Saline-Water Resources of Texas

By A. G. WINSLOW *and* L. R. KISTER

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One State's reserves of saline water—a potential water resource

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ABSTRACT

Large quantities of saline water are available in the world, both on the surface and underground; however, these waters have not been studied extensively as sources of potable water.

Saline water is defined herein as water containing more than 1,000 parts per million of dissolved solids, or, with certain mineralized irrigation waters whose exact dissolved-solids content is not known, water containing more than 60 percent sodium.

Saline ground water occurs as connate water or other saline water that entered an aquifer in the geologic past and has not been flushed from the aquifer; as the result of solution of soluble materials in aquifers by percolating ground water; as a result of salt-water encroachment into aquifers which are in hydrologic connection with saline waters; or as the result of concentration by evaporation, especially in the vicinity of playa lakes.

Surface water may become saline as a result of seepage of highly mineralized ground water; solution of salts from rocks over which the streams flow; intrusion of sea water in tidal reaches of a stream; and discharge of saline wastes from industrial operations.

Most of the aquifers in Texas contain saline water in some parts, and a few are capable of producing large quantities of saline water. Of the early Paleozoic formations, the Hickory sandstone member of the Riley formation of Cambrian age and the Ellenburger group of Ordovician age are potential sources of small to moderate supplies of saline water in parts of central and west-central Texas.

Several of the Permian formations, of which the Blaine gypsum and certain limestone and dolomite strata of the Wichita and Clear Fork groups are the most important, yield varying quantities of saline water in parts of the Osage Plains region. In the Pecos Valley and trans-Pecos regions, large quantities of saline water are used from wells tapping the Rustler and Bone Spring limestones of Permian age.

Some of the aquifers of Cretaceous age are potential sources of moderate to large supplies of saline water, particularly in a belt extending from northeast Texas southwestward into south Texas, and lying roughly parallel to the Balcones fault zone on the east and south of it. The most important of these include the formations of the Trinity group, the Edwards limestone and associated limestones, and the Woodbine sand.

The Eocene strata of the West Gulf Coastal Plain include some potentially large sources of saline water. Beds of the Wilcox group, the Carrizo sand, and the Sparta sand yield moderate to large quantities of fresh water to wells and probably could yield large quantities of saline water in areas downdip from the areas that yield fresh water.

Aquifers of Miocene and Miocene(?) age that are capable of producing moderate to large quantities of saline water to wells in parts of the west Gulf Coastal Plain include the Catahoula sandstone, the Oakville sandstone, and the Lagarto clay.

Aquifers of Pliocene, Pliocene(?), and Pleistocene age on the west Gulf Coastal Plain are probably the greatest potential sources of saline water in the coastal region of Texas. The Goliad sand, Willis sand, and Lissie formation, undifferentiated, and the Beaumont clay yield moderate to large quantities of fresh water to wells along the coast. They could, no doubt, yield large quantities of saline water in a narrow belt immediately adjoining the coast where large supplies of fresh water are not available.

The Ogallala formation of Pliocene age yields saline water in the vicinity of some of the playa lakes on the High Plains.

Pleistocene and Recent alluvial deposits yield large quantities of water to wells in some places in Texas. Probably the most important of the alluvial aquifers are those of the bolson deposits in the trans-Pecos region. In the El Paso area large quantities of fresh water are pumped from the bolson deposits, and recent test drilling has shown that large quantities of saline water underlie the fresh water. Alluvial deposits in the Pecos Valley and in the lower Rio Grande valley yield large quantities of fresh water to wells and are known to be sources of large quantities of saline water in some places.

Surface water becomes saline in the lower reaches of streams that drain to the Gulf of Mexico. The salinity is increased in some places where large withdrawals of stream water cause intrusion of sea water. Disposal of oilfield brines also contributes to the salinity of certain streams from time to time.

Analyses of the Canadian River in the Texas Panhandle show the occurrence of slightly saline water during periods of low flow. However, weighted-average analyses obtained from continuous sampling show that the water is nonsaline.

Upper reaches of the Red, Brazos, and Colorado Rivers and their tributaries contain water that ranges from slightly to very saline. Impounding of floodwater on these rivers and subsequent release during periods of low flow have generally improved the chemical quality of the water in the lower reaches.

The water of the Rio Grande is moderately saline at times near the Fort Quitman and upper Presidio stations. The Falcon Dam at the Zapata-Starr County line probably will eliminate saline water in the river in the lower valley. Water from the Pecos River, tributary to the Rio Grande, ranges from slightly to moderately saline at Orla to very saline at Grandfalls.

INTRODUCTION

PURPOSE AND SCOPE

This report is a contribution to the Department of Interior's Saline Water Conversion Program for investigating feasible ways of demineralizing saline water for use in areas that have insufficient water. It is one of a group of proposed relatively detailed reports on individual States or groups of States which will be necessary to the planning of research in and development of saline-water conversion processes. General information on the occurrence of saline water in the United States will be given in a later report.

Because most processes for removing the salt from water vary in cost in proportion to the salinity of the water, information about the location of saline waters and their typical analyses will be most helpful in determining where particular processes may be technically and economically feasible.

Despite the large quantities of surface or underground saline water available almost everywhere, these waters have not been studied as sources of potable water. It is the purpose of this report to outline the occurrence, quantity, and quality of saline water available in Texas; to discuss and identify aquifers containing saline water, with emphasis on those capable of yielding large quantities; and to delineate areas in which a considerable amount of saline surface water is available. Representative analyses of water from the principal sources also are included. Texas was selected for this preliminary report because of the wide variation in use and need for water, because available information indicated that there are large quantities of saline water in Texas, and because of severe droughts and local shortages of potable water during recent years.

ACKNOWLEDGMENTS

The data on which this report is based were taken from sources in the files of the U. S. Geological Survey at Austin, Tex., from published and unpublished reports by the Texas State Board of Water Engineers prepared in cooperation with the Geological Survey, and from published reports by the Bureau of Economic Geology of the University of Texas. Other data were obtained from records of the Humble Oil and Refining Co., the Texas State Health Department, and the Works Progress Administration.

Time limitations did not permit an exhaustive study of all the possible sources of information on saline water in Texas. The U. S. Bureau of Mines and many of the oil companies have in their files much information which might be obtained if a more comprehensive study of the saline-water resources of Texas were made.

CHEMICAL ANALYSES OF WATER

Most of the chemical analyses reported here were made by the Geological Survey. Most of the analyses show the major water-soluble constituents. Concentrations of the individual constituents are expressed in parts per million (ppm), which is a measure of the weight of 1 part of dissolved substance in 1 million parts of solution.

A comprehensive discussion of the individual mineral constituents is not included in this report. However, definitions are given for specific conductance, dissolved solids, and percent sodium because they are considered to be the most important factors in classifying water as fresh or saline. Boron is discussed briefly because of its toxic effect, in comparatively low concentrations, on many plants.

Specific conductance, expressed in micromhos per centimeter at 25°C, is a measure of the ability of the ions in solution to conduct an electric current. It serves as a general indication of the amount of dissolved material in the water.

The dissolved-solids concentration, in parts per million, is the weight of dissolved material in water and is determined either as the weight of the residue upon evaporation and drying at 180°C or as the arithmetical sum of the weights of the determined constituents, the bicarbonate being computed as carbonate. The residue from some water containing more than 1,000 ppm of dissolved solids includes organic matter and water of crystallization in sufficient quantities to cause considerable variation in the reporting of dissolved solids. For this reason, most of the values for dissolved solids in the tables of analyses in this report are the sums of the individually determined constituents, but some are the weights of the residue after evaporation, particularly where insufficient determinations of individual constituents were available for computing a sum.

The percent sodium is a derived quantity obtained by dividing the equivalents per million of sodium, multiplied by 100, by the sum of the equivalents per million of calcium, magnesium, sodium, and potassium. An excessive proportion of sodium in the water applied to land may cause the soil structure to break down and the soil to become relatively impervious to the passage of water. The percent sodium, therefore, is important to the prospective user of water for irrigation. The usefulness of irrigation water may be indicated also by the sodium-adsorption ratio, recently described by Richards and others (1954). However, percent sodium is used in this report because most available analyses are expressed thus.

According to Richards and others (1954), boron is essential to the normal growth of all plants, but the quantity required is very small. The occurrence of boron in toxic concentrations may be indicated by leaf burn, bleaching of normal plant color (chlorosis), or death of plant tissue (necrosis). Citrus, stone-fruit, and pecan trees are among the plants highly sensitive to boron in irrigation water. Lemons show definite injury when irrigated with water containing 1 ppm of boron, but alfalfa will make maximum growth with irrigation water containing 1 to 2 ppm of boron.

The analyses of saline ground water and the descriptions of the wells sampled are given in tables 1 and 2, respectively. Similar data on quality and source of the saline surface waters are given in tables 3 and 4.

DEFINITION OF SALINE WATER

For the purpose of this report, water containing more than 1,000 ppm of dissolved solids is regarded as saline. This lower limit of dissolved solids was selected because a dissolved-solids content of as much as 1,000 ppm in water is acceptable (though 500 ppm is recommended) to the U. S. Public Health Service in potable water used by interstate carriers (U. S. Public Health Service, 1946). It must be recognized that in many areas of Texas the only available water supply may have a dissolved-solids concentration greatly in excess of 1,000 ppm. Therefore, waters discussed in this report will be classified as "slightly saline," "moderately saline," or "very saline," or as "brine," according to the following tabulation.

Description	*Dissolved solids, in parts per million*
Slightly saline	1,000 to 3,000
Moderately saline	3,000 to 10,000
Very saline	10,000 to 35,000
Brine	More than 35,000

Water used by many small communities, farms, and ranches is in the slightly saline range. Water of this class has been recognized as somewhat unsatisfactory but generally not harmful. Water containing as much as 3,000 ppm of dissolved solids generally has been considered satisfactory for irrigation, depending on other factors relating to the soil and to crop growth.

Water having a dissolved-solids content ranging from 3,000 to 10,000 ppm, herein described as moderately saline, is unsatisfactory for most purposes and is rarely used for domestic supply. Irrigation on the sandy soils of the Pecos Valley in Texas and New Mexico has been carried on with this kind of water for many years, generally with success, although some lands have been abandoned because of salinity problems resulting from irrigation. Natural drainage conditions, however, are particularly favorable in the Pecos Valley for the use of this water, whereas in most other parts of the State and Nation, where drainage conditions are not as favorable, such water could not be used. Experiments have indicated that 10,000 ppm is about the upper limit of salinity that can be tolerated by livestock (Smith, Dott, and Warkentin, 1942, p. 15).

Water containing 10,000 to 35,000 ppm of dissolved solids is classified as very saline. The upper limit of this classification is set approximately at the concentration of sea water. Some of the aquifers in Texas yield varying amounts of water of this class. Closed lakes and basins in which the water is concentrated by evaporation are also capable of yielding supplies of very saline water. Industry has used some sea water along the coast for cooling.

Water having more than 35,000 ppm of dissolved solids is classed as brine; such water probably cannot be demineralized economically at present for general use. In addition to high costs of demineralization, there would be a problem of disposal of salt residues. Brines are used in places for repressuring oilfields, and they are a valuable source of certain minerals.

OCCURRENCE OF SALINE WATER

GROUND WATER

Many of the geologic formations which constitute the aquifers are sedimentary rocks deposited originally in saline water. Some of the saline water in the aquifers at the present time is connate (water in which the formation was deposited); some of it has entered the aquifers since they were laid down. From many formations where there are opportunities for natural discharge, the connate water has been partly or entirely flushed; however, in some formations structural or stratigraphic traps may prevent natural flushing and the saline water remains.

Most ground water is derived from precipitation on the outcrop of an aquifer or from streams that cross the outcrop. As the water percolates through the aquifer, it dissolves the soluble constituents of the rock. The Permian rocks, cropping out in the Osage Plains region and in parts of the Pecos Valley and trans-Pecos regions, include many beds of evaporites such as salt, gypsum, and anhydrite. Water percolating through these beds or running over the outcrop area may dissolve large quantities of these soluble minerals and thus become saline.

Along seacoasts or in other places where aquifers may be in hydrologic connection with saline water, encroachment may occur as a result of a lowering of fresh-water head by drought or pumping. Such contamination by encroachment of saline water has occurred at some places along the Texas coast.

Another type of occurrence of saline ground water is that in the vicinity of playa lakes where there is discharge of ground water by evaporation and transpiration by plants. The concentration of salts in the water increases where the evapotranspiration of ground water takes place, thus causing the water to become saline.

SURFACE WATER

Saline surface water occurs in many of the streams in Texas; however, occurrence of saline surface water for long periods of time is limited to a few areas. The mineral content of water in the streams varies tremendously, depending on the discharge; however, the base or low flow of the streams may be of relatively uniform salinity.

Streams that originate in or pass through the outcrop area of evaporites such as those in the Osage Plains region may, at least at times, be saline; however, these same streams may become fresh in their lower reaches, after receiving fresh water from downstream tributaries. Except for those contaminated by oilfield wastes, streams originating on the West Gulf Coastal Plain are generally fresh in their upper reaches, at least, for evaporites do not occur in quantity in that area.

GENERAL GEOLOGY AND SALINE-WATER AQUIFERS

The geology of Texas presents a diversified picture both stratigraphically and structurally. Rocks ranging from Precambrian to Recent are present, and structures range from those exhibiting the effects of intense diastrophism typical of some of the Precambrian rocks in central Texas to the relatively simple homocline of the West Gulf Coastal Plain.

A comprehensive description of the geology of Texas is given by Sellards, Adkins, and Plummer (1932). Their publication has been used freely in the following geological discussion, and many of the formation descriptions have been taken from it. A general discussion of the geology of Texas perhaps should be related to the physiographic, structural, and geographic features represented in the State (fig. 1).

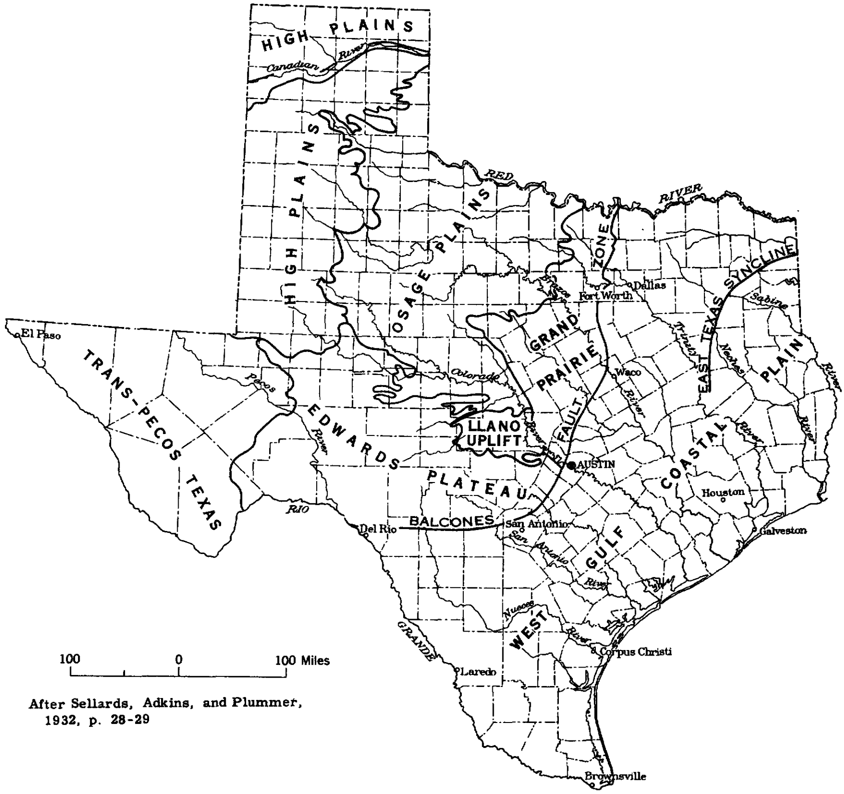


Figure 1.—Map showing physiographic, structural, and geographic features referred to in text.

The oldest rocks, including the Precambrian and lower Paleozoic formations, are exposed in the Llano uplift in central Texas and in places in trans-Pecos Texas. The Precambrian rocks are known to contain only small quantities of water; hence they are not considered further in this report. Some of the Cambrian and Ordovician rocks are aquifers, especially those on the flanks of the Llano uplift and at some places in trans-Pecos Texas.

The upper Paleozoic formations crop out in the Osage Plains region, where they dip generally westward. They crop out also in parts of trans-Pecos Texas. Some of these formations, particularly those of the Permian, are the sources of the salts present in much of the saline water of the State, both on the surface and underground. Thick beds of evaporites are present both in the outcrop area and in the subsurface. Ground water percolating through the beds of salt and gypsum, and surface water flowing on their outcrops, dissolve large quantities of these relatively soluble materials, slowly removing them from the source beds.

Mesozoic formations crop out in a large area of Texas. The outcrop of the Triassic rocks, which consist mainly of sandstone and shale, is confined largely to the western edge of the Osage Plains region. These rocks disappear to the west where they are covered by the younger formations of the High Plains.

The principal outcrops of the Cretaceous rocks are in the Edwards Plateau, in the Grand Prairie region, and in a narrow belt along the west edge of the West Gulf Coastal Plain. These formations, consisting largely of sand, clay, and limestone, dip gently toward the southeast or south, where they pass beneath the Tertiary formations of the West Gulf Coastal Plain.

The largest area of outcrop of the Tertiary formations in Texas is in the West Gulf Coastal Plain, where the rocks consist largely of beds of unconsolidated sand and clay dipping gently toward the coast. Another large area of outcrop of Tertiary rocks is in the High Plains, where the Ogallala formation of Pliocene age forms the surface of the plains and lies as a mantle on Cretaceous and Triassic rocks.

The Quaternary formations of Texas are widespread in outcrop. A narrow belt of Quaternary sand and clay extends along the entire coast. Alluvium occurs in many places in Texas, especially along the stream valleys. Most of the alluvial deposits are thin, although in a few places great thicknesses are found and the deposits form extensive aquifers.

The aquifers that furnish large quantities of fresh water to wells in Texas are few in comparison to the total number of geologic formations. Although the aquifers have been described rather thoroughly in the literature, the hydrologic descriptions, of course, have been largely confined to the parts that contain fresh water. Some of these same aquifers probably are capable of yielding large quantities of saline water in areas where fresh water is not present. Other aquifers that yield only saline water are known and have been discussed in the literature to a lesser extent. This discussion will be limited to those aquifers generally capable of yielding 100 gallons per minute (gpm) or more to individual wells; yields of 100 to 200 gpm are considered small, 200 to 500 gpm, moderate, and above 500 gpm, large. The aquifers will be described in order from oldest to youngest. The following list of saline-water aquifers includes only those that are known to yield saline water. Some of them yield fresh water near the outcrop and saline water at greater depth.

Saline-water aquifers in Texas.

Age	Formation or group	Character of rocks	Saline-water supply
Recent and Pleistocene.	Alluvium and beach deposits.	Sand, silt, clay, and gravel.	Large supplies available in Pecos Valley and trans-Pecos region and lower Rio Grande valley. Small supplies from beach deposits along coast.
Pleistocene.	Beaumont clay.	Clay and sand.	Small to large supplies available along coast.
Pleistocene, Pliocene(?), and Pliocene.	Lissie formation, Willis sand, and Goliad sand, undifferentiated.	Sand, gravel, silt, and clay.	Capable of producing large supplies along coast.
Pliocene.	Ogallala formation.	Sand, gravel, silt, and clay.	Capable of producing moderate supplies in some areas in High Plains.
Miocene(?) and Miocene.	Lagarto clay, Oakville sandstone, and Catahoula sandstone, undifferentiated.	Principally sand and clay. Tuff and sandstone common in lower part.	Probably capable of yielding small to moderate supplies in parts of West Gulf Coastal Plain.
Eocene.	Jackson group and upper part of Claiborne group, undifferentiated.	Medium- to fine-grained sand, and clay.	Probably capable of yielding small supplies in parts of West Gulf Coastal Plain.
	Sparta sand.	Medium- to fine-grained sand and shale.	Probably a potential source of large supplies, especially in east Texas.
	Mount Selman formation.	Sand and clay; some glauconite and lignite. Sand predominant in middle member.	Probably a potential source of small supplies in parts of the West Gulf Coastal Plain.
	Carrizo sand.	Medium-grained sand and sandy clay.	Potential source of large supplies throughout a large area on the West Gulf Coastal Plain
	Wilcox group.	Sand, clay, silt, and lignite.	Potential source of moderate to large supply throughout a large area on the West Gulf Coastal Plain.

Cretaceous.	Navarro group undifferentiated and Nacatoch sand.	Sand and sandy clay.	Potential source of moderate supplies in parts of northeast Texas.
	Blossom sand.	Sand and clay.	Probably a potential source of moderate supplies in parts of northeast Texas.
	Woodbine sand.	Sand and sandy clay.	Potential source of large supplies through a large area in northeast Texas.
	Edwards limestone and associated limestones.	Limestone and shale. Limestone commonly fissured and channeled.	Potential large source in south-central Texas. Limestone possibly equivalent to the Edwards supplies saline water to springs in Balmorhea area.
	Trinity group.	Sand and limestone.	Capable of yielding moderate to large supplies throughout large areas in central and west Texas.
Triassic.	Dockum group.	Red shale and clay; some sandstone and conglomerate.	Capable of yielding small to moderate supplies in parts of west Texas.
Permian.	Rustler limestone in Pecos Valley region. Quatermaster formation in Osage Plains Region.	Limestone and dolomite in Pecos Valley region. Red shale and sandstone with dolomite and gypsum in Osage Plains region.	Yields large supplies in Pecos Valley region. Potential source of small to moderate supplies in Osage Plains region.
	Blaine gypsum.	Red and gray shale, gypsum, dolomite, and some sandstone.	Potential source of moderate to large supplies in parts of Osage Plains region.
	San Angelo sandstone.	Sandstone and conglomerate; some shale.	Potential source of small supplies in parts of Osage Plains region.
	Clear Fork and Wichita groups in Osage Plains region. Delaware Mountain group and Bone Spring limestone in Pecos Valley and trans-Pecos Regions.	Red shale and sandstone and beds of limestone and dolomite in Osage Plains region. Sandstone and limestone in Pecos Valley and trans-Pecos regions.	Potential source of small supplies in parts of Osage Plains region. Yields large supplies locally in trans-Pecos region.
Pennsylvanian.	Undifferentiated.	Limestone, shale, and some sandstone.	Potential source of small supplies locally in Osage Plains region.
Ordovician.	Ellenburger group.	Limestone and dolomite.	Probably a potential source of moderate to large supplies in parts of central and west Texas.
Cambrian.	Hickory sandstone member of the Riley formation.	Sandstone and conglomerate.	Probably a potential source of moderate to large supplies in parts of central Texas.

The maps and tables of analyses show the salinity of ground and surface water at many specific places. No attempt was made, however, to delineate zones or areas of differing salinity in each aquifer, as a guide to the location of supplies of relatively low salinity. For most aquifers considerable additional study of existing data, and many new data, would be necessary for such a delineation.

CAMBRIAN SYSTEM

HICKORY SANDSTONE MEMBER OF THE RILEY FORMATION

The oldest aquifer believed capable of yielding large quantities of water to wells in Texas is the Hickory sandstone member of the Riley formation, of Cambrian age. The Hickory crops out on the flanks of the Llano uplift in central Texas (fig. 2). It dips away from the uplift in all directions and is found at increasing depths away from the Llano area. Yields of 750 gpm have been obtained for public supply at Eden in Concho County and Brady in McCulloch County. Although the Hickory sandstone member furnishes fresh water in most places where it is now used (though not at Eden), it probably contains saline water at greater depth and may be a potential source of large quantities of such water in a small area in central Texas.

The quality of saline water from the Hickory sandstone member is represented by a single analysis of the public supply at the city of Eden. (See well CO–1 in table 1.) The depth of the well at Eden is 4,410 feet. The observed dissolved-solids content was 1,110 ppm, and, therefore, the water could be classified as slightly saline. At Eden the water of the Hickory is predominantly of the sodium chloride type and has a percent sodium of 95. Three wells, ranging in depth from 2,082 to 2,114 feet, are yielding fresh water from the Hickory sandstone for municipal use at Brady in McCulloch County (Sundstrom, Broadhurst, and Dwyer, 1949, p. 81).

ORDOVICIAN SYSTEM

ELLENBURGER GROUP

The Ellenburger group of Ordovician age consists largely of a series of limestones and dolomites. This group crops out on the flanks of the Llano uplift in central Texas and dips steeply away in all directions (fig. 2). According to Sellards (*in* Sellards, Adkins, and Plummer, 1932, p. 72), the Ellenburger ranges from a thin stratum to 2,000 feet in thickness. From oil-well drilling the Ellenburger is known to exist throughout a large area in west and

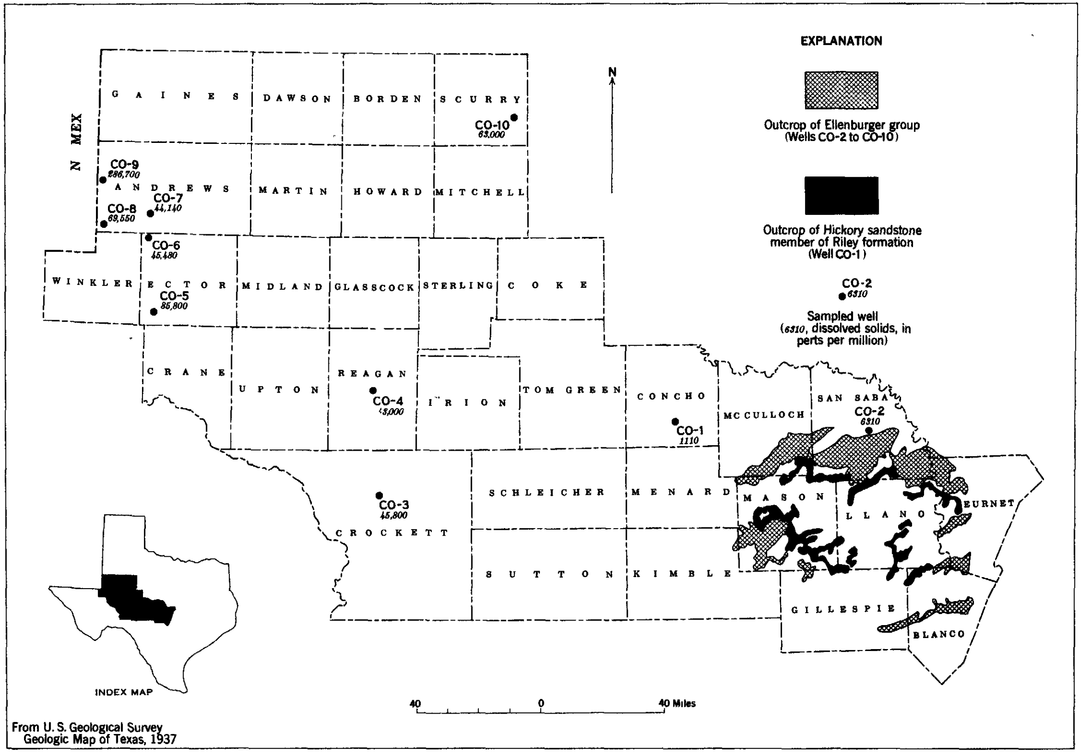


Figure 2. —**Map showing locations of wells sampled and areas of outcrop of Hickory sandstone member of Riley formation and Ellenburger group.**

north-central Texas, extending into Oklahoma. It yields moderately large quantities of fresh water to public-supply wells at Burnet and at Fredericksburg; two of the wells at Fredericksburg have been tested at 550 gpm each.

It seems probable that the Ellenburger could produce large quantities of saline water throughout a large area in west Texas, although the depths of the wells would be greater than 5,000 feet in most places. Much information on the water of the Ellenburger is available in the files of oil companies, because the Ellenburger is one of the principal oil-producing units in west Texas.

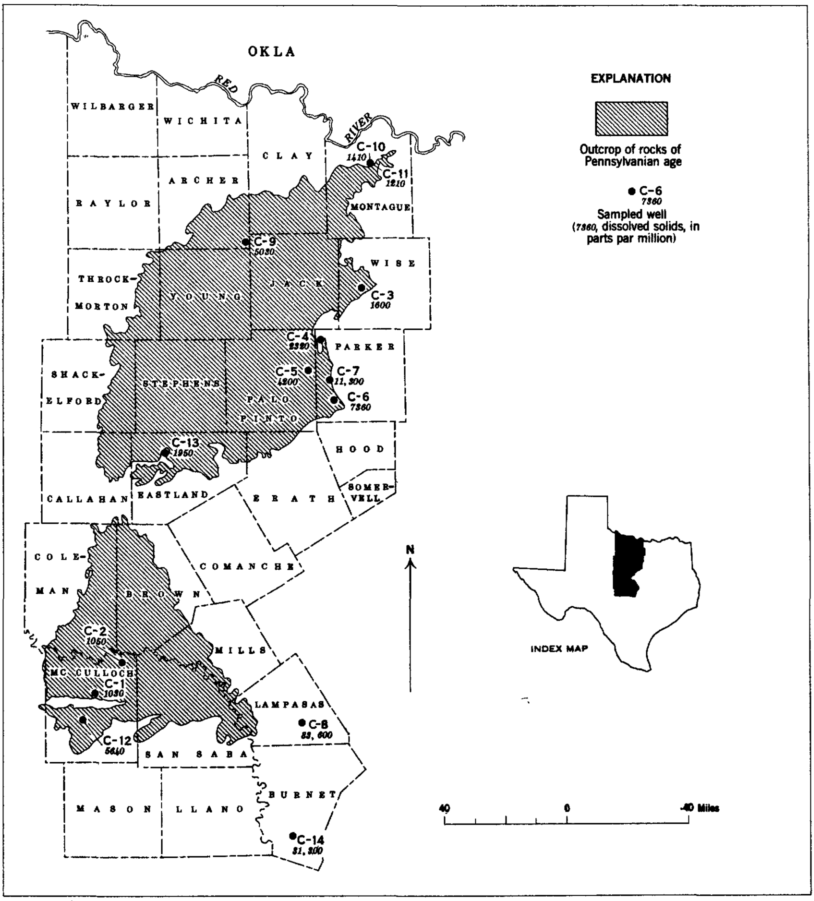
The quality of the saline water from the Ellenburger group is represented by analyses of waters from wells CO–2 to CO–10, shown in table 1. Analyses of water from wells CO–3 and CO–5 to CO–10 were furnished by the Humble Oil and Refining Co. The observed concentration of dissolved solids ranges from 6,310 ppm at a depth of 560 feet in San Saba County to 286,700 ppm at a depth of 10,531 feet in an oil test in Andrews County. The locations of the wells that were sampled are shown in figure 2.

PENNSYLVANIAN SYSTEM

The rocks of the Pennsylvanian system are relatively unimportant as aquifers in Texas, although in parts of north-central Texas small supplies of water are obtained from them. They consist principally of a series of limestones and shales and a few sandstones. The Pennsylvanian rocks crop out in the Llano area and dip gently away from the Llano uplift in all directions. They crop out also in a belt along the east edge of the Osage Plains where they dip gently toward the west and northwest (fig. 3).

Small quantities of saline water are obtained from Pennsylvanian rocks at Mineral Wells in Palo Pinto County. Some of this water is used for public supply, and some of it is used as mineral water in health resorts at Mineral Wells.

The observed concentration of dissolved solids in the saline waters from rocks of Pennsylvanian age ranges from 1,030 ppm in McCulloch County to 83,600 ppm in Lampasas County, as shown in table 1. The locations of the wells from which the samples were taken are shown in figure 3.



From U. S. Geological Survey Geologic Map of Texas, 1937

Figure 3.—Map showing locations of wells sampled and principal areas of outcrop of rocks of Pennsylvanian age in Osage Plains region.

