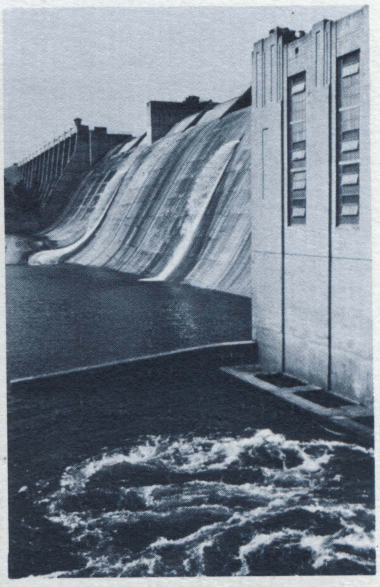
Surface Water Development in Texas



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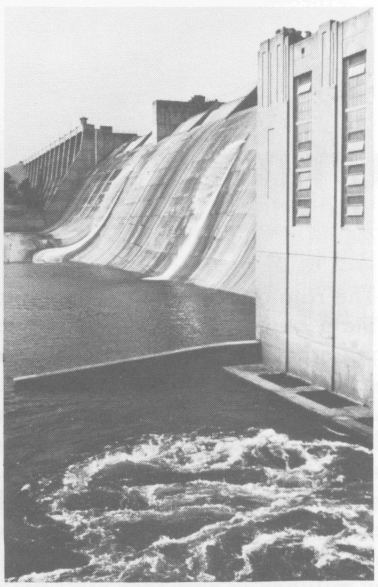

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Summary

The rate of use of water in Texas is increasing. As the State becomes more industrialized and urbanized, competing demands for water increase. Some increased demand is met with ground water, but this is not a long-term solution. The Texas Water Development Board's published estimates show an annual yield of ground water for all Texas river basins of 4.3 million acre-feet per year. By comparison, the Board shows annual use of ground water for irrigation alone to exceed 10.0 million acre-feet per year. Other uses increase the annual deficit by millions of acre-feet.

In Texas, 95 percent of the total conservation storage capacity is concentrated in 63 reservoirs. The Texas Water Development Board has not provided a published figure on average annual yield of surface water from these reservoirs. In addition, on a year-to-year basis, many factors cause variability in reservoir yield. Because the policy has been to build reservoirs in anticipation of need, determining average annual quantity of water available and providing some measure of yearly variation are important.

Institutional constraints imposed by Texas water law prevent coordinated management of ground and surface water. Texas courts have refused to modify judicial law so that conjunctive management can be accomplished. Among the major obstacles to legislative reform is the political resistance of large numbers of existing water rights holders.

In Texas, it is generally established that landowners have the right to intercept and use water that falls on their land until it reaches a watercourse, or sinks into the ground, or is evaporated. This diffused surface water can be impounded by the landowner on his own property without the necessity of obtaining a permit as long as the reservoir does not exceed 200 acre-feet in capacity. Such small impoundments are considered by some engineers to result in major water losses from evaporation, transpiration by vegetation, seepage, and percolation.

If precipitation, runoff, or springflow makes its way to a streamcourse, it becomes subject to riparian and prior appropriation water rights systems. The riparian right arises by operation of common law concepts as an incident to the ownership of land abutting a stream or watercourse, requiring no act other than the acquisition of title to the land. The appropriative right, on the other hand, is regulated by statute. It is not necessarily related to the land ownership and is acquired by compliance with statutory requirements implemented by rules and regulations of the Texas Water Rights Commission. At the end of August 1975, the Commission recognized 10,603 rights and claims to some 53.7 million acre-feet of water. With both rights doctrines recognized in Texas, numerous riparian and appropriative rights exist on the same stream, creating problems for Texas courts and water agencies trying to correlate these conflicting types of rights. The main purposes of the Water Rights Adjudication Act of 1967 are the eventual merger of all surface water claims into the permit system and the final adjudication of all surface water rights. This will require many years.

Texas differs from other States in water resource development in that eight of her major rivers are intrastate streams. River authorities have been created which have the power of water districts for the control, storing, and preservation of storm and flood waters of the river and its tributaries. Counties, cities, and the various kinds of water districts are all authorized by statute to undertake certain projects. Local water districts, together with the Federal agencies, are the action agencies which construct, operate, and maintain most waterworks and water projects.

The Texas Water Development Board acts as State cooperator in water development planning with Federal agencies and serves as the State sponsor of Federal projects where no suitable local agency is available. The Board may make loans to local governments for approved water projects consistent with overall planning objectives. It may also negotiate with the Federal Government for water storage space in Federal projects, purchase storage space in local reservoirs, and construct reservoirs and necessary related facilities. Board figures for November 1976 for 63 major Texas reservoirs show 35 non-Federal reservoirs with conservation storage capacity of 14.6 million acre-feet and 28 reservoirs built, owned, or operated by Federal agencies with conservation storage capacity of 15.4 million acre-feet.

River authorities, municipalities, water districts, and State water agencies exercise the dominant role in

development of municipal and industrial water supplies, supplying about 80 percent of the money invested for these purposes. This percentage is expected to increase in the future.

In 1931, a preference list was devised by the Legislature to guide in appropriation of the State's waters. This preference list provided the following order for all streams in the State with the exception of the Rio Grande: 1. domestic and municipal uses, 2. processing, 3. irrigation, 4. mining and the recovery of minerals, 5. hydroelectric, 6. navigation, and 7. recreation and pleasure.

Ground water was used for irrigating about 82 percent of the land irrigated in Texas in 1974; 15 percent was irrigated from surface water supplies and 3 percent from mixed ground and surface water. Most ground water used for irrigation was from the declining aquifers in the High Plains. More than half the acreage in Texas irrigated by surface water was in the Rio Grande Valley. The Gulf Coast Prairie constitutes the other major irrigation area using surface water.

Only seven of the major reservoirs have water allocations for mining purposes, with small allocations used almost entirely for petroleum production. Water for future mining needs will largely be met by local surface and ground water resources.

A small amount of power is produced by hydroelectric plants in Texas, but because surface water is limited, hydroelectric plants are used in most cases for peaking or emergency purposes. Every method of generating power in large quantities available today results in the unavoidable production of byproduct heat. The disposition of this low-level heat requires using water as a heat transfer and cooling medium. It is anticipated that future powerplants will use existing reservoirs or ponds for cooling whenever possible, since this creates the least additional environmental disturbance and a minimum additional consumption of water. All project costs allocated to power are usually recovered.

The Federal Government carries the dominant responsibility for planning, constructing, and paying for navigation improvement. Navigation was important to exploration and early development in Texas, providing early routes from the Gulf to the interior. Subsequent advances in overland transportation slowed river navigation development, except in the tidewater area along the Gulf.

Outdoor recreation has experienced a phenomenal boom in the past two decades, becoming one of the top 10 major economic activities of the Nation. The Federal Water Project Recreation Act of 1965 was intended to encourage the States and other non-Federal public entities to assume responsibility for developing recreational potentials created by Federal reservoirs. State and local bodies have been reluctant to share in Federal reservoir recreation costs because of Federal agency control, shortage of local financial resources for recreational purposes, and other reasons. Future development of outdoor recreation on Federal and non-Federal reservoirs is still not clear.

The purpose of flood-control works is the prevention of flood damage. In a reservoir project, flood waters are stored in the reservoir and then released at a nondamaging rate. With respect to major reservoirs, costs of flood control, including operation and maintenance, are borne entirely by the Federal Government. Flood-control storage capacities at 26 major Texas reservoirs amounted to 17.4 million acre-feet in 1976. There is evidence of a changing national policy to keep economic development out of the flood plains. It appears that management is to take the place of structural solutions for controlling flood losses. Flood prevention on intrastate rivers and smaller streams will increasingly become the responsibility of the landowners involved.

A general problem exists of allocating Texas water resources among competing uses and users. This problem has been growing in intensity in recent years. Both public and private entities are involved, including commercial agriculture and industrial enterprises, environmental organizations, and the general public at large. Often these interests are in direct or indirect competition for the use and benefits of the various water and related land resources in the State. The final outcome will be determined by the Texas legislature and the courts.

Introduction

Planning for long-range water resource developments for Texas has been conducted by the Texas Water Development Board and other agencies in compliance with a series of statutory enactments. These Legislative directives have reflected the response by the State to the increasing complexity of its water problems (33).

Present water developments are and those of the future will be extremely costly. The State of Texas and its political subdivisions are expected to provide increasing portions of the funds required as Federal funds become less available for this purpose. As potential water needs escalate, it becomes more apparent that existing supplies should be conserved, distributed, and administered in a more efficient manner (33).

The rate of use of water in Texas is increasing rapidly as the population expands and as the State becomes more industrialized and urbanized. A question naturally arises as to whether basic water policies of the past are suited for conditions of the present and the foreseeable future. More consideration may need to be given to conservation and to more efficient use of existing supplies. In addition, more attention is being paid to economic and social consequences of water resource development, including the impact on regional economic growth, institutional arrangements, and esthetic values affecting the quality of life.

The National Water Commission, created by an Act of Congress in 1968 to review national water resources problems, submitted its report and recommendations to the President and the Congress in 1973. The Commission recognized that Federal programs for navigation, reclamation, flood control, and hydroelectric power had made an enormous contribution to national well-being. Demands on the Nation's water supply have accelerated so rapidly that national policies governing water conservation, development, and utilization have lagged far behind national growth. New policies are considered essential by the Commission to assure efficiency in water use and to sustain a healthful, esthetically pleasing environment (19).

Today's major water problems were unknown when the Nation decided to assume responsibility for navigation improvements, reclamation, and flood control. The United States is more fully settled and predominantly urban and gives far greater weight to environmental and esthetic values than when the Nation was young and less settled. The people want action on the enormous problem of controlling the pollution which befouls their rivers, lakes, and estuaries. They are concerned with preserving the recreational values of natural water resources and developing the recreational potential of existing water projects.

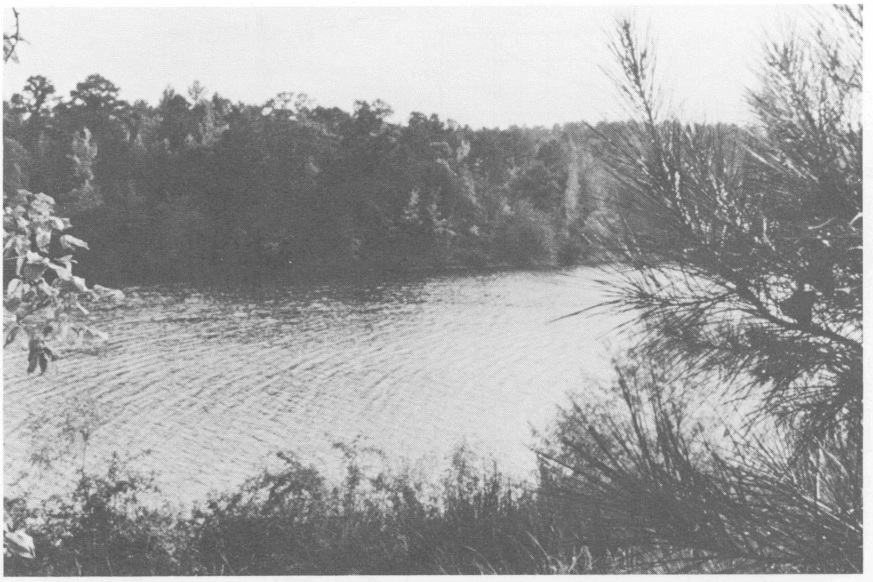
The report of the National Water Commission develops seven recurring themes pertaining to issues of water policy:

1. The level of future demands for water is not inevitable but derives in large part from policy decisions within the control of society.
2. National priorities have shifted from development of water resources to restoration and enhancement of water quality.
3. Water resource planning must be tied more closely to land use planning.
4. Policies are recommended which lead to the conservation of water, that is, policies which will motivate better use of water and reduce water losses by improved efficiency.
5. Sound economic principles should be applied to decisions on whether to build water projects, providing a net increase in the goods and services available to consumers with due regard for protection of environmental values.
6. The laws and legal institutions should be reexamined in the light of contemporary water problems, particularly the need to modernize laws dealing with ground water.
7. Development, management, and protection of water resources should be controlled by that level of government nearest the problem and most capable of effectively representing the vital interests involved. The Federal role in the planning and financing of water programs should gradually diminish (19, pp. 6-10).

In 1975, the Executive Director of the Texas Water Development Board reviewed the factors affecting development of water supply projects in the State. He considered the long time period involved in Federal processes from time of water project conception to actual project construction. He pointed out that construction costs involved in developing water supply projects currently increase at a rate approximating 15 percent a year. He indicated the level of participation by the State in water supplies as follows:

> "Among other things, it is not generally recognized that our State — through its river authorities, municipalities, water districts, and state-level water agencies — exercises the dominant role in development of Texas municipal and industrial water supplies. Many think we rely heavily upon the federal government for financial and other forms of aid in the development of our instate water supply projects. This is not fact. Earlier issues of *Water for Texas* have noted that over the past about 80 percent of the money invested in Texas water projects has been put up by Texas entities of government, State and local." (6, p.2)

In the past, Texas citizens generally have been able to live wherever they chose without concern for the availability of water. It is now more apparent that the State's developable resources are limited. Recognition has come that wise use of available water resources is vital (33).



About three-fourths of the surface water runoff in Texas originates in the eastern one-fourth of the State.

Annual Surface Water Resources

The Texas climate is marked by extremes in many aspects, particularly the amount and timing of precipitation. Annual precipitation in the State ranges from 8 inches or less in far West Texas to more than 56 inches in far East Texas near Orange. This gradual decrease in precipitation in an east to west direction is shown in Figure 1. Isohyets, or lines of equal precipitation, are generally arranged in a north-south direction across the State, reflecting distance from the Gulf of Mexico, which is the source of most atmospheric moisture in Texas. The average decrease in precipitation is about 1 inch for every 15½ miles from east to west (33).

Texas is also subject to wide fluctuations in rainfall from year to year. Precipitation often varies more than 50 percent from calculated averages and, in most years, will be below the annual average. The State is subject to periods of drouth, sometimes of long duration. Due to high summer temperatures and persistent wind, evapotranspiration rates are frequently quite high (7).

In West Texas, water runoff is far exceeded by evaporation and transpiration water losses. Because of the nature of precipitation and terrain in West Texas, surface runoff

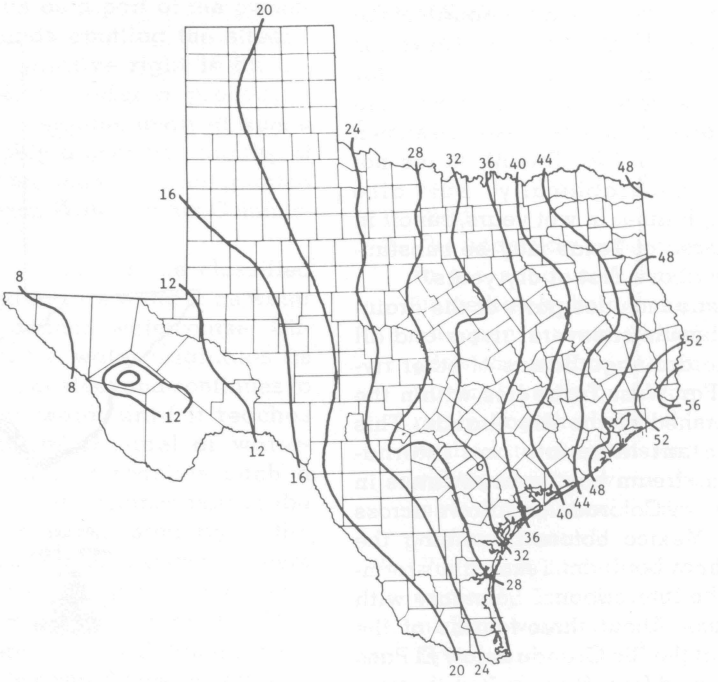


Figure 1. Mean annual precipitation (in inches).
Source: Texas Almanac and State Industrial Guide, 1976-1977, Dallas, A. H. Belo Corp., 1975, p. 164.

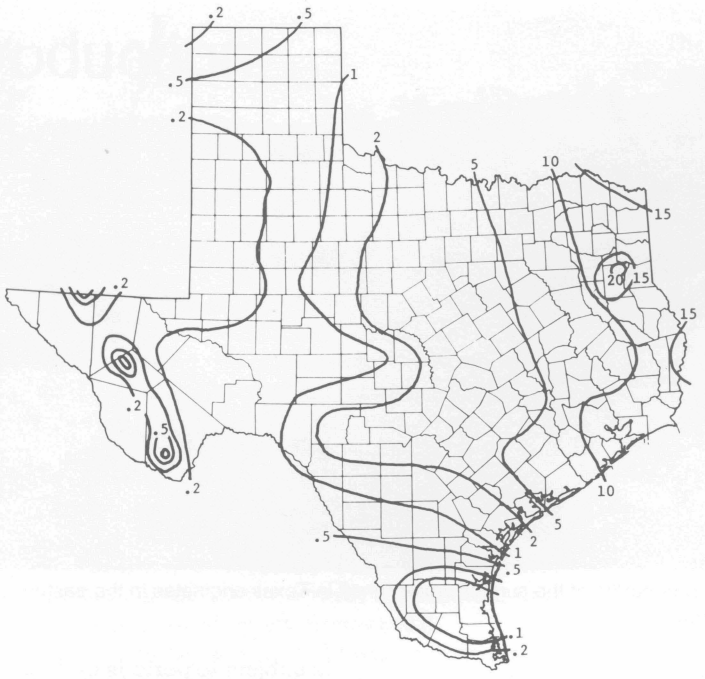


Figure 2. Mean annual runoff (in inches).

Source: Texas Society of Professional Engineers and Texas Section of the American Society of Civil Engineers, *The Effects of Ponds and Small Reservoirs on the Water Resources of Texas*, Austin, The Society, 1974, p. 10.

usually is quite small. About three-fourths of the runoff in Texas originates in the eastern one-fourth of the State (33). Mean annual runoff varies from about 0.2 inch or less in far West Texas to more than 20 inches in a small area of East Texas as shown in Figure 2 (27). Runoff varies not only geographically but also through time. In wet years, runoff in any area of Texas may be substantially above that of dry years.

Texas includes parts of the drainage basins of several rivers and all of the drainage basins of other rivers. Far West Texas lies within the watershed of the Rio Grande. This important interstate and international stream has its headwaters in southern Colorado and flows across New Mexico before traversing the southern border of Texas, thus forming the international boundary with Mexico. About three-fourths of the flow of the Rio Grande below El Paso is derived from Mexico. Its tributary, the Pecos River, rises in the mountains of north-central New Mexico (23).

Major portions of the headwaters of the Nueces, San Antonio, Guadalupe, Colorado, Brazos, and Red Rivers are located in West Texas. Few major reservoirs are on the West Texas portions of these rivers. Problems with sedimentation and high lake surface evaporation loss plague the reservoirs of West Texas (23).

Streams with headwaters on the High Plains generally contribute nothing to streamflow east of the Caprock Escarpment except during rare periods of relatively high rainfall (9). The Canadian River, which bisects the High Plains, rises in the mountains of northern New Mexico. Texas is assured a part of the flow of the Canadian, Red, Rio Grande, and Sabine Rivers through a series of interstate and international compacts and treaties (23).

Most Texas rivers have their sources in the regions of least runoff and flow into the more humid regions of the State (Figure 3). Rivers with their sources in Central and East Texas include the Cypress, Lavaca, Neches, Sabine, San Jacinto, Sulphur, and Trinity (29).

