TEXAS WATER DEVELOPMENT BOARD

REPORT 134

RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE NUECES RIVER BASIN, TEXAS

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Prepared by the U.S. Geological Survey
in cooperation with the
Texas Water Development Board

September 1971

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ABSTRACT

The kinds and quantities of minerals dissolved in surface waters of the Nueces River basin are related principally to the geology of the area and to rainfall and streamflow characteristics; but industrial influences, particularly the disposal of oil-field brine, have affected the quality in some areas.

The basin lies in two physiographic sections—the Edwards Plateau of the Great Plains province and the West Gulf Coastal Plain of the Coastal Plain province. The Edwards and associated limestones and the Glen Rose Limestone of Cretaceous age are exposed on the Edwards Plateau. Rocks exposed in the West Gulf Coastal Plain range in age from Late Cretaceous to Holocene.

Separate and distinct streamflow patterns exist in the two provinces. In the Edwards Plateau section, where streamflow is partially sustained by seeps and springs, flow in the larger streams is perennial. As these streams cross the Balcones Fault Zone (Balcones Escarpment), substantial channel losses occur. Streamflow in the West Gulf Coastal Plain, which is almost entirely dependent on runoff from local precipitation, is intermittent and highly erratic.

Water in surface streams throughout the Edwards Plateau is generally consistently of good chemical quality, having a dissolved-solids content of less than 250 mg/l (milligrams per liter). The water is very hard, and the principal constituents are calcium and bicarbonate. The chemical quality of water of streams in the West Gulf Coastal Plain section varies from poor to excellent. During low flow the water generally contains high dissolved-solids concentrations, in which sodium and chloride predominate. During the short periods of high flow, dissolved-solids concentrations are low and calcium and bicarbonate are the principal constituents. Chemical quality of water in existing impoundments and of water available for storage in potential reservoirs is generally good. Dissolved-solids concentrations are less than 300 mg/l, with calcium and bicarbonate predominating.

Some streams in the southern part of the basin have been degraded from time to time by oil-field brine and by return flow from irrigation. Municipal and industrial wastes may also affect water quality during low flow. These detrimental effects are minimized in impoundments, however, because there is sufficient runoff for dilution.

Lake Corpus Christi provides water of good quality for municipal supply, irrigation, and industrial use. Potential reservoirs on the larger streams in the Nueces River basin would probably store water of similar quality.

RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE NUECES RIVER BASIN, TEXAS

INTRODUCTION

The investigation of the chemical quality of the surface waters of the Nueces River basin was made by the U.S. Geological Survey in cooperation with the Texas Water Development Board as part of a statewide reconnaissance. Reports that have been prepared are listed in the references.

The purpose of this report is to present available chemical-quality data and interpretations that will aid in the proper development, management, and use of the surface-water resources of the Nueces River basin. In the study, the following factors were considered: the nature and concentrations of mineral constituents in solution; the geologic, hydrologic, and cultural influences that determine the water quality; and the suitability of the water for domestic supply, industrial use, and irrigation.

A network of daily chemical-quality stations on principal streams in Texas is operated by the U.S. Geological Survey in cooperation with the Texas Water Development Board and with federal and local agencies. However, this network has not been adequate to inventory completely the chemical quality of surface waters in the State. To supplement the information being obtained by the network, a cooperative statewide reconnaissance by the U.S. Geological Survey and Texas Water Development Board was begun in September 1961. During this investigation, samples for chemical analysis were collected periodically at numerous sites throughout Texas so that some water-quality information would be available for locations where water-development projects are likely to be built. These data aid in the delineation of areas having water-quality problems and in the identification of probable sources of pollution, thus indicating areas in which more detailed investigations are needed.

For this reconnaissance, water-quality data were collected from the principal streams and many tributaries, the major reservoirs, and at a number of potential reservoir sites.

Other agencies that cooperated in the collection of chemical-quality and streamflow data are the Lower Nueces River Water Supply District, the Zavala and Dimmit Counties Water Improvement District No. 1, the Edwards Underground Water District, and the Texas State Department of Health.

NUECES RIVER DRAINAGE BASIN

General Description

The Nueces River basin is in two physiographic sections—the Edwards Plateau of the Great Plains province and the West Gulf Coastal Plain of the Coastal Plain province (Figure 1). The Balcones Escarpment, which separates these two sections, extends westward from San Antonio (about 30 miles east of the report area) across Medina, Uvalde, and Kinney Counties. The basin is bounded on the north and east by the Colorado, Guadalupe, and San Antonio River basins, and the San Antonio-Nueces coastal basin; and on the west and south by the Rio Grande basin and Nueces-Rio Grande coastal basin. The drainage area, which includes all or parts of 21 counties, is about 17,000 square miles.

The Nueces River rises in Edwards County at an elevation of about 2,400 feet and flows 315 miles southeastward to Nueces Bay on the Gulf of Mexico near Corpus Christi. The Frio River, which joins the Nueces River below Three Rivers, is the principal tributary to the Nueces River.

The Edwards Plateau and the Balcones Escarpment are partly protected from erosion by a cap of very resistant limestone. Therefore, in the northernmost part of the Nueces River basin, broad areas of the plateau are relatively undissected by stream erosion. Grass, small trees, and brush cover this part of the plateau. Southward, valleys have been cut in the plateau, and remnants of the resistant limestone caps form cliffs on the crests of the divides. Liveoak, juniper, and sparse stands of native grasses grow on the rocky hills and slopes. Pecan, cypress, sycamore, willow, and native grasses grow on the valley floors.

Figure 1.—Index Map of Texas Showing River Basins and Coastal Areas

The West Gulf Coastal Plain extends from the Balcones Escarpment to the Gulf of Mexico. The terrain is rolling to moderately hilly near the Balcones Escarpment; parallel to the coast line low ridges are formed by beds of resistant sandstone. The streams that drain the West Gulf Coastal Plain have flood plains bounded by terraces that may be several miles wide. Mesquite, several varieties of native brushes, and native grasses grow on the low divides and valley floors. Pecan and other large trees grow along the stream channels.

Population and Economic Development

The population of the Nueces River basin in 1970 was more than 130,000. Cities with a population of more than 5,000 were Uvalde (10,403), Crystal City (8,012), Mathis (5,043), and Carrizo Springs (5,699). A small part of Corpus Christi is in the Nueces River basin; the remaining part of the city is in the Nueces-Rio Grande coastal basin.

The economy of the Nueces River basin is based chiefly on agriculture. Only a small amount of land along the streams in the Edwards Plateau area is suitable for farming; consequently, almost all of the Plateau area is devoted to ranching of goats, sheep, and cattle. Cattle ranching is extensively practiced, in the West Gulf Coastal Plain area, and where ground water is available for irrigation, truck crops, grains, cotton, and livestock feeds are grown.

Oil and gas production and oil-field supply are the major nonagrarian sources of income. The greatest concentration of oil and gas fields is in the southern half of the basin (Figure 6). Production of oil and natural gas in the basin began in 1928 with the discovery of Government Wells North Field in Duval County. Since then, oil and gas fields have been developed in many other parts of the West Gulf Coastal Plain section of the basin.

Tourism and recreation aid the economy of the entire area. Hunting is an important revenue source throughout the basin. The outdoor water-oriented recreation afforded by Lake Corpus Christi and Nueces Bay attract many visitors each year.

SURFACE WATER

Streamflow Records

Streamflow records in the Nueces River basin date from 1915, when the U.S. Geological Survey established streamflow stations on the Frio River near Derby and the Nueces River near Three Rivers. Since that time, other streamflow stations have been established on the Nueces, Sabinal, Frio, and Atascosa Rivers, and on Seco, Hondo, San Miguel, and San Casimiro Creeks. In 1968, the Geological Survey was operating 24 streamflow stations. During this reconnaissance, discharge was measured at other sites where water-quality samples were collected for chemical analysis.

The periods of record for all streamflow stations in the Nueces River basin are given in Table 3 and the locations of these stations are shown on Figure 8. Records of discharge and stage of streams in the Nueces River basin from 1915 to 1960 have been published in the annual series of the U.S. Geological Survey Water-Supply Papers (see table at end of list of references). Beginning with the 1961 water year, streamflow records have been released by the Geological Survey in annual reports for each state (U.S. Geological Survey, 1961-1967). Summaries of discharge records have been published giving monthly and annual totals (U.S. Geological Survey, 1960, 1964a; Texas Board of Water Engineers, 1958).

Streamflow Occurrence

Flow of streams in the Edwards Plateau area of the Nueces River basin is sustained by springs and seeps and local precipitation. As these streams cross the Balcones Escarpment, they lose much of their flow to the subsurface. South of the Balcones Escarpment, tributary streams derive very little, if any, flow from springs, and streamflow is dependent primarily on the quantity and intensity of local precipitation.

Springflow

The Edwards and associated limestones are recharged primarily by precipitation on the outcrops. The water moves rapidly downward from the surface to the water table, thence laterally to areas along stream valleys where it is discharged through seeps and springs at the contacts between the Edwards and associated limestones and the underlying Glen Rose Limestone. This springflow maintains continuous flow in some of the streams in the Edwards Plateau area.

Precipitation

Average precipitation ranges from about 20 inches in the west to about 28 inches in the east. Mean annual precipitation in the basin; average monthly precipitation at Eagle Pass (just west of the report area), Pearsall, and Beeville (just east of the report area); and annual precipitation for the period 1931-67 at Pearsall are shown on Figure 2. Average monthly rainfall is usually at a peak in May and again in September (see average monthly precipitation data for Eagle Pass, Pearsall, and Beeville on Figure 2). Rainfall throughout the basin is relatively low and is subject to much greater variations than indicated by the annual and monthly averages. For example, during the 1931-67 period, precipitation at the three stations in Figure 2 ranged from 0.00 inch during several months to 22.62 inches at Beeville in September 1967. Precipitation that is so unevenly distributed is not conducive to sustaining streamflow; therefore, flow in most tributaries in the basin is intermittent, and long periods of no flow have occurred in the streams in the West Gulf Coast Plain area of the Nueces River basin.

Runoff

Runoff is defined as that part of precipitation appearing in surface streams and is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on stream channels (Langbein and Iseri, 1960). The natural runoff pattern of streams in the Nueces River basin is altered by many small diversions for irrigation and domestic supply, by the Upper Nueces Reservoir above Crystal City, and by Lake Corpus Christi near Mathis (Figure 8).

The average annual runoff for the period 1924-68 from the Nueces River at Laguna and near Three Rivers was 2.4 and 0.7 inches respectively (Figure 2). Annual runoff expressed as mean discharge in cfs (cubic feet per second) and in inches per year is shown on Figure 2 for the Nueces River at Laguna and near Three Rivers. Total runoff for the basin is less than 1 inch.

Because runoff in the Edwards Plateau area is not entirely dependent on local precipitation, streams cease to flow only after long periods of no rainfall. Streamflow records show that the Nueces River near Laguna has flowed continuously since the establishment of this station in 1923.

A contrasting situation exists in the West Gulf Coast Plain area of the Nueces River basin. Runoff is almost entirely dependent on the low, highly variable, local precipitation. Therefore, runoff in streams in this area of the basin is also highly variable. Discharge of the Nueces River near Three Rivers has ranged from no flow on many occasions to 141,000 cfs on September 23,1967.

The magnitude and frequency of high and low flows can be shown by flow-duration curves. A curve with a steep trend throughout indicates a highly variable stream whose flow is largely from direct runoff, whereas a curve with a flat trend shows surface- or ground-water storage. Flow duration curves for the Nueces River at Laguna and near Three Rivers are shown on Figure 3. The steep slope of the curve for the Nueces River near Three Rivers and the gradually decreasing trend of the curve for the Nueces River at Laguna further illustrates the runoff pattern in the two provincial areas of the Nueces River basin.

Surface-Water Development

Because precipitation and runoff are variable in most of the Nueces River basin, storage projects are necessary to maintain dependable supplies. At present many small diversions for irrigation and domestic supply are located on streams throughout the Nueces River basin, and there are two reservoirs with capacities of over 5,000 acre-feet on the Nueces River (Figure 8). The Upper Nueces Reservoir (7,590 acre-feet capacity) above Crystal City is owned and operated by the Zavala and Dimmit Counties Water Improvement District No. 1. Water in this reservoir is used for irrigation. Lake Corpus Christi near Mathis is owned and operated by the Lower Nueces River Water Supply District. This reservoir, with a capacity of 297,800 acre-feet, supplies water for municipal supply and industrial use.

The Texas Water Plan (Texas Water Development Board, 1968) includes the provision for construction of either Choke Canyon or R&M (Reagan and McCaughan) Reservoirs, depending on local decisions as to which of the two alternatives is desired, and possible construction of Montell, Concan, and Sabinal Reservoirs in the basin (Figure 8). Choke Canyon Reservoir would be located on the Frio River above Three Rivers. R&M Reservoir, the alternative to Choke Canyon Reservoir, would be located on the Nueces River below Lake Corpus Christi. Montell, Concan, and Sabinal Reservoirs would provide flood control on the upper Nueces, Frio, and Sabinal rivers, and supplemental recharge to the Edwards and associated limestones during periods of high streamflow.

