corpus Christi	27	2030	2030	$47
Lake Fork Reservoir to Dallas	28	2040	2010	$196
Tehuacana Reservoir to Fort Worth	29	2040	2030	$278
Subtotal - New Major Water Conveyance Systems				$2,407
Prime Alternative/Back-up Conveyance Systems				
Parkhouse I Reservoir to Dallas	30		2030	$313
Parkhouse II Reservoir to Lake Lavon and Tarrant County	31		2040	$313
Cibolo Reservoir to San Antonio	32		2040	$45
Subtotal - Prime Alternative/Backup Conveyance Systems				$671
Total - All Projects				$2,407 to $3,078

Figure 3-14
Conceptual Location of Future Major Water Conveyance Projects, Years 2000-2040



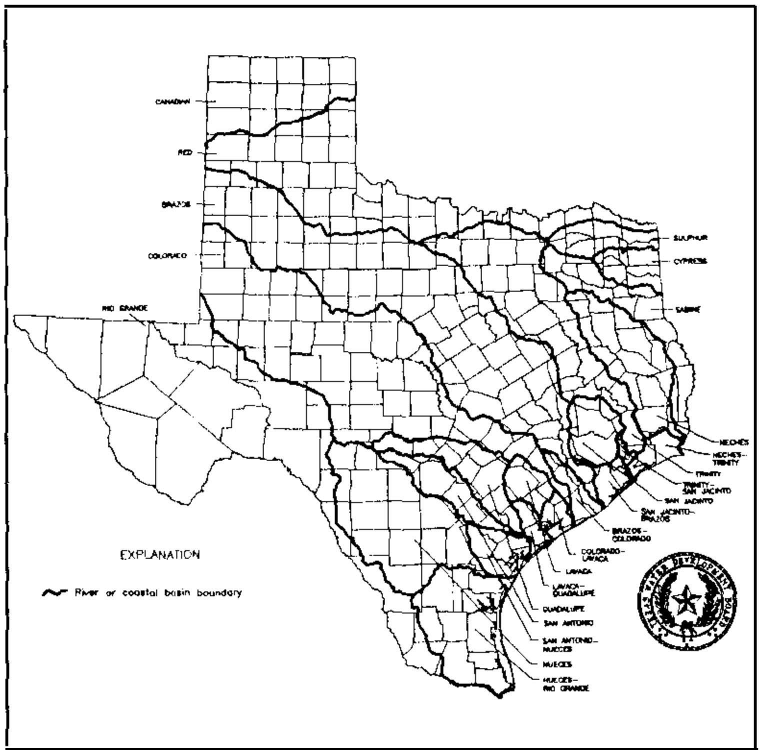


Also, the relative timing of need between the alternative projected water demand scenarios (i.e., with- and without-conservation) is not uniform in all cases. In the instance of projects needed in the near-term, the phased-in conservation savings had only negligible effect on overall demand and timing of need. For projects needed later, the potential impact the Board's conservation scenario had on deferring project timing was affected by the types of water demands that would be utilizing the facilities. Generally, the larger the municipal water demand component in the facility use, the more significant effect the Board's conservation scenario had upon facility need timing.

PROJECTED RIVER BASIN DEMANDS, SUPPLIES AND FACILITY NEEDS

As specified in Chapter 16.051 of the Texas Water Code, the Texas Water Development Board is also required to "define and designate river basins and watersheds as separate units ..." for consideration in planning, projection of in-basin water demands and supply needs, and contemplation of inter-basin water transfers.

As discussed in Section 2, various planning and modeling considerations were made in the water supply allocation studies for the State's river basins, including enhanced conservation practices, limits on ground-water availability, reservoir releases for instream flows and bays and estuaries needs, and other water management issues and techniques.



It was projected that ground-water supplies would be limited in many areas to a "safe yield" volume of pumpage and use to avoid de-watering of the aquifer(s) and the adverse side-effects of intense pumpage in sensitive aquifer areas. It was also determined that various agricultural water demands could not be economically met by replacing ground water supplies for irrigation with relatively expensive surface water supplies.

Both in-basin demands and out-of-basin export demands were projected to determine the total demand for a particular basin's water resources. The total demands on the basin's resources were then compared against available current water supplies from in-basin resources and imported water supplies.

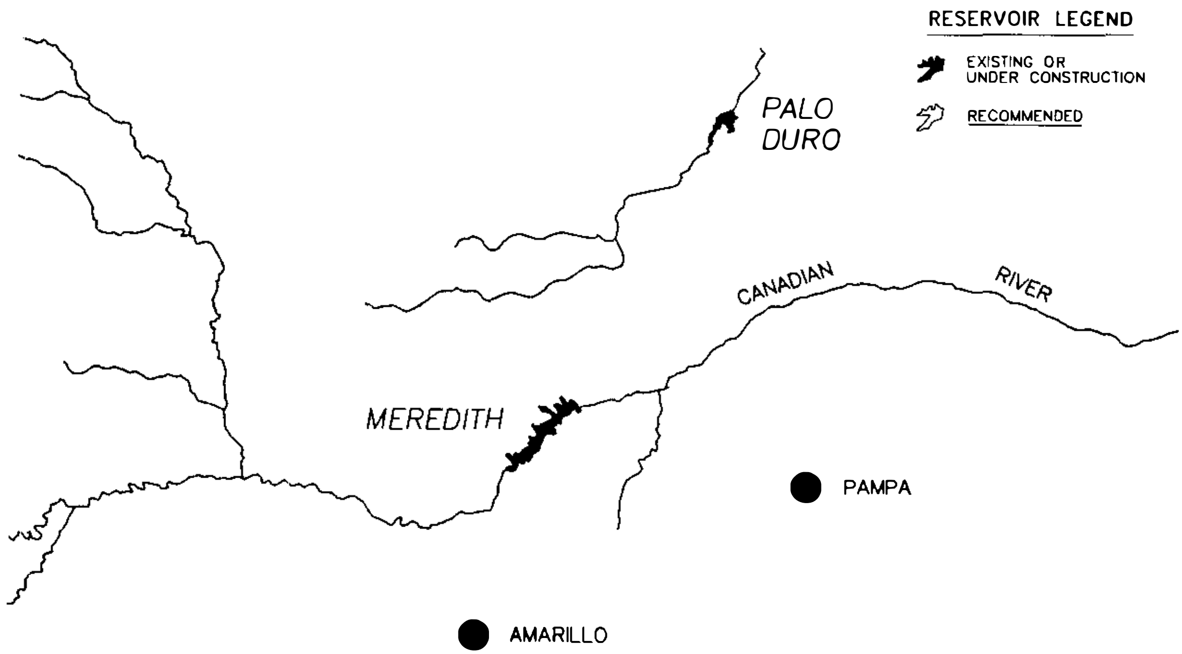
In general, where supply shortages existed for non-agricultural water use sectors and the development of sufficient additional ground-water resources was not feasible, further surface water supplies were projected to be made available from new reservoir projects, new conveyance systems from existing reservoirs, additional supply imports from other river basins, or from additional water reuse or use of return flows.

The Board's water allocation results for each basin are shown in the lower left-hand inset box of each basin "data sheet" description that follows in this section. The percent distribution of current and projected water demands and supplies are shown in the lower right portion.

Also shown is a schematic of the river and its major tributaries, existing major water supply reservoirs, recommended new supply projects, and the years' 2000 and 2040 estimated supplies and uses of those projects. Not shown are reservoirs whose substantive use involves non-consumptive activities (i.e., recreation, fish and wildlife enhancement, hydropower generation purposes, etc.). Current and projected future use of major and selected minor aquifers are also provided.

Summary data on demands, supplies, features and problems of the eight smaller Texas coastal basins follows the discussion of the major river basins. Further detail on individual municipalities, utilities, service areas, project status, and water, wastewater, or flood protection problems and needs can be found in the regional and local sections following the river and coastal basin discussion in Section 3.

CANADIAN RIVER BASIN



Project d Supply and Use of Major Water Supply R s rvoirs
(acre-feet/year)

R servoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Mer dith	74,350	51,884	62,550	61,470
Palo Duro	4,800	0	4,800	4,080

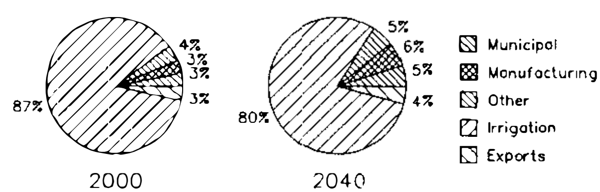
Projected Use of Major and S lect d Minor Aquifers
(acr -fe t/year)

Aquifer	2000 Use	2040 Use
Ogallala (High Plains)	744,570	602,050

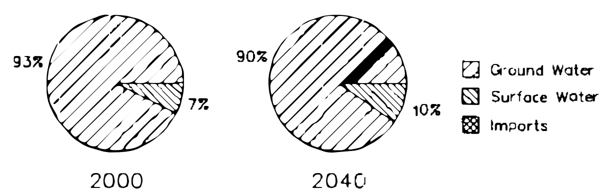
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	41,269	53,908
Manufacturing	37,735	60,004
Steam Electric	23,000	30,000
Mining	4,947	5,202
Irrigation	1,127,340	855,811
Livestock	21,676	21,676
Total In-Basin Demands	1,255,967	1,026,601
IN-BASIN SUPPLIES		
Ground Water	1,223,041	968,513
Surface Water	83,479	77,784
Total In-Basin Supplies	1,306,520	1,046,297
TRANSFERS		
Import Supplies	0	0
Export Demands	43,225	44,459
ADDITIONAL NEW SUPPLIES	12,657	24,810
AGRICULTURAL SHORTAGE	0	(1,753)
NET AVAILABILITY	19,985	1,800

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Canadian River Basin is located in the northern portion of the Texas Panhandle and consists of all or part of 15 counties (see Figure 1-4). The economy of the basin is based on agriculture, oil and gas production, agribusiness, manufacturing, and retail and wholesale trade. In 1980, the population of the basin totaled 167,500 people. Currently, the population of the basin is estimated at 171,800 residents, representing an increase of 2.6 percent from the 1980 population. By the year 2040, the basin population is projected to range between 225,300 and 257,200 residents. Major population centers in the basin include the Cities of Amarillo, Pampa, Borger, Dumas, Perryton, Dalhart, Spearman, Canadian, and Stinnett.

Current Water Uses. Total annual water use in the basin is currently 1,299,574 acre-feet. Water for irrigation purposes is the largest water demand category in the basin with a current use of 1,203,182 acre-feet. Other major water demands on the basin supplies are exports for use in other basins, municipal, and manufacturing water use.

Current Water Supplies. The basin is supplied primarily by ground water from the large multi-state Ogallala Aquifer, which ranges in saturated thickness from 20 to 540 feet, but is realizing long-term declining water level trends. Yields of large capacity wells average about 700 gallons per minute (gpm) and locally can produce up to 1,200 gpm. The City of Amarillo operates well fields in Carson, Randall, and Deaf Smith counties. Other aquifers in the basin include the Rita Blanca and the Dockum.

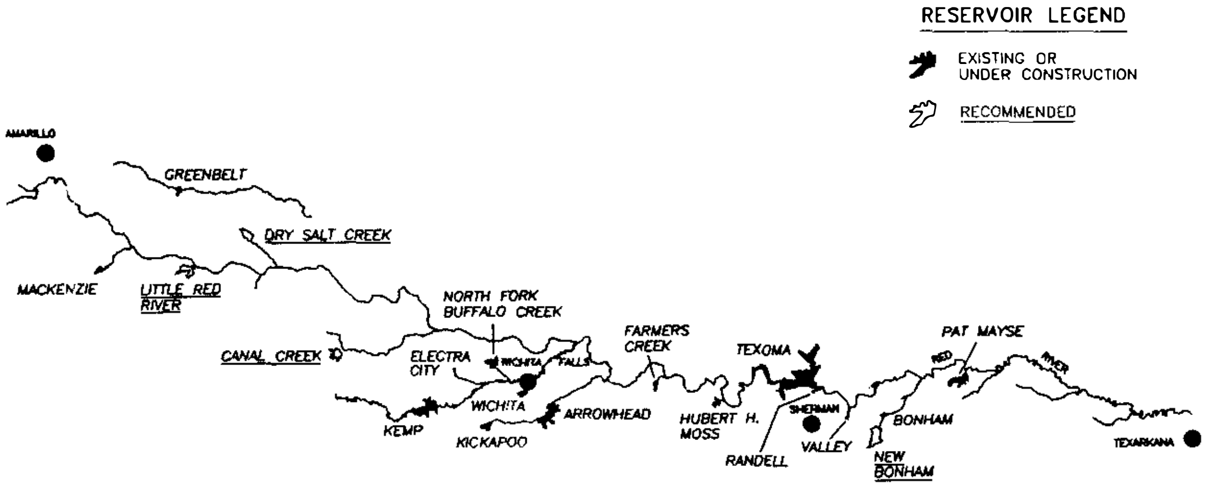
There are three major reservoirs located in the basin, of which two are water-supply reservoirs. Lake Meredith, constructed by the Bureau of Reclamation and operated by the Canadian River Municipal Water Authority, supplies water within the basin to the Cities of Borger and Pampa. The Authority also supplies water to the City of Amarillo, located partially in the Red River Basin; Plainview, Lubbock, Levelland, Slaton, Tahoka, and O'Donnell in the Brazos River Basin; and Brownfield and Lamesa in the Colorado River Basin. The 44,977 acre Lake Meredith Recreational Area is a unit of the National Park Service, managed by the NPS under a cooperative agreement with the U.S. Bureau of Reclamation. There is a proposal in Congress to designate it a National Recreation Area, although in any case, Lake Meredith is operated to conserve the recreational feature of the unit. Lake Palo Duro, currently under construction, will provide water to the member cities of the Palo Duro River Authority. Rita Blanca Lake, constructed by the U.S. Soil Conservation Service, is operated by Dallam and Hartley Counties for recreational purposes.

Current Water Quality. Major surface water quality problems in the basin are the high dissolved salt and solids concentrations (400 mg/l chloride levels and total dissolved solids (TDS) ranging from 1,000 mg/l and higher) in Lake Meredith. Domestic discharge of wastewater is made directly into Rita Blanca Lake, and as a result, the lake has experienced algal blooms, increased pH levels, and winter fish kills. The quality of the Ogallala Aquifer is generally good, although some areas of the aquifer in this basin have fluoride concentrations that exceed regulatory standards while other areas are experiencing saline intrusion as higher quality water supplies are withdrawn.

Future Water Uses. The basin's current water use pattern is not anticipated to change significantly over the 50-year planning period, with irrigation water needs continuing to be the major water use category of the basin. The reduction in irrigation water requirements is reflective of the expected improvements and implementation of more efficient water use irrigation equipment and management practices. With implementation of municipal water conservation programs and practices, annual savings of municipal water in the basin is projected to reach about 3,049 acre-feet by the year 2000, increasing further to about 8,868 acre-feet by 2040.

Future Water Supplies. Due to the scarcity of locally-developable surface water supplies, any additional supplies needed for the basin will likely come from reuse of present supplies and development of additional well fields in the Ogallala. In areas of current salinity problems, continued or expanded use of the aquifer could result in additional saline-water encroachment. It is estimated that by 2040 about 24,810 acre-feet per year of the basin needs will be supplied by reuse. Assuming additional water resources development in New Mexico, the long-range estimate of supplies from Lake Meredith is about 60 percent of the permitted diversion. This is the subject of a Supreme Court lawsuit with Texas and Oklahoma seeking to prevent New Mexico from even further depleting Canadian River flows in alleged violation of the interstate compact. Also, in order to insure the continued suitability of water from Lake Meredith for municipal and manufacturing purposes, the salinity control project proposed by the Bureau of Reclamation near Logan, New Mexico needs to be constructed.

RED RIVER BASIN



Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
N.F. Buffalo Creek	1,120	1,120	1,120	1,120
Mackenzie	5,200	1,702	5,200	5,171
Greenbelt	9,400	4,814	7,666	5,794
Kemp	118,000	70,027	108,700	70,027
Electra City	600	109	600	593
Kickapoo	21,000	10,965	20,200	18,100
Arrowhead	41,000	22,284	37,000	36,652
Farmers Creek	4,500	1,198	4,500	1,753
HubertMoss	8,300	2,563	5,500	5,497
Texoma	147,500	93,287	147,500	144,220
Randell	5,280	5,024	5,280	5,280
Valley	10,000	8,383	10,000	8,383
Bonham	7,240	1,544	4,850	3,951
New Bonham	0	0	93,800	53,391
Pat Mayse	58,900	17,071	58,600	32,518

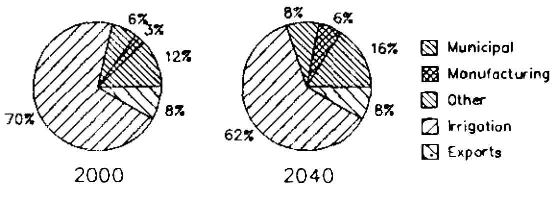
Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Ogallala (High Plains)	639,284	488,929
Seymour	54,357	47,952
Blaine	20,629	22,737
Trinity	2,895	2,965
Carrizo-Wilcox	40	40
Woodbine	5,346	5,414

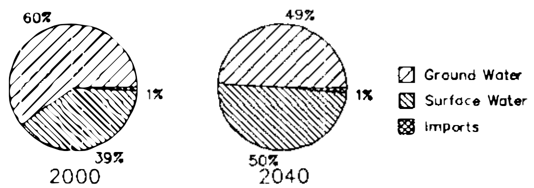
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	122,477	172,191
Manufacturing	26,866	60,907
Steam Electric	18,500	43,500
Mining	1,478	901
Irrigation	719,269	664,947
Livestock	45,949	45,949
Total In-Basin Demands	934,539	988,395
IN-BASIN SUPPLIES		
Ground Water	728,096	555,447
Surface Water	468,175	467,008
Total In-Basin Supplies	1,196,271	1,022,455
TRANSFERS		
Import Supplies	12,208	15,002
Export Demands	85,898	164,211
ADDITIONAL NEW SUPPLIES	1,000	95,300
AGRICULTURAL SHORTAGE	(8,147)	(139,915)
NET AVAILABILITY	197,189	24,766

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Red River Basin is bounded on the north by the Canadian River Basin and on the south by the Brazos, Trinity, and Sulphur River basins (see Figure 1-4). The economy of the area is based on agriculture, oil and gas production, agribusiness, manufacturing, and retail and wholesale trade. The population of the basin totaled about 506,000 people in 1980. Total population of the basin is currently estimated at 533,400 residents, representing an increase of about five percent above the 1980 population. The basin population is projected to range between 817,500 and 944,800 residents by the year 2040. The major population centers of the basin include the Cities of Amarillo, Wichita Falls, Texarkana, Sherman, Paris, Denison, Hereford, Vernon, Canyon, and Burkburnett.

Current Water Uses. Total annual water use supplied by water resources available to the basin is currently 948,101 acre-feet. Irrigation is the largest water demand in the basin with a current use of 770,592 acre-feet. Other major water demand categories in the basin include municipal and livestock water use.

Current Water Supplies. Over 60 percent of the basin needs are supplied by ground water from eight aquifers underlying the basin. From upper basin to lower basin these aquifers include the Ogallala, Dockum, Seymour, Blaine, Trinity, Woodbine, Blossom, and Nacatoch.

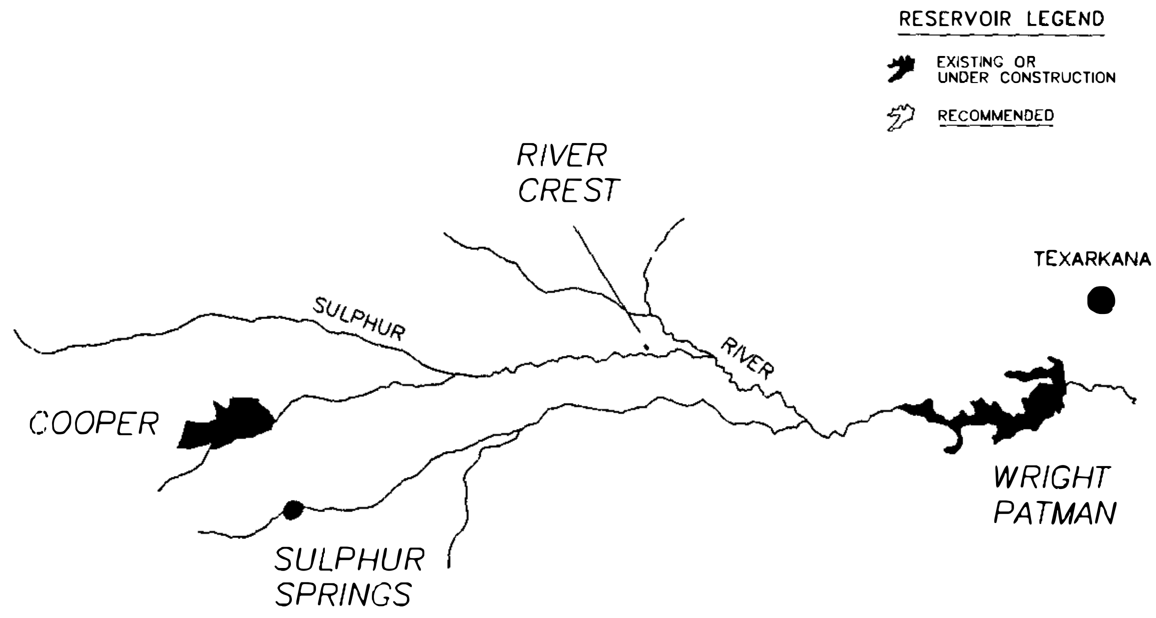
There are 23 major reservoirs in the Red River Basin of which 14 are water-supply reservoirs that have the potential to supply over 441,240 acre-feet per year of surface water to in-basin and out-of-basin users. In terms of major basin imports or exports, portions of the City of Amarillo receive imports from the Canadian River Municipal Water Authority in the upper basin while Lake Texoma in the middle Red River Basin provides exports to the North Texas Municipal Water District in the adjacent Trinity Basin.

Current Water Quality. Under low flow conditions, excessive concentrations of dissolved solids, sulfates, and chlorides are a general problem in most streams of the basin. During these low flow conditions in the upper basin, dissolved solids frequently exceed 25,000 mg/l concentrations, primarily arising from salt springs and seeps. Solids concentrations generally remain high until intervening flows into and below Lake Texoma reduce solids level to 1,000 mg/l or less. Ground-water quality is generally good (less than 1,000 mg/l TDS) in the Ogallala, Seymour, and Trinity aquifers in the upper, middle and lower Red River Basin, respectively, although salinity has increased locally in areas of high pumpage in the Ogallala and in downdip and eastern portions of the Trinity. Ground water in the Woodbine and Nacatoch aquifers in the eastern part of the basin contain generally less than 1,000 mg/l TDS, while the Blaine and Blossom aquifers in the west-central and eastern portions of the basin have TDS levels ranging from 500 to more than 5,000 mg/l.

Future Water Uses. The current water use pattern of the basin is not anticipated to change significantly over the 50-year planning period, as irrigation is projected to remain the major water demand category of the Red River Basin. Although irrigation water requirements are projected to account for a significant portion of the basin's future water requirements, improvements and implementation of more water use efficient irrigation equipment and management practices are projected to reduce irrigation water demands in the basin through the year 2040. Additionally, implementation of municipal water use conservation programs and practices are projected to reduce annual municipal water use by more than 9,555 acre-feet by the year 2000 and by about 29,573 acre-feet by the year 2040 below the Board's without-conservation forecast.

Future Water Supplies. In the future, some cities that are currently on ground water will have to convert to surface water supplies that have already been developed in the basin. Also, some of the smaller communities with ground-water problems will have to develop surface water projects that are considered local in nature (less than 1,000 acre-feet capacity). The only planned major water supply reservoir is the New Bonham Project, which will supply 93,800 acre-feet per year of surface water to the North Texas Municipal Utility District for use in the Dallas area. Construction of the federal chloride control project, including the Canal Creek, Little Red River, and Dry Salt Creek diversion lakes, is also recommended to improve water quality and expand future useable supplies.

SULPHUR RIVER BASIN



Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Cooper	122,000	42,051	122,000	99,988
Sulphur Springs	7,800	5,415	7,800	7,784
River Crest	10,000	1,500	10,000	1,500
Wright Patman	180,000	74,872	180,000	136,263

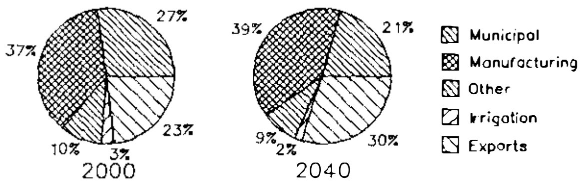
Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Carrizo-Wilcox	4,205	4,350
Trinity	858	748
Nacatoch	1,005	912
Woodbine	820	894
Blossom	512	158

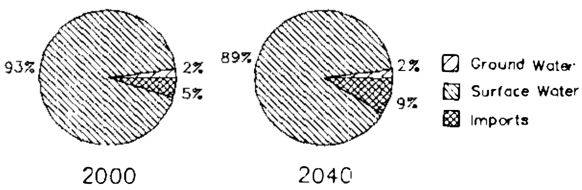
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	43,263	61,560
Manufacturing	58,481	116,509
Steam Electric	6,500	16,500
Mining	587	455
Irrigation	4,804	4,804
Livestock	8,825	8,825
Total In-Basin Demands	122,460	208,653
IN-BASIN SUPPLIES		
Ground Water	7,665	7,521
Surface Water	331,843	331,349
Total In-Basin Supplies	339,508	338,870
TRANSFERS		
Import Supplies	16,997	32,388
Export Demands	38,963	89,220
ADDITIONAL NEW SUPPLIES	0	0
AGRICULTURAL SHORTAGE	(880)	(880)
NET AVAILABILITY	195,962	74,265

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Sulphur River Basin is bounded on the north by the Red River Basin, on the west by the Trinity River Basin, on the south by the Sabine and Cypress River Basins, and on the east by the Texas-Arkansas border (see Figure 1-4). The economy of the area is based on agriculture, agribusiness, manufacturing, retail and wholesale trade, and government. The 1980 basin population totaled 154,000 people. Currently, the basin population is estimated at about 163,300 residents, representing an increase of about seven percent above the 1980 population. By the year 2040, the basin population is projected to range between 246,700 and 293,600 residents. The major population centers in the basin include the Cities of Texarkana, Paris, Sulphur Springs, Commerce, Atlanta, New Boston, Clarksville, Wake Village, Nash, and Mount Vernon.

Current Water Uses. Total annual water use supplied by the basin's water resources is currently 90,405 acre-feet. The largest water use categories within the basin are for manufacturing and municipal purposes with a combined total use of 76,197 acre-feet. Other major water demands are irrigation and livestock water use.

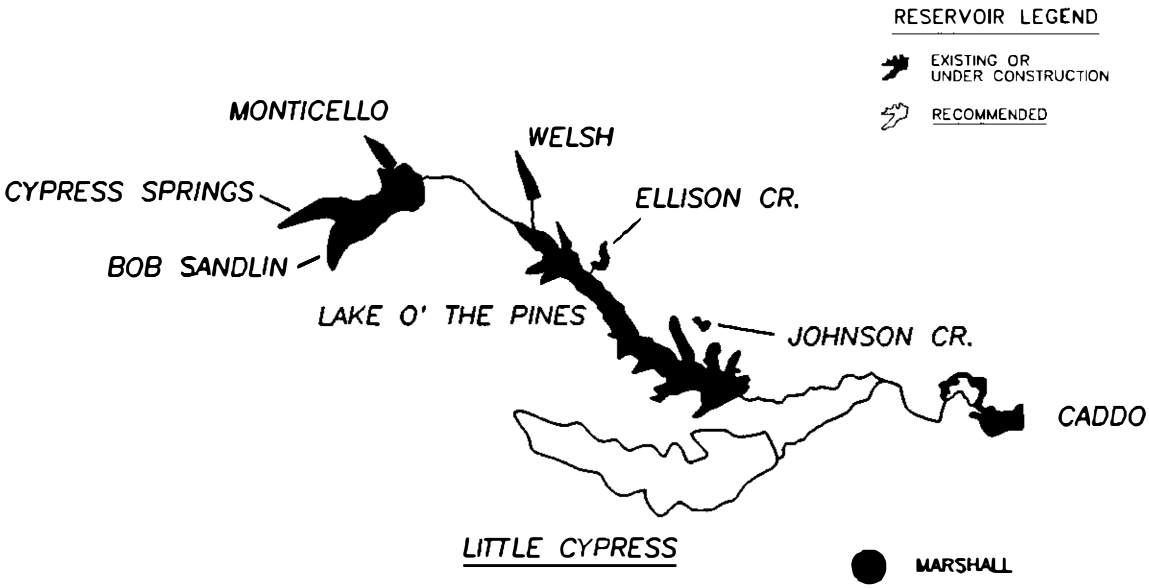
Current Water Supplies. There are three major water-supply reservoirs in the Sulphur Basin and one under construction. Currently, two reservoirs (Lake Sulphur Springs and Lake Wright Patman) are capable of supplying over 187,800 acre-feet per year and are meeting most of the surface-water needs of the basin. Cooper Lake, presently under construction, will provide 122,000 acre-feet per year of surface water to the City of Irving, the North Texas Municipal Water District and the Sulphur River Municipal Water District. In addition, major ground-water supplies are available from the Carrizo-Wilcox Aquifer with lesser supplies occurring in the Trinity, Woodbine, Blossom, Nacatoch, and Queen City aquifers.

Current Water Quality. Generally, both surface and ground-water supplies are of relatively good quality. In the South Sulphur River and Days Creek, municipal wastewater discharges, during low flow conditions, have caused problems of low dissolved oxygen, elevated fecal coliform counts, and elevated nutrients. While the concentrations of TDS are generally less than 500 mg/l, iron concentrations are a problem locally in the Queen City and Carrizo-Wilcox aquifers. Saline encroachment is a potential problem with localized heavy withdrawals from the Woodbine, Nacatoch, and Blossom aquifers. Locally, the concentration of fluoride in the Woodbine, Nacatoch, and Blossom aquifers exceeds the Interim Primary Drinking Water Standards.

Future Water Uses. The current water use pattern of the basin is expected to change over the 50-year planning period as export demand is projected to become the second largest demand on the basin's water supply by the year 2040. In-basin municipal and manufacturing water requirements are projected to account for about 60 percent of the basin's total water requirements for the same year. With implementation of municipal water conservation programs and practices, annual savings in municipal water are projected to reach about 3,509 acre-feet by the year 2000, increasing further to about 10,862 acre-feet by the year 2040.

Future Water Supplies. No additional projects are proposed for this basin; however, if the Board's water demand forecasts are too low due to conservation goals not being obtained, even more rapid growth being realized than projected by the Board, or certain projects recommended for development in other basins cannot be constructed, there are additional sites, such as Parkhouse 1 and 2 and Marvin Nichols 1 and 2, within this basin that could be developed to meet future water-supply needs in other basins.

CYPRESS RIVER BASIN



Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Cypress Springs	16,200	2,613	16,200	4,534
Monticello	7,700	7,700	7,700	7,700
Bob Sandlin	48,500	4,234	48,500	31,375
Welsh	13,100	13,100	13,100	13,100
Ellison Creek	22,100	22,100	22,100	22,100
Johnson Creek	6,700	3,000	6,700	6,700
Lake O' The Pines	130,600	59,808	130,600	65,161
Little Cypress	0	0	129,000	85,076
Caddo	10,000	6,515	10,000	0

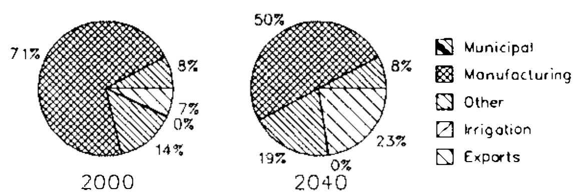
Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Carrizo-Wilcox	14,323	11,104
Queen City	3,014	13,197

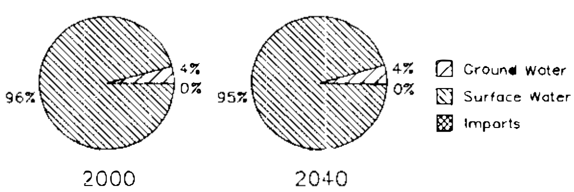
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	22,525	32,317
Manufacturing	204,165	207,277
Steam Electric	35,000	63,500
Mining	1,529	11,523
Irrigation	1,154	1,154
Livestock	4,670	4,670
Total In-Basin Demands	269,043	320,441
IN-BASIN SUPPLIES		
Ground Water	17,337	24,301
Surface Water	259,698	250,167
Total In-Basin Supplies	277,035	274,468
TRANSFERS		
Import Supplies	26	1,743
Export Demands	19,170	93,802
ADDITIONAL NEW SUPPLIES	146,984	276,034
AGRICULTURAL SHORTAGE	0	0
NET AVAILABILITY	135,832	138,002

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Cypress River Basin is bounded on the north by the Sulphur River Basin, on the west and south by the Sabine River Basin, and on the east by the Texas-Arkansas and Texas-Louisiana borders (see Figure 1-4). The economy of the area is based on manufacturing, agriculture, agribusiness, retail and wholesale trade, and mineral production. Population of the basin totaled about 118,200 people in 1980. Currently, the total basin population is estimated at 125,500 residents, representing an increase of about six percent above the 1980 basin population. By the year 2040, population of the basin is projected to range between 200,500 and 230,900 residents. Major population centers within the Cypress River Basin include the Cities of Marshall, Mount Pleasant, Atlanta, Gilmer, Pittsburg, Winnsboro, Daingerfield, Hughes Springs, Linden, and Waskom.

Current Water Uses. Total annual water use within the basin is currently 200,961 acre-feet. The largest water using category is manufacturing with current use of 145,093 acre-feet. Other major water demands placed on the basin's water resources are steam-electric power generation, municipal, and exports for use in other basins.

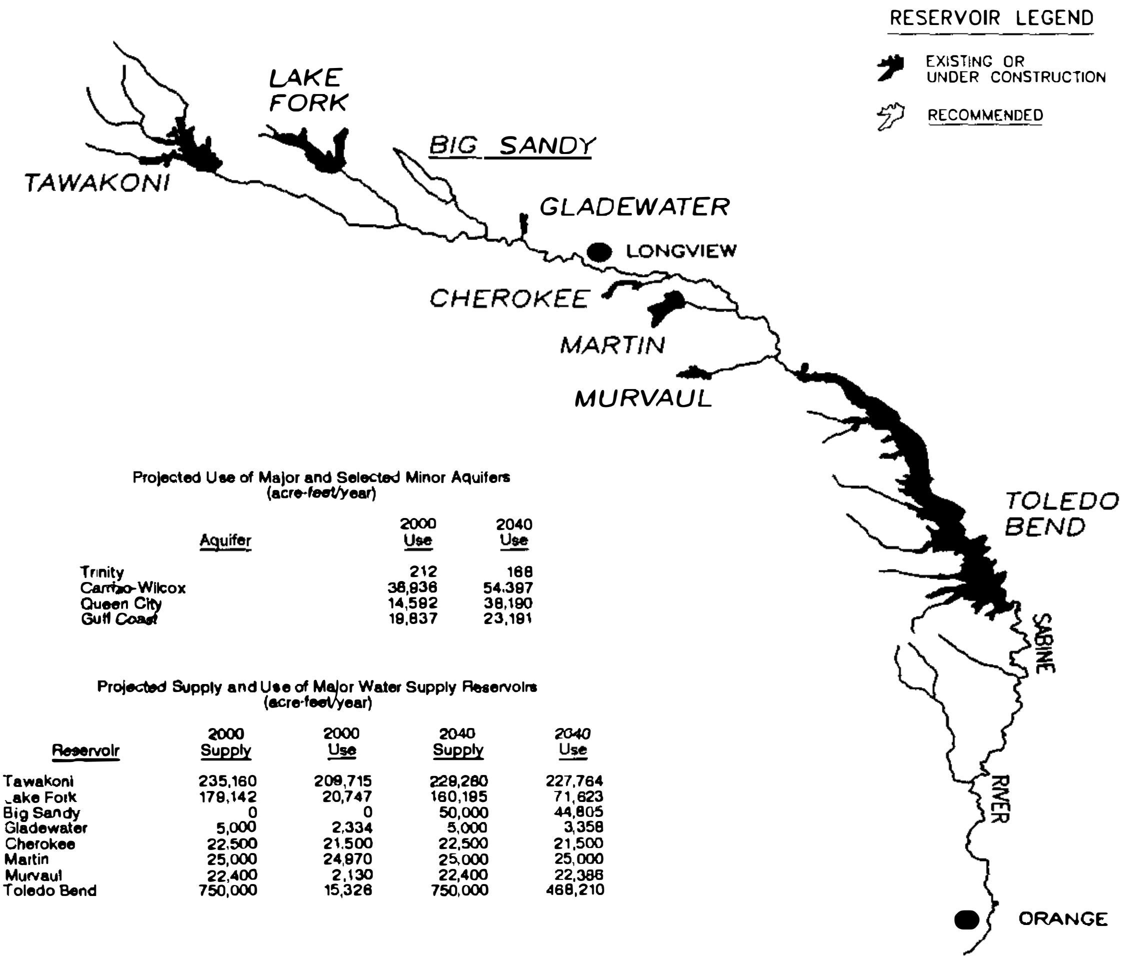
Current Water Supplies. The Cypress River Basin is one of the most developed basins in the State for its size. There are eight major water-supply reservoirs in this 2,812 square mile basin which can supply a total of 254,900 acre-feet per year of water. Most of this supply is used for industrial purposes and steam-electric power generation. The majority of ground-water supplies is obtained from the Carrizo-Wilcox Aquifer with lesser amounts supplied from the Queen City Aquifer.

Current Water Quality. Surface water is generally of good quality, although streams in the Cypress Basin periodically exhibit low dissolved oxygen concentrations sometimes caused by point source wastewater discharges and compounded by sluggish stream velocities and low reaeration rates. Ground-water quality of the Carrizo-Wilcox is generally good, although supplies from the shallow water-bearing sands of the Carrizo-Wilcox and the Queen City aquifers often have high iron levels and high acidity values. Local declines in artesian pressure in the Carrizo-Wilcox Aquifer presents potential problems in the basin, especially saline encroachment.

Future Water Uses. The current water use pattern of the Cypress River Basin is anticipated to change over the 50-year planning period as exports become the second largest demand on the basin's water supply by the year 2040. Manufacturing water requirements are projected to account for about 50 percent of the basin's total water requirements by the end of the planning period. With implementation of municipal water conservation programs and practices, annual savings of municipal water in the basin is projected to reach 1,819 acre-feet by the year 2000, and about 5,688 acre-feet by the year 2040.

Future Water Supplies. Approximately 147,000 acre-feet per year of future needs will be met through reuse by the year 2040, primarily for steam-electric power generation and industrial water uses. In addition, the Little Cypress Utility District has received a permit to constructthe Little Cypress Reservoir. When complete, this reservoir will supply 129,000 acre-feet per year of surface water to meet the future needs within this basin, a portion of the Sabine River Basin, and possibly the City of Shreveport, Louisiana. Environmental considerations related to impacts of potential significant lowering of Caddo Lake levels through expanded water supply use, especially during dry weather periods, preclude it being a viable site for future water supplies in the Board's forecasts. The Northeast Texas Municipal Water District has requested that the Corps of Engineers perform a reallocation study of flood control storage to water supply storage on Lake O' The Pines.

SABINE RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Trinity	212	168
Carrizo-Wilcox	38,936	54,387
Queen City	14,582	38,190
Gulf Coast	19,837	23,191

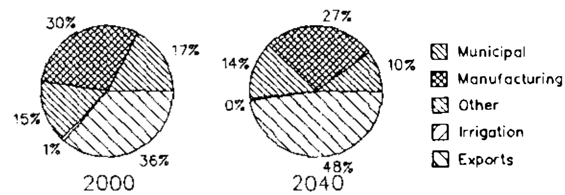
Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Tawakoni	235,160	209,715	229,280	227,764
Lake Fork	179,142	20,747	160,185	71,623
Big Sandy	0	0	50,000	44,805
Gladewater	5,000	2,334	5,000	3,358
Cherokee	22,500	21,500	22,500	21,500
Martin	25,000	24,870	25,000	25,000
Murvaul	22,400	2,130	22,400	22,388
Toledo Bend	750,000	15,326	750,000	468,210

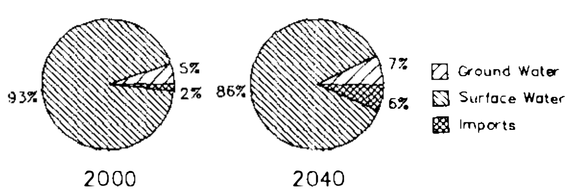
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	93,710	129,895
Manufacturing	165,414	348,573
Steam Electric	65,000	141,000
Mining	6,531	29,484
Irrigation	5,555	5,555
Livestock	12,005	12,005
Total In-Basin Demands	348,215	666,512
IN-BASIN SUPPLIES		
Ground Water	73,658	116,137
Surface Water	1,336,803	1,310,014
Total In-Basin Supplies	1,410,461	1,426,151
TRANSFERS		
Import Supplies	23,217	101,580
Export Demands	197,014	608,870
ADDITIONAL NEW SUPPLIES	0	50,000
AGRICULTURAL SHORTAGE	0	0
NET AVAILABILITY	888,449	302,349

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Sabine River Basin in Texas is bounded on the north by the Sulphur and the Cypress River Basins, on the west by the Trinity and Neches River Basins, and on the east by the Texas-Louisiana border (see Figure 1-4). The economy of the area is based on manufacturing, agriculture, agribusiness, mineral production, retail and wholesale trade, and recreation. In 1980, the population of the basin totaled about 407,300 people. Currently, the basin population is estimated at 456,000 residents, representing an increase of 12 percent above the 1980 population. By the year 2040, the basin population is projected to range between 734,200 and 848,500 residents. Major population centers in the Sabine River Basin include the Cities of Longview, Greenville, Orange, Marshall, Kilgore, Bridge City, and Gladewater.

Current Water Uses. Total annual water use is currently 249,650 acre-feet. The largest demand placed on the basin's water resources is for exports to other basins currently estimated at over 112,000 acre-feet. Other major water demands in the basin include manufacturing, municipal, and steam-electric power generation.

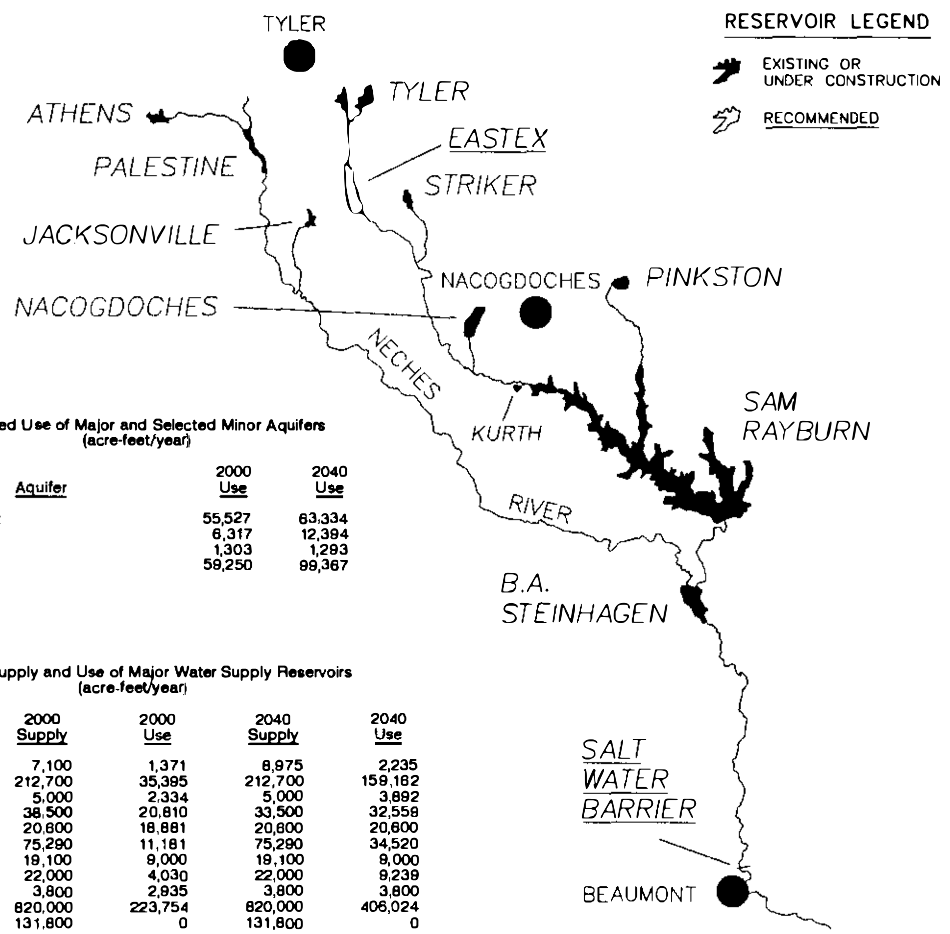
Current Water Supplies. The surface water within the Sabine River Basin was apportioned between the States of Louisiana and Texas by the Sabine River Compact in 1954. Of the 12 major reservoirs in the Texas portion of the basin, five are used for recreation and flood regulation. The remaining seven reservoirs supply about 1,245,450 acre-feet per year of surface water to users within the basin and in portions of the Neches, Sulphur, and Trinity River Basins. Ground water is obtained from the Carrizo-Wilcox, Nacatoch, Trinity, Queen City, Sparta, and Gulf Coast aquifers. Other basin water-supply issues include flooding and drainage, environmental conflicts, and conflicts over local use versus out-of-basin use.

Current Water Quality. While limited areas of the basin exhibit salinity problems in surface water supplies, current surface water quality is generally good. In the past, the Sabine River has experienced frequent dissolved oxygen violations, although improved wastewater treatment has greatly improved river water quality. Generally, dissolved solids concentrations in the Gulf Coast, Carrizo-Wilcox, Sparta and Queen City aquifers are below 1,000 mg/l, while ground water in portions of the Trinity and Nacatoch exhibit relatively higher salinity. Ground water contained in the shallow water-bearing sands of the Carrizo-Wilcox and Queen City aquifers often have high concentrations of iron and acidity. Saline water encroachment and land surface subsidence are potential problems in the basin due to heavy withdrawals of ground water from the Gulf Coast Aquifer in the lower part of the basin.

Future Water Uses. The current water use pattern of the basin is not anticipated to change significantly over the 50-year planning period, as export demand is expected to remain the major water demand on the basin's water supplies. Manufacturing and municipal water requirements are projected to account for about 37 percent of the basin's total water requirements by the year 2040. Annual municipal water savings, through implementation of municipal water conservation programs and practices, are projected to reach about 7,506 acre-feet by the year 2000, increasing further to about 22,713 acre-feet by the year 2040.

Future Water Supplies. To meet future needs, additional ground water will need to be developed, primarily for mining and steam-electric power generation. The Big Sandy Reservoir Project will need to be constructed to supply 50,000 acre-feet per year of surface water to meet municipal and manufacturing needs in the upper basin. At the present time, the acceptance of a federal non-development easement precludes the implementation of the potential Waters Bluff Reservoir Project in the upper basin. This potentially precedent-setting easement (see Federal/State Relations portion of Section 4) has been litigated, and the easement upheld. An appeal to this decision may be filed. Depending upon the outcome of this possible action, the Waters Bluff Reservoir may be a viable site for future water supplies. Depending upon the degree of water conservation savings that can be obtained in the Houston area, between 336,000 and 513,000 acre-feet per year of surface water will need to be exported from Toledo Bend Reservoir to the San Jacinto River Basin to meet the outstanding future needs in the Houston area that are not met with other supplies. Also, existing surface water supply in Lake Fork Reservoir under contract to Dallas is projected to be made available for its use through construction of major conveyance facilities between 2010 to 2030.

NECHES RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

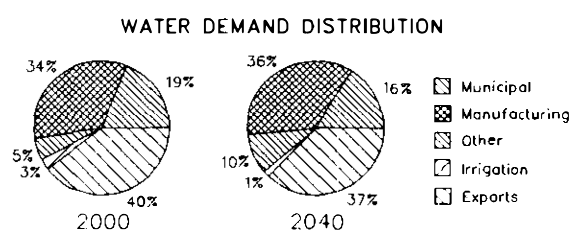
Aquifer	2000 Use	2040 Use
Carrizo-Wilcox	55,527	63,334
Queen City	6,317	12,394
Sparta	1,303	1,293
Gulf Coast	59,250	99,367

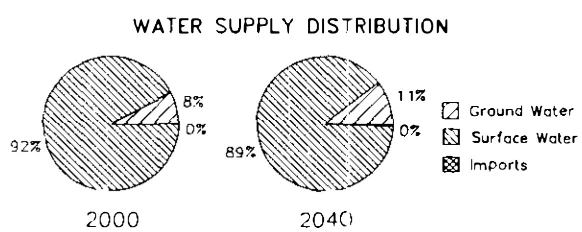
Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Athens	7,100	1,371	8,975	2,235
Palestine	212,700	35,395	212,700	159,182
Jacksonville	5,000	2,334	5,000	3,892
Lake Tyler	38,500	20,810	33,500	32,558
Striker	20,600	18,881	20,600	20,600
Eastex	75,290	11,181	75,290	34,520
Kurth	19,100	9,000	19,100	9,000
Nacogdoches	22,000	4,030	22,000	9,239
Pinkston	3,800	2,935	3,800	3,800
Sam Rayburn	820,000	223,754	820,000	406,024
Steinhagen	131,800	0	131,800	0

PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	111,900	161,441
Manufacturing	198,441	358,441
Steam Electric	17,000	78,000
Mining	3,772	8,308
Irrigation	15,064	15,064
Livestock	11,397	11,397
Total In-Basin Demands	357,574	632,651
IN-BASIN SUPPLIES		
Ground Water	127,048	181,753
Surface Water	1,445,849	1,442,895
Total In-Basin Supplies	1,572,897	1,624,648
TRANSFERS		
Import Supplies	1,413	4,888
Export Demands	234,536	373,341
ADDITIONAL NEW SUPPLIES	75,290	75,290
AGRICULTURAL SHORTAGE	(71)	(336)
NET AVAILABILITY	1,057,559	699,170





Basin Description. The Neches River Basin is bounded on the north and east by the Sabine River Basin, on the west by the Trinity River Basin, and on the south by the Neches-Trinity Coastal Basin (see Figure 1-4). The economy of the area is based on manufacturing, forestry, agriculture, agribusiness, oil and gas production, and retail and wholesale trade. The population of the basin totaled about 506,400 people in 1980. The current population of the basin is estimated at 553,400 residents, representing an increase of about nine percent above the 1980 basin population. The basin population is projected to range between 930,100 and 1,076,100 residents by the year 2040. Major population centers within the basin include the Cities of Beaumont, Tyler, Port Arthur, Lufkin, Nacogdoches, Palestine, Nederland, Groves, Port Neches, and Jacksonville.

Current Water Uses. Total annual water use in the basin is currently 298,293 acre-feet. The largest water demands in the basin are for manufacturing and municipal purposes with a combined use of 242,279 acre-feet. Other major water demands placed on the basin's water supplies are exports for use in other basins and irrigation.