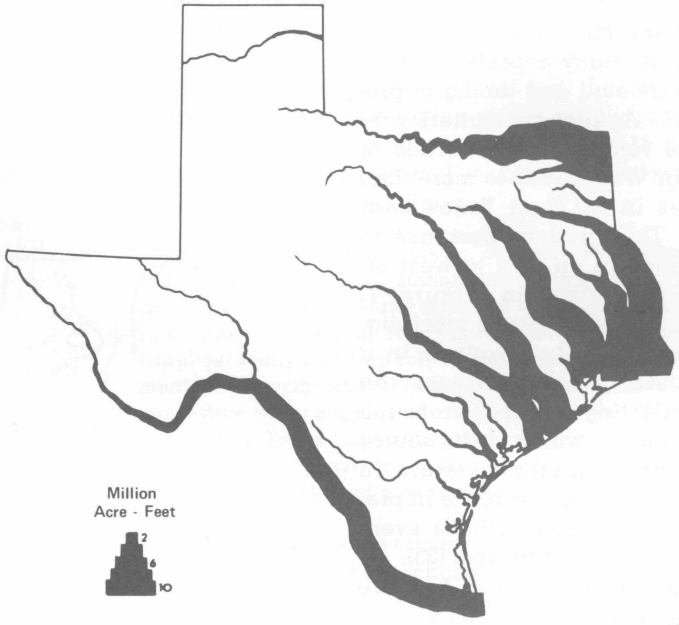
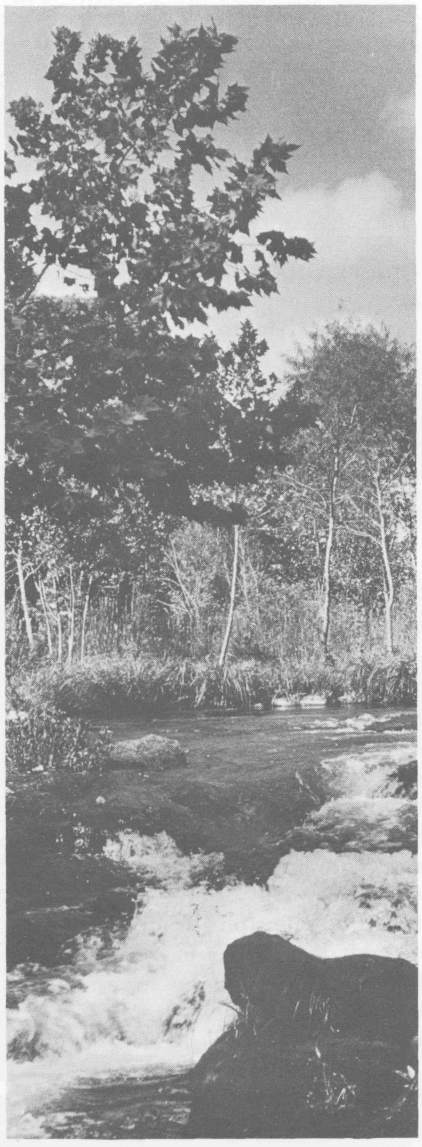


Figure 3. Mean annual streamflow.

Source: Texas Water Development Board, *The Texas Water Plan*, 4 parts, Austin, The Board, November 1968.

Surface water is legally classified as either diffused surface water or water within a defined watercourse.

Surface Water Rights



The two basic doctrines of surface water rights recognized in Texas are the riparian doctrine and the appropriation doctrine. The corresponding water rights perfected under these doctrines are commonly referred to as riparian rights and appropriative rights. The riparian right is a common law right to use a proportionate part of the normal flow of a stream as a part of the ownership of lands abutting the stream. The appropriative right is an acquired right under a procedure provided by statute, to divert from a water supply a specific quantity of public water under a permit granted by the Texas Water Rights Commission (31).

Surface water may be classified as diffused surface water or as water within a defined watercourse. Diffused surface water originates as rain, snow, or sleet and continues to be surface water until it reaches some natural channel or watercourse. Once it reaches such a watercourse, it becomes part of the stream and is the property of the State, subject to the rights of owners of riparian lands and those who have obtained appropriation rights (31).

A watercourse is defined as an identifiable natural stream having a definite natural channel originating from a definite source of supply. Waters in a watercourse may be classified as ordinary or normal flow, underflow, and storm and flood water. The Texas Water Development Board has defined these categories as follows:

1. The ordinary or normal flow of a watercourse has been judicially defined as a flow below the line "which the stream reaches and maintains for a sufficient length of time to become characteristic when its waters are in their ordinary, normal and usual conditions, uninfluenced by recent rainfall or surface runoff." (*Motl* v. *Boyd*, 116 Tex 82, 286 SW 458, 1926).
2. The underflow consists of water in the sand, soil, and gravel immediately below the bed of an open stream, which supports the surface stream in its natural state or feeds it directly, together with the water in the lateral extensions of the subterranean water-bearing material on each side of the surface channel.
3. The storm and flood water is primarily the collected diffused surface water from recent precipitation.

"The legal distinction between ordinary flow, underflow, and storm and flood flow is particularly significant in reconciling conflicting claims to the

same water supply, which arise because of the dual recognition in Texas of both riparian and appropriation doctrines. The riparian right concept relates to and is concerned only with the ordinary flow and underflow of a stream. A riparian right does not attach to that portion of a stream comprised of storm and flood flow, and therefore generally will not attach to waters impounded by large reservoirs." (31, p. 2)

Riparian Doctrine

Templer (23) indicates that the riparian doctrine was introduced into Texas by the Spanish and Mexican governments and later in a somewhat different form by the Republic of Texas. For many years, Texas courts and water agencies ruled that Spanish and Mexican land grants carried extensive riparian water rights, including the right of irrigation. This was determined in the important case of *Motl* v. *Boyd*, 116 Tex 82, 268 SW 458 (1926). Subsequently, more thorough investigations of Spanish and Mexican water law revealed the error of this interpretation. It was finally determined in *Valmont Plantations* v. *Texas*, 163 Tex 381, 355 SW 2d 502 (1962) that riparian rights to water for irrigation did not pass under these land grants, unless specifically included.

Few specific grants of irrigation rights were made except in the vicinity of San Antonio and El Paso. Extensive tracts of land were granted by Spanish and Mexican governments in Texas, and title to some 26 million acres can be traced to these sources, mostly in South and Central Texas (10). Land grants made between 1836 and 1840 by the Republic of Texas also were controlled by Mexican law and possess the same water rights as prior grants (38). The constitution of the Republic of Texas (1836) insured the validity of these existing land titles, and the Treaty of Guadalupe Hidalgo (1848) between the United States and Mexico carried this recognition forward.

More comprehensive riparian water rights attach to all lands granted by the Republic and State between 1840 and the Appropriation Acts of 1889 and 1895, an era when large quantities of land passed into private hands. In 1840, Texas courts adopted the common law of England and with it acquired the riparian doctrine. Subsequent modifications of the original doctrine by the courts gave riparians the right to make reasonable use of water for irrigation or for other extensive and consumptive purposes.

Appropriation Doctrine

The appropriation doctrine was adopted by the State near the turn of the century. Since the Appropriation Act of 1895, land acquired from the State no longer carries riparian rights, and a statutory procedure has existed whereby individuals can obtain water rights from the State. All appropriation statutes expressly recognized the superior position of riparian water rights. At first, appropriation was accomplished through an informal procedure; the landowner simply filed a sworn statement with his county clerk describing his water diversion. Under such a loosely administered appropriation system, claims sometimes overlapped, described huge acreages to be irrigated, or claimed more water than the dependable flow of the stream could produce. Later, certified copies of these claims were recognized by the State, and thus they came to be called "certified filings." Almost 1,000 certified filings were recorded with the State claiming a substantial amount of water (2).

Since 1913, a more strictly administered procedure involves making application to a State agency, now the Texas Water Rights Commission, for a permit to appropriate water from streams. The several purposes for which water may be appropriated are spelled out in Sect. 5.023, *Texas Water Code*, and the order of priority or preferences between these uses is listed in Sect. 5.024, *Texas Water Code*.

At the end of August 1975, the Commission recognized 10,603 rights and claims to some 53.7 million acre-feet of water. Most existing permits claim water for irrigation, although many of the largest are for municipal and industrial use or for hydroelectric power generation. Permit holders must file annual reports of water use with the Water Rights Commission, so that reasonably accurate records of appropriative water use are available to aid water resource administrators and planners (23).

Riparian landowners in Texas may also acquire appropriative water rights and may claim both types of rights, each without prejudice to the other (13). As riparians, they are held to a standard of reasonable use, and the extent of the appropriative rights is determined by their permits. Doubtless, many riparian owners have taken advantage of the more certain water rights derived from permits or certified filings, and perhaps have ceased to claim riparian rights altogether.

With both doctrines recognized in Texas, numerous riparian and appropriative rights exist on the same stream, creating problems for Texas courts and water agencies in trying to correlate these conflicting types of rights. Following years of unsuccessful attempts to correlate these rights, and more accurately define and delimit the nebulous riparian rights, in 1967 a Water Rights Adjudication Act was passed (Sects. 5.301-5.341, *Texas Water Code*), and adjudication of water rights is currently in progress (23).

Correlation of Doctrines

Texas courts and State water agencies have experienced great difficulty in trying to correlate the riparian and appropriative water rights which exist side by side on the same stream. In this century, several attempts have been made to more accurately define or quantify the nebulous riparian rights so that all existing claims to or use of surface water could be inventoried, thus allowing more effective water resource management (24).

In 1917, the Board of Water Engineers was given authority to adjudicate water rights on streams, but

this authorization was held unconstitutional in *Board of Water Engineers* v. *McKnight,* 111 Tex 82, 229 SW 301 (1921). Later in 1926, the attempt was made in *Motl* v. *Boyd,* 116 Tex 82, 268 SW 458, to divide streamflow into "ordinary normal flow" and "flood flow" with riparian rights attaching to the former category. State courts and water agencies found this division difficult, if not impossible, to apply in practice (8). Until adjudication of water rights is completed in Texas, however, this definition remains the basis for correlating riparian and appropriative rights.

Several unsuccessful legislative attempts were made to more accurately delimit riparian rights. In 1955, the Legislature adopted a water user's statute designed to measure riparian water use (13). The act required all water users, including riparians, to file a statement each March with the Commission, stating the amount of water used during the preceding calendar year. It excluded those taking only small quantities of water for domestic and livestock purposes. This did not solve the problem because most riparians ignored the law and failed to file reports, and penalty provisions were inadequate and were not enforced.

Holders of water rights permits issued by the Water Rights Commission are required to file annual reports of water use. As late as 1968, however, the Water Rights Commission had no record of the number of riparian water users in any major river basin, the extent of their claims, or the amount of water they were using. For example, in 1967 only three persons claiming riparian rights filed water user's reports in the Nueces River Basin (22) although eventually more than 200 riparian claimants were discovered claiming nearly 250,000 acre-feet of water. This sizable unknown element obviously made coordinated and efficient administration of the State's surface water resources impossible.

The Water Rights Adjudication Act, designed to remedy this situation, was passed in 1967. Its main purposes are the eventual merger of all surface water claims into the permit system and the final adjudication of all surface water rights. Under the Act, all unrecorded claims of water, such as those of all riparians and some holders of rights under the Irrigation Acts of 1889 and 1895, were required to be filed with the Commission. Minor exceptions were made for those using only small quantities of water for domestic and livestock purposes. The deadline for filing was September 1, 1969, but numerous late claims were received and accepted by the Commission. Exceptions extended the base period and filing date to 1970 and 1971, respectively, for some riparians, and the filing deadline was extended to September 1974 for those who failed to file because of extenuating circumstances or for good cause (23).

For the State as a whole, some 11,600 unrecorded claims, mostly riparian, were filed under the Act, claiming more than 7 million acre-feet of water (36). Many claims showed no water use during the base period (1963-1967) or were for uses excluded under the Act, thus raising the question of how they should be treated by the Commission. An Attorney General's opinion indicated that these claims could be rejected. The Commission, however, elected to review each claim on a time-consuming, individual basis. More than 3,200 claims in this group have now been reviewed and rejected, and it is estimated that more than one-half of the total claims filed can be dismissed (36). Thus, the number of claims in most river basins apparently can be substantially reduced before adjudication begins.

Figure 4 reflects the number and extent of claims as of August 1974 after all claims had been received and a considerable number had been rejected. Almost 90 percent of these claims were for irrigation, although only about two-thirds of the water claimed was for this purpose. In the Rio Grande, Guadalupe, and Colorado River Basins, claims exceeded 1 million acre-feet, and the Red River Basin approached this figure. Significant quantities of more than 200,000 acre-feet were also claimed in the Neches, Trinity, Brazos, San Antonio, and Nueces River Basins. The largest number of claims was in the Neches, Colorado, and Brazos River Basins with more than 1,000 each. The Trinity, Sabine, and Cypress Basins had more than 800 each, and in most other major river basins, several hundred claimants were discovered. By comparison, the number and extent of claims between major streams in the Coastal Basins were relatively small.

Of all claims filed, about 95 percent were riparian. The remainder represented certified filings which had not been recorded as required by the Irrigation Act of 1913. However, almost 60 percent of the 6.3 million acre-feet of water claimed was attributed to these unrecorded certified filings.

The actual process of water rights adjudication started shortly after most of the unrecorded claims were received by the Commission. Once adjudication is complete, certificates of adjudicated water rights will be issued to successful claimants. If the Act survives expected court tests, then for the first time, riparian rights will be limited to a specific maximum quantity of water.

The Water Rights Commission is also attempting to cancel, either wholly or partially, unused appropriation permits. Some permits were obtained under the loosely administered certified filing system. Others represent unused allocations of water made by permit from the Water Rights Commission and its predecessors. Vested water rights such as these cannot be altered without a forfeiture proceeding, and the water to which they pertain is not subject to reappropriation until the permits are cancelled or reduced (31).

In the past, cancellation has been difficult because of several glaring defects in the cancellation statute (37). A 1971 Supreme Court decision, *Texas Water Rights Commission* v. *Wright,* 464 SW 2d 642, allowing administrative cancellation of permits after 10 years of continuous non-use, has permitted the Commission to move more rapidly in cancelling or reducing unused claims, so that as

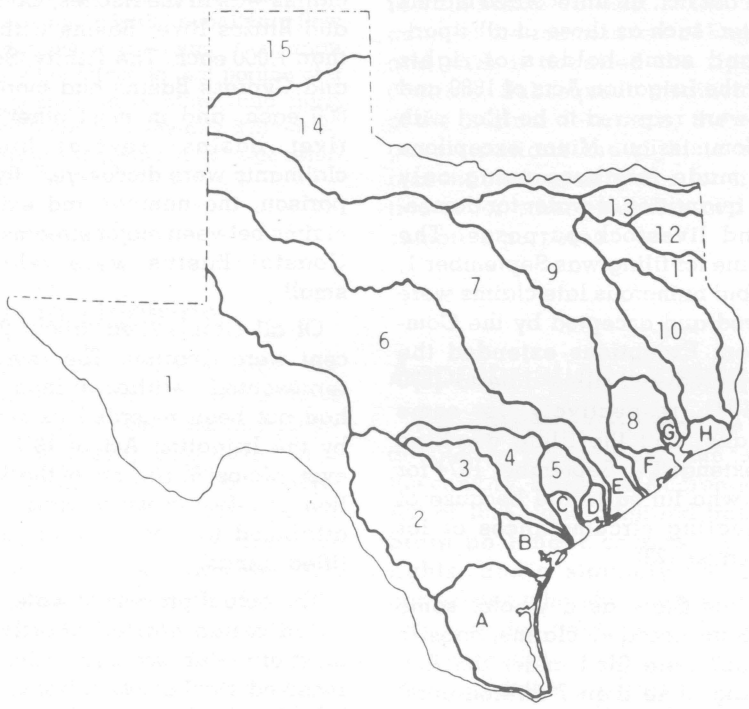


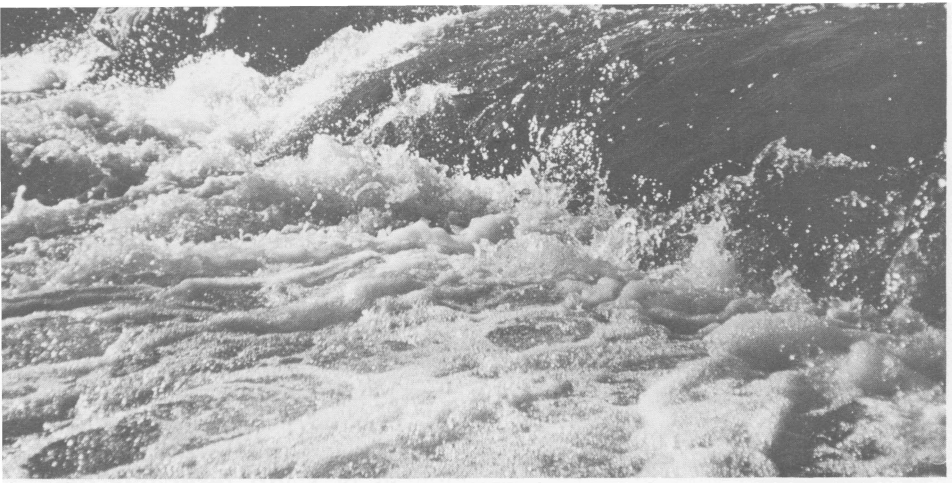
Figure 4. Claims filed under water rights adjudication act.
Source: Texas Water Rights Commission, Austin, Texas (as of August 31, 1974).

Major River Basins	No. of Claims	Water Claimed (acre-feet)
1. Rio Grande*	422	1,344,025
2. Nueces	235	243,999
3. San Antonio	183	172,174
4. Guadalupe	317	1,083,219
5. Lavaca	25	8,580
6. Colorado	1,362	1,142,045
7. Brazos	1,263	169,762
8. San Jacinto	36	65,324
9. Trinity	958	232,686
10. Neches	1,727	514,273
11. Sabine	940	95,213
12. Cypress	835	4,569
13. Sulphur	239	1,810
14. Red	391	979,331
15. Canadian	21	6,080
Coastal Basins		
A. Rio Grande-Nueces	44	32,383
B. Nueces-San Antonio	13	42,566
C. Guadalupe-Lavaca	4	309
D. Lavaca-Colorado	20	9,358
E. Colorado-Brazos	54	17,515
F. Brazos-San Jacinto	64	35,693
G. San Jacinto-Trinity	14	12,644
H. Trinity-Neches	68	149,628
TOTAL	9,235	6,373,236

*Does not include 878 adjudicated rights in the Lower Basin to 2,020,382 acre-feet of water

few as possible will remain before adjudication.

A major benefit expected to accrue from adjudication is that additional unclaimed surface water may be discovered and made available for appropriation. This additional amount is estimated to be as high as 25 percent of the available water supply in some river basins (2). To further underscore the importance of water rights adjudication in Texas, many water resource experts believe that all existing surface water rights in the State must be determined before such massive transbasin diversions as those contemplated in the *Texas Water Plan* are attempted. This is particularly true where existing streamcourses are to be utilized as water transfer routes. It is impossible to keep the transferred water separate and intact to its destination if existing claims and water use along the route stream are unknown. Adjudication of water rights in each river basin will also allow determination of the quantity of surplus water, if any, available for transfer (23).



The final adjudication of all surface water rights will require many years.