CHEMICAL QUALITY OF THE WATER

Chemical-Quality Records

Daily chemical-quality sampling in the Nueces River basin began in October 1941, at the station Nueces River near Three Rivers. The sampling station Nueces River at Cotulla was established in January 1942. The Cotulla station was discontinued in December 1942, and the Three Rivers station was discontinued in October 1952. The stations Nueces River near Mathis (established in October 1947) and the Frio River at Calliham (established in October 1967) were the only daily chemical-quality stations operating in the Nueces River basin in 1968. Periodic sampling was begun as early as 1930, but was sporadic until 1962 when a more intense periodic data-collection program was begun. During this reconnaissance, numerous samples were collected for chemical analyses, and discharge measurements were made at miscellaneous sites on streams throughout the basin.

Locations of the data-collection sites are shown on Figure 8, and selected chemical-quality data for the daily stations are given in Table 4. Results of all periodic analyses are given in Table 5. The complete records are published in an annual series of U.S. Geological Survey Water-Supply Papers and reports of the Texas Water Development Board (see table at end of list of references).

Factors Affecting Chemical Quality of Water

The chemical quality of surface water depends on a number of factors. The more important ones are geology, patterns and characteristics of streamflow, and activities of man.

Geology and Streamflow

The geology of the Nueces River basin has been described by Alexander, Myers, and Dale (1964). Rocks exposed in the basin consist of sediments that range in age from Cretaceous to Quaternary (Figure 8).

The Edwards Plateau section of the basin is underlain by the Glen Rose Limestone and Edwards and associated limestones of Cretaceous age. The Glen Rose Limestone is in the Trinity Group. The Edwards and associated limestones includes the Georgetown Limestone of the Washita Group and the Kiamichi Formation, Edwards Limestone, Comanche Peak Limestone, and Walnut Clay of the Fredericksburg Group. The rocks consist largely of limestone, dolomitic limestone, marl, and shale.

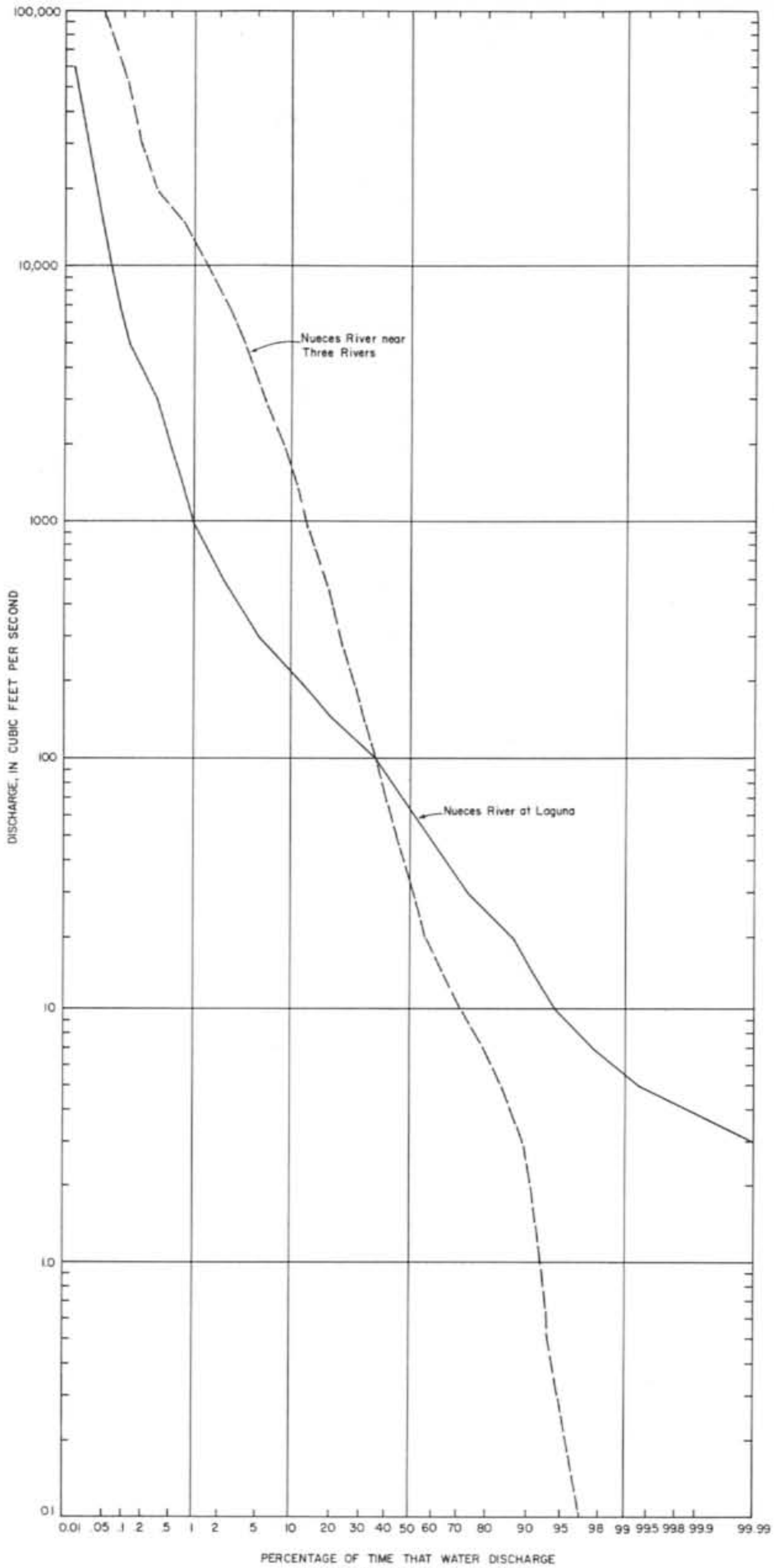

Figure 3
Duration of Flows, Nueces River at Laguna and Near Three Rivers, 1949-68

In the West Gulf Coastal Plain section of the basin, successively younger formations crop out in narrow belts that are roughly parallel to the coast of the Gulf of Mexico. Rocks from the Grayson Shale of Late Cretaceous age to the Midway Group of Paleocene age were considered as a unit by Alexander, Myers, and Dale (1964) and are mapped together on Figure 8. These rocks consist largely of clay, marl, limestone, and sandstone.

Other rocks that crop out in the upper and central parts of the West Gulf Coastal Plain section are the Wilcox, Claiborne, and Jackson Groups of Eocene age; the Frio Clay of Oligocene age; and the Catahoula Tuff and the lower part of the Fleming Formation of Miocene age. These rocks consist largely of sand, sandstone, silt, clay, and gravel.

The formations that crop out in the lower part of the Nueces River basin, in downstream order, are the upper part of the Fleming Formation of Miocene age, the Goliad Sand of Pliocene age, and the Lissie Formation and Beaumont Clay of Pleistocene age. The units are composed of clay, silt, sand, and gravel.

In streams where flow is not regulated by upstream reservoirs, the concentrations of dissolved minerals commonly vary inversely with the flow of the stream. The sustained low flow of a stream is usually predominantly water that has entered the stream as ground-water effluent. This water has been in contact with the rocks and soils for a sufficient time to dissolve part of their soluble minerals. At high flow, the water consists of surface runoff that has been in contact with the exposed rocks and soils for a short time. Therefore, the dissolved-solids concentration of a stream is usally lowest during periods of high flow. This inverse relationship between water discharge and dissolved solids is also true for streams in the Nueces River basin (Figure 4). The curve for the Nueces River near Three Rivers was prepared from the monthly weighted averages of chemical analyses and monthly mean-discharge data. The curve for the Frio River at Calliham is based on analyses of daily composite samples and mean daily discharge for the composite period. The point scatter is typical of western streams, where the intial flows of each runoff event flush out precipitated materials left by evaporation of water that remained in the drainage area after the previous runoff event.

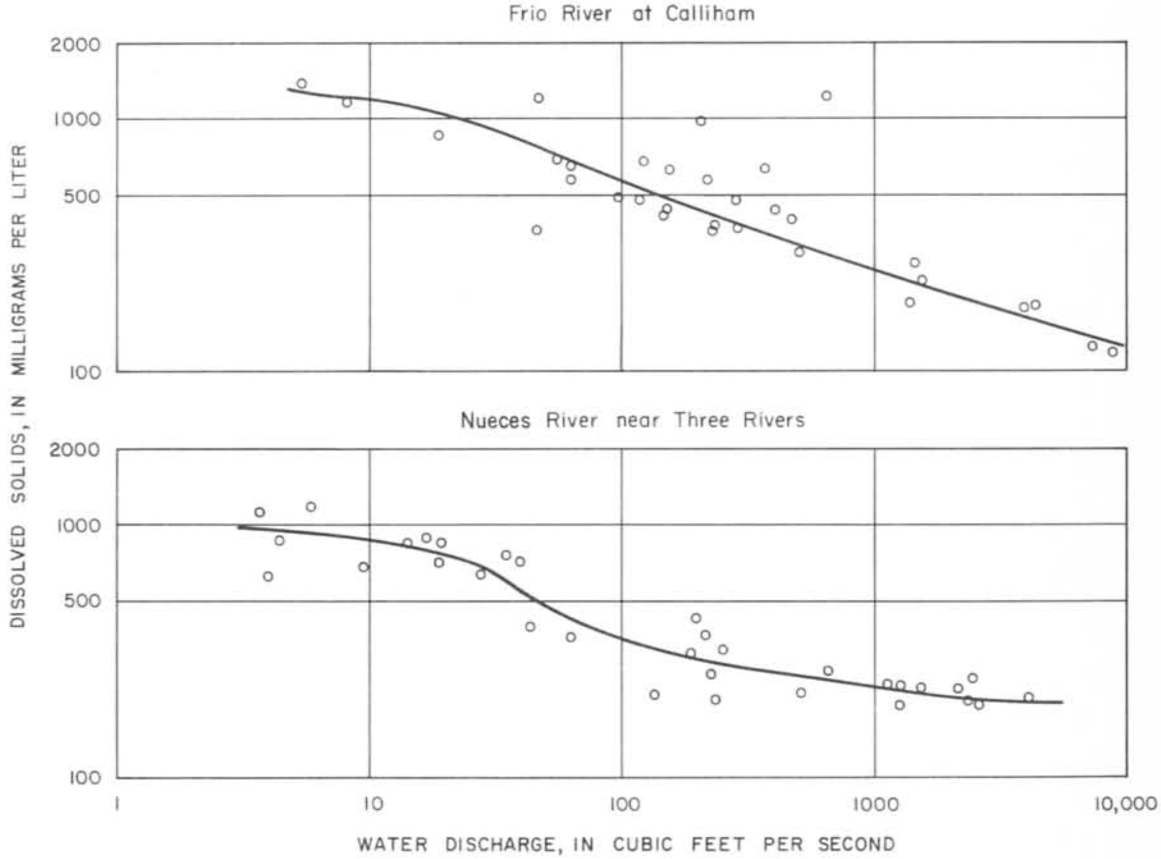

Figure 4.—Relation of Concentration of Dissolved Solids to Water Discharge

Streams in the Edwards Plateau area generally contain calcium bicarbonate water that is low in dissolved solids, regardless of the amount of streamflow. During periods of high flow, streams in the West Gulf Coastal Plain area contain calcium bicarbonate water that is low in dissolved solids. As streamflow diminishes, the water generally changes to a mixed type, with an increase in dissolved solids. During extreme low flow, the dissolved-solids concentrations are increased and the water generally changes to a sodium chloride type.

Chemical analyses of water from the Nueces River near Three Rivers and one typical analysis of water from the Nueces River at Laguna are shown graphically in Figure 5. The total height of each vertical bar is equivalent to the total concentration of anions (negatively charged constituents) or cations (positively charged constituents) expressed in me/l (milliequivalents per liter). The bars are divided into segments to show the concentration of the individual constituents. The analysis of the water from the Nueces River at Laguna is typical of most of the surface water throughout the Edwards Plateau, and the analyses of the water from the Nueces River near Three Rivers typify the water that is in streams in the West Gulf Coastal Plain during varied streamflow conditions.

