TEXAS WATER DEVELOPMENT BOARD

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STUDY AND INTERPRETATION OF CHEMICAL QUALITY OF SURFACE WATERS IN THE BRAZOS RIVER BASIN, TEXAS

By

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ABSTRACT

The Brazos River basin, which begins in New Mexico and extends to the Gulf of Mexico, has a total drainage area of about 45,000 square miles. Of this area about 9,000 square miles in the upper reaches normally does not contribute to streamflow. Ninety-six percent of the basin is in Texas. Included in the basin are parts of four physiographic provinces--the High Plains and the Central Texas section of the Great Plains Province, the Osage Plains section of the Central Lowlands Province, and the West Gulf Coastal Plain section of the Coastal Plain Province. The topography is characterized by the nearly flat elevated surface of the High Plains; the gently sloping plain dissected by entrenched streams in the Osage Plains; and the hilly, gently rolling country of the West Gulf Coastal Plain, which merges with the nearly flat land along the Gulf of Mexico.

In 1960 the population of the basin was about 1,300,000, more than half of which was urban. Twenty-nine cities had more than 5,000 inhabitants in 1960, the largest city being Lubbock with a 1960 population of 128,691. A rapid urban growth has been accompanied by an evolution of the economy of the basin from a base predominantly agricultural to a base that blends agriculture, oil and gas production, and diversified industry.

Precipitation and runoff with the Brazos River basin are unevenly distributed both areally and seasonally. Average precipitation ranges from less than 18 inches per year in the upper portions of the basin to about 48 inches on the coastal plain. Runoff follows the precipitation trend and increases from west to east. During the 1943-64 period, annual runoff from sub-basins ranged from less than 1 inch in the upper part of the basin to more than 4 inches in the lower part.

Because precipitation and runoff in the basin are highly variable with regard to time, many of the streams are frequently dry or nearly dry. Therefore, storage projects are required to make surface water available in dependable quantities for municipal or industrial use. At the end of the 1964 water year, each of 30 reservoirs, either existing or under construction, had a conservation-storage capacity of 5,000 acre-feet or more. Most of these are located on tributaries. Only two reservoirs, Possum Kingdom and Whitney Reservoirs, are located on the main-stem Brazos River.

The dissolved-mineral content and chemical character of surface waters in the Brazos River basin differ widely from one stream to another, from location to location on the same stream, and from time to time at any specified location. Geologic factors, runoff and streamflow characteristics, and activities of man largely determine the nature and amount of dissolved minerals transported by the Brazos River and its tributaries.

Rocks that crop out in the basin range in age from Early Ordovician to Recent and consist of many lithologic types. In the semiarid western part of the basin, many rocks contain large quantities of halite, gypsum, limestone, or dolomite. However, the chemical composition of the rocks, and thus the water of streams that drain from them, varies with local conditions. Base flow in many of these streams usually is non-existent. However, seeps and springs in Permian rocks that crop out in the drainage areas of Croton and Salt Croton Creeks flow much of the time and account for much of the salinity of the Salt Fork Brazos River and thus of the main-stem Brazos River. In the lower part of the basin, where precipitation is heavier, the well-leached rocks and soils usually yield water of low mineralization.

In many streams of the basin not appreciably regulated by upstream reservoirs, concentrations of dissolved minerals usually are minimum during periods of high flow when most of the water is surface runoff. Concentrations usually increase during low flow when the proportion of ground-water inflow to total surface-water outflow is maximum. However, the mineral content of many streams varies over wide ranges at all rates of water discharge. Much of this variation is related to the diverse geology and patterns of runoff from sub-basins. However, the intermittent inflow of brine from oil fields has modified the general streamflow-quality pattern for some streams.

Oil is produced throughout the Brazos River basin, and the disposition of oil-field brine in some areas has worsened the quality of surface streams. Intensified efforts to control disposition of the brine have resulted in the improvement of the quality of water in some streams. However, the quality of water in other streams has improved only slightly, or not at all.

Although minerals are being dissolved and removed from all parts of the Brazos River basin, the rates at which this process is proceeding are far from uniform. Differences in yields of dissolved minerals are caused by a combination of factors--principally, difference in precipitation, geology, and proportion of ground-water inflow to surface-water outflow. Computations for the 1949-64 period show that yields are highest in the upper Brazos River basin, where many of the rocks contain large quantities of soluble material. However, yields from different parts of the upper basin are highly variable because of local differences in the chemical composition of rocks and in the small, but variable, quantities of highly mineralized influent ground water. Highest yields of dissolved minerals are from the drainage area of the Salt Fork Brazos River, which receives inflow of highly mineralized water from seeps and springs in the Croton Creek-Salt Croton Creek area. Yields from the middle Brazos River basin are uniformly low. Yields of dissolved minerals from the lower Brazos River basin are generally low also; highest yields are from the drainage area of the Navasota River where oil-field brines are contributing to the salinity of the surface streams.

Many reservoirs on tributaries in the Brazos River basin store water of good quality. Waters of Possum Kingdom and Whitney Reservoirs on the main-stem Brazos River usually are undesirable for public supply and many industrial uses, but are suitable for irrigation of salt-tolerant crops; water in Whitney Reservoir is of better quality than that in Possum Kingdom.

The concentrations of dissolved minerals in most streams of the Brazos River basin vary over a wide range. Waters in many of the tributaries upstream from Possum Kingdom usually contain excessive concentrations of dissolved solids, chloride, sulfate, and hardness, and therefore often are undesirable for domestic and most industrial uses. However, some of the waters are suitable for irrigation of salt-tolerant crops on land where drainage is good, provided that an excess of water is applied. Although some tributaries downstream from Possum Kingdom Reservoir occasionally contain undesirable concentrations of dissolved minerals, principally during low-flow periods, the waters generally are suitable for all beneficial uses.

The quality of water in the main-stem Brazos River is usually poor in the upstream reaches but progressively improves in the downstream direction. Throughout much of the middle and upper reaches, the main stem contains undesirable concentrations of dissolved minerals. In the upstream reaches, water of the Brazos River is usually unsuitable for most domestic, industrial, and irrigation uses. Although the main-stem water in the reach immediately downstream from Whitney Reservoir is often unsuitable for municipal and some industrial uses, downstream from the mouth of Little River the water is usually suitable for the irrigation of rice (the principal irrigated crop) and other crops, as well as for controlled municipal and industrial use.

Many sites in the Brazos River basin are being studied as potential reservoir sites. Storage of water in some of these proposed reservoirs would decrease the range of dissolved minerals and thus would improve the quality of the water for municipal, irrigation, and many industrial uses. However, water in some of the proposed reservoirs, principally those on the main-stem Brazos River and on the Salt and Double Mountain Forks, would be unsuitable for domestic, industrial, and irrigation use.

Storage of flood waters in proposed reservoirs on tributaries downstream from Whitney Reservoir should make feasible the improvement of the quality of water in the lower reach of the main stem by integrating releases from the proposed and existing reservoirs on tributaries with the more saline releases from Whitney Reservoir. Integrating releases from these reservoirs would narrow the range of dissolved minerals in the main-stem water, thus making the water more suitable for domestic and industrial use. However, because of the large percentage of flow that would not be controlled by this proposed reservoir system, and because of the limited water resources available for quality control, the integration of reservoir releases would be only partly effective in the reduction of water-quality variations.

For any plan to be effective in the improvement of water quality throughout the main-stem Brazos River, it must provide for a reduction of natural salt contamination in the upper part of the basin. Partial control of natural salinity in the drainage areas of Salt Croton Creek and several smaller sources would result in a substantial improvement of water quality throughout the main stem. This reduction of salinity, supplemented by the integrated operation of reservoirs, would greatly improve the quality of the water in the lower Brazos River.

STUDY AND INTERPRETATION OF CHEMICAL QUALITY OF SURFACE WATERS IN THE BRAZOS RIVER BASIN, TEXAS

INTRODUCTION

Purpose and Scope

This investigation of the chemical quality of surface waters of the Brazos River basin was made by the U.S. Geological Survey in cooperation with Texas Water Development Board and the Brazos River Authority as part of a continuing program to determine the nature and concentrations of mineral constituents in surface waters of the basin; the geologic, hydrologic, and cultural factors that influence the chemical quality of the waters; and the suitability of the waters for irrigation, domestic, and industrial uses. In addition, the investigation will provide data and interpretations that will aid in the management of existing and proposed reservoirs to reduce water-quality variations in the lower reaches of the Brazos River, making the water more suitable for domestic and industrial uses.

A network of daily and periodic chemical-quality stations on many streams in the Brazos River basin has been operated by the U.S. Geological Survey in cooperation with Texas Water Development Board, the Brazos River Authority, and various Federal and local agencies. To supplement data obtained from this network, water-quality data were collected at many existing reservoirs, at the sites of a number of proposed reservoirs, and at many other sites on streams where water-quality data were meager or lacking.

Because concentrations of dissolved minerals are likely to be highest during low flows, the analyses of low-flow samples often indicate where pollution and salinity problems exist. Data collected during medium and high flows usually are indicative of the quality of water that will be stored in reservoirs. Therefore, sampling sites were selected at streamflow stations wherever possible; at other sites the water discharge usually was measured when samples were collected.

Previous Investigations

Chemical-quality data for surface streams in the Brazos River basin collected by the U.S. Geological Survey before 1960 were summarized by Irelan and Mendieta (1964).

Preliminary results of chemical-quality and stratification surveys of Belton, Whitney, and Possum Kingdom Reservoirs made by the Geological Survey from October 1961 to March 1962 were described by Mendieta and Blakey (1963). A more comprehensive report concerning the chemical quality and stratification of these and other major reservoirs in the basin is in preparation.

Many other publications have described the chemical quality of surface waters, geology, or hydrology of various areas in the Brazos River basin. Many of the studies were directed toward finding the sources of salinity in the area upstream from Possum Kingdom Reservoir. Blank (1955), in cooperation with the Brazos River Authority, studied parts of the drainage area of the Salt Fork and Double Mountain Fork of the Brazos River. McMillion (1958) studied the ground-water geology and salt-water seepage in parts of the drainage basins of Salt Croton and Croton Creeks. Baker, Hughes, and Yost (1964) studied the natural sources of salinity in the upper Brazos River basin, with particular emphasis on the Salt Croton Creek and Croton Creek basins.

Currently the U.S. Geological Survey is making detailed studies in the upper Brazos River basin to determine the origin of the salt springs and seeps and the factors that control their discharge and salinity (Stevens and Hardt, 1965).

The Geological Survey in cooperation with the U.S. Army Corps of Engineers is continuing its study to locate additional sources of salinity in the upper Brazos River basin and to furnish data that will aid in designing remedial measures to improve the quality of surface waters (Hughes, 1965).

THE BRAZOS RIVER BASIN AND ITS ENVIRONMENT

Physical Features

The Brazos River drains an area of about 45,000 square miles--about 2,000 square miles in New Mexico and about 43,000 square miles in Texas. Of the total area about 9,000 square miles in the upper reaches normally does not contribute to streamflow. The Texas part of the basin is more than 600 miles long, ranges from 1 to 120 miles wide, extends from the New Mexico state line to the Gulf of Mexico, and includes all or part of 69 counties. The basin is bounded on the north by the Red River basin, on the south and southeast by the Colorado River basins, and on the east and northeast by the Trinity and San Jacinto River basins (Figure 1).

In its southeastward course across Texas, the Brazos River basin slopes from an elevation of about 4,400 feet in the headwaters to sea level and includes parts of four physiographic sections--the High Plains and the Central Texas sections of the Great Plains Province, the Osage Plains section of the Central Lowlands Province, and the West Gulf Coastal Plain section of the Coastal Plain Province (Figure 1).

The High Plains section within the Brazos River basin is a high, nearly flat, upland plain that slopes southeastward from an elevation of about 4,400 feet in the western part to about 3,000 feet in the east. Local relief rarely exceeds 20 feet per mile, except in the vicinity of major stream valleys such as the White River and the North Fork Double Mountain Fork Brazos River. The

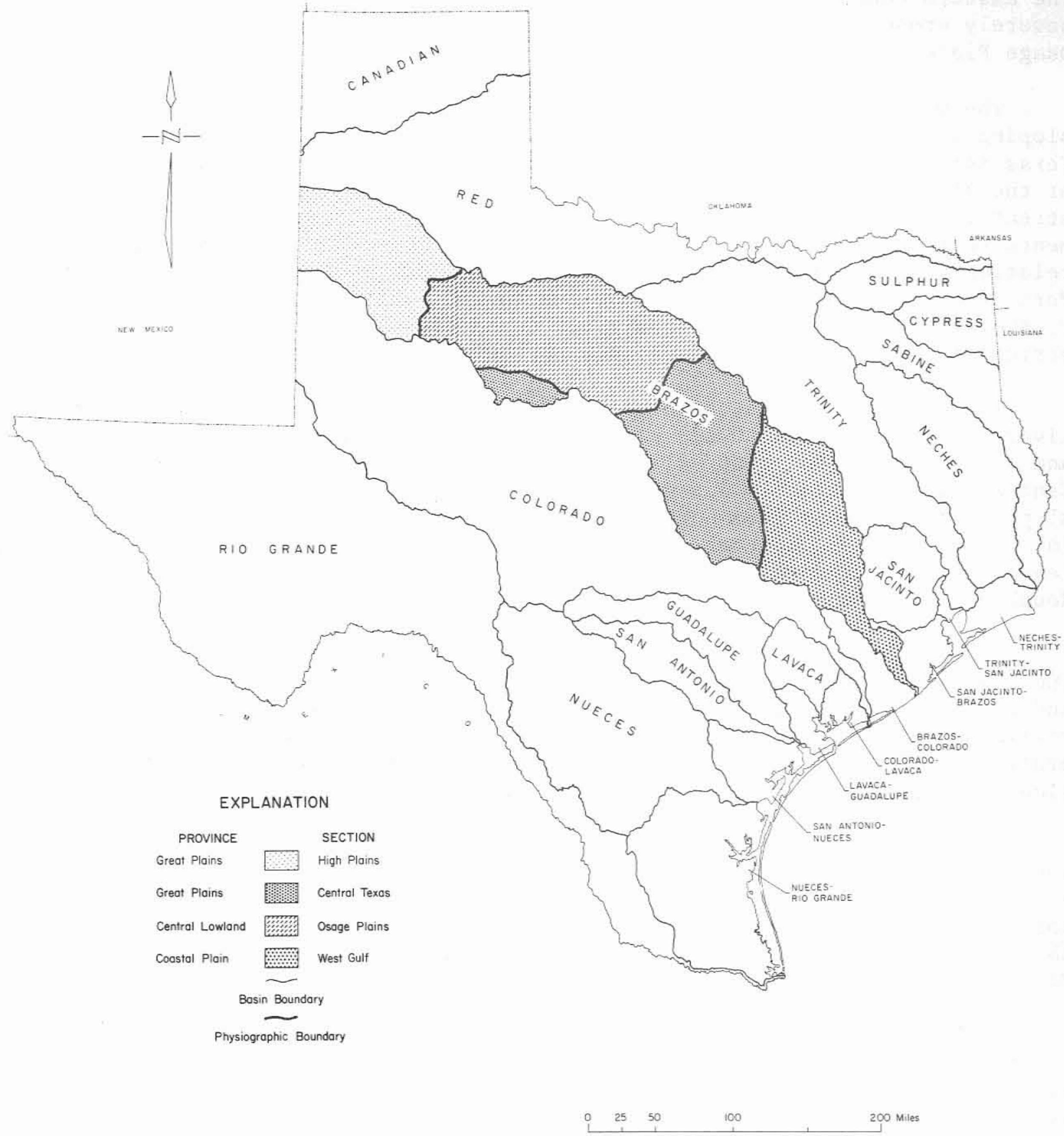

Figure 1

Index Map Showing River Basins in the State and Physiographic Sections of the Brazos River Basin

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

smooth surface of the plain is broken by many undrained depressions or wet weather lakes, a few large water-table lakes, and shallow stream valleys that become deeper toward the eastern edge of the region. Much of the area has almost no surface drainage and normally does not contribute to surface runoff. The eastern edge of the High Plains is defined by the Cap Rock Escarpment, a severely eroded belt of rugged and broken land that slopes abruptly down to the Osage Plains near Post.

The Osage Plains section within the Brazos River basin is an eastward sloping upland plain that adjoins the High Plains on the west and the Central Texas section of the Great Plains Province on the east and south. The surface of the plain is flat to rolling, becoming more broken along the entrenched streams. In places, the gently sloping surface is interrupted by low escarpments formed by beds of gypsum, sandstone, and dolomite. Stream gradients are relatively steep; bluffs along the Salt Fork, Double Mountain Fork, and Clear Fork of the Brazos River range from 100 to 200 feet high. In the eastern part of the area the main-stem Brazos River is deeply entrenched and meanders in a series of almost complete loops in a narrow valley with almost no flood plain.

The Central Texas section of the Great Plains Province within the Brazos River basin adjoins the Osage Plains on the west and north near Mineral Wells and is bounded by the West Gulf Coastal Plains on the east near Waco. The Central Texas section is a region of great topographic variety. The general slope of the land is from northwest to southeast, and most of the streams flow in that direction. However, the section has been dissected heavily by erosion, leaving plateau remnants parallel to and between the deeply entrenched streams. Rough hillsides and valleys border most of the streams in this section.

The West Gulf Coastal Plain section of the Coastal Plain Province within the Brazos River basin adjoins the Central Texas section on the north and west and extends southeastward to the Gulf of Mexico. In this section the gently rolling country of the interior merges with the level, nearly featureless prairie of the Gulf Coast. In the rolling country of the interior, stream slopes are moderately steep; toward the coast they are very flat.

The Brazos River is formed by the confluence of the Double Mountain Fork and Salt Fork of the Brazos River in northeastern Stonewall County near the Stonewall-Haskell County line. From this confluence, the Brazos River flows northeastward across Knox and Baylor Counties, then generally southeastward about 800 river miles (an airline distance of about 400 miles) to the Gulf of Mexico.

Principal tributaries to the Brazos River, in downstream order, are the Clear Fork Brazos River; the Bosque River; the Little River, including its tributaries (the Leon, Lampasas, and San Gabriel Rivers); Yegua Creek; and the Navasota River. Most of these tributaries drain the western side of the Brazos River basin, flow generally southeastward, and join the Brazos River downstream from Whitney Reservoir.

Cultural Features and Economic Development

The Brazos River basin constitutes about 16 percent of the total area of Texas and has more than 13 percent of the State's population. In 1960 the population of the basin was about 1,300,000, more than half of which was urban.

Twenty-nine cities had more than 5,000 inhabitants in 1960. The largest of these are Lubbock in the High Plains, with a population of 128,691 (1960 census); Abilene in the central part of the basin, with a population of 90,368; and Waco and Temple in the eastern part, with populations of 97,808 and 30,419 respectively. During the period 1940-60, the population increased in most of the High Plains counties and in the counties where the larger cities are located. However, the population decreased in most of the other counties, due partly to the migration of people to the large cities. This urban growth was accompanied by an evolution of the Brazos River basin from a predominantly agricultural economy to an economy which blends oil and gas production, diversified industry, and agriculture.

The petroleum industry is the principal industry in the basin. Oil was discovered as early as 1917 at Ranger in Eastland County, and subsequently oil fields have been discovered throughout the basin (Figure 7).

Other industrial activities concerned with the production and processing of mineral products are also important to the economy of the Brazos River basin. These include the operation of sand and gravel plants and stone quarries; the production of cement materials and manufacture of cement; the production of clay and manufacture of brick, tile, and other clay products; the mining and processing of gypsum; and the production of salt and sulphur.

The principal manufacturing plants in the basin are concentrated in or near the large cities. In Waco and Temple, the principal manufacturing centers in the eastern part of the basin, products include automobile tires, insecticides, furniture, textiles, clothing, shoes, glass, rock-wool insulation, cement, clay products, cottonseed oil, and food. Lubbock, in the western part of the basin, is one of the largest inland cotton markets in the world and is the largest cottonseed processing center in the world.

Although the Brazos River basin has undergone rapid industrialization, agriculture contributes substantially to the economy. The rapidly growing population has stimulated agricultural production by creating a large market for local farm produce; and large-scale irrigation, especially in the High Plains and Osage Plains sections, has greatly increased agricultural production. Cotton, grain sorghums, and wheat are the principal crops in the western part of the basin; in the eastern part, cotton and grain sorghums are the principal crops. Beef cattle are raised throughout much of the basin.

SURFACE-WATER DISTRIBUTION

Precipitation

Precipitation within the Brazos River basin is unevenly distributed, both areally and seasonally. Average precipitation ranges from less than 18 inches per year in the western, semiarid part of the basin to about 48 inches in the eastern, subhumid part. Mean annual precipitation in the basin for the 1931-60 period and annual and average monthly precipitation at two U.S. Weather Bureau stations for the 1931-64 period are shown in Figure 2. These data indicate that in the upper part of the basin precipitation is usually minimum during the winter and maximum in late spring and early summer. In the lower part of the basin, precipitation, though usually minimum in the summer, is more uniformly

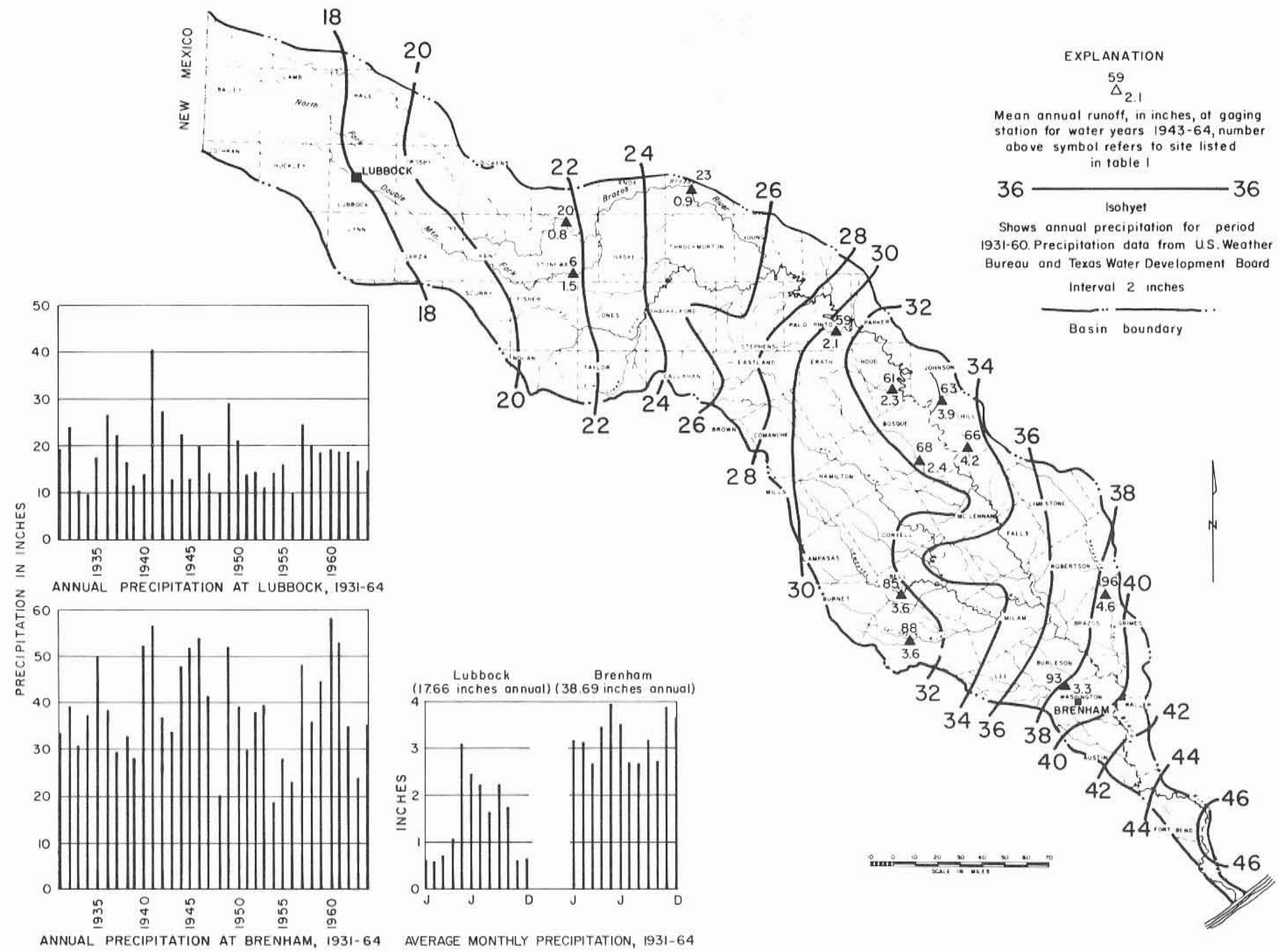

Figure 2

Precipitation and Runoff

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

distributed throughout the year. However, precipitation throughout the basin fluctuates much more than is indicated by the monthly averages. During the 1931-64 period, for example, precipitation at Lubbock ranged from 0.00 inches in several months to 13.93 inches in September 1936. Similarly, precipitation at Brenham ranged from 0.03 inches in July 1955 to 14.22 inches in November 1940. Precipitation so unevenly distributed in time does not sustain streamflow. Therefore, storage projects are required to provide dependable quantities of surface water for municipal or industrial use.

Runoff

Streamflow Records

Flow of the Brazos River was measured by the U.S. Geological Survey as early as 1898, when a gaging station was established at Waco. Records for this station are continuous from October 1898 to date. In 1916 a gaging station was established on the Little River at Cameron; the record for this station is also continuous. Although streamflow records were obtained at a few other stations for short periods before 1923, systematic collection of streamflow data was greatly expanded in 1923 and 1924, when 22 gaging stations were established on the main stem and tributaries. More than 40 years of continuous discharge records are available for several of these stations. In 1964 the Geological Survey operated 10 streamflow stations on the main-stem Brazos River, 65 stations on tributaries, 12 reservoir-content stations, and 32 low-flow partial-record stations. The periods of record for selected streamflow stations operated by the Geological Survey before October 1965 are given in Table 1; locations for these stations are shown in Figure 3.

Records of discharge and stage of streams and contents and stage of lakes or reservoirs from 1903 to 1907 and from 1924 to 1960 have been published in the annual series of U.S. Geological Survey water-supply papers. (See list of references.) Beginning with the 1961 water year, streamflow records have been released by the Geological Survey in annual reports on a state-boundary basis (U.S. Geol. Survey, 1961, 1962, 1963, 1964b). Summaries of discharge records giving monthly and annual totals have been published by the U.S. Geological Survey (1939, 1960, 1964a) and the Texas Board of Water Engineers (1958).

Variation in Runoff from Sub-Basins

Runoff is that part of precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on stream channels. However, the two terms are not synonomous for regulated flow. Flow of the main-stem Brazos River is regulated by Possum Kingdom and Whitney Reservoirs. Similarly, many of the tributaries are regulated by reservoirs, flood-retarding structures, and farm ponds. Therefore, if historical streamflow records from these streams are to be used for computing runoff, they must first be adjusted for the effects of regulation and consumptive water use. Lockwood, Andrews, and Newnam (1960) have computed runoff from Texas watersheds and sub-basins for the 1940-57 period by adjusting historical streamflow records to the 1957 conditions of regulation and use. Such detailed adjustments were beyond the scope of the present study. However, some streams in the Brazos River basin are not yet regulated by reservoirs of appreciable size. In the following summary of runoff, historical streamflow records for these streams were used to show the general pattern of areal runoff within the basin. Because most of the chemical-quality data for streams in the Brazos River basin have been collected since 1942, the 1943-64 period was selected as the base for computing average runoff. Records of streamflow from most of the stations for which runoff data were computed were continuous for the entire base period. For those stations whose records were not complete, runoff data for the missing period of record were estimated by correlating the available data for each station with data for stations in nearby drainage areas (Searcy, 1960, p. 79-84).

Average annual runoff from contributing areas within the Brazos River basin, as measured or estimated at 11 streamflow stations, is shown on the map in Figure 2. These data show that average annual runoff from sub-basins has ranged from less than 1 inch to more than 4 inches. Lowest annual runoff is from the upper part of the basin, where precipitation averages less than 22 inches annually. Although both runoff and precipitation generally increase from the upper to the lower parts of the basin, the progressive increase of runoff from the upper to the lower parts is less uniform than that of precipitation. Part of this inconsistency undoubtedly is due to small but variable amounts of water diverted from some of the streams; other contributing factors include differences in temperature, types and density of vegetation, surface slope, soils, and permeability of aquifers.

Runoff data in Figure 2 show only a measure of the central tendency of streamflow at each selected station. The magnitude and frequency of the high and low flows can best be shown by flow-duration curves. The shape of a flow-duration curve is an index of the variability of flow. A curve with a steep slope throughout indicates a highly variable stream whose flow is largely from direct runoff, whereas a curve with a flat slope shows the presence of surface-water or ground-water storage. Flow-duration curves for three stations on streams in the Brazos River basin for the 1943-64 period are shown in Figure 4. The steep slope of each curve shows that the flow of streams throughout the basin are highly variable. Consequently, storage projects are required to make surface water available in dependable quantities for municipal or industrial use.

SURFACE-WATER RESOURCES DEVELOPMENT

Because precipitation and runoff in the Brazos River basin are highly variable, considerable development of surface-water resources has occurred. Thirty reservoirs, either existing or under construction during the 1964 water year, have conservation-storage capacities of 5,000 acre-feet or more. The capacity, owner, location, and use of these reservoirs are listed in Table 2; the locations also are shown in Figure 3. Most of these reservoirs are primarily for water conservation. Six reservoirs--Whitney, Waco, Proctor, Belton, Stillhouse Hollow, and Somerville--have the additional purpose of flood control; Possum Kingdom and Whitney Reservoirs also generate hydroelectric power.

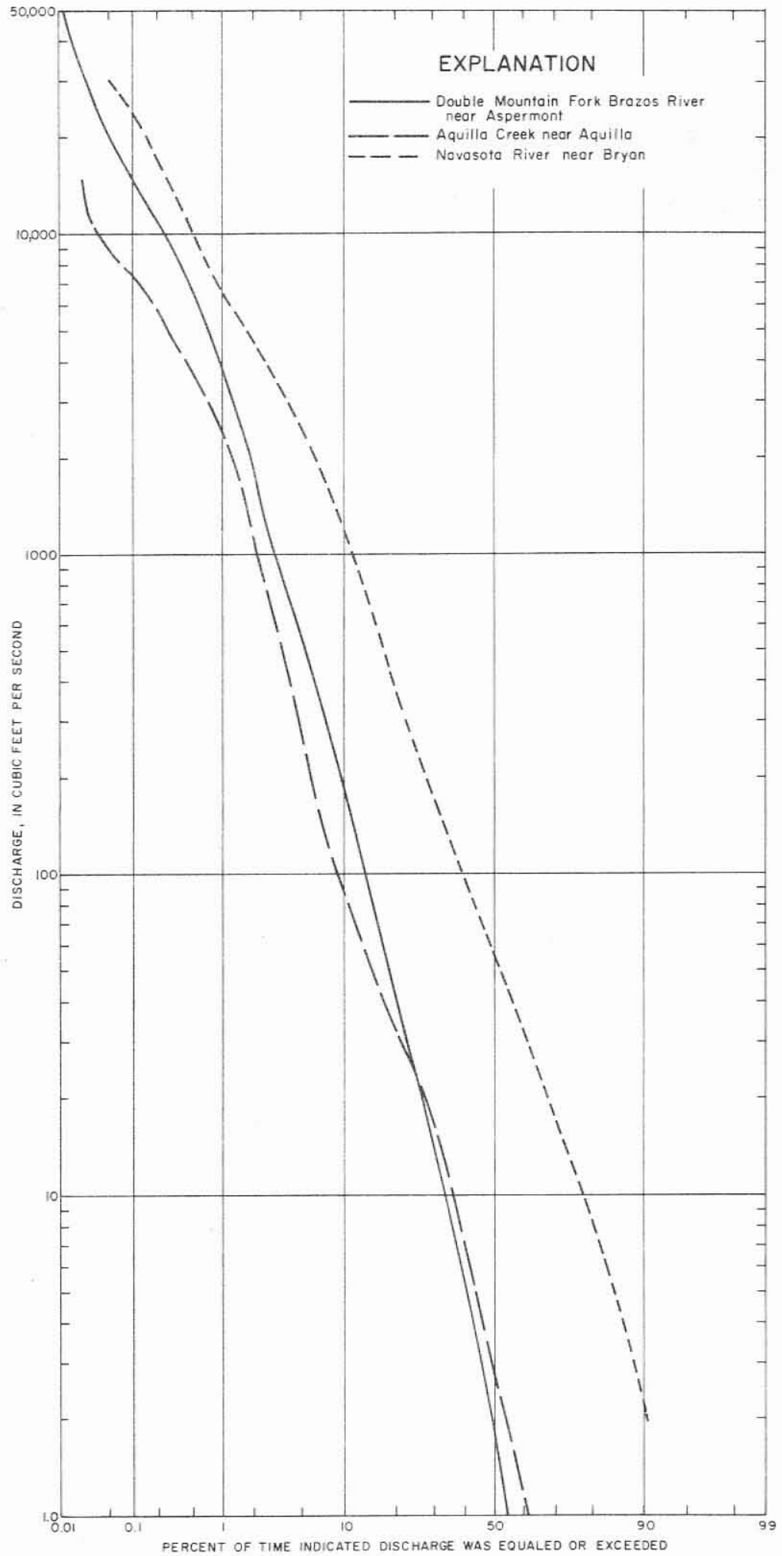

Figure 4

Flow Duration Curves of Daily Flows at Selected Sites, 1943-64

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

CHEMICAL QUALITY OF THE WATER

Chemical-Quality Records

Although the U.S. Geological Survey operated a daily chemical-quality station on the Brazos River at Waco from December 1906 to November 1907, most of the chemical-quality data on surface waters of the Brazos River basin have been collected since 1940. In 1941 a sampling station was established on the Brazos River at Richmond. Data obtained from this station until 1945 consisted of chemical analyses of the filtrate from samples collected by the U.S. Soil Conservation Service for the determination of suspended matter. Usually only specific conductance and chloride determinations were made on these filtered samples. Since October 1945, chemical analyses have been more comprehensive, and the discharge-weighted averages of analyses for the station have been computed annually.

In 1942 daily sampling stations were established on the main-stem Brazos River near South Bend and below Possum Kingdom Dam near Graford, and on the Navasota River near Easterly. (Only specific conductance and chloride content were determined on most of the samples from the Easterly station.) The Easterly station was discontinued in December 1942, as was the South Bend station in March 1948; however, records for the station at Possum Kingdom Dam are continuous to date. Since 1942, the U.S. Geological Survey, for varying periods, has collected chemical-quality data at 32 other daily sampling stations. In addition, periodic or miscellaneous chemical-quality data are available for hundreds of additional sites in the Brazos River basin.

The periods of record for selected data-collection sites are given in Table 1; the locations are shown in Figure 3. Chemical-quality data for the daily stations are summarized in Table 3, and the complete records are published in an annual series of U.S. Geological Survey Water-Supply Papers and in reports of the Texas Water Development Board and predecessor agencies. (See list of references.) Results of selected periodic and miscellaneous analyses are given in Table 4.

The Texas State Health Department since 1957 has maintained a statewide stream-sampling program, which includes the periodic determination of pH, biochemical oxygen demand, total solids, dissolved oxygen, chloride, chlorine demand, and sulfate at 36 sites in the Brazos River basin. Data from this program were made available to the U.S. Geological Survey and were studied during the preparation of this report.

Factors Affecting Chemical Quality of Water

All water from natural sources contains dissolved minerals, but the chemical character and concentrations of dissolved constituents in surface waters may fluctuate widely. Some of the environmental factors that affect the chemical quality of surface waters are variation in climate; geology; patterns and characteristics of streamflow; and activities of man, such as impoundment and diversion, disposition of municipal and industrial wastes, and irrigation.

Waters usually are classified in various ways to demonstrate similarities and differences of composition. In the following discussion, which relates chemical quality of water to environmental factors, water is classified on the basis of dissolved-solids content, principal chemical constituents, and hardness. On the basis of dissolved-solids content, waters are classified as fresh, slightly saline, moderately saline, very saline, or brines as follows:

Classification	Dissolved solids (ppm)
Fresh....................	< 1,000
Slightly saline...........	1,000 - 3,000
Moderately saline.........	3,000 - 10,000
Very saline	10,000 - 35,000
Brines....................	> 35,000

As to geochemical types, waters are classified on the basis of the predominant cations and anions in equivalents per million. For example, a water is referred to as a sodium chloride water if the sodium and chloride ions constitute 50 percent or more of the cations and anions respectively. Waters in which one cation and one anion are not clearly predominant are recognized as mixed types and are identified by the names of all the important cations and anions.

On the basis of hardness, waters are classified as soft, moderately hard, hard, or very hard. (See tabulation on page 53.)

Geology

The amounts and kinds of minerals dissolved in water that drains from areas where municipal and industrial influences are small depend principally on the chemical composition and physical structure of rocks and soils traversed by the water and on the length of time the water is in contact with the rocks and soils. The amount of minerals in the rocks and soils available for solution is decreased by leaching; therefore, in areas of high rainfall, rocks that originally contained large quantities of readily soluble minerals have been leached by circulating water until the mantle rock and residual soil contain relatively small amounts of readily soluble minerals. These rocks usually yield water of low mineralization. However, in arid or semiarid regions most soils, and the rocks from which they originated, are incompletely leached and still contain large amounts of readily soluble material; water in contact with these rocks and soils may become highly mineralized. In the semiarid upper part of the Brazos River basin, some rocks and soils contain large quantities of halite, gypsum, limestone, or dolomite. Waters draining from these rocks and soils usually are highly mineralized. In the lower part of the basin, where precipitation is more abundant, the well-leached rocks and soil usually yield waters of low mineralization.

Most streams in the Brazos River basin traverse more than one geologic formation; therefore, water in these streams usually is a composite of waters from several formations. The chemical character and mineralization of these streams often vary, depending upon the relative quantity of water contributed by each source. Similarly, the mineral composition of a particular formation may differ from area to area; and in some areas the chemical composition of water in the formation may be altered by highly mineralized effluent from another formation with which it is hydraulically connected. For example, detailed explorations (Stevens and Hardt, 1965) indicate that the Croton Creek-Salt Croton Creek area is underlain by two distinct bodies of ground water. Although the waters are in hydraulic continuity, their chemical composition is vastly different. The shallow water contains from 2,000 to 5,000 ppm dissolved solids and is the calcium sulfate type. In contrast, the underlying body of water is a nearly saturated sodium chloride brine. Data from scattered localities and in miscellaneous reports suggest that this brine body extends many miles beneath the High Plains (Stevens and Hardt, 1965, p. 16). Therefore, the mineralization and chemical character of water contributed to surface streams by a particular formation may differ from place to place in the outcrop. In other areas the chemical composition of ground water and surface water is altered by pollution from municipal or industrial wastes. For these reasons the following discussion which relates chemical composition of surface water in the Brazos River basin to geology is very general.

The geology of the Brazos River basin has been described by Cronin and others (1963, p. 20-35). Rocks exposed in the basin consist of a thick series of sedimentary strata that range in age from Ordovician to Recent; the outcrop areas of the various geologic units are shown in Figure 5.

Chemical analyses of selected low-flow samples of surface waters are represented diagrammatically (Stiff, 1951) in Figure 5 to relate chemical composition of surface waters to geology. The shape of the diagram indicates the relative concentrations of the principal chemical constituents of the water (in equivalents per million), and the size of the diagram indicates roughly the relative degree of mineralization.

Headwater streams of the Brazos River rise in the Ogallala Formation of Tertiary age. The Ogallala consists of clay, silt, sand, gravel, and caliche. Some of the sand, gravel, and silt are consolidated; but some cementation occurs, chiefly by calcium carbonate. However, the cementation occurs irregularly throughout the formation. The individual beds or lenses of silt, sand, gravel, and clay are not continuous over wide areas. Because of these local differences, the chemical quality of water in the Ogallala differs from area to area in the outcrop. Chemical analyses of water from selected wells in the Ogallala (Cronin and others, 1963, p. 83) indicate that the water is fresh to slightly saline, very hard, and siliceous. Principal chemical constituents are magnesium, sodium, calcium, and bicarbonate. Water from some of the wells has a high fluoride content. Although most of the High Plains section of the Brazos River basin is underlain by the Ogallala, the effective drainage area of streams underlain by the formation is relatively small. Practically no runoff occurs from most of the outcrop, except after exceptionally heavy rains. Base flow generally is nonexistent in most of the streams that traverse the Ogallala outcrop. However, in the eastern part of the outcrop, seeps and springs contribute a small amount of flow to the North Fork Double Mountain Fork Brazos River and the White River. Low flow of the North Fork Double Mountain Fork downstream from Lubbock is sustained partly by return flow from irrigation and by sewage effluent (Irelan, 1955, p. 12) and, therefore, is not representative of water from the Ogallala. However, water of the White River near Crosbyton that drains from the Ogallala generally contains less than 500 ppm dissolved solids and is very hard. Principal chemical constituents are magnesium, sodium, calcium, and bicarbonate (Figure 5, site 11).

Downstream from the Ogallala outcrop the drainage areas of both the Double Mountain and Salt Forks of the Brazos River, the two principal headwater streams, are underlain successively by rocks of Triassic and Permian age. The Dockum Group of Late Triassic age consists of clay, shale, sandstone, conglomerate, and some gypsum and anhydrite. No generalization can be made concerning the chemical quality of water contributed by the Dockum Group because the chemical composition varies with local conditions. Water from some wells that tap the Dockum Group in Scurry County is fresh, very hard, and the calcium bicarbonate or sodium bicarbonate type (Cronin and others, 1963, p. 58). In other outcrop areas of the Dockum Group, shallow wells yield water that is heterogeneous in chemical composition. However, when water yielded by the Dockum Group contains more than 5,000 ppm dissolved solids, it usually is the sodium chloride type. Data on the chemical quality of water in streams that traverse the Dockum Group are meager. Streams that drain the outcrop are intermittent, usually flowing for only a short time in response to a rain. However, chemical analyses of a few samples collected from these streams indicate seepage of saline water from some of the outcrop areas. Water of the Double Mountain Fork at Justiceburg is slightly to very saline during low flow. Principal dissolved constituents are sodium and chloride (Figure 5, site 1). Water of McDonald Creek, a tributary of the Salt Fork that drains the Dockum Group, is also very saline and the sodium chloride type.

Rocks of Permian age that crop out in the drainage areas of the Double Mountain and Salt Forks of the Brazos River include the Whitehorse, Pease River, and Clear Fork Groups. These rocks consists predominatly of shale, anhydrite, gypsum, limestone, dolomite, and sandstone. The chemical composition of water contributed to surface streams by these rocks varies. During periods of sustained low flow, water of the Double Mountain Fork at the daily chemical-quality station near Aspermont usually is moderately saline and very hard. However, the principal chemical constituents vary. Some low-flow waters are the calcium sulfate type; others are the sodium chloride type; and others are a mixture of the two types. The chemical composition of low-flow waters in Double Mountain Fork tributaries that drain Permian rocks also varies. Low-flow water of Rough Creek near Rotan is slightly saline, very hard, and gypsiferous. Low-flow water of Tank Creek near Rule is slightly saline, very hard, and of no distinct geochemical type (Table 4).