Progress of Water Rights Adjudication

Of the major river basins in Texas, adjudication has progressed farthest in the Rio Grande and San Antonio Basins. Adjudication is essentially complete for the Lower Rio Grande Basin below Falcon Reservoir. The adjudication process here was accomplished largely by the courts in the massive law suit, *State of Texas* v. *Hidalgo County WC & ID No. 18, et. al,* 443, SW 2d 728 (Tex Civ App, 1969) Writ ref., n.r.e., that consumed more than a decade. The result was a court determination of most surface water rights.

Such actions that originated before the 1967 Act are excluded from the adjudication procedure. A complicating factor stemming from that case was that the court allotted "equitable" rights to persons who had been using water in the past, erroneously thinking they possessed riparian or other water rights. Such rights, however, apparently have application only to the Rio Grande Basin. The administrative phase of adjudication is nearing completion for the Middle Rio Grande Basin between Falcon and Amistad Reservoirs and the Barilla Creek subbasin of the Pecos watershed and is well along in the Upper Rio Grande Basin (23).

Elsewhere over the State, rather than adjudicate surface water rights for each major river basin in succession, the Water Rights Commission has chosen to proceed on a "hot spot" basis, determining water rights in smaller sub-basins that have long histories of recurring water disputes. The first such subbasin for which adjudication was ordered was the Cibolo Creek watershed in the San Antonio River Basin, and here adjudication has progressed farthest under the Act. The other sub-basins of the San Antonio River, the Concho River, the Upper Colorado River, Pecan Bayou and Pedernales sub-basins of the Colorado River, and the Upper Guadalupe and Lower Nueces subbasins were also singled out. Adjudication is progressing rapidly in these areas. Most remaining subbasins within the named watersheds are in earlier administrative phases of adjudication. Adjudication appears to be moving in a rather orderly fashion from the water-deficit areas of the State into the more humid regions. Another obvious reason for this progression is the opportunity to apply the adjudication procedure first to those river sub-basins with the fewest water rights claimants (23).

In the remaining basins, the Commission is just beginning preliminary pre-adjudication surveys. These surveys are most advanced in the Trinity and Brazos River Basins. Progress to the judicial phase of adjudication and subsequent appeals probably will take many years. By September 1974, the Water Rights Commission considered that the process of adjudication was about one-third complete (36) and expects adjudication to be completed in the next 10 years. In any event, it will be some time before all Texas surface water rights are reasonably well established (23).

Texas' share of the waters in interstate and international streams is determined on the basis of a series of interstate compacts and international treaties. Several of these agreements are of significance to West Texas. Two treaties between the United States and Mexico govern allocation of water to Mexico from the Rio Grande at Juarez and of the river's waters between the two countries from Ft. Quitman to the Gulf of Mexico. The Rio Grande Compact entered into by Colorado, New Mexico, and Texas controls the use of the Rio Grande above Ft. Quitman. The Pecos River Compact between New Mexico and Texas governs the apportionment of waters of that river. The two compacts have been a major source of dispute between the states (23).

The Canadian River is allocated by a compact between New Mexico, Texas, and Oklahoma. The only interstate stream for which no compact has yet been approved is the Red River. Work is progressing on the completion of a compact for that stream, and a draft compact is currently under review. Texas' interest in interstate waters must be well established so that adjudication of water rights in the State can be completed (23).

Water rights adjudication is progressing for the streams, channels, and rivers of Texas. But as pressure on water supplies continues to grow, diffused surface water and its impoundment is another source of surface water which may become an important issue.

As pressures on water supplies continue to grow, the impoundment of diffused surface water has become an important issue.

Diffused Surface Water

When water falls from the atmosphere as precipitation, it becomes diffused surface water. Diffused surface water is surface drainage over the face of a tract of land which is not yet concentrated into a channel or watercourse. A watercourse has been defined in Texas as having a bed, banks, a water current, and a permanent supply source. The stream need not be perennial but must flow regularly enough that a running stream is maintained for a considerable time (4). An essential characteristic is that flows of diffused surface water are relatively short lived.

In Texas, it is generally established that landowners have the right to intercept and use diffused surface water on their land. Their right is superior to that of adjacent lower landowners and to any surface water right holder on streams into which the runoff water might eventually flow (4). The rule in Texas is similar to that of most other jurisdictions. No State has gone so far as to attempt appropriation of diffused surface water (4).

A Texas statute, Sect. 5.140 of the *Texas Water Code*, provides that diffused surface water can be impounded by the landowner on his own property without the necessity of obtaining a permit so long as the reservoir does not exceed 200 acre-feet in capacity. This includes the small impoundments commonly called stock tanks or farm ponds. Since 1953, water in these small reservoirs may be used only for domestic and livestock purposes. A permit is required from the State if the dam is on a stream course, if the reservoir exceeds the storage limits, or if the water is to be put to other uses. A recent Water Rights Commission survey of reservoirs exceeding 50 acre-feet storage capacity revealed more than 800 reservoirs which may require permits (36).

Downstream water users usually are of the opinion that such small reservoirs and related conservation land treatment practices have the effect of reducing their water supply (3). A recent study of diffused surface water use in Texas by the Texas Society of Professional Engineers (27) gives a great deal of credence to this concern and concludes that such small impoundments result in major water losses.

The impact of such small reservoirs is determined by their size and number and the amount of runoff. The law permitting landowners to construct such reservoirs applies throughout the State and does not consider the wide variations in rainfall, runoff, and other hydrologic factors that affect surface water yield.

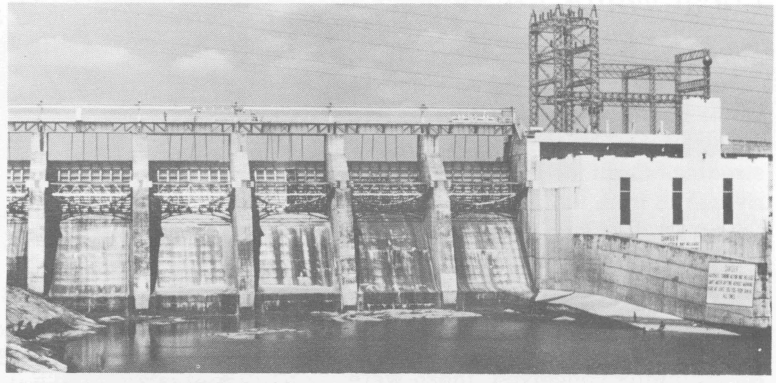
Small reservoirs are most numerous in the central part of the State where annual runoff, except for South Texas, exceeds 1 inch. For example, more than 8,000 stock tanks and farm ponds are in the Nueces River Basin's 19 counties according to a recent survey by the Soil Conservation Service. Because they can be constructed at will by landowners, the number is growing rapidly as reflected by a 29-percent increase from 1962 through 1969. Such reservoirs have an average capacity of only 6.5 acre-feet, but they intercept the runoff from a watershed averaging 136 acres (25).

Statewide, in the period between 1957 and 1967, rather than increasing as in the Nueces River Basin, the number of small reservoirs decreased, but the number of large farm ponds increased. Ponds with capacities greater than 11 acre-feet comprise some 1.5 million acre-feet of the total impoundment capacity of 2.3 million acre-feet (27).

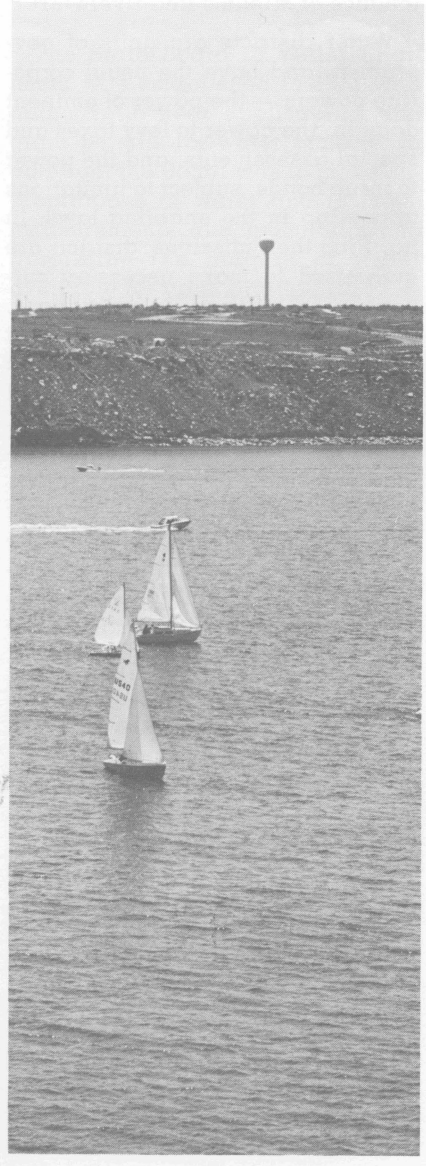
It has been calculated that near El Paso a watershed of 24,000 acres is required, under normal conditions, to supply a 200 acre-foot reservoir permitted under Sect. 5.140, *Texas Water Code;* 10,000 acres on the High Plains; 2,400 acres in Central Texas; and only 600 acres in East Texas (27).

Many small impoundments are quite shallow with large surface areas compared to storage capacity. Losses of water are heavy from evaporation, transpiration by vegetation, seepage, and percolation. In others, the quantity of water allowed to be impounded under Sect. 5.140 is large. A landowner without a permit can impound more than 65 million gallons of water in a single reservoir for domestic and livestock purposes, and he can build as many reservoirs as his land will fill. This is estimated to be 85 times the amount of water actually needed by a typical single-family cattle-ranching operation on three sections of land (27).

The fears of downstream water users that their water rights could be seriously impaired as small reservoirs in the watershed increase in number and size seem justified. Under present Texas law, they would have no legal recourse. The Texas Society of Professional Engineers has recommended that Sect. 5.140 of the *Texas Water Code* be revised and that no small reservoir larger than 10 acre-feet in storage capacity be allowed without a permit from the Water Rights Commission (27).



Local, State, and Federal governmental agencies are active participants in water development programs.



Water Development

Government has played an important role in the protection and development of water resources in Texas. The governmental institutions at Federal, State, and local levels have been participants in active programs aimed at overseeing private development and at developing natural resources for the public at large. The administrative organization and the intergovernmental relationships have been and are relatively complex. Many local, State, and Federal agencies are concerned with different specific water programs. A history of water legislation and related water programs is provided by the Texas Water Development Board (31).

This history of water legislation in Texas dates back to 1889 when the Texas Legislature attempted to provide for the orderly distribution of water resources between livestock and irrigation interests. In 1913, with an Act creating the Board of Water Engineers, orderly development of water rights became possible. This was the first State agency concerned with water development and water rights.

Following severe floods in 1913 and 1914, there was agitation for an amendment to the Constitution which would recognize the State's duty to prevent flood damage and to take steps necessary for the conservation of the State's natural resources. To avoid any question as to the State's legal right to regulate the conservation of natural resources, a Conservation Amendment was adopted in 1917. It stated that the conservation and development of all the natural resources of the State were public rights and duties, and the Legislature was authorized to pass all laws appropriate for this purpose.

As cities and industries developed within Texas, municipal and hydroelectric interests became more competitive for water with cattlemen and irrigators. Competition over the available and sometimes uncertain water supply led to the passage of the Wagstaff Act in 1931. This act declared beneficial use preferences as a guide for the Board of Water Engineers in the granting of future water permits. The act declared that for a given supply of water, domestic and municipal needs must be met first, followed in their respective order, by industrial needs, irrigation,

mining, hydroelectric, navigation, and recreation and pleasure (31).

Local Water Agencies

Texas differs from other States in water resource development in that many of her rivers are intrastate streams. Eight of the major Texas rivers run from their sources in West Texas to the Gulf. This has made possible the creation within the State of a basinwide type of district, called either a conservation and reclamation district or a river authority. As originally conceived, these were attempts to create governmental units that would have an overall basinwide perspective, as well as the authority to develop and conserve the water and soil resources of the basin. In 1929, the State created its first conservation and reclamation district, which later became the Brazos River Authority.

River Authorities

River authorities are created as governmental agencies and vested with all the authority as such under the Constitution and the laws of the State. They have the power of such water districts as are authorized in the provisions of the Conservation Amendment in the Constitution. They may formulate plans for the control, storing, and preservation of storms and flood waters of the river and its tributaries. They have the power to provide and maintain improvements for the common benefit of the district. They are usually given specifically broad powers to do a number of things.

Most river authorities are not given the power to tax. To obtain necessary planning funds, they rely upon the counties to contribute funds. River authorities are empowered to receive loans and grants from the Federal Government. They may issue bonds secured by the revenue to be derived from the sale of water or electrical power. Because of larger jurisdiction, most river authorities are in better position to finance, construct, and operate dams and reservoirs than is a city or local water district. The authority may cooperate with local interests which may contract to purchase water and power from such projects (31).

Counties and Cities

Several units of local government in Texas are authorized to engage in various water programs. Counties, cities, and the different kinds of water districts all are authorized by statute to undertake certain projects.

Texas counties have authority to cooperate with the Federal Government in navigation projects and in flood-control projects. They may issue bonds to purchase land and rights-of-way, and they have the power of eminent domain to aid in carrying out this authority. They have authority to contract with any city or town, and they may acquire water systems and water supply reservoirs for the purpose of supplying water. They also act as administrative agencies of the State government. Under the general water law statutes, the commissioners court of a county is empowered to create all types of water districts which are located entirely within the county. Generally, Texas counties have not been too active in undertaking responsibilities of water resource administration and management (31).

Unlike counties, cities exist primarily to regulate and administer the local or internal affairs of their incorporated territories. For this reason, they have a vital concern in maintaining an adequate municipal water supply. Texas cities may construct municipal water supply systems and issue the bonds required to construct them. They also have authority to contract with private water companies or with water districts to supply municipal water. Flood protection measures are undertaken by cities, directly or by cooperation with the Federal Government. They may generate, purchase, and distribute hydroelectric power.

Water Districts

Since the enactment of a 1904 constitutional amendment permitting the creation of special districts, water districts have become the most important unit of local government undertaking water programs in the State. The local water districts, together with the Federal agencies, are the action agencies which construct, operate, and maintain most waterworks and water projects.

Water districts in Texas undertake all major types of water programs, including flood control, drainage, navigation, sewage disposal, power supply, ground water control, mosquito control, soil conservation, and recreation as well as irrigation, domestic, commercial, and industrial water supply. The tasks of supplying and controlling water often involve the construction of levees, dams, lakes, and power facilities or the channeling, clearing, and maintenance of streams and rivers (31).

Water districts are units of government and have the usual corporate powers — the power of eminent domain, the power to levy taxes and special assessments, and the power to issue bonds, subject to limitations appearing in the enabling laws. In fulfilling their missions, districts are authorized to make necessary surveys, examinations, investigations, and plans, to purchase or construct waterworks and facilities, and to cooperate and contract with Federal agencies, individuals, private corporations, other districts, river authorities, and other municipalities. Little control or supervision of water districts is exerted by either State agencies or the public. The only legal restrictions usually pertain to financial powers and the engineering soundness of proposed projects (31).

Until 1964, local units of government operating with the Federal Government carried the major part of the State's responsibility to develop and conserve Texas' water resources. They undertook and financed the programs to build dams and reservoirs and to operate and maintain them.

As the population and industrialization of the State have grown, increased water problems have made necessary the creation of new water agencies. Much of the responsibility for water development shifted from the counties to water

districts and from single-purpose water districts to multiple-purpose river authorities. Parallel to this development has been the trend in cities toward water districts and the trend toward multicity districts to undertake projects which a city alone could not develop. At the beginning of accelerated water development planning in the 1960's, more than 600 river authorities, water districts, and other local or regional political entities had direct responsibility for some aspect of water development (31).

State Water Agencies

Board of Water Engineers

The State Board of Water Engineers was established in 1913 with authority to hear applications and grant permits for water projects. In addition, the Board was to make appropriations of water and to make measurements and calculations to determine the amount of water available for appropriation. In 1955, this same Board was made responsible for determining the feasibility of proposed Federal projects.

The following additional functions were assigned to the Board in 1957:

1. To prepare and submit to the Legislature a statewide report of the State's water resources.
2. To negotiate with the United States for the development and acquisition of conservation storage in reservoirs constructed by the United States.
3. To cancel water permits or certified filings which had not been put to a beneficial use in 10 years.

These new duties changed the nature of the Board of Water Engineers and brought both water rights management and water development into the picture.

Water Rights Commission

The reorganization of the State Board of Water Engineers in 1962 as the Texas Water Rights Commission laid the foundation for the separation of planning and water rights administration. The State permitted the Commission to delegate administrative responsibility for the planning and engineering functions of the agency to the Chief Engineer of the Water Development Board while retaining the permit functions under the Chairman of the Commission.

Major functions of the Water Rights Commission are to grant permits to individuals, local governments, and the Water Development Board for water use, water storage, project construction, and interbasin transfers of water. The Commission conducts feasibility hearings on proposed Federal projects with the assistance of the staff of the Water Development Board. It designates local sponsors for either State or Federal projects after public hearings. It has the responsibility to cancel water permits which have not been put to use during a 10-year period. The Commission can create certain types of water districts, or these districts can be created by acts of the Legislature. To summarize, the Commission continued all of the functions that were not specifically transferred to the Water Development Board.

Water Development Board

In 1957, the Texas Water Development Board was established and was given the responsibility for administering a $200-million bond program. Funds were to be loaned to local governments for projects where no other financing was available. By legislation in 1961, the Water Development Board was permitted to invest in Federal and other projects for water storage purposes. The Board was responsible for preparing the comprehensive State Water Plan.

The Water Development Board has other major responsibilities. It acts as State cooperator in local water development planning with Federal agencies and serves as the State sponsor of Federal projects where no suitable local agency is available. It negotiates with the Federal Government for the inclusion of water storage space in Federal projects. The board may also purchase storage space in local reservoirs to ensure optimum development of the damsites. Finally, the Board may construct reservoirs and necessary facilities required to move water from reservoirs to cities, districts, or other wholesale customers (18).

The water development fund which was approved for $200 million by the voters in 1957 was increased to $400 million in 1966. The massive bond plan of 1969 was rejected. But in 1971, $100 million was approved for local pollution control projects. In 1976, a constitutional amendment was voted on, considering whether to raise the fund from $400 million to a revolving $800 million and removing the present 6-percent interest rate limit on the bonds. Although the funds had been justified by the Water Development Board for municipal and industrial water supply development from instate sources, the amendment was defeated.

In reviewing and evaluating the surface water resource situation in Texas, a most important consideration is conservation storage of a reservoir. Basically, conservation storage of a reservoir is the volume capacity of the space available to store water for subsequent release or withdrawal to serve the needs for beneficial uses. A detailed discussion is presented in Appendix A.

The Texas Water Development Board provides current and historical conservation storage data for selected major Texas reservoirs by river basins. The monthly report is based on 63 reservoirs that represent 95 percent of the total conservation storage capacity in Texas reservoirs having a capacity of 5,000 acre-feet or more. Conservation storage capacity data for the 35 non-Federal reservoirs are presented in Table 1. These reservoirs have a storage capacity of 14,570,070 acre-feet or 48 percent of the total for major Texas reservoirs. The location of Federal and non-Federal reservoirs is shown in Figure 5.