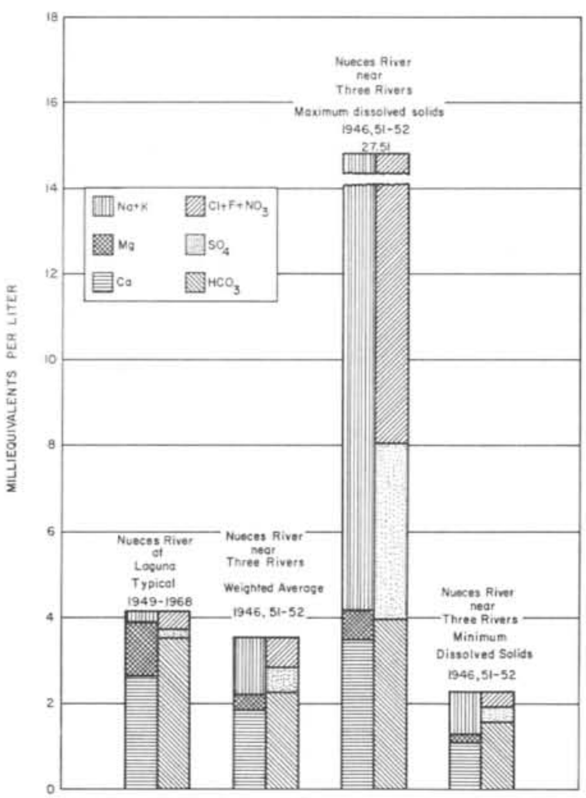

Figure 5.—Comparison of Dissolved Constituents in Water From the Nueces River at Laguna and Near Three Rivers

Activities of Man

The activities of man often alter the chemical composition of surface streams. Depletion of flow by diversion, return flow of irrigation, disposal of municipal and industrial wastes into streams, and evaporation from water-storage projects usually increase dissolved-solids concentration of water in streams.

Many small diversions are located on streams in the Nueces River basin, but the effect on the chemical quality of total streamflow is probably negligible.

Irrigation practices often affect the water quality of streams. Where surface water is diverted for irrigation, the volume of streamflow is reduced. Where crops are irrigated with ground water, the drainage often differs in quality and type from water in the receiving stream. The return flows from irrigated lands carry minerals leached from the soil. In 1964, 507,425 acre-feet of water was used for irrigation in the Nueces River basin, primarily in the Winter Garden (Zavala and Dimmit Counties) and in Atascosa, Dimmit, and Frio Counties, (Gillett and Janca, 1965). Of this total, about 452,407 acre-feet was from ground-water supplies.

Dissolved-solids concentrations of ground water throughout the Nueces River basin range from less than 300 mg/l (milligrams per liter) to more than 11,000 mg/l (Alexander, Myers, and Dale, 1964). The average dissolved-solids concentration for the wells sampled was about 1,760 mg/l.

Municipal, industrial, and domestic wastes may cause some degradation of streams in the Nueces River basin. This problem is minimized because the basin is sparsely populated and has no large cities. The disposition of municipal and industrial wastes has caused only local changes in the quality of surface water and natural streamflow generally is adequate for dilution.

Oil is produced in the central and southern parts of the basin (Figure 6), and brine, which is produced in nearly all oil fields, may, if improperly handled, eventually reach the streams. According to an inventory by the Texas Railroad Commission in 1961 (Texas Water Commission and Texas Water Pollution Control Board, 1963), about 59 percent of the salt water produced in oil fields of the Nueces River basin was reinjected underground; the remaining brine was placed in unlined surface pits or directly into surface streams at that time. Data indicate that oil-field pollution was degrading low flows in the Frio and Atascosa Rivers, and some pollution occurred along the Nueces River. Available data do not indicate all the possible trouble areas, but the effect of oil-field pollution on the quality of the water impounded in Lake Corpus Christi is considered slight. Railroad Commission regulations no longer permit surface disposal of oil-field brine, but residual effects of past disposal practices may affect water supplies for many years.

The Upper Nueces Reservoir and Lake Corpus Christi are the only two major reservoirs in the Nueces River basin (Figure 8). The chemical character of the Nueces River is probably affected only slightly by storage in the Upper Nueces Reservoir. Because flow in the Nueces River below Lake Corpus Christi is almost entirely regulated by the reservoir, the quality of the water is dependent largely on the quality of the stored water. U.S. Geological Survey studies have shown an increase in salinity of the Nueces River below Lake Corpus Christi and concluded that the increase was due to saline ground-water effluent and oil-field brine pollution.

Quality of Water in Surface Streams

The principal cations in natural water are calcium, magnesium, sodium, potassium, and iron. The principal anions are carbonate, bicarbonate, sulfate, chloride, fluoride, and nitrate. Other constituents and properties are often determined to help define the chemical and physical character of water. In the following discussion, concentrations of the dissolved constituents are based on discharge-weighted averages. The discharge-weighted average approximates the chemical character of the water if all the water passing a point in the stream during a period were impounded in a reservoir and mixed with no adjustments for evaporation, rainfall, or other chemical changes that may occur during storage.

Dissolved Solids

The discharge-weighted average concentration of dissolved solids in streamflow in the Nueces River basin is generally less than 300 mg/l. Periodic data from streams north of the Balcones Fault Zone indicate that base flow in the Edwards Plateau area usually contains less than 250 mg/l dissolved solids. During periods of high flow, this concentration would be expected to be much less than 250 mg/l.

In the West Gulf Coastal Plain area, water is also low in dissolved-solids content. Discharge-weighted average concentrations of dissolved solids in water of the Frio River at Calliham (1968), Nueces River near Three Rivers (1946, 1951-1952), and Nueces River near Mathis (1948-1968) were 258, 229, and 233 mg/l, respectively. Periodic analyses of water from tributary streams indicate that their dissolved-solids concentrations are probably in the same range of magnitude, except where local oil-field pollution has occurred (see Opossum Creek near Callaham in Table 5).

The station Nueces River near Three Rivers measures most of the water flowing into Lake Corpus Christi, and the station near Mathis measures outflow from the reservoir. Weighted averages for the period of concurrent record (1951 and 1952 water years) show about 10 percent increase in dissolved solids between the two stations. The analyses showing the maximum and minimum dissolved-solids concentrations and the annual discharge-weighted averages for the Nueces River near Tilden, Frio River at Calliham, Nueces River near Three Rivers, and Nueces River near Mathis for the periods of record are given in Table 4. Dissolved solids determined for miscellaneous sampling sites are listed in Table 5.

Hardness

Periodic analyses of streams in the Edwards Plateau show that surface water in this section of the report area is generally hard (121-180 mg/l) or very hard (more than 180 mg/l). Streams in the plains area would generally be classed as moderately hard (61-120 mg/l) or hard. The discharge-weighted average hardness for the Frio River at Calliham, Nueces River near Three Rivers, and Nueces River near Mathis for the periods of record were 139, 112, and 122 mg/l, respectively. Data for Three Rivers and Mathis would be representative of water in Lake Corpus Christi.

Chloride

The chloride content of waters throughout the Nueces River basin is generally less than 50 mg/l. Periodic data for the Nueces River at Laguna show the chloride content to be less than 25 mg/l. Discharge-weighted averages of chloride concentrations in the Frio River at Calliham, Nueces River near Three Rivers, and Nueces River near Mathis were 48, 23, and 28 mg/l, respectively. Chloride concentrations in tributary streams and in stored water are probably in the same range as in the major streams, except where local oil-field pollution has occurred.

Other Constituents

Other important constituents in evaluating the chemical quality of water include silica, sodium, bicarbonate, sulfate, fluoride, and nitrate. Discharge-weighted averages of these constituents for the Nueces River near Mathis are: silica, 16 mg/l; sodium, 30 mg/l; bicarbonate, 152 mg/l; sulfate, 25 mg/l; and nitrate, 1.7 mg/l. Weighted-average fluoride is not given. However, fluoride concentrations in all streams have consistently been less than 1 mg/l.

Water Quality in Potential Reservoirs

The quality of water may be improved or degraded by impoundment. Beneficial effects include reduction of silica, turbidity, color, and bacteria; stabilization of sharp variations in chemical quality; entrapment of sediment; and reduction in temperature extremes. Detrimental effects may include increased algae growth, reduction of dissolved oxygen, and increases in the concentration of dissolved constituents as a result of evaporation.

Construction of Choke Canyon Reservoir on the Frio River or R&M Reservoir on the Nueces below Lake Corpus Christi is under consideration. The quality of water at the stations Frio River at Calliham and Nueces River near Mathis is representative of the quality of water to be stored in the respective reservoirs. Therefore, the water stored should be of good quality. Any other potential reservoirs on almost all streams in both sections of the basin could be expected to contain good quality water.

Suitability of the Water for Use

Quality-of-water studies usually are concerned with determining the suitability of the water—judged by the chemical, physical, and sanitary characteristics—for its proposed use. Table 1 lists the constituents and properties commonly determined by the U.S. Geological Survey and includes a resume of their sources and significance.

Domestic Supply

The safe limits for the concentrations of mineral constituents found in water are usually based on the U.S. Public Health Service drinking water standards. These standards, originally established in 1914 to control the quality of water used for drinking and culinary purposes on interstate carriers, have been revised several times; the latest revision was in 1962 (U.S. Public Health Service, 1962). These standards have been adopted by the American Water Works Association as minimum standards for all public supplies.

According to the drinking-water standards, the limits in the following table should not be exceeded:

CONSTITUENT	MAXIMUM CONCENTRATION (MG/L)
Sulfate	250
Chloride	250
Nitrate	45
Fluoride	a/ 1.0
Dissolved solids	500

a/ Based on annual average of daily maximum air temperatures at Carrizo Springs.

In the Nueces River basin, concentrations of all the foregoing constituents are generally well below the recommended limits.

Irrigation

The chemical composition of a water is an important factor in determining its usefulness for irrigation because the quality of the water should not adversely affect the productivity of the land. The extent to which chemical quality affects 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 applying it; the kind of crops grown; and the climate of the region, including the amounts and distribution of rainfall. Because these factors are highly variable, all methods of classifying water for irrigation are somewhat arbitrary.

The most important characteristics in determining the quality of irrigation water, according to the U.S. Salinity Laboratory Staff (1954), 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 to crops, and (4) the excess of equivalents of bicarbonate over equivalents of calcium plus magnesium.

The U.S. Salinity Laboratory Staff introduced the term "sodium-adsorption ratio" (SAR) to express the relative activity of sodium ions in exchange reactions with the soil. This ratio is defined by the equation:

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

where the concentrations of the ions are expressed in milliequivalents per liter.

A system for classifying irrigation waters in terms of salinity and sodium hazards has been prepared by the U.S. Salinity Laboratory Staff. Empirical equations were used in developing a diagram that uses SAR and specific conductance in classifying irrigation waters. The diagram is reproduced in modified form as Figure 7. This classification, although embodying both research and field observations, should be used for general guidance only, because other factors 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 ranges of this classification extend from waters that can be used for the irrigation of most crops on most soils to waters that are usually unsuitable for irrigation.

The typical water-analysis data for the Nueces River at Laguna, shown on Figure 7, indicate that the sodium hazard is low and the salinity hazard is medium in the Edwards Plateau section of the Nueces River basin. In the West Gulf Coastal Plain section of the basin, the sodium hazard may range from low to high, and the salinity hazard may range from medium to very high (see Nueces River near Three Rivers in Figure 7),

Table 1.—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 mg/l. High concentrations, as much as 100 mg/l, 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 mg/l of iron in surface waters generally indicates 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 mg/l stains 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 mg/l. 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 sodium 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 mg/l.
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 mg/l.
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 susceptbility 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 mg/l. 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 mg/l dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 mg/l 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 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, 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.

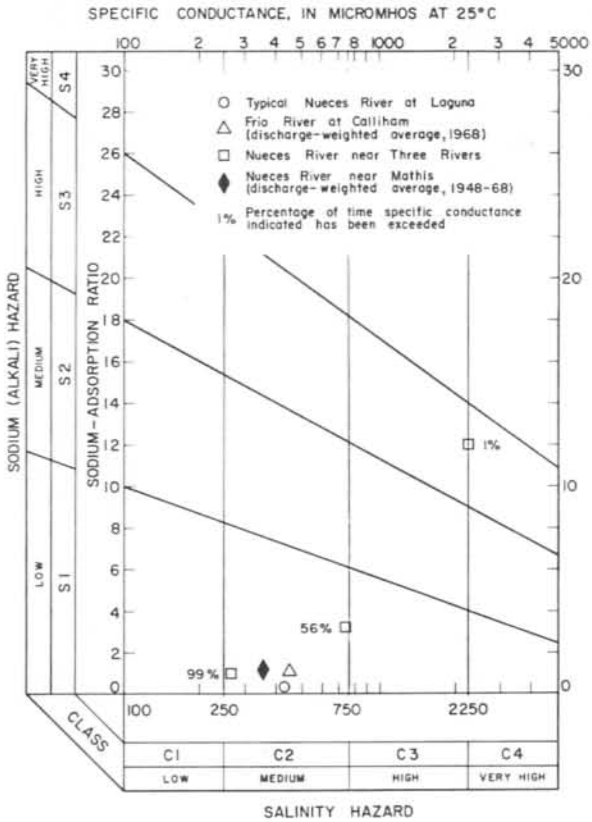

Figure 7.—Classification of Irrigation Waters

depending on streamflow conditions. The weighted averages for the Frio River at Calliham and the Nueces River near Mathis (Figure 7) probably are also representative of the water stored in Lake Corpus Christi and water to be stored in potential reservoirs on streams in the Nueces River basin. Therefore, water stored in reservoirs would have a low sodium hazard and medium salinity hazard. In the Nueces River basin, where the average annual rainfall is about 24 inches, the quality of surface water in reservoirs should be suitable for supplemental irrigation of most types of crops.