PERMIAN SYSTEM

The Permian formations in Texas include some of the most important saline-water aquifers in the State. The Permian rocks crop out in the Osage Plains region of north-central Texas and in places in trans-Pecos Texas. These two areas of outcrop are connected in the subsurface through the Permian basin. The Permian outcrop area is one in which there is a scarcity of potable water but a relative abundance of highly mineralized water. An economical demineralization process would be very helpful to the inhabitants of this region.

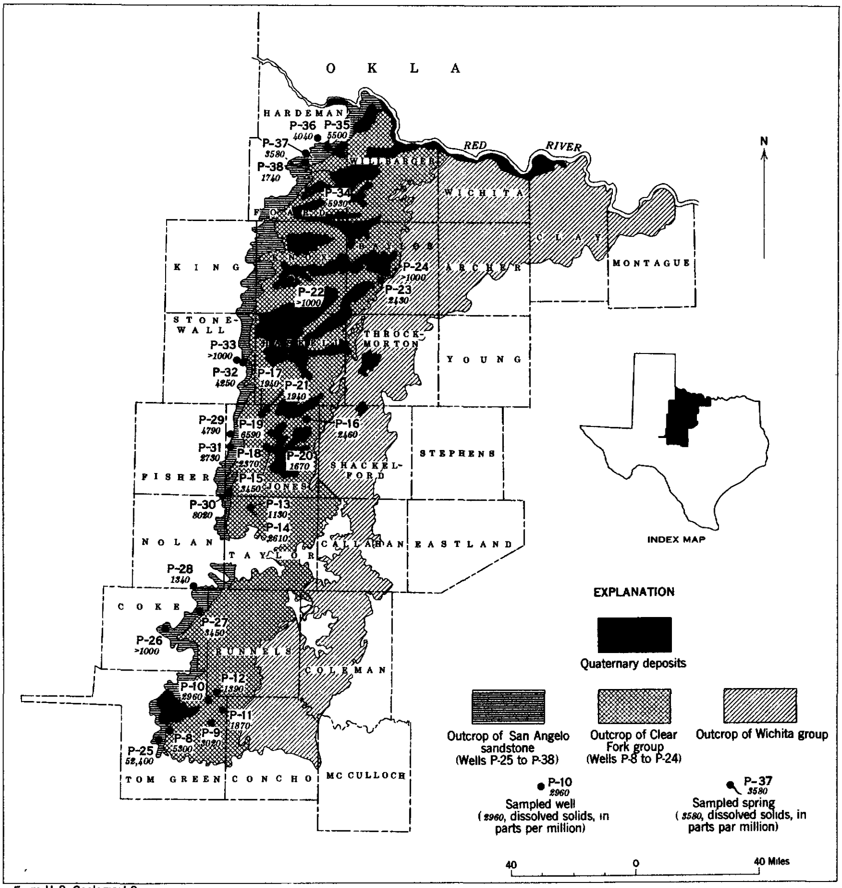
In the Osage Plains region the principal saline-water aquifers include limestones and dolomites of the Wichita and Clear Fork groups, the San Angelo sandstone, the Blaine gypsum, and the Quartermaster formation. These formations crop out in a belt extending from Tom Green and Concho Counties on the south into Oklahoma on the north (figs. 4 to 7). The belt is bounded on the west by the outcrop of the Triassic formations and the High Plains escarpment and on the east by the outcrop of the Pennsylvanian rocks. In the Osage Plains the Permian rocks dip gently toward the west and northwest. The rocks consist of a series of shale, limestone, dolomite, gypsum, and sandstone strata having a total thickness of 4,000 to 5,000 feet.

In places in the Pecos Valley and trans-Pecos regions, Permian limestones and dolomite supply large quantities of saline water, much of which is used for irrigation. The principal saline-water aquifers in this region are the Bone Spring and Rustler limestones.

WICHITA AND CLEAR FORK GROUPS

In the Osage Plains region (fig. 4) the largest supplies of water probably occur in the limestones and dolomites of the Wichita and Clear Fork groups. One of the most important of these is the Bullwagon dolomite member of the Vale formation. Although this member is thin, it yields small to moderate quantities of water. Some irrigation wells producing water from the Bullwagon in Tom Green County are reported to have initial yields of 1,000 gpm (Willis, 1954). A well tapping the Bullwagon at Anson in Jones County is reported to have yielded 500 gpm when drilled. Because the water occurs in fissures and solutional channels in the limestones and dolomites, production is spotty; however, yields similar to those obtained in Tom Green County might be obtained in places in the central part of the Osage Plains region.

The chemical quality of saline water from the Wichita and Clearfork groups is shown in table 1. The Bullwagon member of the Vale formation yields water to public-supply wells at Merkel in Taylor County, at Miles in Runnels County, and at Anson in Jones County. The water from the Wichita and Clear Fork ranges from slightly saline to moderately saline and is the calcium magnesium sulfate type. The water from well P-16 in Jones County contains 5.5 ppm of boron. Locations of the wells sampled are shown in figure 4.



From U. S. Geological Survey
Geologic Map of Texas, 1937

Figure 4.—Map showing locations of wells and springs sampled and areas of outcrop of Wichita and Clear Fork groups and San Angelo sandstone.

SAN ANGELO SANDSTONE

The San Angelo sandstone crops out in a narrow belt extending from Tom Green County on the south into Oklahoma at the Hardeman-Wilbarger County line (fig. 4). It dips gently toward the west. This formation consists principally of sandstone and conglomerate and some shale. In places, especially in or near the outcrop area, the sandstone has sufficient permeability to supply small quantities of water to wells.

The water from the San Angelo contains principally calcium and magnesium sulfates and is therefore hard. Chemical analyses of the water from wells 34 to 1,150 feet deep show a range in dissolved solids from 1,340 to 52,400 ppm. One incomplete analysis of the water from a well 1,140 feet deep shows a chloride content of 30,000 ppm. Water issuing from springs near the base of the San Angelo sandstone in Hardeman County contains dissolved solids as high as 3,580 ppm. Analyses of waters from the San Angelo sandstone are shown in table 1. The location of the wells and springs from which the samples were taken are shown in figure 4.

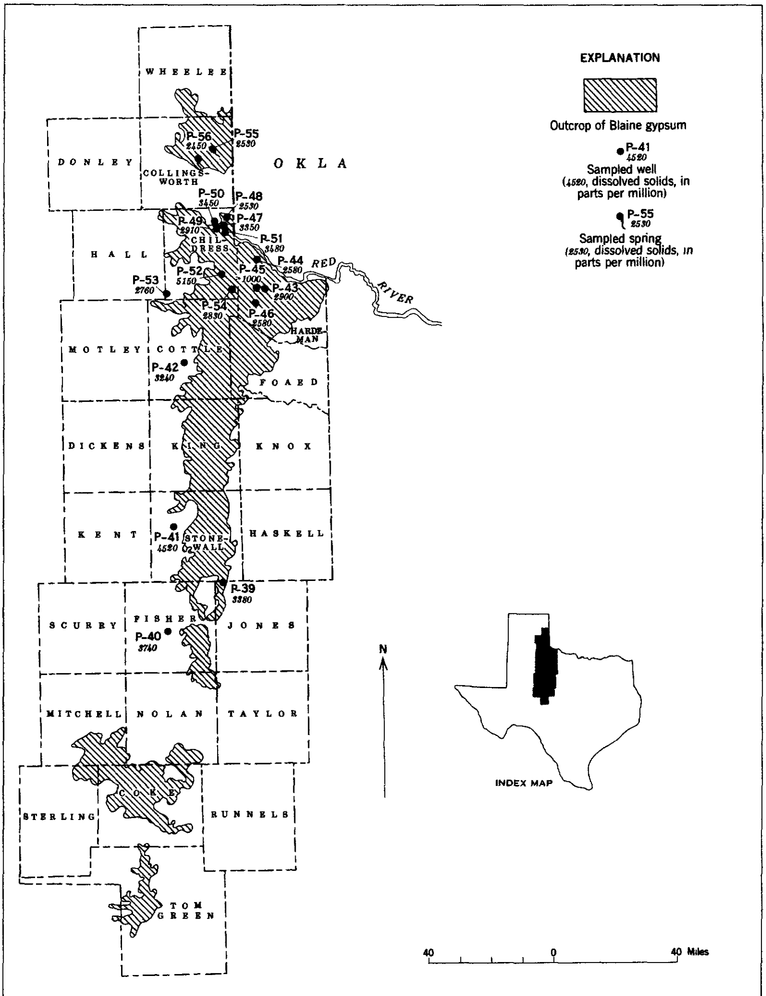
BLAINE GYPSUM

The Blaine gypsum crops out in a south-trending belt in the western part of the Osage Plains region (fig. 5). According to Sellards (*in* Sellards, Adkins, and Plummer, 1932, p. 178) the Blaine consists of red and gray shale, massive beds of gypsum, dolomite, and some sandstone. The Blaine dips gently to the west where it is overlain by the Quartermaster formation. Yields of 1,400 gpm have been reported from irrigation wells ranging in depth from 100 to 300 feet in Childress and Hardeman Counties. Much of the water is probably obtained from solutional cavities in the easily dissolved gypsum. The Blaine is believed to be a potential source of moderate to large quantities of saline water in parts of Nolan, Fisher, Stonewall, King, Cottle, Foard, Hardeman, Childress, and Collingsworth Counties.

Water from wells and springs tapping the Blaine gypsum is of the calcium and magnesium sulfate type. A few of the irrigation wells in Childress County yield water that contains as much as 4 ppm of boron. Water from springs discharging from the Blaine in Collingsworth County is slightly saline. The observed dissolved-solids content of water from wells and springs ranges from 2,450 ppm in a spring in Collingsworth County to 5,150 ppm from a well 270 feet deep in Childress County. Water analyses are shown in table 1, and the locations of the wells and springs sampled are shown in figure 5.

QUARTERMASTER FORMATION

For the purpose of this report, the term Quartermaster formation is used to include all the Permian strata above the Blaine gypsum in the Osage Plains region. The Quartermaster consists of red shale and fine-grained sandstone and thin layers of dolomite and gypsum. The formation crops out in a south-trending belt in the western part of the Osage Plains region and dips gently to the west (fig. 6). The Quartermaster yields small supplies of water to wells in the region, although moderately large supplies



From U. S. Geological Survey
Geologic Map of Texas, 1937

Figure 5. —Map showing locations of wells and springs sampled and area of outcrop of the Blaine gypsum.

might be obtained in some areas where solution channels occur in the dolomite or gypsum beds or where more permeable zones occur in the sandstones.

Chemical analyses of water from wells and springs producing from the Quartermaster formation are shown in table 1. Water from wells, 70 to 585 feet deep, ranges in dissolved solids from 1,680 to 6,440 ppm. Water from springs issuing from the forma-

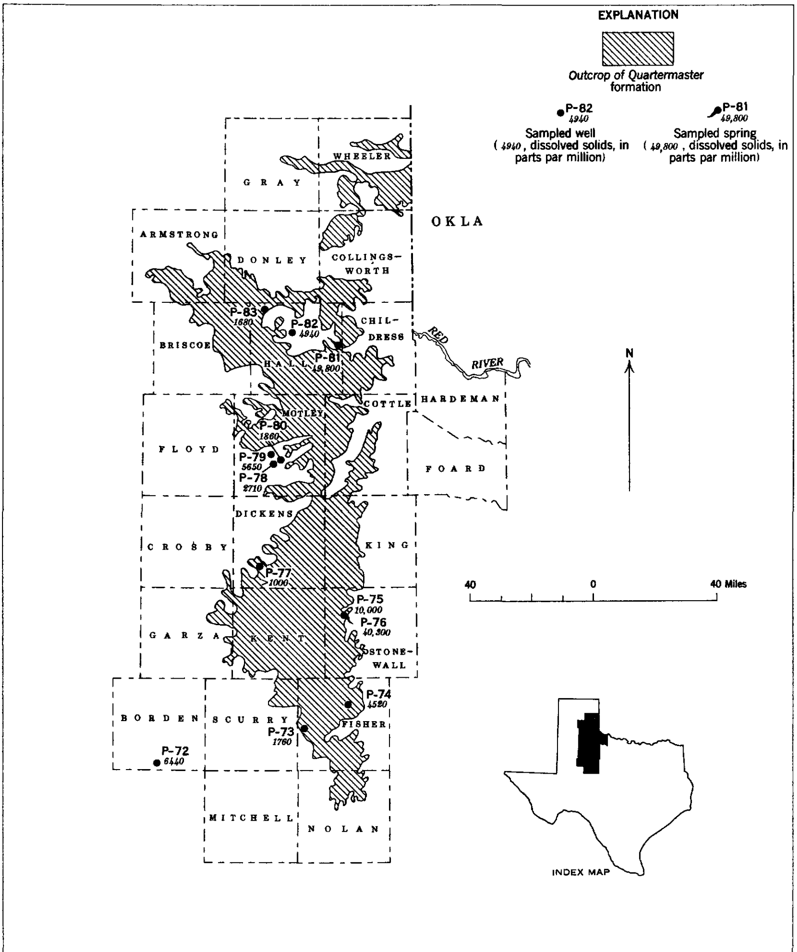


Figure 6. —Map showing locations of wells and springs sampled and areas of outcrop of the Quartermaster formation.

tion in Stonewall and Hall Counties is classified as very saline or as brine, as the observed dissolved-solids concentration ranges from 10,000 to 49,800 ppm. A spring (P–81) in Hall County was reported to be flowing about 500 to 600 gpm of saline water in May 1943. Locations of wells and springs sampled are shown in figure 6.

BONE SPRING LIMESTONE

The oldest of the Permian formations that produces water in the trans-Pecos region is the Bone Spring limestone. This formation crops out on the west side of the Salt Basin and is disclosed in wells at shallow depth in the Dell City area in Hudspeth County (fig. 7). It consists almost entirely of limestone. In some places the limestone is cherty and in other places dolomitic. According to Scalapino (1950, p. 5–6) the Bone Spring limestone in the Dell City area produces water from joints and solution channels. In 1949, 32 irrigation wells with yields ranging from 350 to 3,000 gpm were in use in the area (Scalapino, 1950, p. 7).

Analyses of water from the Bone Spring limestone are shown in table 1. The water from the Bone Spring in the Dell City area falls in the slightly saline class. The observed concentration of dissolved solids ranges from 1,120 ppm in a well 250 feet deep to 1,800 ppm in a well 60 feet deep. The water in this area is used principally for irrigation (Scalapino, 1950, p. 7). The locations of wells that were sampled are shown in figure 7.

DELAWARE MOUNTAIN GROUP

The Delaware Mountain group consists principally of sandstone and limestone. The group crops out in the Delaware Mountains in Culberson County where it has a thickness of about 2,700 feet (fig. 7). The unit is buried beneath younger deposits in the Pecos Valley area. Knowles and Lang (1947, p. 6) report that the Delaware Mountain group occurs at depths ranging from 2,500 to 5,200 feet in Reeves County, where it has been disclosed by many oil tests. Saline water is present in varying amounts where no oil is found and in some places is under sufficient pressure to flow.

Analyses of water from the Delaware Mountain group are shown in table 1. Not enough data are available on the quality of the water from the Delaware Mountain group to establish the general range in concentration or composition. Water from one well 5,100 feet deep, in Reeves County, contains 159,000 ppm of chloride. A well 2,400 feet deep, in Culberson County, yields water containing 922 ppm of chloride. Locations of wells tapping the Delaware Mountain group are shown in figure 7.

RUSTLER LIMESTONE

The Rustler limestone crops out in an area extending from the Texas-New Mexico line, where the outcrop appears in the bed of

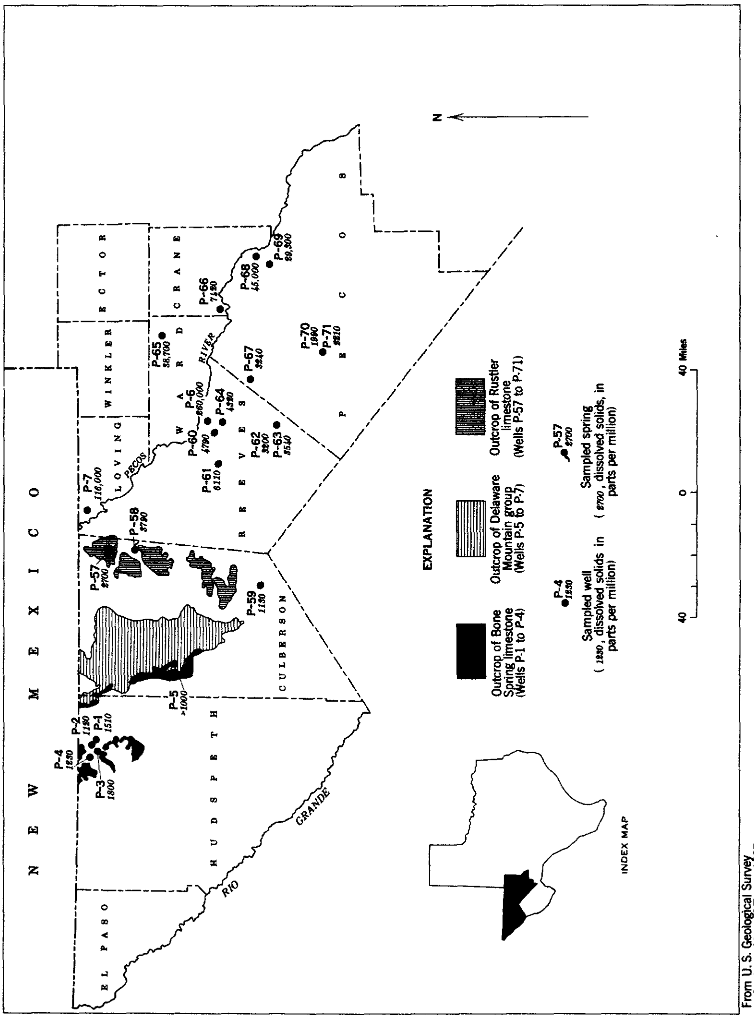


Figure 7. —Map showing locations of wells and springs sampled and areas of outcrop of the Bone Spring limestone, Delaware Mountain group, and Rustler limestone.

the Pecos River, southward nearly to the Davis Mountains (fig. 7). It forms the Rustler Hills in eastern Culberson County. The Rustler dips to the east and is overlain by differing thicknesses of younger formations in Loving, Ward, and Crane Counties and adjacent counties on the east. The Rustler consists largely of dolomitic limestone and smaller amounts of sandstone and conglomerate in the outcrop area, where the total thickness is about 200 feet. It thickens eastward from the outcrop area. Knowles and Lang (1947, p. 7) report that the maximum thickness in Reeves County is about 500 feet.

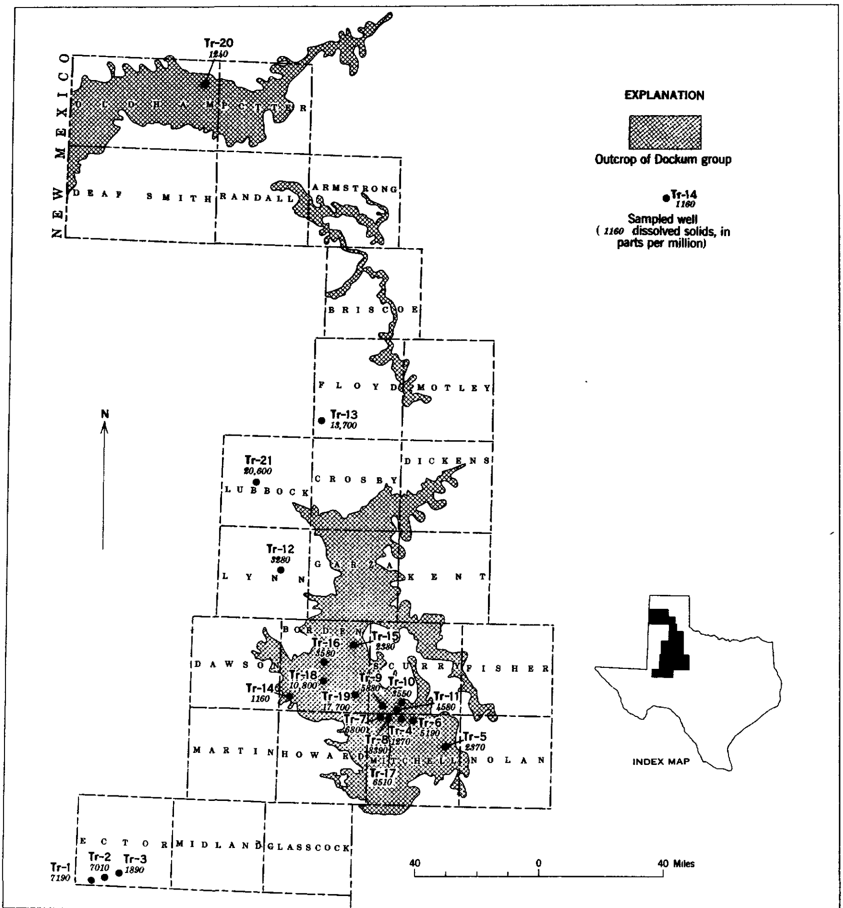
The Rustler supplies large quantities of water to many irrigation wells in Pecos and Reeves Counties, principally from a porous dolomite near the middle of the formation. Flows of 2,500 gpm have been obtained from some wells in Pecos County, although in some others no water at all was found. Large flows also have been reported from the Rustler in southern Reeves County, but in the northern part of that county no flows have been reported. Although the production from the Rustler limestone is spotty, large quantities of water probably could be obtained from it in parts of Loving, Ward, and Crane Counties, and adjacent counties to the east, as well as from the proved areas in Pecos and Reeves Counties.

Water samples collected from wells tapping the Rustler limestone in the Pecos Valley and trans-Pecos areas contain dissolved solids ranging from 1,180 to 45,000 ppm. The locations of the wells and springs that were sampled are shown in figure 7. From the observed data, sulfate is the principal anion in water containing as much as 5,000 ppm of dissolved solids, but chloride becomes the dominant anion in water containing more than 5,000 ppm of dissolved solids. The percent sodium ranges from 1 in water from a well 5,326 feet deep in Pecos County to 85 in water from an irrigation well in Ward County. Analyses of water from the Rustler limestone are shown in table 1.

TRIASSIC SYSTEM

DOCKUM GROUP

Formations of the Dockum group of Triassic age crop out along the eastern edge of the southern High Plains. They crop out also in small areas in Loving, Ward, Winkler, Scurry, and Crane Counties, and in the valley of the Canadian River (fig. 8). The group underlies most of the High Plains and is present also in the subsurface in a large area east of the Pecos River. The Dockum consists principally of red shale and clay and a few beds of sand-



From U. S. Geological Survey
Geologic Map of Texas, 1937

Figure 8. —Map showing locations of wells sampled and principal areas of outcrop of the Dockum group.

stone and conglomerate. The sands of the Dockum are generally fine grained and tightly cemented, and consequently the permeability is low. Locally, however, moderately large quantities of water may be obtained. For example, in Mitchell County, irrigation wells ranging in depth from 115 to 315 feet and yielding an average of about 250 gpm each are producing from Triassic sand and gravel (Dale and Broadhurst, 1953, p. 1).

Water from the Dockum group differs in composition with local conditions. The observed concentration of dissolved solids in the saline water ranges from 1,160 ppm at a depth of 60 feet to 20,600 ppm at a depth of 999 feet. In general, the water is of the sodium chloride type at higher concentrations (more than about 5,000 ppm of dissolved solids). At concentrations of less than about 3,000 ppm and at shallow depths, the waters of the Dockum are heterogeneous in chemical composition, although sulfate is generally the predominant anion. Analyses of saline water from the Dockum group are shown in table 1, and the locations from which the samples were taken are shown in figure 8.

CRETACEOUS SYSTEM

TRINITY GROUP

The Trinity group of Early Cretaceous age has been divided into three formations; from oldest to youngest they are the Travis Peak formation, the Glen Rose limestone, and the Paluxy sand. The group crops out principally in a belt extending from the Oklahoma State line at Montague and Cooke Counties southward to Travis County, thence southwestward into Bandera County where it passes beneath the Fredericksburg group (pl. 1). The Trinity is also exposed locally farther westward. The group dips toward the east and southeast where it is overlain by younger formations.

The basal unit of the Trinity group, the Travis Peak formation, consists largely of sandstone and conglomerate and some shale and limestone in northeast and north-central Texas. Yields of 500 gpm are common from wells tapping the Travis Peak formation in the vicinity of Fort Worth and Dallas. The Travis Peak contains less sand and yields smaller quantities of water to wells in central and south-central Texas along the Balcones fault zone.

The Glen Rose limestone consists typically of alternating limestone and marl. It yields small to moderate quantities of water to wells and springs, especially in areas where the limestone is porous or cavernous.

The upper formation of the Trinity group, the Paluxy sand, consists largely of fine-grained quartz sand and some shale. It yields moderate quantities of water to wells in north-central Texas.

The chemical quality of the water from the Trinity group is shown in table 1. Water from the Trinity in north- and south-central Texas is mainly of the sodium sulfate and sodium chloride types. The observed dissolved-solids content in areas where the water is saline ranges from 1,010 ppm at a depth of more than 2,000 feet in Milford, to 8,020 ppm at a depth of about 3,300 feet at Marlin. Water from the Trinity group is high in fluoride content, which exceeds 1.5 ppm in all but a few samples. Water from a well 1,320 feet deep in Williamson County contained 7.2 ppm of fluoride.

Sulfate is the main constituent in waters from the Trinity group in the Edwards Plateau region. Most of the water from the Trinity in that region falls in the slightly saline class, and the observed samples contained from 459 to 1,460 ppm of sulfate. Several cities in this area are supplied with water obtained from wells tapping the Trinity group (pl. 1).

Many cities in north- and south-central Texas obtain water from the formations of the Trinity group. Although it is one of the most important fresh-water aquifers in Texas, moderate to large quantities of saline water could be produced from the Trinity. Flowing wells, yielding 500 gpm, have been reported by well owners in Hill, McLennan, and Falls Counties. A well owned by the city of Dallas was being pumped at a rate of 1,000 gpm in 1950. Some water from the Trinity used for public supply falls in the slightly saline and moderately saline classifications. The observed dissolved-solids content of the saline water from public-supply wells ranges from 1,010 to 5,580 ppm. Hardness as $CaCO_3$ ranges from 20 to 906 ppm.

EDWARDS LIMESTONE AND ASSOCIATED LIMESTONES

The Edwards limestone and associated limestones of Early Cretaceous age crop out east and north of the Balcones fault zone in central and south-central Texas and in a large area on the Edwards Plateau (pl. 2). They crop out also in smaller areas in west Texas. The Edwards limestone has one of the highest yields of the aquifers in Texas. It consists mostly of massive light-colored limestone that is honeycombed and cavernous in places. The water in the Edwards occurs in cracks and fissures and in solution channels. The formation furnishes large quantities of water of good quality to wells in the San Antonio area and in parts of Kinney, Uvalde, Medina, Bexar, Comal, and Hays Counties. A well tapping the Edwards at San Antonio is reported to have had a flow of 16,600 gpm on June 16, 1942 (Livingston, 1942, p. 3), and is believed to be the largest natural flow on record in the United States. The Edwards also supplies water to the large springs along the Balcones fault zone, such as Barton Springs at Austin, San Marcos Springs at San Marcos, and Comal Springs at New Braunfels. South and east of the fault zone the Edwards contains saline water. In the San Antonio area it is reported (Livingston, Sayre, and White, 1936, p. 104) that the line of demarcation between the nonsaline water to the north and saline water to the south is so sharp as to suggest that a fault cuts off free circulation of water from the north to the south, thereby preventing the flushing of saline water from the aquifer. A similar condition probably exists along the fault zone both to the northeast and to the west from San Antonio, where saline water occurs south and east of the fault. Large quantities of saline water probably could be produced from the Edwards in places south and east of the fault zone. For example, flows of 700 gpm of saline water have been obtained from the Edwards near Thorndale in Milam County.

Limestones which are probably equivalents of the Edwards and associated limestones occur under a large area in the Pecos Valley region where they supply large quantities of water to springs in Pecos and Reeves Counties.

The observed dissolved-solids content in the saline water from the Edwards limestone along the Balcones fault zone differs greatly, ranging from 1,010 ppm in Kinney County to 14,800 ppm in Milam County. The water is of the calcium sulfate type in the lower concentrations and of the sodium chloride-sulfate type in the higher concentrations.

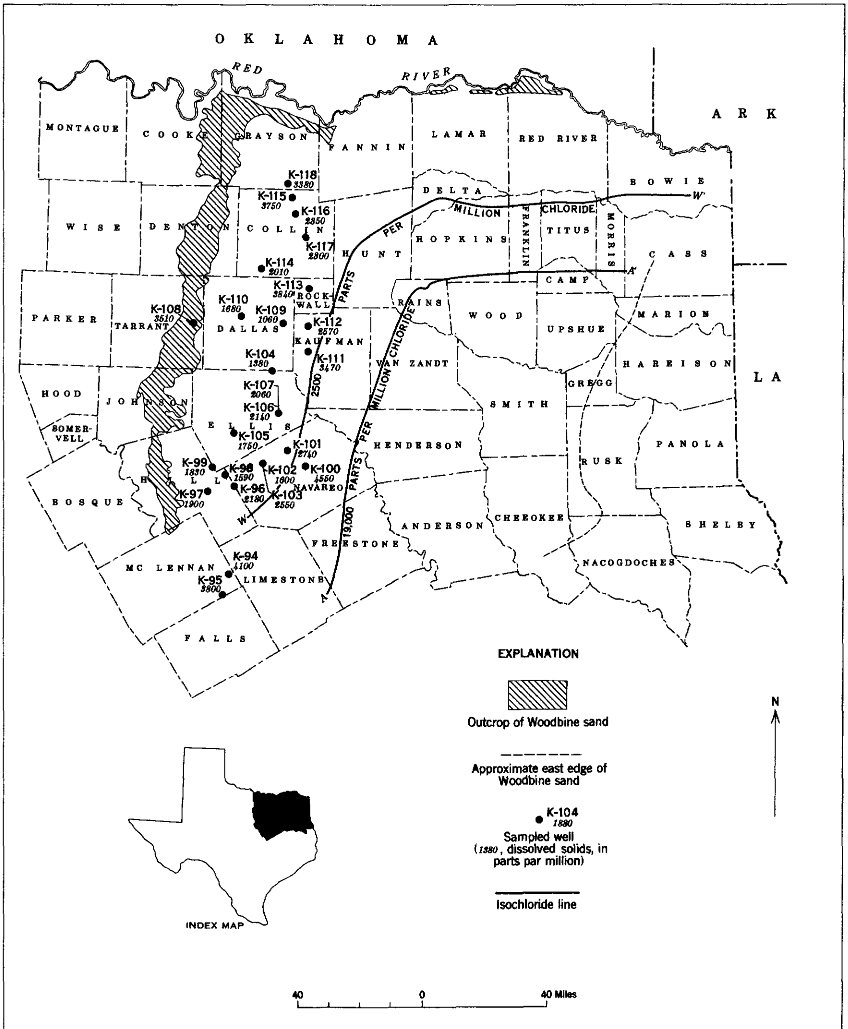
The artesian springs near Balmorhea, Reeves County, are believed to have their source in limestone of Early Cretaceous age (White, Gale, and Nye, 1941, p. 90). The dissolved-solids content of these artesian spring waters varies considerably with discharge. During periods of normal flow the waters from Phantom Lake, San Solomon, and Giffin Springs each contain slightly more than 2,000 ppm of dissolved solids; however, San Solomon Spring, during a period of high flow on October 7, 1932, yielded water containing only 562 ppm of dissolved solids (White, Gale, and Nye, 1941).