TABLE 1. LOCALLY BUILT, OWNED, OR OPERATED RESERVOIRS IN TEXAS

Name of Lake or Reservoir	Number on Map[1]	Owner and (or) Operator	Conservation Storage Capacity (acre-feet)
Red River Basin		**Red River Basin**	
MacKenzie Reservoir	2	MacKenzie Municipal Water Authority	46,250
Greenbelt Reservoir	3	Greenbelt Municipal and Industrial Water Authority – 62.84 percent Texas Water Development Board – 37.16 percent	58,200
Lake Kickapoo	5	City of Wichita Falls	106,000
Lake Arrowhead	6	City of Wichita Falls	262,100
Sulphur River Basin		**Sulphur River Basin**	
Lake Sulphur Springs	9	Sulphur Springs Water District	13,520
Cypress Creek Basin		**Cypress Creek Basin**	
Lake Cypress Springs	11	Franklin County Water District – 48.4 percent Texas Water Development Board – 51.6 percent	66,800
Sabine River Basin		**Sabine River Basin**	
Lake Tawakoni	13	Sabine River Authority	936,200
Toledo Bend Reservoir	14	Sabine River Authority of Texas and Louisiana	4,472,900
Neches River Basin		**Neches River Basin**	
Lake Palestine	15	Upper Neches River Municipal Authority	411,300
Lake Tyler	16	City of Tyler	73,700
Trinity River Basin		**Trinity River Basin**	
Bridgeport Reservoir	19	Tarrant County Water Control and Improvement District No. 1	386,400
Eagle Mountain Reservoir	20	Tarrant County Water Control and Improvement District No. 1	190,300
Lake Ray Hubbard	25	City of Dallas	490,000
Cedar Creek Reservoir	26	Tarrant County Water Control and Improvement District No. 1	679,200
Lake Livingston	29	City of Houston and Trinity River Authority	1,750,000
San Jacinto River Basin		**San Jacinto River Basin**	
Lake Conroe	30	San Jacinto River Authority – 13.15 percent City of Houston – 66.67 percent Texas Water Development Board – 20.18 percent	429,900
Lake Houston	31	City of Houston	140,500
Brazos River Basin		**Brazos River Basin**	
White River Lake	32	White River Municipal Water District	44,300
Millers Creek Reservoir	33	North Central Texas Municipal Water Authority	45,520
Fort Phantom Hill Reservoir	34	City of Abilene	74,300
Lake Stamford	35	City of Stamford	52,700
Hubbard Creek Reservoir	36	West Central Texas Municipal Water District	317,800
Lake Graham	37	City of Graham	45,000
Possum Kingdom Lake	38	Brazos River Authority	569,380
Lake Palo Pinto	39	Palo Pinto County Municipal Water District No. 1. Operated by City of Mineral Wells	42,200
Lake Granbury	40	Brazos River Authority	151,300
Lake Pat Cleburne	41	City of Cleburne	25,300
Colorado River Basin		**Colorado River Basin**	
Lake J. B. Thomas	48	Colorado River Municipal Water District	202,300
Lake Colorado City	49	Texas Electric Service Company	30,800
Champion Creek Reservoir	50	Texas Electric Service Company	41,600
E. V. Spence Reservoir	51	Colorado River Municipal Water District	484,800
Lake Brownwood	55	Brown County Water Improvement District No. 1	143,400
Lake Buchanan	56	Lower Colorado River Authority	955,200
San Antonio River Basin		**San Antonio River Basin**	
Medina Lake	59	Bexar-Medina-Atascosa Counties Water Improvement District No. 1	254,000
Nueces River Basin		**Nueces River Basin**	
Lake Corpus Christi	60	Lower Nueces River Water Supply District	269,900
Rio Grande River Basin		**Rio Grande Basin**	
Red Bluff Reservoir	61	Red Bluff Water Power Control District	307,000
Total			14,570,070

Source: Texas Water Development Board, *Water for Texas,* Vol. 6, No. 4, April 1976.

[1]Reference is to the map presented in Figure 5.

Notes: Conservation storage capacity is the space available to store water above the level of invert of lowest outlet works and below the level of top of conservation pool or normal maximum operating level.

Conservation storage refers to the volume of water held within the conservation storage space. Not included is any water in flood-control storage (above the top of conservation pool or normal maximum operating level), or any water in so-called dead storage (in the bottom of the reservoir, below the invert of lowest outlet works, and consequently not removable by gravity flow alone).

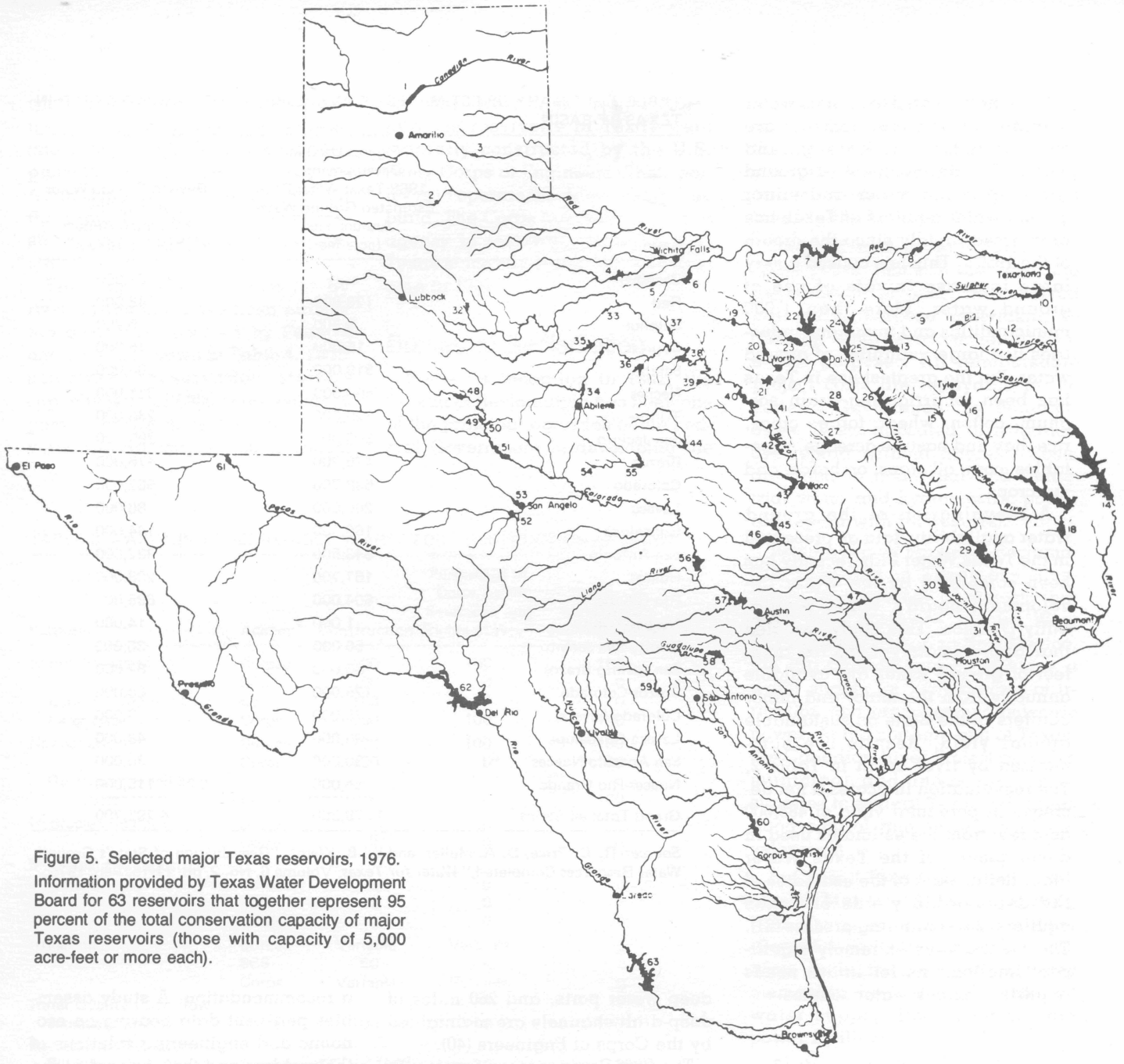


Figure 5. Selected major Texas reservoirs, 1976. Information provided by Texas Water Development Board for 63 reservoirs that together represent 95 percent of the total conservation capacity of major Texas reservoirs (those with capacity of 5,000 acre-feet or more each).

RESERVOIRS SHOWN ON MAP

1. Lake Meredith
2. Mackenzie Reservoir
3. Greenbelt Reservoir
4. Lake Kemp
5. Lake Kickapoo
6. Lake Arrowhead
7. Lake Texoma
8. Pat Mayse Lake
9. Lake Sulphur Springs
10. Wright Patman Lake
11. Lake Cypress Springs
12. Lake O' the Pines
13. Lake Tawakoni
14. Toledo Bend Reservoir
15. Lake Palestine
16. Lake Tyler
17. Sam Rayburn Reservoir
18. B. A. Steinhagen Lake
19. Bridgeport Reservoir
20. Eagle Mountain Reservoir
21. Benbrook Lake
22. Lewisville Lake
23. Grapevine Lake
24. Lavon Lake
25. Lake Ray Hubbard
26. Cedar Creek Reservoir
27. Navarro Mills Lake
28. Bardwell Lake
29. Lake Livingston
30. Lake Conroe
31. Lake Houston
32. White River Lake
33. Millers Creek Reservoir
34. Fort Phantom Hill Reservoir
35. Lake Stamford
36. Hubbard Creek Reservoir
37. Lake Graham
38. Possum Kingdom Lake
39. Lake Palo Pinto
40. Lake Granbury
41. Lake Pat Cleburne
42. Whitney Lake
43. Waco Lake
44. Proctor Lake
45. Belton Lake
46. Stillhouse Hollow Lake
47. Somerville Lake
48. Lake J. B. Thomas
49. Lake Colorado City
50. Champion Creek Reservoir
51. E. V. Spence Reservoir
52. Twin Buttes Reservoir
53. O. C. Fisher Lake
54. Hords Creek Lake
55. Lake Brownwood
56. Lake Buchanan
57. Lake Travis
58. Canyon Lake
59. Medina Lake
60. Lake Corpus Christi
61. Red Bluff Reservoir
62. Intl. Amistad Reservoir
63. Intl. Falcon Reservoir

Intimately related to surface water availability and requirements are characteristics of State ground water. The development of ground water from the major and minor ground water aquifers of Texas has progressed rapidly since the drouth of the 1950's. This has caused a very large increase in rate of use of ground water. More than 1,000 municipalities and numerous industries use large quantities of ground water. But the greatest use in Texas has been for irrigating grain sorghum, cotton, wheat, forage crops, rice, hay and pasture acreage, vegetables, corn, oil crops, orchards, and nut crops.

A reevaluation of the ground water availability data as presented in the Texas Water Plan recently has been completed by the Water Development Board's Water Availability Division. This study revealed that approximately 4,295,700 acre-feet of ground water are available annually from the major and minor aquifers of the State as sustainable annual yield. Results are summarized by river basin in Table 2. The reevaluation indicates a net decrease in perennial yield of 483,600 acre-feet from the estimates used in development of the Texas Water Plan. Refinement of the estimates of the dependable yields of Texas aquifers is a continuing process (21). The results have extremely significant implications for future needs requiring surface water sources.

TABLE 2. SUMMARY OF ESTIMATES OF AVAILABILITY OF GROUND WATER IN TEXAS BY BASIN

Basin	Figures Used in Development of 1968 Texas Water Plan Estimated Ground Water Annual Yield (acre-feet)	Revised Ground Water Availability Estimated Annual Yield (acre-feet)
Canadian	–	91,000
Red	123,600	348,000
Sulphur	5,700	5,700
Cypress	15,000	15,000
Sabine	319,000	98,000
Neches	560,000	311,000
Trinity	326,600	238,000
San Jacinto	500,000	295,000
Brazos	425,200	476,000
Colorado	538,700	562,000
Lavaca	200,000	86,000
Guadalupe	160,300	144,000
San Antonio	343,500	322,000
Nueces	167,700	208,000
Rio Grande	604,000	695,000
Neches-Trinity	1,000	14,000
Trinity-San Jacinto	50,000	36,000
San Jacinto-Brazos	80,000	82,000
Brazos-Colorado	125,000	68,000
Colorado-Lavaca	75,000	8,000
Lavaca-Guadalupe	75,000	48,000
San Antonio-Nueces	30,000	30,000
Nueces-Rio Grande	54,000	115,000
Grand Total all Basins	4,779,300	4,295,700

Source: R. D. Price, D. A. Muller, and W. B. Klemt, "Reevaluation of State's Ground-Water Resources Completed," *Water for Texas,* Volume 6, No. 2, pp. 11-15, Feb. 1976.

Federal Water Agencies

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers entered the Texas water development picture in 1872, concentrating its early efforts on navigation improvements along the Gulf Coast. Today, more than 700 miles of shallow-draft channels comprising the Gulf Intracoastal Waterway and connection channels in Texas, 15 deep water ports, and 260 miles of deep-draft channels are maintained by the Corps of Engineers (40).

The first Corps reservoir project in the State was Denison Dam on the Red River which forms Lake Texoma. Since completion of the Denison project, 28 dam and reservoir projects have been completed by the Corps in Texas. Corps and other Federal cost-sharing is shown in Table 3.

Corps involvement in planning reservoir construction evolves when local interests believe that a need exists for construction or improvement of a water resources project. The local interests petition their congressional representative to direct the Corps to make a survey and a recommendation. A study assembles pertinent data bearing on economic and engineering solutions of the problem and their impact on the environment. Public meetings are held to determine the wishes of local interests. Other agencies concerned with any phase of related resource planning or development are contacted to avoid conflicts and to incorporate joint efforts. Studies may involve an entire river system and require consideration of navigation, flood control, water supply, water quality control, hydroelectric power, drainage, irrigation, recreation, or other purposes.

When the data are analyzed and a determination made of the fullest possible use of the natural re-

sources, the study with its recommendation is submitted to Congress, and if approved, the recommended projects become authorized by an Act of Congress. After authorization, the projects still require congressional appropriations before construction can begin.

The major Texas reservoirs by river basins that have been built or are owned or operated by Federal agencies are shown in Table 4. Their combined conservation storage capacity is 15,387,380 acre-feet, or 52 percent of the State total for reservoirs with capacity of 5,000 acre-feet or more. Most of the larger multipurpose reservoirs in Texas were federally constructed by the U.S. Army Corps of Engineers. Their policy is to operate the dams which they build. The Corps has been the major agency in reservoir construction in Texas since completion of Lake Texoma in 1943.

Bureau of Reclamation

Since its inception in 1902, the Bureau of Reclamation has been one of the principal agencies of the Federal Government in developing the water resources of the West. The Reclamation Act of 1902 authorized the Secretary of the Interior to construct the facilities to develop water for reclamation of arid and semiarid lands in the Western States.

Initiated to encourage farmers to settle public lands in the West, the Reclamation program has evolved into a multipurpose undertaking to develop water resources for all beneficial purposes. All reimbursable project costs are repayable to the Federal Government by beneficiaries. Costs allocated to irrigation are repaid without interest. Costs allocated to municipal and industrial water and hydroelectric power are repaid with interest (12).

Results of past Bureau of Reclamation planning in Texas are illustrated by a number of projects that have been completed. In far West Texas and neighboring New Mexico, the Rio Grande Project provides a water supply for 178,000 acres of irrigation and produces hydroelectric power. At the northern end of Texas, the Canadian River Project provides municipal and industrial water supplies to several Texas cities plus flood control and recreational development.

In Central Texas, the Bureau completed Mansfield Dam, creating Lake Travis on the Colorado River above Austin for the Lower Colorado River Authority. The dam is a key element in the Authority's system of water supply, flood control, and power facilities.

At the southern end of the State, the Bureau designed Falcon Dam and Power Plant on the Rio Grande near Laredo for the International Boundary and Water Commission, which operates the project to provide water supply, flood control, and power for the Lower Rio Grande Valley. Distribution and drainage facilities of several irrigation districts in the Valley have been rehabilitated as part of the reclamation program.

A large part of the Bureau's planning effort in more recent years has been concentrated primarily in investigations of the Columbus Bend,

TABLE 3. MAXIMUM FEDERAL COST SHARES FOR CONSTRUCTION AGENCIES

Purpose	Agency[1]	Construction	Percentage of Costs, Land Easement, and Rights-of-Way[2]	Operation, Maintenance, and Replacement
Flood Protection	Bureau	100	100	100
	SCS	100	0	0
Local Flood Protection	Corps	100	0	0
Large Reservoir	Corps	100	100	100
Navigation	Bureau	100	100	100
	Corps	100	0[3]	100
Recreation; small boat harbors	Corps	50	0	100
Hydroelectric Power	Bureau	0[4]	0	0
	Corps	0[4]	0	0
Municipal and Industrial Water Supply	Bureau	0	0	0
	SCS	50	0	0
	Corps	0	0	0
Irrigation	Bureau	Variable	Variable	0
	SCS	50	0	0
	Corps	Variable	Variable	0
Water Quality (Low flow augmentation)	Corps	100	100	100
Recreation: Fish and Wildlife Enhancement	Bureau	50 and 100[4]	50	0 and 100[5]
	SCS	50	50	0
	Corps	50 and 100[4]	50	0 and 100[5]
Drainage	Bureau	Variable	Variable	0
	SCS	50	0	0
	Corps	50	50	0

Source: National Water Commission, *Water Policies For The Future,* Final Report to the President and to the Congress of the United States, Washington, D.C., June 1973.

[1]Bureau — Bureau of Reclamation; SCS — Soil Conservation Service; Corps — Army Corps of Engineers.

[2]When Federal lands are involved, they are provided to the project without charge.

[3]Costs of lands, easements, and rights-of-way for navigation reservoirs are borne by the Federal Government.

[4]Hydroelectric power users may have benefited from unwarranted allocation of joint construction costs to other project purposes and from repayment arrangements with low interest rates.

[5]The two percentages represent the maximum Federal shares of separable and joint costs, respectively.

TABLE 4. FEDERALLY BUILT, OWNED OR OPERATED RESERVOIRS IN TEXAS

Name of Lake or Reservoir	Number on Map[1]	Owner and (or) Operator	Conservation Storage Capacity (acre-feet)
Canadian River Basin		**Canadian River Basin**	
Lake Meredith	1	Canadian River Municipal Water Authority. Built by U.S. Bureau of Reclamation	821,300
Red River Basin		**Red River Basin**	
Lake Kemp	4	Owner — City of Wichta Falls and Wichita County Water Improvement District No. 2. Design Engineer — U.S. Army Corps of Engineers for rebuilt dam.	319,600
Lake Texoma	7	U.S. Army Corps of Engineers	2,722,300
Pat Mayse Lake	8	U.S. Army Corps of Engineers	124,500
Sulphur River Basin		**Sulphur River Basin**	
Wright Patman Lake	10	U.S. Army Corps of Engineers	142,700
Cypress Creek Basin		**Cypress Creek Basin**	
Lake O' the Pines	12	U.S. Army Corps of Engineers	252,000
Neches River Basin		**Neches River Basin**	
Sam Rayburn Reservoir	17	U.S. Army Corps of Engineers	2,876,300
B. A. Steinhagen Lake	18	U.S. Army Corps of Engineers	94,200
Trinity River Basin		**Trinity River Basin**	
Benbrook Lake	21	U.S. Army Corps of Engineers	88,200
Lewisville Lake	22	U.S. Army Corps of Engineers	464,500
Grapevine Lake	23	U.S. Army Corps of Engineers	187,700
Lavon Lake	24	U.S. Army Corps of Engineers	129,300
Navarro Mills Lake	27	U.S. Army Corps of Engineers	60,900
Bardwell Lake	28	U.S. Army Corps of Engineers	53,580
Brazos River Basin		**Brazos River Basin**	
Whitney Lake	42	U.S. Army Corps of Engineers	622,800
Waco Lake	43	U.S. Army Corps of Engineers	151,900
Proctor Lake	44	U.S. Army Corps of Engineers	59,300
Belton Lake	45	U.S. Army Corps of Engineers	457,300
Stillhouse Hollow Lake	46	U.S. Army Corps of Engineers	234,900
Somerville Lake	47	U.S. Army Corps of Engineers	160,100
Colorado River Basin		**Colorado River Basin**	
Twin Buttes Reservoir	52	U.S. Bureau of Reclamation	177,800
O. C. Fisher Lake	53	U.S. Army Corps of Engineers	119,200
Hords Creek Lake	54	U.S. Army Corps of Engineers	8,600
Lake Travis	57	Lower Colorado River Authority	1,144,100
Guadalupe River Basin		**Guadalupe River Basin**	
Canyon Lake	58	U.S. Army Corps of Engineers	385,600
Rio Grande Basin		**Rio Grande Basin**	
Intl. Amistad Reservoir (Texas)	62	Owner — United States and Mexico. Operated by International Boundary and Water Commission. Built by U.S. Army Corps of Engineers and International Boundary and Water Commission	1,965,500
Intl. Falcon Reservoir (Texas)	63	Owner — United States and Mexico. Operated by International Boundary and Water Commission. Built by U.S. Bureau of Reclamation and International Boundary and Water Commission	1,563,200
Total			15,387,380

Source: Texas Water Development Board, *Water for Texas,* Vol. 6, No. 4, April 1976.