Industrial Use

The quality requirements for many industrial applications, as indicated by the water tolerances, are given in Table 2. One requirement of most industries is that the concentrations of the various constituents of the water remain relatively constant. When concentrations of undesirable substances in water vary, constant monitoring is required, and operating expenses are increased.

Hardness is one of the more important properties of water that affect its utility for industrial purposes (Table 1). Water in the Edwards Plateau section of the Nueces River basin is hard to very hard. Water stored in the West Gulf Coastal Plain section of the basin is moderately hard to hard. Therefore, reduction of hardness would be necessary for many industrial uses.

The corrosive property of a water receives considerable attention in industrial water supplies. A high concentration of dissolved solids in a water may be closely associated with corrosive properties, particularly if chloride is present in appreciable quantities. Water that contains a large concentration of magnesium chloride may be highly corrosive because the hydrolysis of this salt yields hydrochloric acid. The magnesium chloride and dissolved-solids concentrations in surface waters of the Edwards Plateau section of the Nueces River basin are low, but vary widely in the streams in the West Gulf Coastal Plain section, depending on streamflow conditions. Reservoirs throughout the basin can be expected to contain low concentrations of magnesium chloride and dissolved solids. Therefore, the corrosive properties of surface waters in the Nueces River basin generally should be low.

SUMMARY AND CONCLUSIONS

This reconnaissance of the chemical quality of surface water has shown that the Nueces River basin was relatively free of major water-quality problems during the study period. Lake Corpus Christi stores water of good quality for municipal supply, irrigation, and industrial uses. Other potential reservoirs built in either the Edwards Plateau or the West Gulf Coastal Plain area of the basin might also provide supplies of good-quality water. Some streams in the southern part of the basin have been degraded from time to time by oil-field brine and by return flow from irrigation.

A continuous study of streams contributing storage to Lake Corpus Christi and potential reservoirs should be maintained. More data are needed from the many tributaries to the Nueces River so that problem areas may be isolated and preventive or corrective measures can be taken. Of special concern should be streams in or near oil fields, municipal areas, and areas of highly irrigated lands. The relationship between drainage from the Nueces River basin and water quality in Nueces and Corpus Christi Bays is being studied under a cooperative program between the U.S. Geological Survey and the Texas Water Development Board.

Table 2.—Water-Quality Tolerances for Industrial Applications[1]

[Allowable Limits in Milligrams Per Liter Except as Indicated]

INDUSTRY	TUR-BID-ITY	COLOR	COLOR +O_2 CON-SUMED	DIS-SOLVED OXYGEN (ml/l)	ODOR	HARD-NESS	ALKA-LINITY (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	GEN-ERAL[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 mg/l.
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 mg/l (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 mg/l.
13/ Calcium, magnesium, iron, manganese, suspended matter, and soluable organic matter may be objectionable.

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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.
1942-45	–	*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	1744	Bull. 6215
1951	1199	*1951	1961	1884	Bull. 6304
1952	1252	*1952	1962	1944	Bull. 6501
1953	1292	*1953	1963	1950	Rept. 7
1954	1352	*1954	1964	1957	–
			1965	1964	–

* "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 Nueces River basin, Texas, 1915-1960:

YEAR	WATER-SUPPLY PAPER NO.	YEAR	WATER-SUPPLY PAPER NO.	YEAR	WATER-SUPPLY PAPER NO.
1915	408	1930	703	1945	1038
1916	438	1931	718	1946	1058
1917	458	1932	733	1947	1088
1918	478	1933	748	1948	1118
1919	508	1934	763	1949	1148
1920	508	1935	788	1950	1178
1921	528	1936	808	1951	1212
1922	548	1937	828	1952	1242
1923	568	1938	858	1953	1282
1924	588	1939	878	1954	1342
1925	608	1940	898	1955	1392
1926	628	1941	928	1956	1442
1927	648	1942	958	1957	1512
1928	668	1943	978	1958	1562
1929	688	1944	1008	1959	1632
				1960	1712

Table 3.--Index of Surface-Water Records for the Nueces River Basin

Reference no.	Stream and location	Drainage area (sq. mi.)	Type and period of record: Daily chemical quality	Discharge	Periodic chemical quality	Periodic discharge measurements	Reservoir content	Water temperature
1	Nueces River near Camp Wood	--			1952			
2	Nueces River at Laguna	764		1923-68	1949, 1952, 1954, 1966-68			
3	Nueces River above Uvalde	--			1930			
4	West Nueces River near Brackettville	700		1939-50 1956-68	1952			
5	Nueces River below Uvalde	1947		1927-68	1930, 1962-68			
6	Nueces River near La Pryor	--			1930			
7	Turkey Creek west of La Pryor	--			1930			
8	Chaparosa Creek west of La Pryor	--			1930			
9	Turkey Creek near Crystal City	--			1964-68	1962, 1964-68		
10	Pendencia Creek northwest of Carrizo Springs	--			1930			
11	North Fork Carrizo Creek southwest of Carrizo Springs	--			1930			
12	South Fork Carrizo Creek southwest of Carrizo Springs	--			1930			
13	Carrizo Creek at Carrizo Springs	--			1930	1930		
14	Nueces River east of Carrizo Springs	--			1930			
15	Nueces River near Asherton	4082		1939-68	1964-68			
16	Nueces River at Cotulla	5260	1942	1923-68	1962-68			1942
17	San Casimiro Creek near Freer	469		1962-68	1965-68			
18	Colmena Creek near Freer	--			1959	1959		
19	Nueces River near Tilden	8192	1950-51	1942-68	1949, 1959, 1967-68			1950-51
20	Plant Creek near Tilden	--				1966-68		
21	Nueces River at Simmons	8561		1965-68	1965-68			
22	Frio River near Leakey	--			1952			
23	Frio River at Concan	405		1923-68	1952, 1964-68			
24	Dry Frio River near Reagan Wells	117		1952-68	1966-68			
25	Dry Frio River near Concan	--			1952			
26	Frio River below Dry Frio River near Uvalde	661		1952-68				
27	Brushy Creek northwest of Vanderpool	--			1947			
28	Sabinal River near Sabinal	206		1942-68	1964-68			
29	Sabinal River at Sabinal	247		1952-68				
30	East Elm Creek near Sabinal	--				1967-68		
31	Hondo Creek near Tarpley	86		1952-68	1966-68			
32	Hondo Creek at King Waterhole near Hondo	142		1960-68				
33	Bone Creek near Hondo	--				1967		
34	Seco Creek at Miller Ranch near Utopia	43		1961-68	1965-67			
35	Seco Creek at Crook Ranch near D'Hanis	168		1960-68				
36	Frio River near Derby	3493		1915-68	1962-68			
37	Leoncita Creek at Tilden	--			1967	1967		
38	Frio River at Tilden	--			1959			
39	San Miguel Creek near Tilden	793		1964-68	1959, 1965-68			
40	Opossum Creek near Calliham	--			1967	1967		

Table 3.--Index of Surface-Water Records for the Nueces River Basin--Continued

Reference no.	Stream and location	Drainage area (sq. mi.)	Type and period of record: Daily chemical quality	Discharge	Periodic chemical quality	Periodic discharge measurements	Reservoir content	Water temperature
41	Frio River at Calliham	5491	1968	1924-26 1932-68	1942, 1948-49, 1952-53, 1959, 1962-67			1968
42	Atascosa River 3 miles southwest of Poteet	--			1951	1951		
43	Rutledge Hollow Creek at Poteet	--				1967-68		
44	Atascosa River 1.3 miles south of Poteet	--			1951	1951		
45	Atascosa River 3 miles northwest of Pleasanton	--			1951	1951		
46	Atascosa River at Pleasanton	--			1951, 1959	1951		
47	Atascosa River at Coughran	--			1951	1951		
48	Atascosa River near McCoy	--			1951	1951		
49	Lucas Creek near Pleasanton	--				1967-68		
50	Atascosa River at Campbellton	--			1942, 1945, 1951, 1959	1951		
51	Matate Creek southwest of Campbellton	--			1951	1951		
52	La Parita Creek southwest of Campbellton	--			1951	1951		
53	Atascosa River at Whitsett	1171			1942, 1951, 1962, 1964-68	1924-26, 1932-68		
54	Olmos Creek near Whitsett	--			1959			
55	San Christoval Creek near Whitsett	--			1959			
56	Atascosa River near Three Rivers	--			1942, 1949, 1951, 1967	1949, 1951, 1967		
57	Frio River at Three Rivers	--			1942, 1967	1967		
58	Nueces River near Three Rivers	15600	1945-52	1915-68				1945-52
59	Sulphur Creek at Oakville	--			1951	1951		
60	Nueces River below Sulphur Creek near Oakville	--			1951	1951		
61	Nueces River near George West	--			1951, 1959	1951		
62	Nueces River near Mikeska	--			1951	1951		
63	Ramirena Creek near George West	--		1968				
64	Lake Corpus Christi near Mathis	16656					1948-68	
65	Nueces River near Mathis	16660	1947-68	1939-68				1947-68
66	Cayamon Creek at Farm Road 666 near Bluntzer	--			1963, 1966	1963, 1966		
67	Nueces River at Calallen Dam above Calallen	16772		1966-67	1962, 1963, 1966			

Table 4.--Summary of Chemical Analyses at Daily Stations on Streams in the Nueces River Basin

(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 extreme. Results in milligrams per liter except as indicated. Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum): Milligrams per liter (mg/1)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
19. NUECES RIVER NEAR TILDEN																			
Water year 1950																			
Maximum, Jan. 21-31, 1950	0.61	13	79	10	102		238	59	144		0.8	b551	0.75	0.9	238	43	2.9	918	8.0
Minimum, May 28-31	1876	14	30	3.4	26		122	16	20		2.0	181	.25	917	89	0	1.2	278	7.6
Weighted average	275	21	38	3.9	30		144	23	22		2.3	223	.30	166	111	0	1.2	346	--
41. FRIO RIVER AT CALLIHAM																			
Water year 1968 c/																			
Maximum, Sept. 1-4, 1968	5.4	28	148	24	310		252	272	460	0.4	3.8	1370	1.86	20	468	262	6.2	2460	7.7
Minimum, Jan. 20-23	8560	8.2	25	2.3	14		81	18	12	--	1.0	120	.16	2770	72	5	.7	214	7.5
Weighted average	420	11	46	6.0	36		128	46	48	--	2.3	258	.35	293	139	35	1.3	455	7.5
58. NUECES RIVER NEAR THREE RIVERS																			
Water year 1946																			
Maximum, Mar. 18-20, 1946	71.8	--	72	8.3	392		205	64	588		2.5	1230	1.67	238	214	46	12	2250	--
Minimum, Sept. 29-30	8510	--	--	--	--		74	20	6		1.5	105	.14	2410	--	--	--	155	--
Weighted average	1281	--	41	4.2	27		144	25	22		1.6	229	.31	792	120	2	1.1	341	--
Water year 1951																			
Maximum, Feb. 1-10, 1951	4.66	10	46	13	431		562	165	335		1.5	1280	1.74	16	160	0	15	2130	8.4
Minimum, May 21-23, 24, 25-26, 27	4831	21	34	3.4	15		124	15	7.2		6.1	185	.25	2410	99	0	.7	269	7.9
Weighted average	561	22	34	3.4	29		121	30	19		3.6	214	.29	324	99	0	1.3	326	--
Water year 1952																			
Maximum, April 10, 1952	1096	30	70	8.3	537		242	196	685		8.8	b1610	2.19	4760	208	24	16	2830	8.5
Minimum, July 19-23	584	21	22	2.2	23		96	17	10		4.8	b168	.23	265	64	0	1.3	243	7.8
Weighted average	228	21	35	3.7	48		143	38	35		2.6	270	.37	166	102	0	2.1	425	--
65. NUECES RIVER NEAR MATHIS																			
Water year 1948																			
Maximum, June 1-30, 1948	43.7	20	61	8.1	122		218	61	147	--	0.8	548	0.75	65	186	7	3.9	940	--
Minimum, July 7-31	1132	22	41	5.2	43		162	29	38	--	1.2	244	.33	746	124	0	1.7	429	--
Weighted average	148	--	46	6.8	62		174	38	66	--	1.0	325	.44	130	143	0	2.3	554	--
Water year 1949																			
Maximum, Feb. 1-28, 1949	48.7	15	42	5.4	46		168	29	41	--	.5	288	.39	38	127	0	--	445	--
Minimum, April 27-30	19450	12	28	3.6	24		108	22	17	--	2.2	175	.24	9190	85	0	--	261	--
Weighted average	1225	18	11	4.9	29		151	22	26	--	1.4	231	.31	764	122	0	--	366	--
Water year 1950																			
Maximum, May 1-31, 1950	652	18	53	6.3	74		186	54	78	--	.2	375	.51	660	156	6	--	637	7.8
Minimum, June 1-30	1955	24	40	4.6	32		159	21	24	--	1.8	243	.33	1280	119	0	--	381	8.0
Weighted average	340	22	44	5.3	42		168	31	39	0.2	1.3	280	.38	257	132	0	--	452	--
Water year 1951																			
Maximum, May 1-24, 1951	324	22	69	7.0	93		250	50	104	--	.5	468	.64	409	201	0	--	803	7.8
Minimum, Sept. 13-30	5167	19	32	3.3	30		124	26	20	.4	1.0	207	.28	2890	93	0	--	322	8.0
Weighted average	583	21	37	4.2	34		141	27	27	--	1.4	231	.31	364	110	0	--	369	--

See footnotes at end of table.