Water that drains from Permian rocks in the drainage area of the Salt Fork Brazos River generally is highly mineralized. Daily chemical-quality records show that water of the Salt Fork near Aspermont is usually a sodium chloride brine. Although sodium and chloride are the principal chemical constituents, the water also contains large quantities of calcium, magnesium, and sulfate (Figure 5, site 20). Baker, Hughes, and Yost (1964, p. CC 43-48) have shown that much of the salinity of the Salt Fork originates from salt springs and seeps in the drainage areas of Croton and Salt Croton Creeks, which are underlain by the Whitehorse and Pease River Groups. Chemical analyses of water from these streams (Table 4) show that though waters of both streams are highly mineralized and the sodium chloride type, water from Salt Croton Creek is a nearly saturated brine. As mentioned previously, explorations by Stevens and

Hardt (1965) indicate that the entire Croton Creek-Salt Croton Creek area is underlain by a body of saturated brine.

Tributaries that drain Permian rocks and enter the main-stem Brazos River upstream from Seymour include North Croton and Mustang Creeks. Water of North Croton Creek near Knox City during low flow is slightly to very saline, very hard, and the sodium chloride type (Table 4). The chemical composition of water from Mustang Creek varies. At moderate flows, water of Mustang Creek near Knox City is fresh, very hard, and the calcium sulfate type. At very low flows the water is usually moderately saline, but the principal chemical constituents vary. Some low-flow waters are the sodium chloride type; others are the calcium sulfate type, and still others are a mixture of these two types (Table 4).

Water of the Brazos River at the daily chemical-quality station at Seymour is a composite of water from the Double Mountain and Salt Forks of the Brazos River plus inflow downstream from their confluence. Therefore, the chemical composition of the water in the main stem depends largely upon the relative amount of water contributed by the two forks. The chemical composition of water at the Seymour station varies; but during periods of sustained low flow, the water generally is moderately to very saline, very hard, and the sodium chloride type (Figure 5, site 23).

In the reach between the Seymour station and Possum Kingdom Reservoir, the Brazos River basin is underlain largely by rocks of Permian and Pennsylvanian age. Rocks of Pennsylvanian age that crop out in this reach consist of shale, sandstone, conglomerate, limestone, and beds of coal. The relation of chemical quality of water of the main stem to geology in this reach is obscured by the large concentrations of dissolved constituents contributed by areas upstream from the Seymour station. However, chemical analyses of water from tributaries show that water which drains from Permian rocks downstream from the Seymour station generally is less mineralized than water from Permian rocks in the headwaters. During low flow, water of Millers Creek, which drains largely from the Clear Fork and Wichita Groups of Permian age, ranges from fresh to slightly saline. Near Munday, for example, the water of Millers Creek generally contains less than 200 ppm dissolved solids, is moderately hard, and is the calcium bicarbonate type (Figure 5, site 24). Farther downstream, the water is more highly mineralized and is of no distinct geochemical type.

Much of the drainage area of the Clear Fork Brazos River is underlain by rocks of Permian and Pennsylvanian age. However, daily chemical-quality records for the Clear Fork at the Nugent, Fort Griffin, and Eliasville stations indicate that widespread oil-field brine pollution of surface streams is occurring in the drainage area. Daily chemical-quality records of Paint Creek near Haskell and California Creek near Stamford in the upstream part of the drainage area also show evidence of oil-field brine pollution. Similarly, most of the streams in the Hubbard Creek drainage area are being polluted. According to Hembree and Blakey (1964, p. 29) chloride contamination in streams of the Hubbard Creek watershed is so widespread that the quality of water of most of the streams has only a minor relation to surface geology. Therefore, the relation of quality of water of the Clear Fork Brazos River to geology is ill defined. Generally, however, the water is of much better quality than water that drains from Permian rocks in the drainage areas of the Double Mountain and Salt Forks of the Brazos River.

Flow of the upper Brazos River is impounded and becomes mixed in Possum Kingdom Reservoir. Because flow of the main stem between Possum Kingdom and Whitney Reservoirs is partly sustained by releases from Possum Kingdom Reservoir, no direct relation exists between the geology of the intervening area and the chemical quality of the water. Therefore, the following discussion relates the chemical composition of water of tributaries in this reach to geology. Tributaries in this reach for which some chemical-quality data are available include Keechi, Palo Pinto, and Paluxy Creeks, and Nolands River.

Most of the area drained by Keechi and Palo Pinto Creeks is underlain by the Canyon and Strawn Groups of Pennsylvanian age. These rocks consist of limestone, shale, and minor amounts of sandstone and conglomerate. During low flows, water of Keechi Creek near Graford and Palo Pinto Creek near Santo is generally fresh, very hard, and the calcium bicarbonate type (Figure 5, sites 56 and 59).

The drainage area of Paluxy Creek is underlain by the Trinity Group of Early Cretaceous age, which consists of limestone, sand, shale, anhydrite, clay, and conglomerate. During low flow, water of Paluxy Creek at Glen Rose generally contains less than 300 ppm dissolved solids and is very hard. Principal chemical constituents are calcium, magnesium, and bicarbonate (Figure 5, site 61).

Nolands River, which empties into Whitney Reservoir, traverses outcrops of the Washita and Fredericksburg Groups, undifferentiated, of Early Cretaceous age. These rocks consist principally of fossiliferous limestone and marl with some shale, clay, shell agglomerate, and sand. Water of Nolands River at Blum usually contains less than 500 ppm dissolved solids, ranges from hard to very hard, and is the mixed calcium sodium bicarbonate type (Figure 5, site 63).

Downstream from Whitney Reservoir, streams for which some chemical-quality data are available include Aquilla Creek; Bosque River; Little River and its principal tributaries (Leon, Lampasas, and San Gabriel Rivers); Little Brazos River, Yegua Creek, and Navasota River.

The drainage area of Aquilla Creek is underlain largely by the Woodbine Formation of Late Cretaceous age, which consists of crossbedded ferruginous sandstone, clay, shale, and sandy clay interbedded with lignite and gypsiferous clay. Water of Aquilla Creek near Aquilla generally is fresh but very hard. During low flow, principal chemical constituents are calcium, sulfate, and bicarbonate (Figure 5, site 66).

Much of the drainage area of the North and Middle Bosque Rivers is underlain by the Washita and Fredericksburg Groups, undifferentiated. Waters of both the North Bosque River near Clifton and the Middle Bosque River near McGregor usually contain less than 300 ppm dissolved solids, range from hard to very hard, and are the calcium bicarbonate type (Figure 5, site 68).

The Little River, which has the largest drainage area of any Brazos River tributary, receives waters from three principal tributaries--the Leon, Lampasas, and San Gabriel Rivers. Water of each of these is a composite of waters from several formations. The Leon River, the longest of the three tributaries, heads in rocks of Pennsylvanian age, but most of the drainage area is underlain by the Trinity Group and the Washita and Fredericksburg Group, undifferentiated, of Cretaceous age. Records of the daily chemical-quality station on the Leon River near Eastland for the 1951-53 water years and analyses for Leon

Reservoir (1955-63) indicate that water contributed upstream from Eastland usually is low in dissolved solids, hard, and the calcium bicarbonate type. Although water at the Eastland station was generally low in both sodium and chloride, the sodium chloride content increased erratically in some samples, indicating that some brine from oil fields was reaching surface streams. Therefore, the relation of quality of water to geology is partly obscured.

Much of the drainage area of the Lampasas River is also underlain by the Trinity Group and the Washita and Fredericksburg Groups, undifferentiated. In a base-flow study of the Lampasas River, Mills and Rawson (1965) have shown that water draining from these rocks is low in dissolved solids, very hard, and the calcium bicarbonate type. However, much of the sustained flow in the upper reaches of the Lampasas River is contributed by springs in a small Marble Falls Limestone inlier of Pennsylvanian age that crops out in the drainage area of Sulphur Creek. At the surface the Marble Falls Limestone is chiefly a fossiliferous limestone containing thin beds of shale. Chemical analyses of samples from Sulphur Creek have shown that the Marble Falls Limestone yields water that is slightly saline, very hard, and the sodium chloride type (Figure 5, site 83). During low flow, water of the Lampasas River at the daily chemical-quality station at Youngsport, which is a composite of waters from the Marble Falls Limestone; the Trinity Group; and the Washita and Fredericksburg Groups, undifferentiated, usually contains less than 500 ppm dissolved solids and is very hard and the sodium chloride type (Figure 5, site 85).

Formations of the Trinity Group and the Washita and Fredericksburg Groups, undifferentiated, also crop out in the western half of the San Gabriel River drainage area. Water of the North and South Forks of the San Gabriel River, which drains from these rocks, is low in dissolved solids, ranges from hard to very hard, and is the calcium bicarbonate type. Water of the San Gabriel River at Georgetown, which is a composite of waters from the two forks, is similar in chemical character (Figure 5, site 88). Much of the eastern half of the San Gabriel drainage area is underlain by rocks of Late Cretaceous age, including the Eagle Ford Shale, Austin Chalk, rocks of Taylor age, and the Navarro Group, undifferentiated. These formations consist principally of marl, sandy marl, shale, chalky and marly limestone, and calcareous sandstone. Near the eastern limit of the drainage area, narrow bands of the Midway Group of Paleocene age and the Wilcox Formation of Eocene age crop out. The Midway Group consists of glauconitic sand, silt, calcareous and gypsiferous clay, and limestone. The Wilcox consists principally of sand, silt, clay, and lignite. Leifeste and Smith (1965) have shown that the base flow of streams that traverse these formations in the eastern half of the San Gabriel drainage area generally is low in dissolved solids, very hard, and the calcium bicarbonate type.

Water of the Little River at the daily chemical-quality station at Cameron, which is a composite of waters from the Leon, Lampasas, and San Gabriel Rivers, usually is low in dissolved solids, hard to very hard, and the sodium calcium bicarbonate type (Figure 5, site 89).

The drainage area of the Little Brazos River is underlain largely by the Midway Group of Paleocene age and Quaternary alluvium. Low flow of the Little Brazos River near Bryan probably is sustained largely by influent from the alluvium. No generalization can be made concerning the chemical character of water from the alluvium. The dissolved-solids content of water collected from the Little Brazos River near Bryan ranged from 275 ppm to 948 ppm. The water was usually hard or very hard but was of no distinct geochemical type. Sodium and calcium usually were the principal cations and in some samples were present in approximately equivalent amounts. However, in some samples sodium predominated. Bicarbonate was the predominate anion in most of the samples; however, it usually totaled less than 50 percent of the anions. In a few of the samples the chloride content was equivalent to or greater than the bicarbonate content.

Rocks that crop out in the Yegua Creek drainage area in downstream order include the Wilcox Formation, Claiborne and Jackson Groups (all of Eocene age), and Quaternary alluvium. At the daily chemical-quality station near Somerville, water that drains from these rocks during low flow usually contains less than 500 ppm dissolved solids and is a mixed type. Sodium and calcium are the principal cations; sulfate, chloride, and bicarbonate are the principal anions (Figure 5, site 93).

The northern reach of the Navasota River traverses outcrops of the Navarro Group, rocks of Taylor age, Austin Chalk, and Eagle Fork Shale, undifferentiated, of Late Cretaceous age and the Midway Group of Paleocene age; but much of the drainage area is underlain by rocks of Eocene age that also crop out in the Yegua Creek drainage area. However, the chemical composition of water of the two streams differ. Water of the Navasota River at the daily chemical-quality station near Bryan usually contains less than 500 ppm dissolved solids and is the sodium chloride type. However, the dissolved-solids content sometimes increases erratically, mostly due to an increase in the sodium chloride content. These data indicate that pollution by oil-field brine is occurring; therefore, the relation of geology to quality of water of the Navasota River near Bryan is partly obscured.

Downstream from its confluence with the Navasota River, the Brazos River receives inflow from several minor tributaries, but chemical-quality data for these streams are meager or lacking. Therefore, no relation between geology and chemical quality of surface water of these streams is shown on Figure 5.

Streamflow

In many streams where the flow is not regulated by upstream reservoirs, the concentrations of dissolved minerals vary inversely with the water discharge. The concentrations usually are minimum during periods of high flow because most of the water is surface runoff that has been in contact with soluble minerals of the exposed rocks and soils for a relatively short time. Conversely, the concentrations usually are maximum during periods of low flow when the water is predominantly ground water that has been in contact with the rocks and soils for a sufficient time to leach from them more of their soluble mineral matter. Figure 6 shows this general relationship to be true for selected streams in the Brazos River basin, but the scatter of points in Figure 6 shows that the inverse relationship between streamflow and concentration of dissolved solids is not precise. Obviously, the salt content at each selected site has varied over relatively wide ranges at all rates of water discharge. Much of this variation is related to the diversified geology and patterns of runoff in the drainage basin. However, the intermittent inflow of brine from oil fields has modified the general streamflow-quality pattern at some sites. Therefore, the probability of obtaining accurate results by using water discharge to estimate chemical quality of water in many streams of the basin is poor.

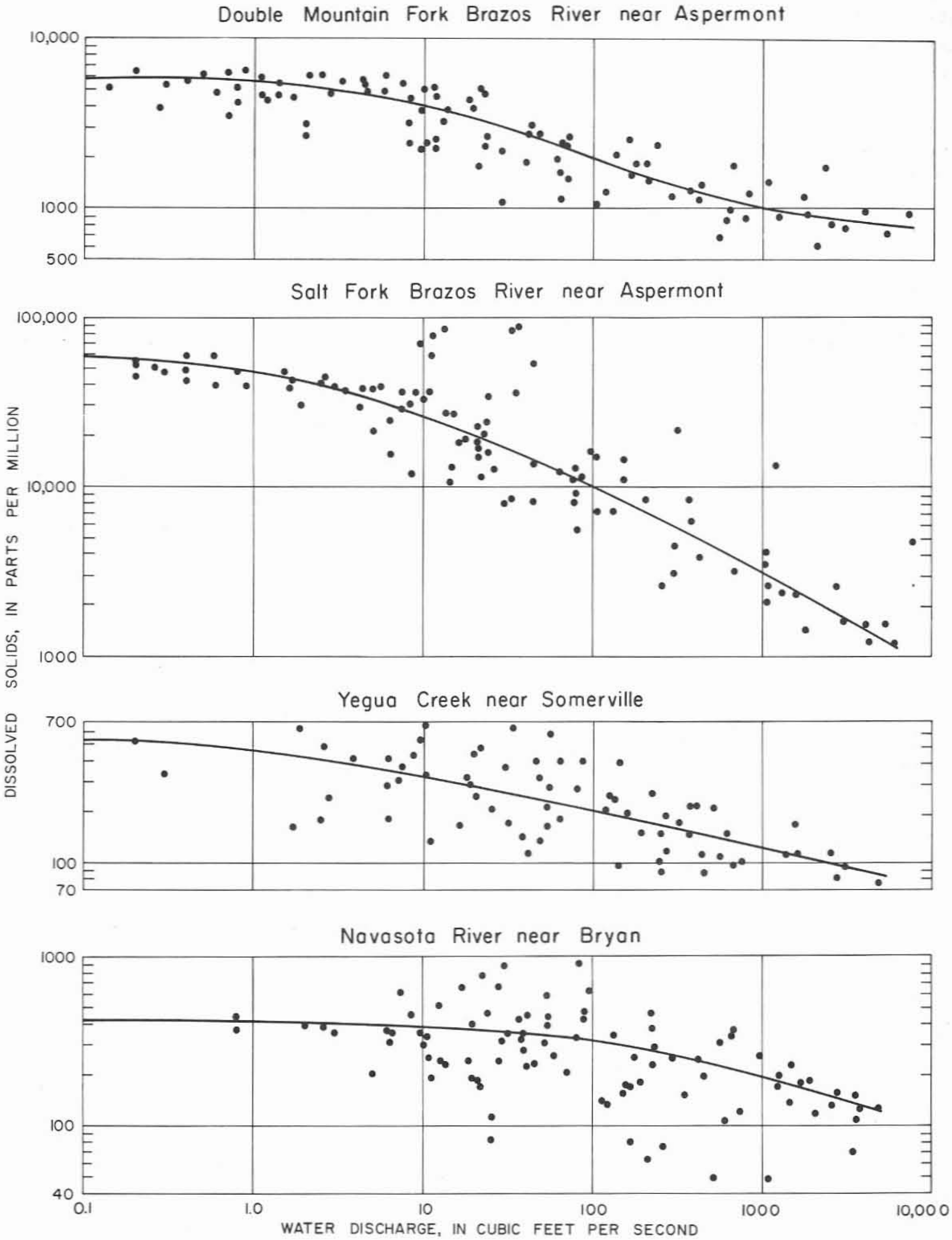

Figure 6

Relation of Concentration of Dissolved Solids to Water Discharge for Selected Tributaries of the Brazos River

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

Activities of Man

The activities of man often worsen the chemical quality of surface water. Depletion of flow by diversion and consumptive use, loss of water because of increased evaporation, and return flow of irrigation usually increase the dissolved-solids concentration of water in streams. Similarly the disposition of municipal and industrial wastes into a stream also degrades the chemical quality of water.

Reservoirs that impound water of good quality for municipal use have been constructed on many tributaries in the Brazos River basin. The resulting depletion of flow undoubtedly has caused higher average concentrations of dissolved solids in water of the main stem, because less water of good quality is now available for dilution of more saline flows. Also, much of the dissolved constituents in the diverted water eventually returns to the river system as municipal, agricultural, or industrial wastes in a volume of water that is greatly reduced by evaporation and consumptive use. Decreased flow as a result of diversion and an increase in the introduction of municipal wastes, resulting from continued municipal growth can be expected to increase the waste-disposal burdens of the stream system. This trend emphasizes the importance of providing the proper treatment of municipal wastes throughout the basin.

Use of both surface and ground water for irrigation may degrade the chemical quality of surface water in a stream system. Water of good quality removed from tributaries is no longer available for dilution of more saline water in the main stem. In addition, return flow from irrigation carries minerals dissolved from the irrigated land back to streams. During the past 25 years, irrigation has expanded rapidly in the Brazos River basin, especially in the High Plains and in the coastal rice belt. However, the use of water by irrigation is not yet a significant factor in the degradation of the quality of water in most streams of the Brazos River basin. Because very little drainage occurs in the High Plains, where most of the irrigation is from ground water, only minor amounts of dissolved solids are contributed to surface streams by return flow from irrigation.

Oil is produced in many areas in the Brazos River basin (Figure 7). Brine is produced in nearly all oil fields and if improperly handled eventually enters surface streams. According to an inventory by the Texas Railroad Commission in 1961, more than 93 percent of salt water produced in oil fields of the Brazos River basin was injected underground to prevent and abate pollution (Texas Water Commission and Texas Water Pollution Control Board, 1963). The remainder of the salt water was disposed of in open surface pits, some of which were unlined. From these so-called evaporation pits, much of the brine has percolated into the ground and has seeped, or eventually will seep, into streams of the basin; also some of it has been washed by surface runoff directly into streams. In addition, brine from abandoned wells and unplugged or improperly plugged test holes may contribute to the salinity of streams in some areas. Injected brine may move upward along fault zones and eventually reach surface streams.

The composition of oil-field brines varies, but the principal chemical constituents, in order of magnitude of their concentrations (in ppm), are generally chloride, sodium, calcium, and sulfate. Generally, an erratic variation of the sodium chloride content of surface water in streams that drain areas where oil fields are located is presumptive evidence that oil-field brine pollution is occurring. Because of the widespread contamination of

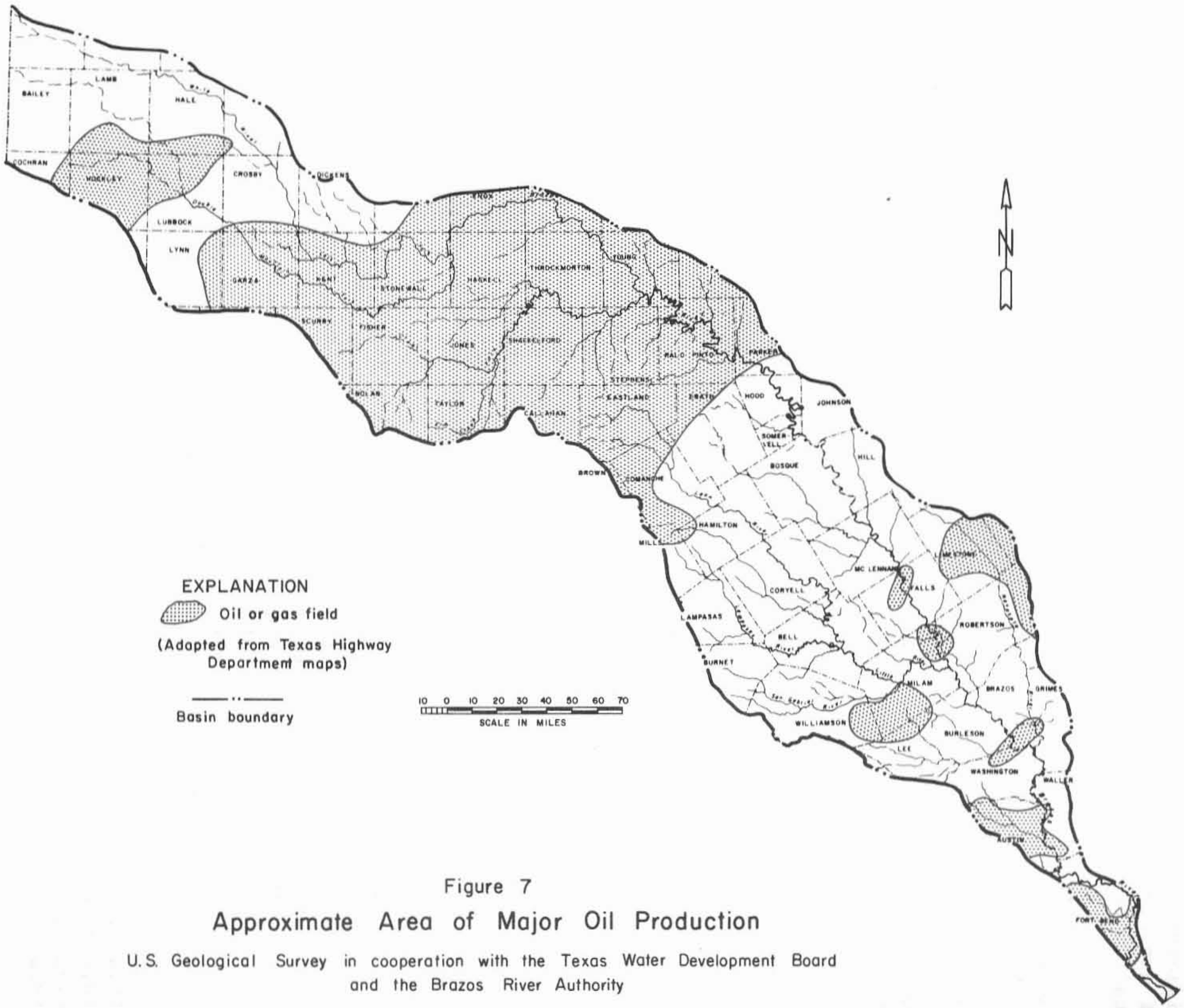

Figure 7

Approximate Area of Major Oil Production

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

streams in the upper Brazos River basin by naturally-occurring sodium chloride brines, distinction between natural contamination and man-made pollution is sometimes difficult. However, the saline water of many streams in the upper basin probably contains salts from both natural sources and oil fields. Daily chemical-quality records and reconnaissance investigations indicate that some brine is reaching surface streams in several parts of the basin. During the 1950-51 period, the erratic variation of the sodium chloride content of daily samples collected from Paint Creek near Haskell, a Clear Fork Brazos River tributary, indicated that pollution by oil-field brine probably was occurring. In July 1958, the Texas Board of Water Engineers conducted a reconnaissance investigation to determine the extent and nature of pollution in the drainage area of California Creek, a Paint Creek tributary. This investigation showed that brine probably was being contributed to surface waters of California Creek and thus to Paint Creek by subsurface leakage from wells tapping oil- and gas-bearing strata, possibly augmented by the effects of brine-injection wells (Shamburger, 1958, p. 2). Daily chemical-quality records of California Creek near Stamford indicate that pollution still is occurring.

Oil-field brine is contributing to the salinity of streams in the drainage area of Hubbard Creek, a tributary to the lower reach of the Clear Fork Brazos River. A large number of dry holes and abandoned wells were not properly plugged and shallow ground-water aquifers in many parts of the watershed have been polluted by oil-field brines. Additional large amounts of salt water brought to or near the surface as a by-product of oil production reaches the streams over the surface or through the ground. Chemical-quality records collected from Hubbard Creek near Breckenridge before closure of Hubbard Creek Reservoir show a progressive increase of chloride content from 1955 to 1962, which indicates that increasing amounts of oil-field brine were reaching surface streams. In December 1961 the Geological Survey in cooperation with the West Central Texas Municipal Water District and the Texas Water Commission began a comprehensive study of the surface-water resources of the Hubbard Creek watershed. According to Hembree and Blakey (1964) and Hembree (written communication, 1965) the investigation has shown:

1. The surface waters of Hubbard Creek watershed were originally low in chloride content; however, at present the chloride concentration of many of the streams is high, especially during low flow.

2. Chemical-quality records indicate a progressive increase in chloride between 1955 and 1962; this increase in chloride coincided with an increase in water-flood projects in the oil fields.

3. An overall improvement in the quality of water since 1962 probably is the results of intensified efforts to control disposition of oil-field brines. However, the quality of water in some streams has improved only slightly if at all.

Oil-field brines also have contributed to the salinity of Salt Creek in Young and Archer Counties. However, daily chemical-quality records collected from Salt Creek at Olney during the 1958-59 period and from Salt Creek at Newcastle during the 1958-60 period indicate that a campaign to reduce pollution and to encourage subsurface injection of salt water resulted in almost immediate improvement of water quality. In November 1962, Lake Graham on Salt Creek contained water with less than 300 ppm dissolved solids.

Another area where oil fields probably are contributing brine to surface streams is the upper reach of the Leon River. Chemical-quality records for a daily sampling station operated on the Leon River near Eastland during the 1951-53 period show that the sodium chloride content of the water usually was low. However, the sodium chloride content increased erratically some of the time. Similarly, analyses of several samples collected from the Leon River near Hasse during the 1962 water year (before closure of Proctor Reservoir) show evidence of oil-field brine pollution. During moderate and high flows, water of the Leon River near Hasse was low in dissolved solids and was the calcium bicarbonate type. During low flows, the water was more mineralized and a mixed type. Most of the increase in dissolved solids resulted from an increase in the sodium chloride content, which is indicative of oil-field brine pollution.

Daily chemical-quality records for the Navasota River near Easterly during 1941-42 and for the Navasota River near Bryan from October 1958 to date indicate that oil-field brine is reaching surface streams in the drainage area of the Navasota River. Reconnaissance investigations by the Geological Survey (C. H. Hembree, written communication, 1962) and by the Texas Water Commission (Burnitt, Holloway, and Thornhill, 1962) have shown that much of this brine originates from oil fields in northeast Limestone County and probably enters surface drainage largely by direct runoff. Despite efforts by the oil-field operators to contain the brine by the construction of large surface pits, the presence of flowing brine in road ditches and intermittent streams during the 1962 investigations indicated that gross seepage of brine from the surface pits was occurring. Leakage of brine from some of the 600 abandoned oil and gas wells in the area, many of which may be inadequately plugged, also may contribute to the salinity of surface streams.

These data show that the disposition of oil-field brines has resulted in the deterioration of water quality in several streams in the Brazos River basin upstream from Richmond. Although the load of dissolved constituents contributed by oil-field brines was not determined, the quality of water in most of these streams probably would be improved substantially if pollution were abated.

Oil-field brines, industrial effluents and sea-water intrusion are contributing to the salinity of the lower reach of the Brazos River. Since January 1962, the U.S. Geological Survey periodically has collected chemical-quality data at many sites on streams in the drainage areas of Big, Cow, and Varner Creeks in Fort Bend and Brazoria Counties. Chemical analyses show that the quality of water in Cow Creek varies widely from site to site (Table 4). The dissolved solids content (as indicated by specific conductance measurements) and chloride content usually are minimum at the upstream site 99 (Figure 3), often increase greatly at site 100, and then usually decrease slightly farther downstream at site 101. The water of Cow and Varner Creeks also varies widely in dissolved-solids and chloride content at all rates of water discharge (Table 4). These data indicate that oil-field brines and other industrial effluents are being contributed intermittently to streams in the drainage areas of Big, Cow, and Varner Creeks and thus to the lower reach of the Brazos River.

Part of the flow of the main-stem Brazos River downstream from Richmond is diverted and stored in the off-channel Harris and Brazoria Reservoirs. Chemical analyses of water from the two diversion sites (Table 3) show that the yearly maximum dissolved-solids concentrations at the Brazoria Reservoir station greatly exceeds those at the Harris Reservoir station. Chemical-quality surveys by the Dow Chemical Company have shown that much of the increase of dissolved solids at the Brazoria Reservoir station is caused by the intrusion to sea water from the Gulf of Mexico (E. T. Kincannon, oral communication, 1964).

Daily Variation of Chemical Quality

Some of the previous sections have shown that the quality of surface water in the Brazos River basin varies not only from stream to stream and from location to location on the same stream but also from time to time at any specified location. The daily variation in concentrations of dissolved solids at a particular location can be shown by a duration curve. Such a curve shows the percentage of days of flow for which specified concentrations of dissolved solids were equaled or exceeded during a particular period, without regard to sequence of occurrence. Figure 8 provides this information for the Double Mountain Fork Brazos River near Aspermont. For example, Figure 8 shows that during the period of the 1949-51, 1957-64 water years the dissolved-solids concentration equaled or exceeded 5,750 ppm on 10 percent of the days, 4,850 ppm on 25 percent, 3,770 ppm on 50 percent, 2,000 ppm on 75 percent and 1,040 ppm on 90 percent. These data also are given in Table 5, as is the equivalent data for sulfate, chloride, and hardness.

Although daily samples usually were collected at each site listed in Table 5, a complete chemical analysis of each daily sample was not feasible. Therefore, two or more daily samples usually were combined into a composite sample for chemical analysis on the basis of the total dissolved-mineral content as indicated by specific conductance measurements of daily samples, supplemented by data on river stage. For this frequency study, the dissolved-solids content of each daily sample was estimated from the specific conductance of the sample. These data for the period of record were used to prepare dissolved-solids duration curves for selected sites in the Brazos River basin. The dissolved-solids values in Table 5 were compiled from these duration curves. Next, curves of relation were plotted between dissolved solids and concentrations of sulfate, chloride, and hardness. Then, for each value of dissolved solids in the table, corresponding concentrations of sulfate, chloride, and hardness were tabulated. The resulting Table 5 shows the concentrations of dissolved solids, sulfate, chloride, and hardness that was equaled or exceeded in the percentage of days shown for the period of record. Insofar as conditions such as precipitation, runoff, temperature, land use, and pollution remain approximately the same as for the period of record, such a table is probably a satisfactory basis for predicting the percentage of time that a particular concentration may be expected in the future. However, data in Table 5 should be used with care because the periods of record are of varying length; some of the records are for a period of less than five years, during which time runoff generally was below the long-term average. Also, the level of upstream development has not remained constant during the period of record for some stations; several large reservoirs have been constructed on the main stem and on tributaries. Chemical-quality frequency data collected from a stream before the construction of a large reservoir is not directly comparable to data collected from the stream after reservoir regulation begins. The removal of water of good quality from reservoirs on tributaries may cause an increase in salinity of water of the main stem. Regulation of flow by flood-control or other type of detention reservoirs from which the consumptive use of water is small may smooth out chemical-quality variations, resulting in more uniformity in the chemical quality of water at downstream sites. Therefore, for some streams affected by

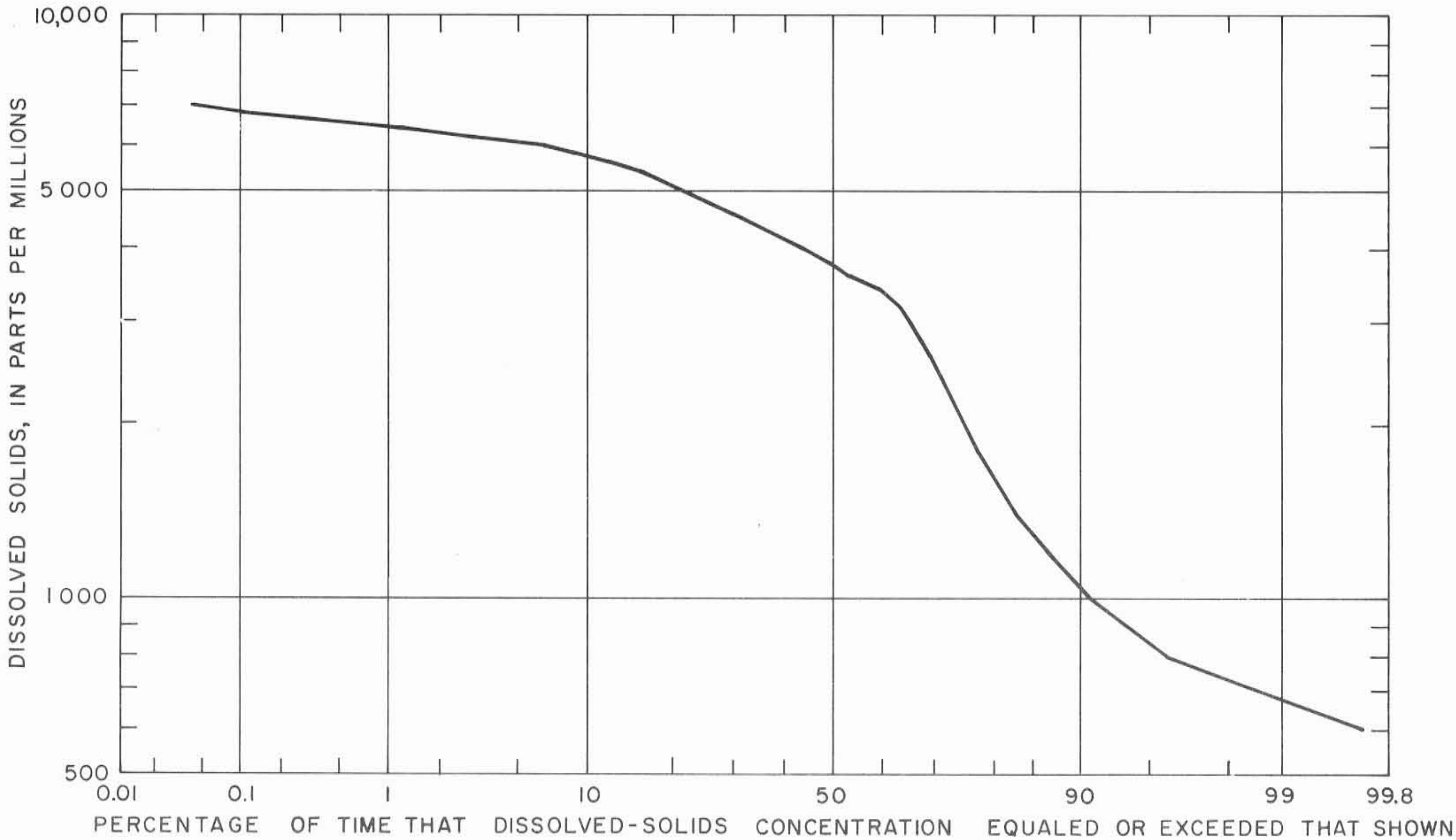

Figure 8

Duration Curves of Dissolved Solids for the Double Mountain Fork Brazos River near Aspermont, 1949-51 and 1957-64

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

reservoir regulation, Table 5 gives chemical-quality frequency data for periods both before and after reservoir construction.

Similarly, the level of pollution in streams of the basin has not remained constant. Although an intensified effort to control pollution during the past few years has resulted in an improvement in the quality of water in some streams, continued municipal and industrial growth have increased the waste-disposal burdens of other streams in the basin.

Regardless of these limitations, data in Table 5 are useful for showing the extent of past water-quality variations, for evaluating some of the factors that have caused these variations, and for determining the suitability of water for various uses.

The chemical quality of water of the Double Mountain Fork Brazos River near Aspermont is highly variable. The dissolved-solids content has ranged from less than 600 ppm to more than 7,000 ppm. During about 90 percent of the period of record, the dissolved-solids content equaled or exceeded 1,040 ppm; for about 10 percent of the time it equaled or exceeded 5,750 ppm. Similarly the sulfate, chloride, and hardness contents of the water are highly variable. During 80 percent of the time, sulfate concentrations ranged between 425 and 1,900 ppm, chloride concentrations ranged between 170 and 1,950 ppm, and hardness concentrations ranged between 460 and 2,470 ppm. The principal factor resulting in the variation of dissolved minerals was water discharge. The dissolved-solids content was usually highest during periods of low flow, when most of the flow consisted of ground-water inflow. The quality of water improved with increase in water discharge (Figure 6).

The dissolved-solids content of water of the Salt Fork Brazos River near Aspermont has ranged from about 1,000 ppm to more than 135,000 ppm. During about 50 percent of the period of record, the dissolved-solids content equaled or exceeded 33,900 ppm. (In comparison, the dissolved-solids content of ocean water averages about 35,000 ppm.) The principal chemical constituents of the water also were highly variable. For example, during 80 percent of the time, the chloride content of the water ranged between 2,280 and 29,400 ppm. For about 50 percent of the time the chloride content equaled or exceeded 18,700 ppm. The dissolved-mineral content of the water was maximum during low flow when most of the flow was contributed by highly mineralized inflow from seeps and springs in the drainage area of Croton and Salt Croton Creeks. However, some medium and high flows also were very highly mineralized because of the solution of large quantities of salt that had been previously deposited in flats around salt springs and seeps and in stream channels (Figure 6).

Water of the main-stem Brazos River at the Seymour station during the 1960-64 period usually was slightly to very saline. Although the dissolved-solids content ranged from about 500 ppm to more than 20,000 ppm, about 50 percent of the time the dissolved-solids content equaled or exceeded 8,100 ppm. Because water at the Seymour station is a composite of water from both the Double Mountain and Salt Forks, the dissolved-solids content and the chemical composition depend largely upon the proportion of water contributed by each fork. When most of the water is contributed by the Salt Fork, the water usually ranges from moderately to very saline and chloride greatly predominates over sulfate When most of the flow is contributed by the Double Mountain Fork, the water usually ranges from slightly to moderately saline; and although chloride usually is the predominant anion, the percentage of sulfate increases.

The water of the Clear Fork Brazos River usually is much superior in quality to that of either the Double Mountain Fork or the Salt Fork. During the 1962-64 water years, the dissolved-solids content of the Clear Fork Brazos River at Eliasville ranged from about 100 ppm to more than 3,200 ppm; but about 50 percent of the time the water contained less than 1,000 ppm. Water of California Creek, a tributary to the upper reach of the Clear Fork, generally was more mineralized than water of the Clear Fork at Eliasville. During the 1963-64 water years, the dissolved-solids content of water of California Creek near Stamford ranged from about 200 ppm to more than 13,000 ppm, equaling or exceeding 5,200 ppm about 50 percent of the time. Although the relation between dissolved-solids content and water discharge was not precise, the dissolved-solids content in both California Creek and Clear Fork usually was minimum during high flows when most of the water consisted of direct runoff. However, the concentrations of principal dissolved constituents, especially chloride, varied markedly during some high-flow periods, apparently because of oil-field brine pollution. Because of this variation, the relation between dissolved solids and individual chemical constituents was ill defined, and values for individual chemical constituents in Table 5 are rough approximations.

Oil-field brine pollution also has resulted in marked variation of the quality of water of Hubbard Creek, the principal tributary to the lower reach of the Clear Fork Brazos River. During the 1956-61 period, before closure of Hubbard Creek Reservoir, the dissolved-solids content of Hubbard Creek near Breckenridge ranged from less than 100 ppm to more than 5,000 ppm. However, for about 50 percent of the time the dissolved-solids content equaled or exceeded 680 ppm. Although the chemical quality usually improved with increase in water discharge, the dissolved-solids content, especially the chloride content, was relatively variable at all discharge rates. Much of this variation probably resulted from oil-field brine pollution. Since the closure of Hubbard Creek Reservoir in 1962, most of the flow passing the Breckenridge station has consisted of runoff from the area downstream from the reservoir and seepage from the reservoir. During the 1963-64 water years, the dissolved-solids content of water at the Breckenridge station ranged from about 100 ppm to more than 2,000 ppm. However, about 50 percent of the time the water contained less than 330 ppm dissolved solids.

A comparison of chemical-quality data for the Brazos River at the Possum Kingdom Dam station with those for upstream stations on both the main stem and tributaries show that storage of water in Possum Kingdom Reservoir has resulted in a decrease of quality-of-water variations. During the 1943-64 period, since the closure of Possum Kingdom Reservoir, the dissolved-solids content of water released or spilled from the reservoir has ranged from about 200 ppm to more than 3,800 ppm. However, for about 80 percent of the time the range has been from about 1,080 ppm to about 1,710 ppm. Similarly, for about 80 percent of the time the sulfate and chloride concentrations have ranged from 245 ppm to 390 ppm and from 380 ppm to 650 ppm, respectively.

The collection of chemical-quality data from the Brazos River near Whitney pre-dates the closure of Whitney Reservoir. Therefore, chemical-quality frequency data for periods both before and after closure of Whitney Reservoir are given in Table 5. During the 1949-51 water years, before the closure of the reservoir, the dissolved-solids content of the water ranged from less than 150 ppm to more than 1,500 ppm. During 50 percent of the time, the dissolved-solids content equaled or exceeded 1,120 ppm. During the same period, the dissolved-solids content of water released from Possum Kingdom Reservoir ranged from about 1,000 ppm to more than 1,600 ppm. Water from the drainage area between the two reservoirs is low in dissolved solids. Much of the time before the closure of Whitney Reservoir, water at the Whitney station consisted largely of water released from Possum Kingdom Reservoir. During the 1953-64 period after the closure of Whitney Reservoir, the dissolved solids content of water at the Whitney station ranged from less than 350 ppm to more than 1,400 ppm. About 50 percent of the time, the dissolved-solids content equaled or exceeded 960 ppm. During the same period, the dissolved-solids content of water released from Possum Kingdom Reservoir ranged from less than 300 ppm to more than 3,800 ppm, and for about 50 percent of the time equaled or exceeded 1,400 ppm. These data show that regulation of flow by Whitney Reservoir has resulted in an integration of the saline releases from Possum Kingdom Reservoir with water of better quality contributed by the intervening area. Mixing of these waters in Whitney Reservoir has resulted in more uniformity in the chemical quality of water at the Whitney station.