Analyses of the water and locations of the wells and springs sampled are shown in table 1 and plate 2, respectively.

WOODBINE SAND

The water of the Woodbine sand has been described by Plummer and Sargent (1931), and the following discussion is based largely on their work.

The Woodbine sand of Late Cretaceous age is one of the chief aquifers in northeast Texas. Figure 9 shows that it crops out in a belt extending from northern McLennan County northward through Hill, Johnson, Tarrant, and Denton Counties to Cooke County, thence it swings eastward, lying roughly parallel to the Red River,



From U. S. Geological Survey Geologic Map of Texas and Plummer and Sargent, 1931, p. 11

Figure 9. —Map showing locations of wells sampled and area of outcrop and approximate subsurface extent of the Woodbine sand and lines denoting chloride concentration.

nearly to the Arkansas State line. The Woodbine dips toward the east and south from the outcrop area and supplies as much as 500 gpm of fresh water to wells in a belt about 40 miles wide lying parallel to the outcrop area. According to Plummer and Sargent (1931, p. 10) the formation is a broad wedge of sand and sandy clay which is thickest at the outcrop and which thins southeastward, extending beneath the surface 120 miles east and west and 150 miles north and south over an area of at least 18,000 square miles. The amounts of chloride and of dissolved solids in the water increase gradually from the northwest to the southeast. One line in figure 9, about 40 miles from the outcrop, shows the chloride content of the water to be about 2,500 ppm; the other line shows the chloride content to be about 19,000 ppm.

The observed concentration of dissolved solids in saline water of the Woodbine ranges from 1,060 ppm in Dallas County to 4,550 ppm in Navarro County. According to Plummer and Sargent (1931, p. 48):

> The concentration in general increases with depth, but is governed to a considerable extent by the freedom of circulation, which in turn is controlled by local and regional structure. As the distribution of chloride is also affected by this same condition, marked variation in the total concentration of the deeper waters is usually associated with variation in the proportion of chloride.

Sodium is the principal cation in water of the Woodbine, and content of percent sodium as high as 99 was observed.

The fluoride content of the water of the Woodbine generally exceeds 1.5 ppm; fluoride concentrations as great as 6.0 ppm are present in the supplies of several cities drawing water from the Woodbine.

Analyses of the water and locations of the wells are shown in table 1 and figure 9, respectively.

BLOSSOM SAND

The Blossom sand of Late Cretaceous age crops out in a narrow west-trending belt in Red River, Lamar, and Fannin Counties in northeast Texas (fig. 10). According to Adkins (*in* Sellards, Adkins, and Plummer, 1932, p. 444) the Blossom consists of brown sandy ferruginous, glauconitic beds interlaminated with thin clay layers. The formation dips toward the south and supplies soft, slightly saline water to the city of Clarksville in Red River County from wells about 600 feet deep. The analysis of the water from a well, reported to be yielding 650 gpm (K–119, fig. 10), at Clarksville is shown in table 1. Perhaps similar quantities of saline water could be obtained from the formation farther south.

NAVARRO GROUP UNDIFFERENTIATED AND NACATOCH SAND

The Nacatoch sand of the Navarro group of Late Cretaceous age crops out in a narrow belt extending westward across Bowie, Red River, and Delta Counties to Hunt County where the outcrop is shown on the map (fig. 10) included with the Navarro group, undifferentiated. In Hunt County the outcrop trends southward through Kaufman and Navarro Counties to northern Limestone County (fig. 10). From Hunt County southward the outcrop of the Nacatoch is differentiated. The formation consists largely of sand and sandy clay and locally contains glauconite. In places the sand is finely cemented and may be concretionary (Sellards, Adkins, and Plummer, 1932, p. 493).

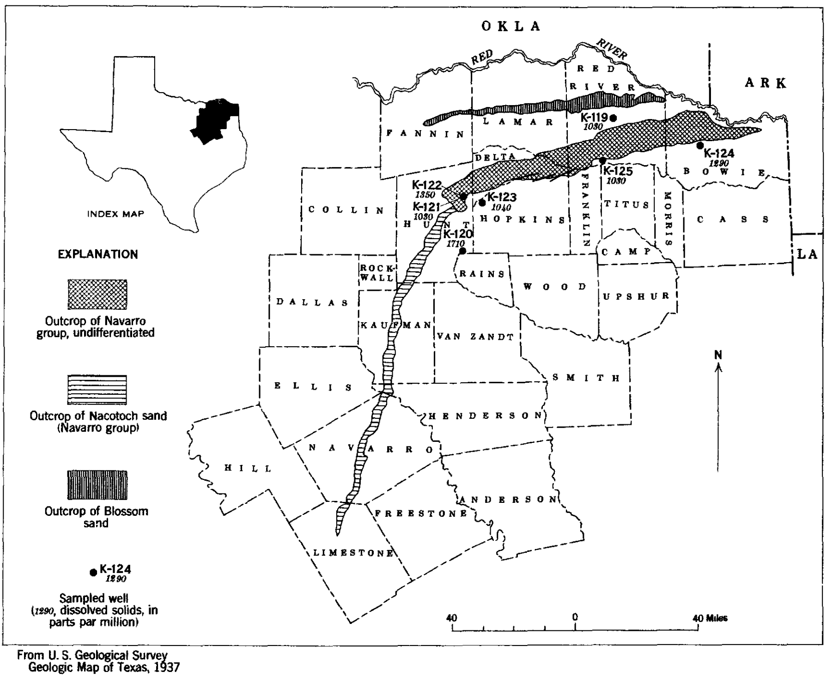


Figure 10.—Map showing locations of wells sampled and areas of outcrop of Blossom sand, Nacatoch sand, and Navarro group undifferentiated.

The Nacatoch sand furnishes moderate quantities of fresh water to public-supply wells at Bogata in Red River County, Commerce and Quinlan in Hunt County, and Cumby in Hopkins County. Yields of 335 gpm have been reported. The city of Talco in Titus County draws slightly saline water from a well tapping the

Nacatoch in Red River County. The Nacatoch is known to occur in the subsurface throughout a large area in northeast Texas and is probably capable of yielding moderate quantities of saline water to wells in the area.

Sulfate constitutes about two-thirds of the total number of anions at depths of about 180 feet in Hunt County. At greater depths the content of chloride increases, to about 50 percent of the total number of anions. Analyses of the water and locations of the wells are shown in table 1 and figure 10, respectively.

TERTIARY SYSTEM

EOCENE SERIES

WILCOX GROUP

The sands of the Wilcox group of Eocene age are the oldest important Tertiary aquifers in Texas. The Wilcox crops out in northeast and east Texas on the limbs of the east Texas syncline. On the northwest limb the outcrop extends in a belt from the Arkansas State line westward across Bowie, Morris, Titus, and Franklin Counties into Hopkins County, thence southwestward to Freestone County (pl. 3). The Wilcox is overlain by younger Eocene formations in the syncline, but it crops out again on the southeast limb throughout all of Shelby and Panola Counties and parts of Marion, Harrison, Gregg, Rusk, and Nacogdoches Counties. Southwest from the area of the syncline, the Wilcox crops out in a belt extending southwestward from Freestone County to Guadalupe County, thence the outcrop trends more toward the west, extending to Uvalde County where it trends to the south, extending into Mexico near the northwestern corner of Webb County. In south Texas the Wilcox group is represented by the Indio formation only.

In areas away from the influence of the east Texas syncline, the Wilcox dips toward the coast, passing beneath the younger formations of the West Gulf Coastal Plain. According to Plummer (*in* Sellards, Adkins, and Plummer, 1932, p. 573) the Wilcox group consists of a thick series of sandy, lignitiferous littoral clays, crossbedded river sands, noncalcareous lacustrine or lagoonal clays, lignite lentils, and stratified deltaic silts. The upper part of the group has a greater proportion of sand than the lower part.

The Wilcox is the principal aquifer in the area of the east Texas syncline, furnishing large quantities of fresh water to wells in the area. Some of the wells yield more than 1,000 gpm. Throughout the remainder of east Texas and in south Texas, the Wilcox supplies smaller quantities of water, and the water is generally more highly mineralized, the effects of mineralization increasing downdip.

The Wilcox group furnishes fresh water to many cities in east Texas. At Kilgore in Gregg County the Wilcox yields slightly saline water to wells at depths of 800 to 900 feet.

The chemical quality of waters from the Wilcox differs locally because of the complexity of the lithology of the group. Analyses of water from the Wilcox are shown in table 1. According to Broadhurst (1950, p. 70) the dissolved solids in water of the Wilcox in Gregg County consist mainly of sodium, bicarbonate, and chloride. Generally the lower sands yield more highly mineralized water than the upper sands. In the Winter Garden district in Zavala and Dimmit Counties and eastern Maverick County, the Indio formation of the Wilcox group yields water of a mixed type, both sodium sulfate and sodium chloride being noted. Concentrations of 1,750 ppm of sulfate have been found in the water of the Wilcox from this area.

The observed dissolved-solids concentration in saline water from the Wilcox group ranges from about 1,000 to nearly 7,000 ppm. The locations of the wells for which analyses of saline water are available are shown in plate 3.

CARRIZO SAND

The Carrizo sand of the Claiborne group of middle Eocene age has one of the highest yields of the aquifers in Texas. The regional distribution of the outcrop of the Carrizo is similar to that of the Wilcox group. The Carrizo crops out on the limbs of the east Texas syncline lying parallel to and adjoining the Wilcox outcrop (pl. 3). It is mantled by younger Eocene formations in the syncline. In the area southwest of the syncline, the Carrizo crops out in a narrow belt along the southeast edge of the Wilcox outcrop.

In the area away from the influence of the east Texas syncline the Carrizo dips toward the coast beneath younger formations. In most places the Carrizo is easily identified in well logs and it has been traced long distances down the dip from the outcrop. The Carrizo sand consists of about nine-tenths medium-grained sand and one-tenth sandy clay (Sellards, Adkins, and Plummer, 1932, p. 617). The sand generally is slightly coarser than that of the Wilcox group. The individual sand strata are generally thick and massively bedded. Crossbedding is conspicuous.

The Carrizo supplies large quantities of fresh water to irrigation wells in the Winter Garden district in south Texas, some of the wells yielding more than 1,000 gpm. The Carrizo also furnishes large quantities of water to public-supply and industrial wells in south and east Texas in a belt lying parallel to the outcrop on the southeast. Flowing wells about 4,000 feet deep near Campbellton in south Texas, about 30 miles downdip from the outcrop, yield 1,000 gpm of water containing about 600 ppm of dissolved solids (see E—33 in table 1).

The observed dissolved-solids content of saline water from the Carrizo sand ranges from 1,080 to 7,430 ppm. The Carrizo sand yields slightly saline sodium bicarbonate water to wells in La Salle, McMullen, Atascosa, Lee, and Brazos Counties, at depths ranging from about 1,300 to 4,150 feet. The carbonate and bicarbonate ions constitute more than 60 percent of the total anions. At shallower depths in Webb, Atascosa, Medina, Caldwell, and Bastrop Counties the water is principally of the sodium chloride and sodium sulfate types. In some places in south Texas the nonsaline water of the Carrizo is contaminated through leaky wells by highly mineralized water from the overlying Bigford member of the Mount Selman formation. Analyses of water from wells tapping the Carrizo sand are shown in table 1. The locations at which the samples were taken are shown in plate 3.

MOUNT SELMAN FORMATION

The Mount Selman formation of the Claiborne group of middle Eocene age consists of three members; in order from oldest to youngest they are the Reklaw member or Bigford member, the Queen City sand member, and the Weches greensand member. The Queen City sand member is the principal aquifer. The Mount Selman crops out in a belt extending from the Rio Grande in Webb County northward into Zavala County, thence eastward and northeastward into Anderson and Cherokee Counties where the outcrop forks, the south fork extending eastward to the Sabine River in Sabine County and the north fork occupying most of the trough of the east Texas syncline and extending into Arkansas and Louisiana at Cass County (pl. 4). Except in the vicinity of the east Texas syncline the Mount Selman dips gently toward the coast beneath younger formations.

The Queen City sand member of the Mount Selman consists principally of medium- to fine-grained sand and some clay or shale. The Queen City furnishes small quantities of water of good quality to wells in the area southeast of the outcrop.

The other members of the formation are unimportant as aquifers. In south Texas, however, the Bigford contains saline water, and in areas where the underlying Carrizo sand is heavily pumped the difference in head between the two formations and the presence of faulty casing in some of the wells have caused local contamination of the Carrizo.

The Mount Selman formation yields slightly saline water to public-supply wells in La Salle and Atascosa Counties in south Texas. Locations of wells tapping the Mount Selman formation are shown in plate 4.

The observed dissolved-solids concentration of saline water from the Mount Selman formation ranges from 1,020 to 11,800 ppm. The Bigford member of the formation yields water that ranges from moderately to very saline. Analyses of water from the Mount Selman formation are shown in table 1.

SPARTA SAND

The Sparta sand of the Claiborne group of middle Eocene age crops out principally in a belt extending from the Sabine River in Sabine County westward into Houston County, thence it trends southwestward and, according to Plummer (*in* Sellards, Adkins, and Plummer, 1932, p. 652), has been traced to northeastern Atascosa County. The outcrop area is shown in plate 5; however, south of Wilson County the Sparta and the overlying Cook Mountain formations are undifferentiated. In addition to the principal outcrop area as described, there are isolated outcrops in the trough of the east Texas syncline. In the area south and southwest from the east Texas syncline the formation dips coastward from the outcrop and has been identified in wells many miles down the dip. The Sparta consists principally of medium- to fine-grained sand and some shale and a few beds of glauconite, limonite, and lignite.

The Sparta furnishes moderate to large quantities of nonsaline water to wells near the outcrop area, especially in east Texas where yields of about 500 gpm are common. In discussing ground water in the Lufkin area, White, Sayre, and Heuser (1941, p. 29) report that an abundant supply of water probably could be obtained from the Sparta, but that the water is too highly mineralized for municipal or most industrial uses. A similar situation probably exists elsewhere in east Texas, and it is probable that the Sparta is a potential source of large quantities of saline water in areas where supplies of fresh water are limited.

The observed dissolved-solids content in saline water from the Sparta sand ranges from 1,030 to 2,090 ppm. The locations of wells tapping the Sparta and the analyses of water from the Sparta are shown in plate 5 and table 1, respectively.

UPPER PART OF CLAIBORNE GROUP AND JACKSON GROUP, UNDIFFERENTIATED

For purposes of discussion, the remaining Eocene aquifers are undifferentiated. These include the Cook Mountain and Yegua formations of the Claiborne group and the formations of the Jackson group. These strata crop out in a belt extending from the Sabine River in Sabine County westward to Houston and Trinity Counties, thence southwestward to La Salle and McMullen Counties where the outcrop swings to the south, reaching the Rio Grande in Webb and Zapata Counties and western Starr County (pl. 5). The formations all dip gently toward the coast.

The upper part of the Claiborne and the Jackson consist principally of medium- to fine-grained sand and clay. The individual sand bodies are for the most part lenticular and not continuous over long distances. These formations are relatively unimportant as aquifers in Texas. In some places, however, they yield small to moderate quantities of water to public-supply and irrigation wells. According to Lonsdale and Day (1937, p. 53) the Cook Mountain formation is an important source of water for domestic use and irrigation in Webb County and is a potential source for additional irrigation water.

The chemical analyses of water from the upper part of the Claiborne group and the Jackson group, undifferentiated, are shown in table 1. The water from these aquifers is of the sodium chloride type. In some samples sodium constitutes 99 percent of the cations. The observed dissolved-solids concentration of the selected water samples ranges from 1,170 ppm in water from the Yegua formation to 25,900 ppm in water from the Jackson group. The locations of the spring and wells sampled are shown in plate 5.

MIOCENE AND MIOCENE(?) SERIES

CATAHOULA SANDSTONE, OAKVILLE SANDSTONE, AND LAGARTO CLAY, UNDIFFERENTIATED

For purposes of discussion, the Catahoula sandstone of Miocene(?) or Miocene age, the Oakville sandstone of Miocene age, and the Lagarto clay of Miocene(?) age are undifferentiated. Although the Catahoula sandstone in most places is easily distinguished from the overlying Oakville, it is included with the Oakville and Lagarto because in many places wells tap both the Catahoula and the Oakville and mixed water is obtained. The Lagarto clay is included with the Catahoula and Oakville because in east Texas, especially, it is difficult to differentiate the Lagarto and Oakville.

The Catahoula, Oakville, and Lagarto formations crop out in a broad belt extending from the Sabine River in Sabine and Newton Counties generally westward to Walker County; thence the outcrop swings more to the southwest, lying roughly parallel to the coast, to McMullen County and northern Duval County. Here the Lagarto and Oakville are overlapped by the Goliad sand, but the Catahoula continues to crop out in a narrow band extending southward to the Rio Grande in Starr County (pl. 6).

These formations consist principally of sand and clay, although the Catahoula contains a considerable quantity of pyroclastic material, especially in south Texas, where it is known as the Catahoula tuff. The sand of the Catahoula is usually light in color and medium to coarse grained in texture. In places the sand of the Catahoula is cemented with silica to form quartzite. The unit formed by the Oakville and Lagarto is predominantly sandy in the lower part, clayey in the upper part. The sand of the Lagarto usually is finer grained than that of the Oakville or Catahoula, and the individual sand beds are usually thinner.

The sand of the Catahoula, Oakville, and Lagarto yields small to moderate supplies of fresh water to wells on and near the outcrop. Yields of 750 gpm from the Catahoula have been reported at Cuero in De Witt County. Similar yields from wells tapping the Catahoula and Oakville have been obtained at Huntsville in Walker County. The sand of the Oakville and Lagarto probably contributes to the deeper wells in the Houston area; however, the sand of the Catahoula probably contains saline water. The water from these formations is mostly of the sodium chloride type, the observed dissolved-solids content of saline water ranging from 1,020 ppm in Jim Hogg County to 17,500 ppm in Starr County.

According to Follett, White, and Irelan (1949, p. 9) many irrigation wells producing from these formations in the Linn-Faysville area in Hidalgo County yield water that contains boron in excess of the safe limits for citrus trees, as suggested by the U. S. Department of Agriculture. The concentration of boron averages 4.0 ppm in 26 wells in the Linn-Faysville area, ranging in depth from 631 to 2,050 feet. One stock well in Starr County, 381 feet deep, yields water containing 13 ppm of boron from the Catahoula.

Analyses of water from the Catahoula sandstone, Oakville sandstone, and Lagarto clay are shown in table 1. The locations of the wells from which samples were obtained are shown in plate 6.

PLIOCENE SERIES

OGALLALA FORMATION

The Ogallala formation of Pliocene age lies as a relatively continuous deposit at the surface of the High Plains of Texas (fig. 11). The Ogallala consists principally of sand, gravel, silt, clay, and, in some places, caliche. The formation has one of the highest yields of the aquifers in Texas. It supplies large quantities of water to irrigation wells, especially in the area south of the Canadian River where yields of 1,000 gpm are common. In most areas the water is of good quality; however, in the vicinity of some of the playa lakes the water is highly mineralized (Leggat, 1952, p. 17).

Water yielded to wells in the Ogallala is generally of the calcium bicarbonate and calcium sulfate types. Most of the wells in the Ogallala yield water containing some fluoride, and in some areas all the well waters are high in fluoride content.

The observed dissolved-solids content of saline water in wells in the Ogallala formation ranges from 1,010 to 17,400 ppm. Selected analyses of saline water from the Ogallala are shown in table 1. The locations of the wells from which the samples were taken are shown in figure 11.

TERTIARY AND QUATERNARY SYSTEMS

PLIOCENE, PLIOCENE(?), AND PLEISTOCENE SERIES

GOLIAD SAND, WILLIS SAND, AND LISSIE FORMATION, UNDIFFERENTIATED

The Goliad sand of Pliocene age, the Willis sand of Pliocene(?) age, and the Lissie formation of Pleistocene age are undifferentiated for purposes of discussion in this report. The sequence crops out in a wide belt roughly parallel to the coast extending from the Sabine River in Newton County generally westward to the Trinity River, thence the outcrop swings more to the southwest and eventually to the south in south Texas (pl. 7). The formations dip toward the coast and thicken coastward. They consist of a thick series of largely unconsolidated sand, gravel, silt, and clay.

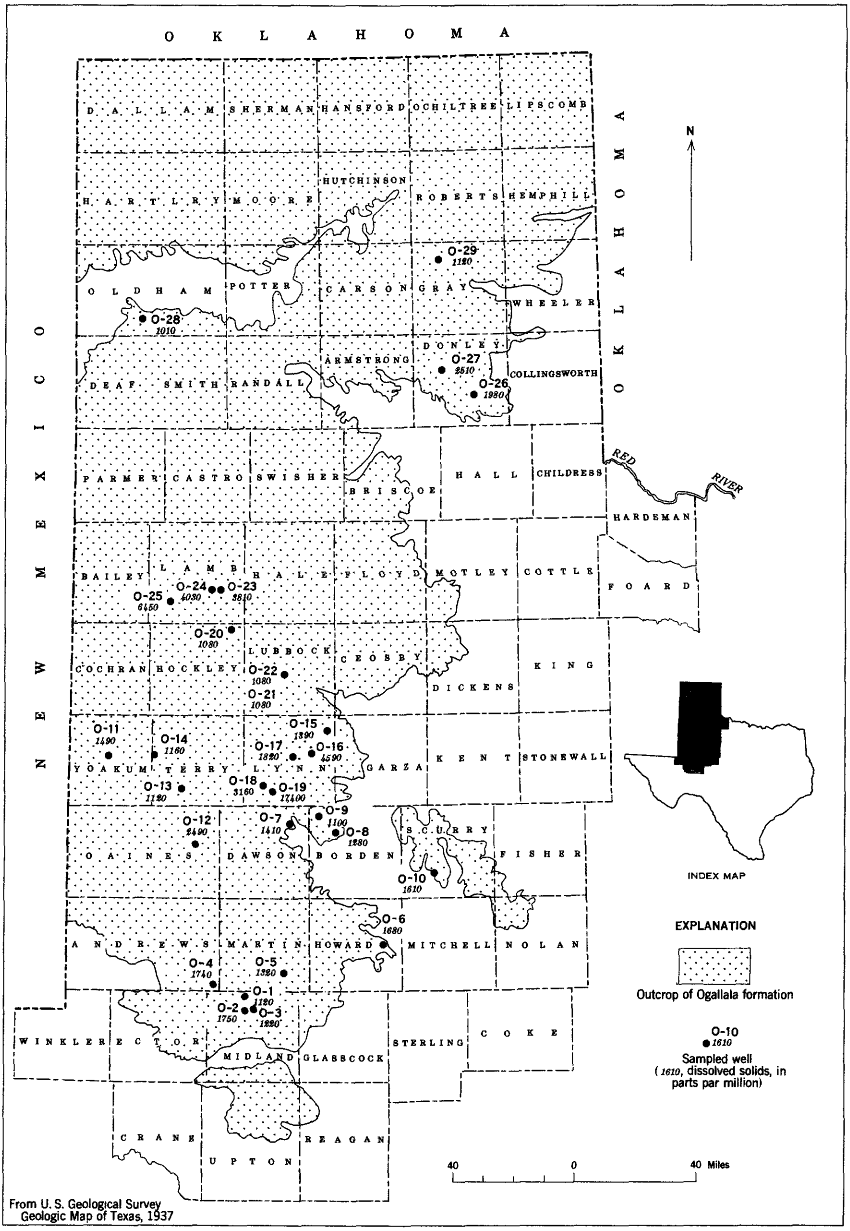


Figure 11.—Map showing locations of wells sampled and areas of outcrop of the Ogallala formation.

The sand of the Goliad, Willis, and Lissie probably constitutes the greatest potential source of ground water in Texas. It supplies large quantities of water to municipal and industrial supply wells in the Houston area. It is also used as a source of supply for the irrigation of rice throughout a large area on the upper gulf coast. Many of the wells in the upper gulf coast area have yields in excess of 2,000 gpm. In this area the upper sand, the Lissie, has the highest yield, whereas in south Texas most of the water comes from the Goliad sand. It is probable that these formations could yield large quantities of saline water in a narrow belt along the coast where only comparatively small supplies of good water are available. Locations of saline-water wells tapping this sequence are shown in plate 7.

Water from the Goliad sand, Willis sand, and Lissie formation varies greatly from place to place in concentration of dissolved solids. Observed concentrations of saline water range from 1,000 to 7,190 ppm in dissolved solids in San Patricio County and Starr County, respectively. The water is of the sodium chloride type.

Water from the Goliad sand in Cameron, Hidalgo, and Starr Counties contains excessive concentrations of boron. The water pumped from one well in Starr County contained 14 ppm of boron. Analyses of saline water from these formations are shown in table 1.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

BEAUMONT CLAY

The Beaumont clay of Pleistocene age crops out in a wide belt adjoining the coast and extending from the Sabine River to the Rio Grande (pl. 7). The formation dips toward the coast and is known to extend out beneath the shoreward part of the Continental Shelf. The formation consists largely of clay but has a few thin layers of fine sand. In an area along the upper coast in Brazoria, Galveston, Harris, Chambers, Jefferson, and Orange Counties, a thick bed of very permeable sand, known locally as the Alta Loma sand, occurs at the base of the Beaumont.

The sands of the Beaumont clay supply small to moderate quantities of water to many industries and to public supplies along the coast. The "Alta Loma" sand yields large quantities of water, especially in Galveston County and southeastern Harris County, where yields of about 2,000 gpm are obtained from wells. In the immediate vicinity of the coast the "Alta Loma" contains saline water. Much of this water is used for industrial cooling purposes.

The Beaumont clay on the whole may be considered a potential source of small supplies of saline water near the coast. Where the "Alta Loma" sand is present, large quantities of water are generally available. Locations of wells furnishing saline water from the Beaumont clay are shown in plate 7. Slightly saline water from a well tapping the Beaumont clay at the Bergstrom Air Force Base on Matagorda Island is being demineralized by an ion-exchange process. This is one example of how saline water can be used for domestic purposes after treatment for removal of objectionable amounts of dissolved minerals. Analyses of the water before and after demineralization (sample B—7) are shown in table 1.

The water from the Beaumont clay is of the sodium chloride type. The observed dissolved-solids concentration of saline water from the Beaumont ranges from 1,060 ppm in Chambers County to 8,410 ppm in Kleberg County. The chemical analyses of saline water from the Beaumont clay are shown in table 1.

PLEISTOCENE AND RECENT ALLUVIAL, EOLIAN, AND LITTORAL DEPOSITS

Thin beds of alluvial material overlie the older formations in many parts of Texas. Locally these deposits are thick enough and so situated that they form aquifers of considerable importance.

Probably the most important alluvial aquifers are the bolson deposits in trans-Pecos Texas. Thick bolson deposits in the El Paso area and in Hudspeth and Culberson Counties furnish large quantities of water to wells. Yields up to 1,000 gpm are common in the El Paso area. Recent test drilling near El Paso has shown that large quantities of saline water are available below the fresh water and in places within the fresh-water zone in that area.

Alluvial deposits in the vicinity of the Pecos River valley are an important source of water. Large quantities of water are pumped from wells tapping the alluvial deposits, especially in Pecos and Reeves Counties where yields of more than 1,000 gpm are common. Many of the wells yield saline water which is used for irrigation.

Another area of large-scale production of water from alluvial materials is the lower Rio Grande valley. In Cameron and Hidalgo Counties many irrigation wells draw moderately saline water from the alluvium of the Rio Grande. Yields of about 2,100 gpm are reported in Cameron County (Dale and George, 1954, p. 11).

In the central part of the Osage Plains region, a thin, discontinuous layer of alluvial material overlies the red beds of Permian age and occupies the surface in parts of Childress, Hardeman, Wilbarger, Foard, Knox, Baylor, Haskell, Throckmorton, Stonewall, Fisher, and Jones Counties. Locally the alluvium has a sufficient saturated thickness to be a source of water for small-scale irrigation and public supply. In most places the water is of good quality; but in others it is highly mineralized.

In many places in Texas, water is obtained from surficial alluvial or sand-dune deposits, but most of these supplies are very small. Locally, small supplies of water are obtained from beach- and dune-sand deposits along the coast. Along some of the streams small quantities of water are pumped from the alluvium in the stream bottoms or from terrace gravels along the streams.

Locations of wells tapping saline water in Pleistocene and Recent deposits are shown in plate 8, and analyses of well waters in several sections of Texas are shown in table 1. The chemical characteristics of the water from these deposits is contingent upon several factors: the nature of the material, rainfall in the area, thickness of the deposits, quality of the water recharging the deposits, and natural flushing of the deposits.

On the basis of the available analyses, a general statement can be made concerning the chemical quality of the water from these deposits. Although alluvial deposits are found in many places throughout the State in different geologic settings, the water is generally of the sodium chloride and calcium sulfate types. The observed concentration of dissolved solids in the saline water ranges from 1,020 ppm in water from the alluvium in Cameron County to 11,800 ppm in water from the alluvium in El Paso County.

Water of good quality is yielded to some municipal supply wells in the Pleistocene and Recent deposits. However, in the absence of water of better quality, many cities use water classified as saline from these deposits.

Boron in concentrations as high as about 4 ppm was found in water from the alluvium in Starr County.

SALINE SURFACE WATER

Movement of surface water is generally much faster than ground water; hence, surface water is less likely to become saline than ground water. However, water in streams or lakes often becomes saline by concentration resulting from surface evaporation of lakes (most common in closed basins); solution of the readily soluble mineral salts present in the rocks over which the stream flows (many streams in west Texas pass over rocks of Permian and Triassic age that contain evaporites exposed at the surface); discharge of saline ground water into effluent streams (fig. 12); intrusion of sea water into coastal streams (often caused by large withdrawal of surface water near the coast; and contamination of streams by man (such as the disposal of oilfield brines into the stream channels).

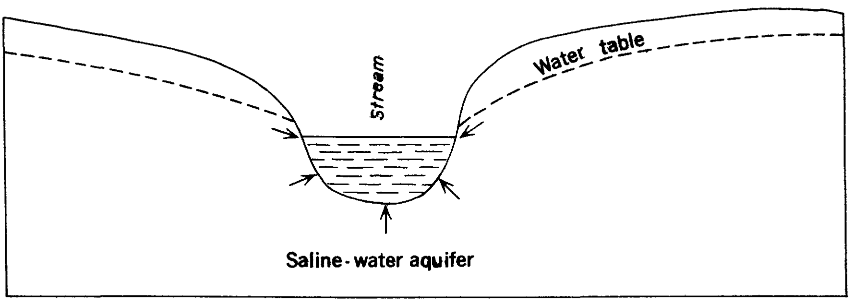


Figure 12. —Typical effluent stream receiving saline water.

In some streams, during the initial rise in stage in a flood, the dissolved-solids content of the water increases because of the solution of mineral salts present in the sediments disturbed by the scouring action of the water. After this first increase in dissolved solids the water often becomes more dilute, reflecting the chemical quality of the floodwater from gullies, other drainageways, and fields. In many streams in Texas the day-to-day quality of the water has been improved by the construction of dams regulating streamflow and impounding the dilute flood flows with the more concentrated low flows. Although saline waters have been found now and again in streams in all parts of Texas, the areas in which saline waters are present for extended periods are rather limited. Only those basins for which saline-water data were available are discussed. The approximate boundaries of the major river basins and the locations of sampling points at which saline surface water have been found are shown in plate 9. Saline surface water occurs most commonly in west and northwest Texas where the rocks at the surface contain easily soluble minerals. Low rainfall and high rates of evaporation also are factors contributing to the presence of saline surface water in this area. Another area where many streams contain saline water is along the gulf coast. Here sea water intrudes the tidal reaches of some of the streams in some areas, in part because of large withdrawals of fresh water for irrigation or industrial use.