Table 4.--Summary of Chemical Analyses at Daily Stations on Streams in the Nueces River Basin--Continued

(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 extreme. Results in milligrams per liter except as indicated. Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum) Milligrams per liter (mg/l)	Dissolved solids (sum) Tons per acre-foot	Dissolved solids (sum) Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
65. NUECES RIVER NEAR MATHIS--Continued																			
Water year 1952																			
Maximum, April 1-30, 1952	157	18	57	8.9	93		224	57	97	0.3	0.5	b478	0.65	203	178	0	3.0	772	8.2
Minimum, Oct. 1-31, 1951	313	22	40	3.6	35	7.6	142	34	30	.3	3.0	b251	.34	212	115	0	1.4	383	7.6
Weighted average	244	25	44	4.6	54		172	37	45	.3	1.2	308	.42	203	129	0	2.1	492	--
Water year 1953																			
Maximum, May 1-20, 1953	531	22	48	5.9	120	7.6	247	58	112	.4	1.0	b530	.72	760	144	0	4.3	880	8.2
Minimum, Sept. 1-30	6725	20	40	4.0	18	3.5	148	20	10	.3	2.0	b207	.28	3760	116	0	.7	311	8.0
Weighted average	741	21	40	4.1	29	4.2	156	25	21	.3	2.0	240	.33	480	117	0	1.2	368	--
Water year 1954																			
Maximum, May 1-31, 1954	60.4	32	59	5.2	100		254	50	96	.5	3.5	478	.65	78	168	0	3.4	801	8.5
Minimum, Nov. 1-30, 1953	687	23	38	3.1	27	5.1	143	25	18	.5	1.0	211	.29	391	108	0	1.1	335	8.0
Weighted average	465	26	46	4.3	38	6.4	178	29	31	.4	2.0	275	.37	345	132	0	1.4	437	--
Water year 1955																			
Maximum, May 1-31, 1955	281	20	52	4.5	83	8.8	229	46	73	.5	4.0	419	.57	318	148	0	3.0	682	7.8
Minimum, Sept. 1-30	385	23	44	3.0	53	6.5	176	35	42	.2	2.8	297	.40	309	122	0	2.1	484	7.9
Weighted average	135	23	48	4.1	63	7.6	201	38	52	.3	3.1	343	.47	125	137	0	2.3	559	--
Water year 1956																			
Maximum, April 1-30, 1956	49.0	21	60	6.2	73	9.1	259	36	62	.5	1.8	410	.56	54.2	175	0	2.4	666	7.9
Minimum, Sept. 1-30	740	17	35	3.2	40	7.5	137	32	34	.5	4.5	254	.35	507	100	0	1.7	406	7.8
Weighted average	184	20	44	3.9	48	7.9	179	31	41	.6	3.5	296	.40	147	126	0	1.9	480	--
Water year 1957																			
Maximum, Sept. 1-30, 1957	1735	17	53	6.1	48		200	31	44	.4	2.5	322	.44	1510	157	0	1.7	509	8.0
Minimum, May 1-31	9482	14	20	10	18	6.6	117	20	15	--	3.0	177	.24	4530	92	0	.8	283	7.2
Weighted average	1962	14	33	6.3	22	7.2	140	20	20	--	3.4	208	.28	1100	108	0	.9	332	--
Water year 1958																			
Maximum, May 1-31, 1958	83.5	15	57	9.7	69	7.1	184	68	85	--	4.0	415	.56	93.6	182	31	2.2	691	7.4
Minimum, Jan. 11-31	5519	12	32	2.5	27	5.2	107	26	24	.5	4.0	186	.25	2770	90	3	1.2	306	7.5
Weighted average	1538	15	40	3.7	31	5.9	139	30	31	--	3.5	233	.32	968	115	1	1.3	380	--
Water year 1959																			
Maximum, Aug. 1-31, 1959	132	16	53	9.0	60	8.7	189	42	77	--	2.0	362	.19	129	169	14	2.0	602	7.8
Minimum, Nov. 1-30, 1958	3372	16	46	5.0	22	6.4	168	21	24	--	1.8	237	.32	2160	136	0	.8	386	7.7
Weighted average	829	17	50	5.7	29	7.4	181	25	33	--	1.6	274	.37	613	148	0	1.0	439	--
Water year 1960																			
Maximum, Oct. 1-18, 1959	3922	23	52	8.9	53	9.2	197	38	66	.2	2.0	351	.48	3750	166	1	1.8	592	7.1
Minimum, Dec. 1-31	107	20	49	5.3	16	7.7	186	16	14	--	1.5	224	.30	64.7	144	0	.6	359	8.0
Weighted average	602	21	48	7.1	41		185	27	41	--	1.4	288	.39	468	149	0	1.5	469	--
Water year 1961																			
Maximum, June 1-30, 1961	1369	12	54	6.6	55		174	40	68	--	1.2	332	.45	1230	162	19	1.9	561	7.6
Minimum, Dec. 11-20, 1960	1407	17	38	4.1	26		135	25	22	--	1.8	200	.27	760	112	2	1.1	350	7.1
Weighted average	847	15	43	5.3	41		157	30	41	--	1.0	266	.36	608	130	1	1.6	438	--

See footnotes at end of table.

Table 4.--Summary of Chemical Analyses at Daily Stations on Streams in the Nueces River Basin--Continued

(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 extreme. Results in milligrams per liter except as indicated. Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum) Milligrams per liter (mg/l)	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
65. NUECES RIVER NEAR MATHIS--Continued																			
Water year 1962																			
Maximum, July 1-31, 1962	133	19	50	7.6	66		185	40	75	0.3	0.8	378	0.51	136	156	5	2.3	616	7.4
Minimum, Nov. 1-30, 1961	105	18	60	7.2	45		209	32	50	.3	.8	328	.45	93.0	179	8	1.5	540	7.6
Weighted average	111	19	56	7.3	57		200	37	64	.3	.8	355	.48	106	170	7	1.9	583	7.5
Water year 1963																			
Maximum, June 1-30, 1963	128	19	46	8.0	101		196	46	111	.3	1.0	428	.58	148	148	0	3.6	730	7.5
Minimum, Oct. 1-31, 1962	107	17	46	7.5	68		179	38	76	.3	.8	344	.47	99.4	146	0	2.4	599	7.7
Weighted average	109	16	49	7.6	80		198	41	87	.3	.7	382	.52	113	153	0	2.8	657	7.5
Water year 1964																			
Maximum, Sept. 1-30, 1964	116	23	39	6.4	93		208	33	84	.4	1.2	382	.52	120	124	0	3.6	634	7.7
Minimum, June 1-30	133	17	42	7.5	74		198	33	69	.8	1.0	341	.46	122	136	0	2.8	596	7.3
Weighted average	104	18	45	7.4	74		211	34	72	.5	.8	358	.49	100	144	0	2.7	619	7.7
Water year 1965																			
Maximum, Oct. 1-7, 1964	3942	21	41	7.2	63	8.8	194	30	60	.4	2.2	329	.45	2610	132	0	2.4	552	7.6
Minimum, Nov. 1-30	384	12	47	4.3	22		176	16	15	.3	.8	204	.28	212	135	0	.8	354	7.6
Weighted average	787	15	49	4.8	30		188	19	24	.3	.8	238	.32	505	142	0	1.1	405	7.2
Water year 1966																			
Maximum, April 1-30, 1966	131	17	60	5.6	43	7.6	225	30	41	.3	.2	316	.43	112	173	0	1.4	536	7.9
Minimum, June 1-30	896	18	46	3.2	30	6.7	167	20	27	.3	3.8	238	.32	576	128	0	1.2	403	7.2
Weighted average	452	16	48	4.8	33	7.3	181	24	33	.2	.8	259	.35	316	141	0	1.2	443	7.5
Water year 1967																			
Maximum, Aug. 1-31, 1967	152	19	66	5.2	53	9.2	238	37	54	.3	.8	362	.49	149	186	0	1.7	601	8.1
Minimum, Sept. 24-27	111300	12	28	1.2	8.4	4.9	91	13	6.6	.4	.5	120	.16	36060	75	0	.4	185	--
Weighted average	2167	12	32	1.6	12	5.2	108	14	9.7	.3	.5	141	.19	824	86	0	.5	224	7.7
Water year 1968																			
Maximum, Jan. 21, 1968	3200	14	58	5.2	38	5.1	182	35	46	.2	.2	291	.40	2510	166	17	1.3	508	8.0
Minimum, Oct. 1-31, 1967	3418	14	39	2.4	16	7.3	142	14	12	.2	.2	175	.24	1620	108	0	.7	285	7.4
Weighted average	1232	13	46	4.2	29		149	30	32	.2	.5	228	.31	758	132	10	1.1	396	7.5

a/ Includes the equivalent of any carbonate (CO_3) present.

b/ Residue on evaporation at 180°C.

c/ Period of record began November 10, 1967.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum): Milligrams per liter (mg/l)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): 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
1. NUECES RIVER NEAR CAMP WOOD																			
June 17, 1952		13	43	16	7.1		190	7.7	13	0.3	4.0	197	0.27		173	17	0.2	357	8.4
2. NUECES RIVER AT LAGUNA																			
May 27, 1949	131	13	58	15	7.8		234	9.3	13	--	4.5	b236	0.32		206	15	0.2	432	7.9
June 16, 1952	--	13	53	15	6.3		215	9.5	13	0.2	4.0	b230	.31		194	18	.2	391	8.2
Sept. 21, 1964	7550	10	64	6.9	3.3	2.0	200	9.2	7.3	.3	18	219	.30		188	24	.1	371	7.1
Jan. 5, 1966	84.3	11	55	15	7.6	1.0	220	14	13	.2	4.5	229	.31		199	19	.2	405	7.4
Mar. 15	60.2	11	61	14	7.4	1.3	222	14	13	.2	5.0	236	.32		210	28	.2	415	7.9
Apr. 26	4.6	--	--	--	--	--	209	--	11	--	2.8	--	--		191	20	--	387	7.4
May 26	74.0	11	31	14	6.7	1.0	140	13	12	.0	3.2	161	.22		135	20	.3	292	7.8
Oct. 12	157	13	54	14	6.5	.9	211	12	12	.2	6.9	224	.30		192	19	.2	390	7.6
Jan. 25, 1967	74.5	11	60	14	6.7	.8	224	14	13	.1	6.0	236	.32		207	24	.2	415	7.6
May 10	39.6	11	58	13	6.8	1.0	220	14	13	.1	4.0	229	.31		198	18	.2	403	7.7
June 14	34.7	13	58	13	6.7	1.1	212	16	13	.3	4.5	231	.31		202	29	.2	394	7.6
Aug. 23	26.0	13	50	14	7.0	1.0	198	13	13	.2	5.4	214	.29		182	20	.2	369	7.8
May 29, 1968	216	--	46	15	--	--	180	--	13	--	--	--	--		176	29	--	357	7.5
July 3	114	--	--	--	--	--	204	--	15	--	--	--	--		194	27	--	398	7.4
Aug. 8	121	--	--	--	--	--	204	--	15	--	--	--	--		192	25	--	394	7.5
3. NUECES RIVER ABOVE UVALDE																			
May 31, 1930		16	50	15	5.0	1.4	208	10	10		1.8	b203	0.28		186	16	0.2		
4. WEST NUECES RIVER NEAR BRACKETTVILLE																			
June 16, 1952		12		7.1	4.8			5.6	9.8	0.2	5.8								8.1
5. NUECES RIVER BELOW UVALDE																			
May 20, 1930	--	19	46	13	6.3	1.7	176	21	11	--	0.5	b201	0.29		168	24	0.2	--	--
May 22	--	15	57	13	7.0	1.6	208	22	12	--	.5	b221	.30		196	25	.2	--	--
Nov. 26	--	--	76	14	3.8		267	15	10	--	8.6	259	.35		247	28	.1	--	--
Nov. 5, 1962	11.2	13	56	11	10		184	22	22	0.3	2.0	226	.31		185	34	.3	398	6.9
Jan. 16, 1963	13.5	12	64	12	9.7	.7	208	23	22	.2	3.5	b268	.36		209	39	.3	436	6.9
Mar. 27	13.3	13	56	11	11		181	22	24	.2	3.2	b242	.33		185	37	.4	398	7.2
June 5	25.4	11	56	11	7.8	1.1	190	18	17	.2	3.8	219	.30		185	29	.2	375	7.0
Aug. 12	9.97	16	44	12	9.2	1.1	162	20	18	.3	.8	201	.27		159	26	.3	339	7.3
Nov. 26	6.84	12	57	11	12		192	24	20	.2	2.5	233	.32		187	30	.4	408	7.2
Mar. 10, 1964	3.77	10	51	12	9.4	1.1	176	26	17	.2	1.8	216	.29		177	32	.3	383	7.5
May 21	3.55	13	43	11	11		154	24	17	.2	.0	195	.27		153	26	.4	340	7.3
July 28	1.23	22	38	13	13		147	26	20	.2	.0	204	.28		148	28	.5	347	7.0
Sept. 21	23700	10	70	5.9	3.4	3.8	204	15	8.4	.2	20	237	.32		199	32	.1	396	7.0
Sept. 24	1860	11	56	8.8	4.9	1.7	174	12	10	.3	23	214	.29		176	33	.2	356	7.8
Oct. 6	265	12	65	11	7.2	1.4	219	15	14	.3	17	251	.34		207	28	.2	422	7.7
Nov. 9	41.9	13	70	12	7.4	1.3	235	19	14	.0	14	267	.36		224	31	.2	454	7.7
May 3, 1965	13.3	8.8	49	12	7.6	1.9	173	25	13	.0	4.0	206	.28		172	30	.3	372	6.8
May 21	c8	11	48	12	12		165	34	15	.2	4.8	218	.30		169	34	.4	376	7.7
July 13	49.8	12	53	11	7.7	1.3	182	19	13	.2	7.6	214	.29		178	28	.3	378	7.0
Jan. 6, 1966	11.9	11	60	12	8.1	1.2	208	23	14	.2	7.0	238	.32		198	28	.2	402	7.6