Current Water Supplies. There are ten major water-supply reservoirs in the basin. These projects, along with run-of-the-river flows, are capable of supplying 1,281,400 acre-feet per year of dependable surface water supplies. Several of the reservoirs provide water to cities out of the basin. Lake Athens provides water to the City of Athens in the Trinity River Basin. Lake Pinkston provides water to the City of Center located in the Sabine River Basin. Over 53 percent of Lake Palestine is owned by the City of Dallas in the Trinity River Basin and will be needed by the Dallas utility before 2010.

Ground water from the Carrizo-Wilcox, Queen City, Sparta, and Gulf Coast aquifers Is used to meet about 40 percent of the current needs of the basin. Localized ground-water declines are a problem in some areas of the basin.

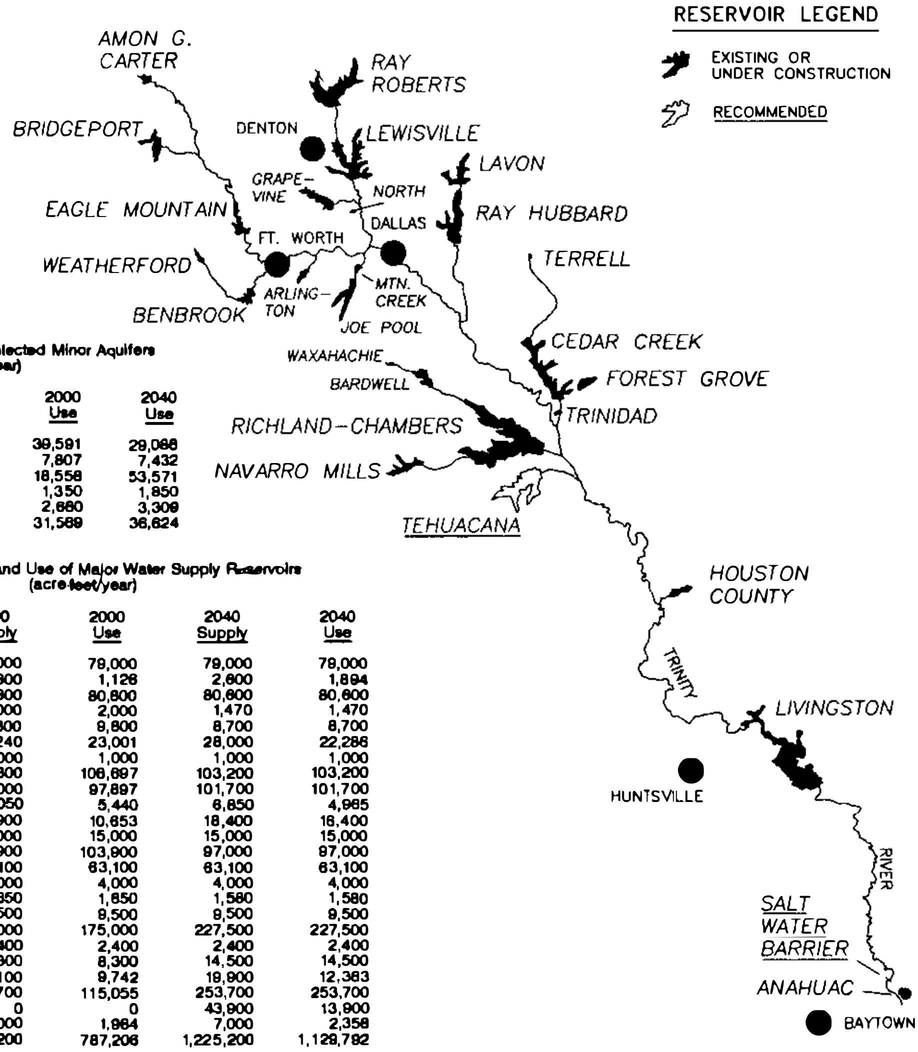
Other water supply-related problems in the basin Include environmental concerns associated with the Big Thicket and other bottomland hardwood habitats, and salt water intrusion in the tidally-influenced reaches of the Neches River.

Current Water Quality. Surface water quality in the basin is generally excellent, although localized areas of higher salinity from oil field run-off are present. Poorer stream quality in the form of low dissolved oxygen and pH may result in the headwaters of Sam Rayburn Reservoir, on the Angelina River, and the Neches River, upstream of Lake Palestine during low flow conditions due to municipal and industrial discharges. In the tidal portion of the basin, reduced waste loadings have substantially improved water quality. Water quality from the Carrizo-Wilcox, Gulf Coast, Queen City, and Sparta aquifers is generally good (less than 500 mg/l TDS), although salinity may increase downdip and high iron and acid concentrations may be present in the shallow water-bearing sands of the Carrizo-Wilcox and Queen City formations.

Future Water Uses. The current water use pattern of the basin is not expected to change significantly over the 50-year planning period, as export demand and manufacturing water requirements are projected to account for about 73 percent of the basin's total water requirements by the year 2040. With implementation of municipal water conservation programs and practices, annual savings in municipal water are projected to reach 8,997 acre-feet by the year 2000, and about 28,328 acre-feet by the year 2040.

Future Water Supplies. In the future, the total quantity of ground water use will increase, but will comprise less than 30 percent of the total water use in the basin. The Angelina and Neches River Authority has received a permit to construct the Eastex Reservoir Project on Mud Creek. This project could supply 75,290 acre-feet per year to municipal and manufacturing entities currently on ground water that may choose to convert to surface water in the future and provide for future additional steam-electric and manufacturing water uses. A salt water barrier is also recommended on the lower Neches River to protect municipal and industrial water supplies in the lower basin from sea water intrusion.

TRINITY RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Trinity	39,591	29,066
Woodbine	7,807	7,432
Carrizo-Wilcox	18,558	53,571
Queen City	1,350	1,850
Sparta	2,660	3,309
Gulf Coast	31,569	36,624

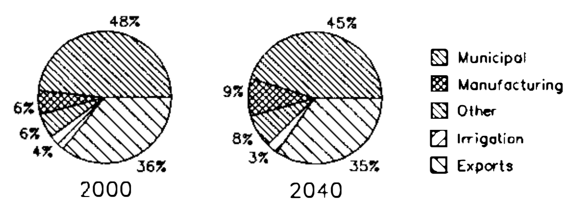
Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Bridgeport	79,000	79,000	79,000	79,000
Amon G. Carter	2,600	1,126	2,600	1,894
Eagle Mountain	80,600	80,800	80,600	80,600
Weatherford	2,000	2,000	1,470	1,470
Benbrook	9,800	9,800	8,700	8,700
Grapevine	27,240	23,001	28,000	22,286
North	1,000	1,000	1,000	1,000
Lewisville	110,800	106,697	103,200	103,200
Ray Roberts	110,000	97,897	101,700	101,700
Arlington	7,050	5,440	6,850	4,965
Joe Pool	16,900	10,653	18,400	16,400
Mountain Creek	15,000	15,000	15,000	15,000
Lavon	103,900	103,900	97,000	97,000
Ray Hubbard	63,100	63,100	63,100	63,100
Trinidad	4,000	4,000	4,000	4,000
Terrell	1,650	1,650	1,580	1,580
Forest Grove	9,500	9,500	9,500	9,500
Cedar Creek	175,000	175,000	227,500	227,500
Waxahachie	2,400	2,400	2,400	2,400
Bardwell	8,300	8,300	14,500	14,500
Navarro Mills	23,100	9,742	19,900	12,363
Richland-Chambers	190,700	115,055	253,700	253,700
Tehuacana	0	0	43,900	13,900
Houston County	7,000	1,964	7,000	2,358
Livingston	1,225,200	787,206	1,225,200	1,129,792

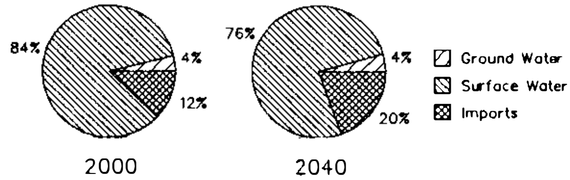
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	1,054,835	1,425,568
Manufacturing	126,356	290,918
Steam Electric	81,300	147,800
Mining	20,262	76,491
Irrigation	86,095	89,039
Livestock	30,296	30,296
Total In-Basin Demands	1,399,144	2,060,112
IN-BASIN SUPPLIES		
Ground Water	105,398	145,880
Surface Water	2,324,595	2,271,142
Total In-Basin Supplies	2,429,993	2,417,022
TRANSFERS		
Import Supplies	339,843	639,639
Export Demands	785,465	1,090,877
ADDITIONAL NEW SUPPLIES	2,000	203,900
AGRICULTURAL SHORTAGE	0	0
NET AVAILABILITY	587,227	109,572

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Trinity Basin is bounded on the north by the Red River Basin, on the east by the Sabine and Neches basins, and on the west by the Brazos and San Jacinto basins (see Figure 1-4). The economy is based on manufacturing, finance, services, transportation, and agribusiness. Basin population in 1980 totaled 3.2 million people. The current basin population is about 4.1 million (a 28 percent increase since 1980) and should reach between 6.8 and 7.7 million residents by 2040. Major population centers include Dallas and Fort Worth, their suburban areas, and the cities of Huntsville, and Corsicana.

Current Water Uses. Total basin annual water use is currently 1,049,721 acre-feet. Due to the large population, municipal water use is, by far, the largest basin demand with a current annual use of 820,967 acre-feet. Other major water demands on the basin's supplies are exports for other basins, manufacturing, and irrigation.

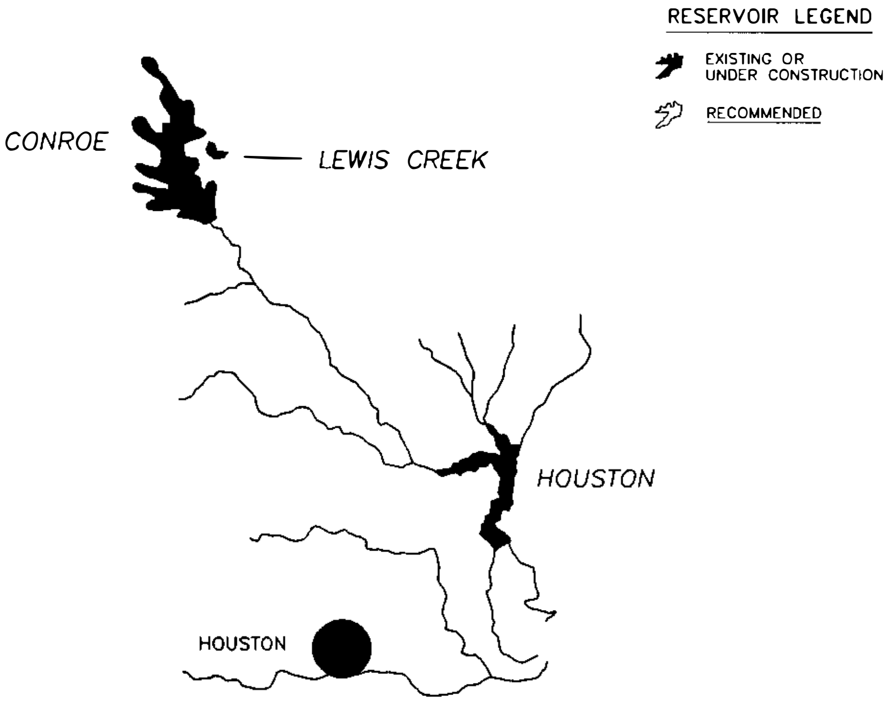
Current Water Supplies. Twenty-four of the 30 major basin reservoirs are for water supply, providing over 2,281,300 acre-feet per year. Lake Livingston, containing over 50 percent of the basin's surface water supply, provides water to Houston and users in coastal basins. Major suppliers in the upper basin are the Dallas Water Utilities, Tarrant County WCID No. 1, and North Texas Municipal Water District (NTMWD). Ground-water supplies are obtained from seven aquifers, including the Trinity, Woodbine, Carrizo-Wilcox, Gulf Coast, Queen City, Sparta, and Nacatoch aquifers. Water supply problems include poor stream and ground-water quality in portions of the basin, water-level declines and depletion of storage in the aquifers, flooding and drainage, concern for wetlands and the Trinity-San Jacinto Estuary, and salt water intrusion in the lower reaches of the Trinity River.

Current Water Quality. Surface water quality varies widely from the cleaner headwaters of the basin to the more effluent-dominated, nutrient-rich waters below the Dallas-Ft. Worth metroplex. Elevated levels of ammonia, nitrogen, and phosphorus with resulting increases in biochemical demand (which causes depressed dissolved oxygen concentrations), fecal coliform, and volatile suspended solids have been prevalent in the upstream reaches in past years during dry periods when flow is effluent-dominated. This historic problem has been much reduced given today's improved wastewater treatment levels. However, depressed oxygen levels and elevated fecal coliform levels are observed in the upper Trinity during rise events in the river stage following significant rainfall, an indication of non-point source pollution problems. Water quality in the Trinity and Gulf Coast aquifers in the upper and lower basin, respectively, ranges from fresh to slightly saline. Water quality in the Queen City, Sparta, and Nacatoch aquifers is generally good (TDS levels below 500 mg/l), while water in the Woodbine Aquifer is relatively poor (TDS levels in excess of 1,500 mg/l). Potential saline encroachment problems exist in the Trinity and Gulf Coast aquifers due to a decline in artesian pressure.

Future Water Uses. The basin's current water use pattern should not change significantly over the next 50 years, as municipal use is projected to remain the basin's major water demand. With implementation of municipal conservation practices, annual water use savings should reach 84,860 acre-feet by 2000, increasing to more than 250,113 acre-feet by 2040.

Future Water Supplies. Ground-water use should decline in the upper basin as cities convert to surface water, while in the central and lower basin, ground-water use should increase. By 2040, about six percent of surface water needs will be supplied by reuse, primarily for steam electric and industrial purposes. A diversion of Trinity River supplies that will allow expanded use of the existing Richland-Chambers and Cedar Creek reservoirs and construction of the new Tehuacana Reservoir is recommended for Tarrant County WCID No. 1 to meet its future supply needs. These projects and system-wide operations will provide over 190,000 acre-feet per year of new supplies, adequate to meet the District's needs beyond 2040. If the Trinity diversion is built, but projected conservation savings are not attained, the District could obtain further supplies by participating in the Parkhouse II or Marvin Nichols reservoirs in the Sulphur Basin. Should the Trinity diversion be infeasible, new supplies from a Marvin Nichols reservoir may be required. The NTMWD will need to construct the New Bonham project in the Red Basin which would provide an additional 93,800 acre-feet of annual supplies. Should the Board's conservation savings not be realized, there would be a need for participation in the Parkhouse II or Marvin Nichols reservoirs. New pipelines from Palestine and Lake Fork reservoirs should provide the Dallas area with adequate surface water supplies through 2040. Parkhouse I Reservoir would be needed by Dallas by 2030 if the Board's predicted conservation savings are not realized. With construction of a salt water barrier in the lower basin, current supplies will be more than adequate to meet future needs of the central and lower Trinity Basin. Additionally, the Tennessee Colony project, if feasible financing were arranged and environmental impacts were acceptable, could provide improved flood protection for the lower basin.

SAN JACINTO RIVER BASIN



Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/years)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Houston	144,600	144,600	130,900	130,900
Lewis Creek	6,300	4,301	6,300	4,301
Conroe	98,200	83,710	91,000	91,000

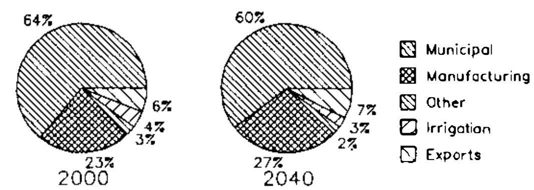
Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Gulf Coast	237,756	226,822

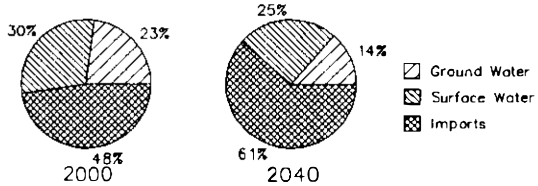
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	656,021	1,010,203
Manufacturing	237,773	460,049
Steam Electric	20,500	27,500
Mining	5,131	5,634
Irrigation	44,850	44,242
Livestock	3,004	3,004
Total In-Basin Demands	967,279	1,550,632
IN-BASIN SUPPLIES		
Ground Water	237,756	226,622
Surface Water	307,164	287,792
Total In-Basin Supplies	544,920	514,414
TRANSFERS		
Import Supplies	495,003	1,028,987
Export Demands	60,000	125,561
ADDITIONAL NEW SUPPLIES	0	130,887
AGRICULTURAL SHORTAGE	(3,745)	(3,904)
NET AVAILABILITY	16,389	1,999

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The San Jacinto River Basin is bounded on the north and east by the Trinity River Basin and the Trinity-San Jacinto Coastal Basin, on the west by the Brazos River Basin, and on the south by the San Jacinto-Brazos Coastal Basin (see Figure 1-4). The economy of the basin is based on manufacturing, finance, services, retail and wholesale trade, agriculture, commercial shipping, commercial fishing, and tourism. The 1980 basin population totaled 2.37 million people. Currently, the total basin population is estimated at 2.75 million residents, representing an increase of about 16 percent since 1980. By the year 2040, population of the San Jacinto Basin is projected to range between 4.8 and 5.6 million residents. The major population centers within the basin include the Cities of Houston, Pasadena, Baytown, Missouri City, Huntsville, Deer Park, Conroe, South Houston, Bellaire, and West University Place.

Current Water Uses. Total annual water use in the basin is currently 738,531 acre-feet. Due to the large basin population, municipal water use is the largest water demand in the basin with a current use of 498,550 acre-feet. Other major water demands placed on the basin's water resources are manufacturing, exports for use in other basins, and irrigation.

Current Water Supplies. About 42 percent of the basin's available supply is ground water from the Gulf Coast Aquifer and is used for municipal, manufacturing, and agricultural purposes. However, the area within the Harris-Galveston Coastal Subsidence District has been given a mandate to convert to between 80 to 90 percent surface water usage by 2010. There are six major reservoirs in the basin of which three are water-supply reservoirs. Lake Conroe, owned and operated by the San Jacinto River Authority, provides municipal and manufacturing water supplies to the City of Houston. Water is also diverted from Lake Conroe to Lewis Creek Reservoir for steam-electric power generation. Lake Houston is owned and operated by the City of Houston for use in its service area. The San Jacinto River Authority also holds water rights to flows in the San Jacinto River. Surface water from the Trinity River Basin is delivered into the basin by the Coastal Water Authority.

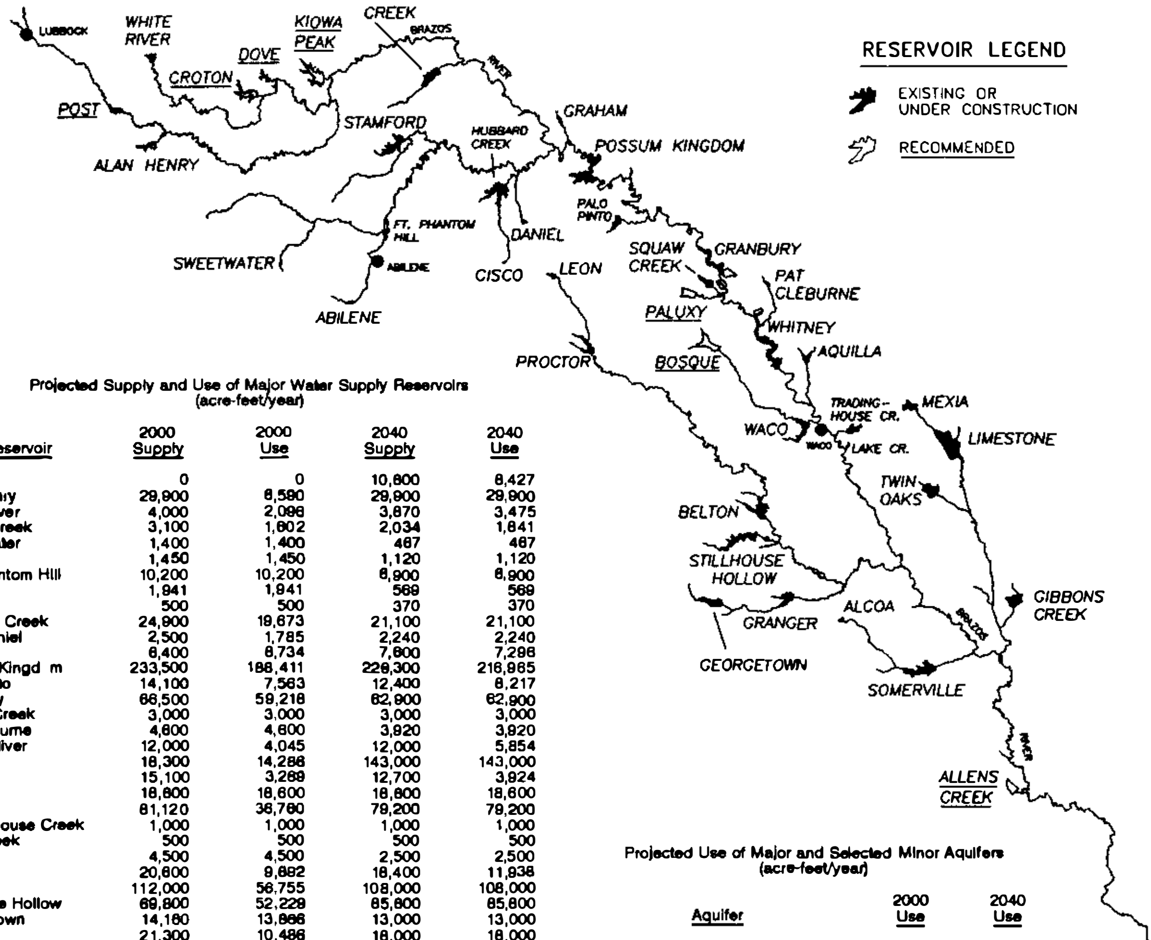
Water-supply problems in the basin include land-surface subsidence due to overdraft of ground water, poor quality ground and surface water, flooding, and environmental concerns for wetlands and the Trinity-San Jacinto Estuary.

Current Water Quality. The basin exhibits wide variations in surface water quality. As the Houston metroplex expands to the north, small wastewater treatment plants increase the organic and nutrient loading and fecal coliform bacteria levels in all major tributaries to Lake Houston. Buffalo Bayou, which drains most of the City of Houston, receives heavy municipal, industrial, and urban stormwater runoff loading. During periods of low flow, low dissolved oxygen and elevated fecal coliform levels are common. Over the past years, water quality in Buffalo Bayou and the Houston Ship Channel has improved due to reduced waste loads, and aquatic and/or marine organisms are inhabiting areas where few had previously been found. Ground water in the Gulf Coast Aquifer generally contains less than 500 mg/l. Land surface subsidence, saline water encroachment, and surface fault activation have occurred as a result of heavy pumpage and corresponding declines in artesian pressure.

Future Water Uses. The current water use pattern of the San Jacinto River Basin is not expected to change significantly over the 50-year planning period, as water requirements for municipal and manufacturing purposes are projected to remain the dominant water using categories within the basin. With implementation of municipal water conservation programs and practices, annual savings in the basin's municipal water are projected to reach 52,905 acre-feet by the year 2000, and increasing further to 177,638 acre-feet by the year 2040.

Future Water Supplies. The basin will need new supplies in the future. Almost all of the additional supplies will be imported into the basin from the Sabine and Trinity River Basins, which will require the development of a major conveyance facility from the Sabine River to either the Trinity River or to terminal storage within the San Jacinto Basin. The development of a salt water barrier on the Trinity River will make surplus supplies in the Trinity River Basin available for export to the San Jacinto River Basin. In addition, by 2040 over 65,200 acre-feet per year of the total water used in the basin will be supplied by the reuse of the supplies for the City of Houston. If the Toledo Bend diversion or diversions from the Trinity River prove infeasible, Lake Creek Reservoir, southwest of Conroe, could be used to meet water demands in the basin. A small local project, Spring Creek Lake, could provide supplemental municipal water supplies to The Woodlands area and Montgomery County.

BRAZOS RIVER BASIN



Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Post	0	0	10,600	8,427
Alan Henry	29,900	8,580	29,900	29,900
White River	4,000	2,098	3,870	3,475
Millers Creek	3,100	1,602	2,034	1,641
Sweetwater	1,400	1,400	467	467
Abilene	1,450	1,450	1,120	1,120
Fort Phantom Hill	10,200	10,200	8,900	8,900
Stamford	1,941	1,941	569	569
Cisco	500	500	370	370
Hubbard Creek	24,900	19,673	21,100	21,100
Lake Daniel	2,500	1,785	2,240	2,240
Graham	6,400	8,734	7,600	7,298
Possum Kingd m	233,500	188,411	228,300	216,965
Palo Pinto	14,100	7,563	12,400	8,217
Granbury	66,500	59,218	62,900	62,900
Squaw Creek	3,000	3,000	3,000	3,000
Pat Cleburne	4,600	4,600	3,920	3,920
Paluxy River	12,000	4,045	12,000	5,854
Whitney	18,300	14,286	143,000	143,000
Aquilla	15,100	3,269	12,700	3,924
Bosque	18,600	18,600	18,600	18,600
Waco	81,120	36,760	79,200	79,200
Tradinghouse Creek	1,000	1,000	1,000	1,000
Lake Creek	500	500	500	500
Leon	4,500	4,500	2,500	2,500
Proctor	20,600	9,882	18,400	11,938
Belton	112,000	56,755	108,000	108,000
Stillhouse Hollow	69,800	52,229	85,600	85,800
Georgetown	14,160	13,866	13,000	13,000
Granger	21,300	10,486	18,000	18,000
Alcoa	9,000	9,000	9,000	9,000
Somerville	41,000	41,000	37,000	37,000
Mexia	3,000	1,211	100	100
Limestone	66,200	53,849	64,000	63,364
Twin Oaks	1,000	1,000	1,000	1,000
Gibbons Creek	1,000	1,000	1,000	1,000
Allens Creek	0	0	66,500	66,500

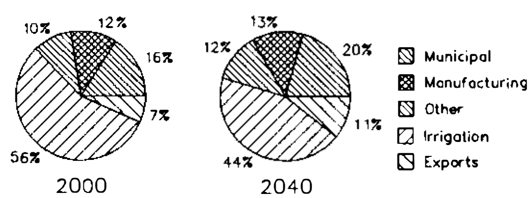
Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Ogallala (High Plains)	1,279,459	1,105,628
Seymour	64,058	51,988
Trinity	27,518	28,239
Brazos River Alluvium	25,982	29,402
Edwards-Balcones	4,275	4,733
Carrizo-Wilcox	92,410	170,125
Gulf Coast	43,401	51,475

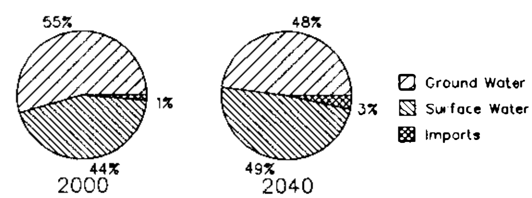
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	417,488	657,865
Manufacturing	310,069	413,735
Steam Electric	167,100	263,600
Mining	18,674	58,156
Irrigation	1,489,439	1,411,868
Livestock	71,277	71,277
Total In-Basin Demands	2,474,047	2,876,501
IN-BASIN SUPPLIES		
Ground Water	1,556,437	1,462,146
Surface Water	1,161,750	1,118,008
Total In-Basin Supplies	2,718,187	2,580,154
TRANSFERS		
Import Supplies	41,273	106,418
Export Demands	179,937	345,771
ADDITIONAL NEW SUPPLIES	95,703	363,529
AGRICULTURAL SHORTAGE	(65,103)	(198,207)
NET AVAILABILITY	266,282	26,036

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Brazos River Basin is bounded on the north by the Red River Basin, on the east by the Trinity and San Jacinto river basins and the San Jacinto-Brazos Coastal Basin, and on the south and west by the Colorado River Basin and the Brazos-Colorado Coastal Basin (see Figure 1-4). The area economy is based on agriculture, agribusiness, manufacturing, mineral production, trades, services, and government. Basin population totaled 1.53 million people in 1980 while the current basin population is about 1.73 million (an increase of 13 percent since 1980). This is expected to increase to between 3.1 and 3.8 million residents by 2040. Major basin population centers include the Cities of Lubbock, Abilene, Waco, Temple-Killeen, Bryan-College Station, Round Rock-Georgetown-Cedar Park-Leander, Sugarland-Richmond-Rosenburg and the Brazosport area.

Current Water Uses. Total annual basin water use is currently 2,034,811 acre-feet. The largest demand placed on the basin's water resources is for irrigation with a current use of 1,427,645 acre-feet. Other major water demands on the basin's water resources are exports for use in other basins, municipal, manufacturing, and steam-electric power generation.

Current Water Supplies. Ground water from the Ogallala and Seymour aquifers supplies most water needs of the upper basin with lesser amounts supplied from the Edwards-Trinity and Dockum aquifers. The Trinity, Edwards-Balcones, and Carrizo-Wilcox aquifers provide most of the ground water in the central basin with lesser amounts from the Queen City, Sparta, and Brazos River Alluvium. The Gulf Coast Aquifer is used in the lower basin.

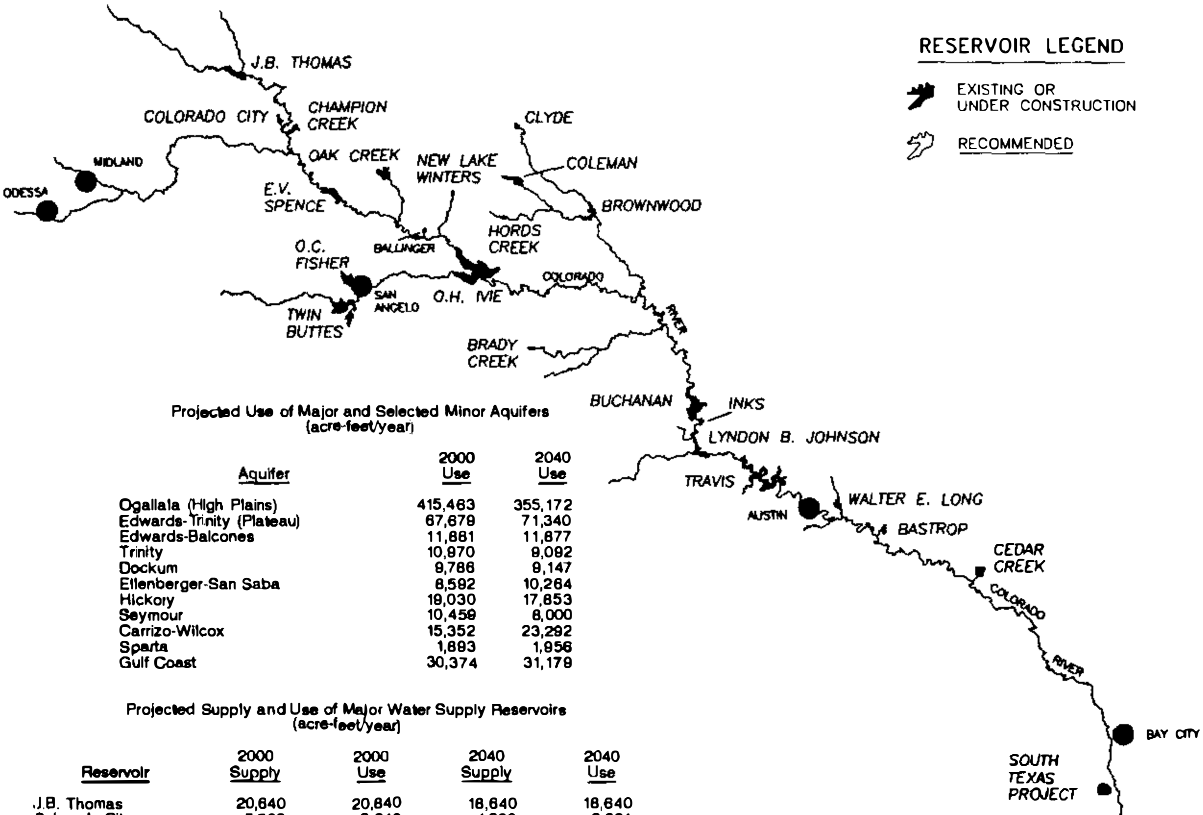
There are 33 major existing water supply reservoirs in the basin. Water is also imported from the Canadian and Colorado basins. The Brazos River Authority (BRA) owns, operates, or has acquired storage in 12 of the reservoirs as part of its basin-wide water system to supply water for in-basin uses and exports to the Trinity and San Jacinto-Brazos basins. Total basin surface water supplies are over 866,000 acre-feet per year.

Current Water Quality. In the many aquifers that traverse the basin, ground-water quality ranges from fresh (Ogallala, Trinity, Carrizo-Wilcox, Edwards, Brazos River Alluvium, and Gulf Coast aquifers) to more highly saline (downdip portions of previous aquifers, Seymour, and locally in the Brazos River Alluvium), with problems of salt water encroachment on both ground-water and surface water supplies present in portions of the upper and central basin. The basin's overall surface water quality is relatively good, but with localized areas of concern. Natural and man-made salt pollution in the upper basin adversely affect surface water quality and municipal supplies. Problems of low dissolved oxygen and elevated fecal coliform levels occasionally exist, during periods of low flow, in the areas of municipal wastewater point source discharges. Frequent elevated fecal coliform levels are a problem in the north Bosque River due to agricultural runoff from local dairy farms.

Future Water Uses. The current water use pattern of the basin is expected to change over the planning period, as municipal and manufacturing water requirements are projected to account for more than 33 percent of the basin water requirements by 2040. Irrigation water use is projected to account for about 44 percent of total basin requirements in 2040. With increased municipal water conservation programs and practices, annual savings are projected to reach 33,736 acre-feet per year by 2000, increasing further to nearly 115,863 acre-feet per year by 2040.

Future Water Supplies. While ground water will continue to provide most of the in-basin supply in the upper basin, two new reservoirs are needed. Lake Alan Henry, already under construction, and Post Reservoir, which already has been permitted, will be required to provide additional supplies to Lubbock. Declining water levels in the Trinity Aquifer have necessitated the planned conversion to surface water by cities in the central basin. The Bosque and Paluxy reservoir projects and the reallocation of storage in Lake Waco will be needed to provide additional surface water supplies. Due to the limited ground-water supplies in the Williamson County area, additional surface water will be needed from Lake Stillhouse Hollow and possibly from imports from the Colorado River Basin. In addition to the Bosque Reservoir Project and Lake Waco reallocation, the Aliens Creek Project and the reallocation of storage in Lake Whitney will be needed to meet the future needs of the BRA system. These projects would supply the lower basin and provide for export to the San Jacinto-Brazos Coastal Basin. These new projects will provide a combined 236,000 acre-feet per year of additional surface water supplies. Reallocation of reservoir storage to water supply would affect some of the existing features of these projects, including flood control and water-based recreation. These would be considered in the permit evaluations. Also, pending the availability of federal and/or state financial support, three brine-retention reservoirs (Croton, Dove, and Kiowa Peak) are recommended for construction in the upper basin to reduce the salinity and improve water quality in several of the basin's reservoirs.

COLORADO RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Ogallala (High Plains)	415,463	355,172
Edwards-Trinity (Plateau)	67,679	71,340
Edwards-Balcones	11,881	11,877
Trinity	10,970	9,092
Dockum	9,786	9,147
Ellenberger-San Saba	8,592	10,264
Hickory	19,030	17,853
Seymour	10,459	8,000
Carrizo-Wilcox	15,352	23,292
Sparta	1,893	1,956
Gulf Coast	30,374	31,179

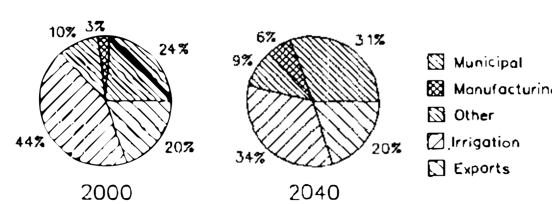
Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
J.B. Thomas	20,640	20,640	18,640	18,640
Colorado City	5,500	2,019	4,280	2,601
Champion Creek	5,000	5,000	5,000	5,000
E.V. Spence	48,100	34,611	43,430	43,930
Oak Creek	4,800	4,180	4,400	4,400
New Lake Winters	1,160	952	1,160	920
Ballinger	1,800	1,142	1,600	1,335
O.C. Fisher	13,200	13,200	9,300	9,300
Twin Buttes	31,400	28,971	29,000	28,881
O.H. Ivie	113,000	5,401	101,000	57,937
Hords Creek	1,200	107	1,200	122
Clyde	760	697	440	440
Coleman	7,090	1,539	8,400	2,257
Brownwood	31,400	12,870	30,466	21,574
Brady Creek	3,100	3,098	3,100	3,100
Highland Lakes	445,266	135,629	445,266	417,381

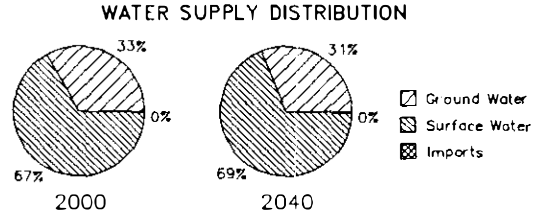
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	353,859	546,757
Manufacturing	45,016	112,090
Steam Electric	74,000	104,100
Mining	36,428	26,447
Irrigation	649,578	602,285
Livestock	37,228	37,228
Total In-Basin Demands	1,196,109	1,428,907
IN-BASIN SUPPLIES		
Ground Water	638,482	582,647
Surface Water	1,274,386	1,258,149
Total In-Basin Supplies	1,912,868	1,840,796
TRANSFERS		
Import Supplies	2,858	4,387
Export Demands	292,979	363,267
ADDITIONAL NEW SUPPLIES	0	14,205
AGRICULTURAL SHORTAGE	(30,731)	(53,975)
NET AVAILABILITY	457,369	121,189

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Colorado River Basin is bounded on the north and east by the Brazos River Basin, on the south and west by the Lavaca, Guadalupe, Nueces, and Rio Grande basins (see Figure 1-4). The economy is based on mineral production, agriculture, agribusiness, manufacturing, trades, and government. The 1980 basin population totaled 1.1 million people, increasing to a current level of 1.3 million (an increase of more than 18 percent). By 2040, the basin population is projected to range between 2.2 and 2.8 million. Major basin population centers include the Cities of Austin, Midland, Odessa, San Angelo, Big Spring, and Brownwood.

Current Water Uses. Total annual basin water use is currently 941,905 acre-feet. Irrigation water use is the largest demand placed on the basin's supplies with a current use of 561,184 acre-feet. Other major basin water demands are exports for use in other basins and municipal water use.

Current Water Supplies. Several aquifers provide water to the basin. The Ogallala, along with the Edwards-Trinity and Dockum aquifers, occur in the upper part of the basin. The Edwards-Trinity and Lipan aquifers are in the west-central part. Lowering of Edwards-Balcones water levels is of concern in areas in the central basin. The Trinity, Edwards-Balcones and Carrizo-Wilcox are in the south-central basin along with minor aquifers which include the Hickory, Ellenberger-San Saba, Marble Falls, Queen City, and Sparta aquifers. The Gulf Coast Aquifer occurs in the lower basin. Use of this aquifer raises concerns over related land subsidence and its attendant problems.

The basin has 26 major reservoirs, which along with the river flows below Austin, can provide over 1,203,380 acre-feet per year of supply. The Canadian River Municipal Water Authority provides water to Brownfield and Lamesa from Lake Meredith. Major suppliers in the basin are the Colorado River Municipal Water District (CRMWD), the Lower Colorado River Authority (LCRA), and irrigation companies in the lower part of the basin. The LCRA and irrigation companies export water to areas in the Brazos-Colorado, Colorado-Lavaca, and Lavaca basins. A study is underway to examine the feasibility of transfers from the Garwood Irrigation District in the Colorado Basin to Lake Texana in the Lavaca Basin. At the mouth of the Colorado, an under-construction river diversion would reestablish the historic flows of the Colorado River back into Matagorda Bay would provide for non-consumptive navigation and environmental water uses. Environmental water use benefits of this diversion are estimated by the Corps at over $9 million annually.

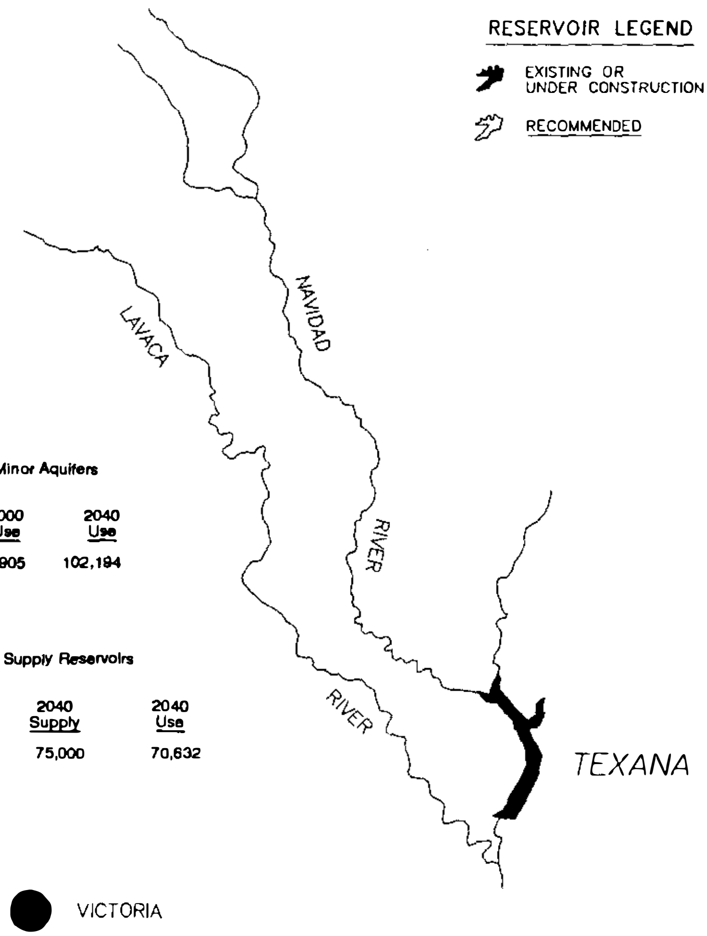
Current Water Quality. Surface water quality ranges from good to poor in the upper reaches of the basin primarily due to salinity intrusion from natural and man-made (primarily oil and gas development) sources. While a recent accidental spill of highly saline water, brought about by more than 80 inches of rain falling within the drainage area of a normally unproductive lake, has adversely affected riverine water quality, overall salinity control projects carried out by the CRMWD continue to significantly improve the riverine quality of the upper basin. The water quality of the Concho, Llano, and Pedernales rivers is excellent with sporadic dissolved oxygen and fecal coliform violations. Surface water quality below Austin has been poor due to wastewater discharges, although with recent upgrades and new construction of wastewater treatment facilities, the quality of the river below Austin is improving. Water quality in the many aquifers that traverse the basin ranges from fresh to highly saline.

While ground-water quality is good in many areas, high dissolved solids (Ogallala and Edwards-Trinity Aquifers) and fluoride (Ogallala) affect some ground-water supplies in the upper portions of the basin. High fluoride and nitrate levels in ground water in the upper basin currently exceed the Interim Primary Drinking Water Standards. In the lower basin, the Sparta and Queen City aquifers have generally high dissolved solids concentrations. Salinity in the Dockum Aquifer results from both natural poor quality and man-made contamination from oil field activities.

Future Water Uses. Current water use patterns of the Colorado Basin are expected to change over the next 50 years, as water use for irrigation decline to only 34 percent of the basin's total water requirements by 2040. Municipal and manufacturing water demands are projected to increase significantly over the planning period, nearly doubling from current usage levels. With implementation of municipal water conservation programs and practices, annual savings of municipal water are projected to reach 28,413 acre-feet by 2000, increasing further to 95,871 acre-feet by 2040.

Future Water Supplies. Ground water will continue to provide over 30 percent of available supply for the basin. However, certain cities in the western and central portions of the basin will need to find alternate supplies due to increasing quality problems with their present supplies. With the projected water conservation savings, there are adequate ground-water and surface water supplies available. If the Board's projected conservation savings are not attained, the Shaws Bend Reservoir would be needed to provide supplies for the middle and lower basin.

LAVACA RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

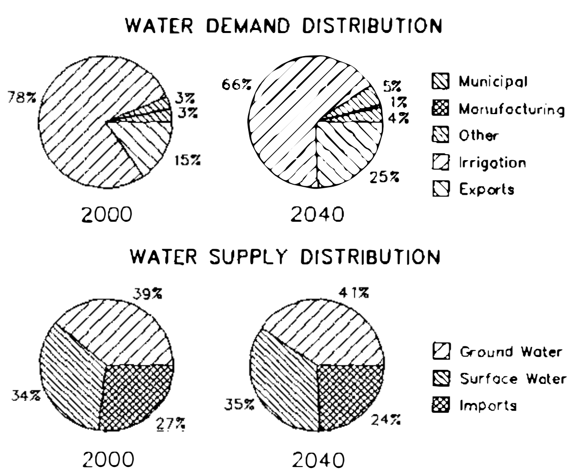
Aquifer	2000 Use	2040 Use
Gulf Coast	98,905	102,194

Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Texana	75,000	40,404	75,000	70,632

PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	8,400	10,348
Manufacturing	733	1,688
Steam Electric	0	6,000
Mining	2,896	3,831
Irrigation	205,155	184,303
Livestock	4,541	4,541
Total In-Basin Demands	221,725	210,771
IN-BASIN SUPPLIES		
Ground Water	99,081	102,468
Surface Water	87,597	88,597
Total In-Basin Supplies	186,678	191,065
TRANSFERS		
Import Supplies	69,404	61,630
Export Demands	40,054	68,530
ADDITIONAL NEW SUPPLIES	0	0
AGRICULTURAL SHORTAGE	(40,293)	(30,914)
NET AVAILABILITY	34,596	4,308



Basin Description. The Lavaca River Basin is bounded on the north and east by the Colorado River Basin, on the west by the Guadalupe River Basin, on the southeast by the Colorado-Lavaca Coastal Basin, and on the southwest by the Lavaca-Guadalupe Coastal Basin (see Figure 1-4). The economy of the basin is based on agriculture, agribusiness, retail and wholesale trade, and manufacturing. In 1980, the basin population totaled about 43,900 people. The current population of the basin is estimated at about 43,800 residents. By the year 2040, population of the Lavaca River Basin is projected to range between 39,400 and 65,900 residents. Major population centers of the basin include the Cities of Yoakum, Edna, Hallettsville, Schulenburg, Shiner, Weimar, Ganado, and Moulton.

Current Water Uses. Total annual water use within the basin is currently 241,700 acre-feet. The largest water demand in the basin is for irrigation with a current use of 229,530 acre-feet. Other major water demands in the basin include municipal and livestock water uses.

Current Water Supplies. The basin's present water needs are met by ground water from the Gulf Coast Aquifer and imports of surface water from the Colorado Basin. The only reservoir in the basin is Lake Texana, operated by the Lavaca-Navidad River Authority (LNRA). The project can supply almost 75,000 acre-feet per year of water for municipal and industrial needs in the basin and adjoining coastal basins. Most cities in the basin use ground water from the Gulf Coast Aquifer.

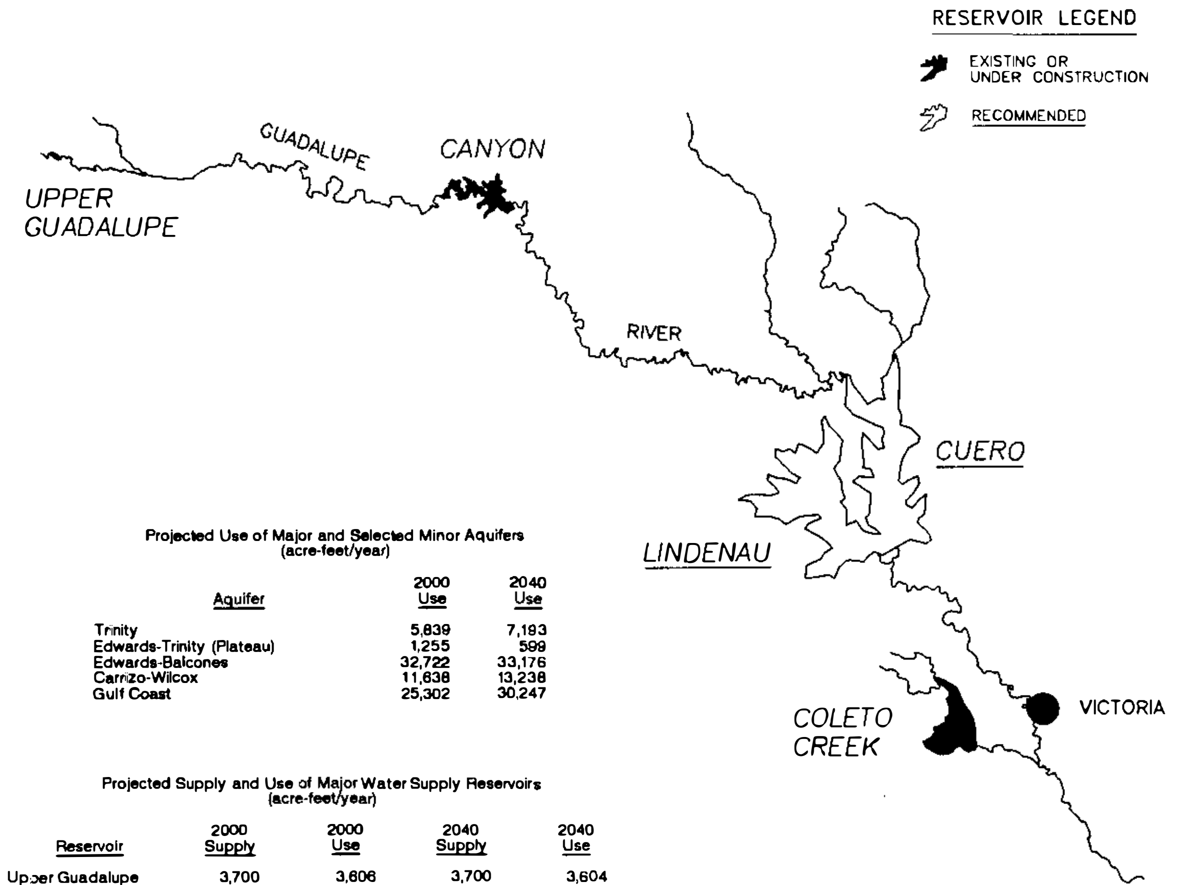
Water supply problems in the basin are overdrafting of the aquifer and related subsidence problems and concerns for reservoir releases for bay and estuary and instream flow needs.