During the 1962-64 period of chemical-quality record for the Lampasas River at Youngsport, the dissolved-solids content of the water ranged from less than 150 ppm to more than 950 ppm. During about 40 percent of the time, the dissolved-solids content equaled or exceeded 500 ppm. Mills and Rawson (1965) have shown that although the base flow of most streams in the drainage area of the Lampasas River contains low concentrations of dissolved solids, the base flow of Sulphur Creek is slightly saline. Therefore, the variation in chemical quality of the Lampasas River at Youngsport is attributed largely to differences in pattern of runoff. When most of the flow is contributed by Sulphur Creek, the dissolved-solids content is maximum. As the percentage of water contributed by other tributaries increases, the chemical quality of water of the Lampasas River improves.

Because water of the Little River at Cameron is a composite of the flow of the Leon, Lampasas, and San Gabriel Rivers, the dissolved-solids content and the chemical composition of the water depend largely upon the pattern of runoff from sub-basins. During the 1961-64 period of chemical-quality record, the dissolved-solids content of the Little River at Cameron ranged from less than 125 ppm to more than 675 ppm. Although the dissolved-solids content was maximum during low flow, it equaled or exceeded 500 ppm only about one percent of the time.

The quality of water of the main-stem Brazos River near Bryan is relatively variable. During the 1962-64 water years, the dissolved-solids content ranged from less than 200 ppm to more than 1,200 ppm. About 50 percent of the time the dissolved-solids content equaled or exceeded 720 ppm. During the same period, the dissolved-solids content of water released from the upstream Whitney Reservoir equaled or exceeded 700 ppm for more than 99 percent of the time. These data indicate that the dissolved-solids content of water at the Bryan station is maximum when most of the flow consists of releases from Whitney Reservoir. As the proportion of water contributed by the intervening area between the reservoir and the Bryan station increases, the chemical quality of water improves.

The dissolved-solids content of water of Yegua Creek near Somerville during the 1962-64 water years ranged from less than 100 ppm to more than 950 ppm. About 40 percent of the time the dissolved-solids content equaled or exceeded 500 ppm. Although the chemical quality clearly improved with increase in water discharge, the dissolved-solids content and concentrations of individual constituents were variable at all discharge rates, but especially during medium and low flows (Figure 6). Although no chemical-quality data are available for tributaries, much of this variation at the Somerville station probably is due to differences in the pattern of runoff from sub-basins.

During the 1959-64 period, the dissolved-solids content of the Navasota River near Bryan ranged from less than 50 ppm to more than 2,200 ppm. However, the dissolved solids equaled or exceeded 500 ppm for only about 15 percent of the time. The dissolved-solids content usually was maximum during low or medium flows. However, the relation between discharge and dissolved-solids content was ill defined (Figure 6). During some periods, both the dissolved-solids and chloride contents of the water increased erratically without a corresponding change in rate of flow. Much of this variation is attributed to oil-field brine pollution.

The collection of chemical-quality data from the Brazos River at Richmond pre-dates the construction of the upstream Whitney and Belton Reservoirs. Therefore, in Table 5 chemical-quality frequency data for the Richmond station are shown for two periods--the period before closure of Whitney Reservoir and the period after closure of Belton Reservoir. During the 1943-51 period before closure of Whitney Reservoir, the dissolved-solids content of the Brazos River at Richmond ranged from less than 150 ppm to more than 1,400 ppm. About 50 percent of the time the dissolved solids equaled or exceeded 500 ppm. During the same period, the dissolved solids in water released from the upstream Possum Kingdom Reservoir ranged from about 800 ppm to more than 1,600 ppm. About 50 percent of the time the dissolved-solids content of water released from the reservoir equaled or exceeded 1,300 ppm. These data show that before the construction of Whitney Reservoir the quality of water at the Richmond station was relatively variable. The dissolved-solids content of the water was maximum when inflow from the intervening area between the Possum Kingdom and Whitney station was deficient. As the proportion of water contributed by the intervening area increased, the chemical quality of water at the Richmond station improved. For example, discharge records for the 1943-51 period indicate that during the January-June months, releases from Possum Kingdom Reservoir averaged less than 7 percent of the total flow at the Richmond station. For 50 percent of the days during the January-June period, the dissolved-solids content of water at the Richmond station was less than 360 ppm. During the July-December months, releases from Possum Kingdom Reservoir averaged more than 20 percent of the total flow at the Richmond station. For 50 percent of the days during the June-December period, water at the Richmond station contained more than 590 ppm dissolved solids.

The dissolved-solids content of the Brazos River at Richmond during the 1955-64 period, since the closure of Whitney and Belton Reservoirs, has ranged from less than 150 ppm to more than 1,200 ppm. About 48 percent of the time the dissolved-solids content has equaled or exceeded 500 ppm. These data indicate that the regulation of flow by Whitney and Belton Reservoirs has not reduced appreciably the day-to-day variations of chemical quality of water at the Richmond station. This is shown more clearly by dissolved-solids duration curves in Figure 9. The similarity of the two curves shows that the range of dissolved solids and the percent of time that a particular concentration was equaled or exceeded at the Richmond station was not greatly reduced by the regulation of flow by the upstream reservoirs.

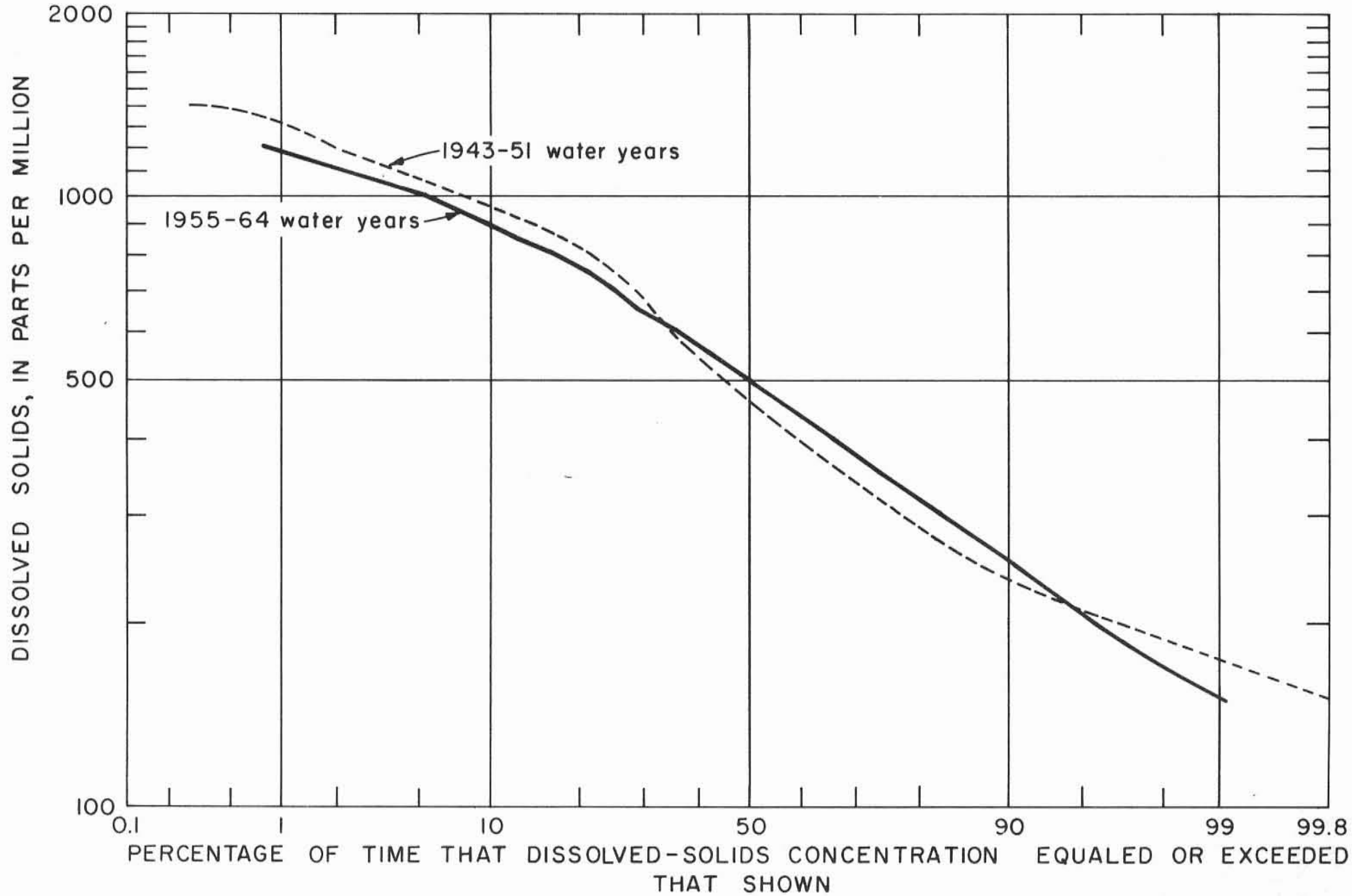

Figure 9

Duration Curve of Dissolved Solids for the Brazos River at Richmond

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

Salt Yields

Although a large stream may contain low concentrations of dissolved minerals, the total dissolved-mineral load transported by the stream usually is very large, because the load is proportional to the product of the concentration of dissolved minerals and the water discharge. Both the dissolved-mineral content and the water discharge of the Brazos River are relatively large; consequently, the river transports immense quantities of dissolved minerals. Minerals are being dissolved and removed from all parts of the Brazos River basin, but the rates at which this process is proceeding are far from uniform. Differences in yield are caused by a combination of factors--principally differences in precipitation, geology, and proportion of ground-water inflow to total surface-water outlfow. Also, the yield of dissolved minerals from natural sources has been increased appreciably by brine from oil fields.

Because salt loads are cumulative, they continually increase in a downstream direction, except where water is diverted or delayed by reservoir storage. Therefore, streamflow and chemical-quality records at various sites on a stream, supplemented by streamflow and chemical-quality records for tributaries, can be used to compute salt yield from intervening areas. Annual summaries of water discharge and dissolved solids, chloride, and sulfate loads for selected sites in the Brazos River basin are given in Table 6. However, these data are not directly comparable because the periods of record are not all concurrent and because water is diverted or stored in reservoirs between some of the stations. Concurrent long-term records of discharge and chemical quality are desirable for a comparison of salt loads. Concurrent daily chemical-quality records for the 1949-64 period are available for the Possum Kingdom Dam (discharge measured at the Palo Pinto station), Whitney, and Richmond stations. Therefore, in the following discussion these stations were used to divide the Brazos River basin into three principal areas, for which salt yields were computed or estimated for the 1949-64 period. Similarly, where possible, the salt yields of subareas were estimated from available data. A summary of estimated yields of dissolved solids, chloride, and sulfate for selected drainage areas for the 1949-64 period is given in Table 7; the computation procedures are explained in the following discussion.

Upper Brazos River Basin

The upper Brazos River basin, for the purpose of this report, is the area 22,550 square miles upstream from Possum Kingdom Reservoir, of which 9,240 square miles is probably noncontributing. The dissolved-solids load contributed by this area, as measured at the chemical-quality station at Possum Kingdom Dam, during the 1949-64 period averaged about 3,080 tons per day, of which 1,110 tons was chloride and 700 tons was sulfate. The annual dissolved-solids yield from the contributing area averaged about 84 tons per square mile, of which about 30 tons was chloride and 19 tons was sulfate. However, the yield from different parts of the upper basin is highly variable. Although daily chemical-quality data have been collected at several sites on the Double Mountain Fork, Salt Fork, and Clear Fork of the Brazos River (the three principal tributaries that drain the area), none of the records are continuous for the entire 1949-64 period. However, both chemical-quality and streamflow records for the Double Mountain Fork and the Salt Fork at the Aspermont stations are of sufficient length that estimates of chemical-quality data can be made for the period of missing record. The method used to extend the chemical-quality records is similar to that described by Iorns, Hembree, and Oakland (1965, p. 58-59). Curves of relation between concentrations of dissolved solids and water discharge were prepared. With data obtained from these curves and from flow-duration curves of streamflow, duration tables of dissolved solids and dissolved-solids discharge were computed. Curves of relation between concentrations of dissolved solids and the concentrations of chloride and sulfate also were prepared. With data obtained from these curves and the duration tables of dissolved-solids concentrations, tables of concentrations and discharges of chloride and sulfate were computed. These estimated data for the Double Mountain and Salt Forks of the Brazos River at the stations near Aspermont are included in Tables 6 and 7. These estimates indicate that for the 1949-64 period the average dissolved-solids load of the Double Mountain Fork Brazos River near Aspermont was about 520 tons per day, of which 90 tons was chloride and 215 tons was sulfate. The annual dissolved-solids yield from the contributing area averaged about 125 tons per square mile, of which 21 tons was chloride and 52 tons was sulfate.

The principal source of salinity in the upper Brazos River basin is the drainage area of the Salt Fork. During the 1949-64 period, the average dissolved-solids load of the Salt Fork Brazos River near Aspermont was about 1,740 tons per day, of which 820 tons was chloride and 260 tons was sulfate. The annual dissolved-solids yield from the contributing area averaged about 308 tons per square mile, of which 145 tons was chloride and 46 tons was sulfate. Several periodic chemical-quality stations have been operated on tributaries of the Salt Fork Brazos River since 1956. Data from these stations indicate that the principal sources of salinity are seeps and springs in the drainage area of Croton and Salt Croton Creeks. According to Hughes (1965, p. 4), the average daily load contributed by the Salt Croton Creek area during the 1957-64 period of record was about 850 tons of dissolved solids, 485 tons of chloride, and 30 tons of sulfate. Based on these data, the annual dissolved-solids yield from the drainage area of Salt Croton Creek averaged about 4,830 tons per square mile, of which about 2,750 tons was chloride and 170 tons was sulfate.

Daily chemical-quality records for other streams in the upper Brazos River basin generally are inadequate for computation of average yields for the 1949-64 period. The average yield for the area exclusive of the Double Mountain Fork and Salt Fork drainage areas can be estimated from records of the main-stem station at Possum Kingdom Dam. On the basis of records for the 1949-64 period, the daily yield from this area was about 825 tons of dissolved solids, 200 tons of chloride and 230 tons of sulfate. The annual yield per square mile averaged about 31 tons of dissolved solids, 8 tons of chloride, and 9 tons of sulfate.

Middle Brazos River Basin

The middle Brazos River basin, as discussed in this report, extends from below Possum Kingdom Reservoir to the Brazos River stream gaging station near Whitney and includes an area of 3,620 square miles. Data in Table 6 indicate that during the 1949-64 period, the daily load of dissolved solids at the Whitney station was 3,200 tons, of which 1,060 tons was chloride and 672 tons was sulfate. However, these data are not directly comparable with load data for the Possum Kingdom Dam station because of storage in Whitney Reservoir. Quality-of-water surveys and daily water-quality records of releases from Whitney Reservoir indicate that at the end of the 1964 water year, water stored in Whitney Reservoir contained about 350,000 tons of dissolved solids, 132,000 tons of chloride, and 64,000 tons of sulfate. Computations based on these data indicate that if storage in Whitney Reservoir had not occurred, the daily load of dissolved solids, chloride, and sulfate at the Whitney station during the 1949-64 period would have been about 3,260 tons, 1,080 tons, and 683 tons, respectively. A comparison of these data with load data for the Possum Kingdom station for the 1949-64 period (Table 6) indicates that the dissolved-solids yield from the area between the two stations was only about 120 tons per day and that an apparent loss of chloride and sulfate occurred.

Although small quantities of water with accompanying loads of dissolved minerals were lost by diversion, seepage, and uptake by phreatophytes, part of the apparent loss of chloride and sulfate loads undoubtedly resulted from deficiencies of chemical-quality and streamflow data. Loads for the Brazos River below Possum Kingdom Dam were computed by using flow data for the streamflow station near Palo Pinto. Although the amount of runoff from the 210-mile area between the two stations usually is small, the water probably is much less mineralized than is the outflow from Possum Kingdom Reservoir. Therefore, use of flow data for the Palo Pinto station to compute loads for the station below Possum Kingdom Dam causes the computed loads to be slightly high. Other sources of error are the sampling schedule, method of computing loads, and streamflow measurements.

Regardless of the source of error, the salt yield of the middle Brazos River basin cannot be computed from records for the two main-stem stations. Also, no daily chemical-quality stations have been operated on tributaries in the area. Some miscellaneous chemical analyses are available for the principal tributaries; but most of these are for low flows. However, chemical-quality data for Palo Pinto Creek near Santo probably is adequate to estimate roughly the salt yield of the drainage area upstream from the Santo station. These data indicate that during the 1949-64 period the daily load of dissolved solids at the Santo station averaged about 39 tons, of which about 5 tons was chloride and about 3 tons was sulfate. Calculations based on these data indicate that the annual yield of dissolved solids per square mile averaged about 25 tons, of which 3 tons was chloride and 2 tons was sulfate.

Chemical analyses of low-flow samples collected from Paluxy Creek at Glen Rose and from Nolands River near Blum indicate that waters of Paluxy Creek and Nolands River generally are of better quality than water of Palo Pinto Creek (Table 4). This also is indicated by analyses of water from Cleburne Reservoir, which impounds water from the upper reaches of Nolands River. The dissolved-solids, chloride, and sulfate content of two samples collected from Cleburne Reservoir during the 1965 water year averaged about 160 ppm, 7.2 ppm, and 13 ppm, respectively.

Assuming that the chemical quality of water of Palo Pinto Creek near Santo is fairly representative of water contributed by the upper half of the middle Brazos River basin and that the chemical quality of water stored in Cleburne Reservoir is fairly representative of water contributed by the lower half of the basin, the dissolved-solids, chloride, and sulfate content of water contributed by the entire area for the 1949-64 period probably averaged about 164 ppm, 13 ppm, and 13 ppm, respectively. Based on these assumptions, the daily yield of dissolved solids was about 267 tons, of which about 21 tons was chloride and about 21 tons was sulfate. Similarly, the annual yield of dissolved solids, chloride, and sulfate per square mile of drainage area was about 28 tons, 2 tons, and 2 tons, respectively. A comparison of these data with estimated yields for Palo Pinto Creek indicates that the salt yield per square mile of drainage area in the middle basin during the 1949-64 period was fairly uniform.

Lower Brazos River Basin

The lower Brazos River basin, as discussed in this report, extends from Whitney Reservoir to the mouth and includes an area of about 18,000 square miles. The lowermost station for which chemical-load data are available is at Richmond, about 90 river miles upstream from the mouth. As discussed in the previous section, the computed salt load at the Whitney station for the 1949-64 period (Table 7) probably was smaller than the actual load. Nevertheless, because of the large area between the Whitney and Richmond stations and because of the large quantity of water contributed by the area, the load data for the Whitney station probably can be used to compute the salt yield from the lower Brazos River basin without introducing appreciable error. However, a comparison of load data at the Whitney and Richmond stations is valid only if load data for the Richmond station are corrected for storage in Proctor and Belton Reservoirs and for two major diversions near Richmond. Such computations indicate the daily yield of dissolved-solids for the lower Brazos River basin upstream from the Richmond station during the 1949-64 period was about 2,580 tons, of which about 281 tons was chloride and about 304 tons was sulfate. The annual yield of dissolved solids, chloride, and sulfate per square mile of drainage area averaged about 53 tons, 6 tons, and 6 tons, respectively.

Although some chemical-quality data have been collected for most of the principal tributaries in the area, none of the records are continuous for the entire 1949-64 period. However, yields from various parts of the drainage area can be estimated from available data.

Miscellaneous chemical analyses for streams in the drainage area of the Bosque River and from Lake Waco (Table 4) indicate that the dissolved-solids content of the water in the area averages about 200 ppm, of which about 15 ppm is chloride and about 30 ppm is sulfate. Based on these data, the daily yield of dissolved solids for the Bosque River during the 1949-64 period was about 222 tons, of which about 17 tons was chloride and about 33 tons was sulfate. The annual dissolved-solids, chloride, and sulfate yield per square mile of drainage area was about 49 tons, 4 tons, and 7 tons, respectively.

Chemical-quality data for the Little River at Cameron (Table 6) indicate that the annual discharge-weighted average concentrations of dissolved constituents are relatively constant. Therefore, these records probably are adequate to estimate the salt yield from the area for the 1949-64 period. Calculations based on chemical-quality records for the 1961-64 period indicate that the daily load of dissolved solids, corrected for storage in Proctor and Belton Reservoirs, was about 968 tons, of which about 110 tons was choride and about 114 tons was sulfate. The annual dissolved-solids, chloride, and sulfate yield per square mile of drainage area was about 51 tons, 6 tons, and 6 tons, respectively.

Daily chemical-quality data have been collected from Yegua Creek near Somerville for the 1962-64 period. However, streamflow during this period was only about 56 percent of the 1949-64 average, and loads of dissolved constituents at the Somerville station for the 1962-64 period probably were less than the 1949-64 averages. Streamflow during the 1963 water year was near the 1949-64 average. Consequently, the discharge-weighted average of dissolved constituents for the 1963 water year should be fairly representative of the 1949-64 average. On the basis of this assumption, the daily load of dissolved solids, chloride, and sulfate at the Somerville station during the 1949-64 period averaged about 125 tons, 25 tons, and 37 tons respectively. The annual yield of dissolved solids per square mile of drainage area was about 45 tons, of which 9 tons was chloride and 13 tons was sulfate.

Daily chemical-quality data have been collected from the Navasota River near Bryan for the 1959-64 period. Flow during this period was about 117 percent of the estimated 1949-64 average. Both periods included years of high, medium, and low flows. Therefore the discharge-weighted average of dissolved constituents for the 1959-64 period should be fairly representative of the 1949-64 period. Calculations based on the 1959-64 records indicate that the daily load of dissolved solids, chloride, and sulfate of the Navasota River at the Bryan station during the 1949-64 period was about 220 tons, 76 tons, and 28 tons, respectively. The estimated annual yield of dissolved solids per square mile of drainage area was about 56 tons, of which about 19 tons was chloride and 7 tons was sulfate.

The estimated annual yield of dissolved-solids, chloride, and sulfate per square mile of the combined drainage areas of the Bosque, Little, and Navasota Rivers and Yegua Creek for the 1949-64 period was about 51 tons, 8 tons, and 7 tons, respectively. As stated earlier, the dissolved-solids, chloride, and sulfate yield per square mile of the entire lower Brazos River basin upstream from the Richmond station, as computed from load data for the Brazos River at the Whitney and Richmond stations, was about 53 tons, 6 tons, and 6 tons, respectively. The agreement between these data indicates that the estimated data are fairly reliable. A comparison of data for the individual streams indicates that the salt yield per square mile of drainage area in the lower basin was relatively uniform. The greatest dissolved-solids and chloride yield per square mile was from the drainage area of the Navasota River where oil-field brines contributed to the salinity of the streams.

Water Quality in Reservoirs

Chemical analyses for most of the principal reservoirs and for some of the smaller ones in the Brazos River basin are given in Table 4. Locations of the principal reservoirs are shown in Figure 3. Many of the reservoirs were constructed on tributaries where quality-of-water problems were minimum. Consequently, the water in these reservoirs usually is satisfactory for public supply, or can be made satisfactory with a minimum of treatment. Water of the main-stem reservoirs generally is less suitable for public supply because of high salinity.

Lake Buffalo Springs.--When sampled in November 1965, water in Lake Buffalo Springs contained 992 ppm dissolved solids and 3.2 ppm fluoride and was very hard. Principal chemical constituents were sodium, magnesium, chloride, sulfate, and bicarbonate.

White River Reservoir.--Impoundment in this new reservoir began in May 1963. The dissolved-solids content of samples collected from the partially-filled reservoir has ranged from 546 ppm to 611 ppm (Table 4). The water was moderately hard to hard and was the sodium bicarbonate chloride type. Fluoride concentrations in the samples ranged from 2.4 ppm to 3.0 ppm.

Lake Sweetwater.-- Chemical analyses indicate that water stored in Lake Sweetwater contains less than 300 ppm dissolved solids, is very hard, and is the calcium bicarbonate type.

Lake Abilene.--Water stored in Lake Abilene is low in dissolved solids, very hard, and the calcium bicarbonate type.

Fort Phantom Hill Reservoir.--Fort Phantom Hill Reservoir stores water from three sources--water from Elm Creek, water diverted from Deadman Creek, and water selectively pumped from the Clear Fork Brazos River. Therefore, the chemical composition of stored water is heterogeneous. However, the water usually contains less than 400 ppm dissolved solids and ranges from hard to very hard.

Lake Stamford.--When sampled in August 1965, water in Lake Stamford contained 348 ppm dissolved solids and was hard. Principal chemical constituents were sodium, calcium, magnesium, and bicarbonate.

Lake Cisco.--Water stored in Lake Cisco is low in dissolved solids (usually less than 200 ppm), hard, and the calcium bicarbonate type.

Hubbard Creek Reservoir.--Impoundment in this newly constructed reservoir began in December 1962. Although the reservoir has not filled to operational level, chemical-quality data have been collected for the reservoir since September 1963. Chemical-quality surveys of the reservoir are made three times annually. During these surveys, specific conductance and water temperature are measured at various depths in selected vertical profiles. Water for chemical analyses is collected at depth where changes in dissolved-solids content occur, as determined by conductivity measurements. Chemical analyses usually consist of chloride and specific conductance measurements, although analyses of some samples are more complete. To supplement these data, in April 1964 a multiple-cell conductivity recorder was installed at the reservoir outlet. Therefore, continuous records of conductivity of water in the reservoir are obtained at three different depths. These conductivity records have been related to chloride concentrations and thus a continuous chloride record has been obtained. A report describing the results of this study is in preparation. Generally the study has shown that the chloride content is relatively variable (from less than 90 ppm to more than 180 ppm). During drought periods, the dissolved-solids and chloride content probably will exceed 500 ppm and 250 ppm respectively, unless oil-field brine pollution is reduced. Representative chemical analyses of samples collected from the reservoir at a site near Hubbard Creek Dam (Table 4) show that the water is very hard; principal dissolved constituents are sodium, calcium, chloride, and bicarbonate.

Lake Daniels.--Water impounded in Lake Daniels is low in dissolved solids, moderately hard to hard, and the calcium bicarbonate type.

Lake Graham.--In April 1958, water stored in Lake Graham contained 2,750 ppm dissolved solids. Much of the salinity was contributed by brine from oil fields. However, this saline water was released from the reservoir and thereafter water quality in the reservoir has improved greatly because of efforts to control oil-field brine pollution. In April 1962, water in the reservoir contained only 252 ppm dissolved solids. Principal chemical constituents were sodium, calcium, and chloride.

Possum Kingdom Reservoir.--A study of Possum Kingdom Reservoir has been included in the Geological Survey's investigation of the chemical quality and stratification of water stored in the major reservoirs of the Brazos River basin. Results of the study to May 1962 have been described by Mendieta and Blakey (1963, p. 5); and a more comprehensive report is in preparation. The study has shown generally that during much of the time some stratification of water occurs because of temperature and salinity differences. The degree of stratification depends largely upon the salinity and temperature of stored water as compared to the temperature and salinity of inflowing water. The study also has shown that much of the time the stored water is undesirable for domestic, municipal, and most industrial uses because of its salinity. This is shown more conclusively by daily chemical-quality records of water released from the reservoir. The dissolved-solids content of water released during the 1943-64 period ranged from about 200 ppm to more than 3,800 ppm. However, about 94 percent of the time the dissolved-solids content equaled or exceeded 1,000 ppm. Similarly, the released water usually contained excessive concentrations of chloride and sulfate. During the 1943-64 period, the chloride content equaled or exceeded 250 ppm about 99 percent of the time; the sulfate content equaled or exceeded 250 ppm about 88 percent of the time. Usually the water was very hard and the sodium chloride type.

Lake Palo Pinto.--No chemical-quality data are available from this recently completed reservoir; however, chemical analyses of samples collected from Palo Pinto Creek near Santo (Table 4) indicate that the stored water will contain about 180 ppm dissolved solids, 25 ppm chloride, and 15 ppm sulfate. The water will be moderately hard to hard and the calcium bicarbonate type.

Lake Mineral Wells.--The dissolved-solids content of water collected from Lake Mineral Wells has ranged from 196 ppm to 262 ppm. The water is hard and the calcium bicarbonate type.

Lake Pat Cleburne.--This newly constructed reservoir stores water that is low in dissolved solids but hard. Principal chemical constituents are calcium and bicarbonate.

Whitney Reservoir.--The Geological Survey has included Whitney Reservoir in its chemical-quality and stratification study of the major reservoirs of the Brazos River basin. Results of the study to May 1962 have been described by Mendieta and Blakey (1963, p. 4-5), and a more comprehensive report is in progress. Generally, the study has shown little vertical stratification of salinity. However, considerable difference in the salinity of water in different areas of the reservoir was noted during some periods. The study also has shown that water stored in the reservoir often is too saline for many uses. This is shown more conclusively by the daily chemical-quality records of water released from the reservoir. During the 1953-64 period, the dissolved-solids content of water released from the reservoir ranged from less than 350 ppm to more than 1,400 ppm. However, about 43 percent of the time the dissolved-solids content equaled or exceeded 1,000 ppm; about 97 percent of the time it equaled or exceeded 500 ppm. The chloride content of the water also was excessive--about 78 percent of the time it equaled or exceeded 250 ppm. Some of the time the sulfate content also was excessive--about 20 percent of the time it exceeded 250 ppm. Usually the released water was very hard and the sodium chloride type.

Waco Reservoir.--The quality of water stored in Waco Reservoir can be inferred from analyses of samples from Lake Waco (recently enlarged to form

Waco Reservoir) and from analyses of samples collected from the Bosque River near Waco (Table 4). These data show that the water is low in dissolved solids, hard to very hard, and the calcium bicarbonate type.

Leon Reservoir.--Water stored in Leon Reservoir usually contains less than 250 ppm dissolved solids but is hard. Principal dissolved constituents are calcium and bicarbonate.

Proctor Reservoir.--Proctor Reservoir has been included in the Geological Survey's chemical-quality and stratification study of the major reservoirs in the Brazos River basin. The study has shown little vertical stratification of waters of different salinities. Selected chemical analyses (Table 4) show that the dissolved-solids content of stored water, although variable, usually is less than 350 ppm. The water ranges from moderately hard to very hard; principal chemical constituents usually are calcium and bicarbonate.

Belton Reservoir.--Belton Reservoir also has been included in the Geological Survey's study of the major reservoirs in the Brazos River basin (Mendieta and Blakey, 1963, p. 3-4). The study has shown generally that vertical stratification of waters of different salinities in the reservoir is not significant. Selected chemical analyses (Table 4) show that the dissolved-solids content, although variable, usually is less than 300 ppm. The water is moderately hard to very hard; principal chemical constituents usually are calcium and bicarbonate.

Lake Mexia.--Available chemical-quality data for water stored in Lake Mexia are meager (Table 4). These data indicate that in February 1962 the water was relatively low in dissolved solids (probably less than 350 ppm) and was hard. The chloride content of the water was 120 ppm, much of which probably was contributed by brine from oil fields. Because the quantity of brine reaching streams upstream from the reservoir varies, the chemical quality of water in the reservoir may vary.

Water Quality at Potential Reservoir Sites

One of the principal objectives of this investigation was to appraise the quality of water available for storage at potential reservoir sites in the Brazos River basin. Many potential sites studied by various federal, state, and local agencies are shown on Figure 3. In the following discussion, evaluations of water quality at these sites are based on present conditions. Continued municipal and industrial growth in some areas will increase the waste-disposal burdens of the stream and, therefore, may cause significant changes in water quality before some of the reservoirs can be built.

Duck Creek Reservoir.--Available chemical-quality data from Duck Creek consist of chemical analyses of low-flow samples. The dissolved-solids content of these samples collected from Duck Creek near Jayton (Table 4) ranged from 948 ppm to 2,630 ppm. The water was very hard and the calcium sulfate type. Sulfate concentrations ranged from 556 ppm to 1,600 ppm. Higher flow probably would have a considerably lower dissolved-solids and sulfate content. Water stored in the reservoir probably would be hard; the dissolved-solids content usually would exceed 500 ppm; and the sulfate content usually would exceed 250 ppm.

Seymour Reservoir No. 1.--Daily chemical-quality records for the Salt Fork Brazos River near Aspermont indicate that water which would be stored in Seymour Reservoir No. 1 would contain more than 5,000 ppm dissolved solids, 2,000 ppm chloride, and 700 ppm sulfate. Hughes (1965, p. 7) has calculated that if 90 percent of the salt load contributed by Salt Croton Creek, the principal source of the salt load, and part of the load contributed by several smaller sources were removed, the average dissolved-solids and chloride content of water impounded in Possum Kingdom Reservoir would be reduced about 25 percent and 37 percent, respectively. Under the same salinity-control conditions, water available for storage in a reservoir at the Seymour No. 1 site probably would contain more than 2,600 ppm dissolved solids, 1,000 ppm chloride, and 600 ppm sulfate.

Seymour Reservoir No. 2.--Daily chemical-quality records for the Double Mountain Fork Brazos River near Aspermont indicate that water which would be stored in the proposed Seymour Reservoir No. 2 usually would contain more than 1,000 ppm dissolved solids, 180 ppm chloride, and 430 ppm sulfate; and the water would be very hard.

Seymour Reservoir.--Based on daily chemical-quality records for the Brazos River at Seymour and for the Double Mountain and Salt Forks of the Brazos River at the Aspermont stations, the dissolved-solids, chloride, and sulfate concentrations of water that would be stored in the proposed Seymour Reservoir usually would exceed 2,600 ppm, 1,000 ppm, and 600 ppm, respectively. Even if 90 percent of the salt load contributed by Salt Croton Creek and part of the load contributed by several smaller sources were removed, the stored water probably would contain more than 1,700 ppm dissolved solids, 500 ppm chloride, and 500 ppm sulfate, and would be very hard.

Millers Creek Reservoir.--The quality of water that would be stored in the proposed Millers Creek Reservoir can be inferred from the analyses of samples collected from Millers Creek near Munday and near Seymour. Although most of the samples from the Munday site were collected during low flow, the maximum dissolved-solids content of the samples was 177 ppm. The water was usually moderately hard and the calcium bicarbonate type. Most of the samples from the Seymour site also were collected during low flow. The dissolved-solids content of these samples ranged from 176 ppm to 2,060 ppm. Higher flows probably would be less mineralized. Thus, if the reservoir fills during a period of average rainfall and runoff, the stored water probably would contain less than 250 ppm dissolved solids and would be moderately hard or hard.

South Bend Reservoir.--Water available for storage in this proposed main-stem reservoir can be inferred from the daily chemical-quality records for the Brazos River at Seymour and below Possum Kingdom Dam. Water in the proposed reservoir would be less saline than water at the Seymour station but more saline than water in Possum Kingdom Reservoir. The dissolved-solids, chloride, and sulfate concentrations in the stored water probably would average more than 2,000 ppm, 800 ppm, and 450 ppm, respectively; and the water would be very hard.

Nugent Reservoir.--Daily chemical-quality records collected from the Clear Fork Brazos River at Nugent during the 1949-53 period indicate that water which would be stored in the proposed Nugent Reservoir would contain about 500 ppm dissolved solids, 70 ppm chloride, and 150 ppm sulfate.

Breckenridge Reservoir.--No recent chemical-quality data are available for the Clear Fork Brazos River at the site of the proposed Breckenridge Reservoir. Daily chemical-quality records of the Clear Fork Brazos River at Fort Griffin for the 1950-51 water years indicate that the natural quality of the Clear Fork is very good. During these two years, the discharge-weighted average concentrations of dissolved solids, chloride, and sulfate at the Fort Griffin station were 357 ppm, 67 ppm, and 81 ppm, respectively. However, some deterioration of the quality of water has occurred because of pollution by oil-field brines. Daily chemical-quality records for California Creek, a tributary to the Clear Fork upstream from the proposed Breckenridge damsite, indicate that California Creek is badly polluted with oil-field brines. Daily chemical-quality records for the Clear Fork Brazos River at Eliasville during the 1963 and 1964 water years indicate that these brines have degraded the quality of the water of the Clear Fork. Now that Hubbard Creek Reservoir is in operation, the chemical-quality record for Eliasville may be fairly representative for the Breckenridge site. During the 1963-64 water years, the discharge-weighted average concentrations of dissolved solids, chloride, and sulfate at the Eliasville station were 652 ppm, 222 ppm, and 126 ppm, respectively; and the water usually was very hard. During these years the streamflow was below average; thus, the water was probably worse in quality than it would be during years of average flow. Nevertheless, during drought periods, the dissolved-solids and chloride content of water in the proposed Breckenridge Reservoir probably would exceed 500 ppm and 250 ppm respectively, unless oil-field brine pollution is reduced.

Keechi Reservoir.--The dissolved-solids content of low-flow samples collected from Keechi Creek near Graford during the 1963 water year ranged from 264 ppm to 631 ppm. During the 1962 water year, the water collected from Keechi Creek Reservoir, a small water-supply reservoir downstream from the Graford site, usually contained less than 250 ppm dissolved solids but was hard. These data indicate that water in the proposed Keechi Reservoir would contain less than 250 ppm dissolved solids and would be moderately hard or hard.

Turkey Creek, Inspiration Point, Hightower, DeCordova Bend, and Bee Mountain Reservoirs.--The development of this five-reservoir system on the main-stem Brazos River between Possum Kingdom and Whitney Reservoirs has been proposed primarily for the generation of hydroelectric power and for flood control (U.S. Study Commission, 1962, p. 113). The chemical quality of water that would be stored in the reservoir system can be inferred from the quality of water stored in Possum Kingdom and Whitney Reservoirs. Because of inflow of water of good quality from intervening areas, the quality of water in the reservoir system generally would improve in a downstream direction. However, this improvement would be partially offset by the concentrating effect of evaporation from the reservoirs. Water in Turkey Creek Reservoir would be similar to that stored in Possum Kingdom Reservoir and usually would contain about 1,300 ppm dissolved solids, 500 ppm chloride, and 300 ppm sulfate. Water in Bee Mountain Reservoir would be similar to that stored in Whitney Reservoir and usually would contain about 1,000 ppm dissolved solids, 350 ppm chloride, and 200 ppm sulfate.

Aquilla Reservoir.--Chemical-quality data for Aquilla Creek near Aquilla indicate that if the proposed Aquilla Reservoir fills during a period of average rainfall and runoff, the stored water would contain less than 250 ppm dissolved solids but would be hard.

Stephenville Reservoir.--Chemical analyses of samples collected from the North Fork Bosque River near Clifton indicate that the proposed Stephenville Reservoir would store water with a dissolved-solids content of less than 200 ppm and that the water would be hard.

Stillhouse Hollow Reservoir.--Daily chemical-quality records for the Lampasas River at Youngsport indicate that the dissolved-solids content of water that will be stored in Stillhouse Hollow Reservoir (now under construction) will average less than 350 ppm; however, the water will probably be very hard.

North San Gabriel, South San Gabriel, Berry Creek, and Laneport Reservoirs.--Chemical analyses of samples collected from the North and South Forks of the San Gabriel River and from the main-stem San Gabriel River indicate that water in the proposed reservoirs in the drainage area of the San Gabriel River would be low in dissolved solids (probably less than 200 ppm), hard, and the calcium bicarbonate type.

Cameron Reservoir.--Daily chemical-quality records for the Little River at Cameron indicate that water which would be stored in the proposed Cameron Reservoir would contain less than 300 ppm dissolved solids but would be hard or very hard.

Somerville Reservoir.--Daily chemical-quality records for Yegua Creek near Somerville indicate that Somerville Reservoir (now under construction) will store water that is low in dissolved solids (probably less than 250 ppm). However, the water will probably be moderately hard or hard.

Wayland Crossing, Marquez, Navasota, Ferguson, and Millican Reservoirs.--The quality of water that would be stored in reservoirs on the Navasota River can be inferred from daily chemical-quality records for the Navasota River near Bryan. The discharge-weighted average concentration of dissolved solids at the Bryan station for the 1959-64 period was 203 ppm. However, the annual discharge-weighted average concentrations of dissolved solids during the same period ranged from 143 ppm to 328 ppm. Much of this variation is attributed to oil-field brine pollution. If the pollution does not increase, water stored in the proposed reservoirs should contain less than 350 ppm dissolved solids much of the time.

Allens Creek Reservoir.--The proposed Allens Creek Reservoir would be an off-channel reservoir that would store water from the Brazos River when flow of the river below Allens Creek exceeds demand. Therefore the quality of water in the reservoir would be variable. However, most of the water for storage probably would be diverted when flow of the Brazos River was high. Therefore, the dissolved-solids content of the water probably would average less than 400 ppm.

POTENTIAL IMPROVEMENT OF WATER QUALITY IN THE BRAZOS RIVER

Integrated Operation of Reservoirs

Floodwaters captured in the flood-control storage space of Belton Reservoir usually are stored temporarily and then released as soon thereafter as possible to maintain the storage space for flood control. Similarly, one of the primary purposes of Whitney Reservoir is flood control. No effective effort has been made to improve the quality of main-stem water by coordinating releases from the two reservoirs. As a result, the regulation of flow by the reservoirs has not reduced appreciably the daily variations of chemical quality of water in the downstream reach of the Brazos River. (See Figure 9.) However, the increased flood storage provided by Proctor Reservoir supplemented by storage in Stillhouse Hollow and Somerville Reservoirs (now under construction) and in the proposed Laneport and Millican Reservoirs should make feasible the reduction of water-quality variations at downstream sites on the main stem by storing flood waters on tributaries and releasing them gradually so as to continually dilute the more saline releases from Whitney Reservoir.

The extent of the potential improvement of the quality of main-stem water through the integrated operation of the reservoir system depends upon several factors, some of the more important of which are:

(1) the quantity and quality of the water available for release and rate of release each reservoir in the system; and

(2) the quantity and quality of tributary inflow that would not be controlled by the reservoir system.

During the 1955-64 period following the closure of Belton Reservoir, about 27 percent of the main-stem flow between the Whitney and Richmond stations was contributed by releases from Whitney Reservoir; about 26 percent was contributed by tributary inflow that would be regulated by the proposed reservoir system; and about 47 percent was contributed from other sources. Because of the large percentage of flow that would not be controlled by the proposed system, the integration of releases from the various reservoirs would be only partially effective in the reduction of water-quality variations at the Richmond station. Deficiencies in data on streamflow, chemical-quality, and time of travel make difficult an accurate evaluation of the benefits that would result from integrating releases from the various reservoirs. However, some of the potential benefits are readily apparent. During the 1964 water year, for example, water at the Richmond station contained more than 500 ppm dissolved solids for 181 days, more than 750 ppm for 68 days, and more than 1,000 ppm for 19 days. If the reservoir system had been in operation and if releases from each reservoir had been regulated so that the rate of release was approximately equal to the mean daily discharge for the 1964 water year, the dissolved-solids content at the Richmond station would not have exceeded 1,000 ppm, seldom would have exceeded 750 ppm; and probably would have exceeded 500 ppm for about 160 days. The discharge-weighted average of dissolved solids would have been approximately the same; but the range of dissolved constituents would have been narrowed substantially. This decrease in range of dissolved constituents generally would make the water more suitable for municipal, industrial, and irrigation use. However, to operate the reservoir system principally for water-quality control is impractical, because first priority in reservoir operation must be given to using the available resources to meet water-supply demands. Therefore, the quantity of water available for quality control and, thus, the improvement of water quality in the lower reaches of the main stem probably would be small. Moreover, water-quality problems would persist throughout the middle and upper reaches of the main stem.