See footnotes at end of table.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations--Continued

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum): Milligrams per liter (mg/l)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
5. NUECES RIVER BELOW UVALDE--Continued																			
Apr. 21, 1966	8.6	--	--	--	--	--	182	--	15	--	2.5	--	--		179	30	--	381	7.3
May 27	11.2	12	52	11	8.0	0.9	181	22	15	0.1	2.2	212	.29		175	27	0.3	377	7.3
June 29	7.7	13	47	11	9.1	1.1	168	22	16	.3	1.0	204	.28		162	25	.3	353	7.8
Sept. 13	520	14	63	11	6.3	1.6	220	14	10	.2	6.0	234	.32		202	22	.2	414	7.5
Oct. 13	65.2	12	60	11	6.8	1.0	206	16	12	.3	5.9	226	.31		195	26	.2	392	7.5
Jan. 26, 1967	17.9	11	56	11	7.7	1.2	194	19	12	.2	5.3	218	.30		185	26	.2	383	7.6
May 11	9.7	12	46	10	8.1	1.3	164	20	12	.1	1.5	192	.26		156	22	.3	338	7.6
June 13	6.8	15	42	11	8.6	1.2	155	21	14	.3	.5	190	.26		150	23	.3	326	7.9
Aug. 22	4.0	17	38	12	9.1	1.3	140	25	16	.2	.2	188	.26		144	29	.3	307	8.0
May 27, 1968	156	--	46	11	--	--	164	--	12	--	--	--	--		160	26	--	330	7.4
July 1	50.6	--	--	--	--	--	172	--	14	--	--	--	--		166	25	--	350	7.5
6. NUECES RIVER NEAR LA PRYOR																			
Nov. 30, 1930			84	17	11		314	22	12		9.0	310	0.42		280	22	0.3		
Dec. 1			84	16	6.4		304	15	10		13	294	.40		276	10	.2		
7. TURKEY CREEK RESERVOIR WEST OF LA PRYOR																			
Oct. 18, 1930			55	8.1	8.3		152	48	8.0		3.5	206	0.28		171	46	0.3		
8. CHAPAROSA CREEK WEST OF LA PRYOR																			
Oct. 7, 1930			23		12		81	12	3.0		2.4	92	0.13		59	0	0.7		
9. TURKEY CREEK NEAR CRYSTAL CITY																			
May 12, 1964	29.3	6.3	34	2.2	16		116	18	10	0.2	1.0	145	0.20		94	0	0.7	258	6.8
Sept. 16	c.6	9.0	38	3.0	12		130	20	3.2	.3	.2	150	.20		107	1	.5	254	7.0
Sept. 23	2610	6.6	27	1.6	1.6	4.4	91	5.2	1.3	.5	1.8	95	.13		74	0	.1	167	6.8
May 26, 1965	7.26	8.5	52	4.9	13		178	18	8.4	.2	.5	194	.26		150	4	.5	340	6.8
May 3, 1966	219	4.8	30	2.1	3.4	5.9	100	7.0	3.3	.1	1.2	107	.15		84	2	.2	194	6.6
Aug. 15	15.1	9.9	38	3.3	13	8.6	124	26	11	.2	1.0	172	.23		108	7	.5	287	6.8
Sept. 4, 1967	4.86	7.3	33	2.7	12	5.2	123	14	6.1	.3	1.0	142	.19		93	0	.5	244	6.9
Jan. 29, 1968	.65	--	45	3.5	--	--	160	--	3.5	--	--	--	--		137	6	--	282	7.5
May 14	2.69	--	37	2.6	--	--	124	--	3.8	--	--	--	--		103	1	--	230	7.4
10. PENDENCIA CREEK NORTHWEST OF CARRIZO SPRINGS																			
Nov. 12, 1930			18		5.3		56	12	2.0		0.3	67	0.09		50	4	0.3		
11. NORTH FORK CARRIZO CREEK SOUTHWEST OF CARRIZO SPRINGS																			
Nov. 12, 1930			12		13		52	15	2.0		0.5	b68	0.09		34	0	1.0		
12. SOUTH FORK CARRIZO CREEK SOUTHWEST OF CARRIZO SPRINGS																			
Nov. 12, 1930			21		5.4		59	15	3.0		0.6	76	0.10		57	9	0.3		
13. CARRIZO CREEK AT CARRIZO SPRINGS																			
April 7, 1930	c0.07	27	91	17	99	9.0	242	73	178		0.1	b632	0.89		297	99	2.5		

See footnotes at end of table.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations--Continued

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum): Milligrams per liter (mg/l)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
14. NUECES RIVER EAST OF CARRIZO SPRINGS																			
Nov. 12, 1930			54	8.3	8.3		150	46	6.0		9.6	206	0.28		169	46	0.3		
15. NUECES RIVER NEAR ASHERTON																			
Nov. 23, 1964	2.47	9.1	57	17	37		139	61	79	0.1	4.8	333	0.45		212	98	1.1	600	7.9
Dec. 28	.06	8.9	189	39	149		384	222	290	.3	.8	1090	1.48		632	318	2.6	1740	7.7
May 19, 1965	3660	7.2	33	3.1	1.1		115	14	6.0	.2	.5	132	.18		95	1	.5	232	6.7
May 3, 1966	3650	--	--	--	--		136	9.8	4.9	--	--	--	--		107	0	--	249	7.9
May 5	3920	7.5	36	1.8	4.7	6.1	121	8.0	3.7	.1	.8	129	.18		97	0	.2	228	6.7
May 7	623	7.8	50	2.5	6.8	6.4	166	10	5.5	.1	.8	172	.23		135	0	.3	300	7.3
June 6	5.8	7.2	45	3.8	13	7.4	168	12	11	.2	.2	183	.25		128	0	.5	319	7.5
Sept. 19	233	12	58	9.7	8.3	2.6	194	18	14	.2	6.2	224	.30		185	26	.3	393	7.2
Sept. 4, 1967	1730	6.5	41	2.5	5.6	5.4	133	15	3.0	.3	2.0	146	.20		113	4	.2	250	7.2
Dec. 18	.57	4.1	72	12	41		200	60	65	.3	.2	353	.48		229	65	1.2	616	8.1
May 6, 1968	171	--	--	--	--		181	--	42	--	--	--	--		204	56	--	477	7.6
May 14	5.5	--	34	2.3	--		114	--	3.8	--	--	--	--		94	1	--	210	7.4
May 17	7020	--	--	--	--		118	--	4.3	--	--	--	--		92	0	--	207	8.7
16. NUECES RIVER AT COTULLA																			
Jan. 1-10, 1942	--	--	30	6.2	227		345	119	133	--	0.3	711	--		100	--	--	1190	--
Jan. 11-19	--	--	23	7.5	255		382	129	139	--	.2	773	--		88	--	--	1280	--
Jan. 21-31	--	--	22	6.4	295		418	148	159	--	.4	866	--		82	--	--	1410	--
Mar. 21-31	--	--	18	10	379		504	179	220	--	.0	1054	--		86	--	--	1780	--
July 21-22, 24-29, 31	--	--	47	6.6	42		189	32	33	--	.8	295	--		144	--	--	460	--
Sept. 11-16, 18-20	--	--	45	4.7	7.6		156	12	5.0	--	1.0	193	--		132	--	--	295	--
Sept. 21-28, 30	--	--	54	7.4	19		198	20	15	--	2.0	249	--		165	--	--	388	--
Oct. 21-31	--	--	57	9.6	11		201	18	14	--	3.2	250	--		182	--	--	402	--
Nov. 1-10	--	--	61	12	16		235	18	15	--	2.5	279	--		202	--	--	428	--
Nov. 11-20	--	--	58	12	29		218	33	30	--	1.5	288	--		194	--	--	481	--
Nov. 21-24, 27-30	--	--	59	13	61		250	48	55	--	.5	387	--		200	--	--	655	--
Dec. 11-20	--	--	66	21	141		289	119	138	--	1.5	651	--		251	--	--	1110	--
Dec. 21-31	--	--	50	15	165		322	100	125	--	[illegible]	[illegible]	--		186	--	--	1070	--
April 26, 1962	0.79	5.7	54	13	49		175	53	66	0.3	1.2	b328	0.45		188	44	1.6	584	7.1
May 14, 1963	809	14	51	4.6	14		158	20	17	.3	1.2	200	.27		146	17	.5	336	6.6
June 1, 1964	21.1	7.7	37	4.3	18		137	18	12	.2	1.5	166	.23		110	0	.7	292	5.8
Aug. 25	6090	6.6	40	3.5	13		134	22	5.9	.3	.0	157	.21		114	4	.5	273	6.5
Sept. 14	c.18	12	58	7.1	29		206	31	24	.4	.2	263	.36		174	5	1.0	450	7.4
Sept. 17	39700	5.2	39	3.8	12		140	17	4.0	.3	.5	151	.21		113	0	.5	249	7.2
Sept. 18	36900	5.3	32	3.2	4.8	4.5	111	11	3.9	.2	2.5	122	.17		93	2	.2	214	6.9
Sept. 19	10200	5.4	28	2.0	5.4	4.2	98	10	3.1	.2	1.0	107	.15		78	0	.3	189	6.9
Oct. 21	101	9.6	76	12	24		235	39	37	.2	8.2	322	.44		239	46	.7	556	7.2
Nov. 23	7.26	8.0	91	17	54		251	79	88	.3	2.2	462	.63		297	92	1.4	788	7.4
Dec. 28	c.02	3.4	101	26	95		246	134	158	.2	.0	639	.87		359	158	2.2	1090	7.4
May 19, 1965	2190	8.1	38	3.2	14		136	14	8.0	.2	.8	153	.21		108	0	.6	265	7.0
Oct. 4	36.7	9.6	45	4.8	23		150	41	11	.3	.5	209	.28		132	9	.9	379	6.8
Jan. 17, 1966	.1	3.2	79	18	136	4.8	270	159	140	.3	.0	673	.92		272	50	3.6	1120	7.5
May 2	150	11	50	4.8	18	7.6	168	26	19	.2	.2	220	.30		144	7	.7	379	7.3
May 5	2820	--	--	--	--	--	145	15	11	--	--	--	--		118	0	--	300	7.1
May 7	4030	8.9	40	2.7	6.7	6.8	136	11	5.8	.1	.2	149	.20		111	0	.3	263	7.2
June 6	21.3	7.9	51	4.8	18	8.0	178	22	19	.2	.2	219	.30		147	1	.6	383	7.2
Sept. 19	342	12	60	7.4	12	4.2	202	22	16	.2	2.0	235	.32		180	15	.4	413	7.1
Apr. 19, 1967	383	12	46	5.2	16	7.2	160	25	14	.2	.8	205	.28		136	5	.6	346	7.4
Apr. 20	798	7.8	52	4.0	8.4	5.4	176	14	6.6	.4	.4	186	.25		146	2	.3	319	7.2
Sept. 5	2390	7.2	35	2.6	5.4	5.0	119	12	2.8	.2	.2	129	.18		98	0	.2	223	7.1
Dec. 19	.5	5.0	63	8.0	40		194	52	45	.2	.5	309	.42		190	31	1.3	552	7.5
Jan. 30, 1968	380	--	44	8.7	--		138	--	29	--	--	--	--		146	32	--	373	7.9
May 17	2490	--	--	--	--		147	--	11	--	--	--	--		127	7	--	296	7.3