The U. S. Geological Survey, working in cooperation with the Texas Board of Water Engineers, has analyzed many thousands of samples of water from Texas streams. Because of the many data available and because this is a reconnaissance report, not all the available analyses of saline surface water in Texas are listed here. Maximum, minimum, and weighted-average analyses for representative years, data on the mean discharge of streams, and other pertinent data are shown in tables 3 and 4, respectively. A weighted-average analysis represents the approximate chemical composition of all the water passing a certain sampling station in 1 year if impounded with thorough mixing in a reservoir, and neglecting evaporation and rainfall. In this report, for clarity, the occurrence of saline surface water is discussed by river basins.

CANADIAN RIVER BASIN

The Canadian River, a tributary of the Arkansas River, flows 190 miles in an easterly direction across the Texas Panhandle (pl. 9). Almost 25 percent of the entire length of the river lies in Texas. The area of the drainage basin in Texas is about 9,700 square miles.

Chemical-quality data have been collected at regular sampling stations on the Canadian River at Tascosa, near Amarillo, and near Borger, and samples from miscellaneous points in the basin have been collected at various times.

Water from the Canadian River stations shows a considerable variation in concentration of dissolved solids. Although the water generally is slightly saline during periods of low flow, weighted-average analyses show that a reservoir proposed for construction at Sanford would impound a mixture of water that would not be saline. Some samples of the river water at Borger have been slightly to moderately saline, and it is probable that some saline water occurs at times in the Canadian River all the way across the panhandle. Perhaps some of this salinity is in part due to pollution from the large panhandle oilfield.

Locations of sampling points and analyses of saline water from the Canadian River basin are shown in plate 9 and table 3, respectively.

RED RIVER BASIN

The Red River is formed by the junction of several small streams rising in the southeastern part of the Texas Panhandle (pl. 9). The Prairie Dog Town Fork drains the largest area and is considered the upstream continuation of the main stem. The Red River forms the boundary between Oklahoma and Texas and Arkansas and Texas. The area of the basin is 4, 580 square miles at the Texas-Arkansas State line. The principal tributaries to the Red River in Texas are the Sulphur, Big and Little Wichita, and Pease Rivers and the Salt and North Forks of the Red River.

The upper tributaries of the Red River cross Triassic and Permian formations which contain much readily soluble material. The Salt Fork of the Red River and Mulberry Creek contain relatively high concentrations of calcium sulfate derived from gypsum. A proposed reservoir on the Prairie Dog Town Fork of the Red River was dropped from consideration because of the high salinity of the water which would be impounded. The Pease River is high in both sulfate and chloride content. Lake Kemp on the Big Wichita River was originally built for irrigation purposes but the salinity of the impounded water limited its use for this purpose. Flood flows stored behind Denison Dam in Lake Texoma have diluted the saline inflow so that the impounded water is seldom saline. However, at Gainesville above the reservoir the river water is moderately saline for long periods.

Some salinity due to salt from the Talco oilfield is found in the Sulphur River during low flows. Salinity due to oil operations occurs in other areas in the Red River basin, particularly near Wichita Falls.

Locations of the sampling points and analyses of saline water in the Red River basin are shown in plate 9 and table 3, respectively.

BRAZOS RIVER BASIN

The Brazos River, which drains an area of 35,400 square miles, is one of the principal intrastate streams in Texas. The Salt Fork and the Double Mountain Fork join to form the Brazos River in the northeastern part of Stonewall County (pl. 9), and the river then flows generally southeastward, emptying into the Gulf of Mexico near Freeport in Brazoria County.

The low flows of the Salt Fork frequently are very saline, but some high flows are fresh. However, weighted-average analyses show that the water is moderately saline. The Double Mountain Fork is fresh during high flows; its low flows are moderately saline, and the weighted-average analyses show the water to be slightly saline. Water from the Clear Fork of the Brazos River is generally fresh, but at times it is slightly to moderately saline. A mixture of the water from the three main tributaries is stored in the Possum Kingdom Reservoir. Water released from the reservoir is slightly saline, and inflow to the Whitney Reservoir downstream is sometimes slightly saline. Formerly, saline water traveled to the mouth of the Brazos River, but since the completion of the Whitney Dam the water has been fresh from Whitney Dam to the mouth of the river, except when oilfield brines are released to minor tributaries entering the river downstream from the dam.

Miscellaneous samples from Colony Creek, tributary to the Leon River in Eastland County, show the water to be moderately saline to very saline. Oilfield brines have been released to this creek from time to time, causing the observed salinity. It is probable that some other small streams in the Brazos watershed are similarly affected.

Sampling points and analyses of the water in the Brazos River basin are shown in plate 9 and table 3, respectively.

COLORADO RIVER BASIN

The Colorado River rises in Dawson County at the eastern edge of the High Plains and flows in a southeasterly course across the State, finally discharging into Matagorda Bay (pl. 9). The contributing area is 29,730 square miles.

The Colorado River is sometimes saline above Colorado City, owing to the discharge of salt springs from the Permian and Triassic formations in the riverbed. Slight salinity has been observed at Robert Lee also. In general, salinity concentrations are lower in the upper reaches of the Colorado than in the upper Brazos watershed. Before construction of the dam forming Lake Colorado City, Morgan Creek often was slightly to moderately saline. The impounded water, however, has always been fresh. Other tributaries of the upper Colorado contain saline water during low flows but are fresh during flood flows.

Sampling points in the Colorado River basin and analyses of the water are shown in plate 9 and table 3, respectively.

RIO GRANDE BASIN

The Rio Grande rises in the San Juan Mountains in southwestern Colorado, flows in a general southerly direction across New Mexico, and then turns southeastward, forming the international boundary between the United States and Mexico and enters the Gulf of Mexico near Brownsville, Tex. (pl. 9). The Rio Grande in the United States has a drainage area of about 89,000 square miles.

The salinity of the Rio Grande increases downstream to the upper Presidio station, where the water is moderately saline at times. Below this station the water has been saline at times all the way to the mouth. Recent completion of the Falcon Dam at the Zapata-Starr County line makes it likely that saline water will no longer occur below the dam except in tidal reaches. The International Boundary and Water Commission operates sampling stations on the Rio Grande and its tributaries. Analyses of saline water from the Rio Grande at El Paso, the station at Fort Quitman, and the upper Presidio station, made by the United States section of the International Boundary and Water Commission (1950), are shown in table 3.

Tributary inflow to the Rio Grande in Texas is generally small and moderately to very saline. The Pecos River, principal tributary to the lower Rio Grande, rises in the Sangre de Cristo Mountains in New Mexico and enters Texas at the Loving-Reeves County line. The Pecos in Texas flows about 260 miles in a southeasterly direction and joins the Rio Grande in Val Verde County (pl. 9).

Red Bluff Dam on the Pecos River just below the Texas-New Mexico State line, completed in 1936, has a storage capacity of 307,000 acre-feet. The quality of the stored water varies, depending on the conditions of discharge into the reservoir. In March 1953 the water discharged from the reservoir was moderately saline (table 3).

Pecos River water near Orla ranges from slightly saline to moderately saline. Below Grandfalls the river water frequently is very saline, owing to return flow of irrigation water which is moderately to very saline when applied.

Locations of samples and analyses of the water in the Rio Grande basin are shown in plate 9 and table 3, respectively.

SALINE LAKES AND RESERVOIRS

Saline water is found in both natural lakes and in artificial reservoirs in Texas. Natural lakes are saline primarily because of concentration by evaporation at the surface. Water in artificial reservoirs may be saline either because of concentration by evaporation or because the impounded stream is fed by saline water. The day-to-day quality of the water in the downstream reaches of a normally saline stream is generally improved by impoundment that permits mixing of the fresh water of high flows with the saline water of low flows.

Natural lakes containing saline water are found in the High Plains, Pecos Valley and trans-Pecos, and Osage Plains regions in Texas. The "Salt Flats," a chain of lakes in Hudspeth County in the Dell City area, illustrate the high salinity typical of closed basins. According to Scalapino (1950, p. 2), the basin is a depression about 150 miles long and 5 to 15 miles wide. It contains a large number of shallow lakes and salt-encrusted flats and is fed by the Sacramento River, which flows only after heavy rains. It is reported that surface flows seldom reach the lowest part of the basin.

Playa basins in central Lynn County contain water-table lakes which occupy depressions created by wind erosion and solution and differential compaction in the underlying Ogallala formation (Leggat, 1952). An analysis shows that the water from Toyah Lake in Reeves County is very saline. Waters from Cedar Lake in Gaines County and Rich Lake in Terry County are classed as brines. The amount of dissolved solids in the waters is about 90,000 ppm.

Artificial reservoirs for which chemical analyses are available include Daniel Salt Lake in Eastland County, whose water contains 136,000 ppm of dissolved solids. This reservoir is on Colony Creek, which is a tributary of the Leon River. Its salinity is due to inflow of saline water from oilfields. Lake Kemp on the Wichita River in Baylor County and Lake Texoma on the Red River in Cooke and Grayson Counties are slightly saline. Lake Balmorhea, also known as Lower Parks Reservoir, is fed by springs on Toyah Creek in Reeves County. It contained slightly saline water in January 1950. Red Bluff Lake in Loving County, formed by impounding water from the Pecos River, normally contains about 7,000 ppm of dissolved solids. Chemical analyses of saline lakes and reservoirs in Texas are shown in table 3.

SALINITY IN TIDAL REACHES OF STREAMS, BAYS, AND ESTUARIES

Saline water is present in the tidal reaches of the streams that empty into bays and estuaries along the gulf coast. Generally the salinity of the river water thus affected is less than that of sea water. In some places large withdrawals of river water for industrial and irrigation use have caused the heavier, more concentrated sea water to form a "wedge" which gradually invades the fresh-water reaches of the streams along the bottoms of the stream channels.

Examples of salinity caused by the intrusion of sea water are provided by the analyses of water from the Trinity River at Anahuac and Old River near Cove (table 3). The water at these two stations ranges from fresh to very saline.

The concentration of dissolved solids in the water in bays and estuaries along the gulf coast of Texas is represented by the analysis of sample 37 (table 3). This sample of the water from Laguna Madre was taken near Riviera, Tex., at the Carolina Beach pier and is classified as a brine.

CONCLUSION

Saline water is widely distributed in the underground reservoirs, streams, and lakes of Texas. In north-central and west Texas, in large areas where no potable water is found, the water ranges from slightly saline to brine. In these areas an economic demineralization would be most helpful.

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TABLES OF BASIC DATA

Table 1.—*Chemical analyses and related physical*

[Analyses in parts per million,

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
						Hickory sandstone member		
CO-1.....	Concho....................	25	0.05	5.9	2.2	417	19	438
						Ellenburger		
CO-2.....	San Saba..................	1.7	....	96	71	2,270		180
CO-3.....	Crockett.................	....	....	1,116	262	15,486		708
CO-4.....	Reagan....................	....	....	18,900	8,290	22,900		25
CO-5.....	Ector......................	....	....	2,668	757	27,221	......	702
CO-6.....	Ector......................	....	....	849	364	14,510		397
CO-7.....	Andrews..................	....	....	1,256	533	14,311		870
CO-8.....	Andrews..................	....	....	2,852	685	21,073	......	232
CO-9.....	Andrews..................	....	....	20,972	3,642	70,198		49
CO-10...	Scurry.....................	....	....	2,476	617	19,964		293
						Pennsylvanian		
C-1.......	McCulloch...............	15	....	14	7.1	384		409
C-2.......	McCulloch...............	15	....	17	8.7	388		403
C-3.......	Wise........................	....	....	230	98	166		536
C-4.......	Parker.....................	3.8	....	6.1	3.2	841		507
C-5.......	Palo Pinto..............	....	....	200	158	974		606
C-6.......	Parker.....................	7.2	0.16	87	46	2,730		293
C-7.......	Parker.....................	9.0	.02	401	637	2,550		156
C-8	Lampasas................	....	....	2,710	1,010	26,400		327
C-9.......	Archer.....................	12	....	36	14	1,910		492
C-10	Montague................	13	.47	6.6	1.9	557		636
C-11	Montague................	11	16	4.6	1.4	481	5.8	698
C-12	McCulloch...............	....	....	....	....	......		116
C-13	Eastland..................	11	....	14	3.7	757		481
C-14	Burnet.....................	13	....	1,010	665	10,200		173
						Bone Spring		
P-1	Hudspeth................	19	....	251	97	89		248
P-2	Hudspeth................	16	....	213	79	25		260
P-3	Hudspeth................	14	....	254	99	192		236
P-4.......	Hudspeth................	18	....	170	90	99		252
						Delaware		
P-5	Culberson...............	14	....	....	....	....		....
P-6	Reeves.....................	....	....	7,680	1,950	90,800		33
P-7	Loving.....................	....	......	7,000	1,520	35,700		46
						Wichita and		
P-8.......	Tom Green..............	11	....	904	340	431		308
P-9.......	Tom Green..............	5.2	....	408	192	250		100
P-10.....	Tom Green..............	21	....	454	162	246	......	258
P-11	Tom Green..............	23	....	254	101	189	......	237
P-12	Runnels..................	15	0.11	204	85	133	6.2	312
P-13	Taylor.....................	16	18	190	49	100	6.7	288
P-14	Taylor.....................	21	.06	464	90	209	12	245
P-15	Jones.......................	....	.15	592	91	278	......	256

measurements of saline ground water in Texas

except as indicated]

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
of Riley formation										
....	23	400	2.6	0.5	1.3	1,110	24	95	2,040	8.0
group										
....	42	3,740	....	....	....	6,310	532	90	11,200	7.9
....	2,850	24,050	....	....	....	45,800	....	....	....	7.5
....	1,020	92,100	....	....	....	143,000	....	38	127,300	....
....	2,640	46,600	....	....	....	85,800	....	....	....	7.8
....	48	24,700	....	....	....	45,480	....	....	....	7.8
....	1,375	24,350	....	....	....	44,140	....	....	....	7.5
....	2,640	37,500	....	....	....	69,550	....	....	....	7.7
....	100	156,100	....	....	....	286,700	....	....	....	5.9
....	1,940	35,400	....	....	....	63,000	....	....	....	7.2
undifferentiated										
....	19	385	....	0.5	....	1,030	64	93	1,930	8.2
12	14	400	....	3.0	....	1,050	78	91	1,960	8.4
....	781	61	....	.0	....	1,600	977	27	....	....
55	774	418	....	. 1.8	....	2,320	28	98	3,640	8.9
....	2,310	260	....	1.2	....	4,200	1,150	65	....	....
....	4.6	4,320	....	16	....	7,360	406	94	12,700	7.2
....	4,530	3,010	....	90	....	11,300	3,620	61	14,400	7.2
....	129	51,200	....	....	....	83,600	10,900	85	108,000	....
20	216	2,590	....	....	....	5,030	148	97	8,760	....
....	44	465	4.4	1.8	....	1,410	24	98	....	8.0
38	53	286	3.0	1.2	....	1,210	18	98	2,160	8.4
37	10	3,310	....	....	....	5,640	....	....	....	9.2
....	2.5	922	....	.5	0.82	1,950	52	97	3,560	7.9
....	129	19,200	....	....	3.2	31,300	5,260	81	48,100	7.5
limestone										
....	798	130	....	2.2	....	1,510	1,030	16	2,050	....
....	624	32	....	2.8	....	1,120	856	6	1,470	....
....	845	268	....	8.5	0.54	1,800	1,040	28	2,480	7.5
....	608	118	....	3.8	....	1,230	794	21	1,750	....
Mountain group										
....	632	922	....	....	....	>1,000	140	....	6,370	7.9
....	546	159,000	....	....	....	260,000	27,200	88	235,000	....
....	1,550	70,100	....	....	....	116,000	....	....	....	....
Clear Fork groups										
....	1,470	1,990	....	3.5	....	5,300	3,650	20	7,810	....
....	1,930	185	....	.0	....	3,020	1,810	23	3,480	....
....	1,760	185	....	.0	0.71	2,960	1,800	23	3,460	7.8
....	1,060	126	....	1.8	.65	1,870	1,050	28	2,470	8.0
....	584	201	1.8	5.2	....	1,390	858	25	2,040	7.4
....	545	56	1.0	20	....	1,130	676	24	1,570	7.2
....	1,410	161	.8	123	....	2,610	1,530	23	3,160	7.2
....	1,590	391	.8	49	....	3,450	1,850	25	....	7.5

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Wichita and Clear
P-16	Jones	16	0.00	60	61	720	3.0	261
P-17	Jones	16	.00	282	80	204	15	189
P-18	Jones	17	.00	314	118	262	3.6	222
P-19	Jones	14	......	556	260	1,270		205
P-20	Jones	19	.22	255	83	149	3.4	124
P-21	Jones	16	.19	282	80	204	15	189
P-22	Knox	......	......	......	......	....		224
P-23	Baylor	31	.02	154	76	596	6.0	543
P-24	Baylor	......	......	......	......	....		357
								San Angelo
P-25	Tom Green	8.6	......	2,460	1,050	16,000		405
P-26	Coke	......	......	......	......	....		......
P-27	Coke	16	......	169	402	395		476
P-28	Nolan	10	......	177	109	107		330
P-29	Jones	8.9	7.8	510	97	887		116
P-30	Jones	17	.28	880	371	1,140		314
P-31	Jones	18	.00	616	98	91	4.4	258
P-32	Stonewall	......	......	595	199	486		186
P-33	Stonewall	......	......	......	......	....		50
P-34	Foard	......	......	652	243	959		110
P-35	Hardeman	......	......	484	214	1,070		73
P-36	Hardeman	......	......	611	262	288		281
P-37	Hardeman	......	......	515	161	383		256
P-38	Hardeman	......	......	......	......	.....		244
								Blaine
P-39	Jones	17	0.00	546	184	227		176
P-40	Fisher	......	......	558	147	404		112
P-41	Stonewall	15	......	812	164	469		52
P-42	Cottle	......	......	534	144	337		232
P-43	Hardeman	......	......	610	100	145		207
P-44	Hardeman	......	......	486	104	145		146
P-45	Hardeman	19	......	......	......	53	....	200
P-46	Hardeman	14	......	592	101	39	....	191
P-47	Childress	17	......	602	139	240	....	190
P-48	Childress	18	......	606	73	50	....	236
P-49	Childress	18	......	600	117	124	....	190
P-50	Childress	18	......	604	151	260	....	162
P-51	Childress	18	......	608	158	256	....	162
P-52	Childress	16	......	620	232	730	....	220
P-53	Childress	17	......	570	130	83	....	104
P-54	Childress	17	......	608	101	116	....	223
P-55	Collingsworth	22	......	600	91	32		225
P-56	Collingsworth	20	.00	574	87	38	3.6	110
								Rustler
P-57	Culberson	......	......	615	51	64		105
P-58	Culberson	......	......	677	166	92		141
P-59	Culberson	14	......	178	68	105		270
P-60	Reeves	19	......	600	285	504		112
P-61	Reeves	......	......	896	253	861		147
P-62	Reeves	......	......	599	218	46		143
P-63	Reeves	......	......	605	216	5.3		130

measurements of saline ground water in Texas—Continued

Fork groups—Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
...	736	725	1.0	1.2	5.5	2,460	400	79	3,940	8.0
...	1,060	138	1.2	45	...	1,940	1,030	30	2,490	7.6
...	1,310	228	.8	6.9	2.3	2,370	1,270	31	3,120	7.6
...	3,070	1,300	.8	17	...	6,590	2,460	53	8,160	7.6
...	882	208	.6	4.0	...	1,670	978	25	2,250	7.9
...	1,060	138	1.2	45	...	1,940	1,030	30	2,490	7.6
...	1,750	395	...	4.2	...	>1,000	2,190	...	...	...
...	524	640	1.4	129	.83	2,430	696	65	3,810	7.6
...	...	2,000	...	...	...	>1,000	...	...	...	...

sandstone

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
...	3,180	29,500	...	...	...	52,400	10,500	77	69,600	...
...	...	30,000	...	...	...	>1,000	...	...	69,200	...
...	1,560	624	...	50	...	3,450	2,080	29	4,690	...
...	640	130	...	3.0	...	1,340	890	21	1,860	...
...	2,860	372	0.9	1.0	...	4,790	1,670	54	5,800	7.7
...	1,740	1,870	2.8	1,840	...	8,020	3,720	40	10,400	7.4
...	1,430	285	.6	62	0.36	2,730	1,940	9	3,340	7.6
14	2,310	560	...	.4	...	4,250	2,300	31	...	...
...	5,890	1,270	...	.4	...	>1,000	1,950	...	...	...
...	2,830	1,180	...	...	...	5,930	2,630	44	...	...
...	3,200	500	...	...	...	5,500	1,780	49	...	...
...	2,340	400	...	...	...	4,040	2,610	19	...	...
...	2,160	232	...	...	...	3,580	1,950	30	...	...
...	970	104	...	...	...	1,740	...	...	...	...

gypsum

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
...	2,180	139	1.1	0.5	...	3,380	2,120	19	3,820	7.5
...	2,310	268	...	1.0	...	3,740	2,000	31	...	...
...	1,620	1,410	...	2.0	...	4,520	2,700	27	6,280	6.9
12	1,370	730	...	1.2	...	3,240	1,920	28	...	...
...	1,790	152	...	...	...	2,900	1,930	14	...	...
...	1,710	63	...	...	...	2,580	1,640	18	...	...
...	1,660	60	...	5.9	0.38	>1,000	1,860	6	2,850	7.0
...	1,680	55	1.2	7.0	.40	2,580	1,890	43	2,760	7.1
...	1,890	360	...	4.6	.93	3,350	2,070	20	3,890	7.4
...	1,580	55	...	31	.41	2,530	1,810	6	2,740	7.4
...	1,770	185	...	4.5	.62	2,910	1,980	12	3,250	7.5
...	1,950	380	...	3.2	1.2	3,450	2,130	21	4,030	7.5
...	1,890	460	...	7.2	.50	3,480	2,170	20	4,120	7.5
...	2,400	1,040	...	.2	4.7	5,150	2,500	39	6,490	7.5
...	1,790	102	...	12	.41	2,760	1,960	8	3,050	7.9
...	1,710	162	...	6.3	.90	2,830	1,930	12	3,190	7.4
...	1,630	41	...	3.0	.28	2,530	1,870	4	2,680	7.0
...	1,610	54	...	12	.12	2,450	1,790	4	2,730	7.7

limestone

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
...	1,640	51	...	25	...	2,700	...	7	2,630	...
...	2,240	83	...	4.0	...	3,720	...	8	3,650	...
...	639	46	...	.0	...	1,180	724	24	1,570	7.8
...	2,540	730	...	.2	...	4,730	2,670	29	5,850	7.2
...	1,780	2,250	...	...	...	6,110	3,280	36	...	...
...	2,230	37	...	...	...	3,200	2,390	4	3,330	...
...	2,180	24	...	2.5	...	3,540	2,400	1	3,280	...

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Rustler
P-64	Reeves	....	....	603	277	342		101
P-65	Ward	18	0.01	984	622	12,800	19	113
P-66	Crane	....	....	852	197	1,480		98
P-67	Pecos	....	....	566	199	12		66
P-68	Pecos	....	....	1,250	608	14,900		225
P-69	Pecos	....	....	835	359	9,450		26
P-70	Pecos	....	....	342	83	194		252
P-71	Pecos	....	....	327	83	184		141
								Quartermaster
P-72	Borden	5.0	....	26	28	2,300		513
P-73	Fisher	....	....	330	109	80		345
P-74	Fisher	....	....	810	232	350		135
P-75	Stonewall	35	....	983	201	2,400		215
P-76	Stonewall	26	....	2,740	620	11,700		134
P-77	Dickens	....	....	....	....	.....		302
P-78	Motley	....	....	....	....	202		111
P-79	Motley	....	....	527	173	1,070		76
P-80	Motley	....	....	172	71	403		362
P-81	Hall	....	....	1,500	293	17,100		126
P-82	Hall	34	....	550	411	394		227
P-83	Hall	44	....	352	82	15	9.2	162
								Dockum
Tr-1	Ector	5.5	....	210	134	2,150		228
Tr-2	Ector	8.5	....	170	90	2,280		348
Tr-3	Ector	8.0	....	9.7	6.2	692		596
Tr-4	Mitchell	20	....	184	61	132		104
Tr-5	Mitchell	21	....	362	118	200	.....	172
Tr-6	Mitchell	12	....	56	56	1,800		226
Tr-7	Mitchell	15	....	112	141	2,240		292
Tr-8	Mitchell	5.0	....	169	88	2,820		291
Tr-9	Scurry	10	....	84	43	1,990		411
Tr-10	Scurry	19	....	502	322	188		388
Tr-11	Scurry	18	....	506	298	520		361
Tr-12	Lynn	26	27	109	237	672		264
Tr-13	Floyd	8.7	....	206	89	4,990	.....	398
Tr-14	Borden	56	....	103	62	211		330
Tr-15	Borden	11	....	46	21	835		218
Tr-16	Borden	10	....	112	76	1,020		570
Tr-17	Mitchell	6.5	....	129	64	2,190		356
Tr-18	Borden	7.2	....	185	94	3,660		279
Tr-19	Borden	9.2	....	679	341	5,390		214
Tr-20	Oldham	13	.2	22	12	434	6.0	806
Tr-21	Lubbock	8.4	.0	284	122	7,420		230
								Travis Peak
K-1	Comal	....	.....	71	71	325		171
K-2	Comal	....	.....	....	....	.....		317
K-3	Travis	....	.....	168	149	110		352
K-4	Travis	....	.....	459	121	24		354
K-5	Travis	12	.....	53	42	1,170		502
K-6	Lampasas	....	.....	51	27	451		365
K-7	Bell	....	.....	39	27	1,210		507
K-8	Bell	14	0.07	12	4.5	440		437

measurements of saline ground water in Texas—Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
limestone—Continued										
......	2,700	350	......	......	......	4,320	2,640	22	4,980	......
......	4,920	19,300	1.7	......	4.3	38,700	5,010	85	52,000	7.4
......	2,190	2,660	......	3.0	......	7,420	2,940	52	10,540	......
......	2,090	18	......	.75	......	3,240	2,230	1	......	......
......	4,940	23,200	......	......	......	45,000	5,620	85	......	......
......	5,100	13,300	......	......	......	29,300	3,560	85	40,800	......
......	959	292	......	.0	......	1,990	1,200	26	......	......
8	960	308	......	.5	......	2,210	1,160	26	......	......
formation										
35	1,730	2,080	......	0.5	......	6,440	180	97	9,900	......
......	950	122	......	3.8	......	1,760	1,270	12	......	......
......	1,780	1,220	......	64	......	4,520	2,980	20	......	......
......	1,590	4,730	......	......	......	10,000	3,280	61	15,100	7.1
......	1,800	23,300	......	......	......	40,300	9,360	73	51,300	6.9
16	1,200	552	......	......	......	>1,000	......	......	......	......
......	1,760	94	0.3	2.5	......	2,710	1,620	......	......	......
......	3,020	815	.3	1.0	......	5,650	2,030	53	......	......
......	401	620	......	10	......	1,850	721	55	......	......
......	4,190	26,700	......	......	......	49,800	4,940	88	69,600	......
......	2,970	432	......	39	......	4,940	3,060	22	5,260	7.4
......	1,080	15	......	1.5	0.07	1,680	1,220	3	1,920	7.4
group										
......	2,440	2,140	......	......	......	7,190	1,080	81	......	......
......	1,580	2,710	......	......	......	7,010	794	86	......	......
......	484	395	......	4.2	......	1,890	50	97	......	......
......	492	220	......	111	......	1,270	710	29	1,960	......
......	1,480	103	1.8	.2	0.83	2,370	1,390	24	2,840	7.3
10	935	2,210	......	3.5	......	5,190	370	91	8,630	......
......	998	3,150	......	......	......	6,800	860	85	11,100	......
......	1,650	3,510	......	......	......	8,390	734	89	12,500	......
20	1,700	1,840	......	4.0	......	5,880	386	92	9,090	......
......	1,620	680	......	27	......	3,550	2,580	14	4,620	......
......	2,660	382	......	20	......	4,580	2,490	31	5,310	......
......	1,270	820	......	15	......	3,280	1,250	59	4,970	7.5
......	863	7,320	1.4	......	2.1	13,700	880	92	22,200	7.7
......	239	312	......	14	......	1,160	512	47	1,890	......
12	208	1,140	......	4.5	......	2,380	202	90	4,350	......
......	1,620	460	......	1.2	......	3,580	574	79	5,220	......
30	1,390	2,540	......	......	......	6,510	585	89	9,970	......
......	2,410	4,300	......	......	......	10,800	848	90	16,100	......
......	3,200	8,020	......	......	......	17,700	3,100	79	25,500	......
......	295	60	1.4	.5	2.1	1,240	104	89	1,840	7.5
......	1,850	10,800	.6	......	2.1	20,600	1,210	93	31,400	7.4
formation										
......	237	560	......	0.0	......	1,350	469	60	......	......
......	870	41	......	......	......	1,560	......	......	......	......
......	877	43	3.2	.0	......	1,520	1,020	19	......	......
......	1,310	27	......	.25	......	2,120	1,640	3	......	......
......	598	1,290	......	4.5	......	3,420	304	89	5,650	7.9
......	407	350	......	3.0	......	1,470	238	80	......	......
......	951	1,010	......	.5	......	3,620	208	93	......	......
13	269	248	2.0	1.8	......	1,200	48	95	......	8.0

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Travis Peak
K-9......	Falls..................	30	0.25	78	18	415	14	350
K-10......	Tarrant..................	11	....	18	2.4	459		688
K-11......	Dallas..................	24	.01	8.0	2.8	381		528
K-12......	Dallas..................	....	.32	126	54	2,230		40
K-13......	Dallas..................	26	.02	6.4	2.4	378		491
K-14......	Dallas..................	25	.02	6.8	2.4	394		488
								Glen Rose
K-15......	Medina..................	11	....	486	347	4.4		230
K-16......	Medina..................	9.5	....	540	369	17		238
K-17......	Medina..................	13	0.62	476	106	53		184
K-18......	Medina..................	9.5	.19	540	434	61		251
K-19......	Medina..................	13	.00	538	344	54		303
K-20......	Medina..................	11	....	186	141	52		350
K-21......	Bexar..................	14	.00	484	247	43		273
K-22......	Bexar..................	14	....	324	267	12		277
K-23......	Comal..................	....	....	326	220	17		360
K-24......	Comal..................	....	....	....	....	.....		245
K-25......	Hays..................	11	....	274	108	54		380
K-26......	Travis..................	10	....	258	214	65		400
K-27......	Bell..................	12	......	39	41	417		409
K-28......	Bell..................	....	....	....	....	.....		438
K-29......	Falls..................	....	9.2	266	62	2,250		300
K-30......	Grayson..................	8.0	.04	128	71	334		193
								Paluxy
K-31......	Bosque..................	15	....	27	20	1,110		598
K-32......	Hill..................	6.0	0.12	11	8.4	629	16	561
K-33......	Hill..................	10	.12	5.2	1.8	492	19	420
K-34......	Dallas..................	22	.12	10	3.8	851	4.4	529
K-35......	Dallas..................	32	.21	4.2	2.0	544		605
K-36......	Dallas..................	20	.07	5.6	1.8	506		597
K-37......	Parker..................	20	....	225	205	167		533
K-38......	Parker..................	22	....	188	39	168		514
								Trinity
K-39......	Pecos..................	....	....	....	....	.....		284
K-40......	Pecos..................	....	....	....	....	.....		150
K-41......	Upton..................	18	....	280	161	248		187
K-42......	Upton..................	18	0.15	150	78	142	5.2	336
K-43......	Upton..................	8.2	.10	150	117	276	7.6	312
K-44......	Reagan..................	10	.11	149	93	547	21	252
K-45......	Reagan..................	8.0	3.9	156	103	285	19	262
K-46......	Reagan..................	11	.28	136	84	238	16	246
K-47......	Reagan..................	6.0	6.9	167	108	306	28	274
K-48......	Medina..................	20	.48	137	67	533		376
K-49......	Bexar..................	28	.07	186	56	619	35	320
K-50......	Kendall..................	....	....	205	120		9	342
K-51......	Hays..................	13	....	198	150	89		343
K-52......	Travis..................	15	.38	91	26	513	29	396
K-53......	Travis..................	18	.08	42	22	294	11	270
K-54......	Williamson..................	13	.08	17	15	632		432
K-55......	Williamson..................	20	.10	17	6.1	462		452
K-56......	Bell..................	10	.86	60	42	712	13	410
K-57......	Bell..................	12	.06	13	7.6	519		490