Reduction of Natural Salt Contamination

For any plan to be effective in the basin-wide improvement of water quality in the main-stem Brazos River, it must provide for a reduction of natural salt contamination in the upper part of the basin. Hughes (1965) has calculated the effect that partial control of natural salinity in the upper Brazos River basin would have on water quality in Possum Kingdom Reservoir (based on the period of the 1957-64 water years). Hughes' data (included in Table 8) indicate that although the average dissolved-solids concentration in Possum Kingdom Reservoir probably cannot be reduced to the U.S. Public Health Service recommended limit of 500 ppm, the quality of the water would be improved substantially. With maximum possible control, the dissolved-solids, chloride, and sulfate concentrations would average about 765 ppm, 229 ppm, and 212 ppm, respectively; and the water would compare favorably with other supplies used in West Texas for municipal, industrial, and agricultural purposes.

Partial control of natural salinity in the upper Brazos River basin would also result in substantial improvement of the quality of main-stem water in the middle and lower reaches of the Brazos River (Table 8). For example, the removal of 90 percent of the salt load contributed by Salt Croton Creek and part of the load contributed by several smaller sources (Hughes, 1965, p. 7) would reduce the average dissolved-solids concentration of Whitney Reservoir from 705 ppm to about 548 ppm. The average chloride content of the water would be reduced substantially also (from 228 ppm to about 143 ppm), but the average sulfate content would be reduced only slightly (from 145 ppm to about 136 ppm). Under the same salinity control conditions, average dissolved-solids and chloride concentrations of the Brazos River at Richmond would be reduced from 343 ppm to about 304 ppm and from 75 ppm to 54 ppm, respectively. Reduction of the average sulfate content would be insignificant, from 57 ppm to about 55 ppm. Because calcium sulfate is widely disseminated throughout much of the upper basin, the maximum possible salinity control measures would reduce the average sulfate content of the main stem only slightly. Nevertheless, the reduction of natural salinity from the upper Brazos River basin would result in a substantial improvement of water quality throughout the main stem. This reduction of salinity, supplemented by the integrated operation of reservoirs in the lower basin, would greatly improve the quality of the water in the lower Brazos River.

RELATION OF WATER QUALITY TO USE

Although other water-quality criteria are important, the suitability of a water for most uses is often determined by its chemical quality. All natural waters contain dissolved-mineral matter, most of which is dissociated into charged particles, or ions. Principal cations (positively-charged ions) in natural water are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and iron (Fe). Principal anions (negatively-charged ions) are carbonate (CO_3), bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), fluoride (F), and nitrate (NO_3). Other constituents and properties are determined to help define the chemical quality of water; Table 9 lists the constituents and properties commonly determined by the U.S. Geological Survey, and includes a résumé of their sources and significance.

To present chemical-quality criteria for all purposes would be an endless task. Because surface water in the Brazos River basin is being used and developments are being planned primarily for municipal, industrial, and irrigation uses, only these uses will be considered in the following discussion.

Domestic Purposes

Because of differences in individuals, varying amounts of water used, and other factors, defining the safe limits for mineral constituents in water to be used for domestic purposes is difficult. The criteria for drinking water usually accepted in the United States are those recommended by the United States Public Health Service. Originally established in 1914 to control the quality of water used on interstate carriers for drinking and for culinary purposes, these standards have been revised several times. The latest revision was in 1962 (U.S. Public Health Service, 1962). These standards have been accepted by the American Water Works Association and by most of the state departments of public health as minimum standards for public water supplies. The limits specified by these standards for various constituents are included in the statements under "Significance" in Table 9. Although the recommended limits for dissolved solids, chloride, and sulfate are 500 ppm, 250 ppm, and 250 ppm, respectively, a considerable number of water supplies exceeding these recommended limits have been used for domestic purposes without adverse effects.

Surface waters of many types and concentrations flow in streams of the Brazos River basin. Most of the water-supply reservoirs upstream from Possum Kingdom Reservoir were constructed on tributaries where quality-of-water problems were minimum. Therefore, water stored in these reservoirs are usually suitable for domestic supply. However, water in many of the other tributaries is often undesirable for domestic supply because of excessive concentrations of dissolved solids, chloride, or sulfate. Table 5 lists the concentrations of dissolved solids, chloride, and sulfate that was equaled or exceeded in the percent of days for the indicated period at selected sites in the Brazos River basin. These data indicate that, most of the time, waters of the Double Mountain and Salt Forks of the Brazos River are unsuitable for public supply. Although water of the Clear Fork Brazos River is usually of much better quality, the concentrations of dissolved minerals often exceed the limits recommended by the U.S. Public Health Service. For example, during the 1962-64 period, the dissolved-solids content of the Clear Fork Brazos River at Eliasville exceeded the recommended 500 ppm limit for about 75 percent of the time. Similarly, the chloride and sulfate content was excessive much of the time.

Dissolved minerals in most tributaries that drain the lower part of the Brazos River basin rarely exceed the limits recommended by the U.S. Public Health Service, and the waters usually are suitable for domestic use. During the 1961-64 period, for example, water of the Little River at Cameron contained less than 500 ppm dissolved solids for more than 98 percent of the time. The chloride content of the water seldom exceeded 90 ppm, and the sulfate content seldom exceeded 70 ppm.

Although generally more mineralized than water of the Little River, the water of Yegua Creek near Somerville contained less than 500 ppm dissolved solids for more than 60 percent of the time during the 1962-64 period. The chloride content of the water seldom exceed 150 ppm; the sulfate content equaled or exceeded 250 ppm for only about 15 percent of the time.

As discussed previously, brines from oil fields are contributing to the salinity of surface waters in the Navasota River drainage area. Nevertheless, much of the time water of the Navasota River near Bryan is suitable for domestic use. During the 1959-64 period, for example, the dissolved-solids content of the water was less than 500 ppm more than 85 percent of the time; the chloride content was less than 250 ppm for about 90 percent of the time; and the sulfate content seldom exceeded 70 ppm.

Although the quality of water in the main-stem Brazos River generally improves progressively as the water flows downstream, data in Table 5 show that at most sites the water is undesirable for domestic use. During the 1960-64 period, for example, water of the Brazos River at Seymour exceeded 500 ppm dissolved solids for the entire period. The water contained more than 1,000 ppm dissolved solids for about 98 percent of the time. Similarly, the water usually contained excessive concentrations of chloride and sulfate.

Usually, water released from Possum Kingdom Reservoir is also undesirable for domestic use. For example, the dissolved-solids content of the water equaled or exceeded 500 ppm for more than 99 percent of the days in the 1943-64 period; and it equaled or exceeded 1,000 ppm for about 94 percent of the days. The chloride content of the water exceeded 250 ppm more than 98 percent of the days; and the sulfate content exceeded 250 ppm about 88 percent of the days.

Although generally of better quality than releases from Possum Kingdom Reservoir, water released from Whitney Reservoir during the 1953-64 period contained more than 500 ppm dissolved solids for about 97 percent of the time and more than 1,000 ppm for about 43 percent of the time. Although the sulfate content of the water exceeded 250 ppm for only about 20 percent of the time, the chloride content exceeded 250 ppm more than 78 percent of the time.

Inflow of water from tributaries downstream from Whitney Reservoir results in a substantial improvement in the quality of main-stem water at downstream sites. During the 1955-64 period, for example, water of the Brazos River at Richmond contained less than 500 ppm dissolved solids for about 52 percent of the time; the chloride content of the water was less than 250 ppm for about 81 percent of the time; and the sulfate content was less than 250 ppm more than 99 percent of the time.

These data show that the dissolved-solids, chloride, and sulfate concentrations in waters of the middle and upper reaches of the main-stem Brazos and in some of the tributaries principally those upstream from Possum Kingdom Reservoir) often exceed the maximum concentrations recommended by the U.S. Public Health Service.

Other chemical constituents or properties usually considered in evaluating a water for domestic use include hardness, iron, nitrate, and fluoride.

A comparison of hardness-duration data for selected daily sampling sites (Table 5) and chemical analyses of water from miscellaneous sites (Table 4) with the classification of hardness in the following table shows that most surface waters in the Brazos River basin are hard or very hard and will require softening in some areas.

Hardness (ppm)	Rating	Usability
0-60	Soft	Suitable for many uses without further softening.
61-120	Moderately hard	Usable except in some industrial applications.
121-180	Hard	Softening required by laundries and some other industries.
181+	Very hard	Softening desirable for most purposes.

Chemical-quality data (Tables 3 and 4) show that the nitrate content of surface water of the basin generally is well within the recommended limit of 45 ppm. One area where high nitrate concentrations have been observed is the North Fork Double Mountain Fork Brazos River downstream from Lubbock. The nitrate content of samples collected at a site 4.3 miles southeast of Lubbock during the 1952-54 period ranged from 38 ppm to 62 ppm. According to Irelan (1955, p. 8-12), the high nitrate content of these samples probably resulted from inflow of sewage and return flow from irrigation.

Only a few iron determinations have been included in the chemical analyses of surface waters of the basin. However, the analyses of samples from some of the reservoirs (Table 4) indicate that the concentrations of iron are usually within the recommended limit of 0.3 ppm.

The optimum fluoride concentration in drinking water for a particular area depends on the climatic conditions of that area, because the amount of water (and consequently the amount of fluoride) ingested is influenced primarily by the air temperature. The annual average of maximum daily air temperatures for most of the Brazos River basin usually is within the 70.7 - 79.2°F range. Therefore, according to the U.S. Public Health Service Drinking-Water Standards (1962, p. 8), the fluoride content of drinking water in the basin should not exceed 1.0 ppm. The fluoride content of surface waters in much of the basin is well within the 1.0 ppm limit. However, during low-flow periods, fluoride concentrations of water in the North Fork Double Mountain Fork Brazos River and the White River, which drains largely from the Ogallala Formation, have exceeded 1.0 ppm (Table 4). When sampled in November 1965, water stored in Lake Buffalo Springs contained 3.2 ppm fluoride; and water in the partly filled White River Reservoir has contained as much as 3.0 ppm fluoride.

Industrial Use

The quality requirements vary greatly for almost every industrial application (see Table 10). However, one requirement of most industries is that quality of the water remain relatively constant. Often water must be treated to make it suitable for a particular industrial application. If concentrations of undesirable minerals in the water vary widely, constant monitoring is required and operating expenses are increased. Data in Table 5 show that the concentrations of dissolved minerals in most streams of the basin are variable. Regulation of flow by Possum Kingdom and Whitney Reservoirs have smoothed out some of the chemical-quality variations. Impoundment on tributaries, which would be required for dependable supplies of water, also would decrease water-quality variations. The integrated operation of proposed and existing reservoirs in the lower part of the basin would further reduce water-quality variations of the main stem and thus make the water more suitable for industrial use.

Corrosion is the most widespread and probably the most costly, water-caused difficulty with which industry must cope. Therefore, the suitability of a water for most industrial uses is determined partly by its corrosiveness. High concentrations of dissolved solids in a water is conducive to corrosion, especially if chloride is present in appreciable quantities. Upstream from Possum Kingdom Reservoir, the main-stem Brazos River and some of its principal tributaries contain high concentrations of dissolved solids and chloride. Therefore, these waters probably are rather corrosive and are unsuitable for many industrial applications. Water in most of the tributaries downstream from Possum Kingdom Reservoir usually contains much smaller concentrations of dissolved-solids and chloride and, therefore, is less corrosive.

Hardness is another important property of water that affects its utility for industrial purposes. Some calcium hardness may be desirable because calcium carbonate sometimes forms protective coatings on pipes and other equipment and thus reduces corrosion. However, excessive hardness is objectional because it contributes to the formation of scale in steam boilers, pipes, water heaters, radiators, and various other equipment where water is heated, evaporated, or treated with alkaline materials. The accumulation of scale increases cost for fuel, labor, repairs, and replacement, and lowers the quality of many wet-processed products. Most surface waters of the Brazos River basin range from hard to very hard and will require softening for some industrial applications.

In summary, water from tributaries downstream from Possum Kingdom Reservoir usually is suitable for many industrial uses, although some industries will require that the water be softened. Water in many tributaries upstream from Possum Kingdom Reservoir is of poor quality for most industrial uses most of the time, principally because of the high degree of mineralization. Although the quality of water in the main-stem Brazos River generally improves progressively in a downstream direction, much of the water upstream from Whitney Reservoir is too highly mineralized for many industrial uses. The quality of water generally improves substantially downstream from Whitney Reservoir, but the quality of water is variable because of the varying quantities of water contributed by tributaries.

Irrigation

The suitability of a water for irrigation depends primarily on its chemical composition. However, the extent to which chemical quality limits the suitability of a water for irrigation depends on many factors, such as: the nature, composition, and drainage of the soil and subsoil; the amounts of water used and the methods of application; the kind of crops grown; and the climate of the region, including the amounts and distribution of rainfall. Because these factors are highly variable, every method of classifying waters for irrigation is somewhat arbitrary.

According to the U.S. Salinity Laboratory Staff (1954, p. 69), the most important characteristics in determining the quality of irrigation water are: (1) total concentration of soluble salts, (2) relative proportion of sodium to other cations, (3) concentration of boron or other elements that may be toxic, and (4) the excess of equivalents of bicarbonate over equivalents of calcium plus magnesium.

High concentrations of dissolved salts in irrigation water may cause a buildup of salts in the soil solution and may make the soil saline. The increased soil salinity may reduce crop yields drastically by decreasing the ability of the plants to take up water and essential plant nutrients from the soil solution. This tendency of irrigation water to cause a high buildup of salts in the soil is called the salinity hazard of the water. The specific conductance of the water is used as an index of the salinity hazard.

High concentrations of sodium relative to the concentrations of calcium and magnesium in irrigation water can adversely affect soil structure. Cations in the soil solution become fixed on the surface of the soil particles; calcium and magnesium tend to flocculate the particles, whereas sodium tends to deflocculate them. This adverse effect on soil structure caused by high sodium concentrations in an irrigation water is called the sodium hazard of the water. An index used for predicting the sodium hazard is the sodium-adsorption ratio (SAR), which is defined by the equation:

$$\mathrm{SAR} = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}},$$

where the concentration of the ions are expressed in equivalents per million.

The U.S. Salinity Laboratory Staff has prepared a classification for irrigation waters in terms of salinity and sodium hazards. Empirical equations were used in developing a diagram, reproduced in modified form as Figure 10, which uses SAR and specific conductance in classifying irrigation waters. This classification, although embodying both research and field observations, should be used only for general guidance because many additional factors (such as availability of water for leaching, ratio of applied water to precipitation, and crops grown) also affect the suitability of water for irrigation. With respect to salinity and sodium hazards, waters are divided into four classes--low, medium, high, and very high. The classification range encompasses those waters that can be used for irrigation of most crops on most soils as well as those waters that are usually unsuitable for irrigation. Selection of class demarcation is discussed in detail in the publication by the U.S. Salinity Laboratory Staff (1954). Interpretation of the diagram is as follows:

"LOW-SALINITY WATER (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

"MEDIUM-SALINITY WATER (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

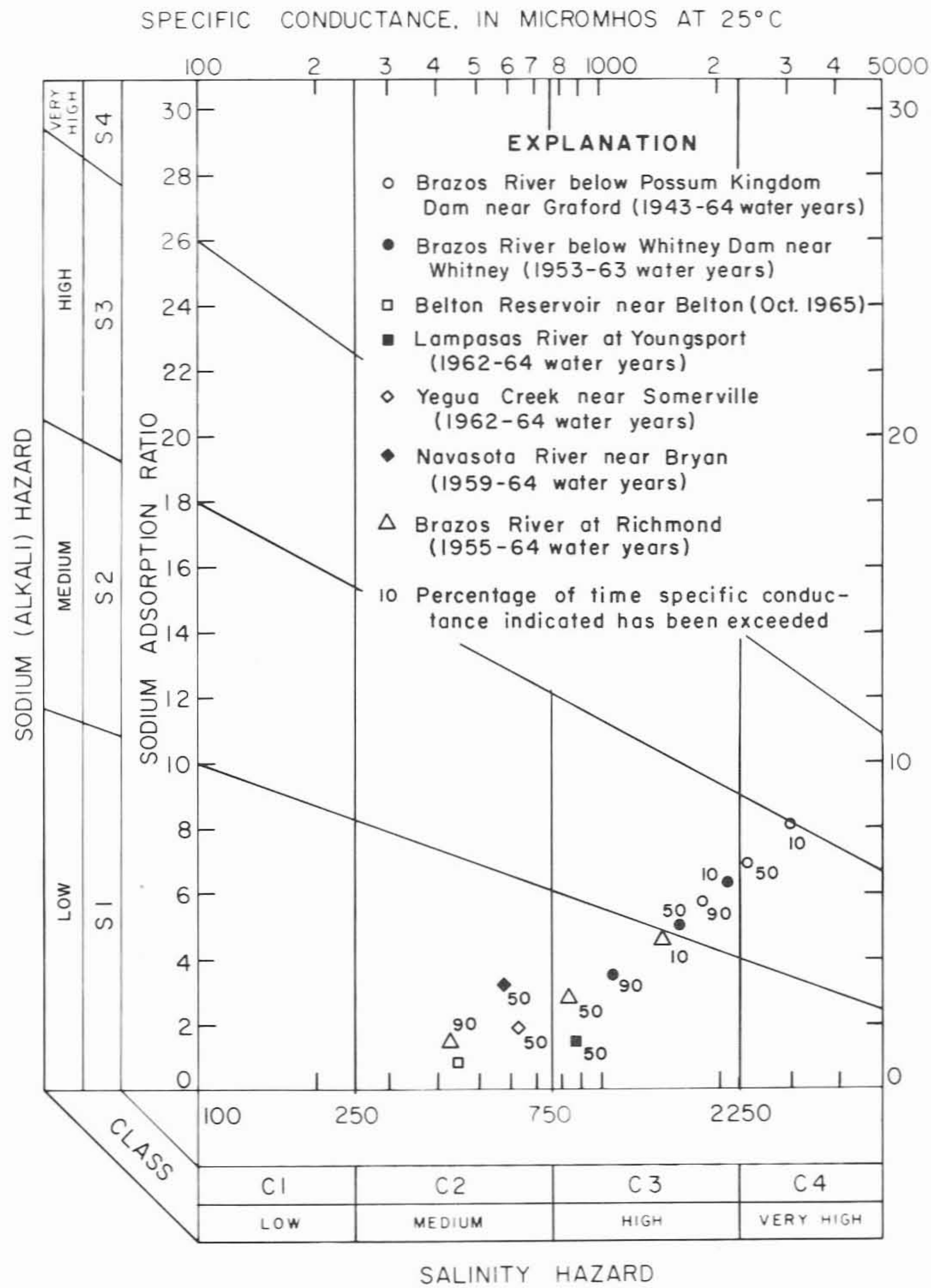

Figure 10

Diagram for the Classification of Irrigation Waters

(Adapted from U. S. Salinity Laboratory, 1954, p. 80)

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Brazos River Authority

"HIGH-SALINITY WATER (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

"VERY HIGH SALINITY WATER (C4) is not suitable for irrigation under ordinary conditions, but may be used occassionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

"LOW-SODIUM WATER (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.

"MEDIUM-SODIUM WATER (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.

"HIGH-SODIUM WATERS (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management--good drainage, high leaching, and organic-matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

"VERY HIGH SODIUM WATER (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible."

The salinity and sodium hazards of water at selected sites in the Brazos River basin are given in Table 11 and Figure 10. These data indicate that much of the time, waters of the principal tributaries in the upper Brazos River basin are unsuitable for irrigation because of high or very high salinity and sodium hazards. Of the three principal forks, waters of the Clear Fork is the most suitable for irrigation; but, even here, the salinity hazard of the water may preclude its use for irrigation much of the time unless drainage is adequate, salt tolerant crops are grown, and an excess of irrigation water is applied.

Although the sodium hazard of tributary waters downstream from Possum Kingdom Reservoir usually is low, the salinity hazard usually ranges from medium to high. These waters generally are suitable for supplemental irrigation on soils of adequate drainage, provided that plants with good salt tolerance are selected.

The salinity and sodium hazards of water of the main stem Brazos River generally decrease in a downstream direction. Both the salinity and sodium hazards of water at the Seymour station usually are very high. Inflow downstream from the Seymour station causes some reduction of the sodium and salinity hazards of the main-stem water. Nevertheless, during the 1943-64 period, the salinity hazard of water released from Possum Kingdom Reservoir ranged from high to very high more than 80 percent of the time, and the sodium hazard was medium most of the time. Therefore, water from Possum Kingdom Reservoir generally is suitable for irrigation only on permeable soils, where drainage is adequate, an excess of water is applied, and salt-tolerant crops are selected.

Inflow from the intervening area between Possum Kingdom and Whitney Reservoirs results in some reduction of the salinity and sodium hazards of the main-stem water. Nevertheless, the salinity hazard of releases from Whitney Reservoir is high most of the time.

Although the sodium hazard of the main-stem water at the Richmond station generally is low, the salinity hazard usually ranges from medium to high. However, the principal use of surface water for irrigation in the Richmond area is for growing rice. Although the concentrations of chemical constituents tolerated by rice varies with the stage of growth, investigators generally agree that water containing less than 600 ppm sodium chloride (350 ppm chloride) is not harmful to rice at any stage of growth (Irelan, 1956, p. 330). Therefore, water of the Brazos River at Richmond usually is suitable for rice irrigation.

As previously stated, other criteria for evaluating the suitability of water for irrigation use include the boron content and the excess of equivalents of bicarbonate over equivalents of calcium plus magnesium (residual sodium carbonate). A few analyses for boron (Table 4) show that boron concentrations in surface waters of the Brazos River basin usually are low. With regard to residual sodium carbonate, surface waters of the basin usually contain an excess of equivalents of calcium plus magnesium over equivalents of bicarbonate. The residual sodium carbonate usually is zero and thus is not a problem.

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Water Year	U.S.G.S. Water-Supply Paper No.	T.W.D.B. Report No.	Water Year	U.S.G.S. Water-Supply Paper No.	T.W.D.B. Report No.
1940-45	--	*1938-45	1955	1402	*1955
1946	1050	*1946	1956	1452	Bull. 5905
1947	1102	*1947	1957	1522	Bull. 5915
1948	1133	*1948	1958	1573	Bull. 6104
1949	1163	*1949	1959	1644	Bull. 6205
1950	1188	*1950	1960	--	Bull. 6215
1951	1199	*1951	1961	--	Bull. 6304
1952	1252	*1952	1962	1944	Bull. 6501
1953	1292	*1953	1963	--	Rept. 7
1954	1352	*1954			

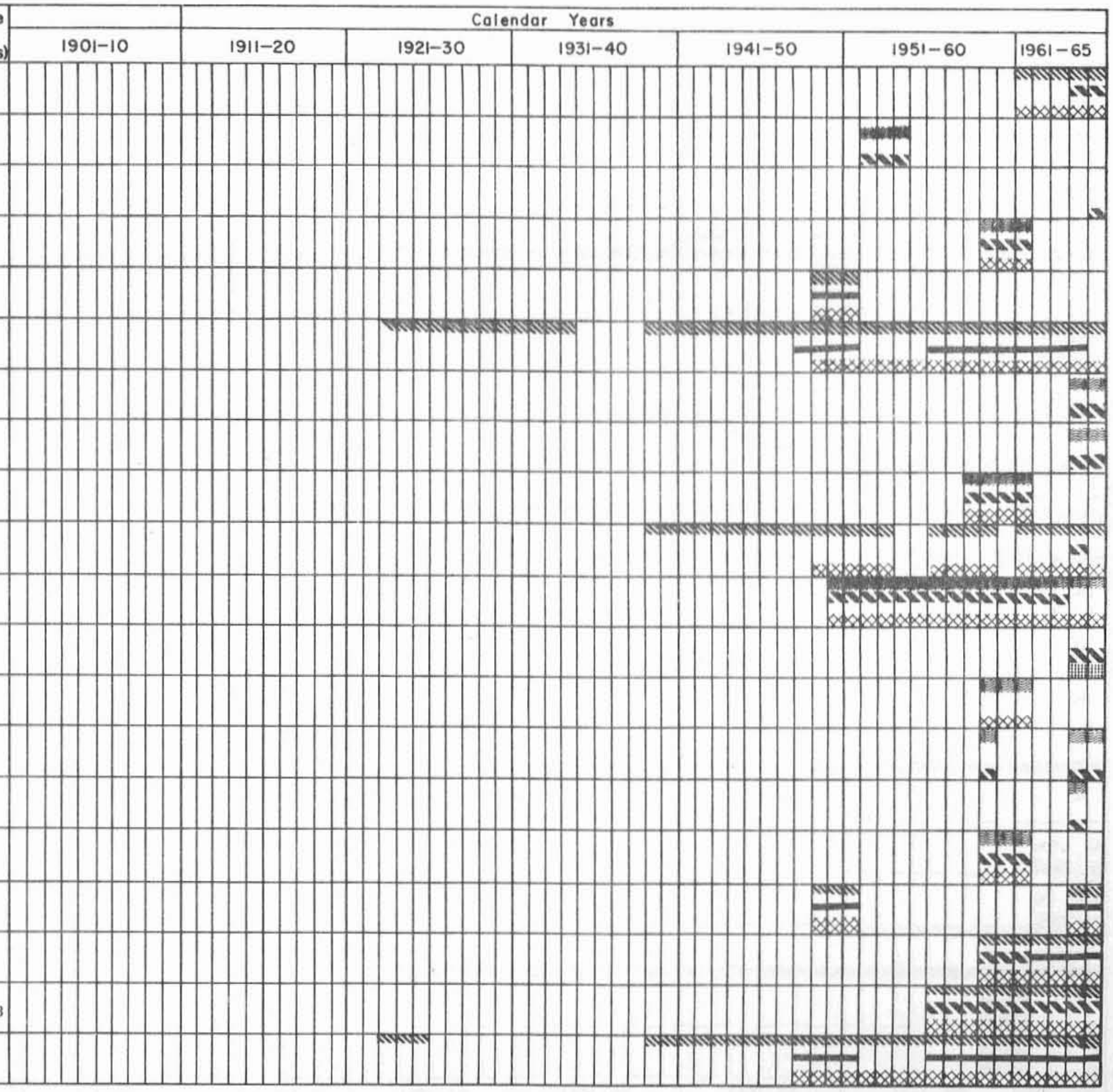
* "Chemical Composition of Texas Surface Waters" was designated only by water year from 1938 through 1955.

The following U.S. Geological Survey Water-Supply Papers contain results of stream measurements in the Brazos River Basin, 1898-1960:

Year	Water-Supply Paper No.	Year	Water-Supply Paper No.	Year	Water-Supply Paper No.
1898	28	1931	718	1946	1058
1899	37	1932	733	1947	1088
1900	50	1933	748	1948	1118
1901	75	1934	763	1949	1148
1902	83	1935	788	1950	1178
1903	99	1936	808	1951	1212
1904	132	1937	828	1952	1242
1905	174	1938	858	1953	1282
1906	210	1939	878	1954	1342
1924	588	1940	898	1955	1392
1925	608	1941	928	1956	1442
1926	628	1942	958	1957	1512
1927	648	1943	978	1958	1562
1928	668	1944	1008	1959	1632
1929	688	1945	1038	1960	1712
1930	703				

Table 1.--Index of surface-water records for selected sites in the Brazos River basin[a].

Reference no.	Stream and Location	Drainage Area (sq. miles)
1	Double Mountain Fork Brazos River at Justiceburg	b1,272
2	r'h Fork Double Mountain Fork Brazos River, ..5 miles northwest of Slayton	
3	Lake Buffalo Springs near Lubbock	
4	Rough Creek at mouth near Rotan	
5	Double Mountain Fork Brazos River near Rotan	c7,739
6	Double Mountain Fork Brazos River near Aspermont	c7,980
7	Double Mountain Fork Brazos River near Rule	
8	Tank Creek near Rule	
9	McDonald Creek at mouth near Post	112
10	Running Water Draw at Plainview	
11	White River near Crosbyton	
12	White River Reservoir near Spur	
13	Red Mud Creek at mouth near Clairemont	
14	Salt Creek near Clairemont	
15	Duck Creek near Jayton	
16	Butte Creek at mouth near Jayton	
17	Salt Fork Brazos River near Peacock	d4,260
18	Croton Creek near Jayton	284
19	Salt Croton Creek near Aspermont	64.3
20	Salt Fork Brazos River near Aspermont	d4,830



Discharge; Gage heights only; Gage heights and discharge measurements; Reservoir contents; Periodic discharge measurements; Daily chemical quality; Periodic chemical quality; Water temperature

See footnotes at end of table.

Table 1.--Index of surface-water records for selected sites in the Brazos River basin[a].--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901–10	1911–20	1921–30	1931–40	1941–50	1951–60	1961–65
21	North Croton Creek at mouth near Knox City								
22	Mustang Creek at mouth near Knox City								
23	Brazos River at Seymour	e14,490							
24	Millers Creek near Munday	113							
25	Millers Creek near Seymour								
26	Lake Trammel near Sweetwater								
27	Lake Sweetwater near Sweetwater	104							
28	Lake Abilene near Abilene								
29	Kirby Lake near Abilene								
30	Lytle Lake near Abilene								
31	Fort Phantom Hill Reservoir near Nugent	478							
32	Clear Fork Brazos River at Nugent	2,200							
33	Lake Stamford near Haskell	360							
34	Hamlin Lake near Hamlin								
35	California Creek near Stamford	465							
36	Paint Creek near Haskell	879							
37	Clear Fork Brazos River at Fort Griffin	3,974							
38	Hubbard Creek near Sedwick	127							
39	Deep Creek at Moran	235							
40	Hubbard Creek near Albany	461							

Discharge — Gage heights only — Gage heights and discharge measurements — Reservoir contents

Periodic discharge measurements — Daily chemical quality — Periodic chemical quality — Water temperature

See footnotes at end of table.

Table 1.--Index of surface-water records for selected sites in the Brazos River basin[a].--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-65
41	Salt Prong Hubbard Creek at U.S. Highway 380 near Albany	65.2							
42	North Fork Hubbard Creek near Albany	38.4							
43	Salt Prong Hubbard Creek near Albany	116							
44	Snailum Creek near Albany	25.5							
45	Big Sandy Creek near Breckenridge	298							
46	Hubbard Creek Reservoir near Breckenridge	1,107							
47	Hubbard Creek near Breckenridge	1,111							
48	Lake Daniels near Breckenridge								
49	Clear Fork Brazos River at Eliasville	5,721							
50	Brazos River near South Bend	e21,600							
51	Salt Creek at Olney	9.6							
52	Salt Creek near Newcastle	57.9							
53	Lake Graham near Graham	205							
54	Brazos River below Possum Kingdom Dam, near Graford	e22,550							
55	Brazos River near Palo Pinto	e22,760							
56	Keechi Creek near Graford								
57	Keechi Creek Reservoir near Graford								
58	Lake Hagaman near Ranger								
59	Palo Pinto Creek near Santo	567							
60	Lake Mineral Wells near Mineral Wells								

Discharge   Gage heights only   Gage heights and discharge measurements   Reservoir contents

Periodic discharge measurements   Daily chemical quality   Periodic chemical quality   Water temperature

See footnotes at end of table.

Table 1.--Index of surface-water records for selected sites in the Brazos River basin[a].--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-65
61	Paluxy Creek at Glen Rose	399							
62	Lake Pat Cleburne near Cleburne								
63	Nolands River at Blum	276							
64	Brazos River below Whitney Dam, near Whitney	e26,170							
65	Brazos River near Whitney	e26,190							
66	Aquilla Creek near Aquilla	306							
67	Green Creek near Alexander	45.5							
68	North Bosque River near Clifton	972							
69	Middle Bosque River near McGregor	182							
70	Waco Reservoir near Waco								
71	Bosque River near Waco	1,655							
72	Brazos River at Waco	e28,500							
73	Cow Creek at Mooreville	79.6							
74	Leon River near Eastland	279							
75	Leon Reservoir near Ranger	252							
76	Proctor Reservoir near Proctor	1,265							
77	Leon River near Hasse	1,268							
78	Lake Eanes near Comanche								
79	Lake Comanche near Comanche								
80	Lake Hamilton near Hamilton								

Discharge; Gage heights only; Gage heights and discharge measurements; Reservoir contents; Periodic discharge measurements; Daily chemical quality; Periodic chemical quality; Water temperature

See footnotes at end of table.

Table 1.--Index of surface-water records for selected sites in the Brazos River basin[a].--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-65
81	Belton Reservoir near Belton	3,560							
82	Leon River near Belton	3,572							
83	Sulphur Creek below Lampasas								
84	Lampasas River near Kempner	817							
85	Lampasas River at Youngsport	1,244							
86	North Fork San Gabriel River at Georgetown								
87	South Fork San Gabriel River at Georgetown								
88	San Gabriel River at Georgetown	399							
89	Little River at Cameron	6,982							
90	Brazos River at State Highway 21 near Bryan								
91	Little Brazos River at State Highway 21 near Bryan								
92	Brazos River near Bryan	e38,400							
93	Yegua Creek near Somerville	1,008							
94	Lake Mexia near Mexia	198							
95	Navasota River near Easterly	940							
96	Navasota River near Bryan	1,429							
97	Brazos River at Richmond	e44,020							
98	Brazos River near Juliff	e44,100							
99	Big Creek at Farm Road 1994 near Guy								
100	Big Creek at Farm Road 762 near Guy								

Discharge; Gage heights only; Gage heights and discharge measurements; Reservoir contents

Periodic discharge measurements; Daily chemical quality; Periodic chemical quality; Water temperature

See footnotes at end of table.

Table 1.--Index of surface-water records for selected sites in the Brazos River basin[a].--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901–10	1911–20	1921–30	1931–40	1941–50	1951–60	1961–65
101	Big Creek at county road 9 miles northeast of Guy								Periodic chemical quality
102	Cow Creek at Kitty Nash Road 8 miles northeast of Damon								Periodic chemical quality
103	Brazos River at Harris Reservoir, near Angleton								Daily chemical quality
104	Varner Creek at State Highway 35 at East Columbia								Periodic chemical quality
105	Brazos River at Brazoria Reservoir, near Brazoria								Daily chemical quality

Discharge ▨ Gage heights only ▥ Gage heights and discharge measurements ▨ Reservoir contents ▥

Periodic discharge measurements ▨ Daily chemical quality ■ Periodic chemical quality ▧ Water temperature ⌇

a Index of records for other sites are found in publications or files of the Texas Water Development Board and the U.S. Geological Survey.
b of which 1,003 square miles is probably noncontributing.
c of which 6,470 square miles is probably noncontributing.
d of which 2,770 square miles is probably noncontributing.
e of which 9,240 square miles is probably noncontributing.

Table 2.--Reservoirs with capacities of 5,000 acre-feet or more in the Brazos River basin.

(The purposes for which the impounded water is used are indicated by the following symbols: M, municipal; I, industrial; Ir, irrigation; Mi, mining; P, hydroelectric power; FC, flood control; R, recreation.)

Name of reservoir	Year operation began	Stream	[a]Total storage capacity (acre-feet)	Owner	County	Use
Lake Buffalo Springs	1960	North Fork Double Mountain Fork Brazos River	5,360	Lubbock County Water Control and Improvement District No. 1	Lubbock	M, I, R
White River	1963	White River	38,600	White River Municipal Water District	Crosby	M, I, Mi
Lake Sweetwater	1930	Bitter and Cottonwood Creeks	11,900	City of Sweetwater	Nolan	M, I
Lake Abilene	1921	Elm Creek	9,790	City of Abilene	Taylor	M
Kirby Lake	1928	Cedar Creek	7,620	City of Abilene	Taylor	M, Ir
Fort Phantom Hill	1938	Elm Creek	74,310	City of Abilene	Jones	M, Ir
Lake Stamford	1953	Paint Creek	53,070	City of Stamford	Haskell	M, I
Lake Cisco	1925	Sandy Creek	25,600	City of Cisco	Eastland	M
Hubbard Creek	1962	Hubbard Creek	317,800	West Central Texas Municipal Water District	Stephens	M, I, Mi
Lake Daniel	1948	Gonzales Creek	10,000	City of Breckenridge	Stephens	M, I
Lake Graham	1929, 1958	Flint and Salt Creeks	53,680	City of Graham	Young	M, I
Possum Kingdom	1941	Brazos River	724,700	Brazos River Authority	Palo Pinto	M, I, Ir, Mi, P, R
Lake Palo Pinto	1964	Palo Pinto Creek	44,100	Palo Pinto County Municipal Water District No. 1	Palo Pinto	M, I
Lake Mineral Wells	1921, 1943	Rock Creek	8,420	City of Mineral Wells	Palo Pinto	M, I
Lake Pat Cleburne	1964	Nolands River	25,560	City of Cleburne	Johnson	M
Whitney	1951	Brazos River	1,999,500	U.S. Army Corps of Engineers	Hill-Bosque	P, FC

Table 2.--Reservoirs with capacities of 5,000 acre-feet or more in the Brazos River Basin.--Continued

Name of reservoir	Year operation began	Stream	[a]/Total storage capacity (acre-feet)	Owner	County	Use
Waco (Enlargement)	1929, 1965	Bosque River	726,400	U.S. Army Corps of Engineers, City of Waco, Brazos River Authority	McLennan	M, I, FC
Lake Creek	1952	Manos Creek (Brazos River off-channel)	8,400	Texas Power & Light Company	do.	I
Leon	1954	Leon River	27,290	Eastland County Water Supply District	Eastland	M, I
Proctor	1963	do.	374,200	U.S. Army Corps of Engineers, Brazos River Authority	Comanche	M, I, Ir, FC
Belton	1954	do.	1,097,600	do.	Bell	M, I, Ir, FC
Stillhouse Hollow	b/	Lampasas River	630,400	do.	do.	M, I, Ir, FC
Alcoa Lake	1953	Sandy Creek (Little River off-channel)	10,500	Aluminum Company of America	Milam	I
Somerville	b/	Yegua Creek	507,500	U.S. Army Corps of Engineers, Brazos River Authority	Burleson	M, I, Ir, FC
Lake Mexia	1961	Navasota River	10,000	Bistone Municipal Water District	Limestone	M, I
Camp Creek Lake	1948	Camp Creek	8,550	Camp Creek Water Company	Robertson	R
Smithers Lake	1957	Dry Creek	18,000	Houston Lighting & Power Company	Fort Bend	I
William Harris	1947	Brazos River & Oyster Creek off-channel	12,000	Dow Chemical Co.	Brazos	M, I
Eagle Nest-Manor Lake	1949	Unnamed Tributary to Varner's Creek	18,000	T. M. Smith, et al	Brazoria	Ir
Brazoria	1954	Brazos River off-channel	21,970	Dow Chemical Co.	do.	M, I

a/ Total storage capacity is that capacity below the lowest uncontrolled outlet or spillway and is based on the most recent reservoir survey available.
b/ Under construction.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.

(Analyses listed as maximum and minimum were classified on the basis of the values for dissolved solids only; values of other constituents may not be extremes. Results in parts per million except as indicated.)

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
5. DOUBLE MOUNTAIN FORK BRAZOS RIVER NEAR ROTAN																			
Water year 1950																			
Maximum, Jan. 21-31, 1950	a0	14	800	156	6,170		126	2,190	9,700		--	19,100	26.0	0.0	2,640	2,530	52	28,900	7.6
Minimum, Sept. 5-9	1,542	13	49	8.3	118		120	177	91		1.2	b531	.72	2,210	156	58	4.1	871	8.1
Weighted average	146	15	97	16	152		126	294	160		1.4	812	1.10	320	308	205	3.8	1,270	--
Water year 1951																			
Maximum, Oct. 22-24, 1950	a0	18	559	110	3,070		117	1,590	4,800		--	10,200	13.9	.0	1,850	1,750	31	15,800	7.7
Minimum, Aug. 21-25, 1951	910	18	98	16	115		127	300	101		1.2	b731	.99	1,800	310	206	2.8	1,100	7.8
Weighted average	32.6	19	176	28	218		121	525	270		--	1,300	1.77	114	554	455	4.0	1,940	--
6. DOUBLE MOUNTAIN FORK BRAZOS RIVER NEAR ASPERMONT																			
Water year 1949																			
Maximum, Mar. 1-10, 1949	0.77	13	636	92	779		116	1,770	1,220	--	1.5	4,570	6.22	9.5	1,970	1,870	7.6	6,340	--
Minimum, Sept. 11-20	1,168	14	81	13	110		115	254	95	--	2.2	b664	.90	2,090	256	162	3.0	1,020	7.7
Weighted average	139	14	138	20	130		120	380	150	--	2.6	916	1.25	344	426	328	2.7	1,410	--
Water year 1950																			
Maximum, Feb. 1-13, 19-28, 1950	1.62	13	614	82	595		116	1,700	920	--	1.2	3,980	5.41	17	1,870	1,770	6.0	5,350	7.8
Minimum, May 11-13	2,275	16	74	9.6	132		120	240	114	--	1.0	646	.88	3,970	224	126	3.8	1,030	7.6
Weighted average	171	15	162	18	138		109	460	148	--	2.3	1,010	1.37	466	478	388	2.7	1,470	--
Water year 1951																			
Maximum, Aug. 5, 8, 1951	a0	23	816	115	553		76	2,340	860	--	.0	4,740	6.45	.0	2,510	2,450	4.8	5,920	7.8
Minimum, Aug. 23-29	743	18	105	17	142		133	330	132	--	3.5	b842	1.15	1,690	332	223	3.4	1,280	7.9
Weighted average	63	18	249	29	167		106	700	203	--	2.4	1,430	1.94	243	740	654	2.7	1,980	--
Water year 1957																			
Maximum, July 9-16, 1957	4.62	26	588	83	787		59	1,720	1,190	--	1.6	4,420	6.01	55.1	1,810	1,760	8.0	6,020	7.5
Minimum, June 1-7, 13-14, 19-20	2,849	16	104	14	89		122	273	87	--	4.2	b689	.94	5,300	317	217	2.2	1,020	7.8
Weighted average	352	14	152	16	110		110	400	123	--	3.0	910	1.24	865	445	355	2.3	1,300	--
Water year 1958																			
Maximum, Feb. 23-28, 1958	9.02	10	640	102	1,470		130	1,660	2,400	--	--	6,350	8.64	155	2,020	1,910	14	9,430	8.0
Minimum, Oct. 22-28, 1957	492	11	61	10	138		137	208	115	--	2.5	b636	.86	845	193	80	4.3	989	8.0
Weighted average	130	14	217	22	207		110	592	265	--	2.5	1,390	1.89	488	632	542	3.6	1,970	--
Water year 1959																			
Maximum, Aug. 1-7, 1959	4.96	18	590	80	969		103	1,600	1,530	--	1.0	4,840	6.58	64.8	1,800	1,720	9.9	6,690	7.2
Minimum, July 1-6	4,604	15	110	14	99		110	318	88	--	3.0	b715	.97	8,890	332	242	2.4	1,060	7.4
Weighted average	219	15	153	18	149		113	429	168	--	2.6	999	1.36	591	456	363	3.0	1,460	--
Water year 1960																			
Maximum, Mar. 1-12, 1960	3.48	12	650	98	1,080		120	1,750	2,090	--	--	5,740	7.81	53.9	2,020	1,930	10	8,350	7.5
Minimum, Dec. 18-21, 1959	559	11	63	11	158		138	204	155	--	3.2	674	.92	1,020	202	89	4.8	1,110	8.1
Weighted average	149	22	139	17	151		112	410	159	--	4.3	977	1.33	393	417	325	3.2	1,410	--
Water year 1961																			
Maximum, May 1-16, 1961	.88	15	870	128	1,160		90	2,210	2,020	0.6	--	6,450	8.77	15.3	2,700	2,620	9.7	8,700	6.9
Minimum, June 16-19	3,058	18	100	14	126		122	291	124	.8	1.8	761	1.03	6,280	307	207	3.1	1,150	6.9
Weighted average	398	15	168	21	185		100	472	237	--	2.4	1,180	1.60	1,270	506	424	3.6	1,720	--
Water year 1962																			
Maximum, Dec. 16-31, 1961	5.9	13	655	116	1,290		163	1,760	2,090	--	--	6,000	8.16	95.6	2,110	1,980	12	8,520	7.4
Minimum, July 18, 1962	464	--	--	--	--		66	490	62	--	--	b851	1.16	1,070	578	524	--	1,230	7.4
Weighted average	173	16	157	20	186		115	455	217	--	3.3	1,140	1.55	532	475	380	3.5	1,650	7.5
Water year 1963																			
Maximum, Mar. 1-31, 1963	.5	12	830	158	1,080		89	2,080	2,000	--	.0	6,200	8.43	8.37	2,720	2,650	9.0	8,260	7.0
Minimum, June 2-12	2,064	18	73	12	112		130	221	94	1.2	3.5	b599	.81	3,340	232	125	3.2	930	7.5
Weighted average	164	17	159	24	182		124	457	220	--	3.0	1,120	1.52	496	496	394	3.5	1,640	7.3

See footnotes at end of table.