See footnotes at end of table.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations--Continued

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum): Milligrams per liter (mg/l)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
17. SAN CASIMIRO CREEK NEAR FREER																			
Nov. 8, 1965	103	15	42	1.0	29		159	21	13	0.4	1.8	201	0.27		109	0	1.2	346	7.1
Dec. 13	.1	12	36	1.4	34	3.2	144	13	28	.2	.5	199	.27		96	0	1.5	355	6.8
May 2, 1966	619	10	47	.4	25	2.9	165	18	14	.3	.8	199	.27		119	0	1.0	345	7.1
May 3	1680	--	--	--	--	--	131	16	12	--	--	--	--		93	0	--	284	7.5
May 7	1190	13	35	.7	21	3.4	128	12	15	.2	.8	164	.22		90	0	1.0	278	7.5
June 6	.2	15	139	6.9	236	8.6	180	59	478	.2	1.2	1030	1.40		376	228	5.3	1920	7.1
Sept. 21	1.0	--	--	--	--	--	116	--	450	--	--	--	--		328	233	--	1690	6.9
Apr. 14, 1967	41.3	13	45	1.3	41	3.3	165	32	24	.5	2.5	244	.33		118	0	1.6	402	7.1
Aug. 29	203	15	41	1.3	38	3.3	159	23	27	.4	2.5	230	.31		108	0	1.6	376	7.6
Sept. 13	1.2	12	56	2.5	62	5.9	188	21	80	.3	1.2	333	.45		150	0	2.2	590	7.5
Sept. 27	382	19	59	2.3	42	5.5	184	20	56	.2	1.2	295	.40		156	6	1.5	494	7.2
Sept. 28	700	12	44	1.2	33	3.6	135	20	39	.2	2.2	221	.30		115	4	1.3	383	7.4
Oct. 4	16.2	16	166	8.3	271		218	70	555	.3	3.7	1200	1.63		448	270	5.6	2210	7.4
18. COLMENA CREEK NEAR FREER																			
Mar. 30, 1959	cl	60	20	7.8	381		683	127	149	3.4	0.2	1080	1.47		82	0	18	1680	8.9
19. NUECES RIVER NEAR TILDEN																			
Aug. 17, 1949	838	--	--	--	--	--	166	38	18	--	--	--	--		--	--	--	384	8.3
Feb. 16, 1959	85	2.3	72	14	65		199	52	110	0.2	7.7	b443	0.60		237	74	1.8	769	8.0
Mar. 30	7.2	4.6	67	15	107		196	67	164	--	1.5	522	.71		228	68	3.1	962	8.1
Apr. 20, 1967	83	20	48	4.0	3.2	8.8	188	28	21	.4	.2	254	.35		136	0	1.2	409	7.4
May 22	634	13	52	2.6	29	5.8	178	36	19	.5	2.2	248	.34		140	0	1.1	412	7.1
May 23	346	13	46	2.2	32	5.6	160	35	21	.5	1.8	236	.32		124	0	1.2	391	7.1
Aug. 22	892	9.9	40	2.8	24	5.2	136	33	14	.3	2.0	198	.27		111	0	1.0	317	7.6
Sept. 5	1420	14	44	2.1	28	5.3	158	27	20	.4	1.5	220	.30		118	0	1.1	366	7.3
May 7, 1968	146	--	63	10	--	--	190	--	55	--	--	--	--		198	42	--	539	7.5
21. NUECES RIVER AT SIMMONS																			
May 21, 1965	3770	15	36	2.0	26		134	20	15	0.4	1.0	181	0.25		98	0	1.1	304	7.0
May 22	3240	13	36	2.2	26		135	21	16	.2	.5	181	.25		99	0	1.1	308	6.7
May 25	4960	17	43	3.1	27		163	22	15	.3	.8	208	.28		120	0	1.1	348	6.7
Mar. 29, 1966	.1	4.2	66	5.8	145	7.4	240	46	188	.4	.0	581	.79		188	0	4.6	1080	7.4
Apr. 21	542	--	--	--	--	--	197	--	32	--	1.2	--	--		134	0	--	445	7.2
Apr. 27	1100	13	55	1.5	25	5.2	194	24	13	.2	.2	232	.32		143	0	.9	396	7.0
Sept. 26	207	12	62	6.9	19	5.1	205	26	26	.2	.8	259	.35		183	15	.6	457	7.1
Aug. 25, 1967	1090	14	46	2.6	26	5.4	146	38	16	.3	3.8	224	.30		125	6	1.0	349	7.4
Sept. 1	946	15	41	2.3	27	5.5	150	26	17	.4	1.2	209	.28		112	0	1.1	342	7.8
Sept. 6	1430	14	36	1.9	25	5.4	127	25	17	.3	1.8	188	.26		98	0	1.1	312	7.7
Sept. 7	1560	14	37	1.9	24	5.2	135	25	14	.3	1.2	189	.26		100	0	1.0	310	7.7
Sept. 11	2050	19	42	2.5	19	7.3	164	17	9.5	.3	.8	198	.27		115	0	.8	319	7.4
Jan. 22, 1968	696	--	--	1.2	--	--	--	--	21	--	--	--	--		--	--	--	--	--
Jan. 23	793	--	84	5.6	--	--	128	--	217	--	--	--	--		232	128	--	1020	7.4
Jan. 24	532	--	66	5.0	--	--	143	--	136	--	--	--	--		185	68	--	762	7.7
Jan. 25	314	--	91	7.3	--	--	164	--	239	--	--	--	--		257	122	--	1130	8.0
Jan. 30	8.68	7.0	76	10	51		204	63	75	.2	2.6	385	.52		230	64	1.5	677	7.4
Feb. 20	161	--	55	10	--	--	184	--	41	--	--	--	--		178	28	--	485	7.8
May 18	486	--	54	9.6	--	--	179	--	39	--	--	--	--		174	28	--	451	7.9

See footnotes at end of table.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations--Continued

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum) Milligrams per liter (mg/l)	Dissolved solids (sum) Tons per acre-foot	Dissolved solids (sum) Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
22. FRIO RIVER NEAR LEAKEY																			
June 17, 1952		11	58	18	5.7		246	0.7	12	0.2	6.1	b240	0.33		219	17	0.2	423	8.2
23. FRIO RIVER AT CONCAN																			
June 16, 1952	--	13	47	16	6.6		200	12	14	0.2	1.0	b210	0.29		183	19	0.2	372	8.0
Dec. 16, 1964	56.2	10	54	16	6.4	0.9	221	15	13	.2	3.8	228	.31		201	19	.2	407	7.5
May 4, 1965	58.2	11	56	17	6.8	.8	226	18	12	.2	1.8	235	.32		210	24	.2	421	7.4
July 15	70.1	12	55	16	7.0	1.0	220	17	13	.2	2.8	232	.32		203	23	.2	413	7.1
Jan. 3, 1966	58.9	10	57	16	7.5	.9	234	15	13	.2	3.8	238	.32		208	16	.2	416	7.6
Mar. 14	52.6	10	61	14	6.3	.8	227	17	12	.2	2.8	236	.32		210	24	.2	430	7.6
Apr. 25	743	13	60	15	6.0	1.6	234	14	12	.3	2.0	239	.33		211	20	.2	429	7.5
Apr. 26	--	10	52	11	4.5	1.7	196	12	9.0	.2	3.5	200	.27		175	14	.1	362	7.3
Aug. 13	39000	10	69	4.9	3.2	3.0	232	4.0	3.2	.1	.5	212	.29		192	2	.1	375	7.0
Aug. 13	6820	8.9	56	4.7	1.8	2.8	176	8.4	4.5	.2	8.2	182	.25		159	15	.1	319	7.2
Aug. 14	2660	10	52	7.6	4.5	2.5	170	11	8.2	.1	11	191	.26		161	22	.2	329	7.3
Sept. 7	180	--	66	14	--	--	236	--	12	--	--	--	--		222	29	--	439	7.4
Jan. 27, 1967	62.4	10	62	15	7.0	.8	230	16	14	.1	6.2	244	.33		216	28	.2	431	7.6
May 9	40.0	11	52	14	7.2	1.0	203	15	13	.1	1.8	215	.29		187	21	.2	383	7.7
June 15	17.1	13	50	15	7.2	1.0	197	17	14	.3	.5	215	.29		186	25	.2	377	7.6
May 28, 1968	215	--	64	14	--	--	228	--	16	--	--	--	--		217	30	--	439	7.6
Aug. 7	109	--	--	--	--	--	217	--	15	--	--	--	--		212	34	--	413	7.9
24. DRY FRIO RIVER NEAR REAGAN WELLS																			
Jan. 3, 1966	14.0	8.4	65	13	8.3	0.7	238	19	12	0.2	4.7	248	0.34		216	21	0.2	433	7.5
May 25	7.9	11	62	13	6.4	.4	222	17	13	.1	.5	232	.32		208	26	.2	408	7.5
June 27	3.1	12	59	13	6.7	1.8	224	14	14	.1	.2	231	.31		201	17	.2	404	7.7
July 8	66.5	--	--	--	--	--	174	--	10	--	--	--	--		166	23	--	340	7.6
Aug. 14	834	9.7	62	8.2	4.4	1.6	189	14	11	.0	14	218	.30		188	34	.1	383	7.3
Oct. 14	32.7	10	74	14	7.1	.6	258	18	15	.3	5.4	271	.37		242	30	.2	471	7.6
Jan. 27, 1967	11.2	8.4	62	13	6.7	.6	215	18	14	.0	5.8	234	.32		208	32	.2	415	7.7
June 15	2.27	11	62	13	7.3	1.0	225	16	14	.3	.5	236	.32		208	24	.2	412	7.6
Nov. 3	--	8.0	58	13	7.1		202	18	13	.2	13	229	.31		198	33	.2	405	7.4
May 28, 1968	55.8	--	60	13	--	--	228	--	15	--	--	--	--		203	16	--	436	7.7
Aug. 7	37.9	--	--	--	--	--	212	--	14	--	--	--	--		202	28	--	410	7.5
25. DRY FRIO RIVER NEAR CONCAN																			
June 16, 1952		10	58	15	7.1		219	16	16	0.3	0.8	b240	0.33		206	27	0.2	407	8.1
27. BRUSHY CREEK NORTHWEST OF VANDERPOOL																			
Aug. 10, 1947							240	10	12						237	40		447	

See footnotes at end of table.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations--Continued