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH

formation—Continued

....	749	83	2.3	0.0	....	1,560	268	76	2,260	8.1
30	106	250	....	2.5	....	1,200	55	95	2,050	8.6
28	253	94	2.6	.5	....	1,030	32	96	....	8.5
12	4,740	293	....	.5	....	7,470	536	90	....	8.5
31	279	88	2.2	.0	....	1,040	26	97	....	8.5
10	341	80	1.7	2.5	....	1,090	27	97	1,690	......

limestone

....	2,320	23	4.0	3.0	0.65	3,310	2,640	4	3,530	7.9
....	2,580	16	....	.0	....	3,650	2,860	1	3,690	7.0
....	1,500	18	....	.0	....	2,260	1,620	7	2,490	7.8
....	2,900	27	....	4.0	....	4,100	3,130	4	4,080	6.7
....	2,480	30	....	1.2	....	3,610	2,760	4	3,640	7.3
....	783	37	.5	.5	....	1,380	1,040	10	1,790	7.3
....	1,980	14	4.0	2.0	....	2,920	2,220	4	3,090	7.2
....	1,610	21	....	.0	....	2,380	1,910	1	3,830	8.0
....	1,380	17	....	.0	....	2,370	1,720	2	....	....
....	2,200	10	....	.2	....	>1,000	....	....	....	....
....	802	70	....	.5	....	1,510	1,130	9	1,830	7.1
....	1,240	33	....	.0	1.1	2,020	1,520	9	2,450	7.7
....	527	205	....	.2	....	1,440	266	77	2,250	8.4
20	250	246	....	....	....	>1,000	....	......	....	......
....	4,470	645	....	.0	....	8,020	919	84	....	......
....	1,050	60	.4	.2	....	1,750	612	54	2,360	7.5

sand

....	1,760	158	3.2	0.8	....	3,390	150	94	4,690	8.3
....	796	105	4.7	1.2	....	1,850	62	94	....	8.0
22	480	173	2.9	1.0	....	1,400	20	96	....	8.2
20	1,190	137	3.6	4.7	2.0	2,500	40	98	3,670	8.7
46	510	91	3.2	.2	....	1,510	18	98	....	8.4
32	466	80	3.2	.0	....	1,390	22	98	....	8.2
....	167	815	....	9.0	....	1,870	1,400	21	3,110	7.8
....	354	132	.3	22	.29	1,180	630	37	1,700	7.6

group

....	584	480	....	....	....	>1,000	774	......	2,820	7.7
....	459	1,460	....	....	....	>1,000	1,680	......	6,990	7.6
....	1,370	202	....	44	....	2,420	1,360	28	3,120	7.5
....	545	108	2.0	12	0.71	1,230	695	31	1,770	7.2
....	919	165	3.0	15	1.6	1,820	856	41	2,430	7.2
....	704	760	2.6	15	....	2,450	754	62	3,770	7.7
....	985	144	2.6	9.0	....	1,840	813	43	2,470	7.7
....	813	112	2.6	11	....	1,540	685	42	2,100	7.7
....	947	244	2.6	.8	....	1,940	861	43	2,680	7.4
....	919	358	2.8	.2	....	2,220	618	65	3,260	7.4
....	956	580	2.4	.2	1.7	2,620	694	65	3,960	6.9
....	688	13	3.1	....	....	1,210	1,000	1	....	......
8	896	54	2.2	2.0	....	1,580	1,110	15	2,070	8.3
....	739	270	4.0	2.2	....	1,910	334	75	2,840	7.5
....	523	62	1.0	.2	3.2	1,110	196	75	1,690	7.7
20	542	360	7.2	.0	....	1,810	104	93	....	8.5
....	421	182	2.7	.0	....	1,330	68	94	....	7.8
....	978	362	5.4	9.4	....	2,400	322	82	....	7.8
....	376	275	4.0	.0	....	1,450	64	95	....	7.9

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Trinity
K-58......	Bell..........................	....	....	63	81	454		408
K-59......	Coryell......	14	0.43	27	7.6	750	56	380
K-60......	Coryell........	3.0	.09	8.4	4.6	437	23	442
K-61......	Coryell..........	65	.52	16	10	412	12	352
K-62......	Coryell.............	11	.03	34	57	898		595
K-63......	Coryell.....	....	....	42	45	613		458
K-64......	Falls.........................	25	.14	55	17	491	12	433
K-65......	McLennan.................	....	....	39	45	1,360		688
K-66......	McLennan.................	20	.83	112	46	933		298
K-67......	Hill...........................	8.5	.10	22	28	668	22	488
K-68......	Hill...........................	18	.18	147	49	855	20	225
K-69......	Hill...........................	14	.08	46	22	401	12	345
K-70......	Ellis........	14	.04	13	5.2	358	7.8	483
K-71......	Ellis.....	21	.07	5.4	2.1	429	7.2	512
K-72......	Parker......................	20	....	224	131	194		500
K-73......	Tarrant............	11	....	6.2	1.6	413		742
K-74......	Collin........................	20	.06	15	5.6	440	3.6	400
								Edwards limestone and
K-75......	Kinney......................	....	5.2	111	63	169		400
K-76......	Kinney......................	....	....	60	74	216		524
K-77......	Uvalde......................	15	....	70	1.7	491		(a)
K-78......	Medina............	12	....	176	107	9.0	.....	273
K-79......	Bexar........................	14	......	652	259	532		313
K-80......	Bexar........................	....	....	231	82	59		380
K-81......	Guadalupe.......	....	....	....	....	.....		196
K-82......	Comal...............	7.2	.25	62	32	301		294
K-83......	Hays.........................	12	....	82	57	207		301
K-84......	Hays.........................	10	....	469	221	2,570		256
K-85......	Travis.......................	12	....	272	206	1,310		288
K-86......	Travis.......................	12	....	515	316	2,680		189
K-87......	Travis.......................	8.0	.00	140	94	115		292
K-88......	Williamson......	18	.14	17	12	534	.....	495
K-89......	Milam........................	....	....	298	79	4,730		207
K-90......	Lynn..........................	25	.10	96	142	262	106	518
K-91......	Jeff Davis..........	19	.04	191	86	473		285
K-92......	Reeves......................	19	.04	190	80	448		286
K-93......	Reeves......................	....	....	189	80	437		284
								Woodbine
K-94......	McLennan.................	....	....	....	....	.....		396
K-95......	McLennan.................	12	....	148	39	1,040		180
K-96......	Hill...........................	7.0	0.04	5.7	2.4	812	10	750
K-97......	Hill...........................	7.0	.06	4.5	2.4	705	11	812
K-98......	Hill...........................	12	.05	3.2	1.5	583	7.6	644
K-99......	Hill...........................	9.8	....	4.4	2.2	660		583
K-100. ...	Navarro....................	....	.12	13	5.4	1,810		1,580
K-101....	Navarro....................	15	.32	9.4	3.0	1,040	11	1,110
K-102....	Navarro....................	14	.03	3.5	1.1	594	10	779
K-103....	Navarro....................	14	.05	6.2	2.4	981	9.2	1,077
K-104....	Ellis..........................	11	.08	3.1	1.7	519	6.6	732
K-105....	Ellis..........................	11	.10	5.0	1.9	645	8.0	730
K-106....	Ellis..........................	11	.31	4.6	2.1	807	9.0	1,005
K-107....	Ellis..........................	10	.06	4.5	2.1	785		974
K-108....	Tarrant......................	24	.00	726	115	214		418
K-109....	Dallas.......................	20	.04	4.1	1.6	394		564
K-110....	Dallas.......................	13	.14	5.0	2.5	613	8.4	698

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
group—Continued										
...	840	190	...	1.5	...	1,830	490	67	...	...
...	700	530	4.4	1.8	...	2,280	98	91	3,760	7.8
...	233	286	4.0	2.2	...	1,220	40	93	2,120	7.6
...	334	246	1.8	5.0	...	1,280	81	90	2,020	7.9
...	1,470	180	...	.2	...	2,940	320	86	4,150	7.8
...	798	295	...	.0	...	2,020	290	82	...	...
...	802	66	3.1	.0	...	1,680	208	83	2,440	7.8
...	2,330	180	...	...	...	4,300	282	91	...	...
...	1,830	242	2.1	1.5	...	3,330	468	81	...	7.6
...	1,090	73	5.0	.2	...	2,160	170	88	...	7.8
...	2,070	76	1.4	1.0	...	3,350	568	76	...	7.8
41	683	40	2.3	4.0	...	1,400	206	80	...	8.2
42	245	110	1.2	.0	...	1,010	54	92	...	8.4
18	112	288	1.7	3.0	...	1,130	22	97	...	8.4
...	88	720	.0	3.0	...	1,630	1,100	28	2,920	7.8
38	91	129	...	3.5	...	1,040	22	98	1,740	8.7
...	371	205	.9	2.0	0.76	1,260	60	94	2,070	8.0
associated limestones										
...	258	212	3.0	0.6	...	1,010	536	41	...	...
...	234	178	...	.5	...	1,020	453	51	...	...
53	784	225	1.0	11	...	1,660	182	85	2,540	9.2
...	625	11	...	.8	...	1,070	879	2	1,410	7.4
...	2,040	1,040	...	2.5	...	4,690	2,690	30	6,060	8.0
...	665	27	...	...	...	1,250	914	12	...	...
...	1,200	1,000	...	...	...	>1,000	...	...	5,060	...
...	349	233	2.6	.0	...	1,130	286	70	...	...
...	324	208	3.2	3.0	...	1,040	439	51	1,740	7.5
...	2,720	3,280	2.8	...	...	9,400	2,080	73	13,400	7.2
...	2,010	1,450	...	1.0	...	5,400	1,530	65	7,840	7.6
...	2,750	3,830	...	...	...	10,200	2,580	69	14,800	6.9
...	93	458	...	2.8	...	1,050	736	25	1,990	7.4
...	384	308	4.4	.5	...	1,520	92	93	2,460	7.7
...	6,300	3,270	...	...	...	14,800	1,070	91	...	...
...	685	222	18	39	...	1,890	824	37	2,680	7.7
...	691	655	...	.6	...	2,310	830	56	...	...
...	651	610	...	.9	...	2,200	803	55	...	...
...	635	608	...	...	...	2,100	800	54	...	...
sand										
...	1,770	760	...	...	...	4,100	305	91	5,930	8.1
...	2,270	198	...	0.0	1.1	3,800	530	81	5,030	...
...	505	460	4.4	2.0	...	2,180	24	98	...	8.0
52	538	199	4.4	4.5	...	1,900	21	98	...	8.2
10	487	166	4.4	1.8	1.5	1,590	14	98	2,440	8.2
...	681	182	3.4	2.2	...	1,830	20	99	2,760	8.3
...	153	1,790	2.5	...	...	4,550	55	99	...	...
10	491	612	2.3	3.2	...	2,740	36	98	4,450	7.5
43	441	131	2.1	4.4	...	1,600	13	98	2,510	7.8
33	172	760	2.4	7.1	...	2,550	26	98	4,220	7.7
18	337	126	3.0	.0	...	1,380	14	98	...	8.4
24	501	195	5.0	8.2	...	1,750	20	98	...	8.4
25	500	285	6.0	.8	...	2,140	20	98	...	8.4
16	488	277	5.6	.5	...	2,060	20	99	...	8.2
...	1,960	258	...	4.5	...	3,510	2,280	17	3,960	6.9
...	307	63	1.4	.0	...	1,060	16	98	...	...
...	498	185	4.0	4.6	3.0	1,680	23	98	3,020	8.0

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Woodbine
K-111	Kaufman	15	0.06	8.5	3.1	1,360	4.0	1,184
K-112	Kaufman	6.0	.02	6.7	2.1	985	3.8	1,076
K-113	Rockwall	....	....	10	4.4	1,530		1,080
K-114	Collin	13	.02	6.0	2.1	758	5.4	803
K-115	Collin	14	.91	14	8.0	1,370	20	701
K-116	Collin	11	.36	8.4	4.5	1,120	6.2	758
K-117	Collin	12	.05	10	4.4	1,030	10	780
K-118	Grayson	17	.14	13	6.6	1,170	13	591
								Blossom
K-119	Red River	15	0.04	5.3	1.0	384	4.8	407
								Nacatoch
K-120	Hunt	16	0.04	4.6	1.4	692		886
K-121	Hunt	10	.06	9.2	2.1	355	12	437
K-122	Hunt	10	.04	40	8.3	405	14	330
K-123	Hopkins	10	....	4.8	1.7	405		513
K-124	Bowie	....	....	2.8	1.2	525		700
K-125	Red River	15	.05	2.8	1.0	413		544
								Wilcox
E-1	Webb	....	....	....	....	....		1,600
E-2	Caldwell	15	0.12	2.2	1.3	525	22	735
E-3	Caldwell	8.0	.09	2.0	1.4	416	5.2	502
E-4	Bastrop	55	.01	382	83	129		276
E-5	Bastrop	20	.07	25	9.1	508	....	659
E-6	Bastrop	....	....	436	144	165		....
E-7	Bastrop	55	....	1,220	423	488		54
E-8	Bastrop	28	....	139	50	198		132
E-9	Brazos	....	....	4	....	459		1,130
E-10	Cherokee	16	.2	1.8	.7	409		892
E-11	Gregg	....	....	15	6	577		281
E-12	Gregg	....	....	....	....	....		598
E-13	Gregg	....	....	....	....	....		586
E-14	Gregg	....	....	4.4	3.9	636		604
E-15	Harrison	....	....	60	11	319		317
E-16	Morris	....	....	134	50	129		12
								Indio
E-17	Dimmit	33	0.10	116	25	291	9.5	502
E-18	Dimmit	19	....	52	34	624		414
E-19	Dimmit	18	....	158	61	964		330
E-20	Zavala	36	....	387	89	604		298
E-21	Medina	16	....	196	80	520		471
E-22	Medina	66	....	213	24	196		410
E-23	Medina	14	....	48	31	991		586
E-24	Medina	42	....	236	11	138		340
E-25	Medina	16	....	52	39	1,020		834

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
sand—Continued										
26	269	1,210	3.7	2.2	....	3,470	34	99	5,970	8.2
24	453	548	4.0	14	....	2,570	25	99	4,210	8.2
....	43	1,730	....	....	....	3,840	43	98	....	....
40	425	378	3.2	5.7	....	2,010	24	98	....	8.2
....	800	1,180	1.6	.5	....	3,750	68	97	....	8.2
68	13	1,270	2.2	10	....	2,850	40	98	....	8.4
51	654	660	2.7	.5	....	2,800	43	98	....	8.3
....	1,400	472	2.6	.8	....	3,380	60	97	....	8.4
sand										
30	201	204	0.4	2.0	....	1,030	17	97	1,790	8.4
sand										
....	2	554	4.8	0.0	....	1,710	18	99	....	8.1
....	354	62	.1	6.2	....	1,030	32	94	1,750	7.6
....	645	65	.0	.0	....	1,350	134	85	2,170	7.4
....	94	265	1.8	5.0	....	1,040	19	98	1,790	8.0
....	4	408	....	1.0	....	1,290	12	99	....	....
....	2	326	.3	.2	....	1,030	11	99	....	....
group										
....	3.9	1,650	....	....	....	>1,000	37	....	6,940	8.1
51	212	222	0.4	1.2	....	1,390	11	97	2,310	8.3
43	227	170	.0	.0	....	1,100	11	98	....	8.4
....	928	272	....	.5	....	1,990	1,290	18	2,590	7.4
29	3.6	450	....	....	....	1,350	101	92	....	8.1
....	1,640	235	....	1.2	....	2,620	1,680	18	....	....
....	967	3,400	....	....	....	6,580	4,780	18	10,900	7.0
....	46	580	....	11	....	1,120	552	44	2,140	7.2
....	11	50	2.2	....	....	1,080	10	....	....	....
58	.0	88	....	....	....	1,470	7.4	99	....	....
....	33	750	....	....	....	1,520	64	95	....	....
....	27	740	.7	....	....	1,780	17	....	....	....
....	23	780	.6	....	....	1,830	23	....	....	....
....	23	630	.5	....	....	1,600	27	98	....	....
....	192	305	.1	....	....	1,040	197	78	....	....
....	584	143	.3	.0	....	1,050	541	34	....	....
formation										
....	385	169	....	0.12	....	1,280	392	82	....	....
....	126	820	....	.0	....	1,880	270	83	3,530	7.8
....	1,750	460	....	.8	....	3,570	646	76	5,030	7.8
....	842	1,080	....	.0	....	3,180	1,330	50	4,860	7.8
....	733	565	....	4.8	....	2,350	818	58	3,610	7.2
....	229	322	....	34	....	1,290	630	40	2,080	8.1
....	393	1,070	....	4.0	....	2,840	248	90	4,830	7.8
....	81	312	....	164	....	1,150	634	32	1,910	7.0
....	15	1,290	....	.0	....	2,840	290	88	5,080	7.6

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Carrizo
E-26......	Webb....................	....	......	....	....	.....		1,559
E-27......	Dimmit..................	26	0.26	350	207	1,610	23	321
E-28......	Dimmit..................	14	.15	68	34	2,630	26	333
E-29......	Dimmit..................	....	......	46	34	714		326
E-30......	Dimmit..................	18	.30	16	6.9	392	25	240
E-31......	La Salle..................	26	.06	2.1	1.0	443		741
E-32......	McMullen...............	36	.06	.6	1.1	591		1,280
E-33......	Atascosa................	30	.19	3.6	.7	244	2.0	504
E-34......	Atascosa................	14	.02	3.1	.8	820		1,402
E-35......	Atascosa................	....	......	297	99	270		170
E-36......	La Salle..................	....	.5	14	4.0	396	.....	714
E-37......	Bexar....................	....	37	....	....	.....		318
E-38......	Wilson....................	31	.3	112	32	151	34	0
E-39......	Caldwell..................	....	......	....	....	.....		....
E-40......	Bastrop..................	10	.21	220	99	1,060		82
E-41......	Bastrop..................	10	......	232	94	189		270
E-42......	Lee........................	12	.01	5.1	2.1	417	9.4	762
E-43......	Angelina.................	....	......	14	7.4	.....		1,024
E-44......	Angelina.................	....	......	11	4.8	.....		432
								Bigford member of the
E-45......	Dimmit..................	....	......	32	15	1,830		384
E-46......	Dimmit..................	12	1.1	385	218	3,390	50	278
								Queen City sand member of
E-47......	Webb....................	....	......	....	....	....		822
E-48......	Atascosa................	10	......	67	37	931		420
E-49......	Wilson....................	16	......	143	58	122	....	194
E-50......	Bastrop..................	106	48	61	27	164	21	....
E-51......	Burleson................	....	.05	3.4	1.2	649		1,445
E-52......	Brazos....................	....	.02	7.0	3.1	669		917
E-53......	Angelina.................	....	......	10	....	....		780
								Mount Selman
E-54......	La Salle..................	37	0.63	3.1	0.7	933	13	1,489
E-55......	Frio.......................	52	.08	176	22	138	12	304
E-56......	Atascosa................	15	......	338	121	1,760		214
E-57......	Atascosa................	14	......	30	15	932		366
E-58......	Atascosa................	14	.08	4.8	1.4	667	4.6	743
E-59......	Atascosa................	12	.04	6.3	1.8	1,220	15	1,600
E-60......	Bastrop..................	....	90	271	3.0	226		70
								Sparta
E-61......	Lee........................	34	......	248	92	350		337
E-62......	Burleson................	16	0.22	129	70	59	....	376
E-63......	Burleson................	....	.02	19	2.3	635		644
E-64......	Angelina.................	....	......	10	2.3	717		226
E-65......	Sabine....................	16	.09	2.0	1.0	514		1,040

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

sand

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
31	7.8	1,260	...	...	...	>1,000	18	...	5,900	8.3
...	1,610	2,350	...	3.0	...	6,400	1,720	67	...	...
...	956	3,460	...	2.3	...	7,430	309	95	...	...
...	402	795	...	.8	...	2,150	255	86	3,730	...
...	212	378	1.0	1.2	...	1,170	68	89	...	7.9
...	104	179	.9	.0	...	1,120	9	99	...	8.4
...	2.6	168	.4	.0	...	1,430	6	100	...	8.2
...	65	44	.6	.0	...	675	12	97	1,010	8.1
48	129	322	3.4	1.8	...	2,010	11	99	3,440	8.3
...	760	570	...	...	...	2,190	1,150	34	...	...
56	110	118	...	...	...	1,150	51	...	...	...
...	...	585	...	...	...	>1,000	1,730	...	3,390	7.3
...	604	180	...	.15	...	1,130	411	24	...	...
...	1,100	700	...	...	...	>1,000	...	...	...	...
...	762	1,700	...	.5	...	3,890	956	71	6,380	7.1
...	858	185	.0	1.5	...	1,700	966	30	2,310	7.8
17	155	94	1.9	.8	...	1,080	21	96	1,720	8.5
66	4	858	...	...	...	2,320	65	97	...	...
...	360	140	...	...	...	1,090	47	95	...	...

Mount Selman formation

...	680	2,190	...	...	...	4,930	142	97	...	...
...	4,070	3,420	...	2.1	...	11,800	1,860	80	...	...

the Mount Selman formation

22	418	1,330	...	...	...	>1,000	20	...	5,890	8.4
...	1,330	435	...	1.8	2.4	2,980	319	86	4,360	...
...	400	202	...	1.0	.64	1,040	596	31	1,640	8.0
...	1,080	370	0.5	5.0	.72	2,050	402	22	2,480	3.7
35	1	144	2.5	.0	...	1,530	13	99	...	...
22	4.1	502	1.1	.0	...	1,650	30	98	...	...
...	1	1,400	...	...	...	>1,000	33	...	...	...

formation

41	192	422	4.4	1.0	...	2,360	10	99	3,660	8.0
...	177	282	...	9	...	1,020	530	36	...	...
...	2,450	1,730	...	2.0	5.3	6,530	1,340	74	9,160	...
...	894	660	...	1.8	2.8	2,690	136	94	4,270	...
29	152	497	1.7	2.0	...	1,710	18	98	3,070	8.2
67	169	850	1.2	1.0	...	3,060	23	98	5,190	8.1
...	621	337	...	...	...	1,890	490	42	...	...

sand

...	557	640	...	0.2	0.70	2,090	998	43	3,390	7.4
...	244	151	0.0	.2	...	1,030	610	17	1,420	7.5
8	98	570	1.4	.0	...	1,720	57	96	...	8.7
...	91	920	...	19	...	>1,000	34	98	...	...
28	3	191	...	.5	...	1,240	9	99	...	...

Table 1.— *Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Upper part of
E-66	Webb	....	0.16	6.5	3.8	1,350		598
E-67	La Salle	11	......	35	11	2,060		439
E-68	La Salle	21	1.8	106	45	430	....	299
E-69	Wilson	....	1.8	8.0	2.0	452		644
E-70	McMullen	122	10	486	211	2,620	123	....
E-71	Burleson	....	.31	69	3.5	587		492
E-72	Burleson	....	.14	62	11	457		370
E-73	Angelina	....	4.9	....	....	....		568
E-74	Angelina	....	20	72	20	473		412
E-75	Jasper	....	......	140	24	2,060		531
E-76	Jasper	....	......	675	66	4,880		217
E-77	Jasper	....	......	3.4	2.4	416		183
								Jackson
E-78	Starr	24	......	702	48	1,990		30
E-79	Starr	18	......	9.5	6.6	1,840		1,614
E-80	Starr	5.6	......	598	165	9,290		93
E-81	Live Oak	....	......	41	5.6	1,200		386
E-82	Walker	46	......	77	7.1	327		164
E-83	Walker	42	......	17	1.8	470		522
E-84	Angelina	....	1.8	49	15	....		444
								Catahoula sandstone, Oakville sandstone,
M-1	Hidalgo	68	......	74	36	993		154
M-2	Hidalgo	....	......	43	27	806		248
M-3	Starr	34	......	491	28	6,160		115
M-4	Starr	24	......	132	27	1,350		167
M-5	Jim Hogg	38	0.17	18	3.7	342	12	198
M-6	Duval	11	.05	52	12	1,650	32	326
M-7	Duval	56	.10	88	24	921	29	353
M-8	Duval	18	.08	52	12	1,660	32	322
M-9	Duval	....	......	....	....	358		243
M-10	Live Oak	30	.56	74	20	300	55	343
M-11	Bee	19	.15	7.1	1.3	514	27	601
M-12	Bee	33	1.9	182	31	166	23	344
M-13	Karnes	46	.18	68	9.4	341	31	428
M-14	Karnes	72	.03	6.7	.6	433	21	313
M-15	De Witt	25	.26	8.8	1.4	408	17	565
M-16	Lavaca	40	......	384	49	248		450
M-17	Walker	72	......	268	32	376		66
M-18	Polk	....	2.7	33	2.7	406		356
M-19	Polk	....	.50	141	13	656		542
								Ogallala
O-1	Midland	58	......	150	48	164		214
O-2	Midland	....	......	100	66	399		218
O-3	Midland	60	0.10	127	79	153	12	235
O-4	Andrews	....	......	164	53	455		192
O-5	Martin	77	......	104	67	237	12	232
O-6	Howard	63	.08	249	94	177	20	260
O-7	Dawson	67	......	142	116	176		316
O-8	Borden	46	......	136	100	144		440
O-9	Borden	50	......	129	57	161		265
O-10	Scurry	9.6	....	7.0	6.3	600		526
O-11	Yoakum	42	.08	114	111	179	34	241

See footnotes at end of table.

measurements of saline ground water in Texas—Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
Claiborne group										
24	1,630	538	......	1.0	......	3,870	32	99	......	......
17	1,830	1,650	1.4	.5	......	5,820	132	97	8,760	8.5
......	589	385	......	.0	2.0	1,720	450	68	2,700	7.7
34	163	202	......	......	......	1,290	28	97	......	......
......	8,680	1,020	......	42	......	>1,000	......	54	13,400	3.3
......	222	585	.5	3.6	......	1,810	187	87	......	7.9
......	284	420	.6	.0	......	1,470	200	83	......	7.5
8	210	250	......	......	......	1,170	18	......	......	......
14	609	375	......	......	......	1,870	262	83	......	......
......	12	3,060	......	......	......	5,450	448	91	......	......
......	9.8	8,700	......	.0	......	15,100	1,960	84	......	......
......	604	41	......	......	......	1,330	18	98	......	......
group										
......	2,600	2,520	......	......	5.1	7,900	1,950	69	10,800	6.5
126	78	1,800	......	0.0	15	4,620	50	99	7,480	8.8
......	2.6	15,800	......	......	13	25,900	2,170	90	38,400	7.1
......	819	1,110	0.2	......	......	3,430	125	95	......	......
......	293	348	......	2.2	......	1,180	221	76	1,850	......
28	1.2	435	......	7.5	......	1,250	50	95	2,170	......
......	460	211	......	......	......	1,460	184	84	......	......
and Lagarto clay, undifferentiated										
23	492	1,300	......	1.5	5.8	3,050	332	87	5,130	......
......	409	950	......	1.5	......	2,360	218	89	4,040	......
......	1,190	9,500	......	......	13	17,500	1,340	91	26,300	7.4
......	384	2,020	......	......	3.6	4,020	440	87	6,920	7.9
......	131	361	0.4	12	......	1,020	60	91	1,740	7.7
......	6.8	2,510	.2	3.2	......	4,440	180	94	8,370	7.4
......	191	1,320	.4	7.0	......	2,810	318	85	5,050	7.4
......	7.8	2,520	.2	2.2	......	4,460	180	94	8,320	7.5
......	54	560	......	29	......	1,220	291	73	......	......
......	316	267	1.4	.0	......	1,230	266	66	1,930	7.4
......	.9	480	1.8	.8	......	1,350	23	95	2,310	7.5
......	81	428	.6	1.2	......	1,120	582	37	1,940	7.2
......	112	365	1.0	5.0	......	1,190	208	75	2,090	7.4
21	109	420	2.2	1.8	......	1,230	19	95	2,170	8.2
......	1.1	334	.4	.2	......	1,070	28	95	1,890	7.8
......	41	910	......	5.5	......	1,900	1,160	32	3,520	7.1
......	996	372	......	3.5	......	2,150	800	51	2,990	......
22	2	470	......	1.0	......	1,100	94	90	2,030	......
18	2	970	......	1.5	......	2,060	406	78	3,680	......
formation										
......	220	365	......	12	......	1,120	572	38	1,900	7.8
......	824	240	......	17	......	1,750	521	62	......	......
......	378	273	2.7	16	......	1,220	642	34	......	7.2
16	587	375	......	7.0	......	1,740	628	61	2,460	......
......	322	378	2.8	6.0	0.81	1,320	535	48	2,130	8.2
......	335	590	1.4	26	......	1,680	1,010	27	2,790	7.2
......	254	472	2.8	23	......	1,410	832	32	2,350	8.2
......	181	238	......	222	......	1,280	750	29	2,050	......
......	260	282	......	28	......	1,100	556	39	1,790	......
28	305	407	......	2.8	......	1,610	44	97	2,770	......
......	779	102	5.5	8.0	......	1,490	741	33	2,160	7.7

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Ogallala
O-12	Gaines	....	....	164	193	420		336
O-13	Terry	....	....	75	95	186		288
O-14	Terry	....	....	70	101	198		270
O-15	Lynn	60	....	98	104	222		314
O-16	Lynn	8	....	69	52	1,590		314
O-17	Lynn	65	....	118	142	288		178
O-18	Lynn	52	....	194	165	595		272
O-19	Lynn	26	....	727	1,520	3,090		276
O-20	Hockley	62	0.08	104	107	83	18	337
O-21	Lubbock	....	....	78	96	164		386
O-22	Lubbock	....	....	76	94	166		345
O-23	Lamb	60	....	216	211	755		326
O-24	Lamb	60	....	251	246	742		410
O-25	Lamb	70	....	552	466	884		236
O-26	Donley	34	....	446	64	42		43
O-27	Donley	44	....	588	61	74		99
O-28	Oldham	17	....	4	4	371		509
O-29	Gray	11	.08	72	31	278	12	228
								Goliad sand, Willis sand and
O-30	Cameron	44	....	104	109	1,140	....	447
O-31	Cameron	32	....	135	81	1,230	....	309
O-32	Cameron	32	....	43	42	1,080	....	574
O-33	Willacy	....	....	106	28	1,070		103
O-34	Willacy	16	0.01	26	8.4	771	4.3	166
O-35	Hidalgo	32	.01	187	67	376	8.3	216
O-36	Hidalgo	18	.00	82	41	543	8.0	258
O-37	Hidalgo	20	.01	78	33	610	6.9	284
O-38	Hidalgo	29	.00	82	46	796	9.0	360
O-39	Hidalgo	24	.00	97	48	657	11	378
O-40	Starr	96	....	292	49	2,080		236
O-41	Starr	26	....	74	7.9	2,640		311
O-42	Jim Hogg	....	....	4	....	585		428
O-43	Kenedy	....	....	17	7.5	467		156
O-44	Kleberg	16	.08	33	11	358		267
O-45	Webb	....	....	....	....	.....		167
O-46	Duval	25	.54	92	48	278	8.5	274
O-47	Duval	29	.02	41	17	364	12	297
O-48	Jim Wells	18	.03	30	17	317	10	358
O-49	Jim Wells	....	....	26	16	451		268
O-50	Jim Wells	20	3.2	70	27	297		389
O-51	Nueces	30	....	33	12	461		395
O-52	San Patricio	13	.28	27	8.7	347	9.9	337
O-53	San Patricio	10	.11	13	2.5	804	14	363
O-54	San Patricio	8.0	.08	18	3.9	992	16	411
O-55	Live Oak	20	....	21	9.1	484		292
O-56	Brazoria	....	....	....	....	920		376
O-57	Galveston	14	....	26	13	750		307
O-58	Harris	18	.02	6.0	2.1	436	1.7	643
O-59	Harris	12	.58	15	6.4	931		706
O-60	Liberty	29	....	85	15	332		264
O-61	Liberty	....	.40	26	3.3	423		240
O-62	Jefferson	21	.46	64	30	1,660		286
O-63	Orange	24	.12	16	4.8	506		436
O-64	Hardin	16	.03	....	....	396		511