Current Water Quality. Generally, surface water quality is excellent, although the river above tidal influences experiences frequent elevated fecal coliform levels with the main source being runoff from non-confined livestock operations. Ground-water quality from the Carrizo-Wilcox Aquifer is poor, ranging from about 2,000 to 10,000 mg/l TDS, while the Gulf Coast Aquifer supplies are fresh to slightly saline, although higher salinity concentrations exist in downdip portions of the aquifer and near Lavaca Bay.

Future Water Uses. The current water use pattern of the Lavaca River Basin is not expected to change significantly over the planning period, as water requirements for irrigated agriculture are projected to remain the largest water demand category, accounting for over 73 percent of the basin's total water requirements. However, water requirements for irrigation purposes are projected to decline over the planning period due to a moderate reduction in irrigated acreage and anticipated improvements in irrigation practices and implementation of more water use efficient irrigation equipment. With implementation of municipal water conservation programs and practices, annual savings of municipal water is projected to reach 681 acre-feet by the year 2000, and increasing further to 1,822 acre-feet by the year 2040.

Future Water Supplies. Portions of Lake Texana are anticipated to be used to meet industrial growth needs in the adjoining Colorado-Lavaca Basin. Because of significant questions over the dependable yields of the City of Corpus Christi's surface water reservoirs and mandated environmental releases from those projects, the Board is recommending construction of a major conveyance system to also provide supplies from Lake Texana to the Corpus Christi area to meet its needs, even if projected water conservation savings are obtained. If these savings cannot be obtained, Palmetto Bend II Reservoir and potentially other supplies would be needed to meet Corpus Christi area demands. However, regional studies are also evaluating the use of Lake Texana and the Palmetto Bend II site to meet other various needs outside of the basin. The Board, in conjunction with the Texas Parks and Wildlife Department, have studied the potential releases from Lake Texana needed for environmental purposes, although no regulatory decision has yet been made.

GUADALUPE RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

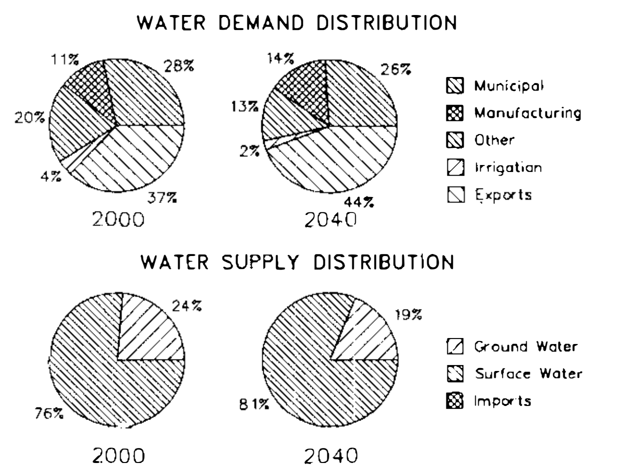
Aquifer	2000 Use	2040 Use
Trinity	5,839	7,193
Edwards-Trinity (Plateau)	1,255	599
Edwards-Balcones	32,722	33,176
Carrizo-Wilcox	11,638	13,238
Gulf Coast	25,302	30,247

Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Upper Guadalupe	3,700	3,606	3,700	3,604
Canyon	50,000	26,024	50,000	50,000
Lindenau	101,600	84,284	0	0
Lindenau & Cuero	0	0	208,000	208,000
Coleto Creek	12,500	12,500	12,500	12,500

PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	80,441	125,668
Manufacturing	32,203	69,296
Steam Electric	42,000	49,000
Mining	2,096	3,166
Irrigation	10,860	10,696
Livestock	12,131	12,131
Total In-Basin Demands	179,731	269,957
IN-BASIN SUPPLIES		
Ground Water	80,576	90,963
Surface Water	159,147	160,748
Total In-Basin Supplies	239,723	251,711
TRANSFERS		
Import Supplies	0	0
Export Demands	106,629	216,010
ADDITIONAL NEW SUPPLIES	101,600	234,146
AGRICULTURAL SHORTAGE	(149)	(206)
NET AVAILABILITY	60,141	96



Basin Description. The Guadalupe River Basin is bounded on the north by the Colorado River Basin, on the east by the Lavaca River Basin and Lavaca-Guadalupe Coastal Basin, and on the west and south by the San Antonio and Nueces river basins (see Figure 1-4). The economy of the basin is based on mineral production, agriculture, agribusiness, retail and wholesale trace, and manufacturing. In 1980, the basin population totaled about 243,300 people. The current population of the basin is estimated at 303,200 residents, representing an increase of about 25 percent from the 1980 population. By the year 2040, population of the Guadalupe River Basin is projected to range between 564,100 and 692,800 residents. Major population centers of the basin include the Cities of Victoria, San Marcos, New Braunfels, Seguin, Kerrville, Lockhart, Gonzales, Cuero, Luling, and Kyle.

Current Water Uses. Total annual water use in the basin is currently 114,321 acre-feet. Water for municipal use is the largest water demand in the basin with a current use of 54,301 acre-feet. Other water demands placed on the basin's water supplies are exports for use in other basins and manufacturing use.

Current Water Supplies. In the upper part of the basin, the Trinity, Edwards-Trinity, and Edwards-Balcones aquifers are major sources of ground-water supplies. The lower portion of the basin is supplied by ground water from the Carrizo-Wilcox, Queen City, Sparta, and Gulf Coast aquifers.

Canyon Lake Reservoir provides over 50,000 acre-feet per year of surface water supply for use by the Guadalupe-Blanco River Authority (GBRA). There are also six hydroelectric reservoirs on the Guadalupe River below New Braunfels. The GBRA operates Coleto Creek Reservoir for cooling purposes. The GBRA also operates a salt water barrier during low flows to prevent salt water intrusion at the Calhoun Canal system. This canal provides water to the industrial complex on the Victoria Barge Canal.

Other water supply issues in the basin include flooding, conflicts of use, concerns for bay and estuary needs, protection of the springs and the environment around the springs, over-pumpage of ground water, and oil field pollution.

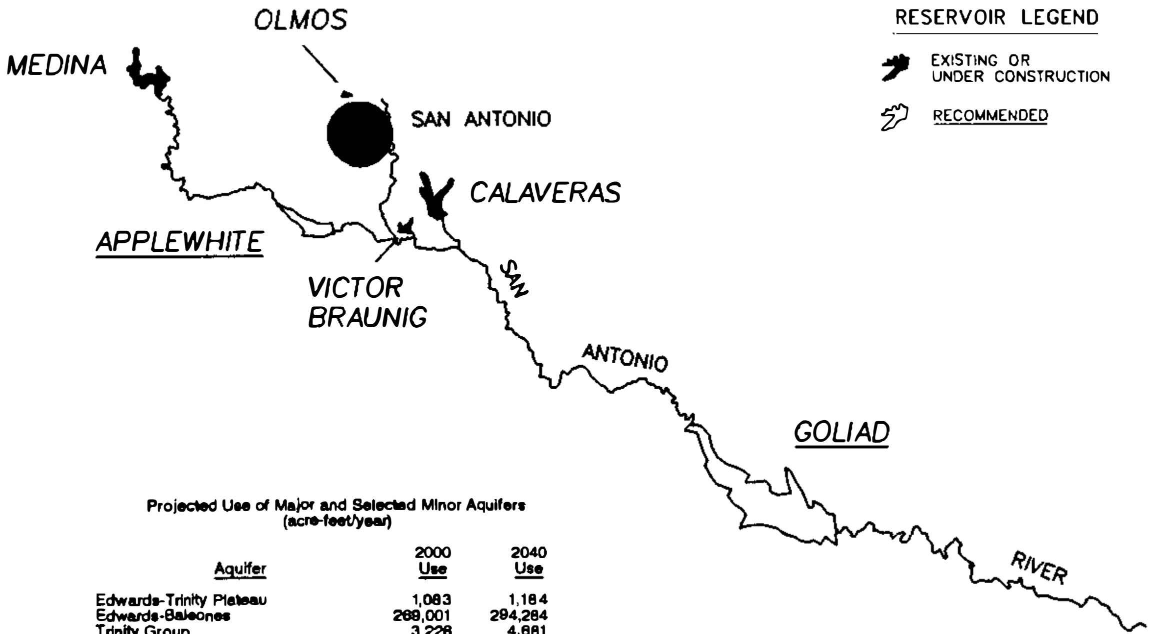
Current Water Quality. Surface water is generally characterized by high quality throughout the basin. Ground-water quality in the basin ranges from fresh (Edwards-Trinity, Trinity, Edwards-Balcones aquifers with TDS levels generally less than 500 mg/l) to fair (Carrizo-Wilcox and Gulf Coast aquifers with TDS generally below 1,000 mg/l). Excessive declines in water levels, potential cessation of springflow, saline water encroachment, and subsidence are problems in use of some of the aquifers in the basin.

Future Water Uses. The current water use pattern of the Guadalupe River Basin is not anticipated to change significantly over the planning period, as water requirements for exports out of the basin are expected to remain the largest water demand on the basin's water supplies. With implementation of municipal water conservation programs and practices, annual savings of municipal water is projected to reach about 6,413 acre-feet by the year 2000, and increasing further to more than 21,929 acre-feet by the year 2040.

Future Water Supplies. In order to insure that the springs at San Marcos and New Braunfels continue to flow, alternative supplies must be developed to supply the San Antonio area. Two reservoirs, Lindenau and Cuero, should be developed in the basin to meet these additional needs. The reservoirs can provide over 208,000 acre-feet per year of dependable supply. Some of the developed supplies can be used to meet needs in the lower part of the basin and the coastal basin presently supplied by Canyon Lake, thus freeing supplies in Canyon to be used in the New Braunfels and San Marcos area.

The Upper Guadalupe River Authority will need to expand the use of in-ground storage to meet the needs in the Authority's service area. It should be noted that while the Cuero site is a recommended surface water supply project because of its proximity to the San Antonio urban area, its large yield, and its relatively low unit cost, it will possibly have major archaeological and environmental problems that would have to be resolved in the permitting process. If they cannot be resolved, then additional supplies in other basins (perhaps as many as two to four replacement reservoirs) would need to be developed to insure the integrity of area spring flows and meet San Antonio area water demands.

SAN ANTONIO RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Edwards-Trinity Plateau	1,083	1,184
Edwards-Balcones	269,001	294,284
Trinity Group	3,226	4,681
Carrizo-Wilcox	21,493	26,371
Gulf Coast	5,795	6,133

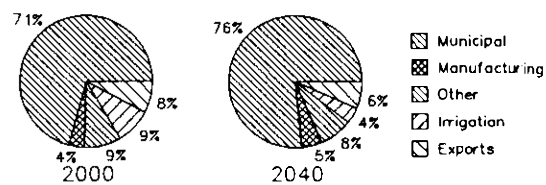
Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Medina	39,200	19,099	39,200	31,001
Applewhite	7,900	7,900	7,900	7,900
Goliad	0	0	148,400	148,400

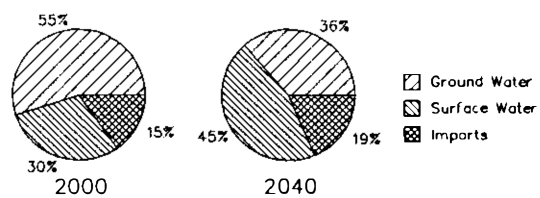
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	359,754	688,959
Manufacturing	19,295	43,993
Steam Electric	36,000	59,000
Mining	3,162	7,972
Irrigation	44,493	35,922
Livestock	6,554	6,554
Total In-Basin Demands	469,258	842,400
IN-BASIN SUPPLIES		
Ground Water	302,165	334,716
Surface Water	127,829	129,468
Total In-Basin Supplies	429,994	464,184
TRANSFERS		
Import Supplies	84,284	172,330
Export Demands	39,470	58,544
ADDITIONAL NEW SUPPLIES	36,872	286,155
AGRICULTURAL SHORTAGE	0	0
NET AVAILABILITY	42,422	21,725

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The San Antonio River Basin is bounded on the north and east by the Guadalupe River Basin, and on the south and west by the Nueces River Basin and the San Antonio-Nueces Coastal Basin (see Figure 1-4). The economy of the basin is based on agriculture, agribusiness, retail and wholesale trade, services, manufacturing, government, and tourism. In 1980, the basin population totaled about 1.1 million people. The current population of the basin is estimated at 1.3 million residents, representing an increase of about 18 percent from the 1980 population. By the year 2040, population of the San Antonio River Basin is projected to range between 2.6 and 3.4 million residents. Major population centers of the basin include the Cities of San Antonio, Leon Valley, Universal City, Live Oak, Schertz, Converse, Kirby, Alamo Heights, and the military installations of Fort Sam Houston, Brook Army Medical Center, Kelly, Lackland and Randolph Field Air Force Bases.

Current Water Uses. Total annual water use supplied by the basin's water resources is currently 319,088 acre-feet. The largest demand placed on the basin's water supplies is for municipal purposes with a current use of 242,041 acre-feet. Other major water demands in the basin are irrigation, steam-electric power generation, and export for use in other basins.

Current Water Supplies. Currently the San Antonio basin is supplied by pumpage from the Edwards-Balcones, Edwards-Trinity (Plateau), Trinity, Carrizo-Wilcox, Queen City, Sparta, and Gulf Coast aquifers. The Edwards Aquifer provides almost all of the supplies in the San Antonio area. Dependence on the Edwards-Balcones Aquifer in the upper portion of the basin and the effects of this pumpage on the ground-water reservoir levels, dependable supplies, and spring flow in the Guadalupe Basin are considered a major problem and are receiving considerable scrutiny from both local users and local, state, and federal governments. The Trinity Aquifer provides a minor amount of variable quality water to the upper part of the basin. Water level declines are common during dry periods.

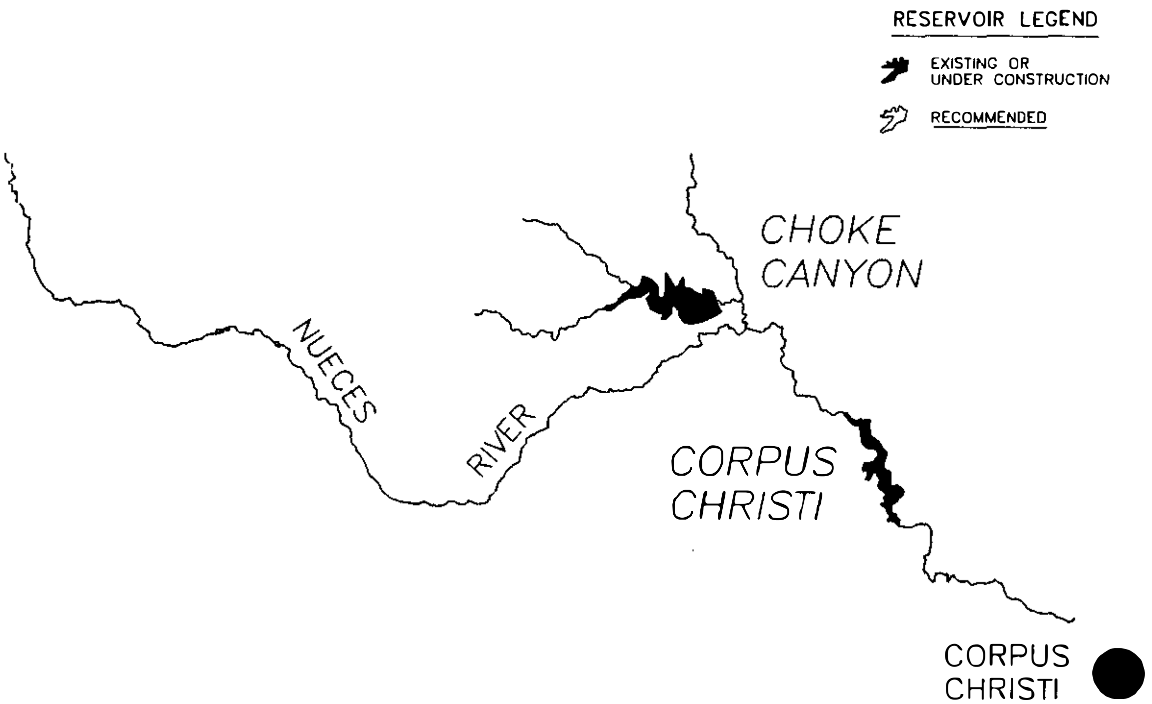
Existing reservoirs in the basin provide water for irrigation (Lake Medina), cooling for steam-electric generation (Braunig and Calaveras Reservoirs), and flood protection (Olmos Reservoir).

Current Water Quality. Improved wastewater treatment facilities have greatly improved surface water quality in the upper reaches of the river. Water quality is stressed or poor in the lower portions of the Leon Creek and the lower Medina River (below the Leon Creek confluence) and mid-Cibolo Creek due to municipal point source discharges. Ground-water quality in the basin ranges from fresh (Edwards-Trinity, Trinity, Edwards-Balcones aquifers with TDS levels generally less than 500 mg/l) to fair (Carrizo-Wilcox and Gulf Coast aquifers with TDS generally below 1,000 mg/l). Excessive declines in water levels, potential cessation of springflow, saline water encroachment, and subsidence are problems in use of some of the aquifers in the basin.

Future Water Uses. The current water use pattern of the San Antonio River Basin is not anticipated to change significantly over the planning period, as water requirements for municipal purposes are projected to account for about 77 percent of the basin's total water requirements by the year 2040. Water requirements for municipal purposes are projected to more than double from current municipal use by the year 2040. With implementation of municipal water conservation programs and practices, annual savings of municipal water are projected to reach about 29,130 acre-feet by the year 2000, and increasing to about 121,496 acre-feet by the year 2040.

Future Water Supplies. If the spring flows in the Guadalupe Basin are to be protected, additional surface water supplies in the San Antonio and Guadalupe River basins will need to be developed for use in the San Antonio area, even with the Board's projected water conservation savings. In the San Antonio Basin, the Goliad and Applewhite reservoirs are recommended for development. These projects will provide over 156,000 acre-feet per year of supplies. Medina Reservoir is also recommended to be converted from only an irrigation supply source to a municipal and irrigation supply source. Among the recommendations for the development of four new surface water reservoirs is the proposed Applewhite Reservoir, scheduled for near-term construction. With the City's proposed operations plan, this project would provide at least 7,900 acre-feet per year during a replication of the historical critical drought. The project could supply about 14,900 acre-feet per year operated on a firm yield basis, and about 45,700 acre-feet per year on a long-term average availability basis. In addition to new reservoirs, the San Antonio area will also need to develop and implement an aggressive reuse program. For the Board's with-conservation forecasts, over 97,000 acre-feet of reuse per year would be needed to meet San Antonio urban area demands. If the projected savings are not attained, Cibolo Reservoir and about 167,000 acre-feet of reuse would be needed to meet the higher area water demands and protect Edwards Aquifer spring flows.

NUECES RIVER BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Edwards-Trinity (Plateau)	1,471	2,845
Edwards-Balcones	115,189	120,352
Trinity	235	296
Sparta	4,890	5,838
Queen City	1,985	1,583
Carrizo-Wilcox	125,418	74,234
Gulf Coast	8,958	10,473

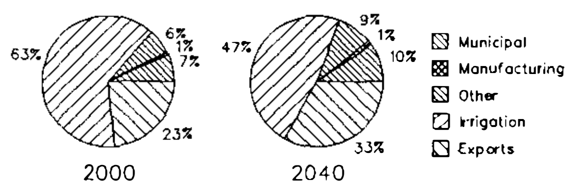
Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Choke Canyon/ Corpus Christi	178,670	162,736	230,549	230,549

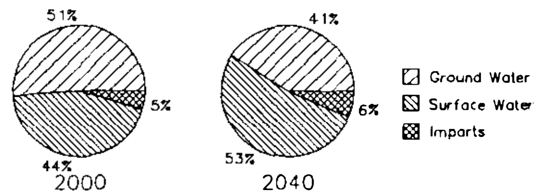
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	44,434	63,269
Manufacturing	3,984	7,211
Steam Electric	17,000	32,000
Mining	4,486	7,492
Irrigation	413,357	311,977
Livestock	17,982	17,982
Total In-Basin Demands	501,243	439,931
IN-BASIN SUPPLIES		
Ground Water	258,503	215,739
Surface Water	222,405	277,934
Total In-Basin Supplies	480,908	493,673
TRANSFERS		
Import Supplies	23,265	33,544
Export Demands	153,876	218,021
ADDITIONAL NEW SUPPLIES	0	0
AGRICULTURAL SHORTAGE	(166,880)	(130,735)
NET AVAILABILITY	15,934	0

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Nueces River Basin is bounded on the north and east by the Colorado, Guadalupe, and San Antonio river basins and the San Antonio-Nueces Coastal Basin, and on the west and south by the Rio Grande Basin and the Nueces-Rio Grande Coastal Basin (see Figure 1-4). The economy of the basin is based on agriculture, agribusiness, trades, and mineral production. The 1980 basin population totaled about 153,500 people (which excludes the majority of Corpus Christi population in the adjacent coastal basin). The current basin population is estimated at 166,800 residents, an increase of about nine percent from the 1980 population. By 2040, basin population is projected to range between 279,600 and 308,900 residents. Major population centers of the basin include a minor portion of the City of Corpus Christi, the cities of Uvalde, Crystal City, Pearsall, Pleasanton, Carrizo Springs, Hondo, Mathis, Devine, and Cotulla.

Current Water Uses. Total annual basin water use is currently 439,500 acre-feet. Water for irrigation is the largest water demand in the basin with a current use of 385,056 acre-feet. Other major demands placed on the basin's water supplies are exports for use in other basins and municipal water use.

Current Water Supplies. The Edwards-Balcones, Edwards-Trinity (Plateau), Trinity, Carrizo-Wilcox, Queen City and Sparta aquifers provide basin ground-water supplies with the Carrizo-Wilcox providing about 60 percent. Overdrafting of the Carrizo-Wilcox is becoming an increasing concern. High pumpage levels in the Edwards-Balcones Aquifer, resultant water-level decline, and related effects on spring and riverine flows are major concerns in the Nueces, San Antonio, and Guadalupe River Basins. The Edwards-Trinity (Plateau) and Trinity aquifers provide a minor amount of variable quality water to the upper part of the basin. Water level declines are common in these aquifers during dry periods.

Lakes Corpus Christi and Choke Canyon are the largest surface water reservoirs in the basin and are capable of producing almost 252,000 acre-feet per year of water supply. However, preliminary studies indicate environmental releases could reduce the supply to 231,000 acre-feet per year. Currently, studies are underway to determine the effective yield of the projects. Most of the supplies in these two projects will be used outside of the basin in the Corpus Christi metropolitan area.

Other water supply problems in the basin are over-pumpage of both the Edwards and Carrizo-Wilcox aquifers resulting in lower water levels as well as saline encroachment. In addition, there is concern about the dependability of Lakes Corpus Christi and Choke Canyon reservoir yields, as well as bay and estuary and instream flow needs.

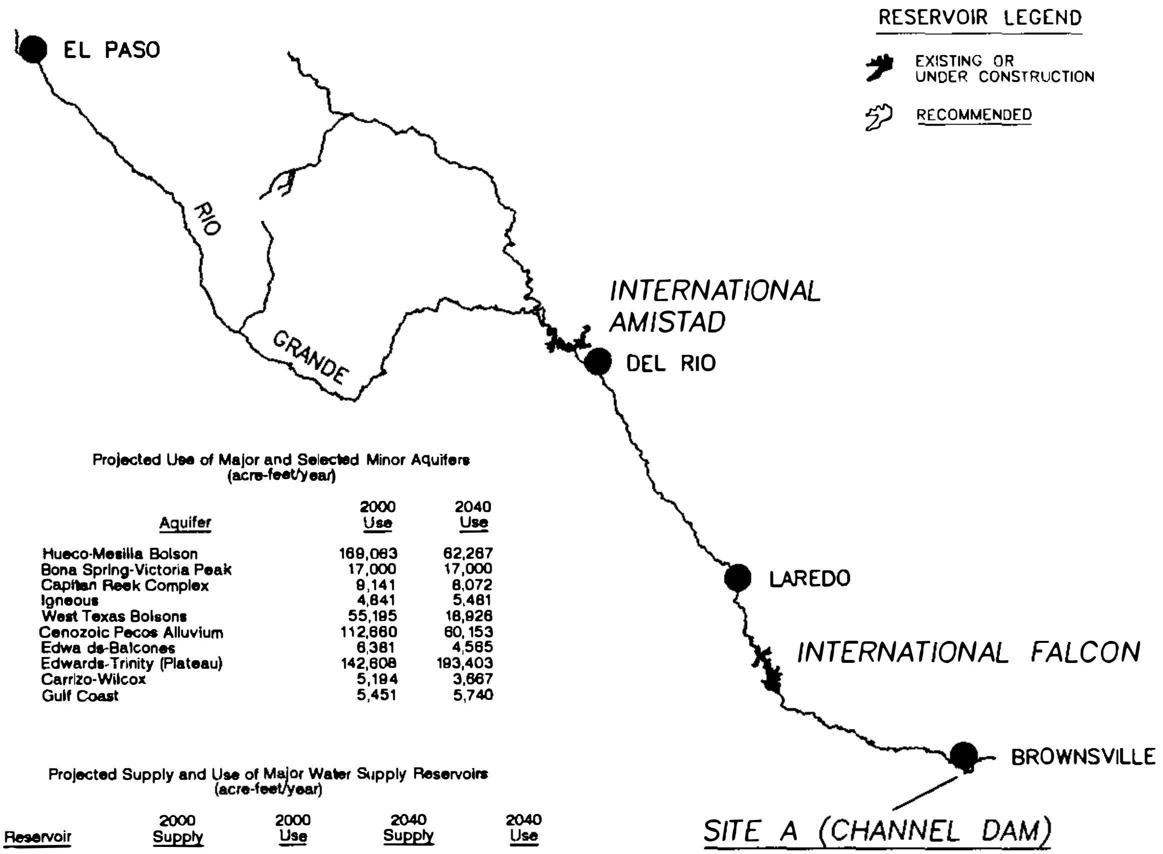
Current Water Quality. Surface water quality in the uninhabited reaches of the river is excellent. Streamflows below the Edwards recharge zone is almost entirely stormwater runoff. During low flow conditions, chloride, sulfate, and total dissolved solids levels increase due to natural conditions and human activities. Water quality of the basin aquifers range from fresh to moderately saline in localized areas. Ground-water quality varies from the higher quality supplies (less than 500 mg/l TDS) of the Edwards-Trinity and Edwards-Balcones aquifers to lesser quality supplies (500 to over 3,000 mg/l TDS) of the Trinity Group, Carrizo-Wilcox, and Gulf Coast aquifers.

Future Water Uses. The current water use pattern of the Nueces River Basin is not anticipated to change significantly over the 50-year planning period,as water requirements for irrigation purposes are projected to remain the major water demand category. However, water demands for irrigated agriculture are projected to decrease over the 50-year period due to a small decline in irrigated acreage and anticipated improvements in irrigation practices and equipment. Likewise, annual savings of municipal water through water conservation are projected to reach 3,428 acre-feet by 2000, and 10,778 acre-feet by 2040.

Future Water Supplies. In the future, ground-water usage in the Carrizo-Wilcox Aquifer will decline due to overdrafting of the aquifer in the Winter Garden area and in the Edwards-Balcones Aquifer in Medina and Uvalde counties.

Lakes Corpus Christi and Choke Canyon will continue to supply water to the San Antonio-Nueces and the Nueces-Rio Grande basins, including the City of Corpus Christi and suburban areas. Concerns over the effective yields of these projects and impacts of environmental releases will require Corpus Christi to obtain additional supplies in the future even with the Board's projected water conservation savings. The Board is recommending construction of a pipeline to secure future supplies from Lake Texana. If conservation savings are not obtained, additional supplies would also be needed from Palmetto Bend II Reservoir or even potentially other sources, given the ultimate result of the Nueces Basin yield studies.

RIO GRANDE BASIN



Projected Use of Major and Selected Minor Aquifers
(acre-feet/year)

Aquifer	2000 Use	2040 Use
Hueco-Mesilla Bolson	169,063	62,267
Bona Spring-Victoria Peak	17,000	17,000
Capitan Reek Complex	9,141	8,072
Igneous	4,841	5,481
West Texas Bolsons	55,195	18,926
Cenozoic Pecos Alluvium	112,660	60,153
Edwa ds-Balcones	6,381	4,585
Edwards-Trinity (Plateau)	142,608	193,403
Carrizo-Wilcox	5,194	3,667
Gulf Coast	5,451	5,740

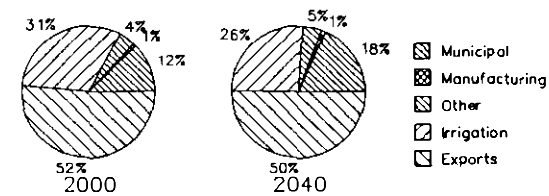
Projected Supply and Use of Major Water Supply Reservoirs
(acre-feet/year)

Reservoir	2000 Supply	2000 Use	2040 Supply	2040 Use
Falcon-Amistad	1,500,000	1,418,060	1,500,000	1,500,000
Rio Grande Project	128,700	128,700	128,700	128,700
Site A Channel Dam	0	0	85,000	84,081

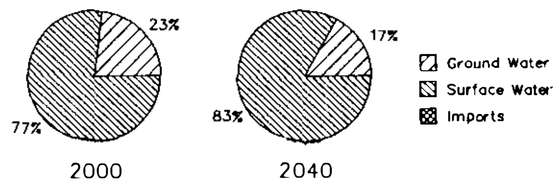
PROJECTED WATER DEMANDS AND SUPPLIES
(acre-feet/year)

ITEM	2000	2040
IN-BASIN DEMAND		
Municipal	277,516	474,030
Manufacturing	15,800	25,607
Steam Electric	16,000	21,000
Mining	54,346	75,343
Irrigation	710,815	673,060
Livestock	21,804	21,804
Total In-Basin Demands	1,096,281	1,290,844
IN-BASIN SUPPLIES		
Ground Water	532,700	388,910
Surface Water	1,725,352	1,750,557
Total In-Basin Supplies	2,258,052	2,139,467
TRANSFERS		
Import Supplies	0	0
Export Demands	1,168,488	1,298,767
ADDITIONAL NEW SUPPLIES	61,100	175,000
AGRICULTURAL SHORTAGE	(27,557)	(171,447)
NET AVAILABILITY	81,940	(103,697)

WATER DEMAND DISTRIBUTION



WATER SUPPLY DISTRIBUTION



Basin Description. The Rio Grande Basin is bounded on the north by New Mexico and on the south by Mexico and stretches southerly toward the Gulf of Mexico (Figure 1-4). The basin economy is based on agriculture, agribusiness, manufacturing, mineral production, trades, government, and tourism. The 1980 basin population totaled about 781,000 people. The current basin population is estimated at 929,900, up about 19 percent since 1980. By 2040, the basin population is projected to range between 2.0 and 2.4 million residents. Major population centers include the Cities of El Paso, Laredo, Del Rio, Eagle Pass, Pecos, Rio Grande City, Fort Stockton, Monahans, Kermit, Alpine, and the Fort Bliss military installation.

Current Water Uses. Total annual basin water use is currently 770,997 acre-feet. The largest demand placed on the basin's supplies is for export to other basins, currently estimated at 1.1 million acre-feet. Much of these exports are delivered for irrigation use in the adjoining Nueces-Rio Grande Coastal Basin. Water for irrigation is the largest basin water demand with a current use of 538,133 acre-feet. Municipal use in the basin is currently 196,090 acre-feet.

Current Water Supplies. In the northern basin, ground water is the major supply source. The City of El Paso is primarily supplied from the Hueco-Mesilla Bolson Aquifer and, to a lesser extent, with Rio Grande surface water. Other important aquifers include the Bone Spring-Victorio Peak, Cenozoic Pecos Alluvium, Edwards-Trinity (Plateau), and West Texas Bolsons. In the El Paso area, supplies (primarily for agriculture) are provided by the Rio Grande Project of New Mexico-Texas with water from Elephant Butte Reservoir in New Mexico. Problems with sedimentation, flooding, and water quality below the dam in New Mexico are or may be affecting river conditions and supplies delivered to Texas. Below Lake Amistad, most water used is from Lakes Amistad and Falcon and the Rio Grande. The 57,292 acre Amistad Recreation Area is a unit of the National Park Service, managed for national park purposes under a cooperative agreement with the International Boundary and Water Commission. Ground-water sources in the middle/lower basin include the Carrizo-Wilcox and Gulf Coast aquifers. Growth along the border in Mexico and New Mexico also places water demands and water quality treatment needs on the rivers and aquifers, thus affecting available water supplies in the basin in Texas, although these are not fully considered in the Board's analysis.

Current Water Quality. Riverine water quality varies significantly in the basin. Effluent and irrigation return flows dominate river volumes below El Paso. Saline inflows increase riverine dissolved solids levels between the confluence of the Pecos River and Lake Amistad. Both of these influences become less severe with more dilution from intervening inflows to the river. Below Amistad, saline irrigation return flows, suspected contaminated agricultural runoff, and municipal and industrial wastewater discharges are or may be impairing downstream water quality. Ground-water quality ranges from fresh to moderately saline in the major aquifers with threat of increased salinity encroachment from declines in ground-water levels.

Future Water Uses. The current basin water use pattern should not change significantly in the next 50 years, as exports are projected to remain the major water use for the basin's water supply. However, water needs for municipal purposes are projected to more than double by 2040. Annual municipal water savings through conservation practices should reach 22,274 acre-feet by 2000, and 83,162 acre-feet by 2040.

Future Water Supplies. In El Paso County, the Board projects additional water reuse will increase available supplies by about 40,000 acre-feet per year. However, without further additional supplies, the El Paso County area will have an overall deficit of over 176,000 acre-feet annually by 2040. The Board's forecast indicates a water deficit of about 70,000 acre-feet per year for the City of El Paso by 2040. A water management plan near completion, being conducted for the city service area by the El Paso Public Service Board and El Paso County Water Improvement District No. 1, indicates slightly higher conservation savings and slightly lower or no water supply deficit results by 2040 (given the degree of ground-water availability from nearby Bolson deposits) when compared to the Board's forecast.

In the lower basin, a new channel dam (Site A) on the river below Brownsville, which would provide for local supplies, is recommended. Various studies indicate that total annual project supplies could range from 15,000 to 200,000 acre-feet. The Board estimates the project's U.S. supply availability at about 85,000 acre-feet annually based on gaged flows in the river near Brownsville. The ultimate availability will be determined during the State permitting process and considering negotiations with Mexico. Concerns about aquatic and terrestrial habitat, water quality, "no charge" pumping, flooding, and off-channel storage options should also be given full consideration in the permitting process.

Even with the Board's projected conservation savings, additional reuse, and the provision of a new reservoir, a supply deficit of about 100,000 acre-feet per year is projected for the basin by 2040.

The projected water demands and supplies of the eight Texas coastal basins are shown in Table 3-4 for the years 2000 and 2040. As previously discussed, the assumption of "safe yield" pumping of the local aquifers has lessened the projected available ground-water supply and results in the agricultural water shortages indicated for many of the coastal basins.

NECHES-TRINITY COASTAL BASIN

Basin Description. The Neches-Trinity Coastal Basin is bounded on the north by the Neches and Trinity river basins, on the east by Sabine Lake, and on the west by Galveston and Trinity Bays (see Figure 1-4). The economy of the area is based on manufacturing, oil production, agriculture, agribusiness, commercial shipping and fishing, and trades. The 1980 basin population totaled 203,700 people. Currently, the basin population is about 198,700 residents, a decline of about 2.5 percent since 1980. By 2040, the basin population should range between 254,300 and 291,000 residents. Major basin population centers include all or portions of the cities of Beaumont, Port Arthur, Nederland, and Groves.

Current Water Uses. Total annual water use in the basin is currently 361,742 acre-feet. By far, the largest water demand in the basin is for irrigation purposes with a current use of 262,768 acre-feet.

Current Water Supplies. There are no major water-supply reservoirs in the basin. The J.D. Murphree impoundments, owned by the Texas Parks and Wildlife Department, are used for wildlife management purposes. Surface water is supplied to the basin primarily from the Trinity and Neches River Basins. The Gulf Coast Aquifer supplies over 13,000 acre-feet per year of ground water to the basin.

Future Water Uses. The regional water use pattern is not anticipated to change significantly over the 50-year planning period as water requirements for irrigated agriculture are projected to remain the largest water use within the basin. Although irrigation is expected to remain the major water demand category, water use for irrigation is projected to decline slightly over time due to improvements and more efficient water use management practices and equipment. Additionally, annual municipal water savings, through implementation of municipal water use conservation programs and practices, are projected to reach 2,591 acre-feet by the year 2000 and nearly 7,427 acre-feet by the year 2040.

Future Water Supplies. Any additional needs for surface water will be met from supplies in the Neches and Trinity river basins. There are adequate supplies available in these basins to meet the future needs of the Neches-Trinity Coastal Basin.

TRINITY-SAN JACINTO COASTAL BASIN

Basin Description. The Trinity-San Jacinto Coastal Basin is bounded on the east by the Trinity River Basin and the Neches-Trinity Coastal Basin, on the west and north by the San Jacinto River Basin and the San Jacinto-Brazos Coastal Basin, and on the south by Trinity and Galveston Bays (see Figure 1-4). The economy of the area is based on manufacturing, agriculture, trades, services, commercial fishing, and tourism. The 1980 basin population totaled 80,200 people. The current basin population is estimated at 92,500, up about 15 percent since 1980. By 2040, the basin population is projected to range between 145,900 and 169,900 residents. Baytown is the largest city in the basin with a population of over 60,000 people. Other basin cities include all or portions of the cities of Highlands, Barrett, McNair, Crosby, and Mont Belvieu.

Current Water Uses. Total annual water use in the basin is currently 119,667 acre-feet. Manufacturing is the largest water using category with a current use of 66,856 acre-feet, followed by municipal water use at 20,093 acre-feet.

TABLE 3-4
PROJECTED WATER DEMANDS AND SUPPLIES OF TEXAS COASTAL BASINS, 2000 AND 2040
(acre-feet per year)

Item	Neches-Trinity 2000	Neches-Trinity 2040	Trinity-San Jacinto 2000	Trinity-San Jacinto 2040	San Jacinto-Brazos 2000	San Jacinto-Brazos 2040	Brazos-Colorado 2000	Brazos-Colorado 2040
IN-BASIN DEMAND								
Municipal	32,337	42,445	18,297	24,280	139,061	205,363	17,721	26,311
Manufacturing	73,863	93,616	73,228	97,137	200,058	418,882	23,595	58,320
Steam Electric	0	0	900	2,000	2,200	2,500	0	0
Mining	1,808	1,893	11,104	12,484	1,388	1,412	12,143	14,328
Irrigation	193,734	196,675	37,079	37,152	135,391	125,075	231,728	207,220
Livestock	1,085	1,085	211	211	1,449	1,449	2,399	2,399
Total In-Basin Demand	302,827	335,714	140,819	173,264	479,547	754,681	287,586	308,578
IN-BASIN SUPPLIES								
Ground Water	13,661	12,742	10,116	10,856	57,600	49,655	79,441	82,352
Surface Water	18,667	19,214	6,033	6,033	61,288	61,882	31,747	33,559
Total In-Basin Supply	32,328	31,956	16,149	16,889	118,888	111,537	111,188	115,911
TRANSFERS								
Import Supplies	270,499	303,758	124,670	156,375	324,136	613,138	166,312	186,802
Export Demands	0	0	0	0	0	0	0	0
ADDITIONAL NEW SUPPLIES	0	0	0	0	0	8,867	0	0
AGRICULTURAL SHORTAGE	0	0	0	0	(36,523)	(21,139)	(10,086)	(5,865)
NET AVAILABILITY	0	0	0	0	0	0	0	0

Item	Colorado-Lavaca 2000	Colorado-Lavaca 2040	Lavaca-Guadalupe 2000	Lavaca-Guadalupe 2040	San Antonio-Nueces 2000	San Antonio-Nueces 2040	Nueces-Rio Grande 2000	Nueces-Rio Grande 2040
IN-BASIN DEMAND								
Municipal	5,206	7,653	7,667	11,418	20,273	28,071	279,524	531,778
Manufacturing	41,919	42,213	24,103	52,634	14,332	28,042	44,008	70,843
Steam Electric	200	200	0	0	0	0	6,000	10,500
Mining	348	206	982	1,136	1,202	292	2,929	2,444
Irrigation	125,684	112,622	49,281	44,574	4,837	4,837	995,792	917,960
Livestock	1,197	1,197	1,592	1,592	3,011	3,011	11,455	11,455
Total In-Basin Demand	174,554	164,091	83,625	111,354	43,655	64,253	1,339,708	1,544,980
IN-BASIN SUPPLIES								
Ground Water	57,036	57,685	22,000	24,420	11,670	11,460	40,163	45,407
Surface Water	7,986	7,986	15,835	13,583	1,608	1,608	5,832	5,973
Total In-Basin Supply	65,022	65,671	37,835	38,003	13,278	13,068	45,995	51,380
TRANSFERS								
Import Supplies	89,386	84,815	38,550	68,680	29,014	49,910	1,293,350	1,493,237
Export Demands	0	0	0	0	0	0	0	0
ADDITIONAL NEW SUPPLIES	0	0	0	0	0	0	0	0
AGRICULTURAL SHORTAGE	(20,146)	(13,605)	(7,240)	(4,671)	(1,363)	(1,275)	(363)	(363)
NET AVAILABILITY	0	0	0	0	0	0	0	0

Current Water Supplies. Cedar Bayou Reservoir, which supplies saline water from Cedar Bayou for steam electric power generation, is the only water supply reservoir in the basin. Almost 9,688 acre-feet per year of ground water are currently being supplied by the Gulf Coast Aquifer to basin users. All other basin needs are supplied by surface water from the San Jacinto River Authority with diversions from Lake Houston and from the Trinity River Basin through the Coastal Industrial Water Authority.

Future Water Uses. Manufacturing water use is expected to continue to be the major water using sector in the coastal basin throughout the planning period. Irrigation is also projected to be a major water user; however, the quantity of use is expected to decline slightly due to improvements in both management practices and equipment. Annual savings in municipal water use, realized through conservation practices, are projected to reach 1,481 acre-feet by the year 2000, increasing to 4,284 acre-feet by 2040.

Future Water Supplies. Future needs of the basin will be supplied by additional use of ground water and additional diversions from the Trinity River Basin.

SAN JACINTO-BRAZOS COASTAL BASIN

Basin Description. The San Jacinto-Brazos Coastal Basin is bounded on the north by the San Jacinto River Basin, on the east by Galveston Bay and the Trinity-San Jacinto Coastal Basin, and on the west by the Brazos River Basin (see Figure 1-4). The economy of the coastal basin is based on manufacturing, agriculture, trades, services, commercial shipping and fishing, and tourism. The current population of the basin is estimated at 647,100 people, up from the 1980 population of 536,800. By the year 2040, the basin population is projected to range between 1.1 and 1.3 million residents. Major cities lying wholly or partially within the basin include Houston, Pasadena, Galveston, Texas City, Missouri City, League City, and Deer Park.

Current Water Uses. Total annual water use in the basin is currently 403,301 acre-feet. The largest water using category in the basin is irrigation with a current use of 155,311 acre-feet. Other major water demands are manufacturing and municipal water use with a combined use of 243,617 acre-feet.

Current Water Supplies. There are no major surface water reservoirs with conservation (water supply) storage in the basin. The only major water supply available within the basin is ground water from the Gulf Coast Aquifer with over 55,000 acre-feet per year in current use. All other supplies are imported from the Brazos, Trinity, or the San Jacinto river basins. The Brazos River Authority provides water to the basin from reservoirs in the Brazos River Basin. Other major suppliers of water from the Brazos River Basin are Dow Chemical Company, Chocolate Bayou Company, and Galveston County Water Authority which use river diversions backed-up by water supplies from the Brazos River Authority. The City of Houston provides treated water to a number of cities in the basin that are converting from ground water to surface water in compliance with the Harris-Galveston Coastal Subsidence District mandate. The Coastal Water Authority also provides water supplies to the coastal basin from the Trinity River Basin.

Future Water Uses. Manufacturing and municipal water requirements are both projected to surpass irrigation water requirements in the basin during the projection period. Irrigation water use is expected to decline due to moderate reduction of irrigated acreage and improvements in management practices and equipment. Through water conservation practices, annual municipal water savings are projected to reach 11,234 acre-feet by year 2000, and nearly 36,151 acre-feet by 2040.

Future Water Supplies. Because of anticipated subsidence problems outside of Harris and Galveston Counties, it was assumed that other areas in the basin would approach the subsidence problem in a manner similar to the Harris-Galveston Coastal Subsidence District (HGCSD). Subsidence problem areas were converted to surface water, phased in over a 20-year period. The conversion was phased in similar to the HGCSD conversion, but 10 years later in time. The conversion to surface water will require the development of additional surface-water supplies in the Brazos River Basin and additional water conveyance facilities from the Trinity and Sabine river basins. By the year 2040, the reuse of wastewater from Houston will provide about 65,000 acre-feet per year of additional supplies to the industrial users in the basin.

BRAZOS-COLORADO COASTAL BASIN

Basin Description. The Brazos-Colorado Coastal Basin is bounded on the east by the Brazos River Basin, on the west by the Colorado River Basin, and on the south by the Gulf of Mexico (see Figure 1-4). The basin economy is based on manufacturing, agriculture, agribusiness, and trades. The 1980 basin population totaled 81,700 people. Current basin population is estimated at 86,800 residents, an increase of nearly six percent from the 1980 population. By 2040, population of the basin is projected to range between 156,000 and 176,500 residents. Major basin population centers include all or portions of the cities of Bay City, Freeport, Wharton, West Columbia, Eagle Lake, Sweeney, Brazoria, Jones Creek, and Needville.

Current Water Uses. Total annual water use in the basin is currently 344,178 acre-feet. The largest water demand in the coastal basin is for irrigation purposes with a current use of 305,591 acre-feet.

Current Water Supplies. Presently the basin is supplied with over 84,000 acre-feet per year from the Gulf Coast Aquifer, imports from the Colorado Basin, and supplies from creeks and rivers in the basin.

Future Water Uses. The current water use pattern of the Brazos-Colorado Coastal Basin is not expected to change significantly over the planning period, as water demands for irrigated agriculture are projected to remain the largest water demand. However, irrigation water demands are projected to decline over the 50-year planning period due to a moderate reduction in irrigated acreage and improvements in irrigation practices and equipment. Likewise, implementation of municipal water conservation programs is projected to reduce municipal water use by more than 1,434 acre-feet by 2000, and 4,638 acre-feet by 2040.

Future Water Supplies. It is anticipated the coastal basin will continue to be supplied from the adjacent Colorado River Basin and that ground-water usage will remain at about its current level.

COLORADO-LAVACA COASTAL BASIN

Basin Description. The Colorado-Lavaca Coastal Basin is bounded on the east by the Colorado River Basin and on the west by the Lavaca-Guadalupe Coastal Basin and the Lavaca River Basin (see Figure 1-4). The economy is based on manufacturing, agriculture, retail and wholesale trades, agribusiness, commercial fishing, and tourism. In 1980, the population totaled 25,600 people, while the current basin population is estimated at about 26,700 residents (an increase of about four percent since 1980). By the year 2040, the basin population is projected to range between 44,600 and 51,400 residents. Major basin population centers include the cities of El Campo, Palacios, and Point Comfort.

Current Water Uses. Total annual water use in the basin is currently 157,097 acre-feet. The largest water demand in the basin is for irrigated agricultural with a current use of 147,188 acre-feet.

Current Water Supplies. Presently the coastal basin is supplied with over 57,000 acre-feet per year from the Gulf Coast Aquifer. Surface water imports are also made from the Colorado and Lavaca river basins. Imports from the Colorado River Basin are mostly used for irrigation purposes, while supplies from the Lavaca Basin meet local industrial needs. Water from the Colorado River is also used to maintain the cooling capacity of the South Texas project. All cities in the coastal basin are supplied by the Gulf Coast Aquifer. However, the major use of the aquifer is for irrigation. Problems in the basin are overdrafting of the aquifer and bay and estuary needs.

Future Water Uses. The current water use pattern of the Colorado-Lavaca Coastal Basin is not expected to change significantly over the next 50 years, as water requirements for irrigation are projected to remain the largest water use category. However, manufacturing water requirements in the coastal basin are projected to increase significantly over the planning period due to the expansion of the basin's petrochemical industrial base. With implementation of municipal water conservation programs and practices, annual savings of municipal water is projected to reach 415 acre-feet by 2000, increasing to 1,337 acre-feet by 2040.

Future Water Supplies. Ground-water withdrawals should be reduced to the safe yield of the Gulf Coast Aquifer, providing supplies of about 57,700 acre-feet a year by 2040. Surface water imports from the Colorado River Basin will continue to meet irrigation and industrial cooling needs of the basin. Imports from the Lavaca Basin will increase with the expansion of industrial plants and conversion of some cities to surface water.

LAVACA-GUADALUPE COASTAL BASIN

Basin Description. The Lavaca-Guadalupe Coastal Basin is bounded on the east by the Lavaca River Basin and the Colorado-Lavaca Coastal Basin, and on the west by the Guadalupe River Basin and San Antonio-Nueces Coastal Basin (see Figure 1-4). The economy of the coastal basin is based on mineral production, agriculture, agribusiness, retail and wholesale trades, manufacturing, and commercial fishing. Basin population totaled 37,900 people in 1980. The current basin population is estimated at 41,400, an increase of about nine percent since 1980. By 2040, the population of the Lavaca-Guadalupe Coastal Basin is projected to range between 68,400 and 78,600 residents. Major basin population centers lying wholly or partially in the coastal basin include the Cities of Victoria, Port Lavaca, and Bloomington.

Current Water Uses. Total annual water use in the coastal basin is currently 81,159 acre-feet. Irrigation is the largest water demand in the basin with a current use of 56,840 acre-feet, followed by manufacturing with a use of 17,693 acre-feet.

Current Water Supplies. All current coastal basin water needs are met from the Gulf Coast Aquifer or with surface water imports from the Guadalupe Basin by the Guadalupe-Blanco River Authority (GBRA). Port Lavaca and the industrial complex on the Victoria barge canal are also supplied by the GBRA.

Future Water Uses. The current water use pattern of the Lavaca-Guadalupe Coastal Basin should change over the planning period, as municipal and manufacturing water uses are projected to surpass irrigation needs. Irrigation water use is projected to decline over the next 50 years due to a moderate reduction in irrigated acreage and anticipated improvements in irrigation practices and equipment. With implementation of municipal water conservation programs, annual savings of water are projected to reach about 623 acre-feet by 2000, increasing to 2,010 acre-feet by 2040.

Future Water Supplies. The basin will continue to be supplied by the GBRA, however the supplies will be from reservoirs in the lower Guadalupe Basin instead of the Canyon Lake reservoir. Ground water will continue to supply over 20 percent of the needs of the coastal basin.

SAN ANTONIO-NUECES COASTAL BASIN

Basin Description. The San Antonio-Nueces Coastal Basin is bounded on the north and east by the San Antonio River Basin and the Lavaca-Guadalupe Coastal Basin, and on the south and west by the Nueces River Basin and the Nueces-

Rio Grande Coastal Basin (see Figure 1-4). The economy of the basin is based on agriculture, agribusiness, retail and wholesale trades, mineral production, manufacturing, commercial fishing, and tourism. The 1980 basin population totaled 98,700 people. Current basin population is estimated at 108,900 residents, representing an increase of about 10 percent from the 1980 population. By the year 2040, population of the San Antonio-Nueces Coastal Basin is projected to range between 172,000 and 191,000 residents. Major population centers of the basin include the Cities of Beeville, Portland, Aransas Pass, Ingleside, Sinton, Rockport, Refugio, Taft, and Odem.