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO$_2$)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO$_3$) a/	Sulfate (SO$_4$)	Chloride (Cl)	Fluoride (F)	Nitrate (NO$_3$)	Dissolved solids (sum): Milligrams per liter (mg/1)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): Tons per day	Hardness as CaCO$_3$: Calcium, Magnesium	Hardness as CaCO$_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
28. SABINAL RIVER NEAR SABINAL																			
Nov. 10, 1964	25.3	11	74	16	12		246	44	18	0.2	4.0	300	0.41		250	49	0.3	504	7.7
Dec. 16	20.4	12	78	17	7.7	1.3	256	47	16	.0	4.2	309	.42		264	54	.2	518	7.8
July 13, 1965	14.4	14	48	15	10		172	38	16	.2	.8	227	.31		181	40	.3	444	7.4
Nov. 29	19.7	13	77	13	7.5	1.3	245	37	14	.2	3.0	286	.39		246	45	.2	495	7.2
Mar. 14, 1966	23.2	12	75	14	7.2	1.1	231	38	14	.3	3.8	279	.38		244	55	.2	489	7.5
May 23	35.7	12	58	14	6.9	.9	196	36	13	.2	1.8	239	.33		202	42	.2	579	7.6
Aug. 13	378	12	62	13	7.7	1.2	210	32	15	.2	.2	246	.33		208	36	.2	434	7.8
Aug. 13	2140	13	64	9.8	4.3	2.4	202	31	8.7	.2	2.8	235	.32		200	34	.1	401	7.4
Oct. 11	96.0	13	66	14	7.7	.9	219	30	14	.3	7.8	262	.36		222	43	.2	448	7.5
Jan. 24, 1967	22.4	10	71	15	7.8	.9	232	36	15	.2	6.9	277	.38		238	48	.2	477	7.5
Apr. 19	489	7.3	60	6.5	2.9	3.3	188	13	6.4	.4	7.7	200	.27		176	22	.1	343	7.2
Sept. 15	5470	8.5	38	1.4	.8	2.9	118	7.0	1.7	.3	.0	119	.16		101	4	.0	177	7.8
Oct. 2	35.9	11	62	14	7.5	1.2	203	31	15	.1	5.8	248	.34		212	46	.2	426	7.5
May 11, 1968	2800	--	--	--	--	--	--	6.4	3.5	--	--	--	--		--	--	--	263	--
June 28	108	--	--	--	--	--	200	--	17	--	--	--	--		206	42	--	424	7.4
Aug. 5	74.4	--	--	--	--	--	220	--	17	--	--	--	--		223	43	--	452	7.5
31. HONDO CREEK NEAR TARPLEY																			
Oct. 13, 1966	20.1	11	61	11	6.3	0.9	189	34	12	0.3	3.8	233	0.32		197	43	0.2	396	7.6
Apr. 5, 1967	2.08	10	54	12	7.4	1.1	145	61	15	.3	.2	232	.32		184	65	.2	396	7.2
Dec. 7	--	10	56	11	8.3		164	39	14	.2	9.7	229	.31		185	51	.3	392	7.5
Feb. 15, 1968	71.1	--	57	11	--	--	163	--	16	--	--	--	--		187	54	--	393	7.6
34. SECO CREEK AT MILLER RANCH NEAR UTOPIA																			
Nov. 29, 1965	5.1	10	67	8.0	7.8	1.1	184	37	14	0.2	6.2	241	0.33		200	49	0.2	449	7.4
Apr. 19, 1966	5.0	9.6	57	11	7.7	1.0	173	41	15	.1	3.5	231	.31		187	46	.2	410	7.4
June 29	3.5	12	54	11	7.2	1.0	174	27	14	.3	3.8	216	.29		180	37	.2	371	7.8
Aug. 14	142	9.7	49	7.4	3.4	1.8	157	18	6.4	.1	6.0	179	.24		153	24	.1	315	7.3
Apr. 4, 1967	1.4	9.2	40	11	8.0	1.3	124	39	16	.0	.2	186	.25		145	43	.3	323	7.4
July 17	.28	14	37	12	10	1.6	116	36	22	.4	.2	190	.26		142	47	.4	330	7.6
36. FRIO RIVER NEAR DERBY																			
Apr. 26, 1962	41.1	11	51	4.5	14		137	21	28	0.2	2.2	199	0.27		146	34	0.5	356	6.8
May 14, 1963	12.5	12	52	4.9	11		154	22	17	.3	.8	196	.27		150	24	.4	326	7.1
Mar. 21, 1964	66.3	9.9	44	2.5	1.6	6.5	146	3.4	4.7	.1	2.0	147	.20		120	0	.1	251	7.0
Mar. 23	30.5	9.8	45	2.6	2.8	7.8	144	9.2	4.5	.2	3.8	157	.21		123	5	.1	267	6.8
Oct. 2	339	12	47	4.3	2.3	7.6	165	11	3.2	.2	1.2	170	.23		135	0	.1	275	6.9
Apr. 1, 1965	270	10	62	2.7	4.5	4.8	202	5.6	7.5	.2	.2	196	.27		166	0	.2	350	7.1
Apr. 5	19.4	9.9	44	3.9	12		154	12	7.8	.3	2.2	168	.23		126	0	.5	300	7.1
Apr. 12	5.03	10	36	1.5	2.5	6.8	122	.6	4.7	.2	1.5	124	.17		96	0	.1	219	6.9
May 18	138	9.5	46	2.5	2.8	7.3	152	7.4	4.4	.6	2.2	158	.21		125	0	.1	274	7.1
Dec. 5	151	8.8	56	2.2	9.7	5.2	172	12	12	.2	4.0	195	.27		149	8	.3	350	6.9
Dec. 14	.4	7.8	36	2.2	6.6	5.1	120	12	6.8	.2	1.0	137	.19		99	0	.3	243	7.1
Apr. 28, 1966	131	11	50	3.4	7.0	11	161	19	9.5	.2	.8	191	.26		139	7	.3	336	7.0
May 4	9.8	10	42	3.0	5.5	9.2	140	10	9.0	.2	.2	158	.21		117	2	.2	276	7.4
Aug. 15	4170	--	65	4.6	--	--	202	--	4.0	--	--	--	--		181	16	--	354	7.1
Aug. 16	5990	10	57	4.6	2.6	4.7	186	6.8	4.6	.0	6.1	187	.25		161	9	.1	329	7.2

See footnotes at end of table.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations--Continued

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum): Milligrams per liter (mg/l)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): 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
36. FRIO RIVER NEAR DERBY--Continued																			
Aug. 17, 1966	1250	11	60	5.6	2.4	4.7	192	9.6	6.2	0.0	6.3	200	0.27		173	15	0.1	354	7.1
Aug. 17	861	--	63	5.8	--	--	196	--	6.4	--	--	--	--		181	20	--	358	7.1
Aug. 18	473	--	57	6.4	--	--	180	--	7.1	--	--	--	--		168	21	--	341	7.8
Sept. 19	260	--	80	6.7	--	--	192	--	56	--	--	--	--		227	70	--	630	6.9
Sept. 4, 1967	292	8.7	61	3.3	2.0	4.4	200	4.2	1.4	.2	1.8	185	.25		166	2	.1	319	7.3
Dec. 18	11.5	8.3	44	14	14		130	29	40	.2	6.0	220	.30		167	61	.5	405	7.7
May 6, 1968	9.4	--	50	12	--	--	136	--	51	--	--	--	--		174	63	--	427	7.6
37. LEONCITA CREEK AT TILDEN																			
Dec. 19, 1967	0.11	17	20	3.4	563	6.4	1380	23	96	1.6	1.5	1410			64	0	31	2210	8.2
38. FRIO RIVER AT TILDEN																			
Feb. 16, 1959		2.1	56	23	288		300	138	330	0.6	3.5	989	1.35		234	0	8.2	1760	8.2
Mar. 30		4.6	40	25	567		526	212	555		1.0	1660	2.26		203	0	17	2860	8.2
39. SAN MIGUEL CREEK NEAR TILDEN																			
Feb. 16, 1959	--	4.4	107	21	89		285	156	106	0.3	0.0	b635	0.86		354	120	2.0	1040	8.0
Dec. 16, 1965	11.4	9.3	25	2.6	18	5.3	84	30	14	.2	.5	146	.20		73	4	.9	254	6.4
May 5, 1966	146	10	46	4.3	24	6.0	115	53	26	.2	2.2	229	.31		132	38	.9	390	7.0
June 9	3.1	13	138	20	134	9.8	328	199	177	.1	.2	852	1.16		427	158	2.8	1410	7.7
July 14	3.1	16	96	12	90	8.2	254	128	108	.3	.2	584	.79		289	81	2.3	948	7.6
Sept. 8	133	--	44	3.5	--	--	108	--	25	--	--	--	--		124	36	--	381	6.6
Oct. 25	.13	13	68	7.4	50	8.6	199	80	52	.1	.8	378	.51		200	37	1.5	640	7.1
Apr. 19, 1967	1.9	13	46	7.3	36	9.0	195	27	30	.2	1.5	266	.36		145	0	1.3	460	7.0
May 22	--	7.3	26	3.0	21	5.4	79	36	16	.3	2.8	157	.21		77	12	1.0	266	6.6
Dec. 19	8.7	18	224	36	222	10	310	452	330	.3	9.2	1450	1.96		707	453	3.6	2210	7.8
Jan. 30, 1968	44.8	--	157	35	--	--	256	--	256	--	--	--	--		536	326	--	1740	7.6
May 7	11.7	--	116	26	--	--	216	--	210	--	--	--	--		396	220	--	1450	7.4
40. OPOSSUM CREEK NEAR CALLIHAM																			
Dec. 20, 1967	0.04	3.9	768	49	2750	32	188	1350	4680	--	--	9720	13.1		2120	1960	--	15300	7.3
41. FRIO RIVER AT CALLIHAM																			
Mar. 20, 1942	--	--	70	16	202		293	84	249	--	0.5	b778	1.06		240	--	5.7	1380	--
July 19, 1948	--	13	138	44	5260		186	239	8200	--	--	14000	19.0		526	--	--	23300	--
July 5, 1949	--	--	--	--	--		--	--	67	--	--	--	--		170	--	--	626	--
Aug. 16	89	--	--	--	--		144	40	50	--	--	--	--		--	--	--	437	8.2
Dec. 17, 1952 and Jan. 1-2, 1953	--	21	128	19	3210		339	240	4880	--	--	8660	11.8		398	120	--	14500	7.8
Jan. 30, Feb. 1-6, 1959	--	7.8	94	19	220		253	129	315	--	6.1	b928	1.26		312	105	5.4	1580	8.1
Apr. 25, 1962	1.40	4.3	55	19	374		306	163	430	0.7	.0	1200	1.63		215	0	11	2060	7.2
July 2	4.07	12	42	5.5	96		186	49	93	.4	.0	b391	.53		128	0	3.7	703	6.7
Sept. 13	3.75	13	40	6.6	246		350	104	188	--	2.5	772	1.05		127	0	9.5	1320	7.3
Dec. 28	c.02	9.9	84	8.3	797		160	172	1180	--	1.5	2330	3.17		244	112	22	4100	6.8

See footnotes at end of table.

Table 5.--Chemical Analyses of Water From Streams in the Nueces River Basin for Locations Other Than Daily Stations--Continued

(Results in milligrams per liter except as indicated.
Calculated values for sodium plus potassium are centered between the two columns.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3) a/	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (sum): Milligrams per liter (mg/l)	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): 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. OLMOS CREEK NEAR WHITSETT																			
Apr. 19, 1959		16	68	2.4	78		141	145	56	0.5	1.0	436	0.59		180	64	2.5	695	7.7
55. SAN CHRISTOVAL CREEK NEAR WHITSETT																			
Apr. 19, 1959		20	37	1.8	20		124	34	4.2	0.3	0.2	178	0.24		100	0	0.9	294	6.4
56. ATASCOSA RIVER NEAR THREE RIVERS																			
Mar. 20, 1942	--	--	102	24	231		364	220	232	--	0.5	989	1.34		353	--	5.3	1650	--
Aug. 16, 1949	35	--	--	--	--		157	226	175	--	--	--	--		--	--	--	1480	8.2
Jan. 25, 1951	4.32	--	--	--	376		510	168	295	--	.8	--	--		192	0	12	1910	8.2
Dec. 21, 1967	24.5	23	139	35	333	10	364	356	388	0.6	2.2	1470	2.00		491	192	6.5	2340	7.9
57. FRIO RIVER AT THREE RIVERS																			
Mar. 20, 1942	--	--	89	20	216		337	139	251	--	0.2	b903	1.23		304	--	5.4	1540	--
Dec. 21, 1967	54.6	20	120	26	240	7.7	290	235	312	0.4	4.2	1110	1.51		406	169	5.2	1850	7.8
59. SULPHUR CREEK AT OAKVILLE																			
Apr. 19, 1959		17	94	14	239		376	97	285	0.5	0.0	932	1.27		292	0	6.1	1640	7.3
60. NUECES RIVER BELOW SULPHUR CREEK NEAR OAKVILLE																			
Jan. 25, 1951	4.34				434		569	183	362		1.0				224		13	2210	8.1
61. NUECES RIVER NEAR GEORGE WEST																			
Jan. 25, 1951	5.49	--	--	--	465		529	150	500	--	0.0	--	--		284	--	12	2550	8.2
Apr. 19, 1959	--	17	102	19	269		323	162	342	0.4	1.8	1070	1.46		332	68	6.4	1860	7.3
62. NUECES RIVER NEAR MIKESKA																			
Jan. 25, 1951	5.29				358		413	139	450		0.0				340	2	8.4	2420	7.9
66. CAYAMON CREEK AT FARM ROAD 666 NEAR BLUNTZER																			
Aug. 30, 1963	0.22	46	79	54	638		208	348	900	1.2	0.0	2170	2.95		419	248	14	3680	7.0
Feb. 23, 1966	c1.0	40	178	70	865	12	280	466	1320	--	6.5	3100	4.22		730	500	14	5210	7.4
Aug. 18	c1.8	55	90	38	459	12	234	248	680	.9	.8	1700	2.31		381	189	10	2910	7.6
67. NUECES RIVER AT CALALLEN DAM ABOVE CALALLEN																			
Jan. 31, 1962	--	15	42	8.3	62	7.9	122	45	96	0.4	0.0	b348	0.47		139	39	2.3	597	7.6
Aug. 31, 1963	--	14	55	7.5	83		190	46	101	.5	.0	400	.54		168	12	2.8	705	7.0
Feb. 15, 1966	148	18	59	5.5	38	6.4	220	27	39	.2	.2	301	.41		170	0	1.3	526	7.5
Feb. 24	--	18	68	7.4	52	7.5	230	36	72	.3	.2	374	.51		200	12	1.6	665	7.3
Aug. 18	--	23	56	5.0	49	8.5	183	31	67	.4	.0	331	.45		160	10	1.7	573	7.6

a/ Includes equivalent of any carbonate (CO_3) present.
b/ Residue on evaporation at 180°C.
c/ Estimated.