[1]Reference is to the map presented in Figure 5.

Notes: Conservation storage capacity is the space available to store water above the level of invert of lowest outlet works and below the level of top of conservation pool or normal maximum operating level.

Conservation storage refers to the volume of water held within the conservation storage space. Not included is any water in flood-control storage (above the top of conservation pool or normal maximum operating level), or any water in so-called dead storage (in the bottom of the reservoir, below the invert of lowest outlet works and consequently not removable by gravity flow alone).

Cuero, Palmetto Bend, and Texas Basin Projects (5).

Soil Conservation Service

Three Acts of Congress provide the authority under which the Soil Conservation Service (SCS) provides the technical and financial assistance on structural measures in watershed programs. The Flood Control Act of 1944 approved operations on 11 major watersheds. Included in Texas are the upper 8¼ million acres of the Trinity River, the 5-million-acre segment of the Colorado River of Texas known as the Middle Colorado, and the Washita River which heads in Texas and flows through Oklahoma into the Red River.

In the 1953 Appropriation Act for the Department of Agriculture, Congress authorized the SCS to plan and carry on a construction program in approximately 60 small watersheds, generally ranging from 20,000 acres up to 100,000 acres in size. Four of these are in Texas. They are the Green Creek, a tributary of the Bosque in Erath County between Dublin and Stephenville; Cow Bayou, a tributary of the Brazos between Waco and Temple; Escondido Creek in Karnes County; and Calaveras Creek in Bexar County. The latter two are tributaries of the San Antonio River.

The third piece of legislation is Public Law 566, the Watershed Protection and Flood Prevention Act passed by the 83rd Congress and amended by the 84th and 85th Congresses. As now amended, the Act provides for works of improvement for flood prevention, including structural and land treatment measures, and for conservation, development, utilization, and disposal of water in watersheds not exceeding 250,000 acres and not including any single structure which provides more than 5,000 acre-feet of floodwater detention capacity and more than 25,000 acre-feet of total capacity. Improvement works may be included for flood prevention, irrigation and drainage, municipal and industrial water supplies, streamflow regulation, fish and wildlife improvement, recreation, and saline water intrusion control.

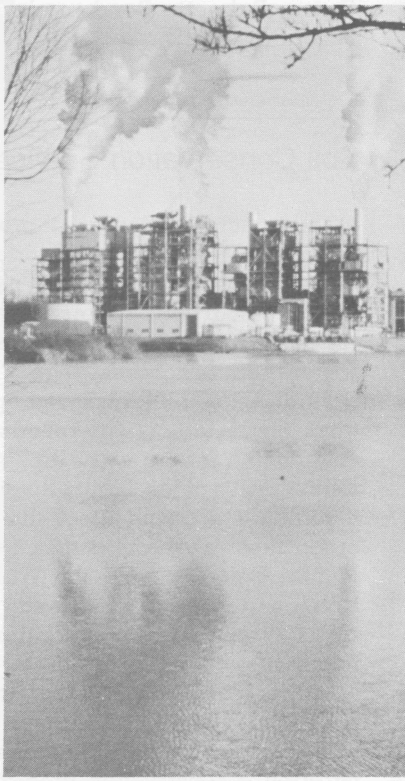
This is the only legislation under which any new project can be undertaken with financial or technical assistance of the U.S. Department of Agriculture. These projects are not Federal but local. Projects must be initiated and carried out by local subdivisions of the State government.

The local organizations must acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the improvement works installed with Federal assistance. They must award and administer contracts for all structures. They also must assume a proportionate share of the costs of installing any improvement works involving Federal assistance which is applicable to the agricultural phases of the conservation, development, utilization, and disposal of water or to fish and wildlife conservation. This share is that determined by the Secretary of Agriculture as equitable in consideration of direct identifiable benefits.

The Federal Government will pay all costs for construction applicable to flood prevention. The local organizations must pay all costs for installing improvements for municipal and industrial water, recreation, streamflow regulation, and saline water intrusion control. The local organizations also must arrange to pay operating and maintenance costs of the improvement works. They must obtain necessary water rights, obtain agreements for the carrying out of recommended soil conservation practices on 50 percent or more of the farm land in the drainage area, and make satisfactory arrangements for repaying loans from the Federal Government.

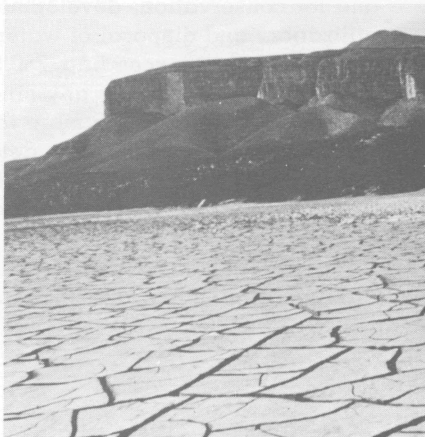
All work of the SCS, except technical assistance in the Agricultural Conservation Program and the Conservation Reserve of the Soil Bank Act, is performed in cooperation with and through subdivisions of State government. These include soil conservation districts, water control and improvement districts, drainage and levee districts, and conservation and reclamation districts, river authorities, counties and municipalities, singly or in combination.

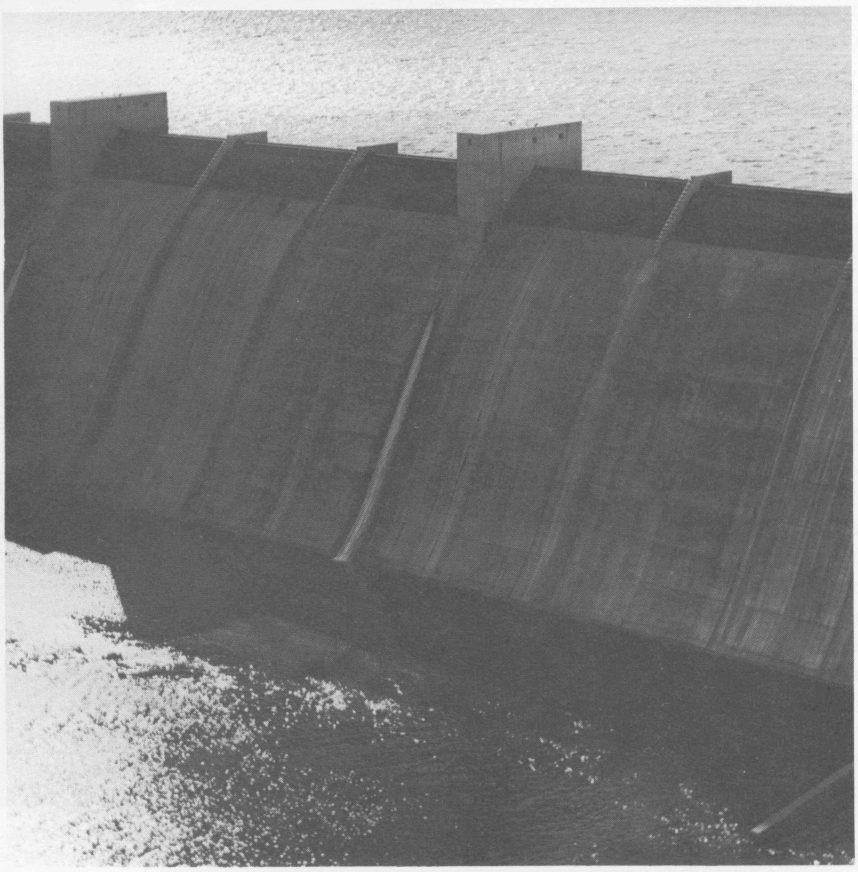
Public Law 566 requires that a State agency must approve a watershed application before Federal assistance can be provided. The State Soil Conservation Board has been designated as this agency in Texas. The Board also recommends to the State Conservationist priorities for planning assistance (17).



In the past, Texas citizens generally have been able to live wherever they chose without concern for the availability of water. But as the State becomes more urbanized and industrialized, her developable water resources become more and more limited.

The Texas Water Development Board's published estimates show an annual yield of ground water for all Texas river basins of 4.3 million acre-feet per year. By comparison, the Board shows annual use of ground water for irrigation alone to exceed 10.0 million acre-feet. Other uses increased the annual deficit by millions of acre-feet. This has critical implications relative to future demands on the surface water resources of the State.



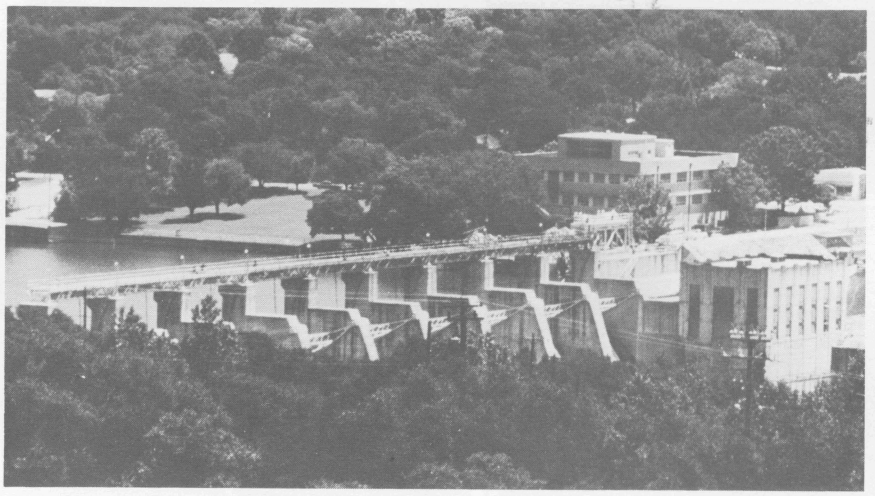


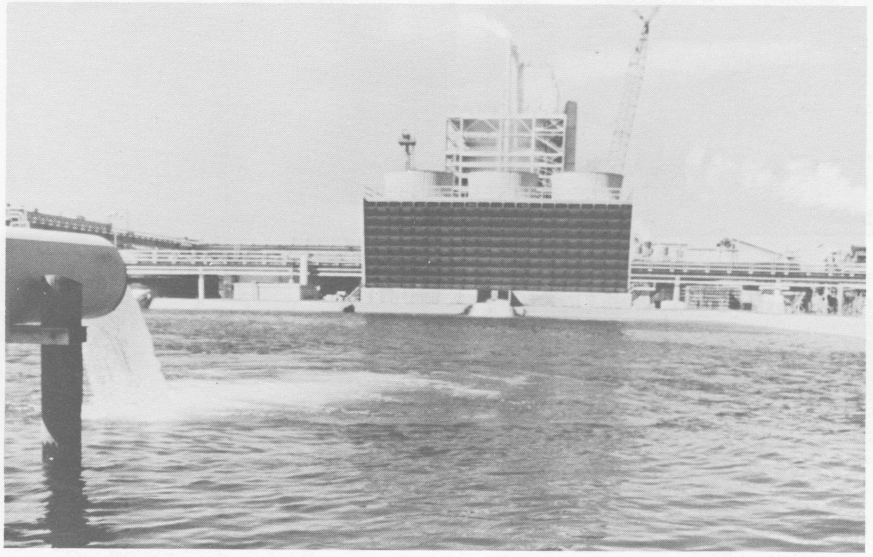
Priority Water Uses

The purposes for which water may be appropriated were established by the Legislature in 1913 as irrigation, mining, milling, manufacturing, development of power, city water uses, and livestock raising. The preference list devised in 1931 to guide the Water Rights Commission provided the following order for all streams in the State of Texas with the exception of the Rio Grande: 1. domestic and municipal uses, including water for sustaining both human and domestic animal life; 2. water to be used in processes designed to convert materials of a lower order of value into forms having greater utility and commercial value and to include water necessary for the development of electric power by means other than hydroelectric; 3. irrigation; 4. mining and recovery of minerals; 5. hydroelectric; 6. navigation; and 7. recreation and pleasure (31).

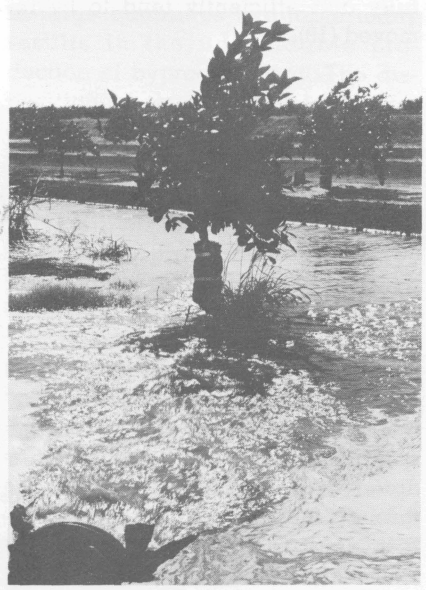
Municipal and Industrial Development

From the earliest days of the Nation, cities and industries have provided their own water supplies. This policy was recognized by the Congress, and several laws contain statements to the effect that the Federal Government will confine itself to a secondary role in this field. In recent years, a tendency for increasing the Federal role in the provision of municipal and industrial water has emerged, similar to the Federal domination in the field of pollution control. Problems of coordination have occurred among public agencies in the planning and financing of water resource development. In some situations, municipal and industrial water supplies have been used or priced with less than maximum effectiveness.





The interest of different water users are often in direct or indirect competition for the use and benefits of the various water and related land resources in the State.



Various legislative attempts to make possible the use of Federal reservoirs to supply municipal and industrial water culminated in the Water Supply Act of 1958 which established a uniform policy for the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. Under this policy, these agencies may provide additional capacity for municipal and industrial water in reservoirs to be constructed primarily for other purposes. All construction costs of storage for present or anticipated future demand must be repaid, with interest, by State or local agencies. No payment for storage costs for future supply need be made until the supply is first used. An interest-free period of up to 10 years is allowed on storage costs as long as that supply is not used. No more than 30 percent of the costs of the project may be allocated to storage for future supply (19).

Capacity for water supply also may be included in reservoirs constructed under the PL 566 program of the Soil Conservation Service. Non-Federal interests must repay all storage costs for future supply and at least one-half the storage costs for present supply needs. Provision is made for postponement of storage cost payments for future supply and for an interest-free period of up to 10 years as indicated in the preceding paragraph.

The grant agencies also provide Federal cost-sharing for storage and conveyance of municipal and industrial water. Housing and Urban Development and Farmers Home Administration provide up to 50 percent of construction and land-rights costs. The Economic Development Administration may supplement other grants up to a maximum of 80 percent of construction costs. Operation and maintenance is a non-Federal responsibility.

The Water Resources Planning Act of 1965 authorized the formulation of comprehensive plans for major river basins or other regions. Municipal and industrial water supply needs are to be taken into account in the preparation of these plans. The Act provides for financial assistance to the States to enable them to play a more effective role in plan preparation. It also provides for coordination by the Water Resources Council.

Municipal water supply systems provide water for domestic purposes, commercial uses, fire protection, street flushing, and lawn and garden irrigation, and in many cities for industrial use. In addition, much water is lost from some systems by leakage. Most industrial water is self-supplied and is used by a relatively small number of firms in five major industries — food, paper, chemicals, petroleum, and metals (19).

Dams and reservoirs that are authorized for municipal and industrial water supply purposes are summarized in Appendix Tables 1 and 2. Several of these dams are owned by the U.S. Corps of Engineers, and many others are owned by cities and other public entities.

H. P. Burleigh, the former Executive Director of the Texas Water Development Board, in 1975 summarized the changing circumstances in financing municipal and industrial water supplies (6). In 1957, the Legislature and the Texas electorate approved the Texas Water Development Fund of $200 million for that purpose. Subsequently, this sum was increased from $200 million to $400 million.

Burleigh pointed out that river authorities, municipalities, water districts, and State water agencies exercise the dominant role in developing Texas municipal and industrial water supplies. During past years, about 80 percent of the money invested in Texas water projects has been supplied by State and local governments. He anticipated that the percentage of State participation in future water supply projects will be at still higher rates with continued decline in Federal financing (6).

Past use of the Texas Water Development Board funds for water supply projects has been a material aid to the State in developing its water supply sources, according to Burleigh. The fund has aided some 72 water supply projects with $215.7 million and has catalyzed the investment of an additional $160.6 million from local interests. Projects aided are expected to pay their own way, and no water project aided by

the Water Development Fund is currently in default. Burleigh emphasized that State and local entities will have to undertake the larger types of water projects. Technical and financial resources are available to develop any necessary type of required municipal and industrial water project (6).

Irrigation

The earliest record of irrigation in Texas is that reported by the Spanish explorer Coronado who found Indians irrigating crops in the vicinity of the present city of El Paso in 1541. The statewide trend in irrigated acreage has been upward since the first historical developments, but the increase has occurred at variable rates. By 1974, the area irrigated in the State had increased to 8.6 million acres, according to the 1974 irrigation inventory (30). Irrigated acres by river basin and source of water are presented in Appendix Table 3.

Ground water was used for irrigating about 82 percent of the land irrigated in Texas in 1974; 15 percent was irrigated from surface water supplies and 3 percent from mixed supplies of ground and surface water. The Texas Water Development Board (30) reports the leading counties in 1974 for surface water irrigation to be the following:

More than 60 percent of the acreage in Texas irrigated by surface water in 1974 was in the Lower Rio Grande Valley, in Cameron, Willacy, Hidalgo, and Starr Counties. Most of the water used for irrigation was obtained from the Falcon Reservoir on the Rio Grande. The other major irrigation area using surface water is the Gulf Coast Prairie. Leading surface water irrigation counties in the Gulf Coast Prairie are Jefferson, Brazoria, Chambers, Colorado, Liberty, Matagorda, and Wharton. Maverick County in the Middle Rio Grande Valley is the remaining county in the top twelve which together comprise 82 percent of total surface water irrigation in Texas (30).

Total acres irrigated by surface water in Texas have changed comparatively little in the summaries published by the Texas Water Development Board for 1958, 1964, 1969, and 1974. Acres irrigated have increased only from 1,126,521 in 1958 to 1,272,397 in 1974. Acre-feet applied were virtually unchanged at 2,170,313 in 1958 and 2,186,062 in 1974. During the same period, and primarily in other areas of the State, use of ground water for irrigation increased substantially (30).

Dams and reservoirs authorized for irrigation are listed in Appendix Table 4 (29). Acre-feet authorized for irrigation from these reservoirs greatly exceed the actual usage. The correlation between the use of irrigation as a reason for reservoir construction and the subsequent use of the impounded water for irrigation purposes is not high.