Current Water Uses. Total annual water use in the coastal basin is currently 24,850 acre-feet. Water for municipal purposes is the largest water demand in the basin with a current level of use of 12,859 acre-feet per year, followed by manufacturing with a water use of 7,240 acre-feet annually.

Current Water Supplies. The coastal basin is supplied by ground water from the Gulf Coast Aquifer and importation of surface water from the Nueces Basin. The San Patricio Municipal Water Authority has contracted for almost 34,700 acre-feet per year of water supplies from the City of Corpus Christi.

Future Water Uses. The current water use pattern of the coastal basin is projected to change significantly over the next 50 years, as water requirements for manufacturing are projected to nearly equal municipal water requirements by the year 2040. Annual savings in municipal water, due to implementation of municipal water conservation programs and practices, are projected to reach 1,594 acre-feet by 2000, increasing further to 4,843 acre-feet by 2040.

Future Water Supplies. The coastal basin will continue to rely on the adjacent Nueces River Basin to provide most of the supplies for the basin. However, additional contractual commitments for future water supplies will need to be secured from Corpus Christi.

NUECES-RIO GRANDE COASTAL BASIN

Basin Description. The Nueces-Rio Grande Coastal Basin is bounded on the north by the Nueces River Basin and on the west and south by the Rio Grande Basin (see Figure 1-4). The economy of the coastal basin is based on agriculture, agribusiness, manufacturing, retail and wholesale trades, mineral production, commercial shipping, commercial fishing, and tourism. The 1980 coastal basin population basin totaled 853,400 people. The current coastal basin population is estimated at about 1.0 million residents, an increase of 21 percent from the 1980 population. By the year 2040, the coastal basin population is projected to range between 2.4 and 2.9 million residents. Major population centers of the basin include the Cities of Corpus Christi, Brownsville, McAllen, Harlingen, Mission, Edinburg, Pharr, Kingsville, Weslaco, and San Benito.

Current Water Uses. Total water use in the Nueces-Rio Grande Coastal Basin is currently 1,195,555 acre-feet. Irrigation water use is the largest water demand in the coastal basin, accounting for 82 percent of the basin's total water use.

Current Water Supplies. The northern part of the coastal basin is supplied by Lakes Corpus Christi and Choke Canyon in the Nueces River Basin. The southern part of the coastal basin is supplied by Lakes Falcon and Amistad in the Rio Grande Basin. Total imports of water into the coastal basin are over 1,100,000 acre-feet per year. The Gulf Coast Aquifer provides over 15,000 acre-feet per year to the basin. Water-related problems in the coastal basin are inadequate wastewater and water facilities in economically distressed areas, flooding, pesticide residue in Arroyo Colorado, and bay and estuary concerns.

Future Water Uses. The current water use pattern of the Nueces-Rio Grande Coastal Basin is not anticipated to change significantly over the planning period, as water requirements for irrigation purposes are projected to remain the major water demand category. Water requirements for irrigated agriculture are projected to decline only slightly over the planning period due to anticipated improvements in irrigation practices and equipment. Municipal water requirements are projected to more than double the current municipal water use in the basin by the year 2040. Annual savings of municipal water through water conservation practices are projected to reach 22,494 acre-feet by the year 2000, and 93,477 acre-feet by the year 2040.

Future Water Supplies. The coastal basin will continue to rely on the Nueces River and Rio Grande basins to meet most of its needs. Imported water supplies will grow to about 1.5 million acre-feet by 2040. This will require the construction of the "Site A" Channel Dam below Brownsville to provide supplies for Brownsville and Harlingen. The northern part of the coastal basin will also need to develop a water reuse program. The program could provide only limited water supplies due to permit constraints on Lakes Corpus Christi and Choke Canyon. Given the potential limitation on reuse, questions concerning the reliability of firm yield estimates for Corpus Christi's surface water reservoirs, and mandated environmental releases, additional supplies imported from Lake Texana and potentially Palmetto Bend II in the Lavaca River Basin are recommended to help meet the future needs of the northern coastal basin area.

PROJECTED REGIONAL AND LOCAL WATER DEMANDS, SUPPLIES, AND FACILITY NEEDS

While the Texas Water Code places emphasis on the evaluation of river basin water demands and supplies, many of the State's water-related problems, needs, and opportunities for action are more closely related to particular regional and local characteristics. The various regions of this large state each possess their own unique socioeconomic, physiographic, climatological, and hydrologic factors that make their needs somewhat distinctive from other areas of the State.

As discussed in the first portions of Section 2, it is the intent of the Board to expand upon the regional aspects of water planning in subsequent updates of the state Water Plan. This revised approach will require careful delineation of new regional boundries and modification of the Board's data bases and computer software.

In this Plan, the Board has evaluated eight regions of the State and has projected costs of identified water, wastewater, and flood protection facility needs over the 50 year planning period (see Figure 3-15). As also indicated previously in Figures 3-9 through 3-14, the magnitude of these prospective water-related facilities expenditures is highly related to the relative population densities of the various regions.

The following section relates a summary of information on a regional and local basis. Shown in each of the following regional sections are those facilities costs related to the Board's high case growth "with conservation" water demand forecast.

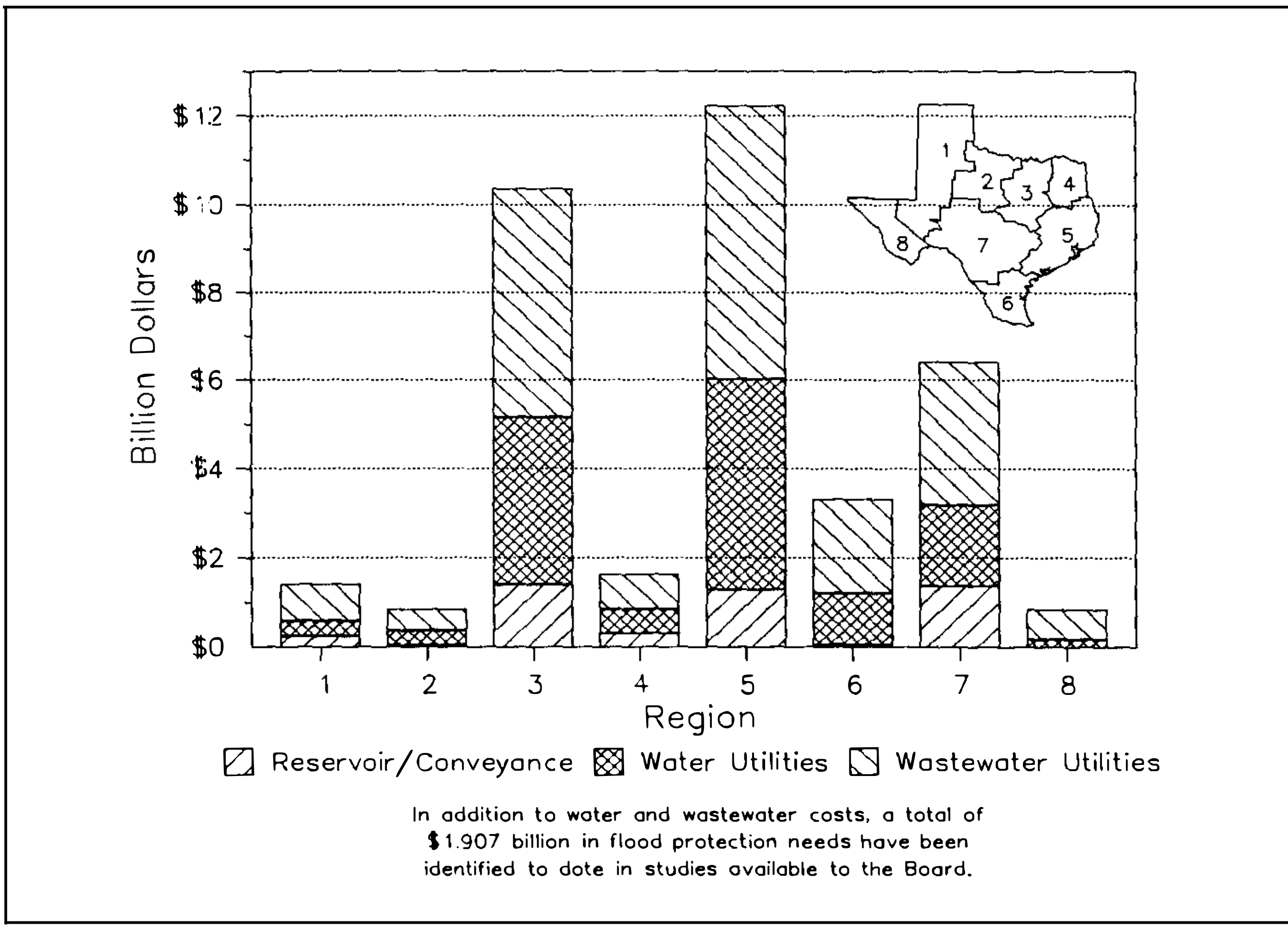
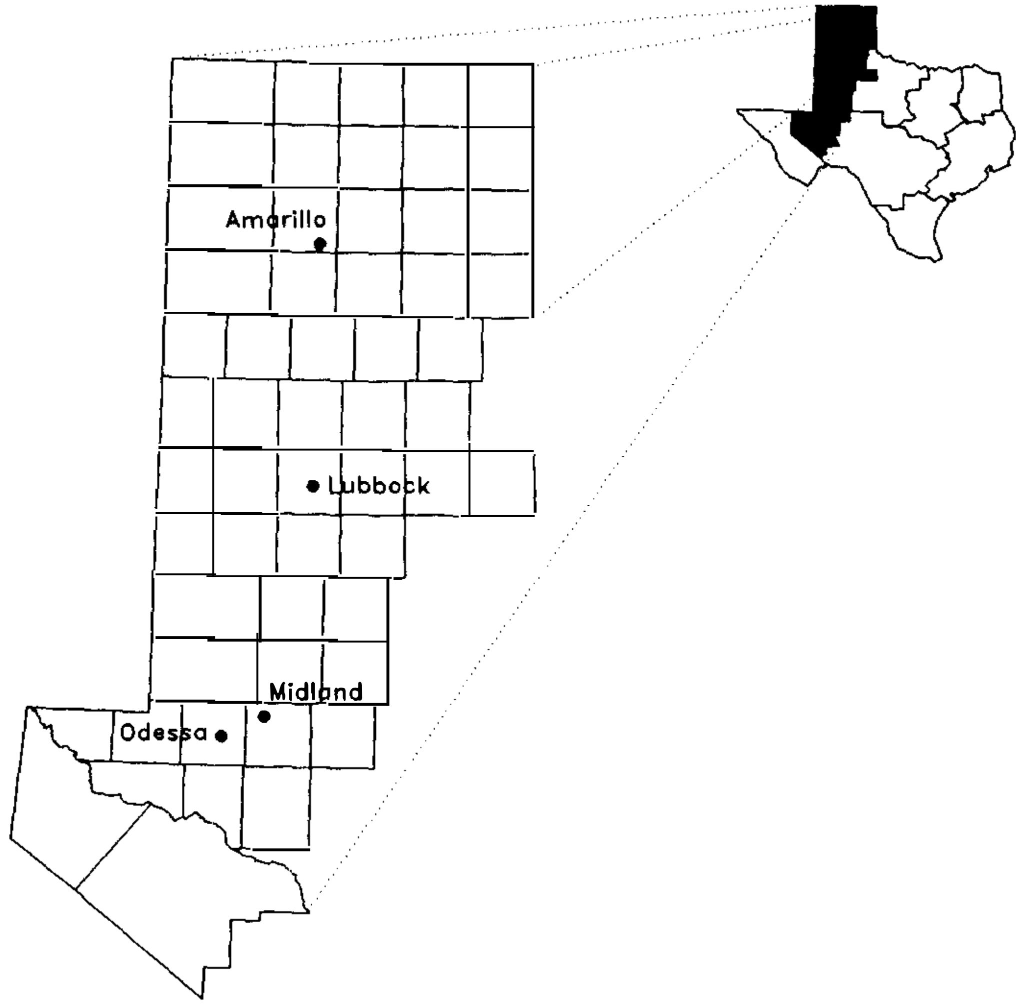


FIGURE 3-15
REGIONAL DISTRIBUTION OF PROJECTED WATER AND WASTEWATER PUBLIC INFRASTRUCTURE COSTS, 1990-2040

HIGH PLAINS AND TRANS-PECOS REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION :	1990	1.160 million
	2000	1.273 million
	2010	1.399 million
	2020	1.575 million
	2030	1.797 million
	2040	1.921 million

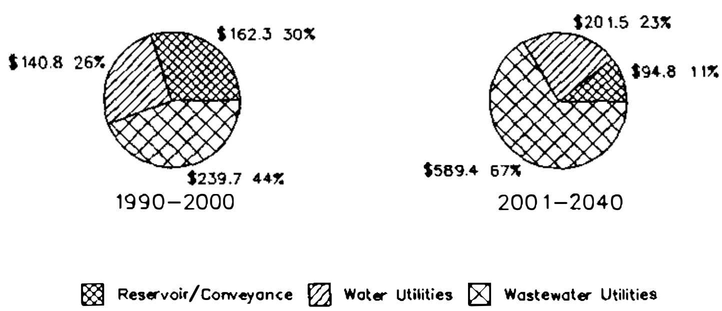
MAJOR ECONOMIC SECTORS: Agriculture, Agri-business, Mineral Production, Manufacturing, Retail and Wholesale Trade

NORMAL ANNUAL PRECIPITATION: 10 to 22 inches

ANNUAL NET EVAPORATION RATE: 53 inches

PHYSIOGRAPHY: In the High Plains, level plains with escarpment boundary on South and Southeast transcending to the Trans-Pecos area of arid, flat plains rising to high mountains.

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Currently Identified Flood Protection
Needs Total $7.3 Million.

Regional Description. The High Plains and Trans-Pecos Region is comprised of 56 counties located in the Canadian River Basin and portions of the Red, Brazos, Colorado, and Rio Grande basins. In 1980, the regional population totaled 1.08 million residents, with the counties of Lubbock, Potter, Midland, Ector, and Randall accounting for more than 54 percent of the total population. The regional population is currently estimated at 1.15 million residents. By the year 2040, population of the region is projected to range between 1.67 and 1.92 million residents. The major population centers of the region are the cities of Lubbock, Amarillo, Odessa, Midland, Big Spring, Plainview, Pampa, Borger, Hereford, and Levelland.

Total annual water use within the region is about 4 million acre-feet, with water used for irrigation purposes accounting for almost 90 percent of total use. The current water use pattern is not expected to change drastically over the 50-year planning period. The projected decline in regional irrigation water requirements is reflective of reduction in irrigated acreage and anticipated improvements in water efficient irrigation equipment and management practices. With the implementation of municipal water use conservation programs and practices, annual municipal water savings are projected to reach 21,700 acre-feet by the year 2000, and about 65,000 acre-feet by the year 2040.

Regional Water-related Problems and Needs. The Ogallala (High Plains) Aquifer is the major source of municipal and irrigation water. Historically, pumpage of ground water from this water-bearing formation has exceeded the natural recharge of the resource resulting in declining water levels. However, some parts of the Ogallala Aquifer have experienced water-level rises over the past five years. Currently, the Ogallala supplies irrigation water to about 4.0 million acres in the Texas High Plains. By the year 2040, it is projected that the Ogallala will supply irrigation water to about 3.8 million acres. Without an effective water conservation program, the region could need about 4.5 million acre-feet per year of water to irrigate the 3.8 million acres. However, an effective water conservation program could reduce the water requirements to about 3.1 million acre-feet per year of water. Even with conservation, water needs for irrigation could exceed supplies in localized areas of the region. Ground water in many areas has higher fluoride and nitrate concentrations than the U.S. Environmental Protection Agency and the State allow for public consumption under the Federal Safe Drinking Water Act. Additionally, localized flooding is a problem throughout the region due to the topography of the area.

The percent distribution of the estimated $1.429 billion in projected total costs for identified water and wastewater infrastructure in the High Plains and Trans-Pecos Region over the 50-year planning period is shown in the inset box at left. Approximately $543 million would be required in the first ten years and an estimated $886 million in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the High Plains and Trans-Pecos Region is described below. Additional information may be obtained from the Board's files.

<u>The Canadian River Municipal Water Authority</u>. The Canadian River Municipal Water Authority (CRMWA) has a permit to divert 103,000 acre-feet per year from Lake Meredith; however, supplies available are estimated to be about 80 percent of the permit. The long-range estimate of supplies, assuming additional water resource development by New Mexico, is about 50 to 60 percent of the permitted diversion depending upon the results of litigation by Texas and Oklahoma against the State of New Mexico for alleged compact violations. The CRMWA's reservoir has water quality problems and sometime in the future could be out of compliance with State Health Department and the federal Safe Drinking Water Act standards. To ensure the water quality of Lake Meredith, the Authority and the U.S. Bureau of Reclamation have proposed the construction of a salinity control project near Logan, New Mexico to reduce the discharge of highly mineralized water into the Canadian River.

<u>Colorado River Municipal Water District</u>. The Colorado River Municipal Water District (CRMWD) has surface water supplies in Lake J.B. Thomas, Lake E.V. Spence, the recently constructed O.H. Ivie Reservoir, and well fields in Martin, Ector, Ward, Howard, Glasscock, and Scurry counties. The CRMWD also provides water quality enhancement by diverting low

streamflows with high salinity to side storage. These diversion points are located on the Colorado River near Colorado City, on Beals Creek near Big Spring, and on Three and Four Mile Lakes. Additionally, the CRMWD will begin construction on a $7 million water quality enhancement project in Mitchell County during 1990. Member cities of the District include Odessa, Snyder, and Big Spring. Over the 50-year planning period, the District is not expected to add new sources of surface water supply but will provide transmission facilities related to the new O.H. Ivie Reservoir project. The District will develop additional ground-water supplies during the planning period and will continue its policy of conjunctive use of ground- and surface water assets.

City of Amarillo. The City is supplied water by the Canadian River Municipal Water Authority and well fields in Carson, Deaf Smith, and Randall counties. The City uses the well fields for water supply and to reduce total dissolved solids (TDS) concentrations of Lake Meredith water. The City plans to continue use of the Carson well fields and develop additional well fields; however, the water supply from these well fields could be limited by the Panhandle Underground Water Conservation District. Additionally, the City has water right holdings in Hartley County which are planned for development over the next 20 to 30 years. Based on the existing and developable supplies, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through the year 2040.

The City of Amarillo has two major wastewater treatment facilities, the River Road plant serving much of the City in Potter County and the Hollywood Road plant serving sections of the City in Randall County. The City is planning a major expansion at the Hollywood Road site in the near future.

In a high flood hazard study completed in September 1986, the U.S. Army Corps of Engineers identified enforced zoning as the most recommended flood damage prevention measure for the playa lakes and creeks in and around Amarillo.

City of Lubbock. The City's primary source of water is from Lake Meredith (CRMWA) and well fields located in Lubbock, Bailey, and Lamb counties. Lake Alan Henry, presently under construction by the City and the Brazos River Authority at an estimated cost of $50 million, is expected to be operational by early 1993 and, with completion of diversion, transmission, and treatment facilities, should provide the City with an additional 29,000 acre-feet per year. Between the years 2030 and 2040, the City is expected to need additional water supplies from the permitted Post Reservoir Project. Based on the existing and developable supplies, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through the year 2040.

The City's Southeast Water Reclamation Plant (SEWRP), permitted to treat 25 million gallons per day (MGD), handles nearly all of the City's wastewater flow. Treated effluent is used as either makeup water for the Southwestern Public Service Company's Jones Power Plant, or for irrigation on over 7,000 acres of farm land at various sites. The City is planning expansion and major upgrading at the SEWRP.

A recently completed flood protection planning contract, sponsored by the Board, proposed a number of structural improvements, relating to additional flood storage in the playa lakes, along with encouragement of the purchase of additional flood insurance by citizens residing within the 100-year floodplain.

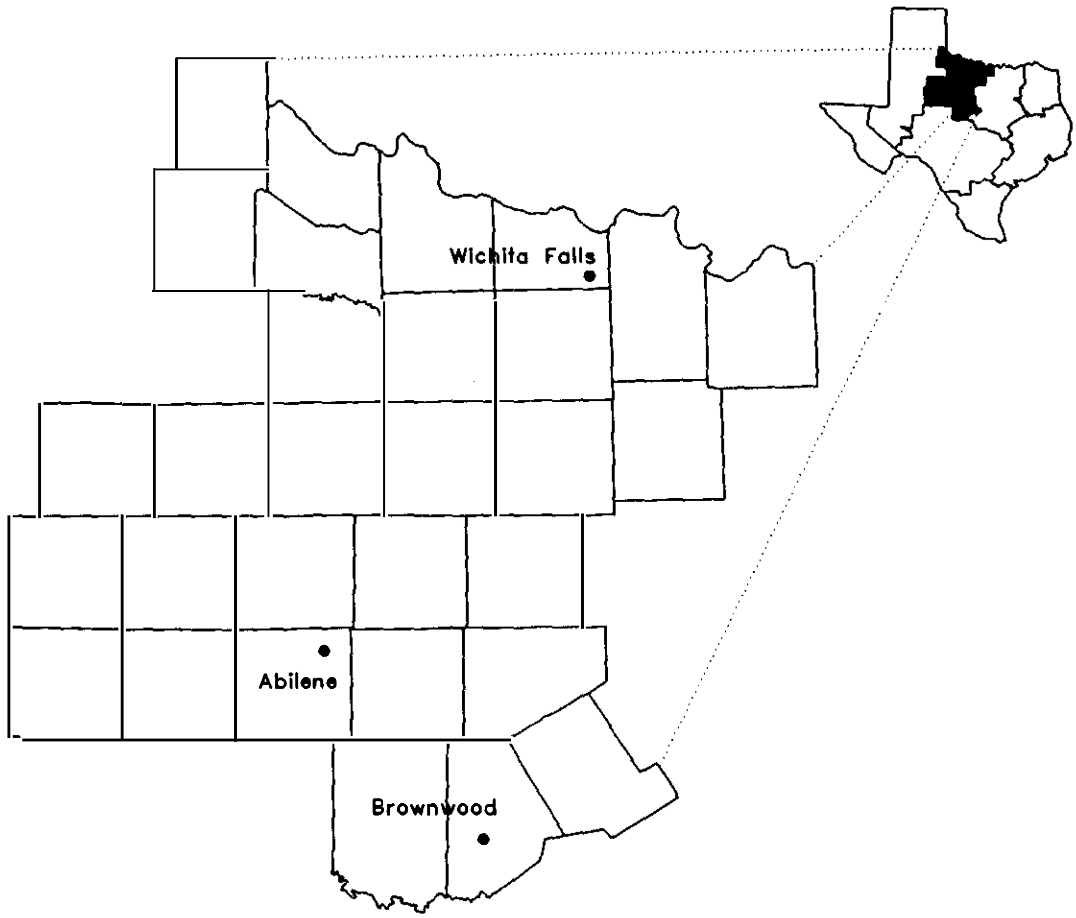
City of Midland. Currently, the City of Midland is supplied water from the Colorado River Municipal Water District, and the City's Paul Davis and McMillan well fields. The City has also purchased approximately 16.54 percent of the water supply from the recently completed O. H. Ivie Reservoir. With the completion of transmission facilities from the reservoir, additional water supplies of about 18,690 acre-feet per year will be available to the City. The existing and planned transmission facilities, in conjunction with an effective water conservation program, are expected to meet the City's future water needs through the year 2040.

Midland is currently served by a 15 MGD wastewater treatment and land application system that utilizes area golf courses and two irrigation sites totalling more than 6,000 acres. A second treatment facility serving the regional airport will be abandoned upon completion of a planned trunk line.

City of Odessa. The City of Odessa, a member city of the Colorado River Municipal Water District, receives both ground water and surface water from the District. With the recently completed O. H. Ivie Reservoir, proposed construction of water transmission facilities, and an effective water conservation program, the City is expected to meet its future water needs through the year 2040.

The City of Odessa operates two wastewater treatment facilities, the 9.5 MGD South Dixie Water Reclamation Plant and the 5.2 MGD East Water Reclamation Plant. Approximately 40 percent of the treated wastewater from the South Dixie plant is reused by area industry. Future alternatives appear to be to expand the reuse system or to upgrade treatment levels for discharge to Monahans Draw.

WEST CENTRAL TEXAS REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION :		
	1990	0.540 million
	2000	0.616 million
	2010	0.694 million
	2020	0.793 million
	2030	0.911 million
	2040	0.977 million

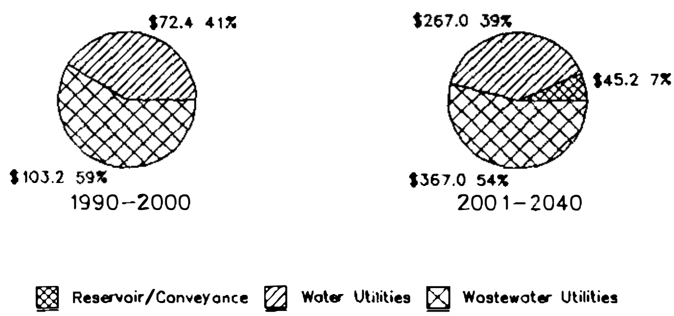
MAJOR ECONOMIC SECTORS: Mineral Production, Agriculture, Agri-business, Manufacturing, Retail and Wholesale Trade, Government

AVERAGE ANNUAL PRECIPITATION: 19 to 30 inches

ANNUAL NET EVAPORATION RATE: 51 inches

PHYSIOGRAPHY: Rolling prairies in the western portion transcending to the flat, relatively treeless, grand prairie and cross timber country in the east

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Currently Identified Flood Protection
Needs Total $64.7 Million

Regional Description. The West Central Texas Region consists of 30 counties located in portions of the Red, Brazos, Colorado, and Trinity river basins. In 1980, the population of the region totaled 518,900 residents, of which 51 percent of the regional population was located in the counties of Wichita, Taylor, and Brown.

Currently, the population of the region is estimated at 537,200 residents. By the year 2040, the population of the region is projected to range between 837,200 and 977,200 residents. The major population centers within the West Central Texas Region are the cities of Abilene, Wichita Falls, Brownwood, Snyder, Vernon, Sweetwater, Burkburnett, Graham, Breckenridge, and Iowa Park.

The West Central Texas Region's current water use is about 337,000 acre-feet per year, of which water used for farm irrigation purposes accounts for approximately 55 percent of this total. The current water use pattern of the region is projected to change over the 50-year planning period as municipal and manufacturing water requirements are projected to increase by more than 63 percent above current water use levels, while irrigation water requirements are projected to remain relatively stable during this time.

Agricultural irrigation water requirements are projected by the Board to remain the major water demand category of the region over the next 50 year planning period. Irrigation demands placed on water resources of the region are, however, expected to diminish over time and ultimately account for only about 51 percent of the regional water demand by the year 2040.

Municipal water requirements of the region are projected to increase by more than 54 percent above the current municipal water use by the year 2040. With the implementation of various municipal conservation programs and practices by cities in the region, savings in annual water requirements are projected by the Board to reach about 10,000 acre-feet by the year 2000, increasing further to approximately 31,500 acre-feet of savings by the year 2040.

Regional Water-related Problems and Needs. Natural salt pollution in the upper reaches of the Red and Brazos river basins precludes the full utilization of the water resources of these basins. Also, leaking oil, gas, and saltwater disposal wells, along with improper disposal of saltwater incidental to oil and gas exploration and production, have resulted in localized contamination of fresh ground- and surface water supplies.

High nitrate concentrations occur in the ground water in some areas in the West Central Texas Region due to naturally-occurring phenomena, locally intensified by contaminants from septic tanks, cesspools, feedlots, agricultural fertilizers, and cultivation practices. Locally, ground water is higher in fluoride concentrations than existing State standards for public consumption under the Federal Safe Drinking Water Act.

Brush infestation of rangeland and growth of woody plant species that obtain water directly from the water table or from the soils just above it (phreatophytes) compete with more useful plants for available fresh water supplies. Due to the topography of the area, localized flooding in the region is also a continuing problem.

The percent distribution of the estimated $855 million in projected total facilities costs for identified water and wastewater infrastructure in the West Central Texas Region over the Board's 50-year planning period is shown in the inset box at left. Approximately $176 million of spending for these facilities would be required in the first 10 years, with an estimated $679 million in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the West Central Texas Region is described in the narrative below. Additional information on the utility demands, facility needs, and problems of these West Central Texas communities and utilities may be obtained from the Board's files upon request.

City of Abilene. The City of Abilene is supplied from Lakes Abilene and Fort Phantom Hill, as well as the West Central Texas Municipal Water District (WCTMWD). The City has a current raw water supply capacity of approximately 36,400 acre-feet per year. The District owns the Hubbard Creek Reservoir and has contracted to provide the City of Abilene with water delivered into Lake Fort Phantom Hill. The water transmission lines to the Lake can provide approximately 17,500 acre-feet per year of supply on the average.

The West Central Municipal Water District, on behalf of the City of Abilene, is participating in the new O.H. Ivie Reservoir Project, located at the confluence of the Colorado and Concho rivers in the Colorado River Basin. The City is entitled to 16.54 percent of the projected firm yield of the new supply project. Major water transmission facilities from the new water supply reservoir will need to be constructed by the City of Abilene by the year 2010. Existing and planned water supplies and an effective water conservation program by the City, are expected to provide sufficient water supplies to meet the future needs of the City and its customers through the year 2040.

All of the City of Abilene's collected wastewater is pumped by the City's Buck Creek Pump Station to the Hamby Water Reclamation Plant (WRP). The City has recently funded improvements to both of these wastewater facilities and to the major upstream trunk interceptor. Municipal capital improvement plans call for expanding the Hamby WRP from 13.4 MGD to 18 MGD, expanding the trunk interceptor system, and may include a new Westside wastewater treatment plant.

The U.S. Army Corps of Engineers has identified over $37 million of flood protection projects, along with a variety of non-structural protection measures, including enforced zoning, permanent evacuation of the floodplain, early warning systems, and flood proofing, to address the area flooding problems in the urbanized Elm Creek watershed.

City of Wichita Falls. The City of Wichita Falls presently draws water supplies from the Kickapoo and Arrowhead Reservoirs. Wichita Falls' present water supply system can provide about 63,000 acre-feet per year, and the City also has water rights to over 70,000 acre-feet per year in Lake Kemp. The City provides water to various water supply corporations serving the rural areas near Wichita Falls. The City's existing water supplies, in conjunction with the implementation of an effective water conservation program, are expected to provide sufficient water to meet the City's future municipal water needs through the year 2040.

The City of Wichita Falls is in the final engineering design stages of a $21.3 million State Water Pollution Control Revolving Fund loan project to upgrade its River Road wastewater treatment plant. The wastewater improvement project will raise the average hydraulic flow capacity of the plant from 17 MGD to 19.91 MGD and will provide for higher levels of treatment.

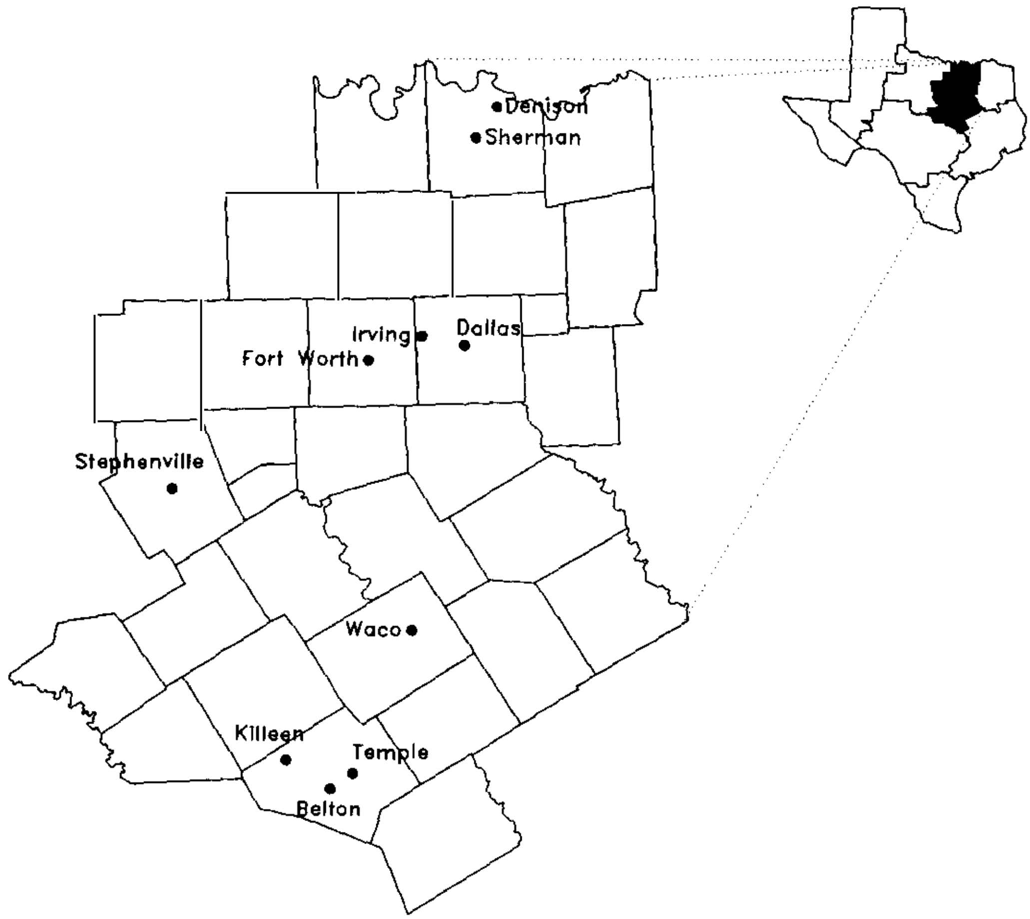
Studies by the U.S. Army Corps of Engineers have identified over $9 million of construction programs to alleviate chronic flooding problems on McGrath Creek, and has recommended the implementation of both enforced zoning by the City and various other non-structural flood prevention measures along Holliday, McGrath, and Plum creeks, as well as the Wichita River.

City of Brownwood. The City of Brownwood receives water from Lake Brownwood, which is owned and operated by the Brown County Water Improvement District No. 1. The City's water supply needs are expected to double over the 50-year planning horizon. With the City's existing water supplies and an effective municipal water conservation program, Brownwood is expected to have sufficient water supplies to meet its future water needs through the year 2040.

Brownwood recently completed construction of an upgraded 3.6 MGD wastewater treatment facility. Projected municipal population increases will likely require future expansion of the City's treatment facilities.

Brownwood suffers from severe recurrent flooding, as evidenced by the tragic Spring floods of 1990, which was the sixth significant flood event in the City since 1972. The Pecan Bayou reservoir was authorized by Congress in 1968 for flood control and water supply purposes, but it is currently considered to have an inactive status. The U.S. Army Corps of Engineers has requested additional FY1990 appropriations funding to re-evaluate the project at full federal expense.

NORTH TEXAS REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION :	1990	4.940 million
	2000	5.778 million
	2010	6.640 million
	2020	7.452 million
	2030	8.283 million
	2040	8.871 million

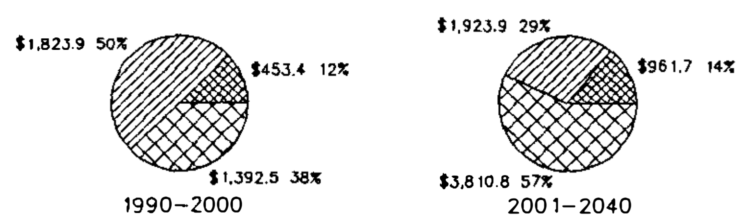
MAJOR ECONOMIC SECTORS: Manufacturing, Retail and Wholesale Trade, Finance, Services, Transportation, and Tourism

AVERAGE ANNUAL PRECIPITATION: 26 to 40 inches

ANNUAL NET EVAPORATION RATE: 41 inches

PHYSIOGRAPHY: Transcending from flat to rolling wooded cross timbers in the west to wooded rolling hills and flat lands of the Blacklands and Post Oak Belt

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Reservoir/Conveyance Water Utilities Wastewater Utilities

Currently Identified Flood Protection
Needs Total $144.1 Million

Regional Description. The North Texas Region consists of 31 counties located predominately in the Trinity and Brazos River Basins and in portions of the Red, Sulphur, and Sabine river basins. In 1980, the population of the region totaled 3.78 million people, with about 64 percent of the regional population located in Dallas and Tarrant counties. Currently, the regional population is estimated at 4.68 million residents. By the year 2040, population of the region is projected to range between 7.7 and 8.9 million residents. The major population centers of the region are the cities of Dallas, Fort Worth, Arlington, Garland, Irving, Plano, Waco, Grand Prairie, Mesquite, and Richardson.

Total current annual water use within the region is about 1,195,000 acre-feet. Due to the large concentration of population within the region, municipal water use is by far the largest water use category, accounting for more than 77 percent of the region's annual water use. The current water use pattern of the region is not expected to change significantly over the 50-year planning period with municipal water requirements continuing to be the largest water use category in the region. With water use conservation programs and practices in place, annual municipal water savings are projected to reach about 96,000 acre-feet by the year 2000, increasing to more than 285,000 acre-feet by the year 2040.

Regional Water-related Problems and Needs. Ground-water levels in the Trinity Aquifer have been lowered severely, resulting in burdensome pumping costs that will increase. The quality of ground water is deteriorating as water levels decline. Fluoride concentrations in ground water are high. In the southern portion of the region, the northern segment of the Edwards Aquifer (which has no ground-water district supervision) provides water to rural and urban areas. Surface water quality suffers from high urban use pressures (dissolved oxygen, suspended solids, phosphates, fecal coliform, algal blooms, and aquatic plants) and runoff from some agricultural areas. High chloride concentrations in Lake Texoma in the Red River Basin and reservoirs in the middle Brazos River Basin preclude full utilization of the water resources of these basins. Surface water development is near the maximum potential for the Upper Trinity River Basin. Water is being imported from neighboring basins to the east. Regional initiatives to address watershed management and water conservation are underway in the Upper Trinity Basin area. Severe flooding is also a problem in the Upper Trinity Basin area. A major regional flood protection study, termed the "Common Vision for the Trinity Corridor," is underway at present to examine structural and non-structural means of addressing this problem.

The percent distribution of the estimated $10.366 billion in projected total costs for identified water-related infrastructure in the North Texas Region over the 50-year planning period is shown in the inset box at left. Approximately $3.670 billion would be required in the first 10 years and an estimated $6.696 billion in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the North Texas Region is described below. Additional information may be obtained from the Board's files.

Tarrant County Water Control and Improvement District No. 1. The District (TCWCID #1) presently owns and operates Eagle Mountain, Bridgeport, Cedar Creek, and Richland-Chambers Reservoirs and storage in Benbrook Reservoir. TCWCID #1 supplies water to Fort Worth, Arlington, Mansfield, communities throughout Tarrant County, and communities adjacent to the District's reservoirs. The District also provides raw water to the Trinity River Authority, who then sells treated water to the cities of Bedford, Euless, North Richland Hills, Grapevine, and Colleyville. The District will serve to augment the raw water supplies of Weatherford and Benbrook in the future. The District's total supply is estimated to be over 457,000 acre-feet per year.

By the year 2030, the District will have to develop additional supplies to meet its customers needs. It is recommended that the District develop the Trinity River Diversion into existing Richland-Chambers and Cedar Creek reservoirs to make expanded use of those facilities, eventually construct the Tehuacana Reservoir project, and build associated transmission facilities to convey supplies associated with both projects. If the diversion is built but the Board's projected conservation savings are not realized, then water supply could be obtained from the Parkhouse II or Marvin Nichols reservoirs depending on regional cooperation and status of potential land use conflicts. However, if the Trinity River Diversion proves infeasible, additional supplies would likely be provided from the potential Marvin Nichols project in the Sulphur Basin.

North Texas Municipal Water District. Over three-quarters of a million people depend on the District for water supplies. The District's service area covers over 1,600 square miles, and it currently supplies over 189,000 acre-feet of water per year. The District's supply sources include: Lake Lavon, Lake Texoma, and Lake Cooper, presently under-construction. The District also provides wastewater treatment and solid-waste disposal for its customer cities. In the future, the District will need to develop the New Bonham Reservoir site and associated transmission facilities and purchase additional water supplies from Cooper Reservoir.

The District owns and/or operates regional and subregional wastewater conveyance and treatment facilities in Collin, Dallas, and Rockwall counties. It has recently expanded its Wilson Creek treatment facility serving Plano, McKinney, and Allen, and is planning further expansion in this system as well as in those serving the cities of Wylie, Mesquite, and Rockwall.

Greater Texoma Water Authority. The Authority has rights in Lake Texoma and is developing diversion facilities in conjunction with the North Texas Municipal Water District. The Authority will provide water to the Sherman-Denison area and has rights to about 69,000 acre-feet per year in Lake Texoma.

Brazos River Authority. The Brazos River Authority (BRA) owns or operates 12 major reservoirs on the Brazos River and its tributaries. Supplies from Lakes Granbury, Proctor, Aquilla, Waco, Belton, and Stillhouse Hollow are used in this region. Supplies from Lakes Possum Kingdom and Whitney are also supplied by the BRA to meet needs in the North Texas Region. The Authority will need to add to its surface water supplies by developing the South Bend project if projected municipal water conservation savings are not realized.

The Brazos River Authority owns two regional wastewater treatment facilities, one serving the Waco metropolitan area and the other serving the cities of Temple and Belton. The Waco treatment plant has a capacity of 37.5 MGD. The Authority has completed construction on an expansion of the Temple-Belton facility from 5 MGD to 10 MGD.

City of Dallas and Dallas Water Utilities. The Dallas Water Utilities (DWU) provides treated water to 22 political subdivisions and 7 raw water customers in Dallas, Denton, and Collin counties. DWU has water permits in Ray Hubbard, Lewisville, Ray Roberts, Grapevine, Palestine, Tawakoni, and Lake Fork Reservoirs. Total available supplies are more than 650,000 acre-feet per year. The DWU also purchases about 10,000 acre-feet per year from North Texas Municipal Water District.

Based on the Utilities' existing water supplies, construction of planned transmission facilities to Lakes Palestine and Lake Fork, and implementation of effective water conservation programs by DWU and its customer cities, the DWU is expected to meet all future water needs of its many customers through the year 2040. The Board's without-conservation forecast indicates that the potential Parkhouse Reservoir 1 would be needed by 2030. The DWU feels that in view of its existing conservation program, the additional conservation reflected in the Board's projected 15 percent conservation savings is not achievable. The DWU has completed a long-range plan in 1989 that projects only seven percent additional savings could be achieved through expanded conservation efforts and says the DWU will need additional supplies from Parkhouse 1 Reservoir by the year 2030.

Dallas Water Utilities operates two of the largest wastewater treatment facilities in Texas, the 150 MGD Dallas Central Plant and the recently expanded 90 MGD Southside Plant. The Central Plant is undergoing an extensive upgrading and modernization program. The Southside Plant is undergoing a number of improvements, primarily in the area of sludge management. In the longer term, Dallas will expand Southside to 150 MGD.

The City of Dallas and the surrounding areas continue to experience significant damage from flooding. Several studies have identified over $5 million of structural improvements for flood protection in the Dallas floodway, along with numerous non-structural flood damage prevention measures.

City of Fort Worth. The City of Fort Worth is the second most populated city in the region and is provided water by the Tarrant County Water Control and Improvement District # 1 (TCWCID #1). With the development of additional surface water supplies by the TCWCID #1, and an effective water conservation program, the City's future water needs are anticipated to be met by the TCWCID #1 through the year 2040.

The City's Village Creek wastewater treatment plant serves 24 neighboring cities in Tarrant and Johnson counties. The City has embarked on a series of projects that will expand Village Creek from 120 MGD to 144 MGD.

Two recent studies in the Fort Worth area have identified numerous non-structural flood damage prevention measures, along with some minor structural improvements in the Edgecliff Branch of Sycamore Creek.

Trinity River Authority. The Trinity River Authority (TRA), through a contract with TCWCID #1, provides water to the cities of Bedford, Euless, North Richland Hills, Grapevine, and Colleyville. TRA is the local sponsor of Joe Pool Reservoir and has contracted to provide water to the cities of Cedar Hill, Duncanville, Grand Prairie and the Midlothian Water District from the project. TRA, through Lakes Bardwell and Navarro Mills, also provides water to the cities of Corsicana, Waxahachie, and other communities in Ellis County. TRA could additionally be the local sponsor for any flood control or water quality protection projects developed in the upper, middle, or lower Trinity Basin. The potential Tennessee Colony Reservoir in the middle Trinity Basin could provide substantial flood control protection for the lower part of the basin, although acceptable federal, state, and/or local funding mechanisms would be necessary to support the cost of this expensive facility.

The TRA is the state's largest operator of regional treatment works. The Central Plant and interceptor system services 19 cities in the "mid-cities" area of Dallas and Tarrant counties, including portions of Fort Worth, Dallas, and the D/FW Airport. TRA recently awarded a $104 million contract to expand the Central Plant from 115 MGD to 135 MGD. The Ten Mile Creek system, recently expanded from 6.78 MGD to 21.5 MGD, serves 6 cities in southern Dallas and Ellis counties. The Red Oak Regional System, presently under construction, which will expand regional service to six cities in Dallas and Ellis County. In addition, the TRA is completing construction of the first phase of a regional system on Denton Creek in southern Denton County. When Red Oak and Denton Creek are complete, the TRA will be treating wastewater from more than 30 cities in a four county area.

Sherman-Denison. The City of Sherman's water needs are currently being met from ground-water supplies; however, the City plans to convert to surface water supplies with the completion of diversion and treatment facilities by the Greater Texoma Water Authority. The City of Denison is presently supplied water from Lake Randall and Lake Texoma, and the City plans to continue to use these supply sources through the foreseeable future. Based on existing water supplies, planned water source conversion, and an effective water conservation program for both cities, the future water needs for the cities of Sherman and Denison are anticipated to be met through the year 2040.

Sherman completed construction of a major upgrade to its 12 MGD Post Oak Creek wastewater treatment facility in 1987. Denison operates three treatment facilities with a combined capacity of 6.4 MGD. The City recently consolidated the operations of two plants in an expanded 4 MGD Paw Paw Creek plant.

A Corps of Engineers high flood hazard area study conducted in Sherman, sponsored by the Board, and completed in September 1986 identified the need for additional flood damage prevention measures, mainly consisting of enforced zoning in Choctaw, Post Oak, and Sand Creeks, as well as several unnamed creeks in and around the Sherman area.

Upper Trinity Regional Water District. The District was created by the Texas Legislature in June, 1989 to provide regional water and wastewater services for the Denton County area. The service area of the District is within the water supply planning boundaries of the City of Dallas Water Utilities. Since Dallas has planned future water supplies for most of Denton County, the District will obtain from Dallas Water Utilities a substantial portion of its water supply requirements.

The long range plan for the District recommends consideration of joint development of water resources with others in the Sulphur River Basin. Consistent with that plan, the District has made a contract with the City of Commerce to supplement Dallas water by temporary use of Commerce's water supply from Cooper Reservoir. Implementation of that agreement is pending a determination of transmission feasibility to Denton County and approval of the temporary interbasin transfer. The District has executed long-term agreements with 10 cities and utilities in Denton County to develop a surface water system with water treatment plant and transmission facilities to each of the contracting entities. For many of the participating entities, this project will be the first step away from total reliance on limited ground-water resources.

City of Denton. The City of Denton currently obtain surface water supplies from Lewisville and Ray Roberts Reservoirs. Total available supply for the City from the two reservoirs is estimated at over 38,000 acre-feet per year. The City and its customer cities are expected to need additional supplies before the year 2030. The Upper Trinity Municipal Water District or the Dallas Water Utilities could provide these additional water needs. With these additional water supplies and an effective water conservation program, the City is anticipated to be able to meet its future water needs through the year 2040.

Denton currently operates a 12 MGD wastewater treatment facility that discharges to Pecan Creek. The City intends to expand the plant in stages to approximately 20 MGD by the year 2010.

City of Waco. The City of Waco is currently supplied water from Lake Waco, which is operated for the City by the Brazos River Authority. It is anticipated that Waco and BRA will provide water from Lake Waco to other cities and rural areas in McLennan County. The Waco project is presently permitted to supply about 58,000 acre-feet per year; however, a permit application has been submitted by the BRA to reallocate authorized storage in the reservoir to municipal supply. Operating the reallocated Lake Waco with the planned Bosque Reservoir as a system could provide the Authority with over 99,000 acre-feet per year of additional supplies. The Authority plans to use the additional supplies to meet the needs in the Waco area and for other systemwide needs.

The City contracts for wastewater treatment at BRA's Waco Metro Regional Plant and will continue to use the facility in the future.

Killeen-Belton-Temple. The Killeen, Belton, and Temple metropolitan areas are supplied water from Belton Reservoir which is operated by the Brazos River Authority. The City of Temple has contracted for up to 26,700 acre-feet per year of water supply from Belton Reservoir. The City of Belton is supplied by Bell County WCID #1, who has contracts for about 47,600 acre-feet per year from Belton Reservoir. The City also has contracted with the BRA to be supplied up to 2,500 acre-feet per year from Belton Reservoir. The City of Killeen is also supplied by Bell County WCID #1. Using BRA's existing water supplies and an effective water conservation program, the cities are anticipated to be able to meet their future water needs through the year 2040.

The City of Killeen's wastewater treatment is handled by Bell County WCID#1 at its 21 MGD regional plant. The plant also provides treatment for Fort Hood. Belton and Temple contract with the Brazos River Authority for treatment at its regional treatment site. Temple also operates its own 5 MGD Doshier Farms wastewater treatment plant, where extensive rehabilitation is anticipated.

City of Irving. The City is currently supplied by Dallas Water Utilities (DWU); however, the City has contracted for use of 40,260 acre-feet per year of supply from the Cooper Reservoir which is currently under construction. The City is planning to develop transmission facilities in conjunction with North Texas Municipal Water District to deliver water to Irving. The City will also continue to need supplies from DWU. Using DWU's existing water supplies, and the City's supply in Cooper in conjunction with an effective water conservation program, the City is anticipated to be able to meet its future water needs through 2040.