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
6. DOUBLE MOUNTAIN FORK BRAZOS RIVER NEAR ASPERMONT--Continued																			
Water year 1964																			
Maximum, May 1, 3-7, 1964	0.7	13	880	181	1,090		82	2,120	2,150	--	--	6,470	8.80	12.2	2,940	2,870	8.7	8,670	7.1
Minimum, Nov. 19, 1963	143	8.2	222	8.8	76		62	568	78	--	3.0	994	1.35	384	590	539	1.4	1,290	7.4
Weighted average	18.8	14	289	38	357		104	875	466	--	2.9	2,090	2.84	106	880	795	5.1	2,860	7.3
17. SALT FORK BRAZOS RIVER NEAR PEACOCK																			
Water year 1950																			
Maximum, Apr. 14-15, 1950	0.19	13	1,050	375	11,200		123	3,250	17,800		--	33,700	45.8	17	4,160	4,060	75	45,100	7.3
Minimum, Sept. 26-28	720	12	56	18	241		121	141	345		4.8	b934	1.27	1,820	214	114	7.2	1,560	7.7
Weighted average	134	16	158	46	731		137	412	1,160		4.3	2,610	3.55	944	583	470	13	4,380	--
Water year 1951																			
Maximum, Apr. 20-24, 30, 1951	.75	24	796	303	8,280		145	3,410	13,200		--	25,100	34.1	51	3,230	3,110	63	35,900	7.7
Minimum, May 19-27	313	22	64	17	163		133	159	218		2.5	b728	.99	615	230	120	4.7	1,280	7.8
Weighted average	31.2	24	195	54	1,150		139	550	1,790		--	3,840	5.22	323	708	594	19	6,280	--
18. CROTON CREEK NEAR JAYTON																			
Water year 1960																			
Maximum, Apr. 28, 1960	c0.91	--	--	--	11,500	--	--	3,540	18,100		--	--	--	--	4,740	--	--	46,700	--
Minimum, July 7-8	791	--	--	--	269	8.5	72	1,600	410		--	--	--	--	1,670	1,610	--	3,630	7.5
Water year 1961																			
Maximum, Apr. 5, 1961	c.54	--	--	--	10,900	--	--	3,720	17,200		--	--	--	--	4,840	--	--	43,700	--
Minimum, Oct. 18, 1960	4,980	--	--	--	130	4.1	58	1,380	182		--	--	--	--	1,430	1,380	--	2,700	7.6
Water year 1962																			
Maximum, Apr. 7-8, 1962	.4	--	--	--	11,900		101	3,480	19,700		--	--	--	--	4,580	4,500	--	45,300	7.4
Minimum, Sept. 2-4, 7	248	--	--	--	232		54	1,590	330		--	--	--	--	1,660	1,620	--	3,340	7.9
Weighted average	13.0	--	--	--	854		75	1,770	1,310		--	--	--	--	1,890	1,790	--	6,160	--
Water year 1963																			
Maximum, Apr. 2-12, 1963	.3	23	1,410	411	11,800		104	3,960	18,900		--	36,600	51.1	30.4	5,210	5,120	71	43,300	7.4
Minimum, Nov. 26-27, 1962	202	18	595	30	334		70	1,530	485		1.0	3,030	4.12	1,650	1,610	1,550	3.6	3,970	7.5
Weighted average	25.4	18	748	64	1,360		76	1,920	1,850		--	5,490	7.47	377	2,130	2,070	12	7,730	7.2
Water year 1964																			
Maximum, Apr. 18, 1964	8.2	30	--	--	12,900		114	4,310	20,900		--	40,300	56.3	892	5,940	5,850	--	50,900	7.5
Minimum, Oct. 21, 1963	26.0	7.2	372	27	431	5.5	52	948	690		2.0	2,510	3.41	176	1,040	996	5.8	3,830	6.9
Weighted average	2.72	13	908	145	3,890		90	2,390	6,200		--	13,600	18.5	99.9	2,860	2,790	29	18,400	6.9
20. SALT FORK BRAZOS RIVER NEAR ASPERMONT																			
Water year 1949																			
Maximum, Mar. 21, 24-28, 1949	8.50	14	1,330	490	28,400		105	2,850	45,400		--	78,500	107	1,800	5,330	5,250	169	90,000	7.6
Minimum, July 16, 31, Aug. 1	109	17	128	34	433		138	336	662		5.0	1,680	2.28	494	460	346	8.8	2,790	--
Weighted average	157	15	274	46	1,160		112	709	1,820		--	4,080	5.55	1,730	873	781	17	6,380	--
Water year 1950																			
Maximum, Apr. 1-15, 30, 1950	a.41	11	1,440	274	16,900		159	3,440	26,880		--	48,900	66.5	54	4,720	4,590	107	60,900	7.7
Minimum, Sept. 6-10, 27-29	1,004	15	166	26	448		116	435	670		4.0	1,820	2.48	4,930	521	426	8.5	3,060	7.8
Weighted average	166	16	320	52	1,400		117	--	2,230		--	4,870	6.62	2,180	1,010	916	19	7,640	--
Water year 1951																			
Maximum, Mar. 11-13, 27, 1951	9.60	17	1,220	445	27,500		114	2,760	43,800		--	75,800	103	1,960	4,870	4,780	171	95,500	7.3
Minimum, May 19-24	713	26	118	19	423		153	320	588		6.3	1,580	2.15	3,040	372	247	9.5	2,760	7.9
Weighted average	64.5	24	384	79	2,250		118	1,020	3,560		--	7 380	10.0	1,290	1,280	1,190	27	11,000	--

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
20. SALT FORK BRAZOS RIVER NEAR ASPERMONT--Continued																			
Water year 1957																			
Maximum, Feb. 1-6, 1957	0.68	12	1,490	455	27,600		149	3,190	44,100		--	76,900	110	149	5,590	5,470	160	86,600	7.9
Minimum, June 2-4	4,590	15	126	19	300		127	319	428		6.1	1,280	1.74	15,860	392	288	6.6	2,080	7.8
Weighted average	299	17	247	33	882		117	625	1,360		--	3,220	4.38	2,600	752	656	14	5,080	--
Water year 1958																			
Maximum, Sept. 1-14, 1958	.72	13	1,540	348	20,700		135	3,630	32,900		--	59,200	83.7	115	5,270	5,160	124	74,100	7.5
Minimum, Oct. 14-19, 23-26, 1957	399	14	119	27	848		129	311	1,290		2.9	2,670	3.63	2,880	408	302	18	4,650	7.9
Weighted average	71.4	13	330	68	2,800		124	826	4,410		--	8,500	11.6	1,640	1,100	1,000	37	12,700	--
Water year 1959																			
Maximum, Mar. 30-31, 1959	.60	24	1,570	556	36,100		90	3,510	57,400		--	99,200	145	161	6,200	6,130	199	101,000	7.3
Minimum, Aug. 8-12	648	23	140	22	609		123	362	910		3.5	2,130	2.90	3,730	440	339	13	3,530	8.2
Weighted average	126	17	263	47	1,540		121	666	2,420		--	5,020	6.83	1,710	850	750	23	7,700	--
Water year 1960																			
Maximum, Apr. 28-30, 1960	2.27	13	1,420	478	30,400		158	3,240	48,300		--	83,900	121	514	5,510	5,380	178	92,400	7.3
Minimum, July 7-9	4,280	22	106	17	310		125	299	420		3.8	1,240	1.69	14,330	334	232	7.4	2,140	7.8
Weighted average	80.2	18	246	49	1,810		126	653	2,820		--	5,660	7.70	1,230	816	712	28	8,340	--
Water year 1961																			
Maximum, Aug. 18, 1961	28.0	13	1,520	523	41,900		103	3,060	66,500		--	114,000	168	8,620	5,940	5,860	236	115,000	7.4
Minimum, Oct. 19-20, 1960	6,115	13	112	16	313		107	226	498		.5	1,230	1.67	20,310	346	258	7.3	2,320	7.8
Weighted average	253	16	322	49	1,470		136	817	2,290		--	5,030	6.84	3,440	1,000	894	20	7,630	--
Water year 1962																			
Maximum, Apr. 1-7, 1962	7.0	13	1,240	403	25,000		122	3,030	39,600		--	69,300	98.9	1,310	4,750	4,650	158	71,900	7.2
Minimum, June 9-10	977	--	--	--	--		84	594	810		--	2,230	3.03	5,880	710	641	--	3,690	7.6
Weighted average	63.2	16	449	78	2,860		111	1,200	4,490		--	9,150	12.4	1,560	1,440	1,340	28	13,000	7.4
Water year 1963																			
Maximum, Aug. 19-20, 1963	13.3	17	1,320	369	32,100		68	2,720	50,800		--	87,400	122	3,340	4,810	4,760	201	96,100	6.6
Minimum, June 18-20	1,191	24	129	20	332		124	344	472		0.8	1,380	1.88	4,440	404	303	7.2	2,250	7.7
Weighted average	80.8	17	319	61	1,850		116	854	2,900		--	6,070	8.26	1,320	1,050	955	20	8,770	7.4
Water year 1964																			
Maximum, July 2, 1964	86.0	38	1,730	621	50,000		99	3,310	79,500		--	135,000	202	34,480	6,870	6,790	--	127,000	7.1
Minimum, June 15-17	256	30	292	39	978		118	822	1,460		3.5	3,680	5.00	2,540	889	792	14	5,740	7.9
Weighted average	19.1	20	629	135	6,270		112	1,570	9,960		--	18,600	25.3	959	2,120	2,030	52	24,800	7.2
23. BRAZOS RIVER AT SEYMOUR																			
Water year 1960																			
Maximum, Mar. 1-16, 1960	27.3	22	644	189	4,310		74	1,830	6,940	0.6	--	14,000	19.2	1,030	2,380	2,320	38	20,800	6.8
Minimum, July 6-15	4,953	18	150	19	256		103	425	340	--	3.5	1,260	1.71	16,850	452	368	5.2	1,990	7.4
Weighted average	279	17	209	32	649		108	576	975	--	--	2,510	3.41	1,890	653	564	11	3,960	--
Water year 1961																			
Maximum, Feb. 27-28, 1961	110	--	--	--	--		95	--	8,700	--	--	17,200	23.6	5,110	2,370	2,290	--	25,000	7.2
Minimum, Oct. 14, 16, 1960	1,686	11	77	15	154		72	210	218	--	2.8	723	.98	3,290	254	194	4.2	1,250	7.7
Weighted average	807	13	211	32	548		96	592	817	--	--	2,270	3.09	4,950	658	580	9.3	3,500	--
Water year 1962																			
Maximum, Apr. 15-23, 1962	6.8	7.6	678	229	5,240		142	2,240	8,210	--	--	16,700	23.0	307	2,630	2,520	44	23,300	7.2
Minimum, Sept. 8	14,600	--	--	--	--		86	404	180	--	--	946	1.29	37,290	415	344	--	1,400	7.3
Weighted average	308	14	241	38	691		103	659	1,060	--	--	2,750	3.74	2,290	759	674	10	4,320	7.4
Water year 1963																			
Maximum, Apr. 5, 7-27, 1963	24.0	7.7	615	181	3,910		144	1,850	6,200	--	--	12,800	17.5	829	2,280	2,160	36	18,400	7.3
Minimum, June 1, 6-10	2,462	14	88	19	183		136	254	222	1.1	4.2	852	1.16	5,660	298	186	4.6	1,400	7.4
Weighted average	299	15	233	42	734		123	646	1,110	--	--	2,850	3.88	2,300	753	652	10	4,390	7.3

See footnotes at end of table.

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
23. BRAZOS RIVER AT SEYMOUR--Continued																			
Water year 1964																			
Maximum, Feb. 9-10, 1964	73.0	15	632	173	6,770		128	1,600	10,800		--	20,100	27.7	3,960	2,290	2,180		28,500	7.8
Minimum, Sept. 22-24	2,682	8.2	121	14	120		78	316	160		1.5	779	1.06	5,640	360	296	2.7	1,250	7.3
Weighted average	87.7	11	250	44	918		90	711	1,410		--	3,390	4.61	803	807	733	12	5,170	7.2
32. CLEAR FORK BRAZOS RIVER AT NUGENT																			
Water year 1949																			
Maximum, Mar. 21-31, 1949	4.15	4.1	370	138	774		140	1,460	1,090		2.5	3,910	5.32	44	1,490	1,380	8.7	5,650	7.8
Minimum, Sept. 15-16	860	8.8	34	1.1	20		104	32	8.0		2.5	158	.21	367	89	4	.9	264	7.4
Weighted average	58.1	10	65	15	54		120	145	63		2.3	425	.58	67	224	125	1.6	659	--
Water year 1950																			
Maximum, Mar. 11-20, 1950	1.42	6.0	314	149	573		106	1,300	852		1.0	3,250	4.42	12	1,400	1,310	6.6	4,760	7.7
Minimum, Oct. 22, 24, 26-28, 1949	234	9.0	33	8.2	13		106	36	13		1.8	b181	.25	114	116	29	.5	294	7.3
Weighted average	64.6	14	59	17	47		119	131	59		3.2	410	.56	72	217	120	1.4	624	--
Water year 1951																			
Maximum, Feb. 11-19, 1951	3.94	6.8	352	157	619		194	1,470	835		4.2	3,540	4.81	38	1,520	1,360	6.9	5,060	7.9
Minimum, July 2-4, 27-31	140	16	36	11	25		117	47	29		4.0	b234	.32	88	135	39	.9	390	7.9
Weighted average	43.8	17	77	24	76		136	197	96		4.4	569	.77	67	290	179	1.9	871	--
Water year 1952																			
Maximum, May 28-29, 1952	5.35	17	325	97	772		132	1,310	1,000		7.3	3,590	4.88	52	1,210	1,100	9.6	5,070	7.9
Minimum, Sept. 22, 24-25	102	8.8	37	7.3	14		104	44	12		5.2	b201	.27	55	122	37	.6	318	7.7
Weighted average	10.8	12	65	28	81		165	165	106		2.8	558	.76	16.3	277	142	2.1	895	--
Water year 1953																			
Maximum, Feb. 11-28, 1953	.22	12	82	86	262		131	383	438		4.0	1,330	1.81	.79	558	450	4.8	2,250	8.2
Minimum, July 15-22	203	14	32	7.3	15		111	22	17		4.7	b179	.24	98.1	110	19	.6	301	8.1
Weighted average	12.4	15	40	10	29		124	48	37		3.4	260	.35	8.7	141	40	1.1	419	--
35. CALIFORNIA CREEK NEAR STAMFORD																			
Water year 1963																			
Maximum, Aug. 17-31, 1963	0.3	7.9	560	353	1,620		108	2,070	2,920		--	7,580	10.3	6.14	2,850	2,760	13	10,700	6.9
Minimum, May 31	1,260	23	40	9.5	30		113	48	42		3.2	252	.34	857	139	46	1.1	406	7.6
Weighted average	d32.9	17	104	52	152		131	348	233		3.8	974	1.32	86.5	461	355	2.3	1,420	7.5
Water year 1964																			
Maximum, Apr. 28-30, 1964	.8	8.0	833	628	2,810		131	3,090	5,280		--	12,700	17.4	27.4	4,660	4,550	--	17,000	7.7
Minimum, June 12-13	86.0	14	48	9.7	43		141	61	52		1.8	298	.41	69.2	160	44	1.5	513	7.9
Weighted average	2.0	9.2	152	105	367		167	670	553		--	1,940	2.64	10.5	811	674	4.5	2,800	7.3
36. PAINT CREEK NEAR HASKELL																			
Water year 1950																			
Maximum, July 25-26, 28, 1950	67.5	14	98	40	294		93	100	615		1.8	1,210	1.65	221	409	333	6.3	2,260	8.0
Minimum, Aug. 17	27.0	12	18	4.4	12		86	9	4.2		3.0	b108	.15	7.9	63	0	.7	173	8.0
Water year 1951																			
Maximum, May 21-22, 24, 26, 1951	118	20	94	42	209		114	168	410		1.5	1,000	1.36	319	407	314	4.5	1,790	6.9
Minimum, May 18-19	911	17	26	7.9	12		116	12	8.0		5.0	b157	.21	386	97	2	.5	249	8.1

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
37. CLEAR FORK BRAZOS RIVER AT FORT GRIFFIN																			
Water year 1950																			
Maximum, Apr. 17, 1950	2,064	8.4	123	44	445		84	112	898		4.2	1,680	2.38	9,360	488	419	8.8	3,120	7.2
Minimum, Nov. 9-21, 1949	.92	14	32	8.4	12		126	17	14		.8	160	.22	.4	114	11	.5	267	7.0
Weighted average	131	12	47	12	45		117	68	67		2.9	333	.45	118	167	71	1.5	544	--
Water year 1951																			
Maximum, May 20-21, 1951	1,533	7.4	132	51	192		101	492	255		2.5	1,180	1.60	4,880	539	456	3.6	1,900	7.7
Minimum, May 19-20	1,119	8.8	31	7.8	21		121	28	18		3.0	b183	.25	553	109	10	.9	314	7.6
Weighted average	88.7	16	58	15	44		119	101	67		3.5	393	.53	94	206	108	1.3	630	--
38. HUBBARD CREEK NEAR SEDWICK																			
Water year 1964																			
Maximum, Feb. 1-3, 1964	0.2	8.7	60	8.9	54		153	15	115	0.2	0.5	337	0.46	0.18	186	60	1.7	638	7.8
Minimum, Nov. 8-11, 19-20, 1963	34.4	7.7	30	1.7	6.4	4.4	85	8.8	14	.0	2.5	118	.16	11.0	82	12	.3	213	6.6
Weighted average	1.3	8.7	42	5.3	24		105	17	53	--	--	207	.28	.73	127	41	.8	388	6.8
39. DEEP CREEK AT MORAN																			
Water year 1963																			
Maximum, Mar. 10-13, 1963	0.1	2.2	365	134	992		92	368	2,240		--	4,150	5.64	1.12	1,460	1,390	11	7,070	6.8
Minimum, May 30-31	1,308	14	--	--	16		122	17	25		3.2	179	--	--	121	21	.6	308	7.5
Weighted average	13.2	13	44	9.7	37		117	28	75		2.9	267	.36	9.52	151	55	1.0	470	7.4
Water year 1964																			
Maximum, Jan. 30, 1964	13.0	--	--	--	--		119	214	1,220		--	2,330	3.17	81.8	925	828	--	4,160	7.5
Minimum, Nov. 20-21, 1963	39.5	5.2	28	5.6	18		81	15	34		2.8	149	.20	15.9	93	26	.8	284	6.5
Weighted average	5.6	8.5	56	12	70		110	31	155		3.6	391	.53	5.91	191	101	2.1	737	6.7
40. HUBBARD CREEK NEAR ALBANY																			
Water year 1962																			
Maximum, Apr. 5-6, 1962	76.0	6.7	209	7.8	539		107	222	1,200		3.5	2,310	3.14	474	842	755	8.1	4,030	7.4
Minimum, Sept. 8-25	58.4	12	32	6.3	24		97	15	43	0.2	1.2	182	.25	28.7	106	26	1.0	326	7.3
Weighted average	e32.0	11	54	13	75		108	37	158		1.6	403	.55	34.8	188	100	2.4	740	7.1
Water year 1963																			
Maximum, Jan. 1-11, 1963	.1	5.0	146	38	237		140	118	565		.5	1,180	1.60	.32	520	406	1.5	2,180	7.8
Minimum, May 22	1,330	8.2	38	4.7	19		110	14	38		1.5	177	.24	636	114	24	.8	316	7.4
Weighted average	17.7	9.5	42	7.5	37		106	24	73		2.0	248	.34	11.9	136	48	1.3	449	7.3
Water year 1964																			
Maximum, May 1-2, 1964	.2	--	--	--	--		142	183	900		--	1,810	2.46	.98	675	558	--	3,150	7.2
Minimum, Sept. 18-21	153	7.5	27	3.1	16		88	12	20		3.0	132	.18	54.5	80	8	.8	236	6.7
Weighted average	16.0	7.3	38	6.5	37		90	19	75		3.4	231	.31	9.98	121	48	1.3	434	6.7
41. SALT PRONG HUBBARD CREEK AT U. S. HIGHWAY 380, NEAR ALBANY																			
Water year 1964																			
Maximum, May 1-4, 12-21, 28-31, 1964	2.1	6.2	90	48	230		240	73	458	0.5	2.0	1,030	1.40	5.84	422	226	4.9	1,880	7.0
Minimum, Nov. 19-20	26.8	10	31	5.0	24		99	14	37		2.8	173	.24	12.5	98	17	1.1	312	7.0
Weighted average	.6	9.0	59	22	100		167	40	196		2.1	512	.70	.83	238	101	2.6	957	7.2

See footnotes at end of table.

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated) Parts per million	Dissolved solids Tons per acre-foot	Dissolved solids Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
42. NORTH FORK HUBBARD CREEK NEAR ALBANY																			
Water year 1963																			
Maximum, Apr. 1-26, 1963	0.4	8.6	620	197	999		116	128	3,050	--	--	5,060	6.88	5.46	2,360	2,260	8.9	8,710	7.1
Minimun, June 11-12	18.4	11	138	29	289		72	13	722	0.2	1.5	1,240	1.69	61.6	464	405	5.8	2,340	7.0
Weighted average	f.7	9.5	368	108	651		105	67	1,860	--	--	3,120	4.24	5.90	1,360	1,280	7.6	5,560	7.0
Water year 1964																			
Maximum, Aug. 22-25, 27, Sept. 1, 1964	.3	9.9	572	193	1,070		113	156	3,050	--	--	5,110	6.95	4.14	2,220	2,130	9.9	8,740	6.4
Minimum, Feb. 4-5	85	12	106	25	192		97	22	480	.1	6.3	891	1.21	204	368	288	4.4	1,740	7.4
Weighted average	1.4	9.8	265	78	484		120	63	1,320	--	--	2,290	3.11	8.66	981	882	6.4	4,180	7.1
43. SALT PRONG HUBBARD CREEK NEAR ALBANY																			
Water year 1962																			
Maximum, May 1-31, 1962	a0.4	9.2	415	138	763		76	120	2,180		--	3,660	4.98	3.95	1,600	1,540	8.3	6,490	6.8
Minimum, June 10	2,420	--	--	--	--		129	24	156		--	397	.54	2,590	200	94	--	769	7.6
Weighted average	e17.8	12	106	27	169		124	34	430		2.6	846	1.15	40.7	376	274	3.8	1,590	7.6
Water year 1963																			
Maximum, May 1-21, 1963	.2	8.8	502	177	836		96	159	2,520		--	4,250	5.70	2.30	1,980	1,900	8.2	7,280	6.8
Minimum, May 22	72.0	--	--	--	--		115	27	395		--	766	1.04	149	346	252	--	1,470	7.6
Weighted average	1.2	8.9	247	78	430		130	103	1,180		1.1	2,110	2.87	6.84	938	831	6.5	3,820	7.1
44. SNAILUM CREEK NEAR ALBANY																			
Water year 1964																			
Maximum, May 8-10, 1964	0.4	7.3	345	102	701		86	78	1,880		1.0	3,160	4.30	3.41	1,280	1,210	8.6	5,660	7.2
Minimum, Nov. 20-24, 1963	2.0	8.4	48	10	69		82	14	163		.0	352	.48	1.90	161	94	2.1	707	6.5
Weighted average	.7	12	84	20	155		80	22	381		3.2	715	.97	1.35	294	228	3.7	1,390	6.9
45. BIG SANDY CREEK NEAR BRECKENRIDGE																			
Water year 1962																			
Maximum, Apr. 1-2, 1962	0.6	--	--	--	--		29	59	4,180		--	6,730	9.19	10.9	2,550	2,530	--	11,900	7.1
Minimum, June 12-14	229	8.7	23	4.1	22		62	11	43		0.0	142	.19	87.8	74	33	1.1	327	8.5
Weighted average	e31.2	10	39	5.8	42		96	14	83		--	243	.33	20.5	121	42	1.7	453	7.1
Water year 1963																			
Maximum, June 22-25, July 11, 1963	.4	12	262	62	576		113	62	1,420		1.5	2,450	3.33	2.65	908	816	8.3	4,380	7.2
Minimum, May 30-31	1,131	17	19	2.1	3.9		62	.8	3.5		9.8	86	.12	263	56	5	2.3	151	7.3
Weighted average	28.5	17	28	3.6	23		76	7.4	43		3.6	162	.22	12.5	85	22	1.3	286	7.3
Water year 1964																			
Maximum, Apr. 5, 6, 10, 1964	.3	12	1,110	221	2,810		118	557	6,460		--	11,200	15.3	9.07	3,680	3,580	--	17,600	7.4
Minimum, Nov. 21, 1963	39.0	11	--	--	--		26	3.2	1.1		--	42	.06	4.42	28	7	--	59	6.5
Weighted average	33.1	10	30	4.2	27		82	13	49		2.8	178	.24	15.9	93	26	.9	307	6.9
47. HUBBARD CREEK NEAR BRECKENRIDGE																			
Water year 1956																			
Maximum, Apr. 17-28, 1956	1.28	5.6	268	48	498		132	32	1,280	0.2	1.2	2,200	2.99	7.60	866	758	7.4	4,120	7.9
Minimum, Oct. 3-10, 1955	88.7	10	32	3.6	13		101	8.7	20	.5	3.5	b152	.21	36.4	95	12	.6	256	7.9
Weighted average	22.7	11	38	4.4	32		106	11	58	.4	2.7	212	.29	13.0	113	26	1.3	386	--

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
47. HUBBARD CREEK NEAR BRECKENRIDGE--Continued																			
Water year 1957																			
Maximum, Aug. 8-31, 1957	0.50	14	204	51	384		149	259	820	0.4	5.9	1,810	2.46	2.44	718	596	6.2	3,160	7.8
Minimum, Feb. 6-8	7,473	6.2	25	2.3	15		79	7.0	21	.2	2.0	118	.16	2,380	72	7	.7	213	7.8
Weighted average	633	8.4	36	4.1	24		98	10	46	.5	2.9	180	.25	308	107	26	1.0	331	--
Water year 1958																			
Maximum, June 13, 1958	20.0	6.7	325	76	741		132	81	1,800	.4	3.0	3,100	4.22	167	1,120	1,020	9.6	5,600	7.7
Minimum, Oct. 14-15, 1957	10,020	6.4	29	3.2	19		87	10	31	.5	1.0	143	.19	3,870	86	14	.9	258	7.6
Weighted average	204	7.6	50	8.6	61		103	23	129	.5	1.8	332	.45	183	160	76	2.1	622	--
Water year 1959																			
Maximum, Apr. 16-30, 1959	a0	5.8	325	81	389		144	702	840	.4	6.8	2,420	3.29	0	1,140	1,030	5.0	3,780	7.9
Minimum, July 16	251	6.8	28	2.5	20		79	12	31	.1	3.5	143	.19	96.9	80	15	1.0	254	7.6
Weighted average	47.9	9.4	51	8.4	56		104	24	121	.2	3.6	325	.44	42.0	162	76	1.9	628	--
Water year 1960																			
Maximum, July 1-5, 1960	a0	--	--	--	--		109	--	3,180	--	--	5,350	7.28	--	1,820	1,730	--	9,220	7.4
Minimum, July 6	1,340	8.8	34	3.5	12		101	11	20	.4	2.0	142	.19	514	99	16	.5	247	8.0
Weighted average	83.0	9.4	51	8.7	58		107	25	120	.2	2.7	330	.45	74	163	76	2.0	601	--
Water year 1961																			
Maximum, May 16-31, 1961	a.06	5.1	275	61	439		163	440	920	.3	1.2	2,220	3.02	.36	937	804	6.2	3,680	7.4
Minimum, June 15	265	--	--	--	--		65	25	10	--	--	112	.15	80.1	78	25	--	189	7.1
Weighted average	134	11	47	8.2	51		105	20	109	.3	2.3	300	.41	109	151	65	1.8	563	--
Water year 1962																			
Maximum, May 1-31, 1962	a.8	7.1	265	82	522		150	264	1,230	--	.5	2,440	3.32	5.27	998	786	7.2	4,290	6.8
Minimum, Sept. 5-30	74.3	13	37	4.8	30		89	18	59	.3	1.8	208	.28	41.7	112	39	1.2	373	7.1
Weighted average	68.5	11	64	13	91		108	27	207	--	--	469	.64	86.7	213	124	2.7	885	7.2
Water year 1963																			
Maximum, Mar. 1-5, 1963	.3	7.1	245	62	250	3.8	88	632	495	.1	1.2	1,740	2.37	1.41	866	794	3.7	2,640	7.3
Minimum, Apr. 27	54.0	7.9	43	5.9	17	5.7	89	42	39	--	4.2	209	.28	30.5	132	59	.6	362	7.2
Weighted average	46.2	9.3	53	8.0	49		128	16	106	--	1.7	307	.42	38.3	165	61	1.7	578	7.2
Water year 1964																			
Maximum, July 30, 1964	8.4	8.5	280	61	227		155	700	415	.3	.8	1,770	2.41	40.1	950	822	3.2	2,590	7.1
Minimum, Sept. 24-30	1.2	7.3	50	6.1	11		65	97	13	--	1.0	217	.30	.70	150	97	.4	370	6.6
Weighted average	29.3	4.7	50	7.7	47		117	19	101	--	1.3	290	.39	22.9	155	59	1.7	561	7.1
49. CLEAR FORK BRAZOS RIVER AT ELIASVILLE																			
Water year 1962																			
Maximum, June 1-5, 1962	390	2.2	255	159	576		134	912	1,050	--	1.5	3,020	4.11	3,180	1,290	1,180	7.0	4,810	7.6
Minimum, June 14-16	9,630	15	44	7.8	28		109	40	48	0.3	3.2	b250	.34	6,500	142	53	1.0	423	7.1
Weighted average	540	13	63	18	86		116	95	156	--	2.5	505	.68	736	230	135	2.1	860	7.2
Water year 1963																			
Maximum, Mar. 16-31, 1963	29.7	6.3	255	100	507		216	620	940	--	2.0	2,540	3.45	204	1,050	870	6.8	4,040	7.1
Minimum, Apr. 29	1,930	10	41	6.2	29		120	19	48	--	6.0	218	.30	1,140	128	29	1.1	364	7.1
Weighted average	194	9.3	80	26	117		141	149	203	--	2.9	661	.90	347	307	191	2.7	1,110	7.1
Water year 1964																			
Maximum, Nov. 10, 1963	206	3.7	192	65	627		73	42	1,420	--	2.5	2,390	3.25	1,330	746	686	10	4,500	7.0
Minimum, Dec. 1-31	175	4.0	49	8.1	56		111	17	119	.3	1.5	310	.42	146	156	65	1.9	610	7.0
Weighted average	71.7	5.4	72	19	133		118	63	273	--	2.1	627	.85	121	259	162	3.3	1,170	7.1

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
50. BRAZOS RIVER NEAR SOUTH BEND																			
Water year 1942																			
Maximum, Aug. 21-23, 1942	364		496	80	1,310		109	1,240	2,140		4.5	5,320	7.24	5,230	1,570	1,480	14	8,250	
Minimum, Sept. 7-9	9,335		40	7.3	60		91	53	92		1.8	299	.41	8,910	130	56	2.3	580	
Weighted average	1,309		110	24	251		125	226	411		2.2	1,080	1.48	4,070	373	270	5.6	1,840	
Water year 1943																			
Maximum, May 20, 1943	310		410	107	2,630		142	949	4,310		.5	8,480	11.5	7,100	1,460	1,350	30	13,800	
Minimum, Oct. 17-20, 1942	24,920		64	9.7	85		89	111	138		1.0	453	.62	30,500	200	126	2.6	901	
Weighted average	678		136	27	340		118	305	549		2.2	1,420	1.93	2,600	450	354	7.0	2,440	
Water year 1944																			
Maximum, Dec. 11-20, 1943	3.35		538	148	1,650		167	390	3,540		2.5	6,350	8.64	57	1,950	1,810	16	10,800	
Minimum, Sept. 1-3, 6, 1944	568		55	11	90		95	50	174		4.3	431	.59	661	182	104	2.9	821	
Weighted average	236		139	27	318		113	284	539		4.9	1,370	1.86	873	458	366	6.5	2,320	
Water year 1945																			
Maximum, Dec. 11, 1944	350		535	113	4,550		111	1,130	7,380		9.7	13,800	18.8	13,000	1,800	1,710	46	22,700	
Minimum, July 8, 1945	959		42	9.2	39		96	48	69		2.5	257	.35	665	143	64	1.4	453	
Weighted average	545		146	24	358		113	294	598		3.3	1,480	2.01	2,170	463	370	7.2	2,470	
Water year 1946																			
Maximum, Aug. 11-20, 1946	0		428	113	1,540		93	413	3,100		2.5	5,640	7.67	0	1,530	1,460	17	10,100	7.3
Minimum, Aug. 23, 29-30	3,461		42	6.3	64		103	30	108		2.5	b332	.45	3,100	131	46	2.4	557	
Weighted average	503		173	25	379		108	394	610		2.1	1,660	2.26	2,250	534	446	7.1	2,670	
Water year 1947																			
Maximum, Apr. 11-16, 1947	62.3		530	127	2,290		110	1,240	3,860		--	8,100	11.0	1,360	1,840	1,750	23	12,800	
Minimum, Nov. 5-6, 1946	1,710		44	9.0	66		107	33	118		2.0	b361	.49	1,670	147	60	2.4	625	
Weighted average	1,032		165	26	308		106	358	514		3.0	1,450	1.97	4,040	519	432	5.9	2,210	
Water year 1948																			
Maximum, Feb. 21-26, 29, 1948	420		364	84	1,380		131	932	2,250		--	5,070	6.90	5,750	1,250	1,150	17	8,190	
Minimum, Nov. 21-23, 1947	471		117	21	236		102	275	370		.0	1,070	1.46	1,360	378	295	5.3	1,810	
51. SALT CREEK AT OLNEY																			
Water year 1958																			
Maximum, July 4-5, 1958	0	4.8	1,190	260	5,910		59	52	11,900	0.0	--	19,300	26.5	0	4,040	3,990	40	29,800	6.7
Minimum, Sept. 26	1.2	--	--	--	--		90	--	15	--	--	120	--	--	78	4	--	214	8.1
Weighted average	2.74	14	41	9.0	118		88	6.6	222	.4	--	458	.62	3.39	140	68	4.3	853	--
Water year 1959																			
Maximum, Apr. 23-26, 1959	0	3.9	194	56	1.140		55	61	2,190	.6	--	3,670	4.99	0	714	670	19	6,670	7.0
Minimum, Sept. 3	20.0	6.0	25	1.7	9.8		84	2.6	12	.1	2.5	101	.14	5.45	69	1	.5	182	7.7
Weighted average	.36	6.0	41	7.7	125		94	9.8	225	.3	1.7	463	.63	.45	134	57	4.7	890	--
52. SALT CREEK NEAR NEWCASTLE																			
Water year 1958																			
Maximum, June 21-30, July 1-5, 1958	a0.15	4.2	350	87	1,190		86	59	2,620	0.2	--	4,350	5.92	1.76	1,230	1,160	15	7,870	7.2
Minimum, May 1-4	289	9.9	21	2.8	26		65	7.2	40	.2	3.0	142	.19	111	64	11	1.4	265	7.3
Weighted average	14.7	11	32	5.4	55		81	9.9	99	.4	3.0	255	.35	19.1	102	36	2.4	477	--
Water year 1959																			
Maximum, Apr. 14-16, 1959	a0	4.1	194	43	568		56	95	1,240	.5	--	2,170	2.95	0	661	615	9.6	3,940	7.5
Minimum, July 18-19	170	13	5.4	2.1	5.8		26	3.6	5.0	--	3.2	51	.07	23.4	22	1	.5	72	7.0
Weighted average	3.12	12	22	4.5	45		58	8.3	81	.3	3.2	205	.28	1.73	73	26	2.3	382	--

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
52. SALT CREEK NEAR NEWCASTLE--Continued																			
Water year 1960																			
Maximum, Oct. 19-29, 1959	a0.10	12	166	38	424		140	32	950	0.4	4.0	1,700	2.31	0.46	570	456	7.7	3,230	8.0
Minimum, Oct 3-4	1,670	18	9.3	2.6	12		47	4.2	10	.4	3.0	82	.11	370	34	0	.9	120	7.3
Weighted average	g36.4	15	16	3.8	27		54	7.3	42	.4	3.1	140	.19	13.8	56	11	1.6	242	--
54. BRAZOS RIVER BELOW POSSUM KINGDOM DAM NEAR GRAFORD																			
Water year 1942																			
Maximum, Feb. 2-9, 1942	189	--	194	43	523		192	424	850	--	2.0	2,130	2.90	1,090	661	504	8.8	3,670	--
Minimum, Sept. 1-10	4,225	--	94	18	182		136	176	290	--	1.5	829	1.13	9,460	308	197	4.5	1,450	--
Weighted average	1,750	--	119	23	220		144	242	352	--	1.6	1,030	1.40	5,030	392	274	4.8	1,770	--
Water year 1943																			
Maximum, Jan. 11-20, 1943	536	--	132	27	302		140	242	516	--	3.0	1,290	1.76	1,870	440	326	6.3	2,330	--
Minimum, Dec. 21-31, 1942	350	--	98	18	183		123	187	298	--	1.8	846	1.15	799	318	218	4.5	1,570	--
Weighted average	1,161	--	109	21	223		138	201	370	--	1.6	994	1.35	3,110	358	246	5.1	1,760	--
Water year 1944																			
Maximum, Feb. 11-20, 1944	73.3	--	138	23	336		148	279	535	--	2.5	1,390	1.89	275	439	318	7.0	2,350	--
Minimum, Dec. 21-31, 1943	40.0	--	131	27	275		136	276	450	--	3.2	1,230	1.67	133	438	326	5.7	2,200	--
Weighted average	164	--	137	28	301		152	274	498	--	2.5	1,310	1.78	580	457	332	6.1	2,270	--
Water year 1945																			
Maximum, Mar. 21-31, 1945	883	--	150	32	381		137	279	658	--	3.2	1,570	2.14	3,740	506	394	7.4	2,740	--
Minimum, Sept. 21-30	320	--	118	26	296		140	204	508	--	1.8	1,220	1.66	1,050	402	287	6.4	2,130	--
Weighted average	528	--	135	27	335		140	256	561	--	2.5	1,390	1.89	1,980	448	334	6.9	2,410	--
Water year 1946																			
Maximum, Nov. 21-30, 1945	173	--	148	26	375		132	280	630	--	3.5	1,530	2.08	715	476	382	7.5	2,660	--
Minimum, July 21-31, 1946	617	--	132	23	285		142	255	468	--	1.0	1,230	1.67	2,050	424	308	6.0	2,180	--
Weighted average	502	--	137	24	310		135	262	519	--	1.3	1,320	1.80	1,790	440	330	6.4	2,300	--
Water year 1947																			
Maximum, Oct. 1-10, 1946	2,123	--	164	31	359		126	325	620	--	1.0	1,560	2.12	8,940	537	434	6.7	2,670	--
Minimum, Sept. 1-30, 1947	620	--	149	23	264		116	338	420	--	2.0	1,250	1.70	2,090	466	372	5.3	2,080	--
Weighted average	1,343	--	145	24	321		113	303	530	--	1.7	1,380	1.88	5,000	460	368	6.5	2,360	--
Water year 1948																			
Maximum, Aug. 1-31, 1948	926	12	166	28	330	12	131	379	538	--	.5	1,530	2.08	3,830	530	422	6.2	2,550	7.6
Minimum, Oct. 1-31, 1947	304		150	22	281		120	344	438	--	2.0	1,300	1.77	1,070	465	366	5.7	2,160	--
Weighted average	470		162	26	321		118	374	510	--	1.5	1,460	1.99	1,850	512	415	6.2	2,450	--
Water year 1949																			
Maximum, Apr. 1-30, 1949	125	8.6	184	29	377		119	417	612	--	2.8	1,690	2.30	570	578	480	6.8	2,860	7.8
Minimum, Sept. 1-30	1,130	9.0	133	20	295		108	298	465	--	1.2	1,270	1.73	3,870	414	326	6.3	2,220	7.4
Weighted average	769	9.9	161	26	333		115	375	531	--	1.2	1,500	2.04	3,110	509	415	6.4	2,540	--
Water year 1950																			
Maximum, July 1-31, 1950	2,255	12	135	22	287		108	286	472	--	.8	1,270	1.73	7,730	428	339	6.0	2,200	7.6
Minimum, Jan. 1-31	140	7.5	122	22	248		108	265	404	--	.8	1,120	1.52	423	395	306	5.4	1,940	7.4
Weighted average	898	10	128	21	281		109	280	451	--	1.3	1,230	1.67	2,980	406	316	6.1	2,130	--
Water year 1951																			
Maximum, Aug. 1-10, 1951	1,281	11	139	27	361		126	309	580	--	.8	1,490	2.03	5,150	458	355	7.3	2,620	7.5
Minimum, Dec. 1-31, 1950	386	9.4	123	24	254		110	267	418	--	1.0	1,150	1.56	1,200	406	316	5.5	1,990	7.2
Weighted average	603	12	131	24	308		120	291	490	--	1.7	1,320	1.80	2,150	426	327	6.5	2,280	--