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

formation—Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
...	931	615	...	...	...	2,490	1,200	43	...	...
...	373	254	0.0	...	...	1,120	578	41	...	...
17	301	320	...	24	...	1,160	590	42	...	...
...	418	320	...	13	...	1,390	672	42	2,210	8.0
...	667	2,050	...	1.2	...	4,590	386	90	7,780	7.8
...	543	555	...	15	1.3	1,820	878	42	3,040	7.9
...	1,560	400	...	56	...	3,160	1,160	53	4,170	7.2
...	5,970	5,920	...	...	...	17,400	8,060	45	21,600	7.6
...	360	166	2.8	12	...	1,080	700	20	1,770	7.2
...	398	151	...	3.2	...	1,080	589	38	...	...
...	421	146	3.2	1.5	...	1,080	576	38	...	...
...	1,670	732	3.2	1.5	...	3,810	1,410	54	5,260	8.0
...	1,780	748	2.4	.5	.85	4,030	1,640	50	5,440	8.0
...	3,020	1,310	4.4	23	3.4	6,450	3,290	37	8,030	7.5
...	1,340	25	1.2	2.0	...	1,980	1,380	6	2,180	7.8
...	1,600	94	...	1.5	...	2,510	1,720	9	2,650	7.7
47	280	60	...	3.2	...	1,010	26	97	1,550	...
...	281	312	1.2	6.0	...	1,120	307	65	1,890	7.8

Lissie formation, undifferentiated

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
22	1,060	1,200	0.6	15	5.8	3,910	708	78	6,090	8.5
...	975	1,450	.8	.5	5.4	4,060	670	80	6,380	7.4
...	757	940	2.8	.2	2.4	3,180	280	89	5,050	7.6
13	1,580	685	...	.4	...	3,530	380	86	...	...
...	830	570	2.4	.0	5.8	2,320	100	94	3,650	7.9
...	570	565	.5	.2	.93	1,910	742	52	3,040	7.4
...	579	542	.7	.2	3.2	1,940	373	76	3,160	7.8
...	663	530	1.1	.2	4.4	2,090	330	80	3,310	8.1
...	672	820	1.8	.2	4.4	2,640	394	81	4,250	7.7
...	459	780	1.4	1.0	2.9	2,270	440	76	3,780	7.9
...	1,640	2,520	.8	...	6.7	6,810	930	83	10,100	7.9
...	885	3,390	...	...	14	7,190	217	96	11,400	7.5
...	314	420	5.0	.46	...	1,480	12	...	...	...
...	513	302	...	.5	...	1,340	73	93	...	...
...	270	278	.2	16	...	1,110	128	86	...	8.3
...	...	950	...	...	...	>1,000	952	...	4,200	7.8
...	75	515	...	7.5	...	1,180	427	58	...	...
...	231	338	.8	20	...	1,200	172	81	2,060	7.8
...	128	289	1.2	12	...	1,020	145	81	...	7.8
...	180	495	...	8.0	...	1,320	131	88	...	...
...	124	332	1.2	16	...	1,080	286	69	1,850	7.6
...	249	390	...	2.2	2.4	1,370	132	88	2,300	7.6
14	43	378	1.0	2.8	...	1,000	116	87	1,770	...
11	.4	1,060	1.2	3.2	...	2,090	61	97	3,830	...
9	.2	1,340	1.4	.0	...	2,590	82	96	4,740	...
...	2.3	638	...	.5	...	1,320	90	92	2,530	8.4
...	2	1,350	...	...	...	2,480	214	...	...	...
...	1	1,060	.6	1.0	...	2,020	118	93	3,680	8.2
25	.7	305	4.8	.2	.25	1,100	24	97	1,950	8.6
43	.8	1,040	2.2	1.2	...	2,380	64	97	5,540	...
...	3.5	550	...	.0	...	1,140	294	73	2,130	...
...	12	560	...	.8	...	1,140	78	92	...	...
...	2	2,590	.2	...	...	4,510	283	93	...	...
...	2	565	1.0	.0	...	1,350	60	95	...	...
...	5	330	3.6	.2	...	1,180	37	96	1,790	7.8

Table 1.— *Chemical analyses and related physical*

Well or spring no	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
						Beaumont clay and		
B-1	Cameron	36	......	122	91	1,310		533
B-2	Kleberg	......	......	569	400	2,020		308
B-3	San Patricio	55	0.16	119	50	829	21	494
B-4	San Patricio	16	.05	21	8.4	531	7.7	380
B-5	San Patricio	16	.02	17	7.6	490	8.8	416
B-6	Aransas	15	......	9.1	9.5	501		516
B-7	Calhoun	17	.08	45	35	837		506
B-7[b]	Calhoun	15	.06	.0	.0	53		26
B-8	Calhoun	......	......	180	70	514		276
B-9	Matagorda	12	.07	11	8.0	519		829
B-10	Matagorda	......	......	12	4.5	535		364
B-11	Brazoria	......	......	......	......	....		274
B-12	Brazoria	......	.50	14	5.5	527		732
B-13	Galveston	34	......	42	15	636	.....	347
B-14	Galveston	29	......	46	16	578		340
B-15	Galveston	35	......	87	53	2 130		330
B-16	Galveston	......	......	61	36	321	.....	616
B-17	Galveston	13	......	47	48	837	.....	542
B-18	Chambers	20	.06	34	10	397		730
B-19	Chambers	16	......	23	11	650		536
B-20	Chambers	17	......	45	19	734		454
B-21	Chambers	16	......	14	4.4	403		571
B-22	Jefferson	......	......	65	9.5	644		342
B-23[c]	Orange	......	......	22	9.2	692		267
B-23[c]	Orange	......	......	27	10	820		272
B-23[c]	Orange	......	......	66	27	1,310		300
				Alluvium				
R-1	El Paso	14	0.06	62	14	501	13	151
R-2[c]	El Paso	4.3	.03	81	26	256	12	77
R-2[c]	El Paso	14	.01	122	26	357	8.3	64
R-2[c]	El Paso	12	.02	370	62	1,940		54
R-2[c]	El Paso	6.8	.02	684	111	3,540		53
R-3	Hudspeth	20	.25	68	19	496	22	340
R-4	Culberson	20	......	240	218	530		142
R-5	Culberson	20	.04	83	55	253	.....	274
R-6	Culberson	......	......	600	192	66		161
R-7	Reeves	32	......	614	232	1,180		195
R-8	Reeves	43	......	856	190	738		152
R-9	Ward	14		763	204	1,090	16	116
R-10	Ward	......	......	352	144	762		179
R-11	Loving	......	......	637	248	369		68
R-12	Mitchell	......	......	198	54	100		336
R-13	Jones	20	.00	38	36	351	2.3	444
R-14	Haskell	......	......	131	41	250		286
R-15	Haskell	21	.02	151	92	221	10	399
R-16	Knox	26	.02	113	60	294	10	394
R-17	Knox	21	.12	112	99	372	15	481
R-18	Knox	......	......	135	55	187		272
R-19	Baylor	15	.05	69	54	231		433
R-20	Wilbarger	......	......	90	105	526		566
R-21	Wilbarger	30	......	332	73	666	.....	176
R-22	Cottle	20	.05	530	140	398	10	243
R-23	Childress	21	.05	184	39	164	6.2	173
R-24	Cameron	50	......	110	45	178	.....	304
R-25	Cameron	44	......	116	40	200	.....	292
R-26	Cameron	40	......	350	156	731	.....	400
R-27	Hidalgo	24	.03	88	38	350	8.5	302
R-28	Hidalgo	30	.00	49	24	364	4.9	376

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
"Alta Loma" sand										
....	1,240	1,280	....	0.0	3.8	4,340	678	81	6,680	7.2
....	627	4,640	....	....	....	8,410	3,060	59	....	....
16	58	1,310	0.8	2.8	....	2,700	530	77	4,720	7.7
14	113	570	1.8	2.8	....	1,470	97	92	2,520	7.7
21	66	508	1.8	2.2	....	1,330	85	93	2,310	7.8
....	28	495	....	.8	....	1,310	62	95	2,360	8.2
....	75	1,120	.7	2.0	....	2,380	256	88	4,200	7.8
....	1.1	65	.5	.0	....	151	0	100	264	7.2
....	19	1,140	....	.5	....	2,060	737	60	3,910	....
....	3	358	.6	.0	....	1,320	60	95	....	....
26	2	630	....	.8	....	1,380	48	96	2,540	....
....	2	1,620	....	....	....	2,820	....	....	....	....
....	25	410	....	.0	....	1,340	58	95	....	....
....	2.9	875	.4	1.0	....	1,780	166	89	3,330	8.0
....	2	820	.4	.2	....	1,660	181	87	2,960	7.9
....	.0	3,400	....	....	....	5,870	435	91	10,500	7.5
....	....	351	....	....	....	1,070	303	70	....	....
....	57	1,160	....	1.0	....	2,430	315	85	4,370	8.2
....	.2	275	.5	.0	....	1,100	126	87	....	8.2
....	.6	762	....	.0	....	1,730	102	93	3,170	....
....	3.5	1,000	....	.8	....	2,040	190	89	3,840	....
....	68	275	....	1.8	....	1,060	53	94	1,830	8.3
....	2	935	....	....	....	1,820	201	87	....	....
14	2	965	....	2.8	....	1,830	93	94	....	....
16	2	1,170	....	2.5	....	2,170	108	94	....	....
9	2	2,030	....	2.2	....	3,590	276	91	....	....
Alluvium										
....	195	708	0.9	0.0	0.29	1,580	212	83	2,870	7.4
....	316	355	.3	3.0	.25	1,090	309	63	1,900	6.9
....	569	405	.3	.0	.32	1,530	412	65	2,460	7.1
....	1,110	2,980	.3	....	....	6,500	1,180	78	10,500	7.3
....	1,990	5,490	.3	....	....	11,800	2,160	78	18,200	7.1
....	373	468	5.3	16	....	1,660	248	80	....	7.8
....	1,280	810	....	23	.60	3,190	1,500	44	4,410	7.5
....	311	308	....	4.5	.34	1,170	433	56	1,970	7.3
....	2,080	90	....	3.5	....	3,440	....	6	3,390	....
....	2,210	1,840	....	6.5	.88	6,210	2,490	51	8,370	7.2
....	1,910	1,510	....	468	1.6	5,840	2,920	37	7,560	7.1
....	2,250	1,920	....	.4	....	6,320	2,740	47	....	....
....	823	1,500	....	.5	....	3,670	1,470	53	....	....
....	2,030	880	—	1.2	....	4,200	2,610	25	5,430	....
....	543	65	....	.5	....	1,240	716	23	....	....
....	235	240	.8	95	2.0	1,240	243	76	2,050	7.9
....	286	320	....	70	....	1,240	496	52	....	....
....	251	365	1.2	177	....	1,490	756	38	2,290	7.6
16	386	296	1.5	26	....	1,410	528	54	....	7.9
....	469	340	1.9	183	....	1,850	686	53	2,660	7.6
24	315	251	....	54	....	1,140	563	42	....	....
....	207	75	1.2	270	....	1,140	394	56	1,790	8.0
....	418	610	....	50	....	2,080	656	64	....	....
....	45	1,680	....	22	....	2,940	1,130	56	5,530	7.5
....	1,350	830	.2	1.8	....	3,400	1,900	31	4,870	7.9
....	409	292	.6	3.0	....	1,200	620	36	1,890	7.3
....	280	208	2.0	.5	.57	1,020	460	46	1,640	7.6
....	267	250	2.0	2.0	.44	1,070	454	49	1,720	7.4
....	757	1,420	....	5.6	1.2	3,660	1,520	51	5,700	7.7
....	332	385	.9	.2	1.5	1,380	376	66	2,300	7.5
....	347	242	1.8	1.0	1.5	1,250	221	78	2,030	7.8

Table 1.—*Chemical analyses and related physical*

Well or spring no	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
				Alluvium				
R-29......	Hidalgo..................	20	0.04	32	13	367	5.2	372
R-30......	Hidalgo..................	23	.02	106	4.5	656	9.0	264
R-31......	Hidalgo..................	21	.04	88	44	756	11	286
R-32......	Hidalgo..................	26	.02	117	47	319	8.8	259
R-33......	Starr.....................	10	....	102	31	1,440		188

[a]Includes 5 ppm hydroxide (OH).
[b]Demineralized.
[c]Drill-stem test.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
Alluvium										
....	296	238	1.5	0.0	3.3	1,160	134	85	1,930	7.8
....	742	630	.9	1.0	3.2	2,350	450	76	3,710	7.5
....	461	950	.9	3.0	3.7	2,480	400	80	4,160	7.5
....	310	468	.6	.2	1.2	1,420	486	58	2,430	7.4
....	1,420	1,330	....	4.0	4.2	4,430	382	89	6,640	7.9

Table 2.—*Records of saline*

[Use of water: D, domestic; S, stock; Ind, industrial;

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
CO-1....	Eden..........................	Concho.........	4,150	8$\frac{5}{8}$, 5$\frac{1}{2}$	Hickory sandstone member
CO-2....	4 mi. SW from San Saba....	San Saba.......	560	....	Ellenburger group
CO-3....	19 mi. NW from Ozona......	Crockett........	6,235	....	.....do.............
CO-4....	4 mi. SW from Stiles........	Reagan.........	9,172	....	.....do.............
CO-5....	23 mi. SW from Odessa.....	Ector............	10,725	....	.....do.............
CO-6....	28 mi. NW from Odessa.....	.....do..........	8,605	....	.....do.............
CO-7....	16 mi. SW from Andrews...	Andrews........	8,948	....	.....do.............
CO-8....	30 mi. SW from Andrews...	.....do..........	10,014	....	.....do.............
CO-9....	28 mi. W from Andrews...	.....do..........	10,531	....	.....do.............
CO-10..	12 mi. SE from Snyder......	Scurry...........	1,610	....	.....do.............
C-1......	9 mi. N from Brady..........	McCulloch.....	2,150	....	Pennsylvanian undifferentiated
C-2......	20 mi. NE from Brady.......	.....do..........	1,500	....	.....do.............
C-3......	2 mi. SW from Bridgeport..	Wise............	58	....	.....do.............
C-4......	19 mi. NW from Weatherford	Parker..........	432	5	.....do.............
C-5......	Mineral Wells................	Palo Pinto......	202	....	.....do.............
C-6......	12 mi. SW from Weatherford	Parker..........	103	4	.....do.............
C-7......	12 mi. W from Weatherford	.....do..........	100	6	.....do.............
C-8......	5 mi. N from Lampasas.....	Lampasas.......	1,091	....	.....do.............
C-9......	16 mi. SE from Archer City	Archer..........	300	....	.....do.............
C-10....	Nocona.......................	Montague......	795	8$\frac{1}{4}$	.....do.............
C-11....	......do.......................	.....do..........	780	8$\frac{5}{8}$	.....do.............
C-12....	3$\frac{1}{2}$ mi. NW from Brady......	McCulloch.....	900	....	.....do.............
C-13....	3$\frac{1}{2}$ mi. NE from Cisco.......	Eastland........	317	....	.....do.............
C-14....	2$\frac{1}{2}$ mi. NE from Marble Falls	Burnet..........	342	6	.....do.............
P-1......	1 mi. E from Dell City.....	Hudspeth.......	187	18	Bone Spring limestone
P-2......	2 mi. N from Dell City....	.....do..........	250	20	.....do.............
P-3......	1 mi. W from Dell City....	.....do..........	187	16	.....do.............
P-4......	2 mi. NW from Dell City..	.....do..........	390	18	.....do.............
P-5......	Near Rustler Spring..........	Culberson......	2,400	....	Delaware Mountain group
P-6......	8 mi. SE from Pecos.........	Reeves..........	5,100	....	.....do.............
P-7......	26 mi. NW from Mentone..	Loving..........	3,414	....	.....do.............
P-8......	2 mi. S from San Angelo...	Tom Green.....	135	....	Clear Fork group
P-9......	15 mi. E from San Angelo...	.....do..........	102.5	6	.....do.............
P-10....	14 mi. NE from San Angelo	.....do..........	218	12	.....do.............
P-11....	......do.......................	.....do..........	180	12	.....do.............
P-12....	Miles..........................	Runnels.........	120	8	.....do.............
P-13....	Merkel........................	Taylor..........	100	....	.....do.............
P-14....	......do.......................	.....do..........	60	5	.....do.............
P-15....	Anson.........................	Jones...........	85	11	.....do.............
P-16....	7 mi. SE from Stamford....	.....do..........	70	6	.....do.............
P-17....	9 mi. W from Stamford.....	.....do..........	50	6	.....do.............
P-18....	2 mi. NW from Anson.......	.....do..........	80	6	.....do.............
P-19....	5 mi. N from Anson.........	.....do..........	60	....	.....do.............
P-20....	......do.......................	.....do..........	65	....	.....do.............

water wells and springs in Texas

Irr, irrigation; P, public supply; N, none]

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
380	Sept. 5, 1945	...	130	P	Mar. 16, 1952	127	
...	...	...	11	...	May 19, 1952	...	
...	...	...	...	...	June 11, 1953	...	Todd oilfield.
...	...	...	...	...	Nov. 1, 1942	...	
...	...	...	...	...	Aug. 1953	...	Yarbrough and Allen oilfield
...	...	...	...	...	June 9, 1953	...	Andector oilfield
...	...	...	...	...	June 10, 1953	...	Martin oilfield
...	...	...	...	...	Aug. 1953	...	Dollarhide oilfield
...	...	...	...	...	June 10, 1953	...	Nelson oilfield
...	...	...	...	...	June 12, 1953	...	Buffalo Creek oilfield
...	...	...	...	...	July 26, 1951	...	
...	...	...	...	...	do.	...	
...	...	...	...	...	Feb. 20, 1942	...	
131.1	Jan. 24, 1950	...	...	S	Jan. 24, 1950	...	
199	Mar. 1931	...	1/10	P	Mar. 9, 1931	71	
17.8	Feb. 21, 1950	...	...	S	Feb. 21, 1950	...	
40	1946	...	...	D	Jan. 27, 1950	...	
...	...	...	...	...	Aug. 9, 1943	...	
...	...	...	...	...	Feb. 1948	...	
...	...	...	10	Ind	Nov. 9, 1944	...	
206.08	Nov. 8, 1944	...	32	P	July 8, 1944	...	
...	...	...	...	...	...	...	
111	Sept. 1951	...	20	S, Irr	Sept. 25, 1951	...	
...	...	...	...	S	June 7, 1949	...	
47.7	Feb. 3, 1949	...	2,200	Irr	Aug. 5, 1948	...	
87.9	do.	...	1,800	Irr	Aug. 6, 1948	...	
128.0	Nov. 11, 1948	...	...	Irr	Aug. 9, 1949	...	
118.5	Feb. 3, 1949	...	...	N	Mar. 11, 1948	...	
...	...	400	...	...	...	...	
...	...	...	...	N	May 5, 1942	...	
...	...	...	...	N	June 14, 1940	...	
69.9	Oct. 11, 1948	...	...	S	Oct. 11, 1948	...	
37.9	Nov. 3, 1948	...	1.5	S	Jan. 20, 1949	...	
98.3	Feb. 24, 1950	...	642	Irr	Aug. 1, 1950	70	
67.1	Jan. 3, 1951	...	963	Irr	Apr. 19, 1951	70	
30	...	...	...	P	Apr. 18, 1946	...	
...	...	...	...	P	do.	...	
...	...	...	125	P	Apr. 19, 1946	...	
...	...	...	60	P	June 16, 1953	...	
59	July 7, 1953	...	...	D	July 7, 1953	...	
20	July 11, 1953	...	...	D, S	July 11, 1953	...	
...	...	...	35	Ind	July 30, 1953	69	
22	July 15, 1953	...	...	D, S	July 15, 1953	...	
...	...	...	...	...	...	...	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
P-21	9 mi. W from Stamford	Jones	50		Clear Fork group
P-22	1 mi. SW from Benjamin	Knox	19	24	do
P-23	2 mi. SW from Seymour	Baylor			do
P-24	Seymour	do	33		do
P-25	7 mi. SW from San Angelo	Tom Green	122		San Angelo sandstone
P-26	Robert Lee	Coke			do
P-27	7 mi. N from Bronte	do	60		do
P-28	Blackwell	Nolan	284		do
P-29	15 mi. NW from Anson	Jones	160		do
P-30	21 mi. SW from Anson	do	90	6	do
P-31	14 mi. W from Anson	do	190	6	do
P-32	9 mi. E from Aspermont	Stonewall	32	36	do
P-33	7 mi. E from Aspermont	do	165	$5\frac{1}{4}$	do
P-34	4 mi. W from Crowell	Foard	34		do
P-35	8 mi. SW from Chillicothe	Hardeman	116	6	do
P-36	8 mi. SE from Quanah	do	125	6	do
P-37	12 mi. S from Quanah	do	Spring		do
P-38	13 mi. S from Quanah	do	Spring		do
P-39	19 mi. NW from Anson	Jones		6	Blaine gypsum
P-40	3 mi. SW from Roby	Fisher	100	4	do
P-41	11 mi. NW from Aspermont	Stonewall	165		do
P-42	Paducah	Cottle	127	7	do
P-43	6 mi. NW from Quanah	Hardeman	165	6	do
P-44	15 mi. NW from Quanah	do	230	6	do
P-45	9 mi. NW from Quanah	do	146		do
P-46	9 mi. W from Quanah	do	103		do
P-47	4 mi. S from Arlie	Childress	150	14	do
P-48	1 mi. SE from Arlie	do	176	16	do
P-49	5 mi. SW from Arlie	do	200+		do
P-50	3 mi. SW from Arlie	do	177	16	do
P-51	6 mi. S from Arlie	do	100	16	do
P-52	7 mi. E from Childress	do	270	16	do
P-53	13 mi. SW from Childress	do	278	16	do
P-54	11 mi. SE from Childress	do	168	16	do
P-55	12 mi. NE from Wellington	Collingsworth	Spring		do
P-56	9 mi. N from Wellington	do	Spring		do
P-57	12 mi. W from Orla	Culberson	Spring		Rustler limestone
P-58	14 mi. SE from Orla	do	Spring		do
P-59	6 mi. NW from Kent	do	451		do
P-60	7 mi. SE from Pecos	Reeves			do
P-61	9 mi. SW from Pecos	do	195		do
P-62	16 mi. E from Saragosa	do	1,525	12	do
P-63	do	do	1,405	12	do
P-64	10 mi. SE from Pecos	do			do
P-65	Monahans	Ward	965		do
P-66	Grandfalls	Crane	461	4	do
P-67	27 mi. NW from Ft. Stockton	Pecos	5,326	14	do
P-68	30 mi. NE from Ft. Stockton	do	430	7, $5\frac{3}{16}$, 4	do
P-69	26 mi. NE from Ft. Stockton	do	1,415	5	do
P-70	9 mi. SW from Ft. Stockton	do	1,373	$8\frac{1}{4}$	do
P-71	do	do	1,550	10	do
P-72	15 mi. S from Gail	Borden	585	6	Quartermaster formation
P-73	15 mi. W from Roby	Fisher	100+	6	do
P-74	7 mi. N from Roby	do	87	$4\frac{1}{2}$	do
P-75	8 mi. NW from Swenson	Stonewall	Spring		do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
...	...	...	...	...	...	...	
...	...	...	...	...	Oct. 11, 1945	...	
21	Mar. 14, 1950	...	...	...	Mar. 14, 1950	...	
17	Oct. 1943	...	...	...	Oct. 1943	...	
71	Oct. 8, 1948	...	...	...	Oct. 8, 1948	...	
...	...	...	...	...	Feb. 3, 1948	...	James oilfield
...	...	...	...	...	Mar. 24, 1948	...	
173.0	Mar. 25, 1948	...	...	D	Mar. 25, 1948	...	
...	...	...	...	...	...	...	
17.68	July 30, 1953	...	...	D, S	July 30, 1953	...	
21.34	do	...	...	D, S	do	...	
...	...	...	...	S	Oct. 30, 1945	...	
...	...	...	...	S	do	...	
30	Feb. 7, 1941	...	...	N	Feb. 7, 1941	...	
...	...	...	...	S	Jan. 9, 1936	...	
...	...	...	...	S	do	...	
...	...	...	...	D, S	Jan. 4, 1936	...	
...	...	...	...	D, S	do	...	
...	...	...	...	S	July 30, 1953	70.5	
...	...	...	...	S	Nov. 25, 1943	...	
...	...	...	...	...	Aug. 3, 1950	77	
32.33	Oct. 25, 1945	...	150	P	Oct. 25, 1945	70	
100	Mar. 1936	...	6	S	Mar. 5, 1936	...	
...	...	...	...	S	Jan. 28, 1936	...	
...	...	...	...	Irr	Aug. 10, 1953	...	
...	...	...	900	Irr	Mar. 24, 1953	...	
27.15	Sept. 26, 1953	...	1,400+	Irr	Sept. 26, 1953	...	
...	...	...	1,050	Irr	Sept. 30, 1953	66	
93.19	Sept. 26, 1953	...	1,000	Irr	Sept. 1953	...	
74.25	do	...	1,300	Irr	Sept. 26, 1953	...	
49.15	do	...	1,800	Irr	do	...	
75	Feb. 1953	...	1,100	Irr	Sept. 24, 1953	65	
55.9	Sept. 25, 1953	...	178	Irr	Sept. 25, 1953	...	
77.99	Jan. 8, 1954	...	400	Irr	do	66	
...	...	1,350	...	D	Sept. 7, 1952	...	
...	...	...	...	S, Irr	Aug. 25, 1953	...	
...	...	...	...	...	Apr. 19, 1940	...	
...	...	...	...	...	May 16, 1940	...	
...	...	...	...	...	May 30, 1949	...	
...	...	...	...	...	June 13, 1949	...	
...	...	...	...	Irr	Sept. 15, 1941	...	
...	...	...	...	Irr	Jan. 17, 1940	...	
...	...	...	...	Irr	Aug. 21, 1940	...	
...	...	...	...	Irr	Aug. 25, 1939	...	
31.6	Mar. 1951	...	600	Irr	Mar. 30, 1951	74	
+2.5	1941	...	...	Ind	Apr. 2, 1941	...	
3.1	Nov. 27, 1946	1,933	...	S	Sept. 6, 1940	...	
...	...	...	...	Irr	Oct. 24, 1946	...	
...	...	...	...	S	Sept. 28, 1940	...	
...	...	...	...	Irr	Apr. 3, 1944	...	
...	...	...	...	Irr	Apr. 11, 1946	...	
231.7	June 10, 1948	...	...	S	June 17, 1948	...	
...	...	...	...	D, S	Dec. 20, 1943	...	
72.5	Dec. 16, 1943	...	...	S	Dec. 16, 1943	...	
...	...	...	...	...	Aug. 3, 1950	75	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
P-76	8 mi. NW from Swensen	Stonewall	Spring		Quartermaster formation
P-77	9 mi. SW from Dickens	Dickens	57	6	do
P-78	2 mi. S from Matador	Motley	80		do
P-79	2 mi. NW from Matador	do	200		do
P-80	2 mi. E from Matador	do	76		do
P-81	2 mi. E from Estelline	Hall	Spring		do
P-82	2 mi. W from Plaska	do	55		do
P-83	2 mi. E of Brice	do	70	16	do
Tr-1	24 mi. SW from Odessa	Ector	650		Dockum group
Tr-2	21 mi. SW from Odessa	do	640	6	do
Tr-3	17 mi. SW from Odessa	do	700	6	do
Tr-4	12 mi. NW from Colorado City	Mitchell	117		do
Tr-5	6 mi. SE from Colorado City	do	261	5	do
Tr-6	8 mi. NW from Colorado City	do	160		do
Tr-7	18 mi. NW from Colorado City	do	170		do
Tr-8	16 mi. NW from Colorado City	do	243		do
Tr-9	9 mi. SW from Ira	Scurry	142	6	do
Tr-10	1 mi. W from Ira	do	120	6	do
Tr-11	4 mi. SE from Ira	do	111		do
Tr-12	5 mi. NE from Tahoka	Lynn	200	6	do
Tr-13	12 mi. SW from Floydada	Floyd	825		do
Tr-14	19 mi. SW from Gail	Borden	63	6	do
Tr-15	13 mi. NE from Gail	do	62	6	do
Tr-16	Gail	do	63	36	do
Tr-17	16 mi. NW from Colorado City	Mitchell	320		do
Tr-18	7 mi. S from Gail	Borden	335	7	do
Tr-19	16 mi. SE from Gail	do	119		do
Tr-20	Tascosa	Oldham	250	8	do
Tr-21	2 mi. NW from Lubbock	Lubbock	999		do
K-1	21 mi. NW from New Braunfels	Comal	280	6	Travis Peak formation
K-2	12 mi. NW from New Braunfels	do	300	6	do
K-3	5 mi. SW from Austin	Travis	977	6	do
K-4	15 mi. NW from Austin	do	422	6	do
K-5	10 mi. N from Austin	do	968	5	do
K-6	4 mi. N from Lampasas	Lampasas	280		do
K-7	4 mi. NE from Killeen	Bell	913		do
K-8	Temple	do	2,000		do
K-9	Lott	Falls	3,305		do
K-10	18 mi. NW from Fort Worth	Tarrant	330		do
K-11	4 mi. SW from Dallas	Dallas	2,921	18, 8	do
K-12	7 mi. E from Dallas	do	3,368		do
K-13	Dallas	do	2,700	26, 10	do
K-14	do	do	2,634	18, 6 5/8	do
K-15	24 mi. NE from Hondo	Medina	671	7	Glen Rose limestone
K-16	18 mi. NE from Hondo	do	495	7	do
K-17	28 mi. NW from Hondo	do	220	6	do
K-18	17 mi. N from Hondo	do	585	8	do
K-19	20 mi. NW from Hondo	do	200	7	do
K-20	18 mi. NW from Hondo	do	460	6	do
K-21	10 mi. N from San Antonio	Bexar	462	4	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
...	...	...	...	...	Aug. 3, 1950	75	
...	...	...	...	...	Feb. 18, 1946	63	
...	...	...	...	...	Nov. 7, 1939	...	
...	...	...	3	...	Nov. 8, 1939	...	
...	...	...	2	...	Nov. 7, 1939	...	
...	...	600	...	...	May 1943	68	
21.95	Nov. 29, 1949	...	150	Irr	Nov. 29, 1949	66	
...	...	...	600	Irr	July 19, 1949	...	
...	...	...	...	N	Sept. 29, 1948	...	
...	...	...	...	S	Oct. 12, 1948	...	
...	...	...	...	S	do.	...	
...	...	...	...	...	May 18, 1948	...	
...	...	...	300	Irr	May 7, 1953	...	
...	...	...	...	...	May 20, 1948	...	
...	...	...	...	...	May 7, 1948	...	
...	...	...	...	...	July 20, 1948	...	
62.02	May 7, 1948	...	...	S	May 7, 1948	...	
...	...	...	...	S	May 12, 1948	...	
102.37	May 12, 1948	...	...	S	do.	...	
30.4	Aug. 17, 1949	...	...	S	Aug. 17, 1949	...	
265	Sept. 29, 1952	...	150	N	Sept. 29, 1952	68+	
56	June 6, 1948	...	...	D, S	June 6, 1948	...	
47	Aug. 25 1948	...	...	D, S	Aug. 25, 1948	...	
40.4	do.	...	...	S	do.	...	
...	...	...	...	...	July 20, 1948	...	
134.6	Sept. 16, 1948	...	...	Ind	Sept. 16, 1948	...	
79.0	June 10, 1948	...	...	N	Sept. 15, 1948	73.5	
...	...	...	30	...	Jan. 20, 1948	...	
...	...	...	...	...	Feb. 1949	...	
113.5	Dec. 10, 1936	...	...	S	Dec. 10, 1936	...	
32.3	Nov. 4, 1936	...	2	D, S	Nov. 4, 1936	...	
...	...	...	14	D	Feb. 24, 1939	...	
342	1938	...	5	...	Nov. 9, 1938	...	
126	1950	...	...	D	Dec. 18, 1950	...	
...	...	...	...	...	Aug. 3, 1943	...	
...	...	...	50	...	...	...	
...	...	...	...	...	Jan. 3, 1944	...	
...	...	...	533	P	June 13, 1944	138	
...	...	...	...	...	Nov. 2, 1950	...	
...	...	...	1,158	P	June 18, 1942	115	
...	...	...	...	...	June 22, 1942	...	
82	Feb. 3, 1940	...	1,000	P	June 20, 1942	...	
...	...	...	930	P	June 26, 1942	104	
374.1	Aug. 13, 1951	...	6	S	June 18, 1952	72	
220.4	Jan. 10, 1951	...	10	S	Jan. 10, 1951	74½	
149.4	Sept. 20, 1951	...	8	S	Sept. 20, 1951	74	
139.9	Nov. 6, 1950	...	5	D, S	Sept. 6, 1950	73	
80.7	Aug. 16, 1950	...	20	D, S	Aug. 15, 1950	...	
243.1	Oct. 11, 1950	...	30	S	Jan. 14, 1942	...	
...	...	...	...	D, S	Aug. 3, 1952	...	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
K-22	22 mi. NW from San Antonio	Bexar	333		Glen Rose limestone
K-23	14 mi. N from New Braunfels	Comal	154		do
K-24	do	do	221	6	do
K-25	5 mi. E from Dripping Springs	Hays	440		do
K-26	7 mi. NW from Austin	Travis	940	6	do
K-27	13 mi. NW from Belton	Bell	265		do
K-28	Temple	do	1,900		do
K-29	Marlin	Falls	3,378		do
K-30	1 mi. N from Gordonville	Grayson	345		do
K-31	7 mi. SW from Meridian	Bosque	400		Paluxy sand
K-32	Hillsboro	Hill	833	13	do
K-33	Mertens	do	1,400	8	do
K-34	Seagoville	Dallas	2,863		do
K-35	do	do	2,790		do
K-36	do	do	2,778		do
K-37	16 mi. N from Weatherford	Parker	80	5	do
K-38	15 mi. NW from Weatherford	do	22	5	do
K-39	10 mi. N from Fort Stockton	Pecos	200		Trinity group
K-40	13 mi. N from Fort Stockton	do	200	8	do
K-41	18 mi. SW from Rankin	Upton	150		do
K-42	Rankin	do	160	7	do
K-43	do	do	170	8	do
K-44	Santa Rita	Reagan	440	6	do
K-45	Texon	do	400		do
K-46	do	do			do
K-47	Big Lake	do	535	6, 7	do
K-48	17 mi. SW from Hondo	Medina	4,200	7	do
K-49	Von Ormy	Bexar	4,518	5	do
K-50	7 mi. NW from Boerne	Kendall	1,982	8¼	do
K-51	2 mi. E from Dripping Springs	Hays	799		do
K-52	Manor	Travis	3,001	8	do
K-53	11 mi. NW from Austin	do	926		do
K-54	Bartlett	Williamson	1,320	10	do
K-55	Taylor	do	3,260	10	do
K-56	Holland	Bell	1,985		do
K-57	Belton	do	1,172		do
K-58	7 mi. S from Killeen	do	250		do
K-59	Copperas Cove	Coryell	640	4	do
K-60	Gatesville	do	768	8	do
K-61	Evant	do	520	6	do
K-62	17 mi. SE from Gatesville	do	370		do
K-63	5 mi. SE from Gatesville	do	505		do
K-64	Chilton	Falls	2,709	10, 6	do
K-65	19 mi. W from Waco	McLennan	355		do
K-66	Leroy	do	2,311	6, 4	do
K-67	Aquilla	Hill	1,400		do
K-68	Malone	do	2,471	13, 6⅝	do
K-69	Abbott	do	1,850	12, 2	do
K-70	Milford	Ellis	2,000-	8	do
K-71	Waxahachie	do	2,950	6	do
K-72	6½ mi. W from Weatherford	Parker	110	4	do
K-73	14 mi. NW from Fort Worth	Tarrant	340		do
K-74	McKinney	Collin	3,230	13⅜	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
...	...	...	...	...	Aug. 30, 1951	...	
41.0	Dec. 8, 1944	...	...	S	Dec. 8, 1944	...	
...	...	3	...	D, S	Sept. 29, 1944	...	
...	...	...	...	D	Feb. 19, 1953	...	
...	...	...	...	...	May 17, 1949	...	
...	...	...	...	D, S	Sept. 28, 1950	...	
...	...	...	...	P	Jan. 3, 1944	...	
...	...	...	...	...	Feb. 23, 1938	134	
...	...	...	10	...	Aug. 23, 1953	...	
...	...	...	...	...	Feb. 1952	...	
150	1941	...	65	P	1941	...	
...	...	...	80	P	Jan. 1943	...	
...	...	...	328	...	July 11, 1944	119	
...	...	...	...	...	Oct. 4, 1944	...	
...	...	...	566	...	Nov. 1944	114	
52.0	Nov. 25, 1949	...	...	D	Nov. 25, 1949	...	
15.2	Dec. 20, 1949	...	...	D, S	Dec. 20, 1949	...	
...	...	...	2	...	Aug. 13, 1950	...	
27.35	Dec. 6, 1946	...	2	S	...do...	69½	
...	...	...	...	...	Mar. 29, 1952	...	
...	...	...	60	P	Sept. 22, 1948	...	
...	...	...	50	P	...do...	...	
...	...	...	...	P	Sept. 11, 1947	69½	
...	...	...	...	P, Ind	...do...	80	
...	...	...	...	P, Ind	...do...	69	
...	...	...	140	P	...do...	69	
...	...	26	...	S	Nov. 28, 1951	86	
...	...	250	...	...	Sept. 25, 1951	...	
...	...	...	...	D, S	Feb. 8, 1940	...	
...	...	...	...	...	Aug. 26, 1952	...	
...	...	110	...	P	Dec. 23, 1946	110	
...	...	...	...	D	July 2, 1953	...	
...	...	35	...	P	Feb. 5, 1941	...	
...	...	526	...	P	Feb. 3, 1941	115	
...	...	...	40	P	Apr. 22, 1943	...	
...	...	...	700	P	June 24, 1943	...	
...	...	...	...	...	Sept. 27, 1941	...	
140	June 3, 1946	...	50	P	June 3, 1946	...	
138	...do...	...	...	P	...do...	77	
...	...	...	9	P	June 4, 1945	72	
...	...	...	...	D, S	Oct. 20, 1953	...	
...	...	...	2	...	Sept. 23, 1942	...	
...	...	500	...	D, S, P	June 13, 1944	112	
45	Apr. 15, 1940	...	...	...	Apr. 15, 1940	...	
45	...do...	20	...	P	Jan. 8, 1943	114	
...	...	...	...	P	Jan. 1943	...	
...	...	50	...	P	...do...	...	
90	1942	33	...	P	...do...	...	
35	Mar. 1942	...	65	P	...do...	...	
40	Jan. 1943	...	250	P	...do...	...	
34.1	Nov. 9, 1949	...	...	D	Nov. 22, 1949	...	
...	...	...	...	...	Nov. 1, 1950	...	
82	Mar. 26, 1952	...	645	P	Mar. 26, 1952	99	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
K-75	Brackettville	Kinney	280		Edwards limestone and associated limestone
K-76	7 mi. E from Brackettville	do.	312		do.
K-77	12 mi. NE from Uvalde	Uvalde	668	7	do.
K-78	24 mi. NW from Hondo	Medina	385	6	do.
K-79	12 mi. NE from San Antonio	Bexar	1,355		do.
K-80	10 mi. N from San Antonio	do.	700	16	do.
K-81	Schertz	Guadalupe	2,350	8, 5	do.
K-82	2 mi. SW from New Braunfels	Comal	513		do.
K-83	10 mi. NE from San Marcos	Hays	450	6	do.
K-84	14 mi. NE from San Marcos	do.	650	6	do.
K-85	12 mi. S from Austin	Travis	390	8	do.
K-86	4 mi. S from Austin	do.	651		do.
K-87	9 mi. N from Austin	do.	400		do.
K-88	Hutto	Williamson	790	8	do.
K-89	2 mi. NE from Thorndale	Milam	2,498	8	do.
K-90	14 mi. SE from Tahoka	Lynn	27	16	do.
K-91	8 mi. SW from Balmorhea	Jeff Davis	Spring		do.
K-92	4 mi. SW from Balmorhea	Reeves	Spring		do.
K-93	do.	do.	Spring		do.
K-94	18 mi. E from Waco	McLennan	2,500±		Woodbine sand
K-95	15 mi. SE from Waco	do.	3,010		do.
K-96	Irene	Hill	915	5	do.
K-97	Bynum	do.	760	10, 4	do.
K-98	Mertens	do.	1,400	8	do.
K-99	10 mi. NE from Hillsboro	do.	538		do.
K-100	Corsicana	Navarro	2,477	10	do.
K-101	Emhouse	do.	2,017	6, 3¾	do.
K-102	Frost	do.	1,184	8, 6	do.
K-103	Blooming Grove	do.	1,488	6⅝, 5 3/16	do.
K-104	Ferris	Ellis	1,408	8	do.
K-105	Forreston	do.	750+	4	do.
K-106	Ennie	do.	1,796	13	do.
K-107	do.	do.	1,796	20, 8¼	do.
K-108	North Arlington	Tarrant	51		do.
K-109	Mesquite	Dallas	2,555	8⅝, 5½	do.
K-110	Dallas	do.	819	11	do.
K-111	Crandall	Kaufman	2,400	6, 4	do.
K-112	Forney	do.	2,051	6	do.
K-113	Rockwall	Rockwall	1,840	6, 3½	do.
K-114	Plano	Collin	1,180	12½, 10, 8¼	do.
K-115	Anna	do.	1,065	6	do.
K-116	Melissa	do.	1,462	4	do.
K-117	Princeton	do.	1,475	6	do.
K-118	Van Alstyne	Grayson	1,155	8, 6	do.
K-119	Clarksville	Red River	602	16, 8	Blossom sand
K-120	Lone Oak	Hunt	521		Nacatoch sand
K-121	2 mi. W from Commerce	do.	181	5⅝	do.
K-122	do.	do.	180		do.
K-123	12 mi. NW from Sulphur Springs	Hopkins	480		do.
K-124	3 mi. SW from Malta	Bowie	508	3, 1½	do.
K-125	14 mi. SW from Clarksville	Red River	408	20, 10¾	do.
E-1	Laredo	Webb	2,442		Wilcox group
E-2	Luling	Caldwell	519	12	do.
E-3	do.	do.	304	16, 8	do.
E-4	11 mi. SW from Bastrop	Bastrop	97	6	do.
E-5	Bastrop	do.	680	10	do.
E-6	McDade	do.	96	4	do.