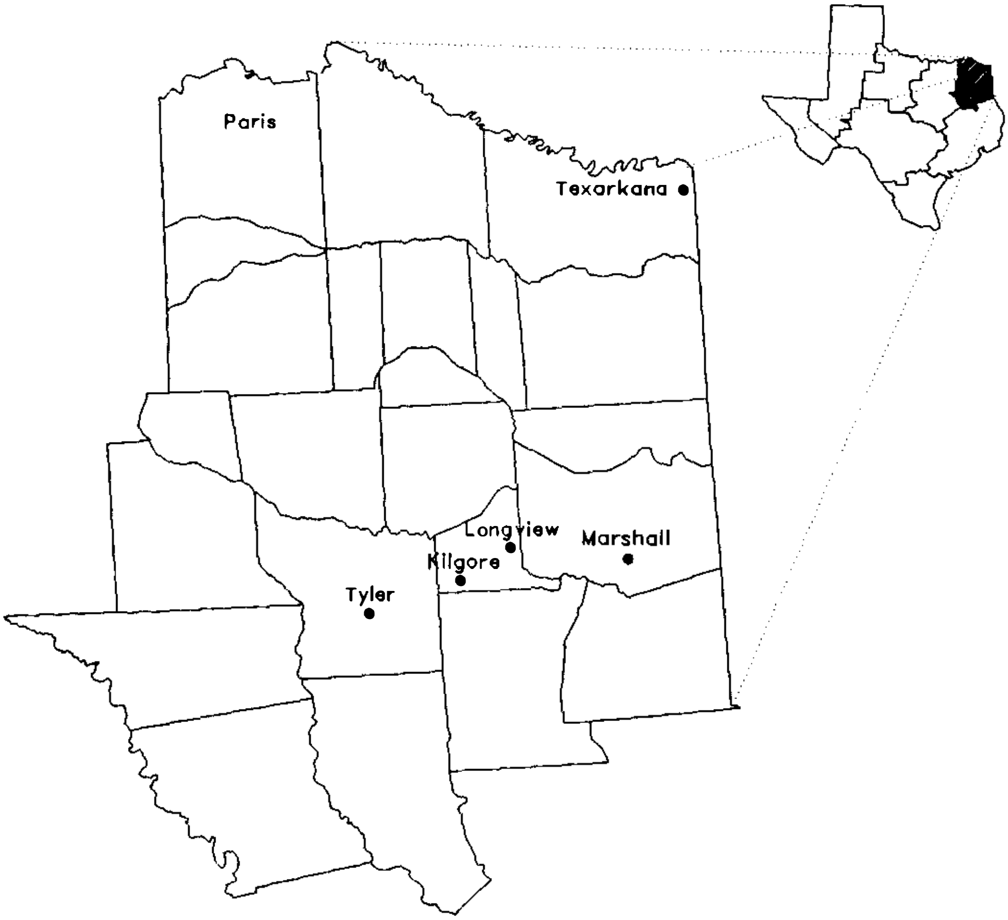
Irving contracts with the Trinity River Authority for wastewater treatment at the Authority's Central Plant.

Recently-completed flood studies for the City of Irving have identified modest structural improvements along Delaware Creek and recommended flood damage prevention measures, including enforced zoning, warning systems, and permanent evacuation of certain areas along Cottonwood Branch, Delaware Creek, Estelle Creek, Grapevine Creek, Hackberry Creek, and Long Branch.

The City of Stephenville. The City currently withdraws water from the Trinity Aquifer; however, it has experienced water supply problems due to declining water levels. The City has contracted with Somerville County Water Authority to purchase water from the permitted Paluxy Reservoir project, which is presently in litigation to establish releases for instream flow needs. With the ultimate development of the Paluxy Reservoir and an effective water conservation program, the City is anticipated to be able to meet its future water needs through the year 2040.

Stephenville is presently served by a 1.85 MGD wastewater treatment facility. The City is anticipating an $8.5 million project to expand capacity to 3 MGD, upgrade treatment levels, and repair and expand its wastewater collection system.

NORTHEAST TEXAS REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION :	1990	0.940 million
	2000	1.109 million
	2010	1.245 million
	2020	1.418 million
	2030	1.618 million
	2040	1.730 million

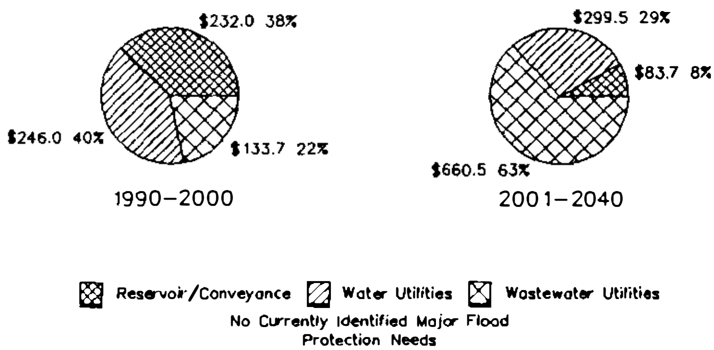
MAJOR ECONOMIC SECTORS: Manufacturing, Wholesale and Retail Trades, Services, Mineral Production, Agriculture, and Agri-business

AVERAGE ANNUAL PRECIPITATION: 42 to 48 inches

ANNUAL NET EVAPORATION RATE: 20 inches

PHYSIOGRAPHY: Flat wooded areas to densely-wooded rolling hills and river valleys

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Regional Description. The Northeast Texas Region consists of 23 counties located in portions of the Red, Sulphur, Cypress, Sabine, Trinity, and Neches river basins. In 1980, the population of the region totaled 806,600 people, with the counties of Smith, Gregg, Bowie, and Harrison accounting for about 44 percent of the regional population. Currently, the population of the region is estimated at 904,600 residents. By the year 2040, population of the region is projected to range between 1.5 and 1.7 million residents. Major population centers of the region are the cities of Tyler, Longview, Texarkana, Paris, Marshall, Palestine, Sulphur Springs, Jacksonville, Kilgore, and Henderson.

Currently, the region's total annual water use is about 539,700 acre-feet. The major water use categories are manufacturing and municipal, almost 77 percent of the total water use of the region. The current regional water use pattern is projected to remain relatively stable over the 50-year planning period as manufacturing, municipal, and steam-electric requirements are projected to remain the major water demand categories of the region. Municipal water requirements are projected to increase about 57 percent above current water use levels by 2040. With implementation of water conservation programs and practices, annual savings in municipal water use are projected to reach about 15,700 acre-feet by the year 2000, increasing further to about 48,600 acre-feet by the year 2040.

Regional Water-related Problems and Needs. In many areas, shallow ground water has high concentrations of iron and is acidic, which makes the water undesirable for municipal use and many manufacturing processes. These problems generally can be solved by completing wells in deeper water-bearing sands or by expensive treatment of water from shallow wells. Surface water and ground-water resources are potentially available to meet projected needs, if projects are planned and developed on schedule. Periodically, dissolved oxygen content in streams is low due to low streamflow and low natural reaeration rates. In many areas of the region, flooding is a major problem.

The percent distribution of the estimated $1.655 billion in projected total costs for identified water-related infrastructure in the Northeast Texas Region over the 50-year planning period is shown in the inset box at left. Approximately $612 million would be required in the first ten years and an estimated $1.043 billion in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the Northeast Texas Region is described below. Additional information may be obtained from the Board's files.

Sulphur Municipal Water District. The District owns 26.282 percent of the conservation storage space in the Cooper Reservoir, presently under construction. The District plans to use its share of Cooper to meet needs of its customer cities (Cooper, Commerce, and Sulphur Springs) in the Sulphur Basin. However, there could be excess supplies available from the District's share of Lake Cooper on an interim basis over the next 50 years. The most likely place of use of this water on a temporary, interim basis would be in the Dallas/Ft. Worth metroplex area. In fact, Commerce and the Upper Trinity Regional Water District have entered into an agreement providing for the temporary, interim sale of water from Commerce's share of Lake Cooper to the UTRWD over the next 50 years. This contract has not yet been considered by the Texas Water Commission. There could be excess supplies available for use by the other two owners of the storage of Cooper Reservoir, North Texas Municipal Water District and the City of Irving.

Little Cypress Utility District. The District has a permit for Little Cypress Reservoir. The reservoir could develop about 129,000 acre-feet per year. The District plans to supply the cities of Marshall, Longview, and Kilgore; and Gregg, Harrison, Rusk, and Upshur counties; and the City of Shreveport, Louisiana.

Northeast Texas Municipal Water District. The District owns storage rights in Lake O' the Pines Reservoir and supplies water to industrial and steam-electric plants in the Cypress Creek and Sabine river basins. The District has excess supplies that could be used to meet demands in the Cypress or Sabine basins. The District has requested that the Corps of Engineers perform a reallocation study of flood control storage to water supply storage on Lake O' The Pines.

Sabine River Authority. The Authority is the owner of three reservoirs in the Sabine River Basin. The Authority has contracted to supply Dallas Water Utilities over 300,000 acre-feet per year from Lake Fork and Tawakoni Reservoirs. The Authority has also entered into an agreement with the San Jacinto River Authority (SJRA) to supply the SJRA up to 672,000 acre-feet per year from Toledo Bend Reservoir.

The Big Sandy project is recommended for development to supply the needs in the upper Sabine Basin. The Authority is attempting to develop the Waters Bluff Reservoir site. However, a federal government non-development environmental easement within the site, which precludes project development without Congressional approval, has been litigated by the Authority and others. The easement was upheld, and an appeal of this decision may be filed. The site could ultimately be a viable site for future water supplies.

Angelina-Neches River Authority. The Authority is the sponsor of the proposed Lake Eastex project which could ultimately provide regional water supplies for Smith, Rusk, Cherokee, Nacogdoches, and Angelina counties. Cities in the area, such as Henderson, and other rural water supply utilities are experiencing ground-water supply problems which could be addressed by this regional water system.

City of Tyler. The City's water needs are met from Lake Tyler and from wells into the Carrizo-Wilcox Aquifer. It is anticipated that withdrawals from the aquifer will remain at about present levels, while withdrawals from Lake Tyler will increase. The City also has supplies in Lake Palestine. The City is anticipated to be able to meet it's future water needs through the year 2040 by using the City's present supplies in conjunction with an effective water conservation program.

The City owns two wastewater treatment facilities: the 13 MGD Westside Plant and the 9 MGD Southside Plant. The Westside Plant is under construction to upgrade treatment levels to recently imposed standards by the TWC. A similar project is planned for the Southside Plant.

City of Longview. The City of Longview has supplies in Lakes Cherokee and Lake Fork and has rights to flows in the Sabine River. The City has experienced water quality problems with the flows from the Sabine River. The City is a member of the Little Cypress Utility District and is participating in the development of Little Cypress Reservoir. The City should be able to meet its future water needs through the year 2040 by using its present supplies and supplies from the District in conjunction with an effective water conservation program.

The City of Longview operates a 13.9 MGD wastewater treatment plant. The City has recently completed improvements to this facility, but the City's capital improvement plans indicate an aggressive program of upgrading, modernization, and expansion of wastewater systems.

The City of Longview, Texas, suffered damages during the March 28-29 and May 16, 1989, floods. Both events were recognized by Federal and State Disaster Relief Teams as being major events. In July, 1989, the City recommended that a flood protection plan be initiated to develop reconnaissance-level plans for flood protection in Federal Emergency Management Agency (FEMA) designated areas. A study was begun in December 1989, to develop this plan with Texas Water Development Board grant fund assistance.

City of Kilgore. The City of Kilgore receives water from Longview and withdraws ground water from the Carrizo-Wilcox Aquifer in Smith County. The City is a member of the Little Cypress Utility District. Using the developable supply of Little Cypress Reservoir in conjunction with an effective water conservation program, the City is anticipated to be able to meet its future water needs through the year 2040.

Kilgore operates a 3 MGD wastewater treatment facility. The City has immediate needs to upgrade this plant to conform to new permit standards.

City of Marshall. The City of Marshall has rights to flows in the Big Cypress Creek. The City's diversion point is in the backwater of Caddo Lake and when the flow in the creek is low, the diversion is from Caddo Lake. The City is a member of the Little Cypress Utility District. By using the District's Little Cypress Reservoir in conjunction with an effective water conservation program, the City is anticipated to be able to meet its future water needs through 2040.

Marshall completed major rehabilitation and expansion on its 5.91 MGD wastewater treatment facility in 1988. These improvements have dramatically improved performance.

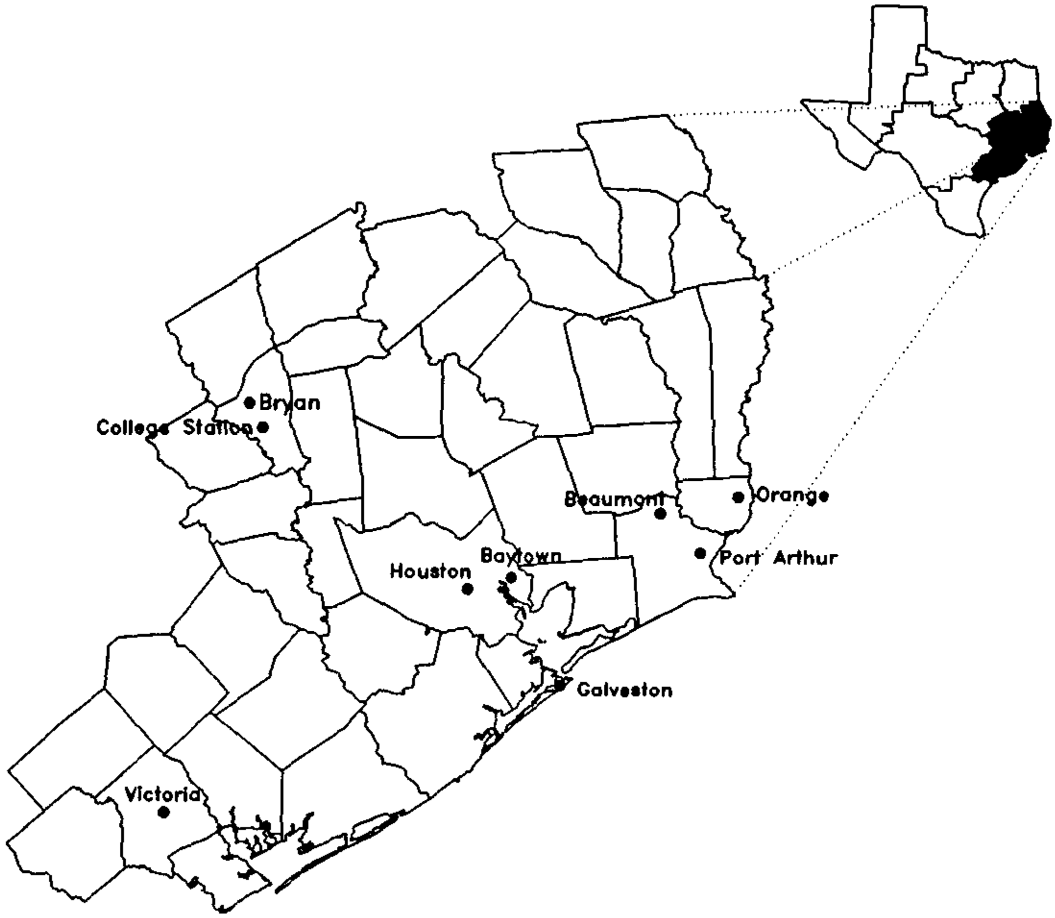
City of Texarkana. The City's water needs are supplied by Lake Texarkana. The City also serves as a regional supplier by serving De Kalb, Nash, New Boston, and Maud. Using the present supplies in Lake Wright Patman in conjunction with an effective water conservation program, the City is anticipated to be able to meet its future water needs and the other cities it supplies through the year 2040.

Texarkana operates three wastewater treatment facilities: the 11.7 MGD New Regional South Plant, the 2 MGD Wagner Creek Plant that serves two adjoining cities, and a smaller plant serving an isolated subdivision. The South Plant became operational in 1988 and is in the final stages of construction to meet advanced treatment requirements. The City has identified additional needs for treatment facility modifications and improvements.

City of Paris. The city's water needs are met from Lakes Crook and Pat Mayes. The City is anticipated to be able to meet it's future water needs through the year 2040 by using the City's present supplies in conjunction with an effective water conservation program.

The City of Paris completed additions to its 7.25 MGD wastewater treatment facility in 1987. Infiltration/inflow and deterioration in components of the collection system are continuing problems.

SOUTHEAST TEXAS AND UPPER GULF COAST REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION :	1990	5.028 million
	2000	5.987 million
	2010	6.970 million
	2020	7.949 million
	2030	9.000 million
	2040	9.756 million

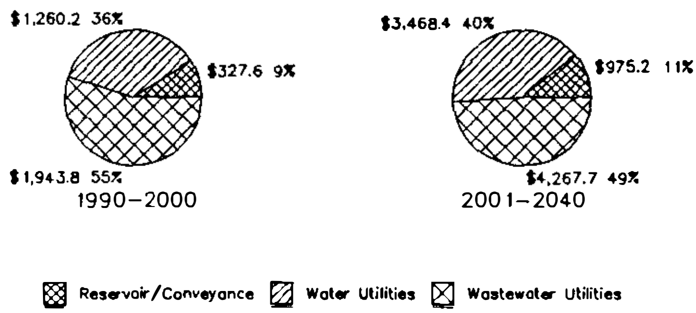
MAJOR ECONOMIC SECTORS: Manufacturing, Mineral Production, Finance, Services, Retail and Wholesale Trade, Agriculture, Tourism, Commercial Shipping and Fishing, and Government

AVERAGE ANNUAL PRECIPITATION: 32 to 56 inches

ANNUAL NET EVAPORATION RATE: 45 inches

PHYSIOGRAPHY: Densely wooded rolling to hilly surface in East Texas transcending to grassy, flat coastal plains

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Currently Identified Flood Protection
Needs Total $1.494 Billion

SOUTHEAST TEXAS AND UPPER GULF COAST REGION

Regional Description. The Southeast Texas and Upper Gulf Coast Region consists of 41 counties located in the lower reaches of the San Antonio, Guadalupe, Colorado, Brazos, Trinity, Lavaca, Sabine, and Neches River Basins and seven Coastal Basins along the Gulf Coast. In 1980, the population of the region totaled 4.9 million people, with Harris, Jefferson, Galveston, and Brazoria counties accounting for nearly 68 percent of the regional population.

Currently, the regional population is estimated at about 5.0 million residents. By the year 2040, population of the region is projected to range between 8.3 and 9.8 million residents. Major population centers of the region include the cities of Houston, Beaumont, Pasadena, Baytown, Port Arthur, Bryan, Galveston, Victoria, College Station, and Texas City.

Currently, annual water use in the region is about 3,350,000 acre-feet. Water used for irrigation purposes accounts for almost 45 percent of the total regional water use, with municipal and manufacturing water use accounting for about 50 percent of regional use.

The current regional water use pattern is anticipated to change over the 50-year planning period as municipal and manufacturing water requirements are projected to account for over 65 percent of the regional water requirements by the year 2040. Water requirements for municipal and manufacturing purposes are projected to nearly double by the year 2040 above current water use levels. With implementation of water conservation programs and practices, annual savings in municipal water use are projected to reach about 88,900 acre-feet by the year 2000, increasing further to over 290,000 acre-feet by 2040.

Regional Water-related Problems and Needs. Land-surface subsidence and saltwater encroachment have resulted from overdevelopment of ground-water supplies. Saltwater intrusion during periods of low flow in the Brazos, Neches, and Trinity Rivers has the potential for contaminating the freshwater supplies at existing intake facilities.

Smaller cities are anticipated to have problems relating to surface water availability, treatment, conveyance, and storage facilities. Navigation facilities, channel maintenance, dredge-spoil disposal, and bay and estuary protection require continuing management programs. Water quality problems require a continuous monitoring and water quality management program. In many local areas, storm-surge flooding and drainage continues to be a serious problem.

The percent distribution of the estimated $12.243 billion in projected total costs for identified water and wastewater infrastructure in the Southeast Texas and Upper Gulf Coast Region over the 50-year planning period is shown in the inset box at left. Approximately $3.532 billion would be required in the first ten years and an estimated $8.711 billion in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the Southeast Texas and Upper Gulf Coast Region is described below. Additional information may be obtained from the Board's files.

Trinity River Authority. The Trinity River Authority has 30 percent of the diversion rights in Lake Livingston. The Authority has over 376,000 acre-feet per year of supply available. Lake Livingston supplies raw water to three water treatment systems, including the Huntsville, Trinity County, and Livingston regional water supply systems.

However some of the overall Lake Livingston water supply is used for the prevention of salt water intrusion that affects the operation of the major irrigation canal systems and the Coastal Water Authority. With the development of the salt water barrier, the water used for intrusion control could be used to meet other water needs in the region.

Brazos River Authority. The Brazos River Authority owns or operates 12 major reservoirs on the Brazos River and its tributaries. Supplies from Lakes Possum Kingdom, Limestone, Granbury, Belton, Somerville, Stillhouse Hollow, and Granger are used to meet needs in the region. With the construction of Lake Bosque, operated as a system with the enlarge Lake

Waco, the Authority will increase its system-wide supplies.

The BRA also will need to develop the Allen's Creek Reservoir site to meet anticipated surface water needs due to the conversion from dependance on Gulf Coast Aquifer ground water in the areas of Fort Bend and western Harris counties. If projected water conservation savings are not realized, the South Bend project should be added to the Authority's water supply sources.

The Brazos River Authority operates a 6.5 MGD regional wastewater treatment plant serving the City of Sugarland, several water districts, and various area industries. Growth in this regional wastewater system will be accommodated by flow transfer to a second facility owned and operated by Fort Bend County MUD #13.

Lower Colorado River Authority. The Lower Colorado River Authority (LCRA) owns and operates six lakes in the Colorado Basin. The LCRA also operates two irrigation supply companies in the lower part of the Colorado Basin. Lakes Buchanan and Travis are capable of delivering over 445,000 acre-feet per year of firm water supply.

The LCRA, through its management plan, has estimated that it has the ability to deliver up to one million acre-feet per year of water supply on a interruptable basis. The LCRA delivers water supplies for irrigation, manufacturing, and cooling water for steam-electric power generation in the region.

Lavaca-Navidad River Authority. The Lavaca-Navidad River Authority owns 43 percent of Lake Texana and has indicated a willingness to purchase the remaining share of the reservoir from the Board to meet anticipated manufacturing needs in the region. Excess supplies that remain in the project could be used to meet needs in the Corpus Christi or San Antonio areas.

Sabine River Authority. The Sabine River Authority (SRA) is the owner of three reservoirs in the Sabine River Basin. The SRA has entered into an agreement with the adjacent San Jacinto River Authority to supply them up to 672,000 acre-feet per year from the Toledo Bend Reservoir. The two river authorities have planned to make use of already constructed canal systems where possible to deliver water to the San Jacinto Basin. This major conveyance project would entail working agreements with various canal agencies and river authorities. The ultimate plan for the conveyance system would be designed reduce environmental impacts associated with the routing of the facilities.

Lower Neches Valley Authority. The Authority provides water to the cities and industrial complexes of Beaumont and Port Arthur and Jefferson County from the Sam Rayburn Reservoir. Construction of a permanent salt water barrier on the lower Neches River would protect the urban supplies from sea water intrusion.

Coastal Water Authority. The Coastal Water Authority is the surface water supply agency for the City of Houston. The Authority provides raw water to the industrial complexes on the Houston Ship Channel as well as to the City's water treatment plant. The Authority will need to increase the delivery capacity of the system and should be the receiver of water from Toledo Bend.

Harris-Galveston Coastal Subsidence District: The Harris-Galveston Coastal Subsidence District regulates the amount of ground water removed from the Gulf Coast Aquifer in the Houston-Galveston area. The District has developed a conversion plan to convert areas currently using ground water to surface water before the year 2010.

The conversion plan will increase the need for additional surface water supplies within the region. These water supplies are anticipated to be met from supplies available to the Houston metropolitan area and supplies imported from the Sabine and Brazos river basins.

San Jacinto River Authority. The San Jacinto River Authority owns Lake Conroe and surface water rights within the basin. The Authority provides water to Houston and the Baytown area. The Authority has entered into agreement to purchase up to 672,000 acre-feet per year from the Sabine River Authority. It is anticipated that the water will be used to meet supply needs in the Houston metropolitan area.

A proposed local project, Spring Creek Lake, could provide supplies for municipal uses to Montgomery County. If the Toledo Bend diversion or diversions from the Trinity River prove infeasible, the Lake Creek project could provide for alternative supplies to the Authority's service area.

The San Jacinto River Authority operates a regional wastewater system serving the districts comprising the Woodlands development in southern Montgomery County. Designed for 6 MGD, the principal treatment facility in this system requires upgrading to meet more stringent treatment standards, and if population projections prove accurate, will require expansion to meet future demand.

City of Houston. Municipal water needs for the City of Houston are anticipated to almost double over the next 50 years. An active water conservation program can reduce the needs to about 705,000 acre-feet per year. These needs will require the development of additional diversion facilities from the Trinity Basin and the use of water supplies from the Sabine Basin. It is anticipated that the City will continue to be a regional supplier, and in fact, will expand its involvement as a supplier.

Houston has approximately 40 operational wastewater treatment facilities ranging in size from the 200 MGD 69th Street Complex to facilities with less than 1 MGD capacity. The City has an aggressive capital improvements plan to deal with problems of collection system integrity, sludge transfer (to regional processing facilities), treatment plant adequacy, and the need for greater regionalization. Solving existing problems and providing for future needs will be a significant undertaking.

Houston has approximately $1 billion in flood project needs, identified in a number of studies conducted over the past 10 years. Major watersheds which are subject to flooding include Clear Creek, Sims Bayou, Upper White Oak Bayou, Buffalo Bayou, and Cypress Creek. A comprehensive regional flood protection study of the Clear Creek watershed was begun in April 1989, with Board grant assistance. The need for a comprehensive plan to include consideration of various land use regulations, channel enlargements and rectifications, and regional detention have been identified by all drainage entities within the region.

City of Galveston. The City of Galveston receives water from the City of Houston through the Galveston County Water Authority. With the development of additional transmission facilities by the City of Houston and the importation of Toledo Bend water, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through the year 2040.

The City is served by two principal wastewater facilities, the 10 MGD Main Treatment Plant and the 3.75 MGD Airport Plant. The City also operates the Park Plant and two subdivision plants on the west end. Current needs revolve around upgrading specific processes at the Main and Airport facilities and maintaining an aging collection system.

Galveston's major flood hazards relate to tropical storms and hurricanes in the Gulf of Mexico. A September 1987 Corps of Engineers high flood hazard area study, partially sponsored by the Board, recommended numerous flood damage protection measures along the Gulf Of Mexico, including evacuations, floodproofing for shallow-flooding, enforced zoning, and installation of flood warning systems. A drainage study of McCloud Bayou watershed also identified several million dollars worth of needed improvements.

City of Baytown. The City uses ground water and surface water purchased from the Baytown Area Water Authority. The Authority is supplied water from Lake Livingston by the Coastal Water Authority (CWA). CWA is expected to increase it's available supplies by importing water from the Sabine Basin. The City is anticipated to be able to meet it's future water needs through the year 2040 by using CWA present supplies and additional supplies imported by CWA in conjunction with an effective water conservation program.

Baytown employs three wastewater treatment facilities with more than 100 MGD of capacity. Major renovations were completed on the 6.2 MGD Central District plant in 1988. The City has identified a need to rehabilitate its aging, infiltration-prone collection system. Projected population increases may require expansion and upgrading at both the 3 MGD East District Plant and the 1.32 MGD West District Plant.

Cities of Bryan-College Station. The cities of Bryan and College Station currently withdraw water from the Carrizo-Wilcox Aquifer. It is anticipated that the cities will continue to make withdrawals from the Aquifer; however, additional water supplies will be needed. It is anticipated that these additional needs could be met from ground-water resources. Using the cities' existing ground-water supplies and additional well field supplies, in conjunction with an effective water conservation program, they are expected to meet their future water needs through the year 2040.

Bryan is served by three wastewater treatment plants: the 6.4 MGD Burton Creek Plant, the 4 MGD Still Creek Plant, and the 0.75 MGD Turkey Creek Plant. Bryan's most immediate task will be to meet upgraded treatment requirements for these facilities.

A May 1986 Corps of Engineers study of Burton Creek identified approximately $2.5 million worth of needed improvements to bridges, flood walls, and other structures. Additional watersheds are also due for study by the City.

The City of Bryan has also completed a flood protection planning study of the Briar Creek watershed finding over $3 million in damages during large flooding events. The City is planning to study all nine of its watersheds over the next several years.

Beaumont-Port Arthur. The Beaumont-Port Arthur area chiefly depends on supplies from Lake Sam Rayburn and the Neches River. The City of Beaumont also withdraws ground water from the Gulf Coast Aquifer. Using the present supply sources available to the cities, with construction of a salt water barrier on the lower Neches River, and with an effective water conservation program, Beaumont and Port Arthur are expected to meet their future water needs through 2040.

Beaumont is served by a single wastewater treatment plant on Hillebrandt Bayou. The City proposes to meet advanced treatment requirements at this 30 MGD plant with an artificial wetland system. In recent years, the City also "separated," at considerable expense, the state's last combined sanitary/storm sewer system.

The City of Port Arthur employs four treatment facilities, two serving the main portion of the City, one serving Pleasure Island, and one serving the Sabine Pass area. The principal plants, the 9.2 MGD Main Plant and the 2.6 MGD Port Acres Plant, have recently been equipped with peak flow handling capabilities. Maintaining collection systems in dynamic soil conditions is a continuing problem for both cities.

Two recently completed floodplain studies for this area identified a number of potential structural improvement measures in the Hillebrandt Bayou drainage basin and recommended flood damage prevention measures including restrictive zoning, no future development, and floodproofing for shallow flooding. A flood protection planning study by the Hardin County WCID No. 1 and the Board was completed in June 1990 and recommended various structural improvements to alleviate local flooding problems, including channel, levee and interior drainage improvements and outfall drainage improvements.

A flood protection study was also completed in May 1990 with Board grant funding assistance by the Port Arthur and Jefferson County Drainage District No. 7. Recommended actions included construction of pumping facilities with detention storage, a levee system, and channelization improvements.

City of Orange. The City of Orange presently withdraws water from the Gulf Coast Aquifer and the Sabine River. Using the present supply sources available to the City, in conjunction with an effective water conservation program, Orange is expected to meet its future water needs through 2040.

The City of Orange operates a 2.9 MGD plant (Jackson Street) and a 0.18 MGD plant serving the Bancroft area. The City has identified projects to expand treatment for high flow periods and to correct problems in the collection system.

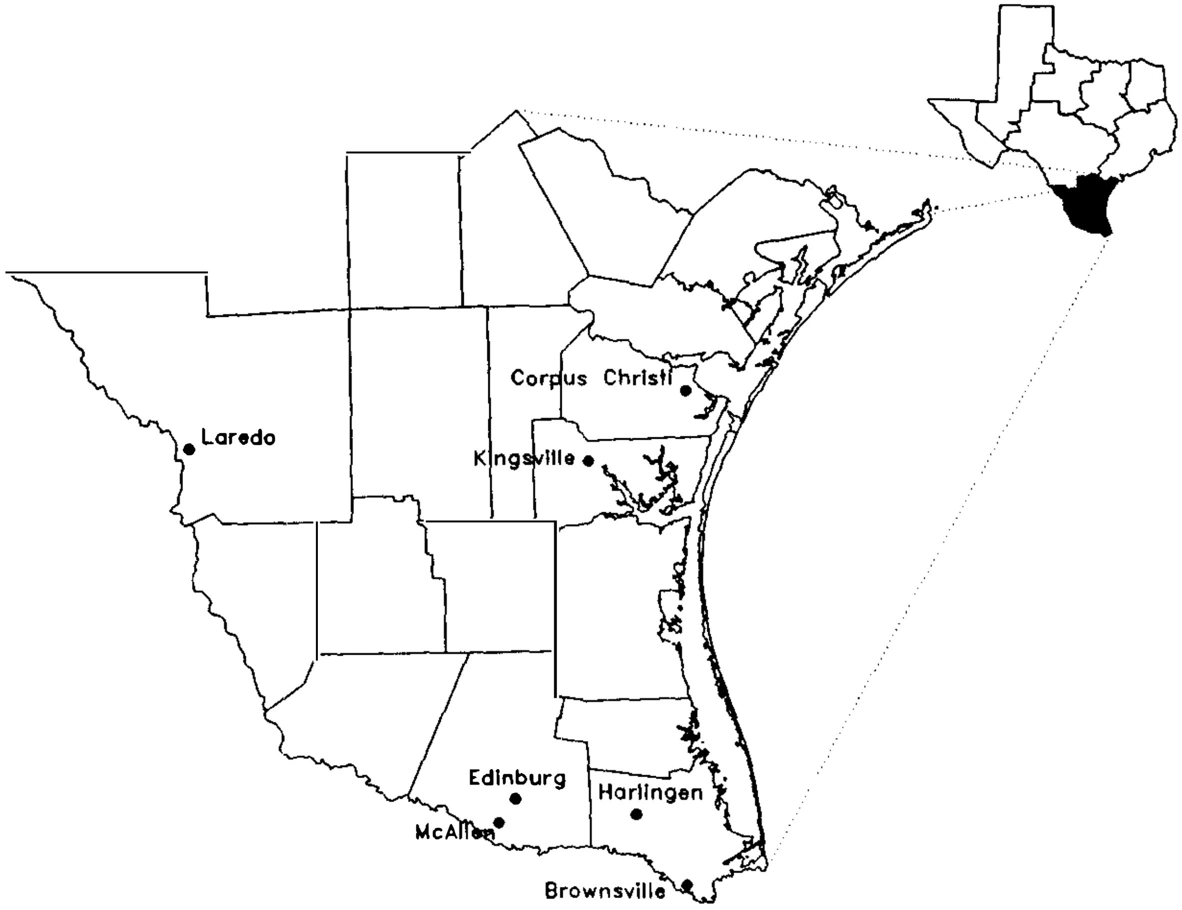
Two recent floodplain studies have identified modest structural improvements along Swifts Slough and recommended flood damage protection measures in the Sabine River Basin, consisting of an area-wide flood control plan, clearing and grubbing, evacuation planning, restrictions prohibiting future development, and other measures.

City of Victoria. The City of Victoria withdraws its water supply from the Gulf Coast Aquifer. If the aquifer is unable to provide enough water supply, excess supplies in Lake Texana could be used to meet any supply shortage. However, present estimates indicate that the City's ground-water supplies, in conjunction with an effective water conservation program, are expected to meet Victoria's future water needs through the year 2030. Studies conducted by the City indicate that a blend of ground water and surface water will be needed by the year 2040.

The City of Victoria operates its own wastewater collection system. It contracts for treatment at two plants operated by the Guadalupe-Blanco River Authority.

Two recent flood protection studies identified over $5 million in structural improvements needed for raising the levee to provide 100-year flood protection. The studies also identified numerous non-structural flood damage prevention measures which should be implemented. The U.S. Army Corps of Engineers is also initiating feasibility phase studies of the levee flood protection problems in Victoria. The City of Victoria and the Board are providing funding participation in this study.

SOUTH TEXAS AND LOWER GULF COAST REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION :		
	1990	1.456 million
	2000	1.807 million
	2010	2.224 million
	2020	2.758 million
	2030	3.351 million
	2040	3.701 million

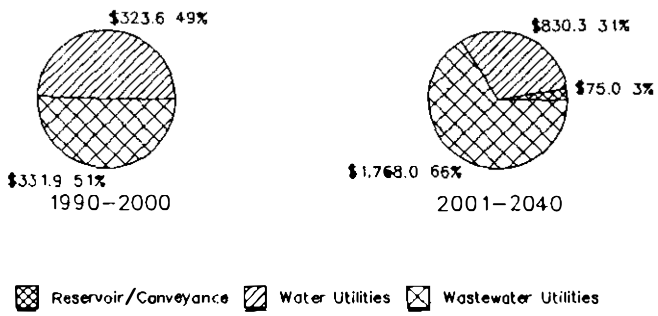
MAJOR ECONOMIC SECTORS: Agriculture, Agribusiness, Manufacturing, Retail and Wholesale Trade, Services, Mineral Production, Tourism, and International Trade

AVERAGE ANNUAL PRECIPITATION: 21 to 40 inches

ANNUAL NET EVAPORATION RATE: 53 inches

PHYSIOGRAPHY: Grassy, brushy flat coastal plains

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Currently Identified Flood Protection
Needs Total $172.8 Million

Regional Description. The South Texas and Lower Gulf Coast Region consists of 19 counties located in portions of the Rio Grande and Nueces River Basins, and the San Antonio-Nueces and Nueces-Rio Grande coastal basins. The 1980 regional population totaled 1.13 million people, with the counties of Hidalgo, Nueces, and Cameron accounting for about 68 percent of the total population. The regional population is currently estimated at about 1.36 million people. By 2040, the regional population is projected to range between 3.1 and 3.7 million residents. Major population centers within the region are the cities of Corpus Christi, Laredo, Brownsville, McAllen, Harlingen, Edinburg, Mission, Kingsville, Pharr, and Weslaco.

Currently, annual water use within the region is about 1,341,700 acre-feet. Water used for irrigation purposes accounts for more than 78 percent of the region's water use. The current regional water use pattern is anticipated to change over the 50-year period as municipal and manufacturing water use are projected to account for about 42 percent of the total regional water demand by 2040, with irrigation water requirements accounting for only 55 percent. The substantial growth in municipal water requirements is reflective of the anticipated rapid growth in population for the Rio Grande Valley. With implementation of water conservation programs and practices, annual municipal water use savings are projected to reach about 29,300 acre-feet by the year 2000, increasing to over 117,800 acre-feet by 2040.

Regional Water-related Problems and Needs. The Region has insufficient quantities of surface and ground water to meet the needs for all water using purposes in areas of the Lower Valley. Surface water quality in the region is generally good, but low dissolved oxygen occurs in some stream segments during summer months. Surface water supplies are practically all developed and committed. Over the years, small unincorporated subdivisions have developed along the Rio Grande with little or no water supply and wastewater treatment facilities to meet their daily needs. Soil salinity and drainage problems are present locally and flooding and storm-surge problems exist in many areas of the region. Navigation facilities, channel maintenance, dredge-spoil disposal, and bay and estuary protection require continuous monitoring and management programs.

The percent distribution of the estimated $3.329 billion in projected total costs for identified water and wastewater infrastructure in the South Texas and Lower Gulf Coast Region over the 50-year planning period is shown in the inset box at left. Approximately $656 million would be required in the first ten years and an estimated $2.673 billion in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the South Texas and Lower Gulf Coast Region is described below. Additional information may be obtained from the Board's files.

South Texas Water Authority. The South Texas Water Authority (STWA) supplies water to Kingsville, Agua Dulce, Riviera Beach, and several other small towns. The Authority purchases water from the City of Corpus Christi. With the ability to purchase additional water supplies from Corpus Christi, the Authority is expected to meet its future water needs through the year 2040.

Nueces River Authority. The Nueces River Authority is the regional planning and management agency in the area. The Authority owns part of Choke Canyon Reservoir which supplies water to the City of Corpus Christi. Using present estimates of available supplies, the Authority should have adequate water to meet the Basin's future needs.

Watermaster Operations. Both Amistad and Falcon Reservoirs are operated by the International Boundary and Water Commission as a system for flood-control and water supply purposes. The United States' share of conservation storage in the projects is administered by the Texas Water Commission (TWC), currently under provisions of the "Lower Rio Grande Valley Water Case." According to the judgment rendered in the court case, water in the two reservoirs is to be allocated to Class A irrigation, Class B irrigation, and municipal, industrial, and domestic use. A watermaster employed by the TWC is responsible for allocating the amount of water which can be diverted by each A and B Class irrigator and for supervising each use of water. In addition to individual industrial plants which have independent water systems, there are over 75 purveyors of municipal, domestic, and light-industrial water supplies within the four-county valley region. These purveyors must purchase Class A and B irrigation rights to increase their water supplies.

A similar Watermaster operation has been recently implemented for the San Antonio, Guadalupe, and Nueces river basins and the three adjacent coastal basins. The newly created effort is in the process of full development and implementation of its programs. As distinct from the Rio Grande Watermasters, the Watermaster in the South Texas region has no similar large storage reservoirs with which to more closely monitor releases and use of rights.

City of Corpus Christi. The City of Corpus Christi owns Lakes Corpus Christi and part of Choke Canyon. These two lakes are estimated to supply over 252,000 acre-feet per year. Preliminary studies indicate that environmental releases could reduce the supplies of these lakes to 231,000. The City provides water to South Texas Water Authority, the Alice Water Authority, Beeville, Port Aransas, Rockport, Mathis, Three Rivers, San Patricio County MWD No. 1, Lamar Pennisula, and the industrial complexes on the Corpus Christi Channel. Also, Nueces County WCID #1 in nearby Robstown is a separate permit holder for water rights on the Nueces River. It is anticipated that with uncertain dependable yields from the City of Corpus Christi's two existing reservoirs and mandated environmental releases from those projects, the City would need additional supplies before 2040. These water supply needs could be partially met with an expanded water reuse program (if allowed by the TWC) or fully met by obtaining additional supplies from the existing Lake Texana and potentially from a future Palmetto Bend II reservoir. Associated construction of major conveyance facilities would be required.

The City of Corpus Christi operates seven wastewater treatment facilities. The City's Westside Plant is currently being expanded to 6 MGD. Additional plant expansion is planned to handle flow diverted from the Broadway STP (10 MGD) service area. The aging Broadway treatment plant will need extensive renovation. Other plants; Oso (16.2 MGD), Allison (5 MGD), Flour Bluff (3 MGD), and Whitecap (0.5 MGD), need expansion and/or modification. The City has an extensive sewer rehabilitation program. The City also plans to build a new Southside plant sometime around the year 2000 to handle anticipated population growth in this area.

Brownsville-Harlingen. The cities of Brownsville and Harlingen use water withdrawn from the Rio Grande which is charged against their water rights in Falcon Reservoir. The cities will probably exceed their diversion permits by 2010. At such time, the cities will need to purchase additional water rights. By 2030 the Cities will need additional supplies which can be met from a channel dam below Brownsville. The project is estimated to be able to supply about 85,000 acre-feet per year, subject to State permitting determination. With the development of the channel dam and the purchase of water rights, in conjunction with an effective water conservation program, the cities are expected to meet their future water needs through 2040.

Brownsville utilizes two major wastewater treatment facilities. The 7.8 MGD South Plant is the City's original facility. The newer Robindale Plant (5 MGD) will be expanded to an intermediate size of 10 MGD, and will be the site for virtually all needed expansion in the foreseeable future. Harlingen also operates two major treatment facilities. The City's number two facility is being upgraded and expanded from 3.5 MGD to 5 MGD in a treatment/reuse scheme with participation by a local industry. Plant Number 1 may require expansion in the future and a third facility may be constructed to handle anticipated growth.

Brownsville has severe flooding problems which were described in a master drainage plan prepared under a Board grant in August 1987. This report identified an immediate improvements program costing over $48 million, involving numerous channel widening projects and re-alignments, along with construction of detention storage and other structural modifications.

McAllen-Edinburg. The cities of McAllen and Edinburg use water from the Rio Grande backed up by storage in Falcon Reservoir. In order to meet future water requirements the cities will need to purchase additional irrigation water rights. By purchasing additional water rights, in conjunction with an effective water conservation program, the cities are expected to meet their future water needs through the year 2040.

McAllen operates two wastewater treatment plants. Plant Number 2, the Main Plant, is a 10 MGD extended aeration facility. More stringent treatment standards may necessitate construction of another plant. Plant Number 3, the 4 MGD North Plant, was constructed in 1987 with federal grant assistance.

This site will handle expected growth in the McAllen area. Edinburg is served by a single 4.5 MGD treatment facility that is actually four autonomous units operating in parallel. Population growth is expected to necessitate expansion sometime after 2000.

City of Kingsville. The City of Kingsville withdraws water from the Gulf Coast Aquifer and is supplied from Lake Corpus Christi by the STWA. It is anticipated that the present supplies to the City, in conjunction with an effective water conservation program, could meet the City's future water needs through 2040.

Kingsville is served by two wastewater treatment plants: the 3 MGD North facility and the 1.0 MGD South plant. Population growth is not expected to require expansion until after year 2010.

The City of Kingsville has constructed local drainage improvements using a Community Development Block Grant to alleviate local drainage problems and flooding problems along Tranquitas Creek.

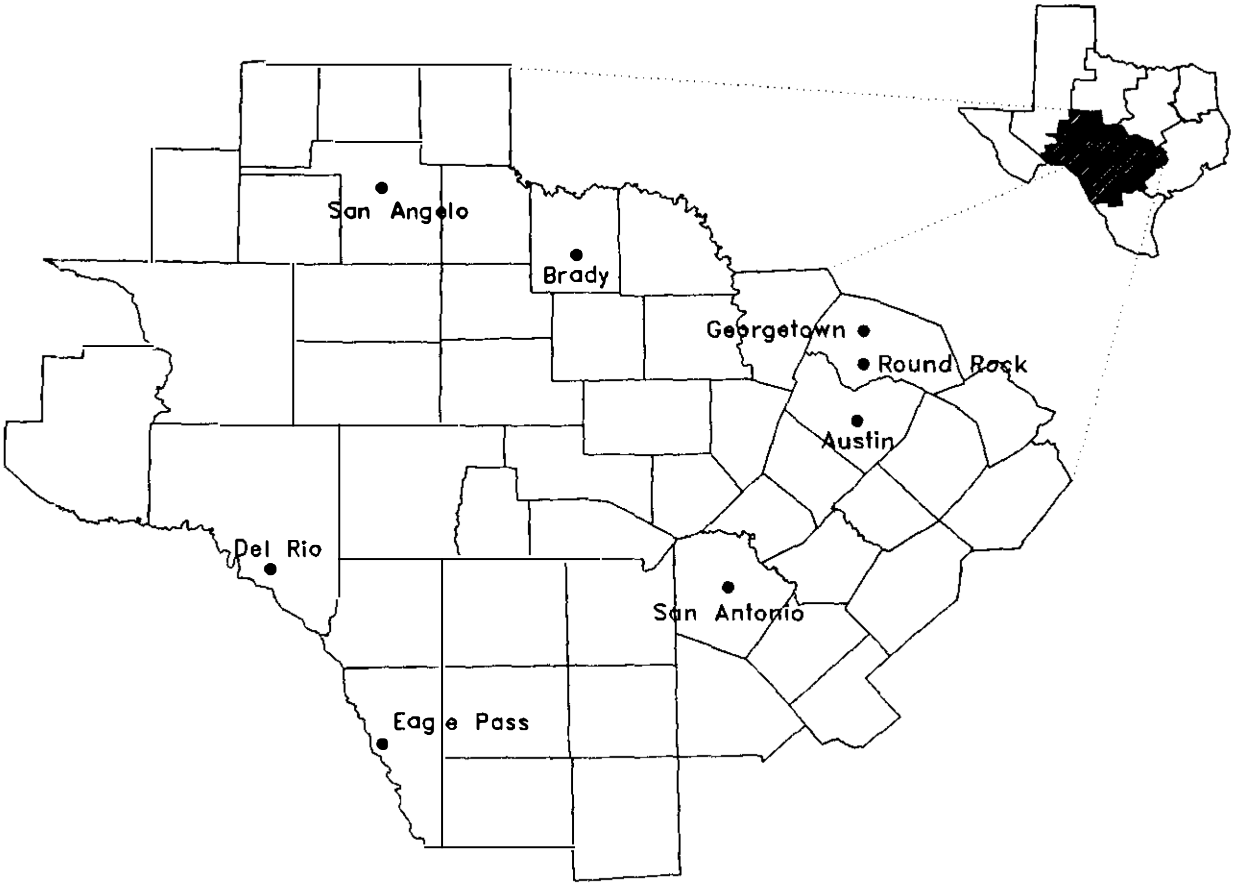
City of Laredo. The City of Laredo is supplied with water withdrawn from the Rio Grande which is charged against its water rights in Amistad Reservoir. The City will need to purchase additional irrigation water rights to meet its future needs. With the purchase of additional rights, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through 2040.

Laredo operates three wastewater treatment facilities: the 14 MGD Zacate Creek Plant, the 3 MGD Southside Plant, and the 0.426 MGD North Laredo Reclamation Plant. The City has a project underway to expand the North system to 0.926 MGD. The City intends to provide for anticipated future growth at the Southside Plant in 3 MGD increments.

An on-going Corps of Engineers flood control study has identified over $15 million worth of needed flood protection improvements, consisting of a detention reservoir and an embankment in the upper Zacate Creek drainage basin.

Rural Areas. Many unincorporated subdivisions characterized by depressed economic conditions, including limited water supplies and limited wastewater facilities, exist within localized areas of the region,typically along the Rio Grande and predominately within Hidalgo, Cameron, and Willacy counties. Recognizing the existing and impending economic and health problems of these areas, the Texas Legislature has directed the Texas Water Development Board to provide financial and technical assistance for construction of facilities to provide suitable water supply and wastewater treatment for these areas.

SOUTH CENTRAL TEXAS REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION :	1990	2.866 million
	2000	3.619 million
	2010	4.348 million
	2020	5.226 million
	2030	6.422 million
	2040	7.136 million

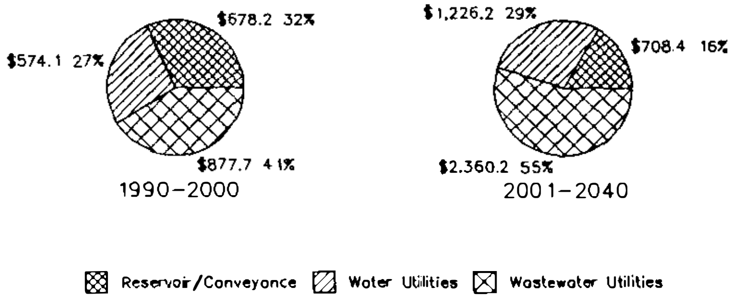
MAJOR ECONOMIC SECTORS: Manufacturing, Retail and Wholesale Trades, Agriculture, Agri-business, Mineral Production, Government, and Tourism

AVERAGE ANNUAL PRECIPITATION: 14 to 42 inches

ANNUAL NET EVAPORATION RATE: 17 inches

PHYSIOGRAPHY: Rolling, grassy prairies in the west transcending to hilly, wooded hill country in the central and eastern portions of the region

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Currently Identified Flood Protection
Needs Total $24.6 Million

Regional Description. The South Central Region consists of 48 counties located in portions of the Nueces, San Antonio, Colorado, and Guadalupe river basins. In 1980, the regional population totaled 2.16 million people, with the counties of Bexar and Travis accounting for more than 65 percent of the total regional population. Currently, the regional population is estimated at 2.69 million residents. By the year 2040, population of the region is projected to range between 5.6 and 7.1 million residents. Major population centers of the region are the cities of San Antonio, Austin, San Angelo, Del Rio, San Marcos, New Braunfels, Round Rock, Eagle Pass, Seguin, and Kerrville.

Currently, total annual water use of the region is estimated at about 1,197,700 acre-feet. The two major water use categories of the region are irrigation and municipal water use, accounting for almost 46 percent and 42 percent of total water use, respectively. The current regional water use pattern is expected to change over the 50-year planning period as municipal water requirements are projected to become the major water demand category of the region, accounting for almost 62 percent of total water use by the year 2040. With implementation of water conservation programs and practices, savings of annual municipal water use are projected to reach over 63,000 acre-feet by the year 2000, increasing to nearly 250,000 acre-feet by the year 2040. The reduction in irrigation water requirements is reflective of expected implementation of more efficient irrigation equipment and management practices.