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas,--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
54. BRAZOS RIVER BELOW POSSUM KINGDOM DAM NEAR GRAFORD--Continued																			
Water year 1952																			
Maximum, Sept. 1-30, 1952	48.5	12	152	27	352	--	136	307	578	--	1.5	1,500	2.04	196	490	378	6.9	2,510	7.5
Minimum, Feb. 1-29	84.9	11	130	24	308		119	288	492	--	1.8	1,310	1.78	300	423	326	6.5	2,240	7.6
Weighted average	294	13	135	23	331		124	295	527	--	1.5	1,390	1.89	1,100	432	330	6.9	2,410	--
Water year 1953																			
Maximum, June 1-30, 1953	334	14	158	31	417		137	344	678	0.3	1.0	1,710	2.33	1,540	522	409	7.9	2,940	7.6
Minimum, Sept. 1-30	748	13	139	29	356		127	295	588	--	.8	1,480	2.01	2,990	466	362	7.2	2,570	7.4
Weighted average	220	13	152	29	388		130	322	636	--	1.0	1,610	2.19	956	498	392	7.6	2,770	--
Water year 1954																			
Maximum, Feb. 6-19, 1954	39.6	12	148	30	463		124	324	750	--	4.0	1,790	2.43	191	493	392	9.1	3,170	7.9
Minimum, July 1-31	985	16	114	20	259		111	250	410	--	1.0	1,120	1.52	2,980	366	276	5.9	1,960	7.6
Weighted average	1,052	14	118	18	289		113	245	460	--	1.3	1,200	1.63	3,410	368	276	6.6	2,100	--
Water year 1955																			
Maximum, May 1-31, 1955	699	14	148	22	379		118	333	595	--	1.0	1,550	2.11	2,930	460	364	7.7	2,620	7.6
Minimum, Sept. 26-30	41,280	15	124	16	253		115	286	378	--	1.0	1,130	1.54	125,900	376	282	5.7	1,850	7.5
Weighted average	1,120	13	133	18	291		114	301	448	--	1.0	1,260	1.71	3,810	406	312	6.3	2,120	--
Water year 1956																			
Maximum, Jan. 1-31, 1956	584	13	266	40	620		128	660	980	--	1.3	2,640	3.59	4,160	828	723	9.4	4,230	7.8
Minimum, Oct. 1-16, 1955	10,920	11	102	12	152		97	235	220	--	1.1	b806	1.10	23,760	304	224	3.8	1,310	7.3
Weighted average	983	11	156	21	292		107	379	445	--	1.2	1,370	1.86	3,640	476	388	5.8	2,220	--
Water year 1957																			
Maximum, Oct. 1-31, 1956	67.3	12	219	30	501		128	518	790	--	.8	2,130	2.90	387	670	565	8.4	3,430	7.6
Minimum, Apr. 26-30, May 1-10, 1957	38,920	7.4	45	5.4	60		74	73	91	--	1.8	b331	.45	34,780	135	74	2.3	573	7.1
Weighted average	4,145	8.0	61	7.2	79		85	108	119	--	1.8	443	.60	4,960	182	112	2.6	743	--
Water year 1958																			
Maximum, Apr. 1-30, 1958	459	8.0	126	18	389		125	253	615	--	1.5	1,470	2.00	1,820	388	286	8.6	2,570	7.4
Minimum, Dec. 1-31, 1957	845	7.6	109	17	208		117	216	335	--	.5	951	1.29	2,170	342	246	4.9	1,640	7.6
Weighted average	1,226	9.6	120	20	276		121	248	443	--	1.1	1,180	1.60	3,910	382	282	6.2	2,010	--
Water year 1959																			
Maximum, Sept. 1-30, 1959	208	12	134	22	327		125	294	515	--	1.8	1,370	1.86	769	425	322	6.9	2,310	7.4
Minimum, Mar. 1-31	68.1	10	104	19	229		114	195	382	--	1.0	996	1.35	183	338	244	5.4	1,780	7.7
Weighted average	458	9.2	115	21	264		123	235	425	--	.9	1,130	1.54	1,400	374	272	5.9	1,950	--
Water year 1960																			
Maximum, Jan. 1-21, 1960	296	9.4	188	32	577		118	416	940	--	.8	2,220	3.02	1,770	600	504	10	3,710	7.5
Minimum, Nov. 1-30, 1959	293	11	118	20	298		109	288	450	--	.5	1,240	1.69	981	376	287	6.7	2,130	8.0
Weighted average	749	10	129	22	345		114	288	546	--	.8	1,400	1.90	2,830	412	319	7.4	2,370	--
Water year 1961																			
Maximum, Feb. 18-30, 1961	108	14	278	57	1,020		137	736	1,600	--	1.0	3,770	5.13	1,100	928	816	15	6,030	7.8
Minimum, Oct. 28-31, 1960	4,515	12	134	18	275		98	296	438	--	.8	1,220	1.66	14,870	408	328	5.9	2,110	7.3
Weighted average	1,409	11	165	28	444		115	398	697	--	.9	1,800	2.45	6,850	526	432	8.4	3,010	--
Water year 1962																			
Maximum, Aug. 1-31, 1962	1,376	11	147	30	365		122	348	580	.5	3.0	1,540	2.09	5,720	490	390	7.2	2,590	7.4
Minimum, Sept. 21-30	1,869	12	77	14	162		93	176	242	--	1.2	764	1.04	3,850	250	174	4.5	1,250	7.3
Weighted average	1,138	11	133	25	319		115	313	500	--	1.3	1,360	1.85	4,180	434	341	6.7	2,290	7.2
Water year 1963																			
Maximum, Mar. 1-31, 1963	144	9.7	138	29	371		134	312	592	.4	.8	1,520	2.07	591	464	354	7.5	2,560	7.2
Minimum, Oct. 1-31, 1962	727	12	104	17	220		106	222	340	.4	1.5	966	1.31	1,900	322	235	5.3	1,680	7.3
Weighted average	867	11	126	25	314		124	286	496	.4	.6	1,320	1.80	3,090	417	315	6.7	2,230	7.2
Water year 1964																			
Maximum, Nov. 1-30, 1963	63.1	12	137	27	358		126	351	540	.4	.8	1,490	2.03	254	453	350	7.3	2,500	6.7
Minimum, July 1-31, 1964	803	11	125	25	313	6.5	113	304	510	.6	.8	1,350	1.84	2,930	415	322	6.7	2,300	7.3
Weighted average	231	11	129	27	323		123	307	515	.6	1.1	1,380	1.88	861	434	333	6.8	2,320	7.2

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
63. BRAZOS RIVER BELOW WHITNEY DAM NEAR WHITNEY																			
Water year 1948																			
Maximum, May 1-10, 1948	816	9.0	152	24	312		130	341	492	--	0.8	1,390	1.89	3,060	478	372	6.2	2,400	--
Minimum, Dec. 8, 12-18 1947	1,748	--	40	5.9	36		103	44	50	--	1.2	b256	.35	1,210	124	40	1.4	420	--
Water year 1949																			
Maximum, Oct. 1-10, 1948	249	13	161	34	345		114	391	562	--	.0	1,560	2.12	1,050	542	448	6.5	2,650	--
Minimum, May 17-22, 1949	24,760	10	43	5.7	21		134	22	30	--	2.2	b216	.29	14,400	131	21	.8	360	8.0
Weighted average	1,566	10	89	16	155		129	172	242	--	1.7	765	1.04	3,230	288	182	4.0	1,300	--
Water year 1950																			
Maximum, Oct. 11-24, 1949	1,121	9.5	126	22	282		112	282	448	--	.8	1,230	1.67	3,720	405	313	6.1	2,090	8.0
Minimum, May 9, 16-21, 1950	1,517	11	38	6.7	39		125	45	39	--	2.5	b242	.33	991	122	20	1.5	390	7.9
Weighted average	1,520	9.2	84	15	159		127	157	244	--	2.4	748	1.02	3,070	271	167	4.2	1,290	--
Water year 1951																			
Maximum, Sept. 21-30, 1951	299	7.8	133	29	344		121	288	565	--	3.0	1,430	1.94	1,150	451	352	7.0	2,500	7.4
Minimum, May 17-21, 25-31	748	9.4	44	8.1	62		102	59	94	--	1.5	b341	.46	689	144	60	2.3	616	7.7
Weighted average	840	8.2	119	23	276		127	260	437	--	2.6	1,190	1.62	2,700	392	288	6.1	2,060	--
Water year 1952																			
Maximum, Oct. 1-10, 1951	514	9.0	131	28	317		144	278	512	--	2.0	1,350	1.84	1,870	442	324	6.6	2,350	7.7
Minimum, June 11-20, 1952	94.1	9.0	30	5.2	27		100	22	35	--	2.2	b183	.25	46.5	96	14	1.2	328	7.8
Weighted average	348	8.3	92	18	211		146	167	332	--	2.1	912	1.24	857	304	184	5.2	1,590	--
Water year 1953																			
Maximum, Nov. 1-10, 1952	42.9	8.8	120	22	269		151	233	430	--	2.5	1,160	1.58	134	390	266	5.9	2,020	7.9
Minimum, June 21-30, 1953	808	8.8	71	11	112		143	93	178	--	1.2	b547	.74	1,190	222	105	3.3	985	8.0
Weighted average	141	9.2	76	12	137		154	112	209	--	1.8	651	.89	248	239	113	3.8	1,140	--
Water year 1954																			
Maximum, Nov. 19-20, 22-23, 1953	76.8	13	124	17	291		119	235	475	--	1.5	1,220	1.66	253	380	282	6.5	2,140	8.0
Minimum, Oct. 1-13	56.2	14	91	16	185		150	144	298	--	2.0	824	1.12	125	293	170	4.7	1,440	7.8
Weighted average	912	9.6	107	18	242		131	198	392	--	1.8	1,040	1.41	2,560	341	234	5.7	1,850	--
Water year 1955																			
Maximum, Apr. 1-30, 1955	78.3	8.0	120	18	289		130	248	450	--	2.8	1,200	1.63	254	374	267	6.5	2,080	7.7
Minimum, June 17-30	4,408	9.0	88	14	190		115	168	298	--	2.0	b850	1.16	10,120	277	183	5.0	1,470	7.8
Weighted average	997	10	104	16	238		124	205	374	--	1.8	1,030	1.40	2,770	326	224	5.7	1,760	--
Water year 1956																			
Maximum, Sept. 1-30, 1956	609	10	137	22	289		115	345	430	--	1.2	1,290	1.75	2,120	432	338	6.1	2,160	7.8
Minimum, Nov. 1-30, 1955	411	8.8	92	14	159		107	196	242	--	1.0	766	1.04	850	287	200	4.1	1,340	7.4
Weighted average	1,571	10	116	16	220		116	255	333	--	1.4	1,010	1.37	4,280	356	260	5.1	1,710	--
Water year 1957																			
Maximum, Oct. 1-31, 1956	639	13	147	26	303		115	361	470	--	1.0	1,380	1.88	2,380	474	380	6.1	2,230	7.9
Minimum, June 11-20, 1957	34,260	12	51	5.6	53		104	67	78	--	1.5	b337	.46	31,170	150	65	1.9	548	7.7
Weighted average	6,213	11	62	7.9	82		106	96	126	--	1.5	459	.62	7,700	187	100	2.6	766	--
Water year 1958																			
Maximum, Sept. 1-30, 1958	564	11	88	14	181		136	147	288	--	1.5	876	1.19	1,330	277	166	4.8	1,390	8.2
Minimum, May 12-31	4,512	13	58	7.4	61		141	61	89	--	3.2	362	.49	4,410	175	60	2.0	621	8.0
Weighted average	2,322	11	80	12	110		146	122	170	--	1.9	604	.82	3,790	249	130	3.0	997	--
Water year 1959																			
Maximum, Feb. 1-28, 1959	596	11	93	18	196		114	176	322	--	.5	b947	1.29	1,520	306	212	4.9	1,560	7.6
Minimum, Aug. 1-31	711	11	87	16	177		137	138	290	--	2.2	b845	1.15	1,620	283	170	4.6	1,400	7.6
Weighted average	681	10	93	17	191		134	165	309	--	1.0	893	1.21	1,640	302	192	4.8	1,500	--

See footnotes at end of table.

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
63. BRAZOS RIVER BELOW WHITNEY DAM NEAR WHITNEY--Continued																			
Water year 1960																			
Maximum, Sept. 1-30, 1960	580	11	84	17	176		141	147	278	--	1.0	831	1.13	1,300	280	164	4.6	1,380	7.6
Minimum, Mar. 1-24	968	9.6	79	13	107		169	106	165	--	2.0	589	.80	1,540	250	112	2.9	977	7.7
Weighted average	1,882	10	79	14	147		136	130	229	--	1.1	705	.96	3,580	254	143	4.0	1,170	--
Water year 1961																			
Maximum, Sept. 1-30, 1961	749	12	136	25	341		111	316	540	0.5	.8	1,430	1.94	2,890	442	352	7.1	2,410	7.4
Minimum, Apr. 1-18	893	10	92	13	162		152	149	250	--	2.8	783	1.06	1,890	283	158	4.2	1,330	7.4
Weighted average	2,054	10	106	18	237		129	213	373	--	1.2	1,040	1.41	5,770	338	233	5.6	1,780	--
Water year 1962																			
Maximum, Oct. 1-31, 1961	1,786	10	136	24	343		110	320	538	.4	.5	1,430	1.94	6,900	438	348	7.1	2,410	7.2
Minimum, Aug. 5-31, 1962	2,876	11	85	16	179		110	176	278	--	4.0	830	1.13	6,450	278	188	4.7	1,400	7.3
Weighted average	1,737	9.9	104	19	234		115	227	364	--	1.7	1,030	1.40	4,830	339	244	5.5	1,750	7.3
Water year 1963																			
Maximum, Sept. 1-30, 1963	580	8.6	106	22	247		140	216	390	.4	1.5	1,060	1.44	1,660	355	240	5.7	1,860	6.9
Minimum, Jan. 1-31	839	8.8	87	16	169		128	168	262	.3	.5	b810	1.10	1,830	283	178	4.4	1,350	7.6
Weighted average	1,215	7.9	95	18	197		129	189	309	.3	.8	896	1.22	2,940	310	204	4.9	1,520	7.1
Water year 1964																			
Maximum, Jan. 1-31, 1964	212	6.4	112	26	282	6.4	126	264	460	.1	.8	1,220	1.66	698	386	283	6.2	2,120	7.6
Minimum, July 1-31	730	5.3	96	20	214	5.1	133	196	342	.4	.5	944	1.28	1,860	322	213	5.2	1,660	7.1
Weighted average	434	6.1	104	25	246		130	226	396	.4	1.1	1,070	1.46	1,250	361	254	5.6	1,870	7.1
74. LEON RIVER NEAR EASTLAND																			
Water year 1951																			
Maximum, Feb. 1-10, 1951		4.1	64	10	37		206	39	50		0.0	b316	0.43		200	32	1.1	555	7.9
Minimum, July 24-26		9.2	29	4.7	12		99	9.8	18		1.8	b152	.21		92	11	.5	244	7.2
Water year 1952																			
Maximum, May 17-20, 1952		8.8	52	6.6	30		124	21	70		1.3	b291	.40		157	55	1.0	466	7.4
Minimum, Sept. 18-19, 22-24		9.0	26	3.6	11		81	8.6	18		3.0	119	.16		80	13	.5	211	7.5
Water year 1953																			
Maximum, Apr. 6, 8-9, 1953		6.6	51	6.1	29		164	13	47		1.0	b259	.35		152	18	1.0	437	7.5
Minimum, Nov. 24-26, 28-29, 1952		5.1	21	3.6	2.7		69	4.4	4.8		2.8	77	.10		67	11	.1	139	7.3
85. LAMPASAS RIVER AT YOUNGSPORT																			
Water year 1962																			
Maximum, Sept. 1-7, 1962	7.8	15	58	38	178		176	18	370	0.4	2.2	767	1.04	16.2	301	157	4.5	1,450	7.7
Minimum, June 27	263	--	--	--	--		120	8.4	23	--	--	156	.21	111	110	12	--	278	7.5
Weighted average	102	11	45	22	55		194	22	98	--	2.1	354	.48	97.5	202	43	1.8	646	7.5
Water year 1963																			
Maximum, Nov. 15-30, 1962	54.5	5.5	68	32	147		241	28	278	--	2.2	b687	.93	101	301	104	3.7	1,260	7.6
Minimum, Oct. 9-13	1,687	11	37	8.2	22		131	11	38	--	2.5	194	.26	884	126	19	.9	351	7.2
Weighted average	57.4	8.7	48	19	64		180	20	119	--	1.6	373	.51	57.8	197	50	1.9	682	7.3
Water year 1964																			
Maximum, Jan. 1-28, 1964	15.8	3.0	84	39	205	7.4	262	27	422	.3	.4	917	1.25	39.1	370	156	4.6	1,760	7.8
Minimum, Sept. 21-25	790	7.8	38	5.2	7.0	2.9	136	6.0	11	--	1.5	146	.20	311	116	5	.3	266	6.9
Weighted average	86.5	7.4	48	15	45		175	15	84	--	1.2	301	.41	70.3	179	36	1.4	568	7.3

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
89. LITTLE RIVER AT CAMERON																			
Water year 1960																			
Maximum, Sept. 29, 1960	375	--	--	--	--		194	--	203	--	--	b607	0.83	615	236	77	--	1,000	7.5
Minimum, June 25-26	630	13	--	--	10		120	6.8	4.0	0.5	2.2	b130	.18	221	92	0	0.5	191	7.1
Weighted average	h2,139	12	66	12	27		226	33	34	.4	7.5	311	.42	1,800	214	29	.8	520	--
Water year 1961																			
Maximum, May 16-31, 1961	665	14	73	19	39		262	40	56	.3	11	b391	.53	702	260	46	1.1	652	7.3
Minimum, June 17-19	11,780	13	38	4.1	14		108	26	15	.5	4.8	168	.23	5,340	112	23	.6	281	7.1
Weighted average	4,154	12	59	11	22		198	31	27	.3	7.1	279	.38	3,130	192	30	.7	458	--
Water year 1962																			
Maximum, Jan. 16-31, 1962	608	7.3	80	15	47		261	52	61	.4	10	401	.55	658	261	47	1.3	693	7.8
Minimum, June 27-30	2,070	16	44	5.0	19		139	24	22	--	2.8	201	.29	736	145	25	.6	369	6.9
Weighted average	854	12	58	12	32		195	37	43	--	4.8	302	.41	696	194	34	1.0	513	7.4
Water year 1963																			
Maximum, Sept. 21-30, 1963	39.8	10	63	22	108		196	41	198	--	.8	539	.73	57.9	248	87	3.0	1,020	7.0
Minimum, Dec. 21-22, 1962	3,835	13	36	4.3	18		100	36	17	--	2.8	176	.24	1,820	108	26	.8	291	7.4
Weighted average	475	9.9	57	11	35		181	44	46	--	4.1	301	.41	386	187	39	1.1	516	7.3
Water year 1964																			
Maximum, Jan. 16-31, 1964	101	1.4	79	19	77		278	57	104	--	9.6	484	.66	132	275	47	2.0	877	7.9
Minimum, Sept. 23-24	3,835	11	40	3.0	4.8	3.0	136	9.2	4.3	--	1.5	144	.20	1,480	112	1	.2	242	7.8
Weighted average	573	7.7	54	9.8	29		182	29	40	--	2.3	263	.36	407	176	26	.9	471	7.2
90. BRAZOS RIVER AT STATE HIGHWAY 21, NEAR BRYAN																			
Water year 1962																			
Maximum, June 18-27, 1962	4,563	17	97	19	197		131	193	310		2.5	b952	1.29	11,730	320	212	4.8	1,590	7.6
Minimum, June 12-15	6,002	--	--	--	--		128	56	22		--	234	.32	3,790	121	16	--	345	8.1
Weighted average	3,538	12	80	14	131		152	134	196		2.2	669	.90	6,390	258	134	3.6	1,110	7.5
Water year 1963																			
Maximum, Apr. 11, 1963	1,040	18	146	30	244		478	303	220		1.2	1,200	1.63	3,370	488	96	4.8	1,840	7.5
Minimum, Nov. 28-29, 1962	11,850	--	--	--	--		100	35	29		--	186	.25	5,950	110	28	--	331	7.0
Weighted average	1,896	7.9	84	16	143		153	146	217		1.3	703	.96	3,600	274	150	3.8	1,200	7.1
Water year 1964																			
Maximum, Oct. 1-25, 1963	744	6.8	140	5.5	251	6.2	150	234	405	0.3	.8	1,120	1.52	2,250	372	249	5.6	1,930	6.9
Minimum, Sept. 25-30, 1964	8,659	9.2	48	4.4	17		158	28	10		1.8	196	.27	4,580	138	8	.6	330	8.1
Weighted average	1,334	7.2	71	12	97		189	96	143		1.4	511	.69	1,840	229	90	2.6	902	7.3
93. YEGUA CREEK NEAR SOMERVILLE																			
Water year 1962																			
Maximum, Apr. 1-15, 1962	43.9	21	116	30	118		129	280	192	0.4	0.5	b884	1.20	105	413	308	2.5	1,310	7.1
Minimum, June 29-30	561	--	--	--	--		32	26	19	--	--	111	.15	168	44	18	--	176	6.8
Weighted average	131	18	43	11	46		67	98	65	--	.9	319	.43	113	150	96	1.6	508	6.8
Water year 1963																			
Maximum, Mar. 5-31, 1963	51.0	19	114	29	110		126	280	175	--	.5	858	1.17	118	404	300	2.4	1,250	7.1
Minimum, Nov. 27-30, 1962	2,762	--	--	--	--		35	16	13	--	--	82	--	--	40	11	--	136	6.7
Weighted average	234	13	27	6.5	26		44	57	39	--	.6	194	.26	123	93	57	1.2	316	6.4
Water year 1964																			
Maximum, Apr. 1-25, 1964	9.7	20	80	18	71	7.4	122	170	112	.3	.8	540	.73	14.1	274	174	1.9	888	6.8
Minimum, Jan. 17	112	--	--	--	--		16	19	6.3	--	--	63	.09	19.1	26	13	--	102	7.0
Weighted average	41.4	15	22	4.7	23		48	45	26	--	1.8	162	.22	18.1	75	35	1.1	267	6.9

See footnotes at end of table.

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated) Parts per million	Dissolved solids Tons per acre-foot	Dissolved solids Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
95. NAVASOTA RIVER NEAR EASTERLY																			
Water year 1942																			
Dec. 5-10, 1941	4.8		48	14	423		70	37	710		--	1,270	1.73		178			2,400	
Dec. 11-14, 16-18	40.7		--	--	190		83	37	328		--	b711	.97		156			1,290	
Jan. 6-7, 1942	15.5		56	17	428		110	47	710		0.0	1,310	1.78		210			2,540	
Jan. 8-10	13.7		43	13	253		122	46	400		.0	815	1.11		161			1,560	
Sept. 11-20	904		34	6.1	38		110	20	58		.5	211	.29		110			415	7.8
Water year 1943																			
Oct. 21-23, 1942	165		40	6.2	34		143	28	37		1.8	217	.30		125			531	
Oct. 24-27	44.5		64	8.8	159		158	29	270		.5	609	.83		196			1,180	
Oct. 28-31	24.2		67	11	356		135	31	598		.2	1,130	1.54		212			2,160	
Dec. 1-10	8.9		39	7.7	69		107	46	102		.0	316	.43		129			610	
Dec. 27-28, 30-31	2,390		21	5.1	35		72	16	52		.8	165	.22		73			327	
96. NAVASOTA RIVER NEAR BRYAN																			
Water year 1959																			
Maximum, Sept. 20-25, 1959	17.8	13	66	15	263		87	44	480		3.8	928	1.26	44.6	226	154	7.6	1,760	7.3
Minimum, Feb. 15	3,400	8.2	8.4	1.5	13		25	14	14		1.2	72	.10	661	27	6	1.1	114	7.5
Weighted average	529	12	21	4.9	52		55	25	80		1.1	226	.31	323	73	28	2.6	414	--
Water year 1960																			
Maximum, June 25, 1960	24.0	--	--	--	--		119	--	578		--	1,130	1.54	73.2	355	258	--	2,110	7.2
Minimum, Dec. 18-21, 1959	6,618	14	9.0	2.2	20		34	14	23		.5	100	.14	1,790	32	4	1.5	154	6.5
Weighted average	532	13	24	6.0	54		59	33	85		.7	248	.34	356	85	36	2.5	438	--
Water year 1961																			
Maximum, Oct. 25-28, 1960	318	12	56	13	458		69	24	785		1.0	1,380	1.88	1,180	193	136	14	2,610	7.0
Minimum, Nov. 22	5,330	--	--	--	--		21	11	9.0		--	52	.07	748	22	5	--	89	6.5
Weighted average	1,373	10	15	3.6	30		41	19	44		.7	143	.19	530	52	19	1.8	256	--
Water year 1962																			
Maximum, Dec. 1-4, 1961	124	12	71	16	606		115	24	1,020		2.2	1,810	2.46	606	243	149	17	3,370	7.0
Minimum, June 30, 1962	209	--	--	--	--		46	18	34		--	132	.18	74.5	52	14	--	254	6.8
Weighted average	289	14	29	7.8	76		63	40	125		1.0	328	.45	256	104	53	3.1	600	6.8
Water year 1963																			
Maximum, Apr. 12-21, 1963	40.1	14	72	19	440		68	54	780		1.8	1,410	1.92	153	258	202	12	2,670	6.7
Minimum, June 20-22	210	5.3	7.5	1.8	11		18	15	13		1.8	64	.09	36.3	26	11	.9	113	6.4
Weighted average	48.7	14	24	7.2	66		40	43	110		1.0	288	.39	37.9	90	57	4.0	516	6.6
Water year 1964																			
Maximum, Feb. 8-11, 1964	54.8	17	61	17	543		47	22	950		.8	1,630	2.22	241	222	184	16	3,120	7.2
Minimum, Sept. 17-18	1,050	6.8	5.5	1.3	8.1		20	7.6	7.7		1.8	49	.07	139	19	3	.8	79	6.7
Weighted average	52.0	13	20	6.0	86		39	30	141		1.9	317	.43	44.5	77	45	5.1	595	6.7
97. BRAZOS RIVER AT RICHMOND																			
Water year 1946																			
Maximum, Dec. 3-4, 1945	6,610	--	63	12	294		172	46	465	--	1.5	966	1.31	17,200	206	66	8.9	1,840	--
Minimum, May 21-31, 1946	32,590	--	39	5.3	15		124	19	21	--	1.8	b195	.27	17,200	119	18	.6	304	8.3
Weighted average	10,220	--	51	8.6	37		155	39	53	--	1.8	299	.41	8,250	163	36	1.3	487	--
Water year 1947																			
Maximum, Nov. 1-4, 1946	4,128	--	114	20	246		155	211	392	--	1.0	1,060	1.44	11,800	366	240	5.6	1,870	--
Minimum, Aug. 27-31, 1947	31,140	--	29	5.9	10		92	16	18	--	1.0	b133	.18	11,200	97	21	.4	228	--
Weighted average	8,765	--	63	11	63		152	70	100	--	1.9	425	.58	10,100	202	78	1.9	691	--

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
97. BRAZOS RIVER AT RICHMOND--Continued																			
Water year 1948																			
Maximum, Sept. 1-10, 1948	1,334	11	134	27	271		147	294	432	--	.2	1,240	1.69	4,470	446	325	5.6	2,120	--
Minimum, Nov. 21-26, 1947	2,538	--	37	7.1	38		130	31	45	--	1.2	b245	.33	1,680	122	15	1.5	400	--
Weighted average	2,687	--	65	11	82		162	84	118	--	1.7	479	.65	3,480	207	74	2.5	791	--
Water year 1949																			
Maximum, Oct. 11-20, 1948	621	14	126	29	220		220	235	345	--	.8	1,080	1.47	1,810	434	253	4.6	1,860	--
Minimum, Apr. 23, 25-27, 29-30, 1949	33,050	11	34	5.8	21		120	24	20	--	2.8	b184	.25	16,400	109	10	.9	289	--
Weighted average	4,645	12	59	10	70		141	76	103	--	2.1	423	.57	5,310	188	72	2.2	703	--
Water year 1950																			
Maximum, Aug. 21-31, 1950	2,033	13	124	21	260		144	254	408	0.4	3.5	1,150	1.56	6,310	396	278	5.7	2,010	7.4
Minimum, Feb. 20-28	13,710	12	37	4.4	28		112	21	40	.3	.8	b213	.29	7,880	110	19	1.2	357	7.4
Weighted average	5,783	13	53	8.1	60		136	58	87	.3	1.3	368	.50	5,750	166	54	2.0	613	--
Water year 1951																			
Maximum, Sept. 1-10, 1951	564	11	122	29	341	1.6	120	291	538	.3	2.0	1,400	1.90	2,130	424	325	7.2	2,440	7.5
Minimum, June 21-25	5,692	17	40	7.0	25	--	120	34	36	.3	3.5	b222	.30	3,410	129	30	1.0	386	8.0
Weighted average	1,418	13	80	16	139	2.4	160	134	214	.3	2.2	696	.95	2,660	266	134	3.7	1,180	--
Water year 1952																			
Maximum, Oct. 21-31, 1951	606	15	108	23	233	.8	196	191	369	.3	1.5	1,040	1.41	1,700	364	204	5.3	1,790	7.5
Minimum, June 1-10, 1952	7,734	21	37	4.5	13	1.6	123	16	16	.2	4.0	b187	.25	3,900	111	10	.6	290	8.0
Weighted average	1,820	18	51	8.8	60	2.8	143	54	85	.3	3.5	370	.50	1,820	163	46	2.0	608	--
Water year 1953																			
Maximum, Oct. 1-10, 1952	142	17	83	19	138	5.2	216	113	214	.2	1.5	b739	1.01	283	285	108	3.6	1,210	8.2
Minimum, Jan. 1-10, 1953	9,914	11	31	3.7	17	3.2	99	21	20	.5	3.2	160	.22	4,280	93	11	.8	276	7.6
Weighted average	4,105	13	36	5.7	23	3.8	115	25	31	.3	3.6	215	.29	2,380	114	20	.9	342	--
Water year 1954																			
Maximum, Aug. 21-31, 1954	800	13	100	19	240	6.7	143	194	372	.2	1.8	1,020	1.39	2,200	328	210	5.7	1,810	7.8
Minimum, Oct. 29-31, 1953	23,870	14	32	3.7	14	3.3	111	18	13	.4	4.8	b168	.23	10,830	95	4	.6	244	8.0
Weighted average	2,727	17	55	9.1	83	4.1	124	72	127	.5	2.5	453	.62	3,340	174	73	2.7	754	--
Water year 1955																			
Maximum, May 29-31, June 1, 9-11, 1955	9,837	12	105	15	225	6.9	124	200	370	.4	2.2	1,050	1.43	27,890	324	222	5.4	1,710	7.9
Minimum, Apr. 14-21	9,624	12	31	4.5	16	4.2	105	18	18	.6	2.5	b161	.22	4,180	95	9	.7	267	7.6
Weighted average	2,168	13	60	8.9	95	4.9	132	83	145	.4	2.6	498	.68	2,920	186	78	3.0	842	--
Water year 1956																			
Maximum, Sept. 21-30, 1956	741	12	127	21	254	7.0	127	300	400	.4	1.5	1,190	1.62	2,380	404	300	5.5	1,960	7.6
Minimum, Feb. 14-19	3,212	9.6	41	4.8	53	4.3	104	45	77	.5	2.2	b318	.43	2,760	122	37	2.1	519	7.6
Weighted average	2,158	12	95	14	166	5.8	136	185	260	.5	1.5	834	1.13	4,860	294	183	4.2	1,380	--
Water year 1957																			
Maximum, Oct 1-10, 1956	593	12	130	22	275		136	307	412	--	1.0	1,230	1.67	1,970	415	304	5.9	2,020	7.9
Minimum, Apr. 24-30, 1957	61,290	8.2	35	4.1	14	3.2	110	23	16	.5	3.0	161	.22	26,640	104	14	.6	280	7.9
Weighted average	15,290	13	50	6.9	46		124	54	65	--	2.5	317	.43	13,090	154	52	1.6	519	--
Water year 1958																			
Maximum, Aug. 21-31, 1958	2,930	13	76	17	122	4.6	183	113	183	--	.5	b645	.88	5,100	260	110	3.3	1,070	7.8
Minimum, Oct. 16-22, 1957	74,000	7.8	31	4.0	11	3.2	99	21	13	--	2.0	142	.19	28,370	94	13	.5	246	8.0
Weighted average	11,870	11	54	7.7	37	3.8	142	50	57	--	4.2	303	.41	9,710	166	50	1.2	508	--

See footnotes at end of table.

Table 3.--Summary of chemical analyses at daily stations on streams in the Brazos River basin, Texas.--Continued

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
97. BRAZOS RIVER AT RICHMOND--Continued																			
Water year 1959																			
Maximum, Apr. 1-7, 1959	1,320	9.2	84	19	124	5.1	188	125	198	0.3	0.5	b718	0.98	2,560	288	134	3.2	1,160	8.1
Minimum, Apr. 11-22	26,950	11	35	4.6	16	4.0	108	23	22	--	2.0	171	.23	12,440	106	18	.7	298	7.6
Weighted average	4,450	12	49	8.0	49	4.5	130	51	74	--	1.9	323	.44	3,880	156	49	1.7	553	--
Water year 1960																			
Maximum, Sept. 18-30, 1960	954	17	81	18	134		211	110	198	--	.8	b694	.94	1,790	276	103	3.5	1,140	7.6
Minimum, June 26-27, 29-30	32,180	11	29	3.9	17		100	16	18	--	1.2	b155	.21	13,470	88	6	.8	245	7.4
Weighted average	8,869	12	54	9.0	48		151	50	67	--	3.2	331	.45	7,930	172	48	1.6	552	--
Water year 1961																			
Maximum, Aug. 18-31, 1961	2,813	14	92	18	160		187	147	244	.4	1.5	b837	1.14	6,360	304	150	4.0	1,340	7.7
Minimum, Nov. 24-30, 1960	25,910	12	30	4.0	20		93	22	24	--	1.2	159	.22	11,120	92	16	.9	268	7.4
Weighted average	16,130	13	49	8.0	44		132	49	64	--	2.4	312	.42	13,590	156	48	1.5	519	--
Water year 1962																			
Maximum, Aug. 1-10, 1962	6,728	16	104	18	230		130	224	348	.5	1.0	1,010	1.37	18,350	334	227	5.5	1,740	7.5
Minimum, June 18-21, 23	5,284	7.9	41	5.2	27		118	38	32	--	1.2	210	.29	3,000	124	28	1.1	377	7.9
Weighted average	4,508	13	71	12	106		153	106	156	--	1.5	551	.75	6,710	229	103	3.0	941	7.3
Water year 1963																			
Maximum, Aug. 1-19, 1963	700	14	94	22	201		171	178	308	.4	1.5	903	1.23	1,710	325	185	4.8	1,580	7.0
Minimum, Dec. 26, 1962	9,120	--	--	--	--		98	21	24	--	--	159	.22	3,980	97	16	--	257	7.0
Weighted average	2,759	11	66	12	97		140	100	145	--	1.3	513	.70	3,820	215	100	2.8	871	7.2
Water year 1964																			
Maximum, Oct. 8-29, 1963	817	9.7	107	25	233		178	210	362	--	2.0	1,040	1.41	2,290	370	224	5.3	1,830	7.0
Minimum, Sept. 28-30, 1964	9,390	18	33	4.5	12		110	22	8.7	--	1.8	154	.21	3,900	101	11	.5	272	7.1
Weighted average	1,715	11	58	11	77		151	74	111	--	1.9	419	.57	1,940	191	67	2.2	742	7.2
103. BRAZOS RIVER AT HARRIS RESERVOIR, NEAR ANGLETON																			
Water year 1962																			
Maximum, May 2, 1962		15	89	12	583		138	133	910	0.4	4.2	1,810	2.46		272	158	15	3,290	7.5
Minimum, Feb. 2-12		13	49	8.2	52		122	59	74	.3	2.2	b330	.45		156	56	1.8	552	7.2
Water year 1963																			
Maximum, Aug. 4-15, 1963		16	93	23	181		201	148	282	.4	2.2	845	1.15		326	162	4.4	1,500	7.3
Minimum, Jan. 1-6		13	33	4.6	23		94	26	33	.3	1.0	180	.24		101	24	1.0	318	7.0
Water year 1964																			
Maximum, Feb. 5-7, 1964		15	77	9.7	486		122	130	745	.2	2.2	1,530	2.08		232	132	14	2,760	7.5
Minimum, Mar. 23-31		12	43	6.5	39		120	46	48	.3	4.2	258	.35		134	36	1.5	454	7.8
105. BRAZOS RIVER AT BRAZORIA RESERVOIR, NEAR BRAZORIA																			
Water year 1962																			
Maximum, Aug. 1-3, 1962		16	164	328	2,970		186	748	5,170	--	--	9,490	13		1,760	1,610	31	15,300	7.4
Minimum, Feb. 2-12		12	48	8.1	52		120	60	73	0.3	2.0	b328	.45		154	55	1.8	546	7.4
Water year 1963																			
Maximum, Sept. 1-6, 9-13, 1963		9.4	286	750	6,540		143	1,620	11,500	--	--	20,800	28.7		3,800	3,680	46	30,100	7.1
Minimum, Jan. 1-7		12	32	4.0	25		86	27	35	.8	1.2	179	.26		96	26	1.1	309	7.6
Water year 1964																			
Maximum, Aug. 1-14, 17-21, 24-28, 1964		5.7	184	328	3,400		142	817	5,840	--	--	10,600	14.5		1,810	1,690	--	17,000	6.9
Minimum, Mar. 24-31		12	42	7.6	39		124	47	47	.4	4.0	260	.35		136	34	1.5	460	7.6

a Includes days of less than 0.05 cubic feet per second discharge.
b Residue at 180°C.
c Discharge at time of sampling.
d Mean discharge for period of record; station started October 12, 1962.
e Mean discharge for period of record; station started February 1, 1962.
f Mean discharge for period of record; station started November 1, 1962.
g Represents 78 percent of flow for water year October 1959 to September 1960.
h Represents 71 percent of flow for water year October 1959 to September 1960.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1. DOUBLE MOUNTAIN FORK BRAZOS RIVER AT JUSTICEBURG																					
Dec. 22, 1964-----	b0.03	7.8		362	150	4,180		252	667	6,880	--	--		12,400	17.0		1,520	1,310	--	18,400	7.7
Jan. 29, 1965-----	b.02	5.8		411	198	5,630		250	887	9,180	--	--		16,400	22.5		1,840	1,640	--	23,200	7.6
May 14-----------	193	13		40	7.5	77		236	43	39	1.2	2.0		339	.46		131	0	2.9	585	7.0
May 18-----------	4.51	13		37	17	510		152	148	700	1.4	1.5		1,500	2.04		162	38	17	2,740	7.6
June 11-----------	220	12		16	4.4	119		248	44	45	1.0	2.0		365	.50		58	0	6.8	623	7.4
June 22-----------	94.3	15		43	11	135		299	87	74	2.1	.2		514	.70		152	0	4.8	835	7.0
2. NORTH FORK DOUBLE MOUNTAIN FORK BRAZOS RIVER, 7.5 MILES NORTHWEST OF SLATON																					
Mar. 4, 1952------	2.35	2.6		63	132	250		390	421	335	5.0	2.0		1,400	1.90		700	380		2,320	8.2
Apr. 3------------	1.88	10		84	142	321		391	503	458	--	1.0		1,710	2.33		794	472		2,940	8.5
Apr. 30-----------	22.5	7.4		40	131	248		341	430	318	--	2.0		1,340	1.82		638	358		2,230	8.6
Aug. 5------------	.18	43		40	124	247		358	371	328	--	4.8		1,330	1.81		610	316		2,220	8.5
Sept. 3-----------	.29	38		42	123	245		393	352	320	--	5.8		1,320	1.80		611	289		2,170	8.4
Oct. 6------------	.50	29		62	127	248		451	375	320	--	5.6		1,390	1.89		676	306		2,240	8.4
Nov. 5------------	.61	30		62	128	247		458	373	318	--	5.8		1,390	1.89		681	306		2,230	8.4
Dec. 2------------	3.20	12		42	144	282		380	475	355	--	4.8		1,500	2.04		697	385		2,400	8.5
Mar. 4, 1953------	4.37	6.0		48	153	290		411	494	370	--	9.0		1,570	2.14		749	412		2,560	8.6
Apr. 14-----------	2.02	7.7		50	158	296		419	516	375	--	11		1,620	2.20		774	430		2,620	8.5
June 10-----------	.25	--		--	129	266		507	430	372	--	4.5		1,590	2.16		812	396		2,570	8.4
Aug. 3------------	.21	19		52	189	371		454	645	460	6.4	5.8		1,970	2.68		906	534		3,040	8.5
Sept. 10----------	.13	36		58	147	287		507	371	388	5.2	12		1,550	2.11		749	333		2,490	8.4
Nov. 30-----------	1.96	14		--	--	--		--	324	238	--	1.5		--	--		--	--		1,850	--
Jan. 21, 1954-----	1.83	8.6		47	114	227		355	372	282	--	4.8		1,230	1.67		586	294		2,050	8.4
Mar. 18-----------	1.88	6.8		49	138	279		405	483	325	--	3.5		1,480	2.01		690	358		2,350	8.5
3. LAKE BUFFALO SPRINGS NEAR LUBBOCK																					
Nov. 19, 1965-----		8.5		48	77	173	28	319	285	208	3.2	3.8		992			436	174	3.6	1,670	7.3
4. ROUGH CREEK AT MOUTH NEAR ROTAN																					
Aug. 19, 1959-----	b0.2					31	6.3	95	935	36							1,000	922	--	1,730	7.4
Jan. 20, 1960-----	.08					--		--	1,140	56							--	--	--	2,020	--
Aug. 9, 1961------	.49					73		108	1,010	119							1,150	1,060	--	2,080	7.6
7. DOUBLE MOUNTAIN FORK BRAZOS RIVER NEAR RULE																					
May 11, 1964------	6.08	8.6		415	35	188		67	1,090	282	0.4	0.2		2,050	2.79		1,180	1,120	2.4	2,640	6.2
Aug. 20-----------	11.3	9.6		425	46	212		84	1,040	395	.6	.8		2,170	2.95		1,250	1,180	2.6	2,880	6.7
Sept. 16----------	196	12		93	10	22		214	104	25	.4	.2		372	.51		273	98	.6	594	7.1
Dec. 21-----------	b.15	3.1		390	87	633		245	762	1,210	--	9.5		3,210	4.37		1,330	1,130	7.5	4,860	7.2
8. TANK CREEK NEAR RULE																					
Mar. 25, 1964-----	b0.04	0.0		290	135	402		244	1,330	400	--	6.6		2,680	3.64		1,280	1,080	4.9	3,470	7.3
Apr. 13-----------	b.02	.1		285	124	374		188	1,290	380	--	2.2		2,550	3.47		1,220	1,070	4.6	3,410	7.4
May 11------------	b.01	6.7		265	95	176		158	974	205	0.6	.2		1,800	2.45		1,050	922	2.4	2,380	7.6
Sept. 16----------	93.1	8.6		87	14	22		166	138	30	.2	.5		382	.52		274	138	.6	614	6.9

See footnotes at end of table.