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
...	...	...	...	...	Apr. 8, 1938	...	
...	...	...	...	...	Apr. 9, 1938	...	
170.31	Apr. 13, 1953	...	7	P	Apr. 14, 1953	...	
259.2	Jan. 10, 1951	...	11	D, S	Jan. 10, 1951	...	
...	...	...	...	...	Jan. 25, 1951	...	
146.70	July 24, 1946	...	...	N	Oct. 11, 1939	...	
37	Apr. 14, 1947	...	...	P	Apr. 14, 1947	...	
20	Sept. 16, 1941	...	...	...	Sept. 16, 1941	...	
...	...	...	...	S	Aug. 26, 1952	...	
179.5	Sept. 5, 1952	...	...	S	do.	...	
20	...	...	...	D, S	Sept. 12, 1949	...	
...	...	...	...	N	Aug. 8, 1949	...	
...	...	...	...	D, S	Oct. 14, 1949	...	
65	July 10, 1940	...	...	P	Oct. 1951	...	
Flows	Aug. 8, 1936	700	...	Ind	Aug. 3, 1936	120	
7.5	Aug. 8, 1949	...	...	P	May 17, 1950	...	
...	...	...	...	...	Oct. 28, 1930	...	
...	...	...	...	...	do.	...	
...	...	...	...	...	Dec. 6, 1930	...	
...	...	...	...	...	July 1950	...	
...	...	...	...	...	Feb. 1949	...	
50	1942	...	50	P	Jan. 15, 1943		
...	...	...	15	P	Jan. 14, 1943	...	
...	...	...	80	P	do.	...	
...	...	...	...	S, Irr	Mar. 15, 1953	...	
81	1938	...	...	P	May 1, 1938	...	
+25	Nov. 7, 1917	...	...	P	Feb. 22, 1944	...	
...	...	...	60	P	do.	92	
...	...	...	100	P	do.	...	
...	...	...	...	P	Jan. 27, 1943	...	
30	Jan. 27, 1943	...	...	P	do.	...	
162	Jan. 6, 1937	...	520	P	do.	...	
...	...	...	446	P	Jan. 1943	...	
17.6	Aug. 18, 1953	...	...	...	Aug. 18, 1953	...	
62	Feb. 25, 1941	...	260	P	July 31, 1941	...	
...	...	...	250	Ind	July 11, 1949	85	
55	1943	...	7	P	July 30, 1943	95	
65	1942	...	100	P	do.	100	
...	...	...	35	P	July 31, 1941	...	
292	Feb. 1949	...	160	P	Feb. 20, 1943	85	
148.70	Mar. 21, 1943	...	50	P	Feb. 19, 1943	...	
146	Feb. 22, 1940	...	30	P	do.	...	
...	...	...	50	P	do.	...	
...	...	...	90	P	Feb. 22, 1943	...	
144	...	...	650	P	Sept. 21, 1943	73	
...	...	...	60		Aug. 11, 1942	...	
...	...	...	...	...	Nov. 12, 1943	...	
...	...	...	2	...	Nov. 2, 1943	$67\frac{1}{2}$	
...	...	...	...	...	Jan. 31, 1953	...	
...	...	2	...	S	Jan. 22, 1945	...	
...	...	...	500	P	May 21, 1942	68	
...	...	...	...	N	Aug. 2, 1953	108	Test well
...	...	...	650	Ind	Feb. 7, 1946	80	
...	...	...	300	P	Feb. 1943	...	
69.2	Mar. 30, 1953	...	6	D	July 8, 1952	...	
...	...	...	...	N	June 11, 1942	...	
69.3	Feb. 3, 1953	...	...	N	Feb. 2, 1946	...	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
E-7	5 mi. W from Elgin	Bastrop	240		Wilcox group
E-8	5 mi. E from Elgin	do	63	36	do
E-9	10 mi. W from Bryan	Brazos	1,500	12½	do
E-10	Jacksonville	Cherokee	1,139		do
E-11	2 mi. W from Longview	Gregg	290		do
E-12	Kilgore	do	875	15½, 8¼	do
E-13	do	do	906	10, 6⅝	do
E-14	do	do	780	16, 10	do
E-15	1 mi. SE from Waskom	Harrison	200	6	do
E-16	13 mi. NW from Daingerfield	Morris	39	8	do
E-17	12 mi. SW from Carrizo Springs	Dimmit	475	6	Indio formation
E-18	10 mi. NW from Carrizo Springs	do	200		do
E-19	10 mi. W from Carrizo Springs	do			do
E-20	16 mi. W from La Pryor	Zavalla	74		do
E-21	20 mi. SW from Hondo	Medina	400	8	do
E-22	12 mi. S from Hondo	do	55	7	do
E-23	13 mi. SW from Hondo	do	300	6	do
E-24	10 mi. SE from Hondo	do	49	7½	do
E-25	11 mi. SE from Hondo	do	145	10	do
E-26	Laredo	Webb	1,945		Carrizo sand
E-27	7 mi. SE from Carrizo Springs	Dimmit	677	10	do
E-28	21 mi. SE from Carrizo Springs	do	1,432	10	do
E-29	4 mi. NE from Carrizo Springs	do	582	8	do
E-30	Catarina	do	1,334	12½, 10	do
E-31	23 mi. S from Cotulla	La Salle	4,200		do
E-32	21 mi. SW from Tilden	McMullen	4,150		do
E-33	Campbellton	Atascosa	4,130	18, 10¾	do
E-34	3 mi. NW from Campbellton	do	3,600±	8	do
E-35	4 mi. N from Poteet	do			do
E-36	Gordendale	La Salle	2,360	14, 2	do
E-37	10 mi. SE from San Antonio	Bexar	200		do
E-38	Sutherland Springs	Wilson	30+		do
E-39	1 mi. S from Delhi	Caldwell	171	2	do
E-40	8 mi. NE from Smithville	Bastrop	800	4½, 2	do
E-41	15 mi. NE from Bastrop	do	449	4	do
E-42	Giddings	Lee	1,364	12, 6	do
E-43	7 mi. NE from Lufkin	Angelina	3,000±	10	do
E-44	14 mi. SE from Lufkin	do	2,186	4	do
E-45	21 mi. SE from Carrizo Springs	Dimmit	70	6	Bigford member
E-46	3 mi. NE from Carrizo Springs	do	435	8	do
E-47	Laredo	Webb	1,481		Queen City sand member
E-48	13 mi. S from Jourdanton	Atascosa	1,200		do
E-49	20 mi. NE from Floresville	Wilson	263	5	do
E-50	16 mi. S from Bastrop	Bastrop	260	3	do
E-51	13 mi. SE from Caldwell	Burleson	1,100		do
E-52	Bryan	Brazos	875		do
E-53	7 mi. W from Lufkin	Angelina	523	6	do
E-54	Fowlerton	La Salle	1,700	8	Mount Selman formation
E-55	Pearsall	Frio	130	8	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
36	Feb. 10, 1953				Feb. 10, 1953		
57.6	Aug. 3, 1950			D, S	Aug. 3, 1950		
		200		S	Nov. 13, 1937		
181	Nov. 8, 1948				Nov. 8, 1948		
145.0	Mar. 30, 1936		50	D	Mar. 30, 1936		
162	Sept. 3, 1941		285	P	May 24, 1943		
157	do		350	P	do	80	
111	Sept. 14, 1934		615	P	do		
				D, Ind	Oct. 29, 1941		
36.51	Mar. 17, 1942			D, S	Mar. 17, 1942		
				D, S	May 20, 1930		
				S	July 18, 1949		
				S	do		
					Oct. 2, 1950		
162.4	Aug. 23, 1951			D, S	Aug. 23, 1951		
53.2	July 24, 1951			D, S	Aug. 24, 1951		
106.5	Aug. 23, 1951			S	Aug. 23, 1951	76	
44.7	Sept. 19, 1951			D, S	Sept. 19, 1951		
80.8	Aug. 20, 1951			D, S	Aug. 20, 1951		
		5			July 30, 1953	104	
				D, S	June 4, 1930		
24.2	Oct. 15, 1930			N	Apr. 17, 1930	94	
35.7	Dec. 4, 1937			Irr	Mar. 1947		
103	Dec. 22, 1938		600	P	May 11, 1945	96	
		500		Irr	Sept. 15, 1942		
					do		
		975		P	Mar. 14, 1951	138	
+40.5	May 25, 1944			S	May 25, 1944	109½	
					Feb. 28, 1940		
			40		Jan. 1913		
				P	Sept. 8, 1953		
				D	June 8, 1911		
88.0	Apr. 26, 1946			D	Apr. 26, 1946	71½	
65.8	Dec. 31, 1952			S	Dec. 31, 1952	75	
110.3	Feb. 13, 1953		2	D, S	Feb. 13, 1953		
160			100	P	Feb. 18, 1944	94½	
+7.0	Feb. 11, 1937	15		N	Feb. 11, 1937		
+1.0	do	2		S	do		
					May 16, 1940		
64.0	May 15, 1930				May 6, 1930		
				N	July 27, 1953		Test well
			15		Mar. 11, 1949		
28	Apr. 17, 1952			D, S	May 17, 1952		
88.4	Jan. 23, 1953			N	Jan. 29, 1952		
					Nov. 2, 1939		
				P	Dec. 7, 1937	87	
		4		Ind	Jan. 19, 1937		
38.4	Aug. 1934		235	P	May 11, 1945	81	
65	Jan. 18, 1928			D, S, Irr	Jan. 8, 1928	76	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
E-56	13 mi. W from Jourdanton	Atascosa	227		Mount Selman formation
E-57	13 mi. SW from Jourdanton	do	588		do
E-58	Christine	do	1,314	6, 4	do
E-59	McCoy	do	900		do
E-60	Paige	Bastrop	170		do
E-61	2 mi. SW from Giddings	Lee	210		Sparta sand
E-62	3 mi. NW from Caldwell	Burleson	178	4	do
E-63	Somerville	do	820		do
E-64	35 mi. SE from Lufkin	Angelina	1,510	6	do
E-65	Hemphill	Sabine	631	8, 6	do
E-66	4 mi. SE from Laredo	Webb	145		Upper part of Claiborne group
E-67	10 mi. SE from Cotulla	La Salle	250		do
E-68	5 mi. SE from Cotulla	do	75		do
E-69	Stockdale	Wilson	614		do
E-70	8 mi. N from Tilden	McMullen	Spring		do
E-71	Somerville	Burleson	198	8	do
E-72	Lyons	do	397	4	do
E-73	18 mi. SE from Lufkin	Angelina	541	10	do
E-74	15 mi. SE from Lufkin	do	435	4	do
E-75	12 mi. NW from Jasper	Jasper	1,400	6	do
E-76	24 mi. NW from Jasper	do	1,249		do
E-77	15 mi. NE from Jasper	do	1,320	8	do
E-78	23 mi. NW from Rio Grande City	Starr	250	$4\frac{1}{4}$	Jackson group
E-79	19 mi. NW from Rio Grande City	do	700	8	do
E-80	10 mi. NW from Rio Grande City	do	275	6	do
E-81	6 mi. NE from Whitsett	Live Oak	454	4	do
E-82	13 mi. NE from Huntsville	Walker	395	4	do
E-83	14 mi. NE from Huntsville	do	2,800	10	do
E-84	11 mi. S from Lufkin	Angelina	74	6	do
M-1	11 mi. S from Linn	Hidalgo	1,430	7	Catahoula and Oakville sandstones
M-2	7 mi. S from Linn	do	1,464	12	do
M-3	15 mi. N from Rio Grande City	Starr	381	$4\frac{1}{4}$	do
M-4	25 mi. NW from Rio Grande City	do	100	5	do
M-5	Hebbronville	Jim Hogg	1,198	8, 6	do
M-6	Freer	Duval	570	7	do
M-7	do	do	700	7	do
M-8	do	do	450	7	do
M-9	Concepcion	do	288	6	Lagarto clay
M-10	George West	Live Oak	500	10	Catahoula and Oakville sandstones
M-11	Beeville	Bee	1,539	$12\frac{3}{4}$, $6\frac{5}{8}$	do
M-12	Pettus	do	367	$8\frac{1}{4}$, 6	do
M-13	Kenedy	Karnes	400	$13\frac{3}{8}$, $6\frac{5}{8}$	do
M-14	Karnes City	do	860	12	do
M-15	Cuero	De Witt	1,207	$12\frac{3}{4}$, $6\frac{5}{8}$	do
M-16	4 mi. SE from Hallettsville	Lavaca	100	4	do
M-17	13 mi. NE from Huntsville	Walker	135	4	do
M-18	Onalaska	Polk	350	8	do
M-19	do	do	320	3	do
O-1	4 mi. N from Midland	Midland	127	$12\frac{1}{2}$	Ogallala formation

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
......	......	......	10	......	Mar. 9, 1949	......	
......	......	......	10	......	Mar. 8, 1949	......	
+25	1929-30	300	......	P	May 25, 1944	......	
......	......	......	......	P	Aug. 14, 1945	91	
......	......	......	......	......	June 28, 1911	......	
88	Mar. 22, 1952	......	120	D, Irr	Mar. 22, 1952	......	
10	July 28, 1951	......	......	D	July 28, 1951	......	
......	......	......	......	......	Nov. 28, 1939	......	
......	......	......	......	P	Apr. 1, 1937	......	
99.75	May 8, 1942	......	40	P	May 22, 1942	80	
......	......	......	......	......	Oct. 18, 1938	......	
......	......	......	......	......	July 1952	......	
20	Oct. 4, 1950	......	......	......	Oct. 4, 1950	......	
460+	Feb. 11, 1911	......	......	......	Feb. 11, 1911	......	
......	......	......	......	S	July 6, 1948	......	
60	Nov. 2, 1939	......	150	P	Nov. 2, 1939	......	
97	Sept. 1939	......	......	D, S	Nov. 3, 1939	......	
27.23	Feb. 12, 1937	......	......	......	Feb. 22, 1937	......	
39.04	Feb. 18, 1937	......	......	......	Feb. 18, 1937	......	
......	......	......	......	S	Apr. 11, 1908	65	
......	......	......	......	......	Sept. 12, 1907	......	
......	......	......	60	......	1914	......	
214.5	Nov. 2, 1950	......	......	S	Nov. 2, 1950	81½	
......	......	......	......	S	Oct. 31, 1950	81	
212.9	Oct. 16, 1950	......	......	D, S	Oct. 16, 1950	......	
80	Aug. 1940	......	9	Ind	Aug. 16, 1940	......	
80	Sept. 14, 1948	......	......	D, Ind	Sept. 14, 1948	77½	
......	......	0.5	......	S	Oct. 15, 1948	......	
+14	Feb. 17, 1937	40	......	Ind	Feb. 17, 1937	......	
+23	June 10, 1947	275	750	Irr	Mar. 24, 1948	......	
+16.3	Mar. 20, 1948	......	......	Irr	Jan. 24, 1948	......	
44.2	Oct. 16, 1950	......	......	S	Oct. 16, 1950	78	
47.4	Oct. 18, 1950	......	......	S	Oct. 18, 1950	79	
35	Aug. 8, 1945	......	135	P	Aug. 8, 1945	......	
165	Mar. 6, 1945	......	30	P	Mar. 6, 1945	89	
200	......do......	......	20	P	......do......	78	
165+	......do......	......	15	P	......do......	88½	
49.5	June 13, 1931	......	......	D, S	June 13, 1931	......	
38.4	Aug. 1934	......	235	P	Apr. 19, 1945	81	
68	Apr. 19, 1945	......	490	P	......do......	95	
......	......	......	40	P	Apr. 18, 1945	......	
90	July 25, 1943	......	375	P	......do......	79	
......	......	......	175	P	Apr. 17, 1945	92	
19+	Dec. 22, 1944	325	......	P	Dec. 22, 1944	91	
45	Mar. 24, 1951	......	6	......	Mar. 24, 1951	......	
80	Sept. 14, 1948	......	......	D, Ind	Sept. 10, 1948	77½	
0.0	Mar. 15, 1947	1	......	S	Mar. 15, 1947	70	
23	1942	......	......	D, S	June 12, 1947	......	
35.02	Nov. 11, 1947	......	700	Irr	July 28, 1949	69	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
O-2	2 mi. N from Midland	Midland	140		Ogallala formation
O-3	3 mi. E from Midland	do	107	18	do
O-4	22 mi. SE from Andrews	Andrews	57	$6\frac{5}{8}$	do
O-5	5 mi. NW from Stanton	Martin	100		do
O-6	Coahoma	Howard	50	48	do
O-7	13 mi. NE from Lamesa	Dawson	70		do
O-8	9 mi. NW from Gail	Borden	46		do
O-9	16 mi. NW from Gail	do	60	4	do
O-10	7 mi. NW from Ira	Scurry	125		do
O-11	Plains	Yoakum	128	12	do
O-12	18 mi. NE from Seminole	Gaines	60	6	do
O-13	Wellman	Terry	142	6	do
O-14	Tokio	do	120	5	do
O-15	15 mi. NE from Tahoka	Lynn	128	16	do
O-16	7 mi. NE from Tahoka	do	200	5	do
O-17	2 mi. N from Tahoka	do	99	16	do
O-18	15 mi. SW from Tahoka	do	82	6	do
O-19	14 mi. SW from Tahoka	do	117	6	do
O-20	Anton	Hockley	115	12	do
O-21	Lubbock	Lubbock	135	22, 18	do
O-22	do	do	150	22, 18	do
O-23	12 mi. E from Amherst	Lamb	208	16	do
O-24	10 mi. E from Amherst	do	198	16	do
O-25	6 mi. SW from Amherst	do	100	5	do
O-26	8 mi. SE from Clarendon	Donley	136		do
O-27	7 mi. NW from Clarendon	do	127		do
O-28	Adrian	Oldham	496	7	do
O-29	Pampa	Gray	450	16	do
O-30	1 mi. S from Sebastian	Cameron	329	$12\frac{3}{4}$	Goliad sand
O-31	4 mi. NE from Santa Rosa	do	697	12	do
O-32	4 mi. N from Santa Rosa	do	390	12	do
O-33	Lyford	Willacy	1,935	10, 8	do
O-34	Raymondville	do	1,196		do
O-35	McAllen	Hidalgo	438		do
O-36	Donna	do	460		do
O-37	Weslaco	do	465		do
O-38	Edcouch	do	338		do
O-39	Edinburg	do	349		do
O-40	16 mi. N from Rio Grande City	Starr	530	$4\frac{1}{4}$	do
O-41	10 mi. N from Rio Grande City	do	204	$5\frac{1}{2}$	do
O-42	8 mi. S from Hebbroville	Jim Hogg	2,005	12,	do
O-43	12 mi. W from Armstrong	Kenedy	960	5, $3\frac{3}{16}$	do
O-44	Kingsville	Kleberg	725	8	do
O-45	34 mi. E from Laredo	Webb	125		do
O-46	San Diego	Duval	240	6	do
O-47	Benavides	do	615	$8\frac{5}{8}$	do
O-48	Alice	Jim Wells	992	16, 8	do
O-49	4 mi. SW from Alice	do	620		do
O-50	Orange Grove	do	288	8	do
O-51	26 mi. W from Corpus Christi	Nueces	596		do
O-52	Mathis	San Patricio	319		do
O-53	Sinton	do	936	6	do
O-54	do	do	940	8	do
O-55	14 mi. SE from George West	Live Oak	200	12	do
O-56	6 mi. SW from Angleton	Brazoria	1,000	6	Lissie formation
O-57	3 mi. NW from Alta Loma	Galveston	1,221	4	do
O-58	10 mi. SE from Houston	Harris	1,676	4	do

and springs in Texas—Continued

Reported water level: Below land surface (feet)	Reported water level: Date of measurement	Yield (gallons per minute): Flow	Yield (gallons per minute): Pump	Use of water	Date of collection of sample	Temperature (°F)	Remarks
...	...	...	...	...	Aug. 23, 1946	...	
53.39	Sept. 25, 1947	...	350	P	May 26, 1944	67½	
38.17	Dec. 11, 1947	...	...	S	Dec. 11, 1947	...	
...	...	...	325	Irr	July 14, 1953	...	
...	...	...	125	P	Aug. 22, 1947	...	
...	...	...	...	...	Nov. 1949	...	
29.0	June 29, 1948	...	...	D, S	June 29, 1948	...	
30	Sept. 16, 1948	...	...	D, S	Sept. 16, 1948	66	
88.9	May 11, 1948	...	...	S	May 11, 1948	...	
72	1940	...	150	P	Oct. 30, 1944	...	
45.8	Aug. 12, 1938	...	...	D, S	Aug. 12, 1938	...	
130	1944	...	...	S	May 23, 1944	...	
89.87	June 20, 1944	...	...	S	June 20, 1944	...	
...	...	...	425	Irr	July 28, 1949	65	
140	July 8, 1949	...	...	S	do.	...	
62.8	Aug. 3, 1949	...	625	Irr	Aug. 3, 1949	...	
61.3	Aug. 16, 1949	...	...	D, S	Aug. 16, 1949	68½	
110.9	June 1950	...	3	Irr	May 17, 1950	64½	
...	...	...	185	P	Mar. 13, 1947	...	
59.4	Sept. 26, 1944	...	535	P	Oct. 2, 1944	...	
53.7	do.	...	640	P	Sept. 22, 1944	...	
81.5	Aug. 25, 1950	...	900	Irr	Apr. 3, 1952	...	
...	...	...	...	Irr	do.	...	
20.0	Apr. 18, 1952	...	...	S	Apr. 18, 1952	...	
81.8	Aug. 24, 1949	...	...	S	Aug. 24, 1949	...	
124.85	Sept. 21, 1949	...	...	S	Sept. 21, 1949	...	
455	Nov. 20, 1947	...	18	P	Nov. 20, 1947	64	
347	1947	...	600	P	do.	...	
18	July 1952	...	...	Irr	July 24, 1952	...	
6	Jan. 1952	...	900	Irr	Jan. 16, 1952	...	
22.3	Sept. 11, 1952	...	650	Irr	Jan. 14, 1952	78	
...	...	...	...	P	Aug. 7, 1944	92	
...	...	...	812	...	Sept. 23, 1953	91½	
...	...	...	1,700	...	Sept. 1, 1953	...	
...	...	...	...	...	Aug. 26, 1953	...	
...	...	...	1,100	...	Sept. 18, 1953	...	
...	...	...	900	...	do.	...	
...	...	...	...	...	Aug. 27, 1953	...	
...	...	...	...	S	Sept. 14, 1950	85	
42.7	Sept. 20, 1950	...	...	S	Sept. 20, 1950	...	
...	...	...	200	S	Mar. 21, 1934	...	
...	...	11	...	S	...	...	
...	...	...	148	P	Feb. 5, 1943	85	
...	...	...	2	...	Oct. 4, 1951	...	
140	Feb. 28, 1928	...	7	D, S	Feb. 28, 1928	...	
88.69	Mar. 7, 1945	...	125	P	Mar. 7, 1945	80½	
110	May 8, 1945	...	375	P	Mar. 5, 1945	86	
...	...	...	...	...	...	...	
120	June 2, 1945	...	75	P	June 2, 1945	78½	
...	...	...	...	...	June 15, 1949	...	
...	...	...	280	P	July 1945	...	
...	...	15	...	P	July 19, 1945	...	
...	...	100	...	P	do.	...	
...	...	...	1,200	Irr	Sept. 20, 1951	...	
...	...	...	...	D, S	July 1, 1941	...	
...	...	...	...	N	Sept. 19, 1952	...	Test well
243±	Sept. 9, 1953	...	10	N	Sept. 9, 1953	...	Do.