Regional Water-related Problems and Needs. Rapid growth of urban areas is straining existing water supply and waste-disposal facilities and subjecting many citizens to the threat of flooding. Pumping from the Carrizo-Wilcox Aquifer in the Winter Garden area has lowered water levels more than 400 feet since 1930. Poor quality water is encroaching into the aquifer in this area and pumping costs may soon render this aquifer an uneconomical source of irrigation water. The upper Colorado River Basin has serious water quality problems due to inflow of saline ground water. Another recurring problem throughout the region is localized flash flooding from intense storms.

Continued protection of the Edwards (Balcones Fault Zone) Aquifer from over-drafting and pollution is essential. Development of alternative water supplies is needed to firm up municipal supplies and reduce reliance on the Edwards (Balcones Fault Zone) Aquifer in critical drought periods. Increased use of surface water would also assist in maintaining the ecosystems and recreational opportunities of Leona, San Pedro, San Antonio, Hueco, Comal, and San Marcos Springs, and the base flow of streams to the south of the aquifer. The Guadalupe and San Antonio river basins have potential surface water projects that could be developed.

The San Antonio area is and will continue to be highly dependent upon ground water for water supply. Water from the Edwards (Balcones Fault Zone) Aquifer is used extensively for municipal, manufacturing, irrigation, domestic and livestock watering purposes in the area. The San Antonio and south Travis/north Hays County segments of the aquifer are supervised by the Edwards Underground Water District and the Barton Spings-Edwards Aquifer Conservation District, respectively. The Districts have varying powers and revenue gathering capabilities. The segment of the Edwards north of the Colorado River has no underground water district supervision.

The Aquifer is essential to the present and future economic well-being of the San Antonio area, since it is the sole water supply for over one million people and their economy. During the severe drought of 1947-1956, water levels in the Edwards Aquifer declined significantly and spring flows from the Aquifer were seriously reduced. To assure an adequate water supply to meet all of the future needs of the area requires "wise" management of the supplies available from the Edwards Aquifer and the integration of supplemental supplies into the overall water supply. Such a plan would also require that the area would not suffer social hardships and no sector of the economy would be deprived of an adequate economical water supply.

The Board has developed a computerized mathematical representation of the Edwards Aquifer, the purpose of which is to simulate the response of water levels in the Aquifer to pumpage and recharge for any given time period. The Board has analyzed various pumping and recharge schemes. The principal conclusions drawn from the analysis are that if total pumpage from the aquifer is limited to a little over 424,000 acre-feet per year for irrigation, municipal, and manufacturing and the assumed recharge sequence occurs, San Marcos Springs can be expected to continue flowing. Extreme water level declines will not occur and the potential saline water intrusion will be greatly reduced. However, studies underway indicate that the pumpage limit may not provide adequate protection.

Any management policy for the Edwards Aquifer which imposes a maximum limit upon annual pumpage will necessitate at some future time the curtailment of additional development by some users of the aquifer. Such aquifer-wide limitations must involve all of Bexar and surrounding counties. If economic growth in Bexar County is not to be inhibited by water shortages, then alternative water supplies must be developed from the most economically available resources. The multiplicity of agencies, cities, and water users in the county should work together to develop the water supply alternative that will fit the needs of the county.

The percent distribution of the estimated $6.425 billion in projected total costs for identified water and wastewater infrastructure in the South Central Texas Region over the 50-year planning period is shown in the inset box located at the introduction to this region's discussion. Approximately $2.130 billion would be required in the first ten years and an estimated $4.295 billion in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the South Central Texas Region is described below. Additional data may be obtained from the Board's files.

Lower Colorado River Authority. The Lower Colorado River Authority (LCRA) owns and operates six lakes in the Colorado Basin. The LCRA also operates two irrigation supply companies in the lower basin. Lakes Buchanan and Travis are capable of delivering over 445,000 acre-feet per year of firm supply. The LCRA, through its management plan, has estimated that it has the ability to deliver up to 1,000,000 acre-feet per year of supply on an interruptable basis. It is anticipated that the LCRA will be able to satisfy the needs of its service area through 2040 if the Board's projected conservation savings can be attained. If projected municipal water conservation savings are not realized, the Shaws Bend Reservoir project will be needed.

Brazos River Authority. The Brazos River Authority has the Lake Georgetown and Granger water supply reservoirs in the region and plans to build a pipeline to transfer water from Lake Stillhouse Hollow to Lake Georgetown to supply future needs in the area.

Guadalupe-Blanco River Authority. The Guadalupe-Blanco River Authority operates Canyon Reservoir and several small hydro-electric reservoirs on the Guadalupe River. The Authority provides water supply and wastewater treatment services to several communities within the Guadalupe Basin. The Authority also provides water supply to Port Lavaca and rural areas of Calhoun County. The Authority is permitted to divert over 50,000 acre-feet per year from Canyon Reservoir. Supplies available to the Authority plus developable supplies in the Lindenau and Cuero Reservoir projects will allow the Authority to meet the future needs of its service area and needs in the San Antonio area.

San Antonio River Authority. The San Antonio River Authority provides flood protection and wastewater treatment plants in the San Antonio River Basin. The Authority could be the local sponsor for the recommended Goliad Reservoir and potentially the Cibolo Reservoir if the Board's projected conservation savings or other sources of supply for the San Antonio area are not realized.

The Authority operates wastewater systems in two San Antonio River tributary watersheds. The Salatrillo Creek system serves the City of Converse and portions of Universal City and Live Oak. Projected population growth will require expansion of this 3.52 MGD treatment facility. The Martinez Creek system is a two-plant system. The 2.21 MGD Martinez I plant may require modification to meet new discharge requirements. The downstream Martinez II plant will be the site of any needed expansion.

Canyon Regional Water Authority. The Canyon Regional Water Authority is the planning and development agency for nearly all of Guadalupe County, a large portion of Bexar County and portions of Hays, Wilson, and Comal counties. The Authority's supply source is the Edwards-Balcones Aquifer. The Authority is encouraging development of alternative sources for users not located directly over the aquifer. It is predicted that needs in the Authority's area will be met by the Guadalupe-Blanco River Authority and supplies developed for the San Antonio area.

Colorado River Municipal Water District. The Colorado River Municipal Water District (CRMWD) has surface water supplies in Lake J.B. Thomas, Lake E.V. Spence, the recently constructed O.H. Ivie Reservoir, and well fields in Martin, Ector, Ward, Howard, Glasscock, and Scurry counties. The CRMWD also provides water quality enhancement by diverting low stream flows of high salinity to side storage. These diversion points are located on the Colorado River near Colorado City, on Beals Creek near Big Spring, and on Three and Four Mile Lakes.

Additionally, the CRMWD will begin construction on a $7 million water quality enhancement project in Mitchell County during 1990. Member cities of the District include Odessa, Snyder, and Big Spring. Over the 50-year planning period, the District is not expected to add new sources of surface water supply but will provide transmission facilities related to the new O.H. Ivie Reservoir project. The District will develop additional ground-water supplies during the planning period and will continue its policy of conjunctive use of ground- and surface water assets.

City of San Antonio. The City of San Antonio is the largest city in the region. San Antonio's sole water-supply source is the Edwards Aquifer. The City is developing sorely-needed surface water supplies at the Applewhite Reservoir site on the Medina River. The project could develop an average of over 50,000 acre-feet per year. However, the supply during a drought could fall to about 7,900 acre-feet per year. The City is evaluating other supply alternatives including additional surface water development of Lindenau and Cuero Reservoirs in the Guadalupe Basin and Goliad and Cibolo reservoirs in the San Antonio Basin, other potential new reservoirs or ground-water sources, reuse of wastewater, purchase of already developed supplies, or various combinations of these alternatives.

The Board is recommending the development of the Lindenau, Cuero, and Goliad reservoir sites, in conjunction with a reuse program. If projected municipal water conservation savings are not realized, the Cibolo Reservoir will be needed, along with increased reuse of water. These water supplies could be used to meet the needs of the City and other entities that draw water from the Edwards Aquifer. These entities would have to comply with any management plan developed for the Edwards Aquifer.

San Antonio operates three large regional treatment plants. Construction on the new 83 MGD Dos Rios plant was completed in 1987. The 36 MGD Salado Creek and 35 MGD Leon Creek plants have also undergone recent modernization/expansion projects. The City has a number of projects identified within each service area. Projected population growth will require expansion either at these sites or at one or more new sites. The City is investigating alternative "water factory" or reuse proposals.

A 1986 Corps of Engineers high flood hazard area study, partially sponsored by the Board, recommended numerous damage prevention measures, including the development of an area-wide flood control plan, flood control levees, and enforced zoning in the 100-year floodplain along the San Antonio River, including 61 small creeks running through San Antonio. A 1989 study by Bexar County and the Board developed flood protection plans for reaches of Leon, Cibolo, and Salado Creek in Bexar County. Recommended improvements include railroad bridge replacement, expanded flood warning, and some channelization improvements.

Bexar-Medina-Atascosa WCID No. 1. The District is the owner of one of the oldest surface water projects in the State that is still used for water supply. Lake Medina is used for municipal supply and to supply irrigation water to farmers in Bexar, Medina, and Atascosa counties. The Lake and diversion facilities also recharges the Edwards-Balcones Aquifer. It is estimated that the Lake recharges as much as 50,000 acre-feet per year to the aquifer. Depending on its operation, the supply available from Lake Medina can range from zero up to 60,000 acre-feet per year. The District is authorized to sell water for municipal use, and the Water Plan recommends that as surplus water occurs, the District converts the surplus to municipal supplies for conjunctive use with ground water in the Bandera County region and for use to supplement other supplies in Bexar County.

Springhills Water Management District. The District's water supply situation is generally representative of problems experienced by a larger region to the north of the San Antonio metropolitan area where primary dependence on ground water for municipal supplies, water level declines in the Trinity-Plateau Aquifer, and diminished supplies, especially during hot weather conditions, have resulted in the designation of the Hill Country Critical [ground water] Area. The critical area report recommends additional conjunctive use of surface and ground water to meet the future water supply needs of the area. The District feels that this could be accomplished through acquisition of water rights or supplies from nearby Lake Medina. The Board has also just approved a regional water supply planning grant study to the Bandera County area to further address the water supply problems and potential alternative solutions.

City of Austin. The City of Austin uses supplies from the Colorado River and Lake Austin. Additional supplies are available through the LCRA. Using the supplies available from the river and the supplies from LCRA in conjunction with an effective water conservation program, the City is anticipated to be able to meet its future supply needs through 2040.

Austin has nearly completed a major round of construction on its three major wastewater treatment facilities. They include: Walnut Creek (60 MGD), South Austin Regional (40 MGD), and Govalle (20 MGD). A fourth facility, Hornsby Bend, receives sludge via pipelines from all plants and is in the process of major upgrading. The City has identified a number of major interceptor projects needed to serve areas in the south and west. The City also participates in a regional system in the Brushy Creek watershed.

The City of Austin has experienced serious flooding over the last 20 years, and several Corps of Engineers studies have identified improvements needed in the Walnut Creek, Shoal Creek, and Onion Creek watersheds. Additional flood damage prevention measures were recommended in a Corps of Engineers high flood hazard study conducted in September 1985, including flood control levees, enforced zoning, clearing and grubbing, and areawide flood planning.

Round Rock-Georgetown. The cities of Round Rock and Georgetown withdraw water from the Edwards Aquifer and from Lake Georgetown. The cities have contracted for over 22,400 acre-feet per year of supply from Stillhouse Hollow Reservoir, owned by the BRA. It is anticipated that the cities will need additional supplies in the future. Additional water supplies may be available through the LCRA. With the development of transmission facilities from Stillhouse Hollow and possibly Lake Travis, in conjunction with an effective water conservation program, the cities are expected to meet their future water needs through 2040.

The City of Round Rock utilizes two wastewater treatment facilities with a total of 5.5 MGD capacity. The City's East Plant (2.5 MGD) will be the site of a major regional plant operated by Brushy Creek WCID #1, with the City of Austin and other entities participating. Georgetown operates a 2.5 MGD facility. Its location on the Edwards Aquifer precludes expansion at that site. The City is proposing a second facility at Dove Springs to the east.

Several floodplain management studies conducted over the past decade have identified over $6 million in recommended structural improvements in the Lake Creek drainage basin, along with needed protection measures, including flood control levees, and no development and zoning enforcement in portions of the Lake Creek and Brushy Creek watersheds.

City of San Angelo. The City of San Angelo receives water from Twin Buttes Reservoir and from Colorado River Municipal Water District. The City also has a well field in McCulloch County. However, the well field has not been developed due to conflicts with the Hickory UWCD over the transfer of water outside of the district. The City has purchased 16.54 percent of the water supply from the recently completed O.H. Ivie Reservoir. With the completion of transmission facilities from the Reservoir, additional supplies of about 18,600 acre-feet per year will be available to the City. With the existing City supply and planned transmission facilities, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through the year 2040.

San Angelo's 7.36 MGD "Sewer Farm" wastewater treatment facility is overloaded. The City intends to finance expansion to 13.2 MGD through the State Water Pollution Control Revolving Loan Fund. The existing and proposed facilities utilize mechanical treatment with irrigation. The City also operates two small facilities in the vicinity of Lake Nasworthy.

A 1985 Corps of Engineers study, partially sponsored by the Board, recommended structural and non-structural flood damage prevention measures in Brentwood Park, East Angelo Draw, North Concho River, Red Arroyo, and South Concho river basins, consisting of zoning and detention reservoirs.

City of Brady. Brady presently receives water from the Hickory Aquifer; however, the water supply from its wells does not meet the Safe Drinking Water Act standards for radioactivity. It is recommended that the City convert to a surface water source. The City has diversion permits for almost 3,100 acre-feet per year from Lake Brady. Using Lake Brady, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through 2040.

Brady plans to replace its existing 1 MGD wastewater treatment facility with a 1.1 MGD facility capable of advanced treatment. A small facility at the City's airport will be abandoned, and flow will be diverted to the new plant as part of this project.

City of Del Rio. The City of Del Rio receives water from local springs and wells into the Edwards-Trinity (Plateau) Aquifer. The springs are estimated to be able to supply about 11,000 acre-feet per year. Using the supplies from the springs supplemented with additional ground water, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through the year 2040.

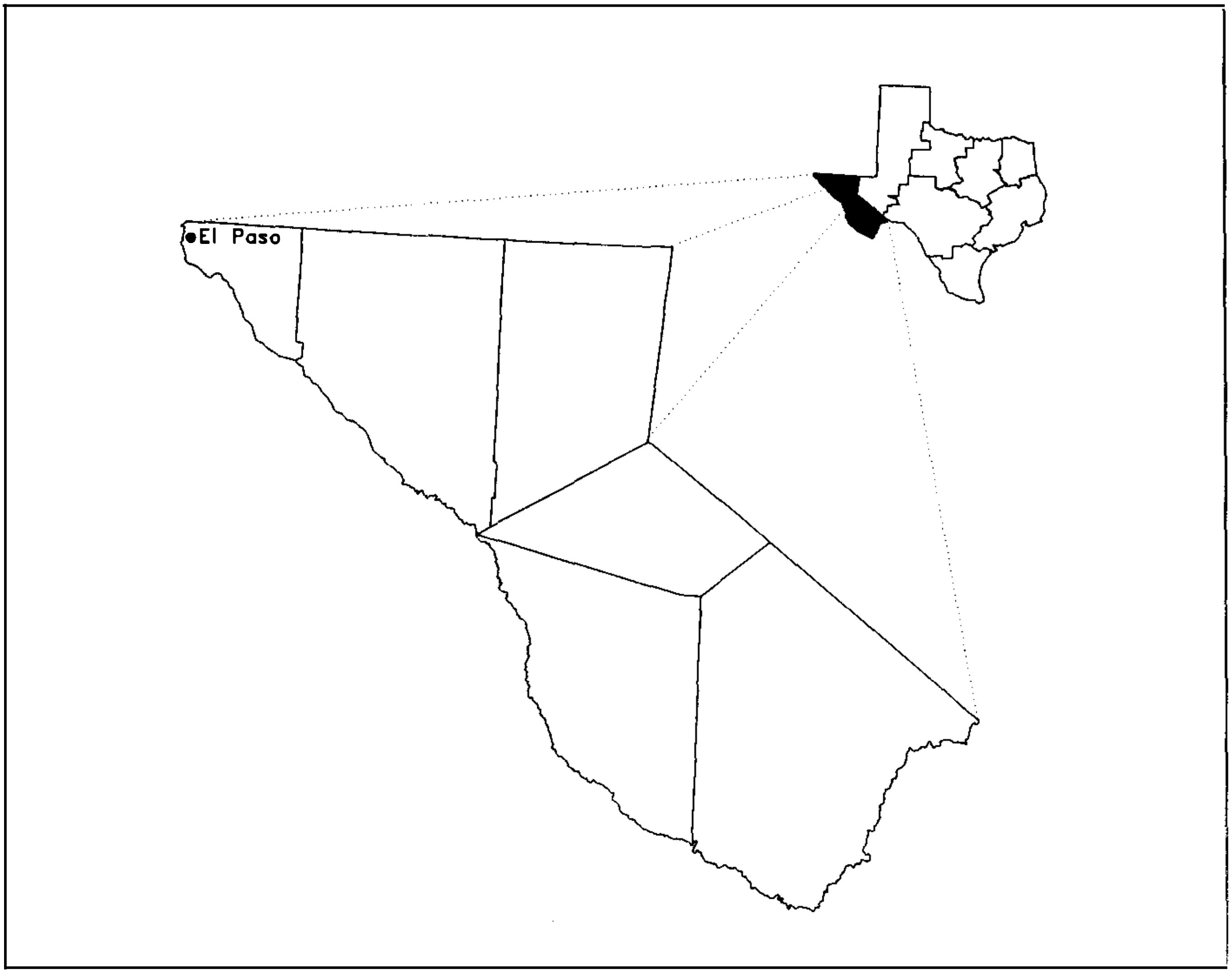
The City of Del Rio operates three wastewater treatment plants: Silver Lake (1.76 MGD), Round Mountain (0.63 MGD), and San Felipe (1.63 MGD). The City is expanding the Silver Lake plant to 2.76 MGD. The City also intends to expand the San Felipe plant to 3.8 MGD and divert the Round Mountain service area to it, thereby reducing the number of facilities to two.

Corps of Engineers high flood hazard area studies, conducted in 1985 and 1989, recommended flood damage prevention measures in the Calaveras, Cantu, and San Felipe Creek basins, and additional streams in the Del Rio area. These measures consist mainly of evacuation plans, flood control levees, and a ban on future development in portions of the floodplain.

City of Eagle Pass. The City of Eagle Pass uses water supplies from the Rio Grande backed with storage in Amistad Reservoir. Using the present supplies, in conjunction with an effective water conservation program, the City is expected to meet its future water needs through the year 2040.

Eagle Pass operates one 3 MGD wastewater treatment facility. Population growth and the addition of previously unserved subdivisions to the system are expected to require expansion at this site.

UPPER RIO GRANDE AND FAR WEST TEXAS REGION



CHARACTERISTICS OF THE REGION
THAT AFFECT WATER SUPPLY AND DEMAND

POPULATION:	1990	0.634 million
	2000	0.796 million
	2010	0.977 million
	2020	1.192 million
	2030	1.407 million
	2040	1.528 million

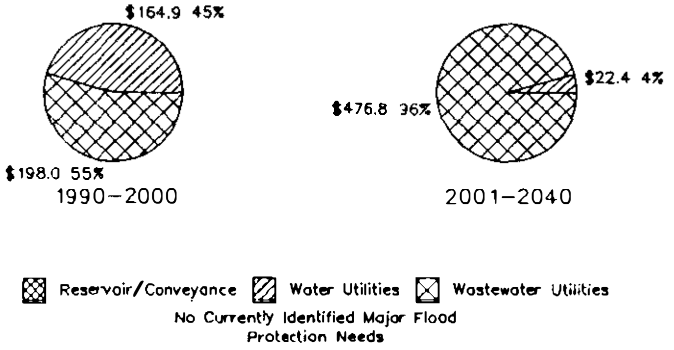
MAJOR ECONOMIC SECTORS: Mineral Production, Manufacturing, Retail and Wholesale Trades, Agriculture, Tourism, and International Trade

AVERAGE ANNUAL PRECIPITATION: 8 to 18 inches

ANNUAL NET EVAPORATION RATE: 66 inches

PHYSIOGRAPHY: Flat to rolling to mountainous, sparsely-vegetated desert with relatively flat, floodplain areas adjacent to the Rio Grande

COST DISTRIBUTION OF IDENTIFIED
REGIONAL WATER-RELATED PUBLIC FACILITY NEEDS
(mill. $)



Regional Description. The Upper Rio Grande and Far West Texas Region is comprised of six counties located entirely in the upper reaches of Rio Grande River Basin. In 1980, the population of the region totaled 500,400 residents with more than 95 percent of the population located in El Paso County. Currently, the regional population is estimated at 594,500. By the year 2040, population of the region is projected to be between 1.27 and 1.53 million residents. The population centers of the region are the cities of El Paso, Alpine, Fabens, Canutillo, Anthony, Van Horn, Marfa, Clint, Fort Davis, Sierra Blanca, and the Fort Bliss military installation.

Total annual water use within the region is estimated at almost 463,400 acre-feet, of which more than 68 percent is used for irrigation purposes.

This current water use pattern is expected to change over the 50-year planning period as municipal and manufacturing water requirements are projected to increase substantially while irrigation water requirements are projected to remain relatively stable. Due to the anticipated rapid growth in population associated with El Paso County, regional municipal water requirements are projected to more than double over the planning period. With implementation of conservation programs and practices, annual savings in municipal water use are projected to reach more than 13,500 acre-feet by the year 2000 and increase to nearly 50,900 acre-feet by the year 2040.

Regional Water-related Problems and Needs. Water supplies are limited throughout the region. The surface water and ground-water supplies of the Region are shared by Texas, New Mexico, and Mexico. During the past 30 years, the Rio Grande delivered only 65 percent of the water needed for the El Paso irrigation area. Ground water from the Hueco Bolson deposits is the primary source of municipal and industrial supply; however, the Bolson is being "mined," resulting in encroachment of saline water from adjacent saline water-bearing sands. High salinity in surface water supplies, due to frequent low flows and increased salinity of municipal and agricultural return flows have been detrimental to crops and cropland. Over the years small unincorporated subdivisions have developed with little or no water supply and wastewater facilities to meet their daily water-related needs.

The percent distribution of the estimated $862 million in projected total costs for identified water and wastewater infrastructure in the Upper Rio Grande and Far West Texas Region over the 50-year planning period is shown in the inset box at left. Approximately $363 million would be required in the first ten years and an estimated $499 million in the remaining 40 years of the planning period.

Local Water-related Problems and Needs. A brief narrative of the Board's evaluation of the water resources situation of major urban areas and large utility suppliers in the Upper Rio Grande and Far West Texas Region is described below. Additional information may be obtained from the Board's files.

<u>The City of El Paso</u>. The City is currently supplied water from the Hueco and Mesilla Bolson and the Rio Grande Project of New Mexico and Texas. Water from the Rio Grande Project is stored in Elephant Butte Reservoir in New Mexico, with annual releases determined by the Bureau of Reclamation. Texas' share of these releases has averaged about 126,000 acre-feet per year with El Paso receiving about 13,500 acre-feet. The City also has a reuse-recharge project that could recharge approximately 10,000 acre-feet to the aquifer. The project is currently recharging up to 6,700 acre-feet. In the future, reuse could increase supplies by about 35,000 acre-feet. The City's water conservation program should extend the available water supplies; however, without additional water supply sources, the City could anticipate a deficit of over 70,000 acre-feet by the year 2040. A water management plan, being conducted for the City service area by the El Paso Public Service Board, indicates slightly higher conservation savings and a slightly lower or no deficit forecast (depending upon the availability of ground water from nearby Bolson deposits) than does the Board's forecast.

El Paso's wastewater treatment needs are handled within four large service areas. The 27.7 MGD Haskell Street Plant serves central areas of the City including Fort Bliss. The 20 MGD Socorro Plant, serving the southern portion of the City, will be replaced by the new 39 MGD Southeast plant which is near completion. The 10 MGD Fred Hervey Reclamation Plant serves northeastern sections of the

City. This plant treats wastewater to drinking water standards, then pumps it into the Hueco Bolson Aquifer for reuse. The 6.4 MGD Quarry Plant treats wastewater from the northwest section of the City. Current plans are to expand this facility to 15 MGD.

El Paso Lower Valley Water District Authority. The approximate 200-square-mile District was created to address the pressing water and wastewater service needs of the relatively poor incorporated and unincorporated areas south of the City of El Paso. In the few years since its creation, efforts by the District, the City of El Paso, local irrigation districts, and citizens groups have resulted in a cooperative program to address area water and wastewater needs. This program has allowed the District to purchase an existing, limited-service-area water system from the City of El Paso. The system was previously used to service the northwestern portion of the District. Using this existing system and other improvements, expanded water service could be developed within the District. The City of El Paso's Socorro wastewater treatment plant would be made available for use by the District in the Lower Valley on completion of the El Paso's Southeast treatment plant.

Rural Areas. Many unincorporated subdivisions characterized by depressed economic conditions, including limited water supplies and limited wastewater facilities, exist within localized areas of the region, typically along the Rio Grande and predominately in El Paso County. Recognizing the existing and impending economic and health problems of these areas, the Texas Legislature has directed the Texas Water Development Board to provide financial and technical assistance for construction of facilities to provide suitable water supply and wastewater treatment for these areas. Due to the limited water supplies for meeting the water needs of rural areas throughout El Paso County, a shortage of approximately 13,900 acre-feet per year is anticipated by the year 2040. An effective water conservation program should be implemented for extending available supplies through the year 2030.

4 POLICY ISSUES AND RECOMMENDATIONS

Strategic planning and management of Texas' water resources is fundamental to the provision of usable water supplies at reasonable costs and acceptable environmental impact. Projections of water-related needs made in this Plan have been based on reasonable expectations that various governmental policy and program actions will occur to keep water resources regulation, management, and development current with the needs of Texas today and tomorrow.

A wide range of issues related to water-related needs, problems, and opportunities were evaluated in this planning effort. Where appropriate, recommendations were made for Legislative, State agency, and local government consideration and action.

Major policy areas evaluated include:

- Alternative Water Supplies
- Surface Water Supply Source Management and Protection
- Ground-water Supply Source Management and Protection
- Regionalization
- Balancing Water Resources Development With Environmental and Land Management Concerns
- Financing Water Management
- Planning, Education, and Research

A summary of *priority policy recommendations*, identified as key issues by the Board, is provided in each of the above major discussion areas of water-related issues. More detailed information on these priority issues and *other important recommendations* for policy and program actions by the Legislature, State agencies, and local governments are contained in the narratives of this Section.

ALTERNATIVE WATER SUPPLIES

Until the early 1980s, the principle approach to meeting projected water supply needs in Texas was to identify new surface water and ground-water supply sources for development. The 1984 Water Plan, however, included important policy and program recommendations on using existing and future municipal and agricultural water supplies more efficiently and, to a limited extent, indicated the potential of alternative water supply management approaches, such as desalinization and water reuse, to contribute to meeting the projected water demands of the State.

The 1990 Water Plan update reinforces the significance of a number of increasingly-used alternative demand and supply management approaches in meeting the State's projected water needs. A summary of recommended key policy initiatives for alternative water supply policies and programs is presented in the inset box on the following page.

Water Conservation

In 1985, the 69th Texas Legislature redefined water conservation in the Texas Water Code to include both the development of water resources and those practices, techniques, and technologies that reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for current and future consumptive and non-consumptive uses. While other parts of the 1990 Water Plan address the development of the State's water resources, the recommendations in this policy section pertain to the water demand and supply management approaches that can also be used to ensure that a sufficient supply of good quality water is available for the future of Texas.

ALTERNATIVE WATER SUPPLIES

PRIORITY POLICY RECOMMENDATIONS	LEGISLATIVE ACTION	AGENCY ACTION	LOCAL ACTION
★ Establish a certification program to set maximum flow standards for plumbing fixtures and appliances purchased for use or sold within the State.	★	★	★
★ Adopt an official policy to guide State water reuse and recycling programs.	★		
★ Amend the Water Code to remove the requirement that the 50-year needs of a basin must be considered before planning for interbasin transfers of surface water.	★	★	
★ Revise the State's surface water rights review and cancellation process to assure that unused and unneeded surface water rights are made available for use.	★	★	

The eight principle methods that can be used to achieve better water use efficiencies in municipal systems include: (1) public education and information, (2) requirements for the use of water-conserving plumbing fixtures and devices in new construction, (3) retrofit programs to improve water use efficiency in existing buildings, (4) conservation-oriented water rate structures, (5) universal metering and meter repair and replacement, (6) water-conserving landscaping, (7) leak detection and repair, and (8) recycling and reuse.

Methods of agricultural water conservation include: (1) increasing the efficiency of water conveyance systems, such as replacing earthen canals with pipelines and lined canals, (2) close monitoring of water use, (3) installing efficient irrigation systems and equipment, (4) making improvements to irrigated land, such as ground leveling and drainage improvements, (5) proper use of fertilizers and chemicals to increase productivity with the use of less water, (6) using efficient irrigation scheduling techniques, such as computerized scheduling systems, and (7) other efficient water use measures.

A wide variety of water conservation measures are also available to industrial water users. Many of these techniques are specific to individual industries and have already been developed and are being implemented by industrial users in their continuing efforts to reduce costs while increasing productivity.

In response to the recognized need for water conservation by all levels of government in the State, numerous regional and local entities have been at the forefront in instituting a wide variety of water conservation programs and activities to address the particular regional and local needs of different areas of the State. Underground water conservation districts, river authorities, other regional and local districts, and municipalities, as well as private interest groups, play a vital role in achieving needed water conservation savings. Several local and regional districts and individual water users, particularly in agricultural areas, were among the first entities in the State to actively implement water conservation programs and measures.

In the period between 1986 when the Texas Water Development Board's (Board) water conservation program mandated by House Bill 2 took effect and the end of 1989, Board-approved water conservation programs in Texas have been developed by over 100 political subdivisions with a service area population of nearly six million people. Many others cities are currently developing conservation programs. The Board's agricultural water conservation assistance program has provided pilot loans to local districts of over $8 million and grants to local districts of nearly $500,000. Because of overwhelming public support and the potential beneficial water supply and cost effects of statewide conservation programs, the Board now considers easily achievable conservation effects in its water demand forecasts for the Water Plan.

In addition, the Texas Water Commission (Commission) was given authority in 1985 to require preparation of a water conservation plan and implementation of a program by applicants for a water rights permit. The Commission is now in the process of finalizing rules on its water conservation requirements.

While the recent legislatively assigned programs of the Board and the Commission were instituted to directly affect how water conservation is incorporated into water supply planning and development throughout the State, other State agencies also play an important role in encouraging the implementation of water conservation. The Texas Agricultural Extension Service, the Texas Department of Agriculture, the Texas Department of Health, the State Soil and Water Conservation Board, the Texas Parks and Wildlife Department, and several other agencies administer programs that encourage water conservation.

Although local, regional, and State programs to implement water conservation programs have been successful, additional follow-up actions are needed to further incorporate water conservation into water programs of the State and to encourage more comprehensive coverage of effective water conservation activities for all water users. At the State agency level, water conservation policy directives have not been fully instituted within all State agency programs, and it is appropriate for the State to take all necessary actions to use water as efficiently as the State requires of its political subdivisions. In addition, the Board, Commission, and other State agencies that conduct conservation activities need to ensure consistency among all water conservation programs, considering the diverse nature of water operations.

The State should establish a program to incorporate statewide use of low water-using plumbing fixtures and household appliances in all new construction and as replacements are needed for existing fixtures. This action will save from 20 to 40 percent of indoor water use when compared with older fixtures and appliances.

In addition to the water resource benefits from such a program, the energy savings achievable through the use of these fixtures and overall consumer cost savings can be substantial. The availability of water efficient fixtures and appliances at costs comparable to more wasteful fixtures and the ease of their use in construction makes a State program governing the sale and use of efficient fixtures and appliances a viable way to achieve substantial statewide water conservation.

While the State can do more at the State agency level and on a statewide basis, certain existing programs should be enhanced to both assist those local and regional entities that have already undertaken water conservation activities and to encourage those entities that have not fully incorporated water conservation into local water planning and development to do so.

Finally, the water conservation education and technical assistance activities conducted by Texas state agencies are very limited when compared with those of other large water-using states, such as California or Florida. Assistance to those State and local entities that do not have the resources to fully develop conservation programs needs to be provided. It is particularly important that the State develop standardized information on how to incorporate the effects of water conservation programs into long-range water plans and capital facility investment plans.

Recommendations:

A. The Legislature should establish a certification program to set maximum flow standards for plumbing fixtures purchased for use or sold within the State. The certification program should also contain water use efficiency standards for household appliances and address commercial and agricultural irrigation systems. The effective compliance date for the program should be September 1, 1992. Enforcement of the certification program should be assigned to either the Texas Department of Health or the Texas Water Commission.

B. The Legislature should incorporate water conservation policy goals into all appropriate activities and programs of State government, including construction and operation of State facilities. To accomplish this, three main actions need to occur.

   First, all agencies responsible for constructing, leasing, or maintaining State facilities and property should be directed to use water-conserving plumbing fixtures and devices, water-efficient landscape practices, and other programs to ensure water use efficiency. The Legislature should provide funds to affected agencies to retrofit existing State facilities with water-conserving devices. The installation of water-conserving fixtures and devices has been proven to be cost effective and will, in all cases, pay for itself in water and energy cost savings.

   Second, agencies responsible for education, training, or certification of water professionals, such as the Texas Department of Health, the Texas Water Commission, the State Board of Plumbing Examiners, the Texas Board of Irrigators, the Texas Water Well Drillers Board, the Texas Department of Agriculture, and the Landscape Architects Division of the Texas Board of Architectural Examiners, should be directed to incorporate water conservation into their education and certification programs.

   Finally, an interagency committee should be established to evaluate additional State activities and programs that should have water conservation included as a policy mandate.

C. Because of the number of State agencies with legislatively assigned responsibilities for encouraging water conservation activities, it is important that all of these agencies periodically consult with each other to ensure the consistency of the water conservation information provided to the public and the water conservation program requirements that are being encouraged or enforced.

D. The Board and the Commission should enact a memorandum of understanding which clearly establishes that fulfilling the water conservation program requirements of one agency will satisfy the requirements of the other agency, unless unusual circumstances arise. Also, the Board and the Commission should coordinate to ensure that the water conservation rules of both agencies are consistent.

E. In order to correspond to the Board's water conservation requirements for receiving a Water Quality Enhancement or State Water Pollution Control Revolving Fund loan, the Legislature should specifically authorize the Commission to require preparation and implementation of a water conservation program by applicants for a wastewater discharge permit.

F. The Legislature should specifically authorize the Commission to require preparation and implementation of a drought contingency plan as part of a water rights or wastewater discharge permit approval.

G. In addition to requiring future water rights permit applicants to implement water conservation programs, the Commission should begin a program to require existing permit holders to implement water conservation programs and to prepare drought contingency plans within a two-year period.

H. The Legislature should ensure that various legislative directives, including sufficient direction and authorization in enabling legislation, are included in the Water Code to assure that river authorities, regional water authorities and districts, underground water conservation districts, and other appropriate districts develop and institute water conservation programs to address local and regional needs, as well as to contribute to statewide goals and objectives. For example, the Legislature has included requirements in the enabling legislation of several river authorities to prepare water conservation plans, to have the plans approved by the Board, and to then implement the approved programs. Funding mechanisms and revenue generating capabilities should be included with any directive to develop comprehensive water conservation programs by local and regional entities.

I. The Board should be funded to increase its water conservation education and technical assistance activities. In particular, the Board should expand its current efforts and establish more comprehensive statewide water conservation education and information and unaccounted-for water reduction efforts. Other State agencies that provide education programs for water conservation should also be considered for funding enhancement where needed.

J. The Board, the Commission, the Texas Agricultural Extension Service, the State Soil and Water Conservation Board, the Texas Department of Agriculture, and other appropriate entities need to make further efforts to encourage and facilitate implementation of water conservation measures in irrigated agriculture. Efforts should be coordinated with local districts and other water management agencies to provide education, technical assistance, and workshops on water conservation techniques and the benefits of conservation.

   While this Plan includes a recommendation under the financing issue that recommends that the Legislature and the Board work to change federal tax laws to make the Board's Agricultural Water Conservation Bond program more effective, other efforts should also be increased. The Board's grant program to provide funds to local districts to purchase agricultural water-use efficiency testing and water quality testing equipment should be continued and supported by the Legislature. In addition, programs by the Texas State Soil and Water Conservation Board and local soil and water conservation districts to evaluate irrigation system efficiency, to assist in installation of efficient irrigation systems, and to provide technical assistance should be supported. Also, education and technical assistance by other State agencies to districts, cities, and individuals in agricultural areas should be enhanced.

K. The Board, the Commission, and the Texas Department of Health should be funded to conduct interagency studies to evaluate changes in water treatment and distribution systems and wastewater collection and treatment system facilities planning and construction standards to reflect operational efficiencies and cost savings achievable through water conservation. As part of this process, the Board should work to determine better methods of accounting for water conservation practices already in place, as well as the effects of practices to be implemented in the future.

Water Reclamation, Reuse, and Effects on Water Rights

Reuse of reclaimed wastewater is a viable method of increasing the usefulness of a limited water supply. Many areas in Texas currently reuse treated wastewater for landscape and agricultural irrigation, industrial process water, aquifer recharge, and other activities. In addition, unplanned reuse has been common in Texas for a long time, as treated wastewater is discharged into streams to be later withdrawn as water supply by a downstream user. The central issues affecting full utilization of reuse techniques have been health concerns, relative cost-effectiveness, and the rights to reclaimed water, especially when the water is used to maintain streamflow.

Currently, the Texas Water Commission and the Texas Department of Health are cooperating to implement rules to clarify how reclaimed wastewater, including "greywater", may be used. However, the Texas Water Code does not include a clear policy statement of the State's position on reuse. Also, some additional research is needed to determine the possible health and environmental effects of reuse and land application of wastewater.

The Texas Water Commission recently published proposed rules that encourage the substitution of reclaimed water in place of potable water where appropriate. As one requirement of the rules, major domestic wastewater dischargers must prepare a study to consider the appropriateness and cost effectiveness of substituting reclaimed water for potable water or fresh water within one year of issuance of any new, amended, or renewed wastewater discharge permit.

Reclaimed water is defined as municipal wastewater that is under the direct control of the treatment plant owner or operator which has been treated to a quality suitable for a beneficial use. Under the rules, the Commission will review water rights with respect to the proposed reclaimed water use plans. The rule changes also address water rights, specifically return and surplus water, by clarifying that the water rights holder has the authority to continue to reuse appropriated water as long as it is for the purposes authorized in the permit, unless the permit specifically requires the return of water once it has been initially used.

Because of the potential supply volume involved, water reclamation and reuse should be given the same level of consideration, from a State water planning standpoint, as development of additional water resources. The expanding consideration of reuse alternatives makes it necessary for the State to take an active role in defining the safe and authorized uses of reclaimed wastewater, identifying programs where reuse should be automatically considered as an alternative, and examining the effects of an expanded reuse program, including the effects on return flows to satisfy downstream needs.

Recommendations:

A. The Legislature should adopt an official policy to guide State water reuse and recycling programs. The policy should favor the reuse of reclaimed water where such reuse is economically feasible and can be accomplished without undue risk to public health, the environment, or existing water supplies. The policy should clearly differentiate between reuse and land disposal of wastewater.

B. The Legislature should authorize and provide funds to the Board, Commission, and Texas Parks and Wildlife Department to conduct a joint study to expand the State's knowledge of return flow needs of State streams and how those streams will be affected by either increased reuse or, alternatively, additional use of freshwater supplies.

C. The Board and Texas universities should receive funding to conduct further education activities to instruct and inform the public and water professionals about reuse alternatives.

Desalinization

In the past, non-conventional approaches to water supply development, such as desalinization, were considered expensive when compared to development or transportation of usable fresh water to areas of need. Thus, although desalinization has been technologically feasible in a number of areas for some time, the use of such technology has not been seriously considered in many cases. However, advancements in membrane technology have made the cost of desalinization more in line with conventional water treatment techniques.

Therefore, given the location and amount of brackish and saline water that occurs in Texas (see maps on pages IV. 14-16 in Volume 2 of Water For Texas, Texas Department of Water Resources, 1984), and the increasingly limited supply of fresh water available to meet projected demands, desalinization needs to be further incorporated into the water supply plans developed in the State. In particular, desalinization should be considered as a primary supply option in certain geographical areas.

Recommendations:

A. The Board should expand its programs to evaluate brackish water availability and should conduct workshops with local governments and utilities on desalinization and its viability for extending freshwater supplies. In conjunction with this effort, the Board should coordinate with State universities to encourage inclusion of desalinization technology into water resources and civil engineering curricula.

B. The Board and the Texas Department of Health should establish an agreement on the identification of areas where desalinization should be considered as the primary water supply option.

C. The Legislature should support national efforts to promote desalinization, such as are being done by the National Water Supply Improvement Association.

Reservoir Storage Reallocation

During the past 30 years, water storage capacity of about one-half million acre-feet has been permanently reallocated from hydropower, navigation, and flood control storage to water supply purposes in seven U.S. Army Corps of Engineer reservoirs in Texas. However, the potential for reallocation in federal projects to address future water needs has barely been realized.

Three major factors have prevented storage reallocation from being more actively evaluated in recent years as a major source of water supply. First, estimates of hydropower, navigation, streamflow augmentation, and flood control storage in federal reservoirs are not readily available or are confusing to parties interested in evaluating storage reallocation as an alternative water supply source. Second, engineering and economic studies to determine reallocation's potential and environmental studies to determine associated ecological impacts are complicated, expensive, and time consuming. Third, the current repayment policy of the Corps of Engineers, which has not been authorized by Congress, requires that water reallocated from existing storage be paid for as if it were being constructed today (i.e., replacement cost) rather than being repaid at the federal government's actual or original cost.

Recommendations: Several actions are necessary to fully realize the potential that reallocation offers to meet future water needs of Texas.

A. The Board should acquire precise information on the actual authorized storage volumes in all federal reservoir projects, conduct studies to determine amounts available for exchange or reallocation, and make the information available to all entities considering new supply source development.

B. Once the data are readily available, the Board should include storage volumes potentially available for reallocation in the <u>Texas Water Plan</u> in exactly the same way that potential new reservoirs are presented.

C. The Texas Legislature and State agencies should undertake a concentrated effort with the Texas congressional delegation to amend the 1958 Water Supply Act to reassert Congress' intention to promote reallocation on the basis of original construction costs.

Transfers and Marketing

Texas does not currently have a formal or effective mechanism to promote water transfers, defined as a change in the nature of use, point of diversion, place of use or period of use of water, in the interest of efficient water use. Importantly, transaction costs and legal uncertainties limit transfers. Entities holding water rights for more than one purpose may also hinder transactions. Also, the Texas Water Code requires that State plans for interbasin transfers of surface water may be considered only for water available in excess of the 50-year water supply requirements of the originating basin. Considering that interbasin transfers of surface water in excess of three million acre-feet per year are already taking place and that the 50-year needs consideration requirement places severe limitations on the State's ability to plan for the provision of water to areas of need, the 50-year limitation needs to be removed. Additional areas of uncertainty associated with the priority of municipal use, status of developed water, and quantification of consumptive use, also need legislative attention.

Concerns that will need to be addressed in conjunction with the development of a market transfer system include potential harm to downstream users or reduced flow for instream needs from changing the location of a diversion or the intensity of use. While water would, in most cases, be transferred from an agricultural use to municipal or industrial uses, areas exporting water may experience direct or secondary economic impacts. Additionally, future water-intensive development could be precluded.

A major water rights transaction in California merits careful examination for its applicability to Texas. In return for financing water efficient improvements in an irrigation district, a district supplying municipal needs will receive over 100,000 acre-feet of the conserved water annually. Similarly, water losses in unlined canals in the Lower Rio Grande Valley can be up to 25 percent, and while some districts have secured U. S. Bureau of Reclamation funding for improvements, another 100,000 acre-feet of water could potentially be saved and made available for use in transfers each year. While salvage or conservation techniques may not appear to be affordable to an individual farmer, the value of water saved for use by others, rather than the farmer, makes the technique cost-effective.

Alternatives available to encourage marketing transfers range from modifying existing institutions to encourage marketing, while still protecting the interests of those that may potentially be harmed by such transactions, to providing for transfers through administrative actions.

Recommendations:

A. The Legislature should amend the Texas Water Code to remove the requirement that only surface water in excess of the 50-year water supply requirements of an originating basin may be considered for interbasin water transfers. This will provide greater flexibility in supplying available water to areas most in need and should help facilitate efficient transfers and marketing of surface water rights.

B. The Board and the Commission should comprehensively review State water law and regulations for language that restricts water transfers and recommend to the Legislature any statutory clarification necessary to encourage voluntary water marketing and transfers.

C. The Board and the Commission should jointly research the role of river authorities and other regional entities in encouraging the emergence of water markets.

D. The Board and the Commission should study the feasibility of transfers between districts and cities in the Lower Rio Grande Valley and other areas in the State involving conserved water from canal improvements. The study should document costs of lining canals, quantify the amount of water that would be saved, determine significant environmental effects, and examine municipal interest in the program. If canal improvements are determined to be effective, studies of various types of transfer opportunities, mechanisms, and procedures should be conducted in other areas.

E. It is recommended that, as restated in the Financing Water Management Section of this plan, the Board and the Texas Legislature work to change federal tax laws to make the Board's Agricultural Water Conservation Bond program more effective. Efforts at increasing the efficiency of agricultural water use will help to increase the amount of water potentially available for marketing transactions.

Water Supply Yield Enhancement

A variety of water supply management approaches are potentially available to locally increase water yield in select areas of the State over the long-term. However, measures to enhance ground-water storage through increased infiltration and artificial recharge, to control or eradicate high water-using vegetation (brush control), to improve the capability of land surfaces and water courses to delay runoff, to maximize ground-water withdrawals using secondary recovery methods, to suppress evaporation from existing surface water sources, and to increase precipitation by weather modification are not widely practiced or uniformly implementable across the State to increase water supply.

The potential water supply benefits, costs, and environmental effects of various watershed management approaches have not been entirely established. For example, while brush control has been shown to increase infiltration, it can also increase runoff and erosion. Further, it has been determined to be effective only in certain areas of the State (refer to the map on page 8 in section V of the Texas State Brush Control Management Plan, Texas State Soil and Water Conservation Board, 1987). In addition, increases in water supply by increasing infiltration or stream flow due to brush control management are difficult to measure.

Furthermore, utilization of water supply yield enhancement techniques will require that other related problems, such as environmental consequences and the surface water right to use the additional water, be addressed before any of the measures are widely accepted and practiced to increase local supplies. Also, questions relating to the financing of these activities remain unresolved, especially considering the time that may be required before the benefits of certain techniques are realized.

Water supply yield enhancement alternatives and their potential to increase local supplies should be considered in several ways. These include increasing the total amount of ground water and surface water available to a local area, altering or varying the amount of water available at different times, improving the quality of water available for supply use, and evaluating the environmental consequences.

Recommendations: While techniques to increase water supply yield are likely to produce only localized benefits, efforts to develop and evaluate augmentation measures should continue, with particular emphasis given to applying the approaches in areas with few, if any, alternative supply sources.

A. The Board should review existing studies, such as information compiled by the Texas State Soil and Water Conservation Board, and conduct a comprehensive evaluation program, in conjunction with other appropriate State agencies, to identify areas where water supply yield enhancement might be beneficial and to further study the possible programs that could be instituted for those areas, with the results to be incorporated into future water plans.

B. The Board, the Texas Water Commission, the Texas Parks and Wildlife Department, the Texas State Soil and Water Conservation Board, and other State agencies should conduct cooperative studies to determine the possible environmental effects of water supply yield enhancement, and guidelines for conducting activities that fully consider environmental factors should be prepared.

C. The Legislature should consider methods to encourage watershed yield enhancement activities, such as funding the legislatively authorized cost-share assistance program for brush management activities to be administered by the Texas State Soil and Water Conservation Board. In addition, the Board should research additional methods to encourage water supply yield enhancement activities. Possible alternatives would be to: (1) establish further State financial incentives for yield enhancement or (2) amend the Water Code to grant a preference to the party that conducts enhancement activities in acquiring the surface water rights to the increased yield in a given State stream due to those enhancement activities.

Nonuse of Surface Water Rights

Surface water rights are subject to cancellation or reduction if the water conveyed through the right is not used beneficially over a 10-year period. Under existing law, a cancellation proceeding can be initiated by the Commission when records indicate that no water has been beneficially used under a permit, certified filing, or certificate of adjudication during the previous 10 years. The holder of the permit, certified filing, or certificate of adjudication must be notified regarding consideration of cancellation, and a hearing must be held to allow presentation of evidence on whether the water has, or has not, been beneficially used for the purposes authorized. The hearing is followed by a Commission finding and action. A similar proceeding that can lead to partial cancellation is established in the Water

Code when some portion of water authorized to be appropriated is not put to beneficial use at any time during a 10-year period.

The current cancellation approach may create incentives to waste water (depending upon the ability of the Commission to determine beneficial use) and, in some instances, has been used as a rationale to not engage in conservation. The potential for cancellation also makes it advantageous for water rights holders to over-report actual use. This reduces the value of water use statistics for planning purposes. Also, the factors that the Texas Water Commission must evaluate in granting a water use permit have changed over the years to consider environmental, water quality, and conservation requirements, and as a result, there are inconsistencies between permits issued at different times. Overall, statutory provisions in Texas for surface water rights cancellation based on nonuse are relatively lenient in comparison with rules in other states.

Although forfeiture and abandonment proceedings have been infrequent, pressure for cancellation of unused rights will increase as water scarcity and competitive pressure for water rights become more acute. Extensive rights being held, but not being used, can necessitate over-investment in new facilities or even constrain economic development in areas with water supply shortages. At the same time, the potential for water rights cancellation is an incentive to engage in market transactions rather than potentially lose the right to the surface water with no compensation.

Also, in a related issue, while cancellation programs for nonuse need to be reviewed, State programs to protect and fairly manage and administer existing water rights are being further implemented and should be enhanced. In particular, established legislation provides that the Commission may divide the state into water divisions for purposes of administering surface water rights through local administration by watermasters.

Recommendations: To allow for more effective use, and conceivably, a more equitable allocation of the State's surface water supplies, several recommendations should be implemented.

A. A revised cancellation proceeding for unused surface water rights should be developed by the Texas Water Commission. This effort must protect investments in facilities associated with those rights, beneficial water use, and foreseeable future water supply needs. The Commission's current 10-year period for review and possible cancellation or reduction of water rights based on nonuse should remain the same.

   However, in order to assure that holders of surface water rights subject to cancellation are not left with debt and unusable facility investments for developing rights which are subsequently canceled, the Commission should consider instituting a market approach to allow water rights holders to recover their investments. One approach would be that, following a 10-year period of nonuse, the Commission should require a permittee holding rights in excess of future demands subject to cancellation, and for which it can be proved that substantial investment was made in developing the cancelable portion of the right, to publish a public notification of the availability for sale of the excess water rights. If the excess rights are not purchased during the two years following the notification at a reasonable price that recovers the permit holder's investment in developing the right, the Commission's cancellation proceeding should be suspended.