Table 4. Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
9. McDONALD CREEK AT MOUTH NEAR POST																					
Dec. 17, 1959-----	12.7					1,160		172	238	1,730							320	179		5,850	7.9
Jan. 20, 1960-----	.22								1,670	13,200							--			33,800	
Feb. 18-----------	b.01								1,910	13,600							--			35,000	
June 22, 1961-----	1.90					2,530			59	3,960							702			12,300	
10. RUNNING WATER DRAW AT PLAINVIEW																					
June 15, 1964-----	23.7	14		33	5.3	2.7	6.9	135	0.8	2.3	0.8	0.2		132	0.18		104	0	0.1	225	6.8
June 16-----------	183	16		54	5.9	12		212	4.4	3.2	.7	.2		200	.27		159	0	.4	333	6.7
June 19-----------	1.41	16		33	5.8	2.8	7.8	140	.8	1.5	.7	.2		138	.19		106	0	.1	231	6.8
11. WHITE RIVER NEAR CROSBYTON																					
Oct. 4, 1950------	6.29	30		50	35	52		374	48	18	--	1.0		c447	0.16		269	0	--	698	8.2
Jan. 19, 1951-----	4.46	36		44	63	105		528	94	40	--	.5		642	.87		359	0	--	1,060	8.2
Jan. 20, 1954-----	2.17	46		--	--	--		--	63	28	--	.5		--	--		--	--	--	879	--
Jan. 18, 1955-----	1.98	48		--	43	--		--	64	23	--	1.0		--	--		--	--	--	812	--
Jan. 19, 1956-----	2.44	41		49	47	78		447	77	27	--	.2		539	.73		315	0	1.9	914	8.2
June 18, 1959-----	1.25	--		--	--	57	11	--	54	22	--	--		--	--		--	--	--	613	--
Mar. 15, 1960-----	.47	--		--	--	--		446	60	24	--	--		--	--		274	0	--	782	--
June 22-----------	3.62	--		--	--	22	8.5	203	19	8	--	--		--	--		137	0	--	358	8.0
Sept. 21----------	.65	--		--	--	62	11	366	50	22	--	--		--	--		234	0	--	698	--
Nov. 6, 1961------	1.60	34		33	33	59		321	45	20	3.1	.0		385	.52		218	0	1.7	622	7.7
Aug. 9, 1962------	.61	35		35	32	68		350	40	20	3.6	.0		406	.55		219	0	2.0	659	7.2
May 8, 1963-------	.92	33		38	41	63	11	408	48	22	4.0	.2		461	.63		264	0	1.7	738	7.7
Aug. 8------------	.36	35		39	36	71		384	45	20	4.1	.0		439	.60		246	0	2.0	702	7.2
12. WHITE RIVER RESERVOIR NEAR SPUR																					
June 3, 1964------		2.5		25	17	163		268	72	132	2.4	0.5		546	0.74		132	0	6.2	956	8.0
Oct. 28-----------		1.6		14	15	204		272	61	158	3.0	.5		611	.83		96	0	9.1	1,060	7.6
May 12, 1965------		7.6		22	12	179		264	74	137	2.6	1.2		565	.77		104	0	7.6	994	7.4
13. RED MUD CREEK AT MOUTH NEAR CLAIREMONT																					
June 15, 1960-----	b0.01					186	11	80	620	250							630	564		1,940	7.3
July 26-----------	.01					4,680	--	--	2,010	7,920							3,320	--		22,100	--
Nov. 16-----------	.04					99	6.9	142	1,400	158							1,540	1,420		2,670	7.3
Jan. 4, 1961------	.12					152	4.8	173	1,640	220							1,800	1,660		3,220	7.7
Mar. 9------------	.10					7,210	--	--	2,990	11,600							4,060	--		30,200	--
Apr. 4------------	.09					6,590	--	--	3,830	10,400							4,380	--		29,100	--
July 7------------	.06					7,300	--	--	2,820	12,000							3,990	--		31,900	--
14. SALT CREEK NEAR CLAIREMONT																					
Jan. 27, 1959-----	b0.15					56,600		101	5,120	87,300				--	--		5,380	5,300		143,000	7.8
Mar. 16-----------	--			1,190	803	67,500		85	5,980	104,000				180,000	277		6,270	6,200	371	152,000	7.8
May 12, 1964------	b.05	4.6		863	1,050	92,900		--	6,380	143,000				244,000	394		6,470	--		164,000	--

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
15. DUCK CREEK NEAR JAYTON																					
Mar. 17, 1964-----	2.51	7.1		435	157	153		112	1,570	235	0.6	5.8		2,620	3.56		1,730	1,640	1.6	3,140	7.1
Apr. 14-----------	1.82	5.4		450	150	150		76	1,600	238	--	4.3		2,630	3.58		1,740	1,680	1.6	3,140	7.5
June 11, 1964-----	8.41	10		163	56	51		94	556	65	.4	.2		948	1.29		637	560	.9	1,310	6.7
16. BUTTE CREEK AT MOUTH NEAR JAYTON																					
Dec. 17, 1959-----	0.60					30	4.8	112	1,260	22							1,320	1,230		2,090	7.9
Jan 4. 1961------	.20					212	5.2	126	1,710	235							1,730	1,630		3 640	7.7
19. SALT CROTON CREEK NEAR ASPERMONT																					
Water year 1957																					
Maximum, Oct. 9, 1956----------	--	--				89,700		--	3,370	146,000							9,860	--	393	166,000	--
Minimum, May 31, 1957----------	760	--				517	12	167	1,450	800							1,580	1,440	5.6	4,810	6.9
Water year 1958																					
Maximum, Sept. 3, 1958----------	.43	--				101,000		--	2,590	159,000							10,400	--	431	144,000	--
Minimum, Nov. 5, 1957----------	360	--				778		140	1,060	1,130							1,110	--	10	5,010	7.6
Water year 1959																					
Maximum, Aug. 5, 1959----------	.6	--				98,800		--	2,710	155,000							9,830	433	--	149,000	--
Minimum, July 17	280	--				1,790		--	640	2,800							--	--	--	9,240	--
Water year 1960																					
Maximum, Aug. 4, 1960----------	.36	--				98,500		--	2,920	156,000							10,100	--	--	152,000	--
Minimum, Oct. 2, 1959----------	670	--				1,970		--	800	3,220							1,060	--	--	10,600	--
Water year 1961																					
Maximum, June 1, 1961----------	.54	--				99,600		--	2,630	158,000							8,890	--	--	154,000	--
Minimum, Oct. 17, 1960----------	8,400	--				1,110		100	1,390	1,680							1,450	1,370	--	7,000	7.1
Water year 1962																					
Maximum, July 10, 1962----------	.3	--				99,100		--	2,690	158,000							10,300	--	424	135,000	--
Minimum, Sept. 17	450	--				2,090		--	1,450	3,310							1,630	--	23	11,200	--
Water year 1963																					
Maximum, Mar. 14, 1963----------	.8	--				85,800		--	3,680	136,000							9,080	--	--	164,000	--
Minimum, Sept. 15	5,400	17				728		140	1,030	1,050		7.0					1,090	976	9.6	4,980	7.5
Water year 1964																					
Maximum, Aug. 19, 1964----------	.6	--				100,000		--	3,150	158,000							8,400	--	--	163,000	--
Minimum, July 2-	7.8	6.2		549	107	6,110		--	1,230	9,790				17,800	24.5		1,810	--	--	26,100	--

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
21. NORTH CROTON CREEK AT MOUTH NEAR KNOX CITY																					
Feb. 16, 1960-----	0.78					4,230		--	2,190	6,940							2,980	--		20,700	--
Mar. 14-----------	.71					3,510		--	2,400	5,960							3,260	--		18,800	--
June 14-----------	2.27					904		68	1,280	1,460							1,430	1,370		6,120	7.5
Nov. 14-----------	5.36					1,700		--	1,870	2,990							2,490	--		11,000	--
Jan. 3, 1961------	3.77					1,260		184	1,790	2,120							2,170	2,020		8,880	7.4
Dec. 9, 1964------	.57	3.2		680	147	1,890		--	1,700	3,200				7,690	10.5		2,300	2,180	17	10,800	7.5
22. MUSTANG CREEK AT MOUTH NEAR KNOX CITY																					
Dec. 15, 1959-----	35.4					19	4.0	68	324	22							370	314		774	7.6
Feb. 12, 1960-----	b.02					572	--	126	2,260	700							2,160	2,060		5,350	7.7
June 14-----------	b.38					832	--	94	1,130	1,280							1,230	1,150		5,500	7.5
Aug. 16-----------	29.8					25	5.2	91	358	30							415	340		901	7.3
Sept. 20----------	b.02					2,520	--	--	2,910	3,680							2,890	--		13,800	--
Oct.11------------	.01					1,990	--	--	2,860	2,990							2,950	--		11,900	--
May 11, 1961------	4.51					278	13	86	1,760	495							1,940	1,870		4,040	7.4
24. MILLERS CREEK NEAR MUNDAY																					
Oct. 10 1962-----	434	9.8		25	5.9	4.1	5.0	104	4.8	3.0	0.3	2.2		111	0.15		87	1	0.2	191	6.9
May 8, 1964-------	9.48	9.8		32	9.8	14		162	9.0	4.2	.4	2.2		161	.22		120	0	.6	288	6.8
May 11------------	2.33	13		26	4.9	11		116	7.4	3.3	.3	1.2		124	.17		85	0	.5	216	6.7
May 30------------	1.49	8.6		32	11	19		174	15	4.4	.4	.2		177	.24		125	0	.7	336	7.3
June 12-----------	2.93	11		28	8.8	17		152	9.0	4.5	.3	1.2		155	.21		106	0	.7	266	6.7
25. MILLERS CREEK NEAR SEYMOUR																					
June 15, 1962-----	6.2	17		38	6.0	13		142	14	11	0.3	1.0		c176	0.24		120	3	0.5	295	6.7
Sept. 14----------	7.10	16		68	17	39		184	98	50	.3	.8		379	.52		240	88	1.1	618	6.8
Nov. 13-----------	b.14	11		92	38	58		216	244	56	.3	1.0		c638	.87		386	209	1.3	943	6.8
Dec. 13-----------	2.55	13		101	38	65		274	202	80	.3	1.0		c670	.91		408	184	1.4	1,000	6.9
Jan. 17, 1963-----	b.20	2.3		109	33	63		150	305	72	.3	1.0		c660	.90		408	284	1.4	1,010	7.1
Feb. 14-----------	b.10	1.4		210	115	218		316	784	280	.4	1.2		1,760	2.39		997	738	3.0	2,440	6.9
Mar. 8------------	b.2	1.2		228	134	266		304	956	320	.4	1.8		2,060	2.80		1,120	871	3.5	2,750	7.0
Apr. 8------------	6.42	14		72	25	53		188	147	63	.4	1.8		c468	.64		282	128	1.4	750	6.7
May 9-------------	2.59	10		47	14	24	5.5	142	77	28	.2	2.0		c300	.41		175	58	.8	462	6.9
June 11-----------	34.7	12		36	7.1	20		137	24	17	.4	.0		184	.25		119	7	.8	321	6.7
26. LAKE TRAMMEL NEAR SWEETWATER																					
July 2, 1946------		7.6	0.00	52	6.8	7.7		164	16	16	0.0	1.0		c193	0.26		158	23		338	7.6
Apr. 22, 1964----		.4		57	14	25		156	73	34	.3	.5		281	.38		200	72	0.8	501	7.2
27. LAKE SWEETWATER NEAR SWEETWATER																					
Jan. 18, 1952-----		3.0	0.05	59	13	13		197	41	20	0.0	0.0		c270	0.37		201	39	0.4	453	7.7
Apr. 22, 1964-----		6.8		53	15	24		184	50	30	.3	.2		269	.37		194	43	.7	485	7.3

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
28. LAKE ABILENE NEAR ABILENE																					
Apr. 18, 1946-----		9.6	0.25	51	15	9.3	5.1	210	21	15	0.2	0.0		c234	0.32		189	17		407	7.6
Apr. 22, 1964-----		4.0		49	21	34		185	43	60	.4	.0		302	.41		209	58	1.0	555	7.3
29. LAKE KIRBY NEAR ABILENE																					
Apr. 18, 1946-----		5.5	0.70	44	12	13	4.9	202	11	9.0	1.0	0.5		c209	0.28		159	0		390	8.0
Apr. 22, 1964-----		.4		44	12	24		182	23	26	.4	.0		219	.30		159	10	0.8	409	7.3
30. LAKE LYTLE AT ABILENE																					
Apr. 22, 1964-----		8.2		61	13	42		210	45	54	0.4	0.2		327	0.44		206	34	1.3	579	7.2
31. FORT PHANTOM HILL RESERVOIR NEAR NUGENT																					
Oct. 1, 1948------		4.7	0.00	33	22	63	14	211	52	70	0.4	1.2		365	0.50		173	0	--	652	7.9
Jan. 18, 1952-----		1.2	.05	40	23	57	8.0	236	40	65	.3	.2	0.17	c362	.49		194	38	1.8	642	7.8
Aug. 16, 1963-----		4.0	.01	46	15	46		160	42	72	.4	.5		305	.41		176	46	1.5	549	7.1
Aug. 22, 1964-----		.6		46	17	51		176	47	72	.4	.0		321	.44		185	41	1.6	586	7.3
33. LAKE STAMFORD NEAR HASKELL																					
Oct. 2, 1953------		9.4	0.17	33	9.5	10	5.2	157	9.4	7.2	0.4	1.5	0.01	178	0.24		121	0	0.4	297	7.9
Aug. 12, 1965-----		9.0	--	38	21	62		220	56	53	.5	.2	--	348	.47		182	1	2.0	598	7.4
34. LAKE HAMLIN NEAR HAMLIN																					
Sept. 20, 1946----		9.0	0.00	27	7.1	9.8	5.6	118	8.1	13	0.0	2.0		c158	0.21		97	0		249	6.8
Apr. 22, 1964-----		.9		43	8.9	4.0	15	182	10	6.8	.3	.0		178	.24		144	0	0.1	330	7.2
46. HUBBARD CREEK RESERVOIR NEAR BRECKENRIDGE																					
Sept. 30, 1963----		3.7	0.34	68	10	58	7.8	166	16	138	0.2	0.0	0.11	384	0.52		210	74	1.7	737	7.1
Aug. 9, 1964------		2.7	--	72	15	76		148	26	182	.3	.2		447	.61		241	120	2.1	883	7.0
Sept. 22, 1965----		3.6	d.40	57	9.2	51		114	15	109	.3	.2		318	.43		180	58	1.7	617	7.4
47. LAKE DANIELS NEAR BRECKENRIDGE																					
Mar. 12, 1959-----		1.3		36	4.1	14		123	9.6	18	0.2	0.0		c150	0.20		107	6	0.6	274	7.7
Mar. 4, 1963------		2.4		44	4.5	8.3	5.6	144	8.4	17	.3	.0		162	.22		128	10	.3	292	6.5
53. LAKE GRAHAM NEAR GRAHAM																					
Apr. 23, 1958-----		2.4	--	278	74	655		157	130	1,530	0.2	0.0		2,750	3.74		998	870	9.0	5,020	7.9
Sept. 12----------		4.9	0.04	56	11	90		138	12	180	.1	.2		422	.57		184	72	2.9	819	7.8
Apr. 8, 1959------		1.2	--	67	15	106		167	17	215	.2	.8		504	.69		228	92	3.1	1,000	7.9
June 10-----------		2.0	.22	64	15	114		139	15	240	.3	.0		c518	.70		221	107	3.3	1,070	7.5
Sept. 9-----------		2.8	--	56	12	95		126	11	198	.3	.5		c480	.65		189	86	3.0	854	7.4
Nov. 11-----------		5.9	--	34	7.2	52		95	6.8	101	.2	.8		c287	.39		114	37	2.1	493	7.2
Sept. 9, 1960-----		4.4	--	44	8.7	60		124	5.6	120	.3	.0		c304	.41		146	44	2.2	593	7.3
June 20, 1962-----		2.7	--	47	7.4	59		115	8.8	122	.4	.0		c304	.41		148	54	2.1	612	6.6
Nov. 13-----------		2.7	--	40	7.1	47		113	6.8	92	.3	.0		c252	.34		129	36	1.8	505	6.8

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
56. KEECHI CREEK NEAR GRAFORD																					
Dec. 11, 1962	14.4	9.2		84	12	35		265	43	51	0.3	0.2		c374	0.51		259	42	0.9	643	7.0
Jan. 10, 1963	8.98	--		--	--	--		--	--	89	--	--		--	--		--	--	--	--	--
Mar. 12	2.38	8.8		84	20	98		227	112	143	.2	.0		c610	.83		292	106	2.5	974	7.2
Apr. 10	1.88	7.1		102	20	99	3.4	259	111	161	.3	.0		631	.86		337	124	2.3	1,080	7.1
May 9	14.3	11		80	12	51	3.9	230	60	83	.3	.2		c450	.61		249	60	1.4	715	7.2
June 11	1.46	9.6		49	8.2	36		146	29	59	.4	1.2		264	.36		156	36	1.3	483	6.9
July 18	.02	17		74	13	53		236	46	78	.4	.0		397	.54		238	44	1.5	680	7.1
57. KEECHI CREEK RESERVOIR NEAR GRAFORD																					
Oct. 30, 1961		7.7		42	6.0	15		149	12	19	0.5	0.0		175	0.24		129	7	0.6	323	7.1
Nov. 6		--		--	--	--		154	--	21	--	--		--	--		130	4	--	330	7.1
Jan. 4, 1962		--		--	--	--		181	--	25	--	--		--	--		158	10	--	395	6.7
Feb. 7		--		--	--	--		212	--	30	--	--		--	--		184	10	--	441	7.2
Apr. 10		4.3		50	8.1	28		183	--	30	.4	.2		c236	.32		158	8	1.0	402	7.1
June 14		7.5		28	3.8	14		82	17	22	.3	.2		133	.18		86	18	.7	239	6.8
58. LAKE HAGAMAN NEAR RANGER																					
Nov. 1945		5.0	0.04	39	6.2	38		102	18	73	0.2	0.0		c248	0.34		123	39		438	7.2
Oct. 30, 1963		1.7		36	2.7	17		116	10	22	.3	.0		147	.20		101	6	0.7	275	7.0
59. PALO PINTO CREEK NEAR SANTO																					
Dec. 7, 1961	0.23	4.3		43	10	28		132	49	35	0.3	0.0		c236	0.32		148	40	1.0	415	7.5
Mar. 23, 1962	.07	3.1		66	15	47		230	73	44	.3	.0		c376	.51		226	38	1.4	617	7.5
May 2	1.75	3.0		94	24	121		158	139	226	.3	2.0		c763	1.04		333	204	2.9	1,190	7.6
June 6	.08	5.0		43	8.2	44		99	43	78	.3	1.0		272	.37		141	60	1.6	485	7.0
June 10	4,300	9.6		42	4.7	14		131	17	18	.3	2.8		172	.23		124	17	.5	295	7.3
Aug. 9	12.5	--		--	--	--		208	--	52	--	--		--	--		206	36	--	563	6.8
Sept. 2	85	--		--	--	--		117	--	75	--	--		--	--		149	53	--	503	6.7
Sept. 4	22	7.5		37	4.6	27		105	12	50	.1	.5		191	.26		111	25	1.1	358	6.6
Sept. 7	1,100	7.7		36	3.9	15		98	17	28	.0	1.0		157	.21		106	26	.6	289	6.7
Sept. 8	6,500	7.2		34	2.6	7.2	3.0	110	6.2	13	.0	1.0		128	.17		96	5	.3	219	7.0
Sept. 10	640	8.4		42	5.1	15		133	14	24	.1	.2		174	.24		126	17	.6	317	6.9
Sept. 19	30.6	8.5		48	6.6	29		142	27	46	.2	.8		236	.32		147	31	1.0	421	6.6
Sept. 22	.01	--		--	--	--		191	--	56	--	--		--	--		186	30	--	539	7.1
Oct. 8	5,600	5.8		38	3.3	1.6	3.4	132	.8	1.0	.2	1.5		121	.16		108	0	.7	215	7.3
Oct. 9	7,000	--		--	--	--		142	--	12	--	--		--	--		125	9	--	278	7.3
Oct. 14	48	9.8		58	9.8	39		188	34	56	.3	.2		c312	.42		185	31	1.2	525	7.1
Oct. 21	15	--		--	--	--		259	--	70	--	--		--	--		256	44	--	711	7.3
Oct. 28	30	--		--	--	--		309	--	76	--	--		--	--		304	51	--	806	7.4
Oct. 29	78	--		--	--	--		212	--	75	--	--		--	--		232	58	--	671	7.3
Nov. 5	11	9.3		97	20	85		270	82	142	.3	.2		c605	.82		324	103	2.1	997	7.4
Nov. 27	240	--		--	--	--		159	--	108	--	--		--	--		232	102	--	763	7.0
Nov. 28	56	--		--	--	--		173	--	142	--	--		--	--		273	131	--	971	7.0

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
60. LAKE MINERAL WELLS NEAR MINERAL WELLS																					
Oct. 1943		15		44	13	22		160	42	24	0.4	0.2		c262	0.36		163	32	0.8	428	8.0
Nov. 1945		9.8	0.04	38	10	14	5.2	137	33	19	.2	.0		c221	.30		136	24	.5	348	7.4
Oct. 30, 1963		4.6		44	8.6	17		162	26	15	.3	.0		196	.27		145	12	.6	347	7.1
61. PALUXY CREEK AT GLEN ROSE																					
Dec. 5, 1961	41.6	10		45	22	24		206	45	27	0.3	0.0		c274	0.37		203	34	0.7	475	7.4
Jan. 10, 1962	56.8	9.0		39	26	22		200	47	28	.2	.2		c269	.37		204	40	.7	482	7.5
Mar. 20	27.2	9.4		31	27	26		176	52	32	.3	.2		265	.36		188	44	.8	465	7.5
May 3	27.1	10		53	22	23		213	47	34	.4	.0		c322	.44		222	48	.7	514	7.3
June 5	10.4	16		39	26	23		198	43	32	.3	.0		c276	.38		204	42	.7	484	7.3
July 11	5.18	14		40	20	20		196	30	23	.4	.0		c248	.34		182	21	.6	430	7.0
Sept. 10	27	9.4		31	11	16		143	20	12	.4	.5		170	.23		123	5	.6	286	7.3
Sept. 18	5.55	10		37	16	18		179	26	16	.4	.0		211	.29		158	11	.6	365	7.1
62. LAKE PAT CLEBURNE NEAR CLEBURNE																					
May 14, 1965		3.2		44	3.5	10		146	14	7.2	0.2	1.8		156	0.21		124	5	0.4	286	6.9
June 21		5.7		48	3.0	10		159	12	7.2	.3	.8		165	.22		132	2	.4	299	7.4
63. NOLANDS RIVER AT BLUM																					
Jan. 8, 1962	28.3	1.3		42	7.6	54		188	47	32	0.4	6.0		c282	0.38		136	0	2.0	487	7.7
Feb. 12	19.0	1.0		77	8.4	60		297	56	36	.6	4.0		c398	.54		226	0	1.7	667	7.6
Mar. 19	17.9	.8		70	7.7	73		296	61	39	.6	3.2		c401	.55		206	0	2.2	682	7.9
Apr. 24	14.4	10		66	6.9	77		297	53	41	.7	2.2		c414	.56		193	0	2.4	666	7.1
June 4	4.58	11		42	5.1	122		320	58	47	.7	.5		c453	.62		126	0	4.7	757	6.9
July 9	9.22	9.4		55	6.0	46		228	33	28	.5	.0		c302	.41		162	0	1.6	506	6.8
Sept. 17	3.99	7.3		40	3.6	35		172	26	16	--	.0		c230	.31		115	0	1.4	362	6.8
Oct. 10	31.4	9.6		35	2.9	23		136	18	12	.4	.8		169	.23		99	0	1.0	290	6.6
Mar. 3, 1964	e4.8	1.2		44	5.3	169		370	100	60	.9	7.7		570	.78		132	0	6.4	958	8.0
66. AQUILLA CREEK NEAR AQUILLA																					
Dec. 4, 1961	35.0	9.9		93	6.8	58		187	173	34	0.6	5.4		c473	0.64		260	107	1.6	727	7.5
Jan. 8, 1962	28.1	5.1		104	9.4	75		192	222	49	.5	4.0		c580	.79		298	140	1.9	876	7.0
Feb. 12	19.1	1.8		138	12	101		264	289	63	.7	4.8		c760	1.03		394	178	2.2	1,120	7.0
Mar. 19	17.0	--		--	--	--		176	--	68	.7	--		--	--		328	--	--	1,030	7.4
Apr. 24	28.6	8.6		135	15	139		295	321	85	.9	3.8		c903	1.23		398	156	3.0	1,260	7.6
June 4	3.53	8.7		108	9.1	72		199	210	54	.7	4.0		c583	.79		307	144	1.8	895	7.2
July 10	4.08	12		130	9.7	76		299	210	45	.8	2.0		c640	.87		364	120	1.7	966	7.0
Oct. 10	124	9.9		87	2.6	17		206	73	12	.5	1.8		c328	.45		228	58	.5	501	6.6
May 9-11, 1965	e3,527	9.4		48	1.5	12		126	37	4.6	--	3.8		178	.24		126	23	.5	293	7.6
May 12-13	e510	11		71	3.1	22		154	83	12	--	11		289	.39		190	64	.7	471	7.9
May 14-17	e5,630	10		46	1.5	6.7	2.7	124	31	4.3	--	2.8		166	.23		121	19	.3	274	7.7
May 18-19	e500	12		63	3.1	20		161	57	12	.5	4.2		251	.34		170	38	.7	410	7.8

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
67. GREEN CREEK NEAR ALEXANDER																					
Oct. 18, 1962	0.25	3.6		41	10	32		134	29	51	0.3	0.0		233	0.32		143	34	1.2	429	6.6
Jan. 18, 1963	.65	3.3		47	18	40		197	38	55	.4	.2		299	.41		192	30	1.3	530	7.6
Dec. 5	.01	4.4		49	14	26		184	29	38	.3	.0		251	.34		180	29	.8	466	7.6
Feb. 4, 1964	91.8	5.3		32	8.3	18		114	19	28	.2	1.0		168	.23		114	21	.7	323	6.9
Feb. 5	25.4	4.7		30	7.1	22		101	20	33	.2	.2		167	.23		104	21	.9	317	6.8
Feb. 6	9.95	3.5		35	9.2	28		118	27	43	.2	.0		204	.28		125	28	1.1	389	6.9
Apr. 21	540	5.5		54	6.4	16		181	16	20	.3	1.0		208	.28		161	13	.5	382	6.9
Apr. 29	2.86	2.4		45	14	36		168	32	54	.3	.5		267	.36		170	32	1.2	503	6.9
68. NORTH BOSQUE RIVER NEAR CLIFTON																					
Dec. 2, 1961	114	9.4		82	8.6	18		248	36	25	0.3	3.8		c319	0.43		240	37	0.5	533	7.1
Dec. 29	118	8.1		74	8.1	23		234	38	23	.4	4.1		c300	.41		218	26	.7	505	7.4
Jan. 31, 1962	82.4	4.9		79	8.8	21		241	38	26	.3	4.4		c304	.41		233	36	.6	526	7.1
Mar. 1	73.9	6.8		76	9.5	25		239	40	29	.4	2.8		308	.42		228	32	.7	536	7.2
Mar. 29	56.8	6.4		49	9.2	26		164	37	30	.3	1.5		c252	.34		160	26	.9	420	7.4
May 1	828	9.0		52	3.7	13		157	21	14	.3	2.2		c206	.28		145	16	.5	323	6.9
May 29	41.9	8.4		65	7.4	18		209	26	21	.4	2.2		c252	.34		193	21	.6	444	6.9
June 29	44.1	8.0		57	6.1	13		174	20	21	.4	2.0		214	.29		167	25	.4	390	6.7
Aug. 29	4.12	14		68	7.2	24		228	22	26	.4	4.8		278	.38		199	12	.7	462	7.0
Sept. 10	150	8.6		34	4.5	5.6	4.3	120	11	6.0	.3	1.2		c138	.19		103	5	.2	228	7.1
Oct. 1	8.18	10		67	6.4	13		217	18	16	.2	3.8		c251	.34		193	16	.4	410	7.1
Oct. 9	3,630	8.7		44	4.1	4.9	3.5	145	8.8	7.5	.4	1.2		154	.21		127	8	.2	274	6.8
Oct. 31	59.2	7.0		56	6.4	16		188	21	16	.4	2.0		217	.30		166	12	.5	382	7.6
Nov. 30	72.9	8.9		70	7.5	21		229	29	22	.3	1.5		273	.37		206	18	.6	480	7.1
Dec. 31	24.9	6.8		77	8.5	17		238	31	24	.4	2.5		284	.39		227	32	.5	502	7.0
Jan. 30, 1963	18.2	4.2		78	9.4	22		241	39	28	.3	2.7		c312	.42		233	36	.6	528	7.3
Feb. 28	11.5	2.4		74	9.3	23		238	36	26	.4	2.2		c292	.40		223	28	.7	514	7.4
Apr. 1	7.70	5.1		66	8.8	23		215	32	28	.3	.8		c276	.38		200	24	.7	479	6.8
Apr. 30	181	6.2		64	22	63		252	57	85	.4	.2		422	.57		250	44	1.7	741	7.2
May 30	142	6.8		40	3.7	6.2	4.9	130	10	10	.2	1.8		148	.20		115	8	.3	253	6.7
June 29	11.6	8.4		39	6.5	13		140	13	16	.3	.2		165	.22		124	9	.5	285	6.9
July 31	.27	11		66	5.9	17		210	20	21	.3	2.8		247	.34		189	17	.5	418	6.9
Aug. 29	.10	12		38	7.6	21		157	12	21	.4	.0		189	.26		126	0	.8	333	6.7
Sept. 30	.07	9.8		32	7.8	23		142	11	24	.3	.2		178	.24		112	0	.9	316	7.7

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
69. MIDDLE BOSQUE RIVER NEAR McGREGOR																					
Dec. 1, 1961------	96.0	8.9		70	2.8	8.7	1.1	199	19	12	0.3	8.6		229	0.31		186	23	0.3	398	7.0
Dec. 28-----------	60.2	6.5		63	2.5		12	176	21	13	.4	9.4		215	.29		168	23	.4	373	7.1
Jan. 31, 1962-----	28	5.1		70	2.6		12	198	22	14	.4	8.1		c235	.32		185	23	.4	404	7.2
Feb. 28-----------	28.3	7.5		63	2.6		12	181	22	13	.4	4.8		214	.29		168	20	.4	375	7.2
Mar. 29-----------	15	6.9		50	2.5		11	141	22	12	.3	2.2		c184	.25		135	20	.4	318	7.2
Apr. 30-----------	16.1	7.5		55	2.5		10	158	19	13	.4	.8		c200	.27		148	18	.4	325	7.4
May 29------------	95	11		42	1.8	4.8	2.4	126	10	5.5	.3	1.5		c146	.20		112	9	.2	243	6.7
July 9------------	15.7	8.9		56	2.6	8.6	1.6	169	16	10	.3	.0		187	.25		150	12	.3	331	6.9
July 31-----------	.5	14		44	2.5		12	132	19	12	.3	.0		169	.23		120	12	.5	281	7.1
Aug. 29-----------	.06	11		38	2.3		16	107	27	15	.4	.0		163	.22		104	17	.7	275	6.9
Oct. 1------------	b.05	7.2		36	2.4	6.9	2.4	110	17	5.5	.3	.0		132	.18		100	10	.3	226	6.9
Oct. 31-----------	b.04	4.5		38	2.6		13	110	25	12	.5	.0		150	.20		106	15	.5	262	7.4
Nov. 30-----------	b.05	4.5		47	2.6		11	127	28	12	.3	1.2		169	.23		128	24	.4	296	6.8
Dec. 31-----------	b3.3	7.9		47	2.1	5.8	1.9	136	16	7.0	.4	2.0		157	.21		126	14	.2	265	7.5
Jan. 30, 1963-----	3.40	4.1		66	2.8		11	183	29	10	.4	6.0		c228	.31		176	26	.4	380	7.2
Feb. 27-----------	b3.1	1.5		55	2.6		12	156	27	11	.4	1.2		188	.26		148	20	.4	335	7.5
Apr. 1------------	.80	4.5		44	2.5		13	125	24	14	.4	.0		163	.22		120	18	.5	292	6.7
Apr. 30-----------	b3.4	9.1		50	2.4		8.4	147	16	10	.3	1.2		169	.23		135	14	.3	291	7.0
May 29------------	32.7	9.6		44	1.0	4.9	2.0	130	9.6	5.2	.4	.8		142	.19		114	7	.2	238	6.8
Mar. 5, 1964------	4.99	3.0		62	.8	8.7	1.4	142	33	11	.3	14		204	.28		158	42	.3	359	6.9
Apr. 9------------	19.0	4.2		61	1.9	8.5	1.8	164	25	11	.4	5.1		200	.27		160	26	.3	357	7.3
May 14------------	28.2	5.6		59	2.1		16	157	39	10	.4	8.8		218	.30		156	27	.6	350	7.0
June 24-----------	59.0	7.5		52	2.5		10	144	22	10	.4	8.0		183	.25		140	22	.4	320	7.5
July 29-----------	1.06	10		49	1.9		14	130	28	13	.4	6.0		186	.25		130	24	.5	317	6.9
Aug. 12-----------	.32	11		46	2.5		14	118	29	15	.3	7.0		183	.25		125	28	.5	308	6.9
Sept. 1-----------	.39	9.3		39	1.1		12	122	16	7.6	.3	.8		146	.20		102	2	.5	243	6.9
70. WACO RESERVOIR NEAR WACO																					
Jan. 8, 1943------		7.6	0.06	70	11	30	0.6	217	52	33	0.8	5.9		c335			220	42		--	8.2
Feb. 29, 1952-----		6.2	.01	50	6.6	15	.0	164	30	14	.3	.5	0.30	c225			152	18		367	7.6
Sept. 17, 1956----		--	--	--	--		--	130	--	17	.5	--		--			122	16		312	7.4
May 24, 1965------		7.5	.00	54	2.7		9.3	128	32	18	.2	2.5		189	0.26		146	41	0.3	335	7.6
71. BOSQUE RIVER NEAR WACO																					
Jan. 18, 1962-----	720	5.7		67	5.9		17	197	32	20	0.3	5.3		c258	0.35		191	30	0.5	432	7.3
Jan. 18-----------	714	6.6		60	5.4		17	174	32	20	.3	5.8		c238	.32		172	29	.6	405	7.1
Feb. 21-----------	62.2	3.4		62	6.3		24	182	46	23	.3	3.8		258	.35		181	31	.8	446	7.6
Mar. 29-----------	73.7	--		--	--		--	127	--	24	.3	--		--	--		--	--	--	357	7.4
Apr. 30-----------	104	4.6		58	6.7		19	172	34	24	.3	2.0		c251	.34		172	31	.6	417	7.0
June 7------------	60.7	7.5		53	5.5		19	164	32	19	.3	.5		c221	.30		155	20	.7	380	7.0
Aug. 15-----------	2.28	13		65	6.7		43	188	53	52	.3	.0		c325	.44		190	36	1.4	557	6.9
Sept. 19----------	7.54	10		54	4.4		17	159	36	14	.3	1.0		c226	.31		153	23	.6	360	7.1
Oct. 23-----------	5.84	9.4		46	5.8	8.7	3.2	148	20	12	.0	.8		180	5.84		138	16	.3	310	7.1
Nov. 28-----------	4.08	7.9		64	5.9		16	196	32	16	.3	.5		239	.33		184	23	.5	409	7.3

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated) Parts per million	Dissolved solids Tons per acre-foot	Dissolved solids Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
71. BOSQUE RIVER NEAR WACO--Continued																					
Jan. 8, 1963------	19.4	6.3		57	5.5	13		178	25	14	0.4	0.2		c221	0.30		165	19	0.4	369	6.9
Feb. 5------------	4.63	5.6		64	5.6	15		193	30	18	.3	.0		c246	.33		183	25	.5	403	6.9
Mar. 9------------	5.14	3.2		62	6.3	19		192	33	19	.3	.0		237	.32		181	23	.6	416	6.9
May 22------------	15.4	4.8		53	5.8	24		162	39	23	.4	.5		230	.31		156	23	.8	391	6.8
June 18-----------	8.23	9.4		46	6.1	51		172	58	34	.4	.0		290	.39		140	0	1.9	478	7.1
Nov. 18-----------	b1.8	8.9		69	7.3	31		178	69	35	.4	.0		309	.42		202	56	.9	558	7.0
Dec. 20-----------	4.68	7.4		72	5.7	23		179	56	32	.3	1.5		286	.39		203	56	.7	520	6.7
Jan. 28, 1964-----	1.86	4.0		68	6.4	14		186	57	9.9	.3	.2		251	.34		196	44	.4	467	7.8
Mar. 4------------	369	5.4		62	3.5	15		170	42	12	.3	2.0		226	.31		169	30	.5	399	6.9
Apr. 8------------	129	4.8		56	4.0	15		160	37	12	.3	3.0		211	.29		156	25	.5	376	7.0
May 13------------	41.6	7.1		54	3.5	12		156	29	9.9	.3	2.2		195	.27		149	21	.4	343	6.9
July 29-----------	1.12	12		64	4.9	20		186	42	18	.3	.5		253	.34		180	27	.6	431	7.0
73. COW CREEK AT MOOREVILLE																					
Mar. 6, 1964------	2.19	4.1		111	5.6	27		176	176	20	0.5	2.8		434	0.59		300	156	0.7	680	7.5
May 1-------------	105	12		82	2.5	11		212	52	5.6	.3	1.8		271	.37		215	41	.3	447	6.8
May 1-------------	61.1	9.1		68	2.5	10		177	45	5.3	.3	2.2		229	.31		180	35	.3	387	6.9
May 15------------	3.53	2.7		85	3.6	23		165	115	15	.6	.0		326	.44		227	92	.7	533	7.4
May 26------------	.55	5.4		83	3.9	25		182	97	18	.6	.0		322	.44		223	74	.7	531	7.0
75. LEON RESERVOIR NEAR RANGER																					
Apr. 15, 1955-----		0.7	0.01	50	6.6	12	8.6	186	7.2	20	0.4	1.5	0.06	c205	0.28		152	0	0.4	364	7.6
Mar. 12, 1959-----		3.0		48	6.6	26		137	24	46	.2	.1		c236	.32		147	35	.9	415	8.1
Mar. 4, 1963------		1.6		43	6.7	21		118	18	46	.3	.0		c212	.29		135	38	.8	379	6.7
Oct. 30-----------		4.1		40	5.2	23		124	14	38	.2	.0		186	.25		121	20	.9	346	6.8
76. PROCTOR RESERVOIR NEAR PROCTOR																					
Jan. 30, 1964-----		1.9		57	11	42		185	22	73	0.3	0.2		298	0.41		187	36	1.3	557	7.6
June 30-----------		.7		54	15	57		174	34	100	.5	.0		347	.47		196	54	1.8	647	7.6
Nov. 4------------		6.5		34	8.3	17		112	13	35	.2	.5		170	.23		119	27	.7	325	7.4
Oct. 1, 1965------		4.2	.18	58	13	59		170	34	106	.3	.0		358	.49		198	58	1.8	685	7.1
77. LEON RIVER NEAR HASSE																					
Oct. 30, 1961-----	2.3	11		75	32	102		248	105	160	0.5	0.2		c656	0.89		318	116	2.5	1,060	7.5
Feb. 16, 1962-----	14.8	7.4		108	55	160		358	160	270	.6	1.5		938	1.28		496	202	3.1	1,620	7.4
May 1-------------	16.1	8.6		96	48	148		301	130	265	.5	1.2		845	1.15		437	190	3.1	1,530	7.4
June 6------------	3.64	11		64	54	143		293	143	211	.9	3.2		c833	1.13		382	142	3.2	1,390	6.9
July 4------------	7.5	8.1		52	16	48		167	42	84	.4	.2		c358	.49		196	58	1.5	629	6.9
Aug. 6------------	14.9	9.9		84	15	91		212	43	177	.3	.0		524	.71		271	98	2.4	974	7.2
Sept. 9-----------	7,300	7.3		21	2.5	5.9	5.0	74	4.2	12	.2	.2		94	.13		63	2	.3	158	6.9
Sept. 9-----------	7,100	5.9		24	3.1	10		77	4.4	19	.1	.0		104	.14		73	10	.5	188	6.5
Sept. 19----------	94.0	12		94	19	81		258	66	147	.3	.0		546	.74		312	101	2.0	980	7.0