A historical problem with Federal water resources development projects for irrigation has been the extent of subsidization by the Federal Government. The water users on some modern reclamation projects repay no more than 10 to 15 percent of the construction costs attributable to irrigation. The remaining cost is borne in part by the Federal Government by not requiring the water users to pay interest on the capital advanced for project construction. Power and other non-irrigation revenues also are credited toward irrigation reimbursement, and an unduly large part of the costs are allocated to nonreimbursable purposes. Finally, water projects that result in large increases in the production of certain commodities have been undertaken with little or no consideration of the demand for those commodities (19).

The National Water Commission recommends that irrigation users served by new Federal projects pay the full costs of water supply. This should result in a lower total cost to society because it will improve efficiency in the use of irrigation water and related resources. When irrigators receive water on a subsidized basis, incentives to use water carefully and efficiently tend to be removed (19).

County	*Acres*		*Acre-feet*	
Hidalgo	378,650		513,317	
Cameron	287,445		392,245	
Jefferson	69,470		173,675	
Brazoria	50,399		134,397	
Chambers	50,105		125,262	
Maverick	41,100		97,600	
Willacy	37,723		53,896	
Colorado	28,710		114,720	
Liberty	26,274		65,687	
Starr	25,576		26,155	
Matagorda	22,401		89,604	
Wharton	19,910		59,730	
12 Counties	1,037,763	82%	1,846,288	84%
Texas	1,272,397	100%	2,186,062	100%

Mining

In 1968, the Texas Water Development Board indicated that water used in Texas for mining was almost entirely for petroleum production. Sand and gravel operations and recovery of other minerals used minor amounts of water. Their calculations indicated an estimated cumulative total of several million acre-feet of water required in Texas through the year 2020 for secondary recovery of oil. Brackish, saline, or fresh water can be used for injection

operations. The choice is usually determined by the economics of water supply and operation and maintenance costs. The largest reserves of oil in Texas potentially recoverable by water injection are in arid areas of the State. Water for most mining needs will largely be met by local surface and ground water resources (34).

Only 7 of the 63 major reservoirs have allocations of water for mining purposes (Appendix Table 5). The allocations are small in comparison to those for other uses. Lignite development may require increased allocations of water in the future. It seems likely that these needs will be met largely with ground water and smaller reservoirs.

Hydroelectric Power

Electric power requirements in Texas are increasing at a rate which requires a doubling of electric generating facilities about every 7 to 9 years. For many years, natural gas has been the principal fuel for power generation in Texas. But natural gas is no longer available for this purpose in the quantities that are needed. The utilities are now turning to coal and lignite and will also be using nuclear energy for power production. The choice of fuels depends upon a number of factors, the most important of which are cost and the reliability of the supply (20).

Every method of generating power in large quantities available today results in the unavoidable production of byproduct heat. The disposition of this low-level heat requires the use of water as a heat transfer and cooling medium. This use is also significant to water conservation in Texas because the method of cooling determines the amount of water consumed as a result of a powerplant's operation (20).

It is recommended that future powerplants use existing reservoirs or ponds whenever possible for cooling, since this creates the least additional environmental disturbance and a minimum additional consumption of water. New cooling reservoirs may be built as multiple-purpose projects which provide water for other uses, such as municipal water supply, flood control, or recreation, in addition to powerplant cooling. Because of their generally inadequate flow, using rivers for once-through cooling is undesirable in Texas and will be avoided. Using cooling towers supplied by fresh water is also undesirable because of their greater consumption of water (20).

A small amount of power is produced by hydroelectric plants, but because surface water is limited, hydroelectric plants in Texas are used in most cases for peaking or emergency purposes (20). The 11 dams and reservoirs authorized for electrical power generation in Texas are presented in Appendix Table 6.

Electric power generated by Corps of Engineers or Bureau of Reclamation projects is generally sold at prices sufficient to recover all project costs allocated to power, including interest. On Federal reclamation projects, power revenues in excess of costs have been used to repay interest-free costs allocated to irrigation. In some projects, power users have benefited from joint costs allocated to such non-reimbursable purposes as flood control or navigation (19).

Navigation

The Federal Government carries the dominant responsibility for planning, constructing, and paying for navigation improvement. It considers a narrow range of alternatives, restricts its research chiefly to methods of channel modification, and relies upon private shippers for technological innovations. The economic analysis is rather rigidly formulated. The primary public constraints are regulating the channels and common carriers. Just how much effect the improvements have had on the economy is difficult to assess. There has been a tendency to ignore side effects, which have been variable (44).

Navigation was important to exploration and early development in Texas. Major rivers, flowing roughly parallel courses from northwest to southeast, provided early routes from the coast to the interior. Subsequent advances in overland transportation slowed river navigation development, except in the tidewater area along the Gulf.

Texas now has 12 ports for deep-draft (30 to 40 foot) vessels and 13 shallow-draft (6 to 14 foot) ports. The intracoastal waterway connects the entire coastal area with a protected shallow-draft route between Texas and other Gulf and south Atlantic ports. The Houston Ship Channel enables this inland area to receive and ship the third largest tonnage of all U.S. seaports.

Continued expansion of coastal facilities for domestic and overseas commerce has accelerated efforts to connect inland industrial areas with them by development of Texas rivers for navigation. Navigation on the Trinity and Red Rivers has been authorized. Proposals have been made for studies on other streams to determine the economic and engineering feasibility of navigation (33).

Recreation

Outdoor recreation has experienced a phenomenal boom in the past two decades. This results mostly from the general increase in leisure time for the average American, improved mobility, greater urbanization, and a generally prosperous economy. The manufacture of goods, transportation of persons and supplies, provision of facilities, and consumption spending for outdoor recreation place it among the top 10 major economic activities of the Nation (19).

The Federal Water Project Recreation Act of 1965 was intended to encourage the States and other non-Federal public entities to assume responsibility for developing recreational potentials created by Federal reservoirs. For any particular Federal water project, the responsible Federal agency is authorized to bear 50 percent of the "separable" cost of providing recreational facilities and to make available Federal lands for the use of non-Federal entities agreeing to operate and maintain these facilities.

All "joint" costs allocable to recreation are borne entirely by the Federal Government.

Only a few non-Federal entities have taken advantage of the terms of the Act. If non-Federal interests do not accept responsibility for recreational development, the responsible Federal agency must bear the cost of developing "minimum facilities that are required for the public health and safety" and that are accessible by roads previously in existence or otherwise necessary for project construction (19).

Although the Soil Conservation Service is primarily a land conservation agency, it is also a reservoir construction agency in connection with the PL 566 program. The SCS assists non-Federal entities to develop recreational potentials created by PL 566 and bears 50 percent of the construction cost thereof, including land rights. For the remaining cost, Federal recreation funds have been used for only about 2 percent of the PL 566 reservoirs.

At flood-control and navigation projects other than reservoir projects, the Corps encourages non-Federal development of recreational potentials by leasing lands without charge and by paying up to 50 percent of development costs if a non-Federal entity will agree to operate and maintain the development. In the case of small-boat harbor projects, the Corps requires non-Federal interests to make cash contributions equal to 50 percent of those harbor costs allocable to recreation and to provide lands, easements, rights-of-way, spoil disposal areas, and onshore facilities.

The costs of major fish and wildlife facilities that remain under Federal administration in connection with a Federal water project or a national wildlife refuge are borne entirely by the Federal Government. If costs are incurred to improve the fish and wildlife resource for recreational purposes, the Federal Government pays 50 percent of separable costs and 100 percent of joint costs allocable to recreation (19).

If maximum benefits are to be derived from recreational development on new Federal reservoirs, the States must consider one of the following alternatives: 1. The State legislatures must increase appropriations for recreation to provide one-half the cost of developing the facilities and all of the operating funds; 2. States must begin charging user fees to provide the funds necessary for cost-sharing in recreational development; or 3. A combination of increased legislative appropriations and user fees must be used to provide the needed funds for recreational facilities (1).

Reluctance of State and local bodies to share in Federal reservoir recreation costs is due to Federal agency control, shortage of local financial resources for recreational purposes, and distortion of local recreational programs which can be caused by financing such major projects as those of the Corps. Because local bodies are reluctant to finance recreation for use by people outside their respective taxing jurisdictions, they desire to have projects taken over by Federal agencies that have broader tax bases. Local bodies also are unwilling to spend local money on Federal land that must remain in Federal ownership. Another consideration is that Federal reservoirs are not always prime recreational assets (19). A State may refuse to participate in the recreational development of new Federal reservoirs under PL 89-72, in which case the likelihood of recreational development is almost nonexistent (1).

Admission and user fees have been in effect in varying degrees at numerous Federal reservoir recreational areas since the Land and Water Conservation Fund first took effect in 1965. The fee system under the Fund Act has not worked well. Collections have underrun projections; there has been little consistency between agencies in designating areas and length of charge season; the honor system has failed; collection costs per dollar of receipts have varied greatly between agencies from minimal to equaling or exceeding receipts. Willingness to try to make a fee system work has varied by agency, and local public oposition to Federal recreation fees has varied. In general, the fee system since 1965 can be classed as a failure and a disappointment (19).

Federal construction agencies such as the Corps of Engineers are construction oriented. They are thus limited in competent and dedicated resource or recreation-management personnel. These staff have little influence on policy and do not occupy top positions. Fundamentally, the construction agencies are managers of neither people nor resources. Within the Corps, for example, several basic management problems are apparent, including inadequate recreation planning and inadequate coordination between construction and land acquisition, lax administration of existing facilities, inadequate facilities, lack of interpretive facilities, and lax enforcement of regulations (19).

Flood Control

The objective of flood-control works to prevent flood damage is accomplished by constructing either reservoirs or channel improvements, or combinations of both. In a reservoir project, flood waters are stored in the reservoir and later released at a nondamaging rate. Flood-control improvements often include multipurpose reservoirs for flood control and water conservation. Benefits from these reservoirs include the prevention of flood damages and the conservation of water for such purposes as municipal and industrial use, navigation, power, preservation of fish and wildlife, and recreation (39).

To serve their purpose of regulating flows and supplying water for beneficial uses, reservoirs have fluctuating pool levels. It is not feasible to attempt to hold for beneficial uses all flood flows. Water temporarily stored in the flood-control pool is released as rapidly as practicable to provide the necessary storage space for subsequent floods. The water in the conservation pool, which is held until needed, will also fluctuate, since the level will drop during

drouths when the withdrawals exceed the rate of replenishment for extended periods (39).

The Federal Flood Control Act of 1936 brought two important changes in the Nation's approach to flood problems. First, it recognized the problems as national in scope and placed major responsibility with the Federal Government. Second, it resulted in policies which placed primary reliance on flood-control structures (15).

Since 1936, the national approach to flood problems has been to assume the major obligation to protect developed areas from damaging floods. In addition, Federal agencies have cooperated with National, State, and local groups in providing relief and rehabilitation assistance at times of flood disasters. The techniques used in the flood-control acts have been essentially building engineering structures — channel improvements, canals, dams, dikes, walls, and levees (15).

Despite a cumulative, massive investment, the estimated annual losses from floods continue an upward climb. Structural measures have not kept pace with the rapidly growing flood problems (17). Building is taking place in flood-vulnerable areas faster than the areas are being protected. Physical protection may be justified for some of the areas. Many flood-prone areas are largely undeveloped and have not yet reached the stage of development that would justify the construction of flood-control works.

The passage of the National Flood Insurance Act of 1968 was another step in the advancement of flood plain management. The adoption of local flood plain regulations which meet the criteria of the Department of Housing and Urban Development is a prerequisite to obtaining subsidized flood insurance under the Act. This flood insurance program has been expanded and changed under the Flood Disaster Protection Act of 1973. The significance of the law is that it requires communities having identified flood-prone areas to participate in the flood insurance program or become ineligible for federally related financing (41).

The National Water Commission in its Final Report in 1973 recommends new cost-sharing policy for Federal and federally assisted water development including flood control as follows:

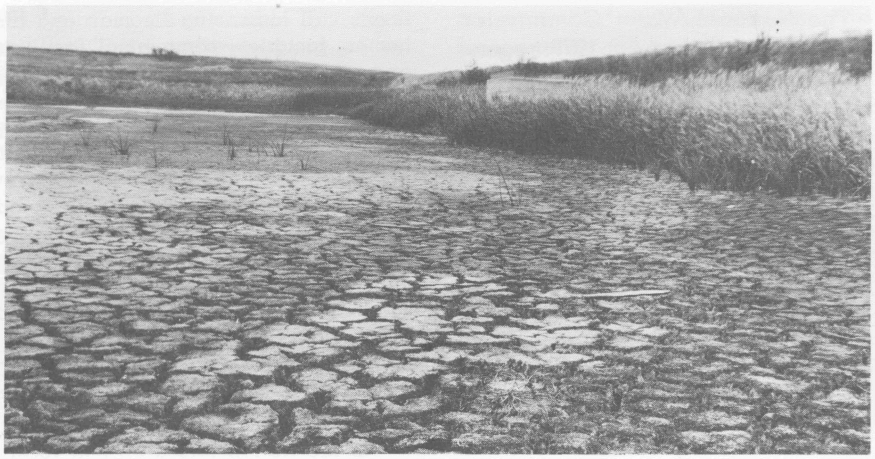
> "Flood Control, Drainage, and Shoreline Protection, Including Hurricane Protection — Costs of Federal or federally assisted projects providing such benefits as protecting lands through flood control, drainage, and shoreline protection, including hurricane protection, should be recovered from identifiable beneficiaries through local units of government such as municipalities, flood control, drainage, or shoreline protection districts that have power to make assessments upon lands benefited by the projects, or through State governments because of their critical role in determining flood plain management, with interest equal to prevailing yield rates on long term U.S. Treasury bonds outstanding at the time of construction." (19, p. 498).

Developed flood-control capacities of the major Texas reservoirs are summarized in Appendix Table 7. Flood control cost-sharing varies with the types of facilities constructed. With respect to major reservoirs, flood-control costs, including operation and maintenance, are borne entirely by the Federal Government. The policy is the same on minor reservoirs except that the Corps of Engineers may recommend that non-Federal interests be required to provide land, easements, and rights-of-way if the reservoir is clearly in lieu of a local protection project. Hurricane protection projects under Corps policy require at least 30 percent cost-sharing for construction and local assumption of all project operation costs. Under the PL 566 program, the Soil Conservation Service pays all construction costs allocated to flood control (19).

One panel of the National Conference on Water held in April 1975 considered flood damage reduction (42). The statement of the continuing problem of flood plain development and flooding describes the present situation in Texas and the United States.

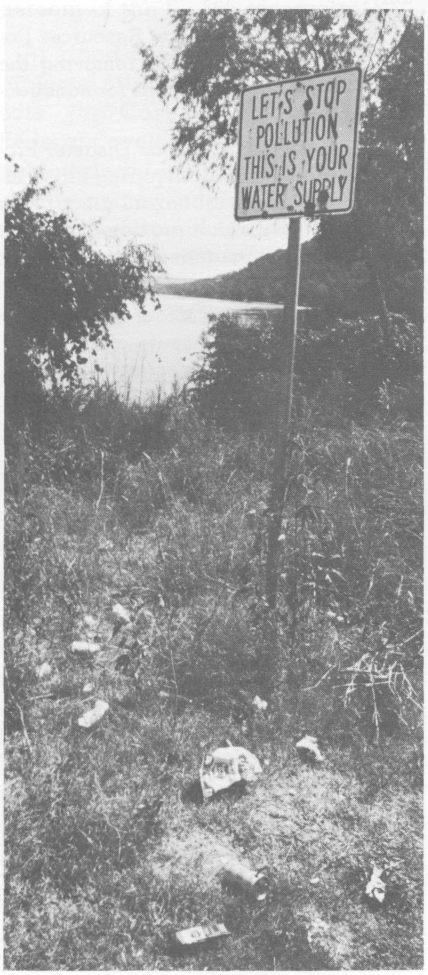
> "After nearly 40 years of concerted national attack on the flood problem in the United States, we find the exposure to floods still increasing for man and his homes, factories, commercial facilities and communication lines. In addition, the costs to the Nation are rising for adjustments to floods, and the vulnerability to catastrophe is increasing. The billions invested in reducing flood losses over this period have, on the whole, repaid themselves. But these investments have not prevented continued, unnecessarily vulnerable settlement of flood plains, in some cases adjacent to already protected areas. Nor have the investments in protective measures prevented the rising demands on all governmental levels for disaster relief.
>
> "As the Nation has grown in recent years, the structural options for reducing the level and extent of floods have dwindled, while the costs of structural measures have risen sharply. From an economic standpoint alone, traditional flood control projects are becoming increasingly more difficult to justify, while environmental concerns often reduce even further the feasibility of such solutions. The U.S. Congress has responded to this realization by a number of enactments intended to reduce the unnecessary costs of floods, most noticeably:
>
> 1. Section 73 of the Water Resources Development Act of 1974, removing the cost-sharing prohibitions for nonstructural solutions.
> 2. Section 102 of the Flood Disaster Protection Act of 1973, requiring Flood Insurance in special hazard areas. Also Section 201, which provides for sanctions for communities not qualifying for insurance.
> 3. Sections 314 and 406 of the Disaster Relief Act Amendments of 1974. Section 314 requires insurance for properties receiving disaster relief; Section 406 requires evaluation and mitigation of natural hazards as a condition of any disaster loan or grant made under provisions of the Act.
>
> "The net effect of these provisions is not yet clear. What is clear is their general intent to slow the growth of incompatible and unnecessarily hazardous development on flood plains." (42, p. 50)

This is evidence of a national policy to keep economic development out of the flood plains. Management is to take the place of structural solutions as a means of controlling flood losses. Flood prevention on intrastate rivers and smaller streams will increasingly become the responsibility of the landowners involved (17).



The wise use of available water resources is vital.

Future Water Development



Texas Water Development Funds have been approved in the past by the Legislature and the electorate. Using these funds for water supply projects has been of substantial aid to the State in developing its water supply sources. To date, the fund has aided, in cooperation with local interests, the development of more than 70 water supply projects. These projects pay their own way. No water project aided by the Water Development Fund is in default. As amortization of one set of projects occurs, the payments become available for reinvestments in new projects. Present and new expenditures contemplated from State funds are for the development of municipal and industrial projects within the State with instate water. Technical and financial resources are available in Texas to develop any type of required municipal and industrial project. It is anticipated that the State will have to rely upon its own resources for developing many more projects, regardless of size (6).

The Texas Water Development Board indicated at its May 1975 meeting that it will presently make no changes in its policy of constructing dams and reservoirs in advance of need unless it gets a directive from the Legislature to change its policy. Thus far, it was indicated by the Board Director that "development of Texas water resources had been rocking along just ahead of need — about 15 to 18 years ahead." He indicated that the Board had been able to keep ahead of the need by financing projects when a need is shown and when there is someone to pick up the cost of the bonds used to finance the projects (28, p. 9).

On March 16, 1976, the Texas Water Development Board (32) adopted a broad policy statement relating to water resource development and current problems and needs. The Board indicated its willingness to consider applications for financial assistance for worthwhile projects. Qualified projects must be financially sound and in the public interest. Cost must exceed the financing capabilities of the sponsor, and the proposed facilities must provide optimum development of the site. Any single project costing in excess of $35 million must have approval by concurrent resolution and adoption by a majority of each house of the Legislature as a single project or as part of a statewide water plan. Proceeds from sale of bonds cannot be used for developing water resources of the Mississippi River. Texas water planning will be appropriately coordinated with other State and Federal programs of importance to Texas. The complete Board statement is quoted in Appendix B (32).