   The Commission should determine an appropriate suspension period before those rights would be subject to further review and possible cancellation. In any water rights transaction initiated as a result of this process, the owner of the water right should be fully reimbursed for previous costs associated with developing the right, including interest expenses.

   If the original owner of the water right must develop a future replacement water supply as a result of the sale, the cost associated with the sale should reflect the cost of the new supply, discounted to current prices. If potential sellers and buyers cannot mutually agree to a reasonable amount for a transaction, the final determination of the price should be appealed to the Commission. In determining a reasonable sales price, the Commission should consider what is fair and reasonable for current and future customers of each entity.

B. The Legislature should clarify conditions for temporary water supply contract transactions to respond to concerns regarding appropriate water rates to be charged and to ensure that the water provider maintains the legal and regulatory right to renew service or discontinue service, with proper advance notice, at the conclusion of the stated contract period.

C. The Commission should evaluate current law and its rules concerning cancellation of water rights for nonuse to determine possible incentives for water rights holders to conserve water. One mechanism already being proposed by the Commission is to provide assurances in its rules that a current permit holder which voluntarily submits a conservation plan for approval by 1993 will not have any water conserved subject to cancellation for 10 additional years from the date their conservation plan is approved.

   Possible additional actions that could be considered include: (a) extending the nonuse period for conserved water before the cancellation proceeding may occur, (b) allowing the permit holder to maintain the rights to the conserved water past the 10-year period if an active effort to market those rights is undertaken, or (c) establishing a system to give preference to the rights to conserved water to an entity that pays a permit holder for conducting the conservation activity or conducts the conservation activity itself (ex., a city lining the canals of an irrigation district in order to obtain rights to water saved).

D. The Commission's program to establish water divisions statewide and appoint watermasters to administer each division should be continued and further supported.

Water Importation

Water supplies in a very limited number of areas in the State are projected to be insufficient to meet long-range needs. In some of those areas, water supplies are limited to finite and exhaustible quantities of ground water. In a few other areas, locally-available surface water supplies may be inadequate to meet long-term water supply needs.

Importation of water from other states has been considered as an option for Texas in the past. The 1968 Texas Water Plan made provisions for the importation of an estimated 12 to 13 million acre-feet of water per year by 2020 to meet Texas' water needs, primarily for irrigation use.

The 1984 Texas Water Plan also considered interstate importation as an alternative. However by 1984, studies had shown that major long-distance interstate diversions of water would be prohibitively expensive and politically difficult.

Under present circumstances and during the 50-year planning horizon used in this update, major interstate importation of water, distinguished from local efforts to import ground water and interstate division of surface water within a shared river basin through existing or future interstate compact agreements, is not necessary to meet projected demands.

In a related issue, the 69th Texas Legislature created the Multi-State Water Resources Planning Commission to study water importation questions and options and to work with other states in an attempt to identify available water supplies and cost-effective import supply alternatives. However, the Multi-State Commission was never provided funding by the Legislature to begin a program of work. Considering the very localized nature of water supply need and a new emphasis on using demand and supply management alternatives other than major long-distance water importation projects to meet projected needs, the future status of the Multi-State Commission needs to be clarified.

Finally, as is discussed in the Transfers and Marketing section, interbasin transfers of water within the State of Texas will continue to be considered in both State and local planning efforts. Changes are

SURFACE WATER SUPPLY SOURCE MANAGEMENT AND PROTECTION			
PRIORITY POLICY RECOMMENDATIONS	LEGISLATIVE ACTION	AGENCY ACTION	LOCAL ACTION
★ Require watershed management plans to protect the quality of sources.	★	★	★
★ Provide a TWDB report to the Legislature on the potential to implement a reservoir site protection program.		★	
★ Authorize TWC to impose administrative penalties to enforce dam safety regulations.	★	★	
★ Establish a fee-based dam safety inspection program to fund TWC dam safety activities	★	★	

needed to the Texas Water Code to provide greater flexibility in planning for interbasin transfers within the State.

Recommendations:

A. The Board, as the State's water planning agency, will continue to evaluate all reasonable water supply alternatives, including interstate importation when and where appropriate, to meet the future needs of the State. The Board should be legislatively assigned the responsibilities of the Multi-State Water Resources Planning Commission.

B. As stated under Transfers and Marketing, the Legislature should remove the requirement that only surface water in excess of the 50-year water in-basin supply requirements of the originating basin may be considered for interbasin water transfers. The removal of this requirement will provide greater flexibility in supplying available water to areas of the State most in need and should help facilitate efficient transfers and marketing of water rights.

SURFACE WATER SUPPLY SOURCE MANAGEMENT AND PROTECTION

Opportunities to develop new surface water supply sources are limited because of the lack of favorable sites, environmental conflicts, rising costs, and available water rights. Given the scarceness of new sources and growing demand, State policy must promote full utilization of currently available resources. Consequently, it is imperative to protect existing water supply sources and needed future sources from impairment, utilize sources more efficiently, and ensure the integrity of dams impounding water supplies.

A summary of priority policy initiatives related to managing and protecting the State's surface water supply sources is presented in the inset box above.

Protecting Surface Water Supply Source Quality

Texas has done a good job of protecting existing surface water supply sources, including both streams and reservoirs, from point sources of pollution. The State has been less effective in limiting non-point pollution sources and restricting detrimental development. New, more comprehensive approaches are required to ensure that water suppliers are not forced to rely on lesser quality surface water sources and that water customers are not unnecessarily required to pay for increasingly expensive treatment techniques. Approaches being used to stop and reverse source degradation by a number of states and a variety of regional and local water suppliers throughout the United States include the formal identification of potential sources, acquisition or imposition of development restrictions for or acquisition of reservoir watersheds, and implementation of both structural (physical) and non-structural (management) measures. Structural methods which are being used or are increasing in use in Texas include physical facilities to treat or control point and non-point source pollution from wastewater discharges, overland runoff, and other waste-generating activities.

Non-structural alternatives which should be used more by the State and local governments in Texas include programs to reduce pollutant generation, such as water conservation and waste minimization and recycling, best management practices (BMPs) to minimize pollution impacts, land development restrictions, and land acquisition of critical areas, such as wetlands, natural open space, stream and lake buffer corridors, and well recharge zones.

Recommendations: A series of actions should be taken by the State to emphasize source protection:

A. All river authorities, regional districts, and local governments responsible for managing surface water and ground water should be given sufficient legislative authority and required to develop and implement watershed management plans to protect existing and identified potential surface water sources. In developing required programs, entities should consider the existing agricultural-related watershed management programs of soil and water conservation districts. Also, State law should ensure that regional and local authorities have the ability to raise revenues to finance watershed management programs. In addition, the watershed management efforts of soil and water conservation districts and the Texas State Soil and Water Conservation Board should be further supported.

B. The State's water quality standards program should be revised to designate potential surface water reservoir sites as public supply.

C. The Board should evaluate protecting critical reservoir sites in advance of need and determining the costs of funding associated mitigation projects. The acquisition of development rights or easements and other protection alternatives could be considered in lieu of complete purchase. Following the Board's evaluation, a report should be provided to the Legislature on the potential to implement a reservoir site protection program.

D. The Board should expand its financing programs to more fully support and encourage the use of low-intensity structural non-point source measures and non-structural alternatives to protect water quality. The Legislature should also provide funding for cooperative non-point source pollution projects involving more than one State agency and for projects on State-owned lands.

Reservoir Operations and Capacity Maintenance

Texas currently has 188 major reservoirs that provide a substantial percentage of the surface water used in the State. However, a number of the impoundments have experienced accelerated sedimentation, and successive reservoirs located on a river system, as well as individual reservoirs, may not be used to their full operational potential to supply water. Because developing water sources is very expensive, the capability of existing projects to continue to supply the maximum amount of water must be protected and enhanced.

Current State policy encourages reservoirs to be locally planned, permitted, and operated on an individual basis even though the experience of several river authorities indicates that reservoir systems operation procedures provide an opportunity to increase available supplies by 20 to 50 percent without new development. At the same time that supplies can potentially be increased through systems operations, current activities to maintain the usable capacity of existing reservoirs must be expanded to ensure that present and potentially available supply quantities are not diminished.

Capacity Maintenance Recommendations:

A. The Legislature should expand funding for a Board program that measures the amount and nature of sediment accumulating in existing reservoirs. A report on the rate and nature of sedimentation for all major supply reservoirs, as well as environmental effects of dredged material removal and disposal, should be completed within five years, and the results incorporated into a future water plan revision.

Similarly, a program to determine sediment needs and dynamics of the State's rivers, bays, and estuaries should be undertaken. Also, a Board program to educate water planners and engineers about techniques for and the benefits of preventing sedimentation and routing sediment through existing and planned reservoirs should be established.

B. The State's water financing programs should be expanded to clearly provide funding authority for sedimentation basins, non-structural approaches, such as vegetative barriers and erosion control measures, and the removal and beneficial use of settled material in conjunction with protecting storage in existing or future reservoirs.

C. The State should vigorously support expanded federal funding for land management programs intended to reduce erosion and resulting reservoir sedimentation. As sediment sources affecting reservoirs are identified, State agencies, such as the Texas Water Commission and the State Soil and Water Conservation Board, should work with federal agencies, such as the federal Environmental Protection Agency and the Department of Agriculture's Soil Conservation Service and Agricultural Stabilization and Conservation Service, to target federal funds for the most critical areas. An added benefit of the program should also be an overall improvement in water quality.

Systems Operations Recommendations:

A. State water rights legislation should be reviewed and, if necessary, revised to ensure that the Texas Water Commission has adequate authority to require that plans for the systematic operation of individual reservoirs and multiple reservoirs be developed. If multiple reservoir owners or operators exist for a group of connected reservoirs, the entities should be required to cooperatively prepare a systems operation plan. The reservoirs may be connected because they are located in the same basin or because conveyance facilities allow water to be transported across basin boundaries.

The Commission should be charged with promulgating procedures and guidelines to be used in preparing the reservoirs systems operations plans, including real-time data acquisition techniques; modeling protocols; and methods for determining net water supply charges, costs and benefits, and acceptable environmental impacts and any mitigative actions produced as a result of operations optimization. The Texas Water Code should recognize that an entity(ies) making more water available by undertaking system operations should be given preference in obtaining a water right to beneficially use the demonstrated additional yield.

Dam Safety

Uneven regulation of floodplain development and the aging of dams in the State pose an increasing risk to property, economic welfare, and human safety. In response, increasing demands are being placed on the Texas Water Commission's dam safety program.

Long-term problems affect the safety of the State's 6,300 dams and the security of 30 percent of the State's surface water supply. These problems include the lack of consistent information on all of the State's 6,250 non-federal dams, downstream development which results in a change in the hazard classification, upstream development which increases watershed runoff, permit issuance for only those dams covered by the State's water rights permitting process, inadequate enforcement procedures, and insufficient financial resources to upgrade deficient structures.

Recommendations:

A. The Legislature should consider establishing a fee-based dam safety inspection program to

GROUND-WATER SUPPLY SOURCE MANAGEMENT AND PROTECTION

PRIORITY POLICY RECOMMENDATIONS	LEGISLATIVE ACTION	AGENCY ACTION	LOCAL ACTION
★ Provide TWDB and TWC support to local districts to develop management policies.		★	★
★ Increase field enforcement of ground-water quality protection regulations.	★	★	★
★ Evaluate State ground-water data systems.		★	

fund the activities of the Texas Water Commission. When authorized, the Commission should work closely with affected entities and individuals to implement the program.

B. The Legislature should require local governments and regional entities, such as river authorities, to adopt, under the direction of the Commission, watershed management plans to reduce potential dam safety and reservoir operations problems.

C. The Texas Water Commission should be adequately funded to continue and expand its educational and public awareness program to inform dam owners of their responsibilities and the general public of the risks associated with development below existing dams. Where dam owners do not have adequate financial resources to rehabilitate these structures and facilities, the Commission should immediately work with the owners to establish acceptable early warning programs.

D. The Legislature should authorize the Texas Water Commission to impose administrative penalties in enforcement matters relating to dam safety.

E. The Legislature should ensure that local entities with substandard dam facilities have adequate authority to obtain sufficient revenue needed to participate in the Board's low-interest flood protection loan program or the proposed new State water-related infrastructure financing program (see recommendation in Financing Water Management Section).

GROUND-WATER SUPPLY SOURCE MANAGEMENT AND PROTECTION

Ground water makes up a large part of Texas' usable and potentially usable freshwater resources. Planning, management, and protection of ground-water resources is an important function of local, regional, and State governments, as well as the private sector. The ground-water policy discussions in this section are separated into ground-water management and ground-water quality protection.

The division of functions between management and protection is indicative of the approach to ground-water that is presently used in Texas, whereby control of the withdrawal and use of ground water is determined locally, while the protection of usable ground water from natural or man-induced contamination and pollution is a function of all levels of government.

A summary of priority policy initiatives related to ground-water management and protection is presented in the inset box above.

Ground-water Supply Source Management

Texas law assigns the ownership of ground water to the owner of the land under which the ground water is located. This legal doctrine is distinct from the manner in which the right to divert and use surface water is assigned.

In general, surface waters in Texas are owned by the State. The right to divert and use portions of the State's surface waters are assigned and reviewed by the Texas Water Commission. While some other states have instituted regulatory programs that allocate the use of ground water similar to the allocation of surface water, private ownership and local control of ground-water resources continues to be supported in Texas. Therefore, the policy discussions and recommendations presented in this Plan are not intended to subvert the current State laws pertaining to a landowner's ownership rights to the ground water occurring beneath that landowner's property.

With the preceding assurance, there are a many areas that need consideration at the local, regional, and State level to assure that an adequate supply of ground water supplies are available and that problems associated with the use of ground water are addressed. Although more data is needed to draw conclusions for all individual areas, experiences in certain areas have shown that over-development of ground water has caused many problems, including water supply shortages, reduction or loss of springflow, land-surface subsidence, intrusion of poorer quality water, and increased potential for contamination by pollution sources.

Consistent with the doctrine of private ownership and local control of ground water, Texas has approached the over-use of ground water by creating underground water conservation districts and assigning the districts the responsibility and authority to develop and implement ground-water management programs. As a result, the State's 35 underground water conservation districts are promoting water conservation, collecting data, monitoring ground-water conditions, educating water consumers and the public, providing assistance to ground-water users, and implementing management requirements.

Outstanding State policy considerations related to ground water include further measures that the State can undertake to assist underground water conservation districts to implement adequate management plans, to encourage the creation of districts in problem areas, and to assure that management programs are implemented in critical areas if district creation elections fail.

At the State level, it is important that State planning agencies, in particular, the Texas Water Development Board, have the ability to obtain complete information on the availability and use of ground water in the State so that ground water can be fully considered in plans to meet the overall future water requirements of Texas. The data gathering and plan development function should be carried out in conjunction with the planning efforts of local entities, but it should also cover those areas where a local entity, such as an underground water conservation district, is not present to collect data and develop planning proposals on ground-water use. Therefore, additional measures are needed to: (1) provide the Board with information concerning the availability and use of ground water, and (2) assure that State planning goals and needs and local area planning goals and needs are compatible, consistent, and mutually considered by all levels of government.

Recommendations:

A. Underground water conservation districts that collect data currently provide available information to State agencies concerning the use of ground water within their areas. However, the resources of the districts may be too limited to permit the information needed by the State to be collected. The Board should be funded to offer additional technical assistance to local districts to increase their capability to gather water use information, and monetary assistance should be provided to districts that assist the State in gathering ground-water availability and use information. In addition, the Board should be funded to increase its ground-water monitoring and data collection activities for areas not covered by a district or other appropriate entity. This increased data collection effort is necessary to enhance the State's ability to develop the long-range State Water Plan.

B. Chapter 52, Texas Water Code, requires that underground water conservation districts prepare and implement management plans to address ground-water problems within their areas. These plans are to be filed with the Texas Water Commission. The Texas Water

Commission should encourage underground water conservation districts to submit copies of their management plans.

C. As part of its statewide water planning function, the Board has identified planning goals for each ground-water area of the State, which in turn are incorporated into the water plan for the entire State. The Commission should ensure that copies of the districts' plans are provided to the Board for incorporation into statewide plans for the development and management of ground water. As part of subsequent water plans, the Board should coordinate its planning goals with local entities, including underground water conservation districts, the Commission, and other appropriate State agencies to ensure that the needs of the local area and the State are addressed.

As part of this activity, the Board should develop more comprehensive State planning assistance programs for local districts. Additional funding is needed to provide planning assistance and promote local coordination. Other State agency programs that provide assistance to local districts and other entities on methods to manage and conserve ground water, such as programs by the Texas Agricultural Extension Service, the State Soil and Water Conservation Board, the Texas Department of Agriculture, the Texas Department of Health, and the Texas Water Commission, should also receive additional support.

D. In those areas with identified existing or potential ground-water problems where the State is unable to establish a district to manage ground water, the Legislature should amend the Water Code to give the Texas Water Commission appropriate authority, consistent with the management authority provided to districts in Chapter 52, Texas Water Code, to work with local entities to establish necessary ground-water management measures. In order to determine appropriate controls for a given area, the Commission, with assistance by the Board, should work with local entities to establish management goals and policies. The Legislature should allow the Board to provide loan funds to local entities to implement Commission-established measures until a district is created which can then repay the Board and fund necessary measures.

E. In order to assure that underground water conservation districts have sufficient means to implement needed programs, the Legislature should ensure that the districts have appropriate methods to raise sufficient revenue.

Ground-water Quality Protection

Newly defined and statutorily assigned policy and goals concerning the protection of ground water in Texas specify that the existing quality of ground water will not be degraded, and where the quality has been degraded, the quality of the ground water will be restored if feasible. The State's nondegradation policy does not mean zero-contaminant discharge but, rather, that discharges regulated by the State will be conducted so as to maintain present uses and not impair potential uses or pose hazards to public health.

Based on available information, the quality of ground water in the State remains generally acceptable, and local, regional, and State entities have all contributed to ground-water protection. However, results of current studies indicate that localized areas, primarily in industrialized urban areas, have been impacted by non-point sources of contamination and from contamination by point source activities not constructed or operated in compliance with protective performance standards or regulations.

Some of the major ground-water quality problems of the State were discussed in Chapter 1. The main contamination sources that have been identified include: (a) improperly completed or abandoned water wells, (b) improperly completed or abandoned oil and gas wells and abandoned oil field waste disposal pits, (c) improperly slted or constructed septic systems, sewage and wastewater disposal systems, and municipal collection lines, (d) industrial wastewater impoundment sites that were in use before more stringent performance standards were enacted, (e) leaking oil and gasoline storage tanks, (f) waste disposal sites, including sites that were inadequately monitored and controlled in the past, (g) agricultural practices, such as improper fertilizer or chemical application and seepage from various sources resulting in high nitrate content, (h) contamination from naturally occurring substances or the intrusion of poor quality water into freshwater aquifers, and (i) other possible non-point sources of contamination, including urban stormwater runoff over recharge areas.

The extent of the ground-water quality problem varies across the State, and many of the problems are already being addressed through combinations of State and local actions. For some of the problems, however, the State is still in the process of determining the extent of contamination and the effects on ground water.

Contamination of ground water from natural sources or intrusion of poorer quality water into freshwater aquifers may affect the largest amount of the State's usable ground-water resources. In addition, a recent report by the Texas Ground Water Protection Committee lists 2,244 documented cases of human-caused ground-water contamination as reported by the State agencies responsible for ground-water quality regulation, monitoring, and enforcement.

The report states that the contamination incidents fall under the following jurisdictions: 90 percent under the Texas Water Commission, two percent under the Railroad Commission of Texas, seven percent under the Texas Department of Agriculture, and less than one percent under the Texas Department of Health. The primary contaminants identified in these cases of human-induced contamination are gasoline, diesel, and other petroleum products from the large number of leaking petroleum storage tanks.

The State currently has programs in effect to address many sources of human-induced contamination. However, the State agencies could use additional resources to quickly and fully implement the programs, such as underground storage tank leak identification and regulatory enforcement, abandoned well identification and plugging, and landfill monitoring and mitigation. Some areas may still need further statutory or agency program direction.

In addition, the number of different State agencies responsible for ground-water programs makes coordination and interaction between agencies important. A ground-water data interface system has been developed to coordinate agency data sharing. However, additional efforts are needed to expand the scope of the data, update data management techniques, and improve interagency cooperation for the interface system.

At the local level, the ability of local and regional governmental entities to enact ground-water protection measures may be limited. In particular, local and regional entities in areas containing sensitive ground-water recharge areas and other areas more susceptible to contamination need to have the authority, the tools, and the incentive to enact protection programs.

Recommendations:

A. An interagency Texas Ground Water Protection Committee was created in 1985 and codified by the Legislature in 1989 to consider and coordinate ground-water protection strategies for the State. The efforts of the Committee and the cooperating agencies should be continued and enhanced through funding to increase data collection and evaluation of the characteristics of the State's aquifers, the quality of ground water and the extent of its use, and the management initiatives needed at all levels of government to implement the State's nondegradation policy. In particular, funding for the Board's studies of the occurrence of natural contaminants, currently considered to be the most common type of contamination of usable ground water in the State, and of the feasibility of natural contaminant removal needs to be increased.

In addition, the Ground Water Protection Committee is working to develop a strategy to define and control contamination from agricultural chemicals (fertilizer and pesticide) and wastes. The Committee's strategy should be supported and funding provided for implementation. Also, State agencies should complete and implement strategies for addressing problems identified in the Ground Water Protection Committee's ground-water non-point source assessment. The Board should work to better incorporate findings made through the various ground-water quality studies into future updates of the Water Plan.

B. Local efforts at ground-water quality data collection need to be encouraged and supported. The Board program for providing funding to local districts to obtain ground-water quality testing equipment should be continued and possibly expanded by raising the amount of interest funding available to the Board from the Agricultural Trust Fund.

C. Concurrent with additional studies of ground-water quality, the Legislature needs to provide the State agencies responsible for water quality enforcement programs with additional funding to increase their field enforcement efforts, especially for abandoned well identification and plugging, onsite waste disposal (septic) system regulation, the underground storage tank program, industrial waste site cleanup, and landfill monitoring and contamination mitigation. In particular, the Railroad Commission of Texas' field enforcement capabilities and activities for ground-water regulations pertaining to the oil and gas industry should be enhanced. As part of its ground-water protection responsibilities, the Railroad Commission should use underground water conservation districts, through contract agreements or delegation of authority, to assist in monitoring oil and gas industry activities in certain areas for compliance with ground-water protection regulations. Well plugging regulation monitoring is an example of where local districts could help expand the Railroad Commission's monitoring capabilities.

D. The Legislature should direct the Ground Water Protection Committee to evaluate existing State ground-water data systems and make recommendations to the Legislature, which may include legislative funding or individual agency budget requests, so that the systems will allow ready access and ensure usability of data maintained by different State agencies.

E. The Legislature should increase funding for the Wellhead Protection Program being implemented by the Texas Water Commission and the Texas Department of Health. This type of preventive program should be encouraged and enhanced at all levels of government within the State.

F. The Ground Water Protection Committee should review the need for more local, regional, and State authority to enact comprehensive ground-water protection regulations, including development controls, and make formal recommendations as part of the next Ground-water Protection Strategy. As part of this process, the Legislature should provide the Board and the Commission funding to increase efforts to identify areas currently needing additional protection and areas of potential future water supplies that need to be protected. The Committee should review the information available from the Board and Commission and make recommendations to the Legislature for providing local and regional entities any additional authority to develop and enact protection plans for identified areas.

G. The Commission has made advances, through the DRASTIC mapping program, in the use of computer-aided mapping and geographic information systems to make ground-water information available to local and regional planners.

REGIONALIZATION

PRIORITY POLICY RECOMMENDATIONS	LEGISLATIVE ACTION	AGENCY ACTION	LOCAL ACTION
★ Establish a formal policy which preferentially favors feasible regional, rather than individual, system development.	★	★	
★ Fund State financial assistance programs at a sufficient level to provide financing terms that will allow these programs to be used as an effective regionalization incentive.	★	★	
★ Authorize TWDB and TWC to designate water and wastewater utility service areas where regionalization may be preferable	★	★	

The Legislature should support this program and provide funding to the Commission to increase its efforts, to the Board to better incorporate this technology and information into its water planning and local assistance activities, and to other water-related agencies through the guidance of the Ground Water Protection Committee and the Texas Natural Resource Information System to use the mapping and geographic information system technologies available to increase ground-water management and protection capabilities in the State.

State agencies should continue to work together to further identify areas sensitive to ground-water contamination and in need of protection and to assist local and regional entities to enact programs for sensitive areas.

REGIONALIZATION

State policies should encourage cost-effective provision of water and wastewater service with acceptable environmental impacts, regardless of the type of facility or the institutional structure chosen. In many instances, regionalization, which may include either physical facilities or management agreements, is an effective way to achieve these objectives.

Experience with most regional water and wastewater utility systems has demonstrated the advantages of regionalization, including cost-effective service, improved operations, and more consistency in meeting water quality and drinking water requirements. Recent trends in infrastructure provision, including funding constraints and more demanding State and national environmental and public health regulations, increase the viability of regional systems.

Despite demonstrated advantages, regional approaches are not appropriate in all cases. Characteristics of the area needing service, including development densities and distance between areas of concentrated population, may affect the economic viability of regional options. The effluent discharge from a large regional wastewater plant could have a more deleterious effect on water quality than the same volume discharged by several smaller facilities. A regional facility may also cause more significant secondary environmental effects than localized facilities.

On balance, the benefits provided by feasible regional systems, both management agreements and facilities, can outweigh the disadvantages, and a coordinated State program incorporating financial incentives, district formation requirements, and technical assistance should be undertaken to encourage regionalization where it is a feasible alternative to individual facilities. The program must be flexible in design to accommodate the varied conditions in Texas.

A summary of priority policy recommendations is presented in the inset box above.

Regionalization of Water Supply and Wastewater Systems

A number of problems at the State and local utility level create impediments to regionalization. These typically include a strong tradition of local control, competition and distrust among entities leading to the lack of political cooperation, concerns of elected officials about losing direct influence over rates and delivery of services, unfamiliarity with resulting benefits, differing rates of customer growth, unequal financial capabilities of entities, and development densities that do yet not justify regional service.

A determination of whether a regional facility alternative is the optimum technical solution can usually be made by considering physical, environmental, economic, and engineering factors separately from existing institutional constraints. The two latter factors will, however, often prevent implementation of a feasible regional solution even when it has been determined to be the most effective alternative. In particular, the involvement of multiple jurisdictions in the comparative selection of efficient engineering and economic alternatives can hamper efficient regional provision of service.

Local districts are generally the lowest-level governmental entity to provide stand-alone service. Districts can, in specialized instances, provide advantages by more directly linking benefits received to costs recovered through taxes, utility rates, and fees imposed on those receiving services rather than taxpayers at large and by maximizing flexibility in extending services to urban fringe and rural areas. While district service provision can be effective in areas where cities elect not to extend services or where regional feasibility is limited, the creation of localized and special-purpose districts is not automatically appropriate and may impede the provision of more efficient and economical regional service and interfere with the growth and annexation policies established by neighboring municipalities.

There are over 15 different types of water resource districts and more than 1,500 active and inactive individual districts in Texas. The jurisdictions and authorities among the more than 1,500 districts are often inconsistent because district creation can occur through the general laws of the State with approval of the Commission, a special act of the Legislature, or a county commissioner's court approval for districts within a single county. While creation of new districts has been most prevalent during periods of rapid growth, the current depressed economic activity and slower growth patterns provide an ideal opportunity to encourage consolidation and to more fully evaluate the potential for regionalization during the district creation review process.

Cities, the other major provider of water and wastewater service, are the most common intermediate-size service provider between smaller local districts and larger regional entities in Texas. Cities often have opportunities for regionalization within their own boundaries in centralized utility management and inter-connecting utility facilities and operating these various plants as a system. In areas of the State where cities are geographically clustered, regional facilities among cities and other utilities are more likely to be technically feasible. In other areas of the State, including rural portions of West Texas and South Texas, regional management may be feasible, but the options for constructing regional facilities are limited because of the distances between cities and customers. However, the larger cities in these areas can provide some of the benefits of regional service by constructing larger facilities and extending service to outlying areas; in general, cities, as well as special districts, should be encouraged to fully utilize regional options in service delivery.

In addition to the traditional concept of regional utility facilities, regional management systems may also provide more cost-effective and better managed central purchasing, operations, and technical assistance for individual water or wastewater facilities. This should be recognized as part of a broader State-established definition of regional systems.

The Legislature has implicitly established a general policy to promote regionalization through authorizing provisions for individual water agency programs. However, additional actions are needed.

A first step in overcoming some of the impediments that have been outlined would be for the State to establish an explicit formal policy for regional systems. As a second step, State agencies should be provided full authority to actively pursue regionalization where it is determined to be beneficial and in the public interest. Lastly, financial incentives should be provided to help overcome the significant up-front cost typical in developing regional systems (inherent when entities are at different stages of growth), which often is a major impediment in many areas where local entities lack the front-end resources or local consensus to initiate regional system development (see discussion of State Financial Incentives for Regionalization).

Recommendations:

A. The Legislature should enact a formal policy which preferentially favors regional, rather than individual, system development. Where feasible, approval to develop individual systems should be conditioned to require ultimate incorporation into longer-term regional systems. Regional systems, including physical facilities and management agreements, should define by statute what economic, engineering, and physical factors would constitute a regional system in a given situation.

B. The Legislature should create a program within the Board and the Commission to study, determine, and designate water supply and wastewater service areas where regionalization may be preferable. Regional and local entities should cooperate in the study. The determination should be used, in turn, by the Commission, the Texas Department of Health, and the Board to target approval and permitting, financing, and assistance programs to promote development of regional systems.

C. State agencies should cooperate to: (a) identify critical utility service areas characterized by numerous small or inadequate systems or water problems that threaten water quality or reliability of service, (b) designate a regional service provider, and (c) require through regulatory processes that all proposed and existing facilities, when economically feasible and practical, participate in the regional system.

D. The Legislature should give all regional utility authorities the ability to develop and manage regional utility systems where this would not replicate existing regional authorities with similar powers and service areas.

E. The Legislature should authorize the Commission to approve the development of new utility facilities by municipalities, existing districts, and new districts being created only after the Commission has determined that the creation of a regional system or obtaining services from an existing regional or adjacent facility where uncommitted capacity is available or can be provided through facility expansion is technically or economically infeasible or impractical.

F. The Legislature should ensure that statutes authorizing district creation by the Texas Water Commission include the concept of regional management or operating systems as well as regional facilities.

G. The Texas Water Code currently authorizes the Texas Water Commission to designate regional wastewater service providers. The description of regional and areawide waste collection, treatment, and disposal facilities included in Section 26.081 of the Texas Water Code should, however, be expanded to incorporate the concept of regional or areawide management or operating systems.

H. The Legislature should develop and establish a statutory procedure for designating regional water supply providers comparable to the designation of regional wastewater service providers currently authorized under the Water Code.

State Financial Incentives for Regionalization

State financial programs can be an important tool to encourage creation of regional systems in geographical settings where they can be beneficial.

However, two elements of the Board's current financial program authorities should be changed to better encourage regionalization. First, the Board should require in all of its financing programs that proposed projects are consistent with an State-approved regional plan. Second, the Board has also been unable to implement the State Participation Program because of the likely draw on general revenue needed for debt service costs during the early years of a State Participation project.

Recommendations:

A. Authorizing legislation for the Board's financial assistance programs and similar legislation for related water infrastructure financing by other State agencies should be enacted to require that, where applicable, all projects receiving State funding are consistent with the long-term regional goals of a State-approved regional water supply or wastewater plan.

B. State financial assistance programs should be funded to provide sufficiently attractive financing terms (beyond the current extension of the State's credit rating to loan recipients) to provide be more effective incentives to encourage regionalization (see Recommendations, Financing Water Management).

BALANCING WATER RESOURCES DEVELOPMENT WITH ENVIRONMENTAL AND LAND MANAGEMENT CONCERNS

Several major environmental laws were enacted by the federal government in the 1970s to prevent further deterioration of the natural environment caused by human activities and development. The 69th Texas Legislature also enacted key changes in the Water Code in 1985 to give greater emphasis to important environmental aspects of water resources decision-making, particularly freshwater inflows to bays and estuaries and flow maintenance needs for instream water uses, water quality, and fish and wildlife habitats.

Federal and State laws have contributed substantially to a more comprehensive and coordinated management of the State's water resources. These laws have slowed the degradation and improved the condition of aquatic and terrestrial biological resources dependent on wetlands, streams, lakes, bays, and estuaries. However, competition between environmental and non-environmental water uses will remain pervasive and must be given serious consideration when selecting alternatives to best meet the State's projected water needs. Similarly, conflicts between using and reserving land resources for divergent private and public purposes also influence and, in many cases, limit the water development or environmental protection options available to the State.

A summary of key policy recommendations related to balancing water development projects and environmental and land management concerns is presented in the inset box on the following page.

Environmental Uses of Water

While there are positive environmental impacts associated with water development, the principal areas of environmental conflict affecting water planning in Texas today involve determinations of the extent and suitability of fish and wildlife habitat and associated water release and other mitigation requirements necessary to support migratory waterfowl, threatened and endangered species, and viable populations of sport and commercial fish and shellfish in both freshwater and estuarine environments. The lack of sufficient data on environmental resources, disagreement over the appropriate analytical methods to use in evaluating potential or realized impacts to these resources, and conflicts in the legal responsibilities of different agencies restrict conjunctive use and contribute to less than optimum use of the State's water resources for both human and environmental purposes.

Another area of potential inconsistency and conflict involves potential duplication or differences in state and federal permitting procedures, scheduling, and requirements. The process of obtaining the

BALANCING WATER RESOURCES DEVELOPMENT WITH ENVIRONMENTAL AND LAND MANAGEMENT CONCERNS

PRIORITY POLICY RECOMMENDATIONS	LEGISLATIVE ACTION	AGENCY ACTION	LOCAL ACTION
★ Encourage TWDB, TWC, and TPWD to develop a common analytical methodology to evaluate the water requirements of environmental resources.		★	
★ Prepare a TWDB report, in cooperation with the TWC and TPWD, on the feasibility of permitting each proposed reservoir site and include updates with revisions of the Water Plan.		★	
★ Create a formal program to preserve the integrity of each preliminarily proposed reservoir site.	★	★	★
★ Create an interagency committee to report on the potential to create a State river protection system.	★	★	

required State water rights permit and Section 401 water quality certification and federal Section 404 permits often involves similar studies, conducted at different times, and may produce different and inconsistent findings and permit requirements.

A final area of conflict occurs because of the lack of clear agreement on the use and acceptability of the different types and amounts of mitigation measures that are available to offset impacts of new water projects. Likewise, different evaluation methods used to determine mitigation requirements creates the potential for implementation conflicts.

Recommendations: Several actions should be undertaken to minimize areas of existing and potential environmental and water development conflict.

A. Data collection and analytical programs need to be expanded and conducted on an on-going basis by State agencies to fully assess and quantify the value of physical and environmental resources where water development and environmental protection goals appear to be in conflict. Conflicts often occur in coastal areas, but they can also occur in inland environments. In particular, initial resource inventories and assessments for long-range water planning purposes should be conducted by the Board, in cooperation with the Commission and Texas Parks and Wildlife Department, for all reservoir sites recommended in the Texas Water Plan.

B. State statute assigns the responsibility for determining the environmental resource requirements for water projects to the Commission and the Texas Parks and Wildlife Department. However, the Board, because of its responsibility for identifying and planning for alternatives that can meet the State's future water supply needs, has been developing a planning-level procedure to evaluate the potential water requirements of environmental resources associated with new water supply developments. This modeling technique may not necessarily agree with the results of other agencies' modeling and assessment procedures.

To avoid the further development and use of conflicting procedures among State agencies, a cooperative interagency review of the results of all procedures being applied or developed by the various agencies should be conducted. The interagency review should include the General Land Office when State-owned lands are involved. The objective of the review would be to develop a common analytical methodology, appropriate to conditions in Texas, that would be used by all State agencies to evaluate the water requirements of environmental resources.

At the conclusion of the cooperative review process, an interagency memorandum of understanding on the appropriate data set and evaluation methods to be used should be executed by the involved agencies. A similar process should be established to ensure that all State-level mitigation determinations are made in a consistent manner. The agreements should include the understanding that agreed-upon methodologies will be flexible enough to allow for the needs and particular circumstances of each situation and that additional information may be considered. For example, while one situation may only require simple evaluation using an agreed-to desk-top method, a more complex situation may require more extensive evaluation and consideration using one or more complete evaluation models.

C. The Commission should work with the Corps of Engineers on establishing better coordination of project permitting schedules. The Commission and the Corps should work to establish a parallel time schedule for submission, review, comment, and official action on project permit applications requiring both State and federal issuance.

D. The Board should maintain a bay and estuary program to collect necessary data and maintain updated modeling capabilities which can be used by the Commission and the Texas Parks and Wildlife Department in making the water allocation decisions stipulated in the Texas Water Code.

Recreational Uses of Water

Other areas of conflicting surface water use involve proposals to designate segments of free-flowing streams for recreational, aesthetic, and heritage purposes and the potential for attendant unauthorized use of adjacent private property by water-based recreationalists. Recreation, aesthetic, and heritage use proposals for free-flowing rivers may be in direct conflict with other potential uses, such as the development of surface water supply reservoirs. Additionally, proposals to maintain free-flowing rivers for recreational purposes may, if not structured properly, conflict with the real property rights of private landowners.

Recommendations:

A. In conjunction with initiation of the statewide rivers assessment proposed in the 1990 Texas Outdoor Recreation Plan (TORP), a State interagency committee should be created to identify potential conflicts and pursue agreements on the use of free-flowing riverine resources for recreational, aesthetic, and heritage purposes. An interagency report on the potential to create a State river protection system should be prepared as a legislative information document prior to January 1993. The report should include due consideration to methods to protect the rights of riverside property owners from intrusion and trespass and should clarify those types of river segments and non-navigable streams not available for public use. As appropriate, federal agencies with recreation expertise or management responsibilities in river reaches that might potentially be included in a State river system, such as the National Park Service and the U.S. Forest Service, should cooperatively participate with the interagency committee.

B. The Board should complete a formal agreement with the Texas Parks and Wildlife Department on incorporating the appropriate water-related outdoor recreation recommendations from the Texas Outdoor Recreation Plan (TORP) into the Water Plan.

C. The Board should encourage the involvement of State and federal agencies with water-related recreation expertise in the preparation of recreation plans developed for reservoir projects that will be constructed with State financial assistance.

Land Management

Existing and expanding human land uses create the need for water projects and influence the amount of useful water supply. Land use patterns can affect the amount of usable water supply through point and non-point source pollution loadings (especially industrial discharges and erosion) and development encroachment on potential reservoir sites.

Encroachment problems at or near desirable reservoir sites can include urban and recreational development and surface (highways and electric power lines) and subterranean (gas and oil pipelines) utility corridor routing. Deliberate actions that could be implemented by the State and local interests to reduce the prospect that potential reservoir locations may be unusable or unaffordable at the time reservoir development is needed. These actions could include restrictive zoning, land use and watershed water quality controls, and advance acquisition of reservoir sites.

The lack of adequate engineering, socioeconomic, and environmental information required to assess existing or prospective conflicting use problems and potential project feasibility creates serious obstacles to utilizing advance site acquisition to help meet the State's future surface water supply requirements. Additionally, advance site acquisition by the State implies the need for substantial amounts of up-front capital, which could require large front-end general revenue fund commitments or draws on general revenue to meet debt service repayment schedules.

Recommendations:

A. A State program should be created to identify and catalog potential reservoir sites identified in the Texas Water Plan as needed within the next 50 years. The program should include coordinated assessments and field studies of each potential site by appropriate State agencies to determine existing and potential land use, water quality, economic, social, and environmental conflicts. A report on the feasibility of permitting each site should be prepared by the Board, with cooperation of other agencies, and updated in conjunction with official revisions of the Water Plan.

B. A formal program to preserve the integrity of each site determined to be preliminarily feasible as a reservoir site, following consideration of alternative sites, should be created and implemented. The program should incorporate alternative methods of watershed and site protection; consider various local, State, and federal plans and programs; and identify appropriate and alternative land uses. Highway construction planning; avoidance zoning; and utility, water quality, and waste disposal permitting should be fully coordinated and utilized to prevent compromising site integrity.

If advance site acquisition is determined to be the alternative with the greatest potential to protect a developable supply source, the Texas Water Development Board should request line-item general revenue funding in the biennial budget requests. In addition, appropriate interim land uses should be identified and authorized for sites obtained through advanced acquisition.

FINANCING WATER MANAGEMENT

The 1990 Water plan departs from previous water plans by establishing a new emphasis on improved water management. The policies that are recommended to implement improved management include a mix of voluntary and mandatory approaches ranging from technical assistance to regulation. Of the alternatives, provision of financial assistance is considered to be the most direct incentive.

Introduction

Since its beginning in 1957, State involvement in financing local water infrastructure has been guided by a legislative directive to assist hardship political subdivisions, i.e., communities that could not sell bonds or sell bonds at a reasonable rate in the public market. In 1985, the Legislature added conversion from ground water to surface water supplies, flood protection, and development of regional facilities to the list of policy purposes to be supported by State water financing. In 1989, the Legislature expanded financial eligibility to include subsidized assistance to Economically Distressed Areas.

The history of Texas government participation in providing financial assistance to local political subdivisions for water infrastructure has been predicated on several purposes. Initially, water supply funding was provided to help communities recover from the impacts of the drought of the early and mid 1950s. However, other more fundamental structural purposes have provided the justification for the continuation and expansion of State financial assistance. These purposes include: the basic responsibility of government to provide for the essential needs of its citizens, the overall saving realized by utilizing the State's financial standing to improve borrowing and lending terms, use of financial assistance to promote State government policy, and providing for public health and economic prosperity by insuring water infrastructure availability. All of these purposes are evident in the past evolution of the State's water financing programs.

Water-related projects in Texas have been overwhelmingly funded by local and federal sources in the past. Considerable federal assistance has been provided by the Soil Conservation Service, the Bureau of Reclamation, and the Corps of Engineers to construct both major and minor surface water reservoirs. The Environmental Protection Agency, the Farmers Home Administration and the Department of Housing and Urban Development have provided substantial assistance to help finance wastewater treatment facilities. Water supply systems have been developed with funding from the Farmers Home Administration and the Department of Housing and Urban Development. A variety of other federal assistance programs have provided funds to conserve soil and water resources, abate flooding damages, and support sound water development. However, the provision of federal financial assistance has declined since the early 1980s and that trend is expected to continue in the future.

The substantial decline in federal financing, the trend toward reliance on regulatory approaches to address water problems, the emergence of a broader State role in promoting water policy initiatives, high interest rates, and changes to the federal tax code have collectively caused state governments to consider different water financing approaches that rely less on direct public market bond issuance than has been the case in the past.

While state-level legislative appropriations can be used to fund water infrastructure improvements, this approach has only been used once, with the 1981 establishment of a $40 million Water Assistance Fund, by the State of Texas. Direct appropriations have not been uniformly applied to all problems by the federal government. To achieve the national water quality goals established in 1972, the U.S. Congress appropriated money to fund grants for local municipal wastewater treatment improvements, and although on a phase-out schedule, the federal government continues to capitalize state revolving loan funds for this purpose. Similar federal assistance programs have not been extended to help public water suppliers meet the requirements of the new Safe Drinking Water Act, but a few states have provided direct appropriations for local water supply development.

Some states use dedicated taxes for water improvements, while countries like France and Germany use pollution taxes, or effluent fees, as alternative funding mechanisms because they also discourage the waste of water and pollutant discharge. The State of Kentucky has had the authority to impose a statewide water use fee for more than 15 years. Kansas passed similar legislation and began collecting the fee two years ago, and legislation considered in Virginia would have allowed a 10 cents per thousand gallon charge on water to be used to meet the requirements of the Safe Drinking Water Act.

A portion of sales tax revenue could be directed to infrastructure improvements. Illinois taxes specific goods with the receipts directed to the Build Illinois fund. The Missouri Soil and Water Sales Tax Fund is generated through an additional state sales tax of 0.1 percent. Concerns regarding sales taxes include regressive impacts, opposition to increases due to the existing relatively high rate, and other potential demands on sales tax receipts.

Still other financing methods can lower the costs of obtaining funds. Bond insurance can reduce the cost of financing and could be particularly beneficial for relatively high-risk communities. The State of Utah provides zero-interest loans to communities to purchase bond insurance, and although Texas is authorized to use $250 million of the full faith and credit of the State to insure up to $500 million worth of local bonds, the legislatively authorized program has not been activated due to uncertainties about program demand and the actual cost savings that may be realized. Additionally, start-up costs associated with the Texas program are high due to legislatively established financial soundness stipulations.

Public-private partnerships can provide alternative sources of funds and operational economies. Examples include turnkey projects, contracted private operation and maintenance, voluntary developer/municipal partnerships, involuntary developer financing, privatization, and merchant facilities. Currently, these techniques are not widely used in Texas, generally because substantive comparative advantages over current approaches are not apparent.

While some states have already instituted innovative steps to fill the void left by diminished federal assistance, Texas has just recently begun the process of rethinking its approach to providing financial assistance for water infrastructure. A 1989 survey by the Technology Resource Center at Texas A&M University identified water and wastewater as one of the top priorities of cities in Texas.

Recent national and Texas polls demonstrate extremely strong public support for environmental protection, including an expressed willingness to accept governmental expenditures or additional costs necessary to protect environmental quality. A statewide public opinion poll taken prior to the 1984 water plan indicated that a majority of Texans would be willing to pay an additional one dollar per month on their water bill, with the revenue to be dedicated to water research. A national survey completed in early 1990 indicated that the U.S. public is willing to pay more taxes dedicated to protect wildlife and wilderness, clean up water pollution, and dispose of chemicals and toxic wastes. A 1990 Rice University poll indicated strong support for environmental protection, including 63 percent of survey respondents supporting more stringent pollution controls even if this resulted in higher costs of $200 per year on certain products or purchases. Also, recommendations received through correspondence and public meetings on the draft 1990 Water Plan indicate considerable support for greater State involvement in water infrastructure financing.

Although economic studies prepared by the Federal Reserve Bank of Chicago have demonstrated a positive link between investment in infrastructure and economic activity, a recent national study of state conditions contributing to economic development concluded that Texas ranked lower than many other states. The study specifically identified the lack of a state infrastructure initiative as a major policy deficiency. At the same time, Texas cities and other utilities are expressing significant concerns that public policies on public health and environmental protection have come to rely too heavily on regulatory directives, compared to the past mix combining financial assistance with regulatory measures.

Federal tax legislation, budget reductions, changes in cost-sharing requirements, and more stringent public health and environmental regulations have closed many options previously available to state and local governments to finance water infrastructure. Not surprisingly, local entities are increasingly seeking more assistance from state funding sources at the very time that traditional state financing alternatives are proving limited in their ability to meet the full range of financial demands.

Smaller size systems are more likely to violate provisions of the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA), and even with use of current financial alternatives, projects may still be too costly for less populated communities. Non-point source (NPS) pollution management is expected to increase in importance and in its demand for funding as uncertainties over pollution loadings and effectiveness of treatment or management techniques are resolved. As utilities have turned to conservation as a tool for assuring adequate water supplies for the future, the ability of utilities to finance conservation programs and activities has become an issue. A main area of concern is the ability of utilities to obtain financing for programs and projects which have not traditionally been included under state and federal financial assistance programs.

Although no loans have yet been made, limited funding for NPS structural measures is available through the State Water Pollution Control Revolving Fund. Other Board programs, such as Water Quality Enhancement Fund loans with appropriate legislative modifications, are also potential funding sources for NPS control measures. The Legislature has also authorized municipal drainage utility systems to provide a financial and institutional framework for treating urban runoff problems. In 1989, the 71st Texas Legislature also amended the Texas Water Code to specifically allow financial assistance from the Water Development Fund to be used for projects that are solely water conservation-oriented.

Some water supply and quality problems affecting Texas streams originate outside the State and require cooperative action with other states or federal agencies. In parts of the State, wastewater treatment facilities, man-made activities or natural contamination discharging into streams flowing into adjacent states may not meet other States' water quality standards. Failure to address problems originating in Mexico can cancel much of the benefits of wastewater capital improvements in Texas and threaten public health. Federal interest in and commitment to these projects has not been consistent, with resulting uncertainties in funding and considerable delay in many cases.

Interstate compacts for the Red River, the Pecos River, the Canadian River, the Sabine River, and the Rio Grande apportion water for multistate streams. The compacts may also provide a basis for cooperative action by states, and some projects with interstate benefits have been proposed or discussed in the Water Plan.

The Red River Chloride Control Project would improve the quality of water by removing salt pollutants from sources in Texas and Oklahoma and would additionally benefit Arkansas and Louisiana. The Lake Meredith Salinity Control Project would correct salinity problems originating from natural sources in New Mexico and improve drinking water quality in the High Plains. Shreveport, Louisiana has expressed interest in securing a portion of the supply from the proposed Little Cypress Reservoir in East Texas while the Rio Grande in West Texas is affected by sedimentation and water quality problems in the watershed of Elephant Butte Reservoir in New Mexico.

One international project aimed at improving Rio Grande water quality is underway. The International Boundary and Water Commission (IBWC) will supervise construction of a new wastewater facility in Nuevo Laredo, Mexico that will reduce excessive bacteria levels in the river that result from untreated discharges originating in Mexico. The 71st Texas Legislature passed Senate Bill 2 and made federal agencies, such as IBWC, eligible to receive funding from the Water Loan Assistance Fund for certain sewer projects covered by international treaties. Texas will provide up to $2 million in funding for the Nuevo Laredo project. While the most significant problems occur downstream of Nuevo Laredo, other border communities in Mexico may subsequently require wastewater improvements.

Another important policy question associated with State of Texas funding of interstate and international projects is whether funds should be expended in areas outside the State when sufficient financial assistance is not available for all identified needs within Texas.

Financing issues that must be considered include improving methods to generate and deliver funds, funding the most cost-effective projects, promoting rehabilitation and replacement projects equally with new project development, and developing approaches to finance emerging water management technologies.

A New Approach to Water Financing

As discussed above, the State of Texas and its local governments face a variety of significant financial challenges as a result of federal regulatory and tax policies, antiquated and deteriorating water and wastewater facilities with inadequate capacity for new demand, competing claims for limited funds, and the emergence of new problems and priorities requiring expenditures. Consequently, it is very likely that the Legislature will be increasingly faced with requests to modify the State's financial assistance programs for water infrastructure to address limited problems or special needs.

One of the key alternatives to achieve water management goals and define the direction of water management for the next century will be development of a comprehensive water infrastructure financing approach. Rather than continuing to amend the financial assistance sections of the Texas Water Code in response to piecemeal requests or individual water problems, a preferential course would be for the Legislature to entirely revise the philosophy behind the State's provision of financial assistance for water management.

Therefore, the 1990 Water Plan recommends coordination of a new conceptual approach to a broader State involvement in water financing. A comprehensive overhaul of the State's water financing program would also have the added benefit of allowing new assistance priorities and approaches to be introduced. Although this would represent a substantial departure from past practice by the State, such an approach is warranted to minimize the problems that have been associated with national financing programs intended to further federal policy goals and to respond to State policy priorities, federally and State mandated requirements, and local water management initiatives.