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
78. LAKE EANES NEAR COMANCHE																					
Mar. 20, 1946-----		6.4	0.08	54	13	32	5.2	200	47	36	0.2	0.0		292	0.40		188	24	1.0	505	7.4
Oct. 30, 1963-----		2.4		36	7.6	13	6.7	133	22	18	.3	.0		171	.23		121	12	.5	305	7.0
79. LAKE COMANCHE NEAR COMANCHE																					
Oct. 30, 1963-----		3.6		36	13		29	146	34	36	0.4	0.0		224	0.30		143	24	1.1	408	7.2
80. LAKE HAMILTON NEAR HAMILTON																					
Mar. 19, 1946-----		7.8	0.22	59	5.2	9.4	4.8	183	25	13	0.2	0.5		226	0.31		169	19	0.3	375	8.0
Sept. 24, 1964----		2.7		34	3.7	6.7	4.0	110	18	9.5	.3	.0		133	.18		100	10	.3	244	6.9
81. BELTON RESERVOIR NEAR BELTON																					
Sept. 9, 1955-----		6.4	0.01	44	4.4		16	159	9.2	15	0.2	0.5		c196	0.27		128	0	0.6	319	7.3
Aug. 22, 1956-----		2.9	.02	44	5.0		15	163	7.9	14	.3	.5		170	.23		131	0	.6	317	7.4
Aug. 28-----------		2.8	.02	49	5.0		15	157	17	19	.3	.2		185	.25		142	13	.5	338	7.9
June 17, 1957-----		9.6	.04	37	3.4		8.2	122	10	7.5	.4	2.2		138	.19		106	6	.3	245	7.2
Mar. 24, 1958-----		9.0	.00	67	9.1		22	201	30	35	.2	7.7		c300	.41		204	40	.7	484	8.1
Nov. 13, 1963-----		6.4	.02	46	13		39	160	37	59	.4	.2		280	.38		168	38	1.3	511	7.3
May 26, 1964------		4.4	--	45	12		33	158	33	48	.3	.5		254	.35		162	32	1.1	464	7.8
Nov. 6------------		4.5	--	40	10		15	138	19	28	.2	.0		185	.25		141	28	.5	351	7.5
Oct. 1, 1965------		5.8	.13	55	8.7		24	182	22	36	.3	.8		242	.33		173	24	.8	448	7.0
82. LEON RIVER NEAR BELTON																					
Mar. 28, 1961-----	e2,130	8.4		65	9.5		18	206	28	27	0.3	5.4		c272	0.37		201	32	0.6	463	7.5
May 31, 1962------	32	7.0		62	11		22	215	29	28	.3	2.0		267	.36		200	24	.7	475	7.0
June 8------------	103	5.2		52	12		26	185	34	34	.3	.8		255	.35		179	28	.8	449	7.3
June 22-----------	440	3.4		52	11		26	178	32	36	.4	.5		249	.34		175	29	.9	447	7.4
July 11-----------	225	4.4		49	13		23	171	33	36	.4	.5		243	.33		176	36	.8	456	6.8
Aug. 16-----------	5.00	8.8		42	15		66	196	57	62	.5	1.2		348	.47		166	6	2.2	609	6.9
Sept. 5-----------	6.48	6.8		53	13		24	189	31	35	.4	.5		c262	.36		186	31	.8	454	7.0
Sept. 17----------	3,200	7.0		51	13		27	186	30	38	.3	.8		c276	.38		181	28	.9	458	6.8
Oct. 23-----------	246	7.0		48	13		26	171	32	39	.4	.0		c258	.35		173	33	.9	453	6.8
Nov. 27-----------	31	6.5		45	13		26	163	32	38	.4	.2		241	.33		166	32	.9	437	6.9
Jan. 10, 1963-----	273	5.7		38	11		22	132	26	37	.4	.2		205	.28		140	32	.8	382	6.9
Feb. 4------------	12.6	4.9		56	13		32	194	36	46	.4	.2		c292	.40		193	34	1.0	515	6.8
Mar. 14-----------	9.29	6.0		54	13		36	194	37	48	.4	1.0		c301	.41		188	29	1.1	514	6.9
Apr. 24-----------	18	6.3		54	12		37	192	35	49	.5	.8		289	.39		184	26	1.2	505	7.7
May 23------------	15.7	7.0		54	13		39	192	39	52	.4	.2		299	.41		188	30	1.2	521	6.9
June 19-----------	349	6.0		46	14		36	160	38	56	.3	.0		275	.37		172	42	1.2	481	7.3
July 23-----------	13.2	7.5		50	13		46	184	41	60	.4	.0		308	.42		178	28	1.5	538	6.7
Aug. 28-----------	3.66	8.0		47	14		60	191	49	69	.5	.0		342	.47		175	18	2.0	611	6.8
Oct. 2------------	6.64	6.6		48	14		43	186	37	56	.4	.2		296	.40		178	25	1.4	543	6.9
Nov. 6------------	6.4	8.1		55	13		43	198	36	58	.4	.8		311	.42		190	28	1.4	567	6.8

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
82. LEON RIVER NEAR BELTON--Continued																					
Dec. 9, 1963	5.45	8.3		54	14	43		201	36	58	0.5	0.8		314	0.43		192	28	1.4	566	7.2
Jan. 13, 1964	5.44	7.4		52	13	40		184	36	57	.4	.8		297	.40		183	32	1.3	543	7.8
Feb. 17	21.0	7.4		54	13	40		189	36	56	.4	1.8		302	.41		188	33	1.3	537	7.8
Mar. 23	9.1	5.6		54	13	34		188	34	49	.4	1.8		284	.39		188	34	1.1	521	7.1
Apr. 30	2,230	5.3		49	13	37		171	37	55	.4	.2		281	.38		176	36	1.2	513	7.2
June 2	15.0	6.9		57	12	33		189	35	50	.3	1.2		288	.39		192	36	1.0	531	7.3
July 6	1,330	6.2		40	6.4	18		132	21	25	.4	.0		182	.25		126	18	.7	335	6.5
Aug. 10	5.0	9.3		51	7.5	21		180	17	25	.4	2.8		223	.30		158	11	.7	392	7.8
83. SULPHUR CREEK BELOW LAMPASAS																					
July 7, 1964	6.01	6.2		77	53	439		192	20	840	0.3	0.0		1,530	2.08		410	252	9.4	2,890	6.6
84. LAMPASAS RIVER NEAR KEMPNER																					
June 3, 1963	10.1	5.3		56	40	230		192	21	440	0.4	0.1		887	1.21		302	144	5.8	1,680	7.5
Mar. 20, 1964	227	7.8		50	9.5	20		170	16	36	.2	.8		204	.30		164	24	.7	418	7.2
June 2	23.5	5.7		61	26	148		195	17	285	.3	.2		639	.87		259	99	4.0	1,240	6.9
86. NORTH SAN GABRIEL RIVER AT GEORGETOWN																					
Feb. 24, 1961	b80	11		92	15	13		310	22	18	--	21		c364	0.50		291	37	0.3	586	7.3
Mar. 28	121	--		--	--	--		234	27	27	--	--		--	--		238	46	--	529	7.3
Jan. 4, 1962	23.0	7.4		65	19	17		244	24	32	0.2	6.6		c302	.41		240	40	.5	520	7.3
Aug. 24	1.88	16		29	18	25		123	22	54	.3	.1		c237	.32		146	46	.9	392	7.5
Sept. 8	--	10		48	5.4	2.1	3.5	163	11	3.5	.2	3.5		167	.23		142	8	.1	284	7.0
Oct. 31	15.7	7.9		45	9.2	5.4	2.0	162	12	10	.3	.0		c178	.24		150	17	.2	307	6.6
Nov. 26	4.56	5.3		41	20	13		175	24	30	.2	1.2		221	.30		185	41	.4	409	7.5
Jan. 11, 1963	1.63	5.7		47	15	11		154	42	21	.3	2.0		220	.30		179	53	.4	394	6.9
Feb. 5	5.53	3.6		5.5	21	14		216	26	33	.2	2.2		c268	.36		224	46	.4	480	7.3
Mar. 22	5.92	4.6		48	18	14		196	24	26	.3	.8		232	.32		194	33	.4	428	7.1
Apr. 25	4.53	7.0		39	19	20		173	19	40	.5	.8		c237	.32		175	34	.7	420	7.2
May 27	1.75	9.6		33	16	16		152	15	30	.3	.0		195	.27		148	24	.6	344	7.4
June 20	.64	20		32	19	24		140	21	52	.3	.2		238	.32		158	43	.8	401	7.2
87. SOUTH SAN GABRIEL RIVER AT GEORGETOWN																					
Feb. 24, 1961	b440	10		74	14	14		254	25	18	--	17		c311	0.42		242	34	0.4	520	7.6
Mar. 28	75	--		--	--	--		230	29	25	--	--		--	--		220	32	--	505	7.0
Jan. 4, 1962	16.6	5.1		57	15	17		211	26	23	0.2	9.1		c258	.35		204	31	.5	449	7.4
Oct. 31	5.64	9.4		43	12	14		137	42	21	.3	.0		c217	.30		157	44	.5	368	6.5
Nov. 26	2.63	5.9		44	14	12	1.5	141	45	20	.2	2.0		c216	.29		167	52	.4	379	7.2
Jan. 11, 1963	10.8	5.1		50	18	11	.8	194	21	24	.3	5.5		231	.31		199	40	.3	422	6.9
Feb. 5	1.32	5.0		52	16	17		180	44	25	.3	3.5		c254	.35		196	48	.5	436	7.1
Mar. 18	2.61	4.2		45	15	14		158	41	22	.3	1.2		221	.30		174	44	.5	388	7.0
Apr. 25	1.66	7.3		36	15	16		137	37	23	.7	.8		203	.28		152	39	.6	347	7.5
May 27	.04	7.3		28	17	16		126	29	28	.3	.5		188	.26		140	36	.6	340	6.5
June 30	.25	6.8		28	18	16		136	26	25	.3	6.0		193	.26		144	32	.6	334	7.3

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
88. SAN GABRIEL RIVER AT GEORGETOWN																					
Feb. 24, 1961	e527	9.8		75	15		14	262	24	18	0.1	18		c309	0.42		248	34	0.4	532	7.7
Mar. 28	e201	--		--	--		--	248	28	26	--	--		--	--		246	43	--	538	7.5
Dec. 11	62.5	7.6		--	17		--	--	21	24	.3	11		--	--		--	--	--	--	--
Jan. 4, 1962	53.9	7.0		70	18		14	256	23	26	.2	11		c297	.40		248	38	.4	520	7.2
Jan. 17	43	7.5		68	18		14	249	23	26	.2	12		c298	.41		244	40	.4	523	7.0
Mar. 29	34	7.2		33	17		14	138	23	28	.2	7.0		197	.27		152	39	.5	357	7.5
May 1	89.3	7.6		53	13		12	199	18	18	.2	4.0		c240	.33		186	23	.4	396	7.5
June 11	50.5	11		58	14		11	219	18	17	.3	3.0		240	.33		202	23	.3	421	7.4
Aug. 17	8.08	12		78	19		15	297	17	26	.3	7.6		321	.44		272	29	.4	567	7.0
Sept. 21	11	9.1		76	18		13	286	18	22	.2	9.8		307	.42		264	29	.3	531	7.2
Nov. 14	13	7.6		65	19		15	255	20	24	.3	10		286	.39		240	31	.4	509	7.0
Nov. 26	17	7.3		74	18		12	274	23	22	.3	6.2		298	.41		258	34	.3	537	7.1
Jan. 11, 1963	19.7	4.0		39	12	7.8	.6	146	14	16	.2	5.1		171	.23		147	27	.3	333	7.3
Feb. 5	16	6.9		71	19		13	266	23	24	.2	9.0		307	.42		255	37	.4	529	7.1
Mar. 18	21	6.8		66	17		15	250	24	23	.3	4.8		296	.40		234	30	.4	495	7.0
Apr. 25	15.4	5.3		76	17		19	286	21	26	.7	7.3		c318	.43		260	25	.5	521	7.8
May 27	16.4	8.5		80	19		13	304	18	21	.3	8.8		318	.43		278	28	.3	542	7.2
June 20	7.95	10		76	20		16	300	18	26	.3	6.8		321	.44		272	26	.4	549	7.3
Aug. 1	1.54	15		39	19		16	198	16	21	.3	1.2		224	.30		175	13	.5	393	7.5
Sept. 5	2.7	12		86	22		11	342	14	19	.3	8.1		340	.46		305	24	.3	596	6.8
91. LITTLE BRAZOS RIVER AT STATE HIGHWAY 21 NEAR BRYAN																					
Oct. 24, 1962	3.94	13		43	8.7		68	209	40	55	0.4	0.0		c341	0.46		144	0	2.5	573	7.5
Jan. 2, 1963	30.4	15		51	11		60	152	76	70	.3	.0		c370	.50		172	48	2.0	596	6.5
Mar. 13	24.2	11		56	13		68	146	94	86	.3	.0		c424	.58		193	74	2.1	681	6.6
May 22	90.6	15		59	13		84	200	89	88	.4	1.5		448	.61		200	36	2.6	734	6.9
July 25	6.66	13		84	23		234	318	178	258	.3	1.8		948	1.29		304	44	5.8	1,560	6.8
Oct. 8	.15	9.8		45	17		59	176	23	100	.4	1.0		342	.47		182	38	1.9	618	7.2
Dec. 18	3.80	7.3		51	10		134	350	62	76	.5	.2		513	.70		168	0	4.5	880	7.1
Feb. 24, 1964	9.06	6.1		48	10		87	196	79	76	.3	.0		402	.55		161	0	3.0	658	8.4
Mar. 24	28.2	12		41	11		38	98	71	52	.3	1.5		275	.37		148	67	1.4	488	6.8
June 19	11.1	11		60	14		127	280	93	106	.4	8.1		558	.76		207	0	3.8	932	7.0
Aug. 20	4.14	12		53	28		260	430	153	212	.3	.0		929	1.26		247	0	7.2	1,550	7.4
94. LAKE MEXIA NEAR MEXIA																					
Feb. 13, 1962								128		120				350			125	20		630	7.4

See footnotes at end of table.

Table 4.--Chemical analyses of streams and reservoirs in the Brazos River basin for locations other than daily stations.--Continued

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) (a)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
99. BIG CREEK AT FARM ROAD 1994 NEAR GUY																					
May 2, 1962	b30									22										219	
June 9	b50									18										195	
Dec. 3	b890									10										116	
Feb. 14, 1963	b2									75										564	
Oct. 15	b1.3									310										1,550	
Feb. 6, 1964	b330									16										190	
Mar. 2	b1,100									4.7										398	
100. BIG CREEK AT FARM ROAD 762 NEAR GUY																					
May 2, 1962	b50									402										1,480	
June 9	b60									13										176	
Dec. 3	b1,100									6,890										18,700	
Feb. 14, 1963	b2									85										652	
Oct. 15	b1.8									292										1,500	
Feb. 6, 1964	b440									13,000										33,400	
Mar. 2	b660									9,150										25,100	
101. BIG CREEK AT COUNTY ROAD 9 MILES NORTHEAST OF GUY																					
May 2, 1962	b50									225										934	
June 9	b60									18										232	
Dec. 3	b1,100									5,460										15,300	
Feb. 14, 1963	b2									121										954	
Oct. 15	b2.2									298										1,470	
Feb. 6, 1964	b550									8,850										24,100	
Mar. 2	b660									63										457	
102. COW CREEK AT KITTY NASH ROAD 8 MILES NORTHEAST OF DAMON																					
Apr. 10, 1962	b0.8									208										943	
Dec. 3	b45									10										164	
Feb. 14, 1963	b.3									46										320	
Aug. 15	b220									12										180	
Oct. 15	b.4									645										2,510	
Feb. 4, 1964	b550									15										187	
Feb. 6	b220									21										199	
Aug. 18	b1.3									121										772	
104. VARNER CREEK AT STATE HIGHWAY 35 AT EAST COLUMBIA																					
May 2, 1962	b17									40										262	
Dec 3	b13									1,060										3,460	
Feb. 14, 1963	b.08									1,520										5,000	
Aug. 15	b45									385										1,540	
Jan. 14, 1964	b.1									305										1,540	
Feb. 5, 1964	b550									61										325	
June 16	b2.2									2,600										7,830	
Sept. 17	b66									910										3,040	

a Includes the equivalent of any carbonate (CO_3) present.
b Field estimate.
c Residue on evaporation at 180°C.
d Total Iron.
e Mean daily discharge.

Table 5.--Concentrations of selected constituents (in parts per million) that were equaled or exceeded for indicated percentage of days of flow.

Station (Fig. 3)	Stream and location	Percent of days				
		10	25	50	75	90
6	Double Mountain Fork Brazos River near Aspermont 1949-51, 1957-64 water years:					
	Sulfate (SO_4)	1,900	1,720	1,480	870	425
	Chloride (Cl)	1,950	1,520	1,050	425	170
	Dissolved solids	5,750	4,850	3,770	2,000	1,040
	Hardness as $CaCO_3$	2,470	2,110	1,670	900	460
20	Salt Fork Brazos River near Aspermont 1949-51, 1957-64 water years:					
	Sulfate (SO_4)	3,000	2,920	2,600	1,720	780
	Chloride (Cl)	29,400	25,500	18,700	7,800	2,280
	Dissolved solids	51,500	45,000	33,900	15,000	4,900
	Hardness as $CaCO_3$	4,650	4,400	3,800	2,300	1,030
23	Brazos River at Seymour 1960-64 water years:					
	Sulfate (SO_4)	1,910	1,740	1,500	980	600
	Chloride (Cl)	6,200	5,200	3,750	1,650	720
	Dissolved solids	12,400	10,700	8,100	4,100	2,120
	Hardness as $CaCO_3$	2,300	2,100	1,750	1,060	630
35	California Creek near Stamford 1963-64 water years:					
	Sulfate (SO_4)	2,550	2,220	1,930	1,220	440
	Chloride (Cl)	2,600	2,200	1,800	1,100	380
	Dissolved solids	7,100	6,150	5,200	3,500	1,460
	Hardness as $CaCO_3$	2,600	2,300	2,000	1,400	640

Table 5.--Concentrations of selected constituents (in parts per million) that were equaled or exceeded for indicated percentage of days of flow.--Continued

Station (Fig. 3)	Stream and location	Percent of days				
		10	25	50	75	90
47	Hubbard Creek near Breckenridge					
	1956-61 water years:					
	Sulfate (SO_4)	220	140	62	25	14
	Chloride (Cl)	930	580	240	92	48
	Dissolved solids	1,810	1,280	680	335	210
	Hardness as $CaCO_3$	740	550	320	175	115
	1963-64 water years:					
	Sulfate (SO_4)	340	72	18	13	11
	Chloride (Cl)	275	155	115	94	80
	Dissolved solids	1,000	470	330	278	250
	Hardness as $CaCO_3$	525	258	184	156	141
49	Clear Fork Brazos River at Eliasville					
	1962-64 water years:					
	Sulfate (SO_4)	620	400	205	64	30
	Chloride (Cl)	880	650	410	190	120
	Dissolved solids	2,210	1,600	1,000	500	365
	Hardness as $CaCO_3$	890	640	410	225	175
54	Brazos River below Possum Kingdom Dam, near Graford					
	1943-1964 water years:					
	Sulfate (SO_4)	390	340	305	280	245
	Chloride (Cl)	650	565	500	450	380
	Dissolved solids	1,710	1,510	1,350	1,230	1,080
	Hardness as $CaCO_3$	515	465	425	395	370
64	Brazos River below Whitney Dam, near Whitney					
	1949-51 water years:					
	Sulfate (SO_4)	330	300	245	148	59
	Chloride (Cl)	510	470	400	250	102
	Dissolved solids	1,380	1,290	1,120	770	395
	Hardness as $CaCO_3$	450	425	375	275	165

Table 5.--Concentrations of selected constituents (in parts per million) that were equaled or exceeded for indicated percentage of days of flow.--Continued

Station (Fig. 3)	Stream and location	Percent of days				
		10	25	50	75	90
64	Brazos River below Whitney Dam, near Whitney					
	1953-64 water years:					
	Sulfate (SO_4)	280	245	200	155	113
	Chloride (Cl)	445	400	330	265	195
	Dissolved solids	1,230	1,120	960	795	635
	Hardness as $CaCO_3$	405	375	330	280	235
85	Lampasas River at Youngsport					
	1962-64 water years					
	Sulfate (SO_4)	28	23	20	15	12
	Chloride (Cl)	280	215	170	117	81
	Dissolved solids	660	550	468	370	298
	Hardness as $CaCO_3$	295	262	235	200	172
89	Little River at Cameron					
	1961-64 water years:					
	Sulfate (SO_4)	59	50	42	36	30
	Chloride (Cl)	81	66	52	43	32
	Dissolved solids	447	385	325	289	242
	Hardness as $CaCO_3$	269	234	202	182	156
90	Brazos River at State Highway 21, near Bryan					
	1962-64 water years:					
	Sulfate (SO_4)	195	172	143	107	71
	Chloride (Cl)	330	280	220	152	89
	Dissolved solids	960	850	720	560	400
	Hardness as $CaCO_3$	338	312	280	240	196

Table 5.--Concentrations of selected constituents (in pasts per million) that were equaled or exceeded for indicated percentage of days of flow.--Continued

Station (Fig. 3)	Stream and location	Percent of days				
		10	25	50	75	90
93	Yegua Creek near Somerville					
	1962-64 water years:					
	Sulfate (SO_4)	275	212	125	66	41
	Chloride (Cl)	170	142	86	42	23
	Dissolved solids	800	635	390	220	143
	Hardness as $CaCO_3$	382	300	180	98	62
96	Navasota River near Bryan					
	1959-64 water years:					
	Sulfate (SO_4)	49	43	37	30	24
	Chloride (Cl)	260	180	122	76	49
	Dissolved solids	570	427	320	225	165
	Hardness as $CaCO_3$	150	125	103	80	61
97	Brazos River at Richmond					
	1943-51 water years:					
	Sulfate (SO_4)	196	149	86	53	36
	Chloride (Cl)	330	240	127	72	45
	Dissolved solids	960	750	465	315	235
	Hardness as $CaCO_3$	347	290	206	156	126
	1955-64 water years:					
	Sulfate (SO_4)	182	137	92	60	40
	Chloride (Cl)	300	219	136	82	51
	Dissolved solids	895	695	490	345	255
	Hardness as $CaCO_3$	330	275	215	166	134

Table 6.--Annual summaries of water discharge and dissolved solids, chloride, and sulfate loads at selected stations in the Brazos River basin.

Water Year	Water discharge (cfs)	Dissolved solids		Chloride		Sulfate	
		Weighted-average concentration	Load (tons per day)	Weighted-average concentration	Load (tons per day)	Weighted-average concentration	Load (tons per day)
6. DOUBLE MOUNTAIN FORK BRAZOS RIVER NEAR ASPERMONT							
1949	139	916	344	150	56.3	380	143
1950	171	1,010	466	148	68.3	460	212
1951	63.0	1,430	243	203	34.5	700	119
1957	352	910	865	123	112	400	380
1958	130	1,390	488	265	93.0	592	208
1959	219	999	591	168	99.3	429	254
1960	149	977	393	159	64.0	410	165
1961	398	1,180	1,270	237	255	472	507
1962	173	1,140	532	217	101	455	213
1963	164	1,120	496	220	97.4	457	202
1964	18.8	2,090	106	466	23.7	875	44.4
Avg. 1949-51 1957-64	180	1,090	530	189	91.9	458	223
Avg. 1949-64	184	1,040	520	180	90	430	215
20. SALT FORK BRAZOS RIVER NEAR ASPERMONT							
1949	157	4,080	1,730	1,820	771	709	301
1950	166	4,870	2,180	2,230	999	786	352
1951	64.5	7,380	1,290	3,560	620	1,020	178
1957	299	3,220	2,600	1,360	1,050	625	505
1958	71.4	8,500	1,640	4,410	850	826	159
1959	126	5,020	1,710	2,420	823	666	227
1960	80.2	5,660	1,230	3,820	611	653	141
1961	253	5,030	3,440	2,290	1,560	817	558
1962	63.2	9,150	1,560	4,490	766	1,200	205
1963	80.8	6,070	1,320	2,900	633	854	186
1964	19.1	18,600	959	9,960	514	1,570	81.0
Avg. 1949-51 1957-64	125	5,270	1,780	2,480	837	776	262
Avg. 1949-64	132	4,890	1,740	2,300	820	725	260
23. BRAZOS RIVER AT SEYMOUR							
1960	279	2,510	1,890	975	734	576	434
1961	807	2,270	4,950	817	1,780	592	1,290
1962	308	2,750	2,290	1,060	881	659	548
1963	299	2,850	2,300	1,110	896	646	522
1964	87.7	3,390	803	1,410	334	711	168
Avg. 1960-64	356	2,540	2,440	962	925	616	592
47. HUBBARD CREEK NEAR BRECKENRIDGE							
1956	22.7	212	13.0	58	3.55	11	0.67
1957	633	180	308	46	78.6	10	17.1
1958	204	332	183	129	71.1	23	12.7
1959	47.9	325	42.0	121	15.6	24	3.10
1960	83.0	330	74.0	120	26.9	25	5.60
1961	134	300	109	109	39.4	20	7.24
Avg. 1956-61	187	240	121	77	38.9	15	7.57

Table 6.--Annual summaries of water discharge and dissolved solids, chloride, and sulfate loads at selected stations in the Brazos River basin.--Continued

Water Year	Water discharge (cfs)	Dissolved solids		Chloride		Sulfate	
		Weighted-average concentration	Load (tons per day)	Weighted-average concentration	Load (tons per day)	Weighted-average concentration	Load (tons per day)
			49. CLEAR FORK BRAZOS RIVER AT ELIASVILLE				
1962	540	505	736	156	227	95	139
1963	194	661	346	203	106	149	78.0
1964	71.7	627	121	273	52.9	63	12.2
Avg. 1962-64	269	553	402	178	129	105	76.3
			54. BRAZOS RIVER BELOW POSSUM KINGDOM DAM, NEAR GRAFORD				
1943	1,161	994	3,110	370	1,160	201	630
1944	164	1,310	580	498	221	274	121
1945	528	1,390	1,980	561	800	256	365
1946	502	1,320	1,790	519	703	262	355
1947	1,343	1,380	5,000	530	1,920	303	1,100
1948	470	1,460	1,850	510	647	374	475
1949	769	1,500	3,110	531	1,100	375	779
1950	898	1,230	2,980	451	1,090	280	679
1951	603	1,320	2,150	490	798	291	474
1952	294	1,390	1,100	527	418	295	234
1953	220	1,610	956	636	378	322	191
1954	1,052	1,200	3,410	460	1,310	245	696
1955	1,120	1,260	3,810	448	1,350	301	910
1956	983	1,370	3,640	445	1,180	379	1,010
1957	4,145	443	4,960	119	1,330	108	1,210
1958	1,226	1,180	3,910	443	1,470	248	821
1959	458	1,130	1,400	425	526	235	291
1960	749	1,400	2,830	546	1,100	288	582
1961	1,409	1,800	6,850	697	2,650	398	1,510
1962	1,138	1,360	4,180	500	1,540	313	962
1963	867	1,320	3,090	496	1,160	286	669
1964	231	1,380	861	515	321	307	191
Avg. 1949-64	1,010	1,130	3,080	406	1,110	257	701
Avg. 1943-64	924	1,160	2,890	422	1,050	260	649
			64. BRAZOS RIVER BELOW WHITNEY DAM, NEAR WHITNEY				
1949	1,566	765	3,230	242	1,020	172	727
1950	1,520	748	3,070	244	1,000	157	644
1951	840	1,190	2,700	437	991	260	590
1952	348	912	857	332	312	167	157
1953	141	651	248	209	79.6	112	42.6
1954	912	1,040	2,560	392	965	198	488
1955	997	1,030	2,770	374	1,010	205	552
1956	1,571	1,010	4,280	333	1,410	255	1,080
1957	6,213	459	7,700	126	2,110	96	1,610
1958	2,322	604	3,790	170	1,070	122	765
1959	681	893	1,640	309	568	165	303
1960	1,882	705	3,580	229	1,160	130	661
1961	2,054	1,040	5,770	373	2,070	213	1,180
1962	1,737	1,030	4,830	364	1,710	227	1,060
1963	1,215	896	2,940	309	1,010	189	620
1964	434	1,070	1,250	396	464	226	265
Avg. 1949-64	1,527	777	3,200	257	1,060	163	672

Table 6.--Annual summaries of water discharge and dissolved solids, chloride, and sulfate loads at selected stations in the Brazos River basin.--Continued

Water Year	Water discharge (cfs)	Dissolved solids		Chloride		Sulfate	
		Weighted-average concentration	Load (tons per day)	Weighted-average concentration	Load (tons per day)	Weighted-average concentration	Load (tons per day)
			85. LAMPASAS RIVER AT YOUNGSPORT				
1962	102	354	97.5	98	27.0	22	6.1
1963	57.4	373	57.8	119	18.4	20	3.1
1964	86.5	301	70.3	84	19.6	15	3.5
Avg. 1961-64	82.0	340	75.3	98	21.7	19	4.2
			89. LITTLE RIVER AT CAMERON				
1961	4,154	279	3,130	27	303	31	348
1962	854	302	696	43	99.1	37	85.3
1963	475	301	386	46	59.0	44	56.4
1964	573	263	407	40	61.9	29	44.9
Avg. 1961-64	1,514	282	1,150	32	131	33	135
			90. BRAZOS RIVER AT STATE HIGHWAY 21, NEAR BRYAN				
1962	3,538	669	6,390	196	1,870	134	1,280
1963	1,896	703	3,600	217	1,110	146	747
1964	1,334	511	1,840	143	515	96	346
Avg. 1962-64	2,256	647	3,940	191	1,160	130	792
			93. YEGUA CREEK NEAR SOMERVILLE				
1962	131	319	113	65	23.0	98	34.7
1963	234	194	123	39	24.6	57	36.0
1964	41.4	162	18.1	26	2.9	45	5.0
Avg. 1962-64	135	231	84.2	46	16.8	69	25.2
			96. NAVASOTA RIVER NEAR BRYAN				
1959	529	226	323	80	114	25	35.7
1960	532	248	356	85	122	33	47.4
1961	1,373	143	530	44	163	19	70.4
1962	289	328	256	125	97.5	40	31.2
1963	48.7	288	37.9	110	14.5	43	5.7
1964	52.0	317	44.5	141	19.8	30	4.2
Avg. 1959-64	471	203	258	70	89.0	26	33.1
			97. BRAZOS RIVER AT RICHMOND				
1946	10,220	299	8,250	53	1,460	39	1,080
1947	8,765	425	10,100	100	2,370	70	1,660
1948	2,687	479	3,480	118	856	84	609
1949	4,645	423	5,310	103	1,290	76	953
1950	5,783	368	5,750	87	1,360	58	906
1951	1,418	696	2,660	214	819	134	513
1952	1,820	370	1,820	85	418	54	265
1953	4,105	215	2,380	31	344	25	277
1954	2,727	453	3,340	127	935	72	530
1955	2,168	498	2,920	145	849	83	486

Table 6.--Annual summaries of water discharge and dissolved solids, chloride, and sulfate loads at selected stations in the Brazos River basin.--Continued

Water Year	Water discharge (cfs)	Dissolved solids		Chloride		Sulfate	
		Weighted-average concentration	Load (tons per day)	Weighted average concentration	Load (tons per day)	Weighted average concentration	Load (tons per day)
			97. BRAZOS RIVER AT RICHMOND--Continued				
1956	2,158	834	4,860	260	1,510	185	1,080
1957	15,290	317	13,090	65	2,680	54	2,230
1958	11,870	303	9,710	57	1,830	50	1,600
1959	4,450	323	3,880	74	889	51	613
1960	8,869	331	7,930	67	1,600	50	1,200
1961	16,130	312	13,590	64	2,790	49	2,130
1962	4,508	551	6,710	156	1,900	106	1,290
1963	2,759	513	3,820	145	1,080	100	745
1964	1,715	419	1,940	111	514	74	343
Avg. 1949-64	5,651	367	5,600	85	1,300	62	946
Avg. 1946-64	5,899	368	5,860	84	1,340	61	972

Table 7.--Summary of estimated yields of dissolved solids, chloride, and sulfate for selected drainage areas, 1949-64 water years.

Sub-basin and location	Contributing drainage area (square miles)	Dissolved-solids yield		Chloride yield		Sulfate yield	
		Tons per day	Tons per sq mile per year	Tons per day	Tons per sq mile per year	Tons per day	Tons per sq mile per year
Upper Brazos River basin (area upstream from Possum Kingdom Dam).....	13,310	3,080	84	1,110	30	700	19
Double Mountain Fork sub-basin upstream from Aspermont station.	1,510	520	125	90	21	215	52
Salt Fork sub-basin upstream from Aspermont station..........	2,060	1,740	308	820	145	260	46
Salt Croton Creek sub-basin upstream from Aspermont station.	64.3	850	4,830	485	2,750	30	170
Remainder of contributing area in upper Brazos River basin........	9,740	825	31	200	8	230	9
Middle Brazos River basin (area between Possum Kingdom and Whitney Dams)....	3,620	267	28	21	2	21	2
Palo Pinto Creek sub-basin upstream from Santo station................	567	39	25	5	3	3	2
Lower Brazos River basin (area between Whitney Dam and Richmond station)...	17,850	2,580	53	281	6	304	6
Bosque River sub-basin upstream from Waco station.................	1,655	222	49	17	4	33	7
Little River sub-basin upstream from Cameron station..............	6,982	968	51	110	6	114	6
Yegua Creek sub-basin upstream from Somerville station..........	1,008	125	45	25	9	37	13
Navasota River sub-basin upstream from Bryan station................	1,429	220	56	76	19	28	7

Table 8.--Observed average concentrations and loads of dissolved solids, chloride, and sulfate at selected sites on the Brazos River for the 1957-64 water years and hypothetical averages based on partial control of natural salinity.

Constituent	Observed weighted average		With low flow (2 cfs or less) of Salt Croton Creek removed.		With 90 percent of salt load of Salt Croton Creek removed.		With 90 percent of salt from Salt Croton Creek controlled, plus partial control of other sources.	
	ppm	Tons per day	ppm	Tons per day	ppm	Tons per day	ppm	Tons per day
a/ 54. BRAZOS RIVER BELOW POSSUM KINGDOM DAM NEAR GRAFORD								
Dissolved solids	1,020	3,510	861	2,970	794	2,740	765	2,640
Chloride	365	1,260	270	930	239	825	229	790
Sulfate	226	780	223	770	218	750	212	730
63. BRAZOS RIVER BELOW WHITNEY DAM NEAR WHITNEY								
Dissolved solids	705	3,930	608	3,390	566	3,160	548	3,060
Chloride	228	1,270	168	940	150	835	143	800
Sulfate	145	810	143	800	140	780	136	760
97. BRAZOS RIVER AT RICHMOND								
Dissolved solids	343	7,590	318	7,050	308	6,820	304	6,720
Chloride	75	1,660	60	1,330	55	1,220	54	1,190
Sulfate	57	1,260	56	1,250	56	1,230	55	1,210

a/ Data from Hughes (1965, p. 6)

Table 9.--Source and significance of dissolved mineral constituents and properties of water.

Constituent or property	Source or cause	Significance
Silica (SiO_2)	Dissolved from practically all rocks and soils, commonly less than 30 ppm. High concentrations, as much as 100 ppm, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 ppm of iron in surface waters generally indicate acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 ppm stain laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. U.S. Public Health Service (1962) drinking-water standards state that iron should not exceed 0.3 ppm. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (See hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and potassium (K)	Dissolved from practically all rocks and soils. Found also in ancient brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high content may limit the use of water for irrigation.
Bicarbonate (HCO_3) and carbonate (CO_3)	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. U.S. Public Health Service (1962) drinking-water standards recommend that the sulfate content should not exceed 250 ppm.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. U.S. Public Health Service (1962) drinking-water standards recommend that the chloride content should not exceed 250 ppm.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual. (Maier, 1950)
Nitrate (NO_3)	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average may suggest pollution. U.S. Public Health Service (1962) drinking-water standards suggest a limit of 45 ppm. Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing inter-crystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes some water of crystallization.	U.S. Public Health Service (1962) drinking-water standards recommend that waters containing more than 500 ppm dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 ppm dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$	In most waters nearly all the hardness is due to calcium and magnesium. All the metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness as much as 60 ppm are considered soft; 61-120 ppm, moderately hard; 121-180 ppm, hard; more than 180 ppm, very hard.
Specific conductance (micromhos at 25° C)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
Hydrogen ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, and phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.

Table 10.--Water-quality tolerances for industrial applications. 1/

[Allowable limits in parts per million except as indicated]

Industry	Turbidity	Color	Color + O_2 consumed	D.C. (ml/1)	Odor	Hardness	Alkalinity (as $CaCO_3$)	pH	Total solids	Ca	Fe	Mn	Fe + Mn	Al_2O_3	SiO_2	Cu	F	CO_3	HCO_3	OH	$CaSO_4$	Na_2SO_4 to Na_2SO_3 ratio	General 2/
Air conditioning 3/	--	--	--	--	--	--	--	--	--	--	0.5	0.5	0.5	--	--		--	--	--	--	--	--	A, B
Baking	10	10	--	--	--	(4)	--	--	--	--	.2	.2	.2	--	--		--	--	--	--	--	--	C
Boiler feed:																							
0-150 psi	20	80	100	2	--	75	--	8.0+	3,000-1,000	--	--	--	--	5	40		--	200	50	50	--	1 to 1	--
150-250 psi	10	40	50	.2	--	40	--	8.5+	2,500-500	--	--	--	--	.5	20		--	100	30	40	--	2 to 1	--
250 psi and up	5	5	10	0	--	8	--	9.0+	1,500-100	--	--	--	--	.05	5		--	40	5	30	--	3 to 1	--
Brewing: 5/																							
Light	10	--	--	--	Low	--	75	6.5-7.0	500	100-200	.1	.1	.1	--	--		1	--	--	--	100-200	--	C, D
Dark	10	--	--	--	Low	--	150	7.0 →	1,000	200-500	.1	.1	.1	--	--		1	--	--	--	200-500	--	C, D
Canning:																							
Legumes	10	--	--	--	Low	25-75	--	--	--	--	.2	.2	.2	--	--		--	--	--	--	--	--	C
General	10	--	--	--	Low	--	--	--	--	--	.2	.2	.2	--	--		1	--	--	--	--	--	C
Carbonated beverages 6/	2	10	10	--	0	250	50	--	850	--	.2	.2	.3	--	--		.2	--	--	--	--	--	C
Confectionary	--	--	--	--	Low	--	--	(7)	100	--	.2	.2	.2	--	--		--	--	--	--	--	--	--
Cooling 8/	50	--	--	--	--	50	--	--	--	--	.5	.5	.5	--	--		--	--	--	--	--	--	A, B
Food, general	10	--	--	--	Low	--	--	--	--	--	.2	.2	.2	--	--		--	--	--	--	--	--	C
Ice (raw water) 9/	1-5	5	--	--	--	--	30-50	--	300	--	.2	.2	.2	--	10		--	--	--	--	--	--	C
Laundering	--	--	--	--	--	50	--	--	--	--	.2	.2	.2	--	--		--	--	--	--	--	--	--
Plastics, clear, undercolored	2	2	--	--	--	--	--	--	200	--	.02	.02	.02	--	--		--	--	--	--	--	--	--
Paper and pulp: 10/																							
Groundwood	50	20	--	--	--	180	--	--	--	--	1.0	.5	1.0	--	--		--	--	--	--	--	--	A
Kraft pulp	25	15	--	--	--	100	--	--	300	--	.2	.1	.2	--	--		--	--	--	--	--	--	--
Soda and sulfite	15	10	--	--	--	100	--	--	200	--	.1	.05	.1	--	--		--	--	--	--	--	--	--
Light paper, HL-Grade	5	5	--	--	--	50	--	--	200	--	.1	.05	.1	--	--		--	--	--	--	--	--	B
Rayon (viscose) pulp:																							
Production	5	5	--	--	--	8	50	--	100	--	.05	.03	.05	<8.0	<25	<5	--	--	--	--	--	--	--
Manufacture	.3	--	--	--	--	55	--	7.8-8.3	--	--	.0	.0	.0	--	--		--	--	--	--	--	--	--
Tanning 11/	20	10-100	--	--	--	50-135	135	8.0	--	--	.2	.2	.2	--	--		--	--	--	--	--	--	--
Textiles:																							
General	5	20	--	--	--	20	--	--	--	--	.25	.25	--	--	--		--	--	--	--	--	--	--
Dyeing 12/	5	5-20	--	--	--	20	--	--	--	--	.25	.25	.25	--	--		--	--	--	--	--	--	--
Wool scouring 13/	--	70	--	--	--	20	--	--	--	--	1.0	1.0	1.0	--	--		--	--	--	--	--	--	--
Cotton bandage 13/	5	5	--	--	Low	20	--	--	--	--	.2	.2	.2	--	--		--	--	--	--	--	--	--

1 American Water Works Association, 1950.
2 A--No corrosiveness; B--No slime formation; C--Conformance to Federal drinking water standards necessary; D--NaCl, 275 ppm.
3 Waters with algae and hydrogen sulfide odors are most unsuitable for air conditioning.
4 Some hardness desirable.
5 Water for distilling must meet the same general requirements as for brewing (gin and spirits mashing water of light-beer quality; whiskey mashing water of dark-beer quality).
6 Clear, odorless, sterile water for syrup and carbonization. Water consistent in character. Most high quality filtered municipal water not satisfactory for beverages.
7 Hard candy requires pH of 7.0 or greater, as low value favors inversion of sucrose, causing sticky product.
8 Control of corrosiveness is necessary as is also control of organisms, such as sulfur and iron bacteria, which tend to form slimes.
9 $Ca(HCO_3)_2$ particularly troublesome. $Mg(HCO_3)_2$ tends to greenish color. CO_2 assists to prevent cracking. Sulfates and chlorides of Ca, Mg, Na should each be less than 300 ppm (white butts).
10 Uniformity of composition and temperature desirable. Iron objectionable as cellulose adsorbs iron from dilute solutions. Manganese very objectionable, clogs pipelines and is oxidized to permanganates by chlorine, causing reddish color.
11 Excessive iron, manganese or turbidity creates spots and discoloration in tanning of hides and leather goods.
12 Constant composition; residual alumina 0.5 ppm.
13 Calcium, magnesium, iron, manganese, suspended matter, and soluble organic matter may be objectionable.

Table 11.--Suitability of waters for irrigation

Station (Fig. 3)	Source	Date or period	Salinity hazard (C) and sodium hazard (S) that was equaled or exceeded for indicated percentage of days of flow at selected daily chemical-quality stations.					Salinity hazard (C) and sodium hazard (S) of water from miscellaneous sites
			10	25	50	75	90	
6	Double Mountain Fork Brazos River near Aspermont	1949-51, 1957-64	C4-S4	C4-S4	C4-S3	C4-S2	C3-S1	--
20	Salt Fork Brazos River near Aspermont	1949-51, 1957-64	C4-S4	C4-S4	C4-S4	C4-S4	C4-S4	--
23	Brazos River at Seymour	1960-64	C4-S4	C4-S4	C4-S4	C4-S4	C4-S3	--
24	Millers Creek near Munday	Oct. 10, 1962	--	--	--	--	--	C2-S1
49	Clear Fork Brazos River at Eliasville	1962-64	C4-S2	C4-S2	C3-S1	C3-S1	C2-S1	--
54	Brazos River below Possum Dam, near Graford	1943-64	C4-S2	C4-S2	C4-S2	C3-S2	C3-S2	--
59	Palo Pinto Creek near Santo	Oct.14, 1962	--	--	--	--	--	C2-S1
61	Paluxy Creek at Glen Rose	June 5, 1962	--	--	--	--	--	C2-S1
62	Lake Pat Cleburne near Cleburne	May 14, 1965	--	--	--	--	--	C2-S1
64	Brazos River below Whitney Dam, near Whitney	1953-64	C3-S2	C3-S2	C3-S2	C3-S1	C3-S1	--
70	Wace Reservoir near Waco	May 24, 1965	--	--	--	--	--	C2-S1
76	Proctor Reservoir near Proctor	Oct. 1, 1965	--	--	--	--	--	C2-S1
81	Belton Reservoir near Belton	Oct. 1, 1965	--	--	--	--	--	C2-S1
85	Lampasas River at Youngsport	1962-64	C3-S1	C3-S1	C3-S1	C2-S1	C2-S1	--
89	Little River at Cameron	1961-64	C3-S1	C2-S1	C2-S1	C2-S1	C2-S1	--
93	Yegua Creek near Somerville	1962-64	C3-S1	C3-S1	C2-S1	C2-S1	C1-S1	--
96	Navasota River near Bryan	1959-64	C3-S1	C3-S1	C2-S1	C2-S1	C2-S1	--
97	Brazos River at Richmond	1955-64	C3-S1	C3-S1	C3-S1	C2-S1	C2-S1	--