Some attitudes of the Board relate to problems of a continuing nature. State and Federal wildlife agencies are trying to use a new Federal wetlands protection program to get State reservoir builders to provide for mitigation of their wildlife damages. Reservoirs increase lake fishing opportunities for the public, but they reduce stream fishing and land habitats for all birds and animals (32).

Lakes as well as other stream alteration projects now require Corps of Engineers permits, even when built by cities or river authorities. They come under the Federal environmental review process and

the Federal requirement that mitigation lands be provided for the public when wildlife habitat is destroyed. The Texas Water Development Board policy statement recommends that on non-Federal projects, the Texas Parks and Wildlife Department should provide adequate recreational and park facilities as well as wildlife management areas determined necessary for habitat loss due to construction of water supply projects. This position is in line with State law and past State practices but may be contrary to Federal law (32).

Under the Fish and Wildlife Coordination Act, the Texas Parks and Wildlife Department must be consulted concerning federally funded or licensed water development projects. Its role is principally factfinding — to inventory species, to evaluate the status of fish and wildlife habitat, and to assess the probable effects of project construction. The Department has no power to require or condemn land for mitigation and no funds to support a large program of intensive management of mitigation lands. The Coordination Act states further that costs of mitigation will be defrayed by the construction agency. The construction agencies, however, are opposed to increasing the cost of water resource projects to cover mitigation. Additional legislation or changes in policy may eliminate this apparent impasse (35).

A general problem of allocating Texas' water resources among competing uses and users over time exists. This problem has been growing in intensity in recent years. It touches upon both the quantity and the quality aspects of waters in surface streams, in underground aquifers, and in coastal estuaries. There are considerations of market values for purposes of agriculture, recreation, industry, manufacturing, food processing, and electrical generation. There are also problems of such extra market values as public health, recreation, fish and wildlife, esthetic, cultural, and others.

Both public and private entities are involved including commercial agriculture and industrial enterprises, environmental organizations, and the general public at large. Often these interests are in direct or indirect competition for the use and benefits of various water and related land resources in the State. Interrelationship between multiple uses of a single resource and across different types of resources is usually involved. These may be competing, complementary, or independent of each other. Conditions may change over time and become more or less satisfactory (45).

Examples include the multiple uses of Galveston Bay and its adjoining watershed; the many users of the underground aquifer under Houston for municipal, industrial, and irrigation water supplies; the discharge of wastes into coastal waters; the multiple uses of reservoirs for irrigation storage, disposal of treated sewage effluents, and recreational fishing.

"We must respond, in Texas of all places, to the justifiable needs to use our water to the maximum beneficial use through a highly developed and sophisticated water management plan which will incorporate the esthetics along with recreation and maximum beneficial use and reuse of our available supplies. We, without a doubt, face a reallocation of our water resources to those uses which will demonstrate an economic base as well as an esthetic value. Above all, we must find a way to put an end to some of our wasteful practices which encourage the consumptive use of water without gaining a maximum benefit in terms of product value and employment opportunities. A prime example is the folly of our present statutory allowance of 200 acre-feet for any purpose to be impounded without a permit or any question of what the water will be used for. In the midwestern and western portions of our state the thousands of private fishing lakes on watersheds are a flagrant waste of our water resources where the water is needed the most. It is very difficult for knowledgeable people in the urban water resources field to support a plan for importation when we are so wasteful locally and take so little cognizance of our own practices. Seemingly, it is better to spend billions of dollars than it is to face the hard facts of establishing priorities for water applications and disciplining ourselves to proper use of our available supplies." (11, p.14)

The problem as posed is crucial to Texas at the policy level. Allocational decisions are ultimately made at operating levels where direct control over outputs and inputs are involved. But these operating level decisions are made within an institutional framework that governs what uses can be made of water and its interrelated land resources, and who benefits, and who bears the cost of such uses. The imbalances that exist in Texas and in the Nation with respect to the uses of natural resources and the resulting incidence of social costs and revenues are the result of imperfections at the institutional level.

It might become necessary for Texas to make adjustments similar to those recommended by Kelso for water users in Arizona (14). There water is considered to be economically scarce in some areas but not so physically limited as to be a serious threat to the viability of the State's economy.

Much of the scarce water supplies are legally, and by reasons of location, locked into uses of low economic productivity. Curtailment of these low-valued uses because of increasing water scarcity is judged to have but modest effects on the State's economy. Changing the structure of the State's economy both by curtailing water uses producing lowest net income per unit of water used and by expanding uses which produce higher net incomes will permit continued economic growth.

Such transfer of water use is expected to be economically advantageous in aggregate to the State's economy, as it means that the State is using its scarce water in higher income producing activities and adding to economic growth. By creating a water market or by facilitating water transfers from lower to higher value productivity, the economy will continue to grow without significant restraints from water shortages (14). The Texas water problem also partially results from a lack of appropriate policies for developing and transferring water among uses. Future plans for the development and allocation of water will need to consider present uses of relatively low economic productivity as well as new water supplies.

Appendix Tables

APPENDIX TABLE 1. DAMS AND RESERVOIRS AUTHORIZED FOR MUNICIPAL USE

Name of Reservoir	Impoundment Began	Owner	Acre-feet for Municipal Use	Other Authorized Uses (1,2,3,4,5,6,7)*
Canadian River Basin		**Canadian River Basin**		
Lake Meredith	1965	Canadian River Municipal Water Authority	100,000	2
Red River Basin		**Red River Basin**		
MacKenzie Reservoir	1974	MacKenzie Municipal Water Authority	4,000	2
Greenbelt Reservoir	1966	Greenbelt Municipal and Industrial Water Authority – 62.84 percent; Texas Water Development Board – 37.16 percent	14,500	2,4
Lake Kickapoo	1946	City of Wichita Falls	40,000	
Lake Arrowhead	1966	City of Wichita Falls	45,000	
Pat Mayse Lake	1967	U.S. Army Corps of Engineers	25,000	2
Sulphur River Basin		**Sulphur River Basin**		
Lake Sulphur Springs	1973	Sulphur Springs Water District	7,800	7
Wright Patman Lake	1953	U.S. Army Corps of Engineers	20,000	2
Cypress Creek Basin		**Cypress Creek Basin**		
Lake Cypress Springs	1970	Franklin County Water District – 48.4 percent; Texas Water Development Board – 51.6 percent	1,300	2
Lake O' the Pines	1957	U.S. Army Corps of Engineers	42,000	2
Sabine River Basin		**Sabine River Basin**		
Lake Tawakoni	1960	Sabine River Authority	184,600	2,3
Toledo Bend Reservoir	1966	Sabine River Authorities of Texas and Louisiana	100,000	2,3
Neches River Basin		**Neches River Basin**		
Lake Palestine	1962	Upper Neches River Municipal Water Authority	196,000	
Lake Tyler	1966	City of Tyler	20,000	
Sam Rayburn Reservoir	1965	U.S. Army Corps of Engineers	50,000	2,3
Trinity River Basin		**Trinity River Basin**		
Bridgeport Reservoir	1932	Tarrant County Water Control and Improvement District No. 1	5,000	3,4
Lewisville Lake	1954	U.S. Army Corps of Engineers	11,000	**
Grapevine Lake	1952	U.S. Army Corps of Engineers	1,250	**
Lavon Lake	1953	U.S. Army Corps of Engineers	50,000	2
Lake Ray Hubbard	1968	City of Dallas	89,700	
Cedar Creek Reservoir	1965	Tarrant County Water Control and Improvement District No. 1	175,000	
Navarro Mills Lake	1963	U.S. Army Corps of Engineers	19,400	
Bardwell Lake	1965	U.S. Army Corps of Engineers	9,600	
Lake Livingston	1968	City of Houston and Trinity River Authority	40,000	2,3

APPENDIX TABLE 1. (cont'd.)

Name of Reservoir	Impoundment Began	Owner	Acre-feet for Municipal Use	Other Authorized Uses (1,2,3,4,5,6,7)*
San Jacinto River Basin		**San Jacinto River Basin**		
Lake Conroe	1973	San Jacinto River Authority – 13.15 percent; City of Houston – 66.67 percent; Texas Water Development Board – 20.18 percent	66,000	2,4
Lake Houston	1954	City of Houston	168,000	3
Brazos River Basin		**Brazos River Basin**		
White River Lake	1963	White River Municipal Water District	4,000	2,4
Millers Creek Reservoir	1973	North Central Texas Municipal Water Authority	3,500	2,4
Fort Phantom Hill Reservoir	1938	City of Abilene	30,690	
Hubbard Creek Reservoir	1962	West Central Texas Municipal Water District	44,800	2,4
Lake Palo Pinto	1964	Palo Pinto County Municipal Water District No. 1	12,500	2
Lake Granbury	1969	Brazos River Authority	10,000	2,4
Lake Pat Cleburne	1964	City of Cleburne	6,000	
Waco Lake	1965	U.S. Army Corps of Engineers	59,100	
Belton Lake	1954	U.S. Army Corps of Engineers	95,000	2,3
Stillhouse Hollow Lake	1968	U.S. Army Corps of Engineers	74,000	2,3
Somerville Lake	1967	U.S. Army Corps of Engineers	50,000	2,3
Colorado River Basin		**Colorado River Basin**		
Champion Creek Reservoir	1959	Texas Electric Service Co.	2,700	2
E. V. Spence Reservoir	1968	Colorado River Municipal Water District	40,000	2,4
Twin Buttes Reservoir	1962	U.S. Bureau of Reclamation	29,000	3
Hords Creek Lake	1948	U.S. Army Corps of Engineers	2,240	

Source: Engineering Data on Dams and Reservoirs in Texas, Texas Water Development Board Report 126, Parts I, II, and III.

*1. Municipal
2. Industrial
3. Irrigation
4. Mining
5. Hydroelectric
6. Navigation
7. Recreation

**Other individual multiple uses.

APPENDIX TABLE 2. DAMS AND RESERVOIRS AUTHORIZED FOR INDUSTRIAL USE

Name of Reservoir	Impoundment Began	Owner	Acre-feet for Industrial Use	Other Authorized Uses (1,2,3,4,5,6,7)*
Canadian River Basin		**Canadian River Basin**		
Lake Meredith	1965	Canadian River Municipal Water Authority	51,200	1
Red River Basin		**Red River Basin**		
MacKenzie Reservoir	1974	MacKenzie Municipal Water Authority	1,200	1
Greenbelt Reservoir	1966	Greenbelt Municipal and Industrial Water Authority – 62.84 percent; Texas Water Development Board – 37.16 percent	1,500	1,4
Pat Mayse Lake	1967	U.S. Army Corps of Engineers	36,600	1
Sulphur River Basin		**Sulphur River Basin**		
Lake Cypress Springs	1970	Franklin County Water District – 48.4 percent; Texas Water Development Board – 51.6 percent	14,000	1
Wright Patman Lake	1953	U.S. Army Corps of Engineers	100,000	1
Cypress Creek Basin		**Cypress Creek Basin**		
Lake O' the Pines	1957	U.S. Army Corps of Engineers	161,800	1
Sabine River Basin		**Sabine River Basin**		
Lake Tawakoni	1960	Sabine River Authority	23,075	1,3
Toledo Bend Reservoir	1966	Sabine River Authorities of Texas and Louisiana	600,000	1,3
Neches River Basin		**Neches River Basin**		
Sam Rayburn Reservoir	1965	U.S. Army Corps of Engineers	660,000	1,3
Trinity River Basin		**Trinity River Basin**		
Lavon Lake	1953	U.S. Army Corps of Engineers	8,000	1
Lake Livingston	1968	City of Houston and Trinity River Authority	212,150	1,3
San Jacinto River Basin		**San Jacinto River Basin**		
Lake Conroe	1973	San Jacinto River Authority – 13.15 percent; City of Houston – 66.67 percent; Texas Water Development Board – 20.18 percent	28,500	1,4
Brazos River Basin		**Brazos River Basin**		
White River Lake	1963	White River Municipal Water District	1,000	1,4
Millers Creek Reservoir	1973	North Central Texas Municipal Water Authority	1,000	1,4
Hubbard Creek Reservoir	1962	West Central Texas Municipal Water District	1,200	1,4
Lake Palo Pinto	1964	Palo Pinto County Municipal Water District No. 1	6,000	1
Lake Granbury	1969	Brazos River Authority	70,000	1,3
Belton Lake	1954	U.S. Army Corps of Engineers	150,000	1,3
Stillhouse Hollow Lake	1968	U.S. Army Corps of Engineers	74,000	1,3
Somerville Lake	1967	U.S. Army Corps of Engineers	50,000	1,3
Colorado River Basin		**Colorado River Basin**		
Champion Creek Reservoir	1959	Texas Electric Service Co.	4,050	1
E. V. Spence Reservoir	1968	Colorado River Municipal Water District	2,000	1,4

Source: Engineering Data on Dams and Reservoirs in Texas, Texas Water Development Board Report 126, Parts I, II, and III.

*1. Municipal
2. Industrial
3. Irrigation
4. Mining
5. Hydroelectric
6. Navigation
7. Recreation

APPENDIX TABLE 3. IRRIGATION SUMMARY FOR RIVER AND COASTAL BASINS, 1974.

River Basin	All Irrigation		Surface Water Irrigation Only		Ground Water Irrigation Only		Irrigation Using Combined Supplies		Sprinkler Systems
	Acres	Acre-feet	Acres	Acre-feet	Acres	Acre-feet	Acres	Acre-feet	Acres
Canadian	1,355,936	1,915,834	0	0	1,353,896	1,913,693	2,040	2,141	174,486
Red	1,465,092	2,053,161	27,011	36,109	1,436,238	2,015,153	1,843	1,899	161,879
Sulphur	0	0	0	0	0	0	0	0	0
Cypress	494	293	474	285	0	0	20	8	474
Sabine	4,939	10,023	3,529	8,030	1,085	1,876	325	117	735
Neches	17,370	35,979	11,769	25,570	4,058	8,735	1,543	1,674	3,255
Neches-Trinity	104,291	206,728	104,291	260,728	0	0	0	0	0
Trinity	43,797	88,968	30,858	66,797	11,039	19,751	1,900	2,420	6,592
Trinity-San Jacinto	12,682	32,605	9,632	25,480	1,000	2,000	2,050	5,125	0
San Jacinto	49,294	120,420	0	0	48,994	119,670	300	750	90
San Jacinto-Brazos	64,924	171,430	57,074	152,463	5,800	13,500	2,050	5,467	0
Brazos	2,775,086	3,850,388	52,026	53,585	2,700,830	3,772,824	22,230	23,979	488,083
Brazos-Colorado	64,893	213,863	37,353	134,229	17,960	49,577	9,580	30,057	1,645
Colorado	969,549	1,043,174	69,772	129,760	893,953	906,315	5,824	7,099	833,909
Colorado-Lavaca	61,753	202,554	1,000	4,000	34,518	100,173	26,235	98,381	135
Lavaca	100,051	311,164	20,090	78,047	77,230	224,363	2,731	8,754	1,241
Lavaca-Guadalupe	21,555	76,297	10,651	42,156	10,904	34,141	0	0	0
Guadalupe	11,303	9,752	5,844	4,851	5,409	4,859	50	42	9,761
San Antonio	50,288	58,102	20,651	21,272	28,813	36,031	824	799	22,690
San Antonio-Nueces	12,909	6,318	30	20	12,879	6,298	0	0	320
Nueces	299,799	465,198	18,723	33,611	254,349	384,168	26,727	47,419	121,437
Nueces-Rio Grande	757,257	1,023,352	680,363	926,992	16,814	13,307	60,080	83,053	18,414
Rio Grande	374,792	1,132,659	111,256	182,077	173,855	653,558	89,681	297,024	8,747
State Total	8,618,054	13,082,262	1,272,397	2,186,062	7,089,624	10,279,992	256,033	616,208	1,853,893

Source: Texas Water Development Board, Report 196, "Inventories of Irrigation in Texas 1958, 1964, 1969 and 1974," October 1975.

APPENDIX TABLE 4. DAMS AND RESERVOIRS AUTHORIZED FOR IRRIGATION USE

Name of Reservoir	Impoundment Began	Owner	Acre-feet for Irrigation Use	Other Authorized Uses (1,2,3,4,5,6,7)*
Sabine River Basin		**Sabine River Basin**		
Lake Tawakoni	1960	Sabine River Authority	23,075	1,2
Toledo Bend Reservoir	1966	Sabine River Authorities of Texas and Louisiana	50,000	1,2
Neches River Basin		**Neches River Basin**		
Sam Rayburn Reservoir	1965	U.S. Army Corps of Engineers	110,000	1,2
Trinity River Basin		**Trinity River Basin**		
Bridgeport Reservoir	1932	Tarrant County Water Control and Improvement District No. 1	52,000	1,4
Lake Livingston	1968	City of Houston and Trinity River Authority	99,450	1,2
San Jacinto River Basin		**San Jacinto River Basin**		
Lake Houston	1954	City of Houston	1,500	1
Brazos River Basin		**Brazos River Basin**		
Lake Granbury	1969	Brazos River Authority	20,000	1,2
Belton Lake	1954	U.S. Army Corps of Engineers	150,000	1,2
Stillhouse Hollow Lake	1968	U.S. Army Corps of Engineers	74,000	1,2
Somerville Lake	1967	U.S. Army Corps of Engineers	50,000	1,2
Colorado River Basin		**Colorado River Basin**		
Twin Buttes Reservoir	1962	U.S. Bureau of Reclamation	10,000	1
Lake Brownwood	1933	Brown County Water Improvement District No. 1	50,590	1,2
San Antonio River Basin		**San Antonio River Basin**		
Medina Lake	1913	Bexar, Medina, Atascosa Counties Water Improvement District No. 1	150,000 acres of land	
Rio Grande Basin		**Rio Grande Basin**		
Red Bluff Reservoir	1936	Red Bluff Water Power Control District	300,000	5

Source: Engineering Data on Dams and Reservoirs in Texas, Texas Water Development Board Report 126, Parts I, II, and III.

*1. Municipal
2. Industrial
3. Irrigation
4. Mining
5. Hydroelectric
6. Navigation
7. Recreation

APPENDIX TABLE 5. DAMS AND RESERVOIRS AUTHORIZED FOR MINING USE

Name of Reservoir	Impoundment Began	Owner	Acre-feet for Mining Use	Other Authorized Uses (1,2,3,4,5,6,7)*
Red River Basin		**Red River Basin**		
Greenbelt Reservoir	1966	Greenbelt Municipal and Industrial Water Authority – 62.84 percent; Texas Water Development Board – 37.16 percent	1,500	1,2
Trinity River Basin		**Trinity River Basin**		
Bridgeport Reservoir	1932	Tarrant County Water Control and Improvement District No. 1	2,000	1,3
San Jacinto River Basin		**San Jacinto River Basin**		
Lake Conroe	1973	San Jacinto River Authority – 13.15 percent; City of Houston – 66.67 percent; Texas Water Development Board – 20.18 percent	5,500	1,2
Brazos River Basin		**Brazos River Basin**		
White River Lake	1963	White River Municipal Water District	2,000	1,2
Millers Creek Reservoir	1973	North Central Texas Municipal Water Authority	500	1,2
Hubbard Creek Reservoir	1962	West Central Texas Municipal Water District	10,000	1,2
Colorado River Basin		**Colorado River Basin**		
E. V. Spence Reservoir	1968	Colorado River Municipal Water District	8,000	1,2

Source: Engineering Data on Dams and Reservoirs in Texas, Texas Water Development Board Report 126, Parts I, II, and III.