The opportunity to develop and implement a new comprehensive water financing program, at the very time when a receptiveness and desire exists on the part of decision makers and the public to approach water problems differently, offers the State a range of choices on how to best address current and future water financing needs. Most importantly, the State can combine alternatives to extend its credit rating, provide economies of scale financing, consolidate and streamline previous piecemeal or fragmented public assistance programs, and redirect expenditures to key issue areas.

Creation of a new financing approach should be predicated on the State providing more favorable economic incentives for activities and projects that are consistent with or that further the policy objectives of the State Water Plan. The new approach could be designed to provide increasing subsidies for two major categories of assistance (see Table 4-1).

At the lowest level of assistance or subsidy (Level I), the State's *credit rating could be extended* to all political subdivisions to provide for a broader array of financing assistance than currently exists. Hardship, ground-water conversion, and regionalization restrictions could be removed from the Board's current financing programs. Lower-cost financial assistance could be extended to many new eligible entities for water-related infrastructure investments not dictated by federal or State requirements, for major high cost projects with limited geographic benefits (Level IA), and for small scale direct loans not backed by local bonds (Level IB). Expanding participant eligibility in the State's loan portfolio could also offset riskier hardship loans with more conventional loans.

At a second and more restricted level of financial participation (Level II), *subsidized funding* assistance would be extended at a more favorable rate than provided under the first tier. For projects associated with significant new federal and state regulatory requirements (Level IIA), subsidized low-interest revolving loans could be provided. Level IIB assistance would provide the lowest-cost financing terms. Level IIB assistance could be extended for projects that provide for essential human and social needs and that respond to broad purpose water policy objectives, such as regionalization, water conservation, and water reuse. If much of the State's infrastructure must be upgraded or replaced, it is imperative that adequate incentives be provided to effectively induce cost-efficient and less environmentally-impacting approaches to supplying these needed facility improvements which may be impeded by traditional means of behavior, lack of political cooperation, or financing constraints.

TABLE 4-1
CONCEPTUAL STRUCTURE OF NEW STATE WATER-RELATED INFRASTRUCTURE FINANCING PROGRAM

Funding Category	Source of Funds/Backing	Type of Program Incentive	Types of Projects Funded	Rationale
Level IA	Sale of State General Obligation or Revenue Bonds/Backed with Issuance of Local General Obligation or Revenue Bonds	Low Interest Extension of State Credit Rating	- Misc. Major Water, Wastewater, Flood Protection, and Solid Waste Infrastructure Construction and Rehabilitation not tied to Significant New Federal/State Regulations nor limited by utility size or amount - Major Infrastructure with High Cost and Hard to Allocate, Limited Area Public Benefits (i.e. major flood protection reservoirs, chloride control, "former Corps Projects", etc.)	- Expands financial assistance to wider range of water-related needs not currently eligible. Helps keep overall state water-related infrastructure in upgraded condition to promote economic development and public health and safety. - Helps fill gap caused by reduction in federal financial assistance, especially for projects that have noticeable, but more narrow, public benefit and are more difficult to allocate to specific beneficiaries.
Level IB	Sale of State General Obligation or Revenue Bonds/Backed with Direct Loan Agreement	Low Interest Extension of State Credit Rating	- Misc. Water, Wastewater, Flood Protection, and Solid Waste Infrastructure Construction and Rehabilitation not tied to Significant New Federal/State Regulations, but limited to small utilities (say less than 5,000 population) and capital-related loans within a certain range (more than $10,000 but less than $100,000)	- Expands financial assistance to wider range of water-related needs not currently eligible and to utilities that cannot afford the expense of bond backing for small loan needs.
Level IIA	Board Funds and Dependable General Revenue Appropriation/Backed with Local General Obligation or Revenue Bonds	Lower Interest, Subsidized Revolving Loan Fund(s)	- Major Water, Wastewater, and Solid Waste Infrastructure Construction and Rehabilitation Associated with New Federal and State Regulatory Requirements (i.e., drinking water, stormwater quality, increased effluent standards, solid waste)	- Assists Texas cities and utilities in dealing with the considerable, cumulative cost impact of multiple new federal and state regulations related to potable water supply and water quality protection.
Level IIB	Board Funds and Dependable General Revenue Appropriation/Backed with Local General Obligation or Revenue Bonds	Lowest Interest, More Highly Subsidized Revolving Loan Fund(s)	- New Level II Projects that Regionalize Two or More Utilities - Water Conservation Retrofit/Rebate Programs - Major Utility Reuse Programs - Economically Disadvantaged Areas	- Provides even greater financial incentives than Level I and II assistance programs to better induce infrastructure actions that will promote key state water policy initiatives: (1) cost-effective, less impacting, cooperation-fostering regionalization (also helps improve the economics of State participation money-out through lower interest costs); (2) highly cost-effective water conserving retrofit/rebate programs that can save a significant amount of water and reduce wastewater discharge; (3) better incentives to conduct major reuse programs, where feasible, to more efficiently use water and defer new supply construction; (4) low-cost financial assistance to economically-disadvantaged areas not limited to county definitions of EDAP

FINANCING WATER MANAGEMENT

PRIORITY POLICY RECOMMENDATIONS	LEGISLATIVE ACTION	AGENCY ACTION	LOCAL ACTION
★ Establish a new policy approach to comprehensive water infrastructure financing.	★	★	
★ Extend TWDB financial assistance programs to all political subdivisions in Texas.	★	★	
★ Work with the Texas Congressional delegation to amend the provisions of the federal tax code that unreasonably limit the use of State tax-exempt financing.	★	★	★

The proposed State role for water-related finance represents a major departure from existing practice. It recognizes expanded financial assistance as instrumental to achieving State goals in the future. It is based on an assessment that conditions defining water planning and financing in the past have changed substantially. These changes are described in this report in the discussions of planning concepts and policy issues. Recognizing the implications of these recommendations on State and local finance, it is important to determine the degree of consensus on the question of an expanded state role in water-related finance.

A Task Force on Infrastructure Finance for the Future should be convened. A cross-section of geographic, public, and professional interests should be represented on the task force. The task force should examine the feasibility of implementing the proposed conceptual approach recommendations for Level II financing. The charge of the task force should be to compare future infrastructure financing needs and available resources, identify alternative revenue sources if the State assumes a larger role in financing, and recommend any modifications to financial programs necessary to promote greater efficiency in water use while protecting key environmental values, consistent with recommendations of the plan update.

A summary of priority policy recommendations related to the financing of water management is shown in the inset box above while those and other recommendations are discussed in more detail in the following discussion.

Recommendations: Legislation should be enacted to establish a new policy approach to comprehensive water infrastructure financing. This policy should include the following provisions.

A. Legislative restrictions that limit Board financial assistance to instances of hardship, conversion from ground water to surface water, and regional facilities should be removed, and the State's credit rating should be extended to all political subdivisions in Texas.

   Level I assistance involving access to the State's credit rating should be provided for lower risk water infrastructure projects that promote economic activity; projects that produce narrow or geographically limited benefits, such as flood protection, chloride control, and interstate or international projects; and projects that would have previously received federal financing.

   Projects eligible for Level IA funding would include water, wastewater, flood protection, and solid waste infrastructure not tied to significant new federal or state regulation, as well as major, high-cost infrastructure producing benefits that are difficult to allocate. These projects would be eligible for lower interest produced by merely extending the State's credit rating. The rationale for easing eligibility requirements would be to help keep water infrastructure in a condition that promotes public health, safety, and economic development and to provide a State response to reductions in federal funding assistance. Additionally, a stronger loan portfolio would be less costly to manage and maintain.

A second area of eligibility (Level IB) would involve water infrastructure projects with slightly higher risk and a direct non-bond backed loan program for small communities. The small-scale loan program could utilize contracts to provide limited direct financial assistance to purchase capital equipment necessary to maintain water and wastewater system operations and to address minor violations of regulatory requirements. The Board would investigate which of these recommendations could be implemented under existing authority.

B. A special task force should be convened to study an expanded role in State finance, including Level II finance, and a dedicated revenue source to capitalize a Board-managed trust fund to provide such assistance.

Level IIA funding would cover major water, wastewater, and solid waste facilities to meet new federal and state regulatory requirements. These projects would be eligible for lower interest subsidized loans than provided under Level I. This would assist utilities and cities in meeting the costs associated with more stringent state and federal regulations.

Level IIB funding would provide more substantial financial incentives for projects consistent with identified high priority State policies. These could include projects that would regionalize two or more utilities, water conservation retrofit/rebate programs, major utility reuse programs, and economically disadvantaged areas.

This would help promote policies of cost-effective, less impacting, cooperation-fostering regionalization; water savings through water reuse and water conservation; and service to areas that would be unlikely to acquire or upgrade service without exceptionally favorable financial assistance. Level IIB financing would also allow for State participation in regional projects, with up-front State financing and subsequent payback to the State.

Actions to Support State Water Financing

While creation of a new water financing program will contribute substantially to meeting the State's facility needs, a variety of supportive actions also should be pursued. These actions range from efforts to amend the federal tax code to helping local governments recover appropriate expenses associated with water supply provision.

In passing the Tax Reform Act of 1986, Congress sought to limit use of tax-exempt financing in order to minimize losses in federal revenue. However, the new federal restrictions on tax-exempt financing that were established in 1986 have effectively reduced local and state options for funding needed facilities.

In particular, non-profit water supply corporations are not eligible to receive loans through tax-exempt bond financing, agricultural conservation bonds authorized by Texas voters may not satisfy the tax code's private beneficiary test, and bonds designed to meet federal environmental and other mandates may not qualify as non-taxable. In response to financing problems created by federal tax reform, the Anthony Commission on Public Finance, in a report to U.S. Congressman Beryl F. Anthony, and others have argued for a tax policy that contributes to meeting national infrastructure improvement needs.

Reductions in federal spending have caused delays in or deferral of interstate projects needed to improve water quality. At the same time, the federal government has redefined national interest to withdraw a previous acknowledgement of the shared federal responsibility for projects that benefit more than one state.

In addition to the funds administered by the Board, communities can seek federal assistance for facility improvement through other State agencies or directly from federal agencies. Lack of a centralized source of funding or funding information increases the likelihood that financial assistance opportunities will be missed.

In some areas of the State, ground water is underutilized based on the potential supply. Ground water may be perceived as an uncertain source of supply in comparison with surface water. Better knowledge of aquifers, and improved production and management techniques can make ground-water a more attractive supply option. Certain policies on recovery of costs for rate-regulated utilities can also make use of ground water more feasible.

Recommendations:

A. The Legislature and the Board should aggressively work with the Texas congressional delegation to amend the provisions of the federal tax code that unreasonably limit the use of state tax-exempt financing. Specifically, federal law should be changed to allow water conservation-related financial assistance to individuals which is intended to significantly advance public purposes, but which may incidentally benefit individuals, to be supported through tax-exempt debt issuance. Further, restrictions that prevent extending non-taxable debt financing to non-profit water supply corporations should be removed. Finally, the federal tax code should be amended to provide that bonds issued for facilities designed to meet federal environmental and other mandates which are truly for public purpose use are classified as tax exempt.

B. The Texas Legislature and agencies of the State should continue to support congressional funding for interstate projects designed to improve the water quality of Texas streams and receiving waters of adjacent states. The State of Texas should also ensure that the water flowing from Texas into adjacent states meets water quality criteria that will support beneficial uses established by those states.

C. The Board, the Department of Commerce, and the Governor's Office should work together to establish a coordinated clearinghouse to assist and direct local units of government to appropriate federal and State sources of financial assistance.

D. Related financing policy recommendations described in other portions of Chapter 4 include: (1) expanding the State financing program eligibility to cover measures such as sediment control projects designed to protect storage capabilities in existing or future surface water reservoirs (Reservoir Operations and Capacity Maintenance, recommendation B), (2) providing financial assistance to help upgrade deficient dam structures (Dam Safety), (3) adequately funding State programs to serve as incentives for regionalization (State Financial Incentives for Regionalization, recommendation B), and (4) giving local units of government authority to develop and use alternative methods to develop revenue sources to pay for flood protection measures (Threats and Hazards, Flood Protection, recommendation C).

E. To encourage local financing responsibility, as well as participation in the State's water infrastructure financing programs, legislative initiatives should continue to be developed to authorize local districts to establish alternative non-overlapping methods to develop revenue sources that can be used to repay debt and support continuous maintenance. An example of past innovative legislative initiatives was the authorization for the use of drainage repair fees for the Harris County area in 1987.

F. The Texas Water Commission should clarify the ability of local utilities to incorporate *reasonable* costs of protecting water quality, securing surface water supply, and developing ground-water supplies in selected cases (where further ground-water development is both feasible and cost-efficient) into utility revenue recovery mechanisms where those utility rates are reviewed by the Commission directly or on appeal.

G. The Board should initiate a non-point source (NPS) pollution financing needs assessment in conjunction with the Texas Water Commission, Texas State Soil and Water Conservation Board, and the Texas Railroad Commission. The assessment should quantify funding amounts needed for NPS structural and non-structural measures. Additionally, the cost of complying with new stormwater point source discharge quality requirements should also be quantified.

H. The Board's education and technical assistance activities should apprise eligible political subdivisions of the financial assistance programs that are available to conduct water conservation programs and projects, particularly projects to increase system efficiency and reduce waste within the system as an alternative to constructing major water supply or treatment facilities.

I. To assist small communities, utilities, and districts in meeting water-related environmental and public health requirements, the Board's technical assistance program to help identify alternative approaches should be expanded. This could include expanding both the types of entities receiving assistance and expanding the range of alternatives considered. Technical assistance is also recommended for water conservation and wellhead protection, non-point source pollution protection, and other ground-water protection programs. Additionally, it is recommended that technical outreach functions of all State agencies that manage water resources and utilities should be expanded to provide various levels of assistance in the areas of planning, engineering, finance, and management practices.

PLANNING, EDUCATION, AND RESEARCH

A summary of priority policy initiatives associated with water resources-related planning, education, and research is presented in the inset box on the following page.

Water Research

Policy makers often face uncertainty regarding the implications of water-related regulatory, planning, and investment decisions. While a research program addressing priority issues can improve water management, strong State financial support of research programs is not typical, and research findings have not been shown to be a strong determinant of State water policies. Further, a recent nationwide study of State research and development policies has shown that State agencies have not emphasized possible infrastructure improvements resulting from science and technology.

Texas has funded more than $7 million of research contracts using the Board-administered Research and Planning Fund since 1983. However, only $1.1 million in the past seven years has been directed to research projects intended to introduce new technology to meet the State's water needs; the remaining funds have been primarily used for data collection projects and studies on various water-related problems. While federal research funding continues to be more significant, there is little assurance that the federal research agenda will match State concerns.

Texas universities have strong water resources research capabilities. The Texas Water Research Institute at Texas A & M serves as the focal point for federally funded water-related research. Other State universities with water research institutes include Southwest Texas State University, Texas Tech University, and the University of Texas at Austin. The Texas Agricultural Experiment Station and Texas Agricultural Extension Service also conduct water-related research, including research on improved agricultural water use efficiency. The State of Texas funds the Advanced Research Program (ARP) and Advanced Technology Program (ATP), the nation's largest competitive, state-supported university research grant program. In 1989, ARP and ATP funded approximately $2.1 million in water-related research out of a total award of $64 million.

In some areas, cost or dispersed settlement precludes the use of centralized wastewater treatment systems. Section 17.189 of the Water Code requires consideration of certain specified innovative, nonconventional wastewater treatment techniques as an eligibility requirement for financial assistance from the Water Quality Enhancement Fund. Also, the

PLANNING, EDUCATION, AND RESEARCH

PRIORITY POLICY RECOMMENDATIONS	LEGISLATIVE ACTION	AGENCY ACTION	LOCAL ACTION
★ Update the Water Plan on a two-year revision schedule.		★	
★ Direct TWDB and other State agencies and State universities to cooperatively develop a five-year water resources research agenda.	★	★	
★ Establish a Water Resources Coordinating Council to encourage coordination between water and related resources agencies.	★	★	
★ Establish an integrated and comprehensive flood hazard mitigation program for the State.	★	★	★
★ Establish a blue ribbon panel to develop formal recommendations to address water resources impacts of climate change.	★	★	
★ Establish that the decisions of the TWC on a contested case represent the State's position in any federal proceedings.	★		
★ Conduct an annual coordination conference involving water supply agencies and entities and agencies and entities responsible for fish and wildlife protection.	★	★	★

Onsite Wastewater Treatment Research Council supports research and technical transfer to promote effective onsite systems.

Recommendations: A future water-related research program incorporating several components should be built on existing university and State capabilities.

A. A five-year water resources research agenda should be jointly developed by the Board, other State agencies involved in water management, and State universities. The agenda should be used as a guide to establish priorities for research funding.

B. A base level of at least $1.0 million for State water-related research through the Research and Planning Fund should be available annually to provide continuity and adequate funding levels.

C. An on-going mechanism needs to be developed to improve the linkage between universities and State agencies to ensure that the most critical research topics are addressed first, studies are not unnecessarily duplicated, and research results are made available to decision makers.

At least biennially, the Board, in conjunction with Texas universities with water research institutes, should sponsor a conference attended by State agencies, university representatives, and other water and environmental interests to help develop a consensus on water research needs.

Environmental Data Collection and Research

The evaluation and selection of alternative water projects and facilities is increasingly affected by the environmental resources that may be impacted by water development choices. Unfortunately, the capability of all levels of government involved in water resources decision-making to choose among various development, non-development, and mitigation alternatives is limited by the lack of sufficient data and the use of different evaluation techniques. To fully assess and compare the consequences of alternative facility approaches and locations, both issues need to be expeditiously resolved.

The State has a range of choices that may be individually or collectively pursued to address the incomplete data and analytical problems affecting sound environmental analyses. On one hand, the responsibility for completing required environmental evaluations could be recognized as exclusively the responsibility of the individual, group, business, or governmental entity promoting a proposed action (i.e., the permit applicant). Since the entity proposing the action, regardless of the specific nature of the action, will be the beneficiary of the public decision that is ultimately made, the appropriate State position may be merely to have sufficient information to confirm or refute the environmental evaluations prepared by individual project proponents.

At the other end of the spectrum, the State's role could range from specifying the data set and procedures to be used to analyze the data to conducting comprehensive environmental resource inventories and establishing, independent from a project sponsor or proponent, the preliminary environmental requirements that would be associated with water development alternatives. As an example of this approach, the Board was authorized in 1985 to undertake a four-year data collection and analytical program to determine the needs for freshwater inflows to bays and estuaries. Despite the recognized difficulty and cost in obtaining and evaluating data, the State's ability to utilize evaluation results in actually implementing alternatives may be the most difficult problem to overcome.

Recommendations:

A. The State's ability to evaluate circulation, salinity, and water quality in bays and estuaries should be expanded and improved.

B. Additional funding is needed to expand the State's tide gage network to include 65 improved gages.

C. Adequate funding is needed to collect data on the hydraulic conditions, aquatic habitat, and other environmental resources of rivers and streams potentially affected by recommended water supply projects. In turn, consistent procedures for evaluating instream flow needs and other environmental effects that can be accepted and utilized by all State agencies involved in making environmental resource evaluations of water projects need to be demonstrated and applied as a part of the State's decision-making and permitting process.

Decision Support Systems

Entities at all levels of government and the private sector rely on various information sources and systems, databases, reports and records, and other decision support systems to make effective planning decisions. Currently, water and environmental-related decision support systems and activities are spread among various federal, state, and local governmental entities, as well as the private sector.

In the case of centralized governmental programs, the decision support activities generally lack focus, organization, and an effective information dissemination capability. In the private sector, the activities are often piecemeal, occasional, and may not incorporate some of the latest techniques or accepted methodologies.

The primary factors that should be considered when developing or selecting alternative decision support systems are level of approach, efficiency, and performance. Accordingly, the State needs to consider various actions to better develop effective decision support systems that promote consistency, efficiency, and improved quality in water resources planning by all levels of government and the private sector.

The most direct approach would be through centralized provision of information clearinghouse services for relevant planning data and methods which, at the same time, recognizes the valuable role of the private sector and universities in consulting and supports decision making by local entities.

Recommendations:

A. The Texas Water Plan should be updated by the Board on a more frequent, regular basis to maintain accurate information and to keep current with ever-evolving water issues and

State policy needs. A regular two-year revision schedule is recommended for publication of plan updates.

B. The technical outreach functions of all State agencies that manage water resources and utilities should be coordinated and expanded to provide enhanced and on-going decision support assistance in the areas of planning, environmental assessment, engineering, finance, and management practices. These activities should fully consider the role and involvement of the private sector in decision support systems.

C. The Commission should better consider, as a part of the State's water rights and wastewater permit review and approval process, the consistency of proposed actions with the principles and conceptual direction of the State Water Plan.

D. The growth in the capabilities of computerized information systems has greatly enhanced or has the potential to enhance the ability of various agencies to store and evaluate data and information, to conduct their programs, and to make accurate and timely information available to planners and decision-makers at all levels of government and in the private sector.

Currently, the Texas Natural Resources Information System (TNRIS), which is statutorily assigned to and located at the Texas Water Development Board, is designated as the State's interagency natural resources information clearinghouse. While TNRIS maintains data inputs from the various agencies, independent development of and limited access to data and evaluation systems by different agencies creates on-going problems, particularly when data from one agency are incompatible with systems used in another agency or by the private sector.

Texas currently has the opportunity to establish statewide standards for obtaining and sharing geographic information. Such standards would greatly enhance the capability of natural resource agencies to access and use statewide information gathered from a multitude of sources. In particular, TNRIS data and information coordination capabilities should be enhanced. Greater authority should also be provided to TNRIS to coordinate with natural resource agencies to ensure that all agency information is accessible to other agencies. The Legislature should direct TNRIS to conduct a review and evaluation of natural resources data bases at other agencies and entities within the State, with the intent of developing recommendations for better sharing of natural resources information by the State natural resources agencies.

E. TNRIS should expand its role as a central information coordinator and provide various governmental entities and the general public with better centralized access to natural resources, socioeconomic, and water facilities database information that underlies the State's water planning efforts.

For example, a toll-free telephone "hot" line (1-800-WTR-DATA) could be implemented within TNRIS to provide a focused single point of contact for water-related information. As a part of this effort, TNRIS staff should be expanded and further trained in adequate oversight knowledge of the various water-related programs of federal, State, and local governments and the key contact persons in those agencies.

As a next step, the Board should evaluate the possibility of providing expanded direct access, through TNRIS, to natural resources databases. This access could be provided to the public through a modern electronic data interchange system and to other agencies via wide area network technology. The Board's evaluation should include consideration of the equipment needs and possible liability problems associated with establishing a direct access system.

The Board should support TNRIS in its role as coordinator and distributor of federally-generated data and information. This should be done through TNRIS affiliation with the Texas State Data Center (for Census data) and through the TNRIS affiliations with the Texas Mapping Advisory Committee and the U.S. Geological Survey (for cartographic data).

Also, the newly created Texas Department of Information Resources is in a position to serve as a focal point to ensure that independent agency geographic information (GIS) system and other information activities are compatible and complimentary.

TNRIS should work with the Department of Information Resources to formally advise the Legislature of needed statutory amendments resulting from enhanced data accessibility. This approach would further assist regional and local entities in obtaining local area water planning information that, due to its volume, could not be included in the State Water Plan and other State water-related documents.

Threats and Hazards

1. Drought

At least one major drought has plagued parts of Texas in every decade of the 20th century. While there is little that individual Texans can do to prevent periods of dry weather and accompanying reductions in available water, there is much that can be done to prepare plans to lessen the impact of future droughts on the people of Texas.

With increasing development in Texas, the State's water resources will become more valuable as they are extended to available supply and capacity limits. Therefore, it is important that State water planning efforts consider actions that can be taken at the state level to deal with droughts.

Existing State policy for drought planning relies primarily on actions by local and regional entities to address drought situations. Therefore, statewide efforts in support of local and regional actions should be coordinated. Alternatives that should be considered by the State range from enhancing current local assistance programs to preparing a comprehensive statewide drought management and response plan with responsibilities assigned to applicable State agencies to take an active role in all phases of drought planning and preparedness, drought condition monitoring, drought response, and mitigation. A statewide plan would serve to coordinate State agency efforts but would not be designed to take the place of local drought planning and program implementation.

Recommendations:

A. The Legislature should appoint an interagency drought planning task force made up of representatives of the State Division of Emergency Management, Texas Water Commission, Texas Water Development Board, Texas Department of Agriculture, Texas Department of Health, Texas Parks and Wildlife Department, State Soil and Water Conservation Board, other appropriate State agencies, universities, and various other State, regional, and local entities to develop a comprehensive State drought management plan. Representatives of the Federal Emergency Management Agency, the U.S. Department of Agriculture, the U.S. Army Corps of Engineers, the National Oceanic and Atmospheric Administration, and other federal agencies should be consulted and could also be invited to participate as part of the interagency task force.

In developing the plan, the task force should consider plans enacted by other states and model plans developed by organizations such as the Western States Water Council. Any state drought plan should also consider plans prepared by local and regional entities and should not be implemented in place of acceptable local and regional plans. Instead, a state drought plan should provide direction for coordinated actions to be taken by State agencies and assistance activities to be provided to local and regional entities to plan for a drought and to respond to droughts that occur.

B. The Legislature should amend the Texas Water Code to specifically authorize the Commission to require, where appropriate, preparation of a drought contingency plan, in addition to a water conservation plan, by applicants for water rights and wastewater discharge permits.

C. As a basis for drought contingency planning, all water suppliers and State agencies should incorporate risk-based variable demand analysis as a part of water supply planning.

D. The Board should enhance its water conservation and drought contingency planning, education, and technical assistance programs.

2. Intentional and Inadvertent Water Supply and Environmental Contamination

Maintaining the high quality of Texas' water supplies is an essential part of protecting public health, maintaining adequate supplies, and promoting the economic welfare of the State. The State's surface water and ground-water supplies are, however, subject to inadvertent and, potentially, intentional contamination. While recommendations for controlling recognizable point and non-point sources of water pollution have been presented in other policy issues, risks to the safety and security of public water supplies and facilities from natural disasters, accidental spills, illegal discharges and waste disposal, vandalism, and acts of terrorism constitute potential threats that seldom receive sufficient attention. Additionally, environmental and economic damage resulting from inadvertent contamination, such as oil spills, necessitates enhanced preparedness and response capability.

Recommendation: A variety of planning and routine practices should be promoted to safeguard the State's water supplies and environmental values associated with water resources.

A. The Texas Department of Health should be given the legislative authority to direct all public water suppliers to develop emergency water supply contamination contingency plans.

B. The Texas Water Commission should require that all new districts with water supply responsibility prepare emergency water supply contamination contingency plans.

C. All emergency water supply contamination contingency plans should include provisions for coordination during both development and implementation with federal, state, and local emergency response personnel.

D. The Legislature should establish a strong State program to respond to oil and toxic materials spills. The program, to be coordinated between the Texas Water Commission, the General Land Office, the Railroad Commission of Texas, and the Division of Emergency Management, should include a State-level response fund, emergency response equipment stockpiles, research and technology development efforts, and the legal authority to fully recover actual damages and other costs, including expenses for damage assessment.

3. Flood Protection

While flooding causes millions of dollars of damages to property and results in the loss of life nearly every year in Texas, efforts to address flood protection needs have been given only passing attention as a part of the State water planning process in the past. The lack of significant State involvement has occurred, in part, because of an almost exclusive reliance on federal agencies to reduce flood damages. However, decreased funding, more narrowly defined interests and commitments, and increased cost-sharing requirements for federal flood protection programs are forcing the State to assume a much broader role in reducing flood losses.

Several other factors have also limited the State's involvement in flood protection. These include the enormous amount of State land that is floodprone, the absence of comprehensive information on flooding risks and damages, and the inability to prioritize between problems attributable to different types of flooding. Although the 100-year floodplain has been mapped for most floodprone communities in Texas, many available maps are outdated and do not contain sufficiently detailed information on floodway locations and flood elevations at different frequency or recurrence intervals. In addition, ineffective enforcement or the lack of local restrictions to limit urban expansion into floodplains, the inability of local governments to raise revenues to pay for flood protection measures, and the difficulty with and the attendant controversy over implementing measures to reduce repetitive losses impede State and local initiatives to prevent or mitigate flood hazards and damages and may also result in major unmitigated damage to biological resources in the floodplain.

Recommendations:

A. The Texas Water Development Board should develop and continuously update a comprehensive State-level database on existing and projected major flooding problems as a component of the State water planning program. The database should also be used to identify important riparian habitat and biological values and establish geographic rankings on flooding vulnerability.

B. An integrated and comprehensive flood hazard mitigation program should be established for the State. Subchapter I (Flood Insurance and Control Act) in Chapter 16 of the Texas Water Code should be amended to require that a statewide master flood hazard mitigation plan, incorporating appropriate local and federal plans and activities, be developed as one component of the State Water Plan. The statute should also be amended to mandate a coordinated approach to enforce floodplain management requirements for State-owned lands and projects. Lastly, Subchapter I should be reviewed to identify any local or State authority deficiencies and, in turn, be revised to provide full statutory basis to develop, implement, and vigorously enforce floodplain management regulations.

C. All local units of government, in particular districts, must be given the authority to develop and use alternative, non-overlapping methods to develop revenue sources to pay for structural and non-structural flood protection measures. Revenue raising methods should be adequate for both construction of capital facilities or features and implementation of programs and measures not requiring construction. Local government ability to raise funds should also be sufficient to pay for flood protection planning and for facility operation, maintenance, and rehabilitation. The Legislature should consider authorizing districts throughout the State to impose impact fees, as has already been authorized for the Houston area.

4. Climate Change

Water resources decision making has always been characterized by varying degrees of uncertainty because of the inherently unpredictable nature of the hydrologic cycle. Scientific findings and public debate on climate change and its potential impact on water have introduced a vast new dimension of uncertainty into water resources planning in recent years. While research and discussion continues on the extent and severity of regional and local watershed impacts of climate change, almost universal scientific agreement on the warming of Earth's climate has now been established.

Studies and reports by the National Academy of Sciences, the American Association for the Advancement of Science, the U.S. Environmental Protection Agency, the International Water Resources Association, the International Council of Scientific Unions, and the United Nations confirm an unprecedented rapid rise in global temperatures due to the accumulation of greenhouse gases that are changing the chemical composition of the atmosphere. Average global mid-latitude temperatures are predicted to increase by two degrees Fahrenheit (1.1° Celsius) by the year 2025 and by as much as seven degrees Fahrenheit (4.0° Celsius) by the year 2100.

The water resource impacts of global climate change have the potential to seriously affect the State's economy and citizens, attributable in part to the inability of natural and man-made systems to adapt rapidly enough to the rate of predicted warming. Important water resources consequences resulting from climate warming that is already underway will likely include an increased probability of extreme flood, drought, and hurricane events; reduced precipitation and increased evaporation resulting in decreased soil moisture, ground-water recharge, and overall water availability; and a rise in sea level of several feet accompanied by higher storm surges, increased beach erosion, permanent coastal inundation, saltwater intrusion into freshwater coastal aquifers, and the destruction of marine and coastal ecosystems.

Other potential economic, physical, and biological impacts include an increase in electrical power demand for air conditioning, monumental changes in the State's wood products and agricultural industries, and the loss of natural species biodiversity; virtually every aspect of human and natural life in the State would be affected.

Also, even a minor change in climate attributable to global warming would have a substantial impact on the laws and institutions that have been established to manage Texas' water resources. In a state that is so dependent on its water resources, water managers, as well as elected decision makers, can no longer afford to ignore climate change as a variable in planning for the future use of the State's water resources.

Alternative responses available to address climate change include prevention, that is curtailing the buildup of greenhouse gases, and both passive and active adaptation. A third type of response, technical measures to counteract climate change, may, because of extreme unpredictability, cause more problems than are solved.

Recommendations: Most experts and scientific reports recommend that a combination of preventive and active adaptation measures be immediately undertaken to modify and reduce the potential impacts of global warming. The most frequently recommended responses are those that will yield salutary benefits in their own right even if climate changes do not materialize as forecast and that will produce vastly greater benefits if changes occur as now predicted. The State's actions should be predicated on assuring the widest possible range of water management options for future choices.

A. Water resources planning and investment decisions at all governmental levels should incorporate climate uncertainty as a formal variable and attempt to identify alternative actions or choices that will provide the State with the greatest degree of flexibility to respond to variable climate change impacts.

B. The Governor, the Lt. Governor, and the Speaker of the House should establish a select blue-ribbon panel of credible scientists, business leaders, and public policy decision makers, chaired by the Chairman of the Texas Water Development Board, to develop formal recommendations on how State legislation, policy, and programs should be revised to respond to the water resources impacts of climate change. The panel, which could work cooperatively with the Texas Environmental Policy Forum proposed by the Texas Water Commission, should present a report with recommendations to the 73rd Regular Session of the Texas Legislature. The Board and other agencies should provide staff to the panel and every effort should be made to obtain federal assistance to support the work of the panel.

Federal/State Relationships

A variety of factors influence interactions between the State of Texas and the various arms and agencies of the federal government. Since a number of State agencies share similar water management responsibilities, there is no assurance that a consistent State policy will be expressed when dealing with federal agencies. Further, federal water policy is divided among three cabinet-level departments and a number of independent agencies. Some federal agencies are modifying their historic roles. For example, the U.S. Bureau of Reclamation is currently emphasizing water management rather than construction, and the U.S. Environmental Protection Agency has been elevated to cabinet level. While federal agencies are providing less financial assistance to states, federal regulations continue to impose significant controls and costs on state and local governments.

Texas has ranked near the bottom of all states in total receipt of federal funds. A recent State initiative to ensure that the State is more competitive in securing funding has been undertaken. At the same time, improved State technical capabilities, in general, have decreased reliance on federal assistance. Also, experience from the 1980s decade indicates that innovative public policies are increasingly likely to originate at the state and local levels rather than the federal level, as states continue to depart from federal directives by implementing more stringent environmental requirements.

A recent national study recommended creation of a President's Water Council to provide better coordination among federal agencies, and federal legislation that would improve policy coordination with western states has been introduced. To develop a more coordinated state position on various issues, the Texas Legislature has created a number of coordinating councils, with statutes establishing coordinating entities for toxics, ground water, solid waste, and international health and environmental issues. Alternative coordinating mechanisms that could be established include informal contacts between agencies, consolidation of agencies, and agreement on common techniques for planning and evaluating water projects.

Certain federal decisions and actions can limit water supply alternatives. An example is the U.S. Fish and Wildlife Service's acceptance of a donated non-development easement to protect an area of East Texas bottomland hardwoods for migrating water fowl habitat, which conflicts with the Sabine River Authority's plans to construct the Water's Bluff Reservoir. This issue was elevated to the U.S. District Court for the Eastern District of Texas, Texarkana, which ruled in favor of the U.S. Fish and Wildlife Service. Quoting from the summary of the court decision,

> "the alleged effect of the FWS's action--elimination of a potential reservoir site--is not within the scope of NEPA because there is no causal relationship between the alleged effect and any change in the physical environment caused by the acquisition of the easement...."

Current law and regulations are directed to ensure that water resource development is evaluated with due consideration to resulting environmental effects and other tradeoffs associated with development. There is not an equivalent requirement for a formal comparison of benefits gained from protecting important wildlife habitat with benefits foregone as a consequence of foreclosing an option to construct a reservoir for which there is also a limit on resource availability, i.e. good reservoir sites. The conclusion of the court that proper coordination procedures had been observed contrasts with continuing expressions of concern that the public had insufficient input into an action with long-term implications for the area.

In broader terms, the case raises questions about the effect of easements as an intentional technique to preclude use of some of the limited number of sites recommended for new reservoirs in this plan. One alternative response could be to attempt to amend federal legislation to require preparation of an Environmental Impact Statement when a potential federal action might preclude utilization of potential reservoir sites or inadvertently foreclose other water development opportunities.

Alternatively, a formal state-level resource evaluation process could be developed that would address issues in addition to those considered under federal procedures. A short-term response would be to encourage water supply interests and fish and wildlife protection interests to cooperate to identify and to address, in advance, potential areas of conflict with balanced consideration of both development and preservation interests.

Recommendations: Until such time as a State water coordinating council may be legislatively created, the following actions should be undertaken:

A. The Legislature should enact legislation establishing that the Texas Water Commission's decisions made through a contested case hearing represent the State's position on issues that are in any federal proceedings. All State and regional entities, including the Attorney General, should support this position in federal proceedings. This recommendation would affect only those issues where a decision has been made through the Commission's hearings process and would not apply to other issues of State concern that are considered in federal proceedings.

B. To influence federal legislation and rules that may potentially have significant impacts on Texas, State water agencies should work closely with the Texas congressional delegation, the Office of State-Federal Relations, and organizations such as the Western States Water Council, Council of Infrastructure Financing Authorities, Western Governors' Association, Arkansas-White-Red Basins Interagency Council, Interstate Council on Water Policy, Association of State and Interstate Water Pollution Control Administrators, and Association of Drinking Water Administrators.

C. The Texas Legislature, Board, Commission, and other water supply-related entities in the State should work with the Texas congressional delegation to enact legislation to ensure that the U.S. Fish and Wildlife Service's (FWS) acceptance of non-development easements through its Bottomland Hardwood Preservation Program does not preclude development of needed reservoirs or other water-development projects if the water-supply benefits out-weigh the environmental benefits.

   Legislative approaches that should be considered include requiring the FWS to: (1) give the same consideration to the water supply needs of an area as it does to the environmental benefit derived from a non-development easement, (2) if an area proposed for an easement is designated as a reservoir or water-development site in a State Water Plan or official regional or local planning document, prepare a complete Environmental Impact Statement as part of the consideration process, and (3) conduct 10-year reviews of an easement, giving State and local entities the opportunity to present new information on the effect of the easement, with consideration given to removing the easement if water-supply needs outweigh the environmental benefits.

D. Annual coordination conferences involving agencies with water supply responsibilities and those involved in fish and wildlife preservation should be held to address potential water resource and environmental conflicts.

Water Planning Purpose and Coordination

Agreement on the precise purpose of the State Water Plan is necessary to define the scope and the content of future plan updates. The number of diverse entities preparing local and regional plans greatly increases the likelihood of inconsistency and, therefore, the importance of State coordination.

A plan could primarily list projects to be funded or, alternatively, comprehensively examine problems, policies, and infrastructure needs. According to experts, the fundamental aspects of a water plan include an assessment of resources and needs and a comprehensive process for developing structural and management solutions that is policy-based, dynamic, and enforceable. Essential water resource planning components identified for inclusion in the State Water Plan are updated estimates of present and future water, wastewater, and flood protection needs, improved evaluation of alternatives, accelerated institutional agreement, and expanded procedures for increasing cooperation and public involvement.

Ensuring coordination in water planning in a large state, such as Texas, can be difficult given the diversity of geographic needs and the large number of affected interests. To address this problem, several State programs have coordination requirements. For example, statutes on State solid waste planning require that all plans be consistent with the State plan and that regional plans be adopted as rules. Alternatively, adequate opportunity for the public to help influence planning recommendations can also be viewed as a coordinating mechanism. For example, the Texas Outdoor Recreation Plan incorporates the broadest public participation effort of any State natural resource plan. This includes opinion surveys, regional public meetings, interviews, workshops, and wide distribution of report drafts for review and comment. Lastly, in addition to a coordination process, all planning efforts must have an effective affirmative consideration process if planning recommendations are to have generally accepted credibility.

Recommendations:

A. The Legislature should establish a Water Resources Coordinating Council, as originally recommended in the December 1988 Report of the Governor's Committee on Water Resources Management, to encourage coordination by water and related resource agencies.

B. State Water Plan updates should be prepared by the Board on a regular two-year interval. A report should be provided to the Legislature at the beginning of each regular session documenting the status of Plan contents.

C. The Board should be adequately funded to develop a broader and more comprehensive on-going process for identifying and monitoring emerging water management issues so they can be incorporated into future Water Plan updates.

D. The Board should establish a process that promotes early and full public involvement in all updates of the Water Plan.

E. The Board should further develop and document sound and consistent planning criteria to be used in updating future water plans.

F. Expanded interagency coordination is needed to avoid conflicts between the Water Plan and other State-prepared plans relating to water resources. The Board should develop more formal procedures, working arrangements, or agreements that establish how key water-related recommendations from plans prepared by other State agencies will be incorporated into updates of the Water Plan and vice-versa.

Environmental Dispute Resolution

Because of the limited resource constraint and the many potentially disparate interests involved, water issues are, by their very nature, contentious. Some degree of conflict is inherent in the desires of different regions, users, and levels of government to exert control over limited supplies of water. In recent years, strong public support for protecting environmental values has clashed with other competing water demands, with these conflicts often leading to litigation. With the commitment of resources required on all sides, significant issues may remain unresolved for long periods of time. Ultimately, control over decision-making may be lost to outside, higher authorities. As an alternative to an increasing number of adversarial proceedings, dispute resolution through consensus-building techniques has been increasingly employed with demonstrated success. This can range from innovative public education and planning processes to environmental mediation.

Considerations in selecting a dispute resolution approach include identifying effective methods to achieve consensus, relying on disinterested parties to lead the process, and recognizing that some interests benefit from the status quo. Concerns associated with departures from current practice include overcoming the perception that it will restrict public involvement in decision-making, assuring representation of all affected parties, and ensuring implementation once an agreement is reached.

Successful resolution of disputes will encounter many obstacles regardless of the approach that is used to avoid or reduce conflict. This is especially true in long-standing conflicts where entities have firmly established views or significant economic interests. Because current efforts to resolve disputes are costly, lengthy, and characterized by limited success, the State can play a role in offering alternative approaches when local interests cannot concur or reach an acceptable compromise. The following recommendations are not intended to exclude the public or any party from the decision-making process.

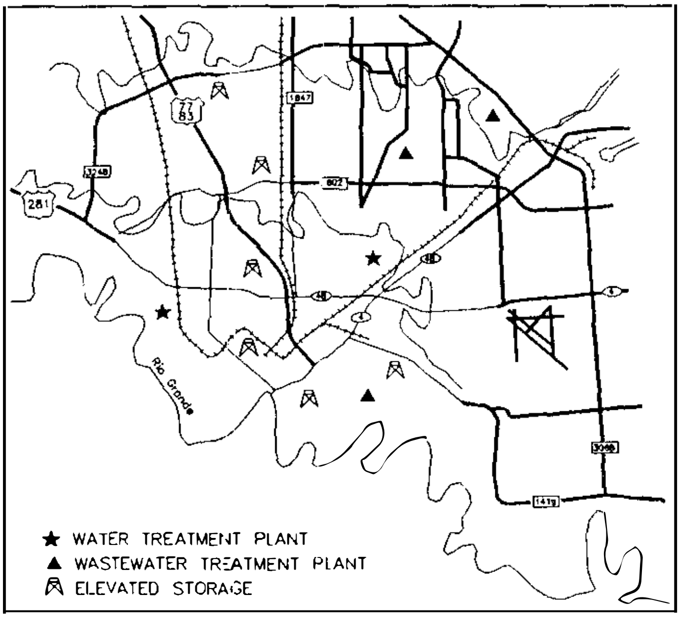
Recommendations:

A. The State Management Development Center should offer training on environmental dispute resolution for State agencies with statutory responsibilities for natural resources and for those agencies constructing major projects subject to environmental review.

B. The Legislature should evaluate the Open Meetings and Records Act to identify any legal impediments to the use of dispute resolution approaches and techniques, such as the involvement of third party mediators and requirements for confidentiality. Consideration should be given to modifying legal restrictions that could preclude the use of conflict resolution approaches while at the same time respecting the public access principles of open government. Since proper conflict resolution approaches could involve the breadth of various entities involved in the dispute, proper balance should be maintained to protect the overall public interest.

APPENDIX A

EXAMPLES OF LOCAL UTILITY FACILITIES SUMMARIES



Population:

1970 act. - 52,222
1980 act. - 84,997
1990 est. - 105,839
2000 est. - 156,449
2010 est. - 188,497
2040 est. - 276,065

Current Capacity Data:

Water Supply: 20.0 MGD
Elevated Storage: 7.5 MG
Ground Storage: 6.75 MG
Service Pumps: (4) 1020 GPM

SYSTEM DESCRIPTIONS

WATER. The sole source of raw water for the City of Brownsville is the Rio Grande. Brownsville is at the downstream end of the river, and the water quality is partly dependent on the discharges of the riverside communities on both sides of the river. Three water pumps obtain water from the river and discharge into a large terminal reservoir. Water from the reservoir is treated and then supplied to the distribution system which contains two pressure planes.

ADJUDICATED RIGHTS #: 23-865A
27120.446 acre/feet per annum from the Rio Grande Cameron County - Rio Grande Basin

WASTEWATER. Wastewater is collected in a network of 6 to 30 inch clay and PVC sewers. The system includes 104 lift stations. Flows are directed to three wastewater treatment plants: a 7.8 mgd activated sludge plant; a 5.0 mgd trickling filter plant; and a 0.09 mgd package extended aeration plant.

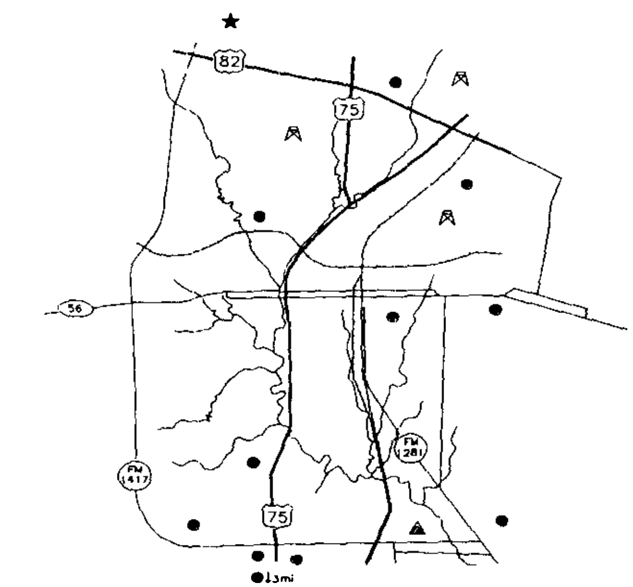
TWC PERMIT #(S): 10397-01, Q=7.8 MGD @ 20/20
10397-03, Q=5.0 mgd @ 20/20
10397-04, Q=0.09 mgd No Discharge

FLOOD PROBLEMS. Brownsville, like most other cities on the Texas Gulf Coast, experiences localized flooding each year. In 1987, a Master Drainage Plan was formulated for the city. At the present time, the US Army Corps of Engineers is completing a drainage plan for Cameron County.

PROJECTION OF ADDITIONAL FACILITY NEEDS

	1990-2000		2000-2010		2010-2040		TOTAL	
Facility Item	Additional Capacity	Cost (1,000$)	Additional Capacity	Cost (1,000$)	Additional Capacity	Cost ($1,000)	Additional Capacity	Cost (1,000$)
Water Supply	13.83 MGD	$8,981	4.83 MGD	$4,507	18.63 MGD	$10,918	37.29 MGD	$24,406
Elevated Storage	---	---	---	---	---	---	---	---
Ground Storage	---	---	---	---	---	---	---	---
Water Pumping	---	---	0.87 MGD	$20	18.63 MGD	$209	19.5 MGD	$229
Water Distribution	927,104 LF	$23,178	723,753 LF	$18,094	1,897,519 LF	$47,438	3,548,376 LF	$88,709
Wastewater Treatment	1.15 MGD	$1,454	2.91 MGD	$3,341	8.85 MGD	$9,061	12.91 MGD	$13,856
Wastewater Collection	927,104 LF	$36,716	723,753 LF	$28,018	1,897,519 LF	$80,037	3,548,376 LF	$144,771
Flood Protection	---	---	---	---	---	---	---	---
Total Estimated Costs (1,000$)		$70,329		$53,980		$147,662		$271,971
Potential State Funds Needed		$10,435		$7,868		$20,188		$38,491

REMARKS: Water: The City is involved in exploration work, drilling, and testing wells in a five square mile area located approximately 25 miles west of the City of Brownsville. TWDB projections show that a new channel dam will be needed by approximately 2030 to increase surface water supplies. Wastewater: The 5.0 MGD trickling filter plant will be expanded to 10 MGD capacity. Construction is to begin in late 1990.



Population:

1970 act. - 29,061
1980 act. - 30,413
1990 est. - 31,812 (act. 34,546)
2000 est. - 34,892
2010 est. - 37,940
2040 est. - 47,702

Current Capacity Data:

Water Supply:	17.1 MGD
Elevated Storage:	3.75 MG
Ground Storage:	12.15 MG
Service Pumps:	53.7 MGD

SYSTEM DESCRIPTIONS

WATER. Supply now consists of 30 wells into the Trinity and Woodbine Aquifers. The maximum sustainable yield of the well field was measured at 8.8 mgd. The water wells have a peak pumpage rate of 17 mgd. This is at or near the maximum capacity of sustainable use of the ground-water aquifer available to the City of Sherman. A new 10.4 mgd surface water treatment plant, which incorporates a 4 mgd demineralization process, will process water from Lake Texoma. It will be owned and operated by the Greater Texoma Utility District (GTUD) and financed by the TWDB fund with a $17.6 million loan. The distribution system consists of elevated and ground storage (15.9 mg) and pipelines between 2 and 24 inches with a booster pump capacity of 37,275 gpm. The pipelines are primarily cast iron and plastic. The distribution system has two pressure planes at Elev. 835 and at Elev. 762.

ADJUDICATED RIGHTS #(s): 02-4905. Reservoir for recreational purposes 251 AC-FT. #02-4906 Reservoir for recreational purposes 350 AC-FT.

WASTEWATER. Wastewater is collected in a network of 6 to 42 inch clay, concrete, plastic and cast iron sewers. The system includes eleven lift stations. Flows are directed to a combined trickling filter-activated sludge treatment.

TWC PERMIT #(s): 10329-001, Q = 12 mgd @ 20/20

FLOOD PROBLEMS. Reoccurring flood damage has required constructing small watershed structures to protect the city.

SANITARY LAND FILL. Present site must be abandoned. Exploring new regional site. Under litigation.

PROJECTION OF ADDITIONAL FACILITY NEEDS

	1990-2000		2000-2010		2010-2040		TOTAL	
Facility Item	Additional Capacity	Cost (1,000$)	Additional Capacity	Cost (1,000$)	Additional Capacity	Cost ($1,000)	Additional Capacity	Cost (1,000$)
Water Supply *	---	$1,975	---	---	---	---	---	$1,975
Elevated Storage	---	$900	---	---	---	---	---	$900
Ground Storage	---	---	---	---	---	---	---	---
Water Pumping	---	---	---	---	---	---	---	---
Water Distribution	91,000 LF	$3,759	90,000 LF	$2,248	246,000 LF	$6,158	427,000 LF	$12,165
Wastewater Treatment *	2.5 MGD	$3,075	1.03 MGD	$1,320	3.30 MGD	$3,745	6.83 MGD	$8,140
Wastewater Collection *	91,000 LF	$1,905	90,000 LF	$2,793	246,000 LF	$8,575	427,000 LF	$13,273
Flood Protection *	---	$2,745	---	---	---	---	---	$2,745
Total Estimated Costs (1,000$)		$14,359		$6,361		$18,478		$31,198
Potential State Funds Needed		$1,320		$3,745		$8,140		$13,205

* CIP Costs