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
O-59....	La Porte....................	Harris............	1,158	4	Lissie formation
O-60....	Raywood....................	Liberty..........	443	....	.....do.............
O-61....	5 mi. NW from Dayton.....	.....do...........	834	20, 16	.....do.............
O-62....	2 mi. SE from Beaumont...	Jefferson.........	620	$12\frac{3}{4}$, $8\frac{5}{8}$	.....do.............
O-63....	18 mi. NW from Orange....	Orange...........	740	6	.....do.............
O-64....	Sour Lake..................	Hardin...........	763	....	.....do.............
B-1.....	4 mi. N from Brownsville...	Cameron.........	200	....	Beaumont clay
B-2.....	1 mi. S from Kingsville.....	Kleberg..........	100	$5\frac{3}{8}$	.....do.............
B-3.....	Odom.......................	San Patricio.....	126	10	.....do.............
B-4.....	Taft........................	.....do...........	200	....	.....do.............
B-5.....	......do.....................	.....do...........	216	24, 16	.....do.............
B-6.....	3 mi. N from Rockport.....	Aransas..........	165	4	.....do.............
B-7.....	7 mi. S from Port O'Conner	Calhoun.........	333	8	.....do.............
B-8.....	8 mi. W from Port Lavaca..	.....do...........	360	4	.....do.............
B-9.....	6 mi. S from Matagorda....	Matagorda......	600	$2\frac{1}{2}$	.....do.............
B-10....	12 mi. SE from Bay City....	.....do...........	744	4, 2	.....do.............
B-11....	3 mi. W from Freeport......	Brazoria.........	1,100±	3	.....do.............
B-12....	1 mi. N from Pearland......	.....do...........	1,773	20, 14	.....do.............
B-13....	2 mi. SW from Texas City.	Galveston.......	1,000	....	"Alta Loma" sand
B-14....	Alta Loma..................	.....do...........	884	20	.....do.............
B-15....	Galveston..................	.....do...........	1,317	....	.....do.............
B-16....	4 mi. SW from Texas City.	.....do...........	100	2	Beaumont clay
B-17....	5 mi. SW from Galveston..	.....do...........	279	....	.....do.............
B-18....	Winnie.....................	Chambers.......	192	....	.....do.............
B-19....	Anahuac....................	.....do...........	420	....	.....do.............
B-20....	9 mi. S from Anahuac......	.....do...........	546	....	.....do.............
B-21....	4 mi. SW from Anahuac....	.....do...........	487	....	"Alta Loma" sand
B-22....	15 mi. SW from Beaumont.	Jefferson........	200	2	Beaumont clay
B-23....	Orange.....................	Orange...........	941	4	"Alta Loma" sand
R-1.....	10 mi. N from El Paso......	El Paso..........	1,200	....	Alluvium
R-2.....	10 mi. NE from El Paso....	.....do...........	1,020	3	.....do.............
R-3.....	Sierra Blanca...............	Hudspeth........	1,000	6	.....do.............
R-4.....	17 mi. NE from Van Horn..	Culberson.......	....	....	.....do.............
R-5.....	10 mi. NE from Van Horn..	.....do...........	....	....	.....do.............
R-6.....	Near Orla..................	.....do...........	....	....	.....do.............
R-7.....	5 mi. NW from Pecos.......	Reeves...........	135	$10\frac{1}{2}$	.....do.............
R-8.....	2 mi. NW from Pecos.......	.....do...........	225	....	.....do.............
R-9.....	1 mi. W from Barstow......	Ward.............	115	8	.....do.............
R-10....	3 mi. E from Pyote.........	.....do...........	110	....	.....do.............
R-11....	Mentone....................	Loving...........	246	....	.....do.............
R-12....	Colorado City..............	Mitchell..........	220	....	.....do.............
R-13....	5 mi. E from Stamford.....	Jones............	101	8	.....do.............
R-14....	1 mi. N from Rochester....	Haskell..........	65	108	.....do.............
R-15....	Haskell.....................	.....do...........	28	240	.....do.............
R-16....	Goree......................	Knox.............	45	144	.....do.............
R-17....	Munday.....................	.....do...........	37	240	.....do.............
R-18....	Knox City..................	.....do...........	38	240	.....do.............
R-19....	Red Springs................	Baylor...........	....	....	.....do.............
R-20....	Vernon.....................	Wilbarger.......	22	18	.....do.............
R-21....	12 mi. N from Vernon......	.....do...........	92	18	.....do.............
R-22....	Paducah....................	Cottle............	127	7	.....do.............
R-23....	Childress...................	Childress........	400	....	.....do.............
R-24....	7 mi. NW from Harlingen...	Cameron.........	40	$1\frac{1}{2}$	.....do.............
R-25....	8 mi. SW from Harlingen..	.....do...........	35	2	.....do.............
R-26....	8 mi. NE from Harlingen...	.....do...........	....	2	.....do.............
R-27....	San Juan...................	Hidalgo..........	346	....	.....do.............
R-28....	Mercedes...................	.....do...........	346	....	.....do.............
R-29....	McAllen....................	.....do...........	512	12	.....do.............
R-30....	Weslaco....................	.....do...........	547	....	.....do.............
R-31....	Mission.....................	.....do...........	363	....	.....do.............
R-32....	Pharr.......................	.....do...........	312	....	.....do.............
R-33....	24 mi. NW from Rio Grande City	Starr............	100	6	.....do.............

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
				N	Nov. 17, 1945		Test well
				Irr	Sept. 1948		
45	Aug. 1943		2,000	Irr	Apr. 19, 1945	78	
19.79	Sept. 23, 1941		1,130	Ind	Sept. 23, 1941		
		2		N	Sept. 26, 1941		
			250+		Aug. 5, 1953		
					Apr. 21, 1950		
				D, S	Feb. 1, 1938		
60	July 1945		60	P	July 1945		
			300	P	do.		
70	Nov. 7, 1944		260	P	do.		
				D	May 17, 1952		
				D	Nov. 18, 1953		Matagorda Island
					Sept. 1947		
		4		P	June 11, 1943		
				D, S	May 1947		
+3	July 11, 1941	25		D, S	July 11, 1941		
82.6	Nov. 15, 1946		1,200	Irr	Nov. 15, 1946		
			600		Aug. 26, 1952		
79.1	Apr. 18, 1944			P	Sept. 24, 1952		
			2,000		Apr. 10, 1951		
				D, S	Apr. 18, 1939		
					Jan. 15, 1952		
					May 1943		
					Dec. 14, 1948		
					Dec. 17, 1948		
					Apr. 16, 1953		
1.05	May 22, 1941			N	May 22, 1941		
				N	June 1945		Test well
379.0	July 22, 1953			N	July 20, 1953		Do.
308.4	Apr. 9, 1954			N	June 1953		Do.
			35	P	July 23, 1943	88	
			3	Irr	June 30, 1950		
			5	Irr	May 4, 1950		
					Apr. 19, 1940		
16.9	Nov. 4, 1946		1,200	Irr	Mar. 7, 1950		
				Irr	Mar. 28, 1950	69½	
8.0	Oct. 21, 1930		1,000	Irr	Oct. 21, 1930	65	
82.8	Oct. 4, 1940			S	Mar. 1, 1943		
28					Dec. 16, 1940		
			32	P	Mar. 6, 1946		
60	July 1953			D, S	July 29, 1953	69½	
42.55	Mar. 24, 1944		750	Irr	Mar. 23, 1944		
19	Mar. 17, 1944		400	P	Mar. 17, 1944		
21.7	Mar. 22, 1944		220	P	Mar. 22, 1944		
13	do.		500	P	do.		
18.5	do.		375	P	do.		
					Oct. 1944		
15.89	Oct. 9, 1943		225	P	Oct. 9, 1943		
22.27	Jan. 31, 1952		430	N	Feb. 7, 1952		Do.
33	Sept. 16, 1947		150	P	Mar. 10, 1946		
			400	P	Sept. 24, 1945		
				Irr	Sept. 19, 1952	77	
8.0	July 9, 1952			Irr	July 9, 1952		
7.0	Nov. 17, 1952			Irr	Nov. 17, 1952	78	
			750	P	Aug. 24, 1953		
			880	P	June 4, 1953		
60.0	May 26, 1953		815	P	May 26, 1953	80	
			900	P, Ind	June 4, 1953		
			700	P	July 21, 1953		
50.0	May 25, 1953		550	P	May 25, 1953	81	
92.0	Nov. 1, 1950			D, S	Nov. 1, 1950	82	

Table 3.—*Chemical analyses and related physical measurements of saline surface water in Texas*

[Analyses in parts per million, except as indicated]

No. on plate 9	Source and range of samples[a]	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
1......	Canadian River at Tascosa																	
	max	16	.....	96	62	521		250	604	560	1.0	1.2	....	1,980	494	70	3,190	7.9
	min	16	.....	26	8.7	71		189	41	40	....	1.2	....	297	101	60	515	7.8
	wt avg	18	.....	44	18	147		208	155	121	.8	2.2	....	622	184	63	1,020	......
2......	Canadian River near Amarillo																	
	max	36	.....	177	62	400		272	523	520	4.4	66	....	1,920	696	56	3,040	8.0
	min	16	.....	21	9.1	90		140	85	56	1.2	1.5	....	385	90	69	602	7.7
	wt avg	22	.....	48	20	146		202	158	130	1.0	4.9	....	640	202	61	1,040	......
3......	Canadian River near Borger																	
	max	26	.....	698	504	591		200	431	3,180	.4	....	....	5,530	3,810	25	9,580	7.8
	min	15	.....	32	12	84		150	95	60	.5	5.0	....	392	130	58	641	7.8
4......	Salt Fork Red River near Wellington																	
	max	28	.....	542	101	185		110	1,690	225	.7	2.5	....	2,830	1,770	19	3,310	7.7
	min	26	.....	141	25	51	......	125	359	65	.5	1.5	....	730	455	20	1,080	7.7
5......	Mulberry Creek near Brice																	
	max	44	.....	472	144	219		79	1,730	270	....	0.5	....	2,920	1,770	21	3,480	7.7
	min	18	.....	128	17	43		80	334	49	....	1.8	....	693	391	19	918	8.0
6......	Prairie Dog Town Fork Red River near Brice																	
	max	25	.....	813	217	4,410		153	2,270	7,110	....	....	....	14,900	2,920	77	21,400	7.8
	min	20	.....	202	36	308		110	583	440	....	3.8	....	1,650	652	51	2,540	8.0
	wt avg	23	.....	229	44	454		129	669	663	....	....	....	2,140	752	57	3,370	......

7......	Pease River near Crowell																	
		max	....	......	864	170	4,050	145	2,300	6,480	....	2.5	....	14,300	2,860	75	20,400	......
		min	12	0.12	326	33	134	76	847	208	.6	1.5	0.6	1,600	949	23	2,420	......
		wt avg	13	.08	424	64	783 ǀ 16	112	1,130	1,250	.4	3.2	....	3,740	1,320	57	5,540	......
8......	Lake Kemp near Mabelle..............		7.4	.02	240	57	694	106	675	1,100	.4	.0	....	2,830	834	64	4,650	7.4
9......	Wichita River at Wichita Falls.......		12	......	230	61	614	113	629	1,000	....	2.0	....	2,600	825	62	4,320	7.4
10.....	Lake Texoma at Perrin AF Base......		6.3	.01	97	28	243	111	236	388	.3	1.5	....	1,060	357	60	1,850	7.6
11.....	Red River near Gainesville																	
		max	....	......	310	97	1,030	214	751	1,740	....	3.5	....	4,040	1,170	66	6,550	......
		min	....	......	49	11	54	b125	50	91	....	1.8	....	360	168	41	592	......
		wt avg	....	......	97	24	194	137	169	335	....	3.5	....	891	340	55	1,540	......
12.....	Sulphur River near Darden																	
		max	7.5	......	194	52	1,970	158	733	2,900	....	....	....	5,930	698	86	10,000	......
		min	5.8	......	17	1.5	14	66	10	10	....	1.0	....	122	49	39	150	......
		wt avg	7.3	......	24	3.5	22	81	20	25	....	1.1	....	168	74	39	252	......
13.....	Salt Fork Brazos River near Aspermont																	
		max	11	......	1,440	274	16,900	159	3,440	26,800	....	....	....	48,900	4,720	89	60,900	7.7
		min	15	......	166	26	448	116	435	670	....	4.0	....	1,820	521	65	3,060	7.8
		wt avg	16	......	320	52	1,400	117	786	2,230	....	....	....	4,870	1,010	75	7,640	......
14.....	Double Mountain Fork Brazos River near Aspermont																	
		max	13	......	614	82	595	116	1,700	920	....	1.2	....	3,980	1,870	42	5,350	7.8
		min	16	......	74	9.6	132	120	240	114	....	1.0	....	646	224	56	1,030	7.6
		wt avg	15	......	162	18	138	109	460	148	....	2.3	....	1,010	478	39	1,470	......
15	Clear Fork Brazos River at Nugent																	
		max	4.1	......	370	138	774	140	1,460	1,090	....	2.5	....	3,910	1,490	53	5,650	7.8
		min	8.8	......	34	1.1	20	104	32	8.0	....	2.5	....	158	89	32	264	7.4
		wt avg	10	......	65	15	54	120	145	63	....	2.3	....	425	224	34	659	......

See footnotes at end of table.

Table 3.—*Chemical analyses and related physical measurements of saline surface water in Texas*—Continued

No. on plate 9	Source and range of samples[a]	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
16.....	Brazos River at Possum Kingdom Dam near Graford wt avg	13	.....	152	29	388		130	322	636	....	1.0	....	1,610	498	63	2,770	......
17.....	Daniel Salt Lake in Eastland County....	22	......	8,310	2,080	41,400		43	21	84,500	....	....	....	136,000	29,300	75	131,000	6.9
18.....	Colony Creek in Eastland County	18	......	1,860	483	6,080		79	166	13,900	....	....	....	22,500	6,630	67	33,300	7.5
		16	......	318	66	1,010		64	25	2,250	....	....	....	3,720	1,060	67	6,690	7.6
19.....	Rich Lake in Terry County...............	....	......	2,500	7,500	18,000		561	40,600	23,700	....	....	....	92,600	37,000	51	....	......
20.....	Cedar Lake in Gaines County.....	....	......	1,180	2,280	30,100		110	25,000	36,600	....	....	....	95,200	12,300	84	....	......
21.....	Colorado River above Bull Creek near Knapp max	29	......	510	176	2,250		154	1,310	3,830	....	....	....	8,180	2,000	71	12,500	8.1
	min	13	......	18	5.1	62		118	50	35	....	2.5	....	244	66	67	404	7.9
22.....	Colorado River at Colorado City max	8.1	......	641	253	6,180		125	2,060	9,810	....	....	....	19,000	2,640	84	28,100	7.4
	min	10	......	22	5.0	65		116	35	60	....	1.8	....	264	75	65	482	7.8
	wt avg	13	......	43	13	214		123	89	303	....	2.5	....	742	161	74	1,330	......
23.....	Colorado River at Robert Lee max	5.1	......	434	116	1,420	....	76	1,300	2,230	....	....	....	5,540	1,560	66	8,700	7.4
	min	17	......	38	6.8	49		107	41	66	....	6.5	....	294	123	46	511	7.6
	wt avg	17	......	69	18	223		197	153	290	....	3.0	....	888	246	66	1,510	......

24.....	Bull Creek near Ira																	
	max	11	......	111	39	1,000		69	317	1,580	....	5.0	....	3,100	438	83	5,510	7.6
	min	12	......	24	4.6	23		114	17	11	....	4.0	....	152	79	39	263	7.4
	wt avg	15	......	32	6.4	47		134	37	40	....	3.6	....	256	106	49	427	......
25.....	Bluff Creek near Ira																	
	max	17	....	120	55	662		258	423	930	....	1.5	....	2,340	526	73	3,960	8.2
	min	14	....	32	6.6	19		118	22	18	....	4.1	....	195	107	28	297	8.1
26.....	Morgan Creek near Colorado City																	
	max	2.8	....	238	116	1,540		159	1,130	2,200	....	....	....	5,310	1,070	76	8,540	......
	min	15	....	26	5.2	24		104	29	15	....	1.0	....	171	86	37	276	7.6
27.....	Rio Grande at El Paso																	
	max	....	......	90	30	319	....	133	421	272	....	....	.32	1,400	....	67	2,020	8.1
	min	....	......	69	22	144	....	88	252	124	....	1.9	.17	758	....	53	1,160	7.7
28.....	Rio Grande at Fort Quitman																	
	max	....	......	346	125	1,220	....	87	1,230	2,000	....	.6	.73	5,160	....	66	7,650	7.8
	min	....	......	66	12	77	....	65	93	126	....	2.5	.12	507	....	44	802	7.9
29.....	Rio Grande at the upper Presidio station																	
	max	....	......	498	116	955	....	215	1,230	1,680	....	.6	.59	4,890	....	55	6,960	7.7
	min	....	......	45	6.2	56	....	157	103	17	....	2.5	.10	353	....	47	507	7.8
30	Red Bluff Lake on Pecos River in Loving and Reeves Counties............	1.2	.00	571	227	1,770	48	120	2,090	2,790	1.2	....	.85	7,560	2,360	61	11,100	7.2
31	Pecos River near Orla																	
	max	23	......	590	219	1,500		96	2,120	2,380	......	....	....	6,880	2,370	58	10,100	7.2
	min	11	......	241	34	270		70	635	430	......	4.5	....	1,660	742	44	2,560	7.3
	wt avg	21	......	505	164	813		109	1,750	1,260	......	1.4	....	4,580	1,930	48	6,420	......

See footnotes at end of table.

Table 3.—*Chemical analyses and related physical measurements of saline surface water in Texas*—Continued

No. on plate 9	Source and range of samples[a]	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
32....	Lake Balmorhea on Toyah Creek in Reeves County.....	11	.00	184	92	464	15	245	689	650	1.2	1.2	.45	2,230	838	54	3,330	7.8
33....	Toyah Creek below Toyah Lake near Pecos max	....	......	876	157	2,380		60	4,250	2,510	....	....	....	10,200	2,830	65	13,500	.....
	min	11	......	408	37	218		38	1,190	265	....	2.0	....	2,150	1,170	29	2,780	.....
34....	Pecos River below Grandfalls max	19	......	745	372	2,790		191	2,930	4,430	....	....	....	11,400	3,390	64	15,600	7.6
	min	30	......	627	306	1,990		146	2,530	3,120	....	....	....	8,670	2,820	61	12,200	7.9
	wt avg	22	......	715	354	2,420		154	2,850	3,840	....	....	....	10,300	3,240	62	14,400	......
35	Old River near Cove max	9.8	......	91	68	667		150	203	1,150	....	1.2	....	2,260	506	74	4,190	......
	min	9.5	......	32	5.6	22		116	9.9	30	....	3.2	....	179	103	32	307	7.7
36	Trinity River at Anahuac max	13	......	263	704	4,860		126	1,290	8,990	....	....	....	16,200	3,550	75	25,600	7.7
	min	7.8	......	17	5.2	34		70	18	42	....	1.8	....	184	64	53	286	7.4
37	Laguna Madre at Carolina Beach Pier..................	....	......	439	1,260	12,400		244	3,030	21,300	....	....	....	38,500	....	81	57,000	......

[a]Maximum and minimum refer to dissolved solids; weighted average refers to all constituents.
[b]Includes equivalent of 8 ppm carbonate (CO_3).

Table 4.—*Records and stream data of saline surface water in Texas*

[Frequency of sampling: D, daily; W, weekly; M, monthly; Inf, infrequently]

No. on plate 9	Source	Drainage area (square miles)	Water discharge (cubic feet per second)	Date	Number of analyses	Frequency of sampling	Remarks
1......	Canadian River at Tascosa..................	19,200	16.8 5,645 196	Mar. 2-3, 14-15, 1951 May 14-15, 1951 Nov. 1, 1950 to Sept. 30, 1951	46	D D D	Records available: June 1948 to Sept. 1953
2......	Canadian River near Amarillo.............	19,287	15.1 533 198	Jan. 21-31, 1951 Aug. 10-12, 1951 Oct. 1, 1950 to Sept. 30, 1951	48	D	Records available: Sept. 14, 1950 to present
3......	Canadian River near Borger...............	....	....	Oct. 2-3, 7-10, 1950 Sept. 21-30, 1951	44	D	Records available: Sept. 14, 1950 to Oct. 15, 1952
4......	Salt Fork Red River near Wellington.	....	....	Aug. 6, 8, 18-20, 1953 May 11-12, 14, 16-20, 1953	32	D	Records available: June 6, 1952 to present
5......	Mulberry Creek near Brice..................	534	.25 204	June 24, 1950 July 24, 1950	25	D	Records available: Aug. 1, 1949 to July 31, 1951
6......	Prairie Dog Town Fork Red River near Brice.	5,646	10.1 6,032 162	Jan. 15, 1951 May 17-20, 1951 Oct. 1, 1950 to Sept. 30, 1951	25	D	Records available: Aug. 1, 1949 to July 31, 1951
7......	Pease River near Crowell....................	2,940	9.0 1,060 146	Dec. 24, 1942 Apr. 17, 1943 Oct. 1, 1942 to June 3, 1943	22	D	Records available: July 1, 1942 to June 30, 1943
8......	Lake Kemp near Mabelle....................	....	....	June 16, 1952	1	Inf	Miscellaneous sample
9......	Wichita River at Wichita Falls............	....	....	Oct. 12, 1951	1	Inf	Miscellaneous sample
10....	Lake Texoma at Perrin AF Base...........	....	....	Oct. 1953	1		Miscellaneous sample

Table 4.—*Records and stream data of saline surface water in Texas*—Continued

No on plate 9	Source	Drainage area (square miles)	Water discharge (cubic feet per second)	Date	Number of analyses	Frequency of sampling	Remarks
11.....	Red River near Gainesville..................	29,460	504 18,090 4,193	Jan 11-20, 1945 Apr. 1-3, 1945 Oct. 1944 to Sept. 1945	58	D	Records available: May 1, 1944 to Sept. 30, 1947
12.....	Sulphur River near Darden..................	2,754	23.7 28,750 2,225	Oct. 24, 27, 29, 1948 Jan. 28-29, 31, 1949 Oct. 1948 to Sept. 1949	64	D	Records available: Oct. 1, 1947 to Jan. 15, 1950
13.....	Salt Fork Brazos River near Aspermont....	4,834	.41 1,004 166	Apr. 1-5, 30, 1950 Sept. 6-10, 27-29, 1950 Oct. 1, 1949 to Sept. 30, 1950	40	D	Records available: Oct. 1, 1948 to Oct. 3, 1951
14.....	Double Mountain Fork Brazos River near Aspermont.	7,979	1.62 2,275 171	Feb. 1-13, 19-28, 1950 May 12-13, 1950 Oct. 1949 to Sept. 1950	40	D	Records available: Oct. 1, 1948 to Nov. 30, 1951
15.....	Clear Fork Brazos River near Nugent......	2,220	4.15 860 58.1	Mar. 21-31, 1949 Sept. 15-16, 1949 Oct. 1, 1948 to Sept. 20, 1949	48	D	Records available: Aug. 20, 1948 to Sept. 30, 1953
16.....	Brazos River at Possum Kingdom Dam near Graford.	22,550	220	Oct. 1, 1952 to Sept. 30, 1953	12	D	Weighted average for 1953 water year. Records available: Jan. 15, 1942 to present
17.....	Daniel Salt Lake in Eastland County......	....	....	June 8, 1950	1	Inf	Miscellaneous sample. Colony Creek drainage
18.....	Colony Creek in Eastland County..........	....	....	June 8, 1950 Sept. 11, 1950	4	Inf	Miscellaneous samples. Shows pollution by oil well brine
19.....	Rich Lake in Terry County..................	....	....	May 18, 1938	1	Inf	Represents saline lake on High Plains

20......	Cedar Lake in Gaines County..............	....	....	Aug. 5, 1938	1	Inf	Represents saline lake on High Plains
21......	Colorado River above Bull Creek near Knapp.	....	.30 45.7	Apr. 12, 1950 July 21-29, 1950	29	D	No weighted average computed. Records available: Apr. 12, 1950 to Jan. 31, 1952
22......	Colorado River at Colorado City..........	4,082	.0 1,091 86.6	Mar. 10, 20-31, Apr. 1-12, 1950 Sept. 6-9, 1950 Oct. 1949 to Sept. 1950	51	D	Records available: May 8, 1946 to present
23......	Colorado River at Robert Lee..............	15,770	1.0 1,548 75.8	Apr. 1-10, 1951 June 3-4, 1951 Oct. 1950 to Sept. 1951	50	D	Records available: Oct. 1, 1947 to Sept. 30, 1951
24......	Bull Creek near Ira...........................	388	.36 110 30.3	Aug. 16-20, 1950 May 2, 1950 Apr. 12, 1950 to Sept. 30, 1950	28	D	Records available: Apr. 12, 1950 to Jan. 12, 1954
25	Bluff Creek near Ira...........................	38	....	Aug. 30, Sept. 1, 1950 May 1950	32	D	No weighted average computed. Records available: Apr. 12, 1950 to Sept. 30, 1950
26......	Morgan Creek near Colorado City.........	....	.05	Feb. 1-2, 6-8, 12, 1949 May 7-9, 1949	22	D	No weighted average computed. Records available: May 1, 1947 to July 31, 1949
27......	Rio Grande at El Paso........................	29,267	740 86.2	July 1-30, 1951 Oct. 1-31, 1951	12	D	Records available: 1924 to present. Information from International Boundary and Water Commission, Water Bulletin 21, 1951
28......	Rio Grande at Fort Quitman.................	31,990 including 1,384 in Mexico	8.0 128 (partly estimated	Apr. 1951 Aug. 1951	12	W	Do.
29......	Rio Grande at the upper Presidio Station.	35,000 including 2,773 in Mexico	1.5 (estimated) 27.6	Mar. 1951 Aug. 1951	12	W	Do.

Table 4.—*Records and stream data of saline surface water in Texas*—Continued

No. on plate 9	Source	Drainage area (square miles)	Water discharge (cubic feet per second)	Date	Number of analyses	Frequency of sampling	Remarks
30......	Red Bluff Lake on Pecos River in Loving and Reeves Counties.	....	....	Mar. 19, 1953	3	Inf	Miscellaneous sample
31......	Pecos River near Orla........	21,300	19.6 82.8 152	Sept. 1-30, 1951 Oct. 1-4, 1950 Oct. 1950 to Sept. 1951	15	D	Records available: July 1, 1937 to present
32......	Lake Balmorhea on Toyah Creek in Reeves County.	....	....	Jan. 28, 1950	1	Inf	Miscellaneous sample
33......	Toyah Creek below Toyah Lake near Pecos.	3,709	.1 15	Sept. 1-8, 1947 July 31, Aug. 1, 1948		D	Records available: Sept. 1939 to Oct. 1940 Oct. 1, 1943 to Sept. 30, 1944 Oct. 9, 1946 to Sept 1, 1950
34......	Pecos River below Grandfalls........	27,820	28.0 28.4 25.1	Dec. 1-31, 1949 Oct. 1-31, 1949 Oct. 1949 to Sept. 1950	12	D	Records available: Apr. 1, 1939 to June 30, 1942 Oct. 11, 1946 to present
35......	Old River near Cove........	....	....		16		Represents a normally fresh water stream affected by intrusion of Gulf water.
				Aug. 22-23, 27-28, 30, 1948		Inf	Aug. 23, 1946 to Oct. 16, 1946 Aug. 24, 1947 to Oct. 1, 1947
				Mar. 11-20, 1950		D	June 1, 1948 to Oct. 20, 1948 June 1, 1949 to present
36......	Trinity River at Anahuac........	....	....				Represents a normally fresh water stream affected by intrusion of Gulf water.
				Mar. 1-10, 1950		Inf	Aug. 22, 1946 to Sept. 22, 1946 Aug. 2, 1947 to Sept. 15, 1947 June 1948 to Sept. 30, 1948
				Oct. 21-31, 1952		D	June 1, 1949 to present
37......	Laguna Madre at Carolina Beach pier.....	....	....	May 11, 1942	30	Inf	Special study

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