*1. Municipal
2. Industrial
3. Irrigation
4. Mining
5. Hydroelectric
6. Navigation
7. Recreation

APPENDIX TABLE 6. DAMS AND RESERVOIRS AUTHORIZED FOR ELECTRIC POWER GENERATION

Name of Reservoir	Impoundment Began	Owner	Kilowatts of Power Generating Capacity	Other Authorized Uses (1,2,3,4,5,6,7)*
Red River Basin		**Red River Basin**		
Lake Texoma	1943	U.S. Army Corps of Engineers	70,000	7
Sabine River Basin		**Sabine River Basin**		
Toledo Bend Reservoir	1966	Sabine River Authorities of Texas and Louisiana	80,750	1,2,3
Neches River Basin		**Neches River Basin**		
Sam Rayburn Reservoir	1965	U.S. Army Corps of Engineers	52,000	1,2,3
Brazos River Basin		**Brazos River Basin**		
Possum Kingdom Lake	1941	Brazos River Authority	23,000	1,2,3,4,7
Whitney Lake	1951	U.S. Army Corps of Engineers	30,000	
Colorado River Basin		**Colorado River Basin**		
Lake Colorado City	1949	Texas Electric Service Co.	833,000	1,2,5
Lake Buchanan	1937	Lower Colorado River Authority	38,000	
Lake Travis	1940	Lower Colorado River Authority	85,000	1,3,4,7
Rio Grande Basin		**Rio Grande Basin**		
Red Bluff Reservoir	1936	Red Bluff Water Power Control District	2,300	3
International Amistad Reservoir	1968	United States and Mexico	160,000	
International Falcon Reservoir	1953	United States and Mexico	31,500	

Source: Engineering Data on Dams and Reservoirs in Texas, Texas Water Development Board Report 126, Parts I, II, and III.

*1. Municipal
2. Industrial
3. Irrigation
4. Mining
5. Hydroelectric
6. Navigation
7. Recreation

APPENDIX TABLE 7. CONSERVATION STORAGE DATA AND FLOOD-CONTROL STORAGE DATA FOR SELECTED MAJOR TEXAS RESERVOIRS, 1976

Name of Lake or Reservoir	Number on Map[1]	Conservation Storage Capacity (acre-feet)	Flood Control Storage Capacities (acre-feet)
Canadian River Basin	**Canadian River Basin**		
Lake Meredith	1	821,300	543,200
Red River Basin	**Red River Basin**		
Mackenzie Reservoir	2	46,250	0
Greenbelt Reservoir	3	58,200	0
Lake Kemp	4	319,600	186,200
Lake Kickapoo	5	106,000	0
Lake Arrowhead	6	262,100	0
Lake Texoma	7	2,722,300	2,659,600
Pat Mayse Lake	8	124,500	64,600
Sulphur River Basin	**Sulphur River Basin**		
Lake Sulphur Springs	9	13,520	0
Wright Patman Lake	10	142,700	2,506,000
Cypress Creek Basin	**Cypress Creek Basin**		
Lake Cypress Springs	11	66,800	0
Lake O' the Pines	12	252,000	587,200
Sabine River Basin	**Sabine River Basin**		
Lake Tawakoni	13	936,200	0
Toledo Bend Reservoir	14	4,472,900	0
Neches River Basin	**Neches River Basin**		
Lake Palestine	15	411,300	0
Lake Tyler	16	73,700	0
Sam Rayburn Reservoir	17	2,876,300	1,145,000
B. A. Steinhagen Lake	18	94,200	0
Trinity River Basin	**Trinity River Basin**		
Bridgeport Reservoir	19	386,400	0
Eagle Mountain Reservoir	20	190,300	0
Benbrook Lake	21	88,200	76,550
Lewisville Lake	22	464,500	525,200
Grapevine Lake	23	187,700	247,000
Lavon Lake	24	129,300	279,800
Lake Ray Hubbard	25	490,000	0
Cedar Creek Reservoir	26	679,200	0
Navarro Mills Lake	27	69,900	148,900
Bardwell Lake	28	53,580	85,100
Lake Livingston	29	1,750,000	0
San Jacinto River Basin	**San Jacinto River Basin**		
Lake Conroe	30	429,900	0
Lake Houston	31	140,500	0

APPENDIX TABLE 7. (cont'd.)

Name of Lake or Reservoir	Number on Map[1]	Conservation Storage Capacity (acre-feet)	Flood Control Storage Capacities (acre-feet)
Brazos River Basin	**Brazos River Basin**		
White River Lake	32	44,300	0
Millers Creek Reservoir	33	25,520	0
Fort Phantom Hill Reservoir	34	74,300	0
Lake Stamford	35	52,700	0
Hubbard Creek Reservoir	36	317,800	0
Lake Graham	37	45,000	0
Possum Kingdom Lake	38	569,380	0
Lake Palo Pinto	39	42,200	0
Lake Granbury	40	151,300	0
Lake Pat Cleburne	41	25,300	0
Whitney Lake	42	622,800	1,620,400
Waco Lake	43	151,900	573,900
Proctor Lake	44	59,300	314,800
Belton Lake	45	457,300	887,000
Stillhouse Hollow Lake	46	234,900	394,700
Somerville Lake	47	160,100	347,400
Colorado River Basin	**Colorado River Basin**		
Lake J. B. Thomas	48	202,300	0
Lake Colorado City	49	30,800	0
Champion Creek Reservoir	50	41,600	0
E. V. Spence Reservoir	51	484,800	0
Twin Buttes Reservoir	52	177,800	454,400
O. C. Fisher Lake	53	119,200	277,200
Hords Creek Lake	54	8,600	16,670
Lake Brownwood	55	143,400	0
Lake Buchanan	56	955,200	0
Lake Travis	57	1,144,100	778,000
Guadalupe River Basin	**Guadalupe River Basin**		
Canyon Lake	58	385,600	354,700
San Antonio River Basin	**San Antonio River Basin**		
Medina Lake	59	254,000	0
Nueces River Basin	**Nueces River Basin**		
Lake Corpus Christi	60	269,900	0
Rio Grande Basin	**Rio Grande Basin**		
Red Bluff Reservoir	61	307,000	0
Intl. Amistad Reservoir	62	1,965,500	1,744,300
Intl. Falcon Reservoir	63	1,563,200	613,100
State Total		29,937,450	17,430,920

Source: Texas Water Development Board, *Water for Texas,* Vol. 6, No. 3, March 1976.

[1]Reference is to the map presented in Figure 5 of the text.

Notes: Conservation storage capacity is the space available to store water above the level of invert of lowest outlet works and below the level of top of conservation pool or normal maximum operating level.

Conservation storage refers to the volume of water held within the conservation storage space. Not included is any water in flood-control storage (above the top of conservation pool or normal maximum operating level) or any water in so-called dead storage (in the bottom of the reservoir, below the invert of lowest outlet works, and consequently not removable by gravity flow alone).

Appendix A
Major Conservation Storage Reservoirs

The Texas Water Commission and other State water agencies have disseminated considerable information on the development of surface water resources in Texas, resulting from construction of conservation storage reservoirs. Particularly important are a report by Louis L. McDaniels (16) which summarized historical data on surface water resource development and the current data which are published monthly by the Texas Water Development Board.

Several hundred thousand surface storage reservoirs are located in Texas, ranging in size from a fractional acre-foot to several million acre-feet. An acre-foot in volume is equal to a depth of 1 foot on an acre and totals 325,851 U.S. gallons. Most of the reservoirs are small, commonly referred to as farm ponds or stock tanks, and are used for domestic and livestock purposes on farms and ranches. The term "major reservoir" is used here to refer to reservoirs with a storage capacity in excess of 5,000 acre-feet (16).

The space in a reservoir basin may be divided into dead storage, inactive storage, conservation storage, and flood-control storage spaces. The dead storage space is below the level at which water begins to flow through the lowest outlet provided in the dam forming the reservoir. Water cannot be released or diverted from the dead storage space by using existing facilities in a dam. The inactive storage space is reserved for the design sedimentation in the reservoir above the lowest outlet or dead storage level. The conservation storage capacity designed to provide a particular yield is included in the space above the lowest outlet. If the inactive sediment storage space and the design conservation storage space are combined, the initial conservation storage capacity decreases over time after sedimentation begins (16).

Flood-control storage space is defined here as the space in a reservoir within which floodwaters can be captured and held and as soon as possible released. Surcharge storage space differs from flood-control space as it cannot be regulated. Each affects a reduction in floods, but with each, downstream floods may occur, but with reduced frequency.

The term "conservation storage" as applied to water-supply reservoirs means the volume capacity of the space available in a reservoir to store water for subsequent release or withdrawal to serve the needs for beneficial uses.

All water captured and conserved in storage in surface reservoirs is not available for beneficial uses. Some water re-enters the hydrologic cycle through the processes of evaporation from the water surface, evapotranspiration from the vegetation and ground adjacent to the water, and seepage or infiltration from the reservoir into permeable soils. The capability of conservation storage reservoirs to supply water annually is dependent on combinations of natural and man-made conditions which vary widely (16).

The performances of reservoirs in supplying water requirements under historically critical conditions usually provide the basis for forecasting yields of reservoirs in the future. However, data on the degree of severity of historically critical drouths in a specific area may be inadequate for planning conservation storage reservoirs to serve expected future water needs. A more severe and prolonged drouth than any known in a watershed may begin at any time.

A reservoir's yield will be reduced each year it is in operation as the initial conservation storage capacity is reduced by sedimentation. Sediments consisting of silt, clay, rock, sand, and other materials are transported in suspension and by movement along streambeds by water flowing into reservoirs. The degree of sedimentation of reservoirs varies from place to place and is related to watershed characteristics and operational procedures and practices (16).

Some uses of water supplied from reservoirs are more tolerant of water shortages than others. Supplementary water supplies may be available from other sources such as wells, streams, or other reservoirs. During periods of water shortages, domestic and municipal uses may be curtailed through rationing of water for less essential purposes. Shortages of water used for some industrial purposes may require curtailment of certain processes and reuse of water within acceptable limits of quality. Irrigators may need to decrease the frequency and amount of water applied to crops. Sanitation and public health is dependent on ample supplies of water of good quality. Fish and wildlife also are limited in the degree of shortage tolerance. Water-related recreational areas and facilities are subject to severe economic losses during extended periods of water shortages.

The deterioration of water quality is a serious effect of shortages in water supplies for some uses. Diminishing inflows to reservoirs during drouths are usually characterized by increases in concentration of chemicals in solution that may be of natural or man-made origin. Quality deteriorates as the flow from saline springs, seeps, and the return flows of water used by man become an increasingly larger percentage of the total inflow. This quality deterioration is further increased by concentration of chemicals caused by continuing evaporation from water surfaces (16).

"In humid East Texas, a reservoir may provide a firm yield equal to or larger than its conservation storage capacity. In sub-humid Central Texas, a reservoir may provide a firm yield equal to only one-fifth or less of its conservation storage capacity. In semiarid and arid West Texas, a reservoir may provide a firm yield varying within a range equal to one-tenth to one-thirtieth or less of its conservation storage capacity. . . . . Therefore, compilations of reservoir capacities and contents are relatively indicative of the available water supply *only*, and are

necessarily evaluated through detailed study to provide reliable estimates of the true water-supply potential." (16, p. 8)

With increasing demands being placed on the water resources of Texas, the operation of multipurpose reservoirs is planned to provide the most benefits within a practical balance of the needs for water and the priority of uses served. The development of hydroelectric-power facilities in upriver reservoirs serving downstream needs for municipal, industrial, irrigation, navigation, and other uses exemplifies such operations. In some reservoirs, seasonal use of part of the flood-control storage space is permissable. This affords more efficient use of available waters during seasons having a low expectancy of floods, particularly in the operation of a number of reservoirs as a coordinated river system development (16).

Major reservoirs in Texas are discussed in conjunction with the State or Federal agency responsible for their development. Location and conservation storage is presented by reservoir.

Appendix B
Water Development Board Policy

The statement is quoted as it appeared in the April 1976 issue of *Water For Texas* which is published by the Texas Water Development Board.

TEXAS WATER DEVELOPMENT BOARD POLICY STATEMENT CONCERNING DEVELOPMENT OF WATER RESOURCES IN TEXAS

"For purposes of carrying out the duties and responsibilities of the Texas Water Development Board, as specified in the Texas Water Development Board Act of 1957 as amended by subsequent legislative acts,* the following general policies are stated.

"It is the Board's view that population and economic growth of Texas will continue and that continued orderly development of Texas water resources to meet present and increasing future needs is imperative. In meeting the water requirements of the people of Texas, the Board recognizes that it is necessary to plan well so as to provide the necessary water resources while at the same time proper provision is made to protect the environment, in compliance with the Texas and national water laws and national environmental policy as expressed in the National Environmental Policy Act of 1969 (P.L. 91-190), the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), the Water Resources Planning Act of 1965 (P.L. 89-80), the Safe Drinking Water Act (P.L. 93-523), and the Water Resources Development Act of 1974 (P.L. 93-251).

Use of Texas Water Development Fund

"The Water Development Board will receive and fully consider all applications for financial assistance for worthwhile projects — but at the same time adhering to constitutional and other statutory provisions relating to administration of the Texas Water Development Fund. In order to acquire reservoir facilities, the Board is required to determine that:**

1. It is reasonable to expect that the State will recover its investment in the facilities;
2. The cost of the facilities exceeds the current financing capabilities of the area involved, and the facilities cannot be reasonably financed by local interests without State participation;
3. The public interest will be served by acquisition of the facilities; and
4. The facilities, to be constructed or reconstructed, contemplate the optimum development of the site which is reasonably reserved under all existing circumstances of the site.

"Senate Joint Resolution 49, a proposed constitutional amendment which, if approved by the electorate in November 1976, provides that $400 million additional funds be made available, subject to the following stipulations:

1. No single water development project requiring an expenditure of proceeds of these additional bonds in an aggregate amount in excess of $35 million may be undertaken without approval by concurrent resolution and adoption by a majority of each house of the Legislature; or the project can proceed if it is a part of a statewide water plan approved by concurrent resolutions adopted by a majority of the members of the House and Senate, and
2. Proceeds, from the sale of these additional authorized bonds may not be used for the development of water resources of the Mississippi River.

Population Increase

"It is the position of the Board that the Water Development Fund be thus enlarged in that it is necessary for continuation of satisfactory water resources support to Texas citizens and the Texas economy. Texas now ranks third among all states with a current (1975) population estimate of 12,237,000. The most recent Water Development Board population projections indicate that the State population could exceed 18.2 million in the year 2000 and be as much as 22 to 26 million by the year 2020.

*Chapter 11 of the Texas Water Code of 1971, and Article III, Sections 49c and 49d, Constitution of the State.

**Subchapter H, Texas Water Code.

Economic Growth

"The level of economic growth required to provide employment for the future labor force of Texas and to produce the necessary goods and services is expected to exceed growth rates of the past. Such economic growth will require adequate supplies of suitable quality water, which can only be made available through a strong State water resources development program.

Assistance to Local Governments

"Implementation of environmental legislation and especially of P.L. 93-253, the "Safe Drinking Water Act," will have a major financial impact on the State, local government, and other purveyors of water supplies. Primary drinking water standards already promulgated by the Environmental Protection Agency indicate that possibly as many as 500 municipal water systems in Texas will not be capable of meeting maximum concentrations for one or more water quality parameters. Although temporary variances may offer some relief, the statute requires all systems to ultimately meet prespecified goals. Promulgation of secondary standards, to include maximum allowable limits on such parameters as sulfate, chloride, and possibly sodium, will beyond a doubt impact upon hundreds of water systems in Texas, particularly in North and West-Central Texas and South Texas. The ultimate costs of providing the necessary level of treatment of such supplies to meet specified standards, if such are physically and economically attainable, will be staggering. Local political subdivisions will not be capable of absorbing this added financial burden in many areas without financial assistance that can be provided by the Water Development Fund.

Return on the Investment

"The Board's experience indicates that investments in water development projects and water quality improvement programs produce services, the value of which is used to repay the loans made to finance the investments. In addition to being sound and necessary investments, for the future, Texas Water Bonds, when used to fund water development projects, set in motion economic activity through the construction and associated economic sectors, the result of which is immediate employment for unemployed people and unused machinery and materials. This increased economic action, in addition to the beneficial employment and income effects to the people involved, benefits the general public through increased local, State, and federal tax revenues paid by the economic sectors that are directly and indirectly engaged in water resources development and operation. The property tax base is increased in the vicinity of reservoirs and the sales, income, and excise tax bases are increased throughout the economy. Tax revenues estimated at more than 20 percent of construction costs begin to flow immediately from such action and continue as the water resources are put to beneficial use. The loan repayment obligations of those who use the water, and thereby receive its benefits, repay the bonds. The whole process contributes to improving the economic, social, and environmental well-being of Texas and the nation.

Texas Water Plan

"It is the intent and goal of the Water Development Board to make available to the 65th Texas Legislature an updated and revised comprehensive State water plan.

The Environment

"In carrying out a water resources development and management program for Texas, the overall environmental impact of each project will be given full consideration under currently practiced procedures adopted by the Texas Interagency Council on Natural Resources and the Environment.

Protecting the Bays and Estuaries

"The water needs of Texas' vitally important bays and estuaries are currently being assessed through a comprehensive interdisciplinary program of studies and investigations involving many State agencies. Legislation enacted by the 64th Legislature has specifically charged the Texas Water Development Board, in cooperation with all major State natural resources and fish and wildlife agencies, to factually define the relationships between fresh water inflows and the environment and productivity of the State's estuarine systems. This program is a major element of the Board's overall water resources planning effort. Further, the 64th Legislature, through resolution, instructed the Texas Coastal and Marine Council to take the lead in addressing the institutional and financial aspects of providing fresh water inflows to the estuaries, including costs and potential cost sharing policies. The Board is committed to maintaining the viability of Texas bays and estuaries to the maximum possible extent.

Providing for Recreational Needs

"In assessing and evaluating the environmental impact of water resources development projects, recreational needs around major projects and mitigation of loss of fish and wildlife habitat by project development will continue to receive full consideration. Insofar as non-federal projects are concerned, it is the position of the Texas Water Development Board that the Texas Parks and Wildlife Department, utilizing its power, duties, authorities, and funds available under the Texas Park Development Fund, as authorized by the constitution, as well as other sources of available revenue, should provide adequate recreational and park facilities associated with water resources projects as well as wildlife management areas that may be determined necessary as mitigation for habitat loss due to construction of water supply projects.

Protecting the Wildlife

"With respect to federal projects, which are subject to provisions of the Federal Fish and Wildlife Coordination Act, it is the position of the Board that the need for

mitigation of potential damage to or loss of wildlife habitat should be carefully and thoroughly evaluated on a project-by-project basis. Where a need for mitigation is clearly demonstrable and in the public interest, the Board favors allocation of a portion of project costs for such purposes. However, since the benefits from mitigation are widespread throughout Texas and extend beyond the State to other parts of the nation, it is the position of the Board that costs associated with mitigation must be allocated to other agencies whose major responsibilities are the development and management of the Texas wildlife and outdoor recreational resources. Such costs should be borne through funds appropriated to federal and State fish and wildlife agencies.

Coordination

"In the extremely important matter of economy and efficiency in the use of all our public funds and other resources, it is imperative that economic development, water resources development, water quality improvement, fish and wildlife improvement and enhancement, transportation, energy, food production, and other natural resources and human resources development planning be carefully coordinated so as to be supportive of each other and produce the desired results at the lowest possible cost. It is the position of the Board that Texas water planning work will be appropriately coordinated with other State and federal programs of importance to Texas."

Source: Water Development Board, *Water For Texas,* Vol. 6, No. 4, April 1976, pp. 13-15.

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