TEXAS WATER DEVELOPMENT BOARD

REPORT 75

WATER-DELIVERY STUDY

LOWER NUECES RIVER VALLEY, TEXAS

By

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Prepared by the U.S. Geological Survey
in cooperation with the
Texas Water Development Board
and the
Lower Nueces River Water Supply District

May 1968

Published and distributed
by the
Texas Water Development Board
Post Office Box 12386
Austin, Texas 78711

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd.)

Page

TABLES

FIGURES

TABLE OF CONTENTS (Cont'd.)

WATER-DELIVERY STUDY

LOWER NUECES RIVER VALLEY, TEXAS

SUMMARY

The water released to the lower Nueces River from Lake Corpus Christi flows to a channel lake behind Calallen Dam, which is 35 river miles downstream from Lake Corpus Christi. Most of the water in the channel lake is pumped for municipal and industrial use in the Corpus Christi area. Previous studies in the area have shown that water is lost along much of this stretch of the river and that the water increases in mineralization, particularly in the channel lake.

The purpose of this investigation, which began in January 1966 and was completed in March 1967, was to determine the cause of this water loss and increase in mineralization. Two new streamflow stations were installed along the study reach, 37 test holes were drilled in the alluvium of the Nueces River to determine the elevation of the water table and the quality of the ground water, and three investigations were made to determine gains and losses in river flow and the quality of the river water.

The lower Nueces River valley is underlain by sedimentary deposits of Pliocene, Pleistocene, and Recent ages. The alluvium of the flood plain, into which the river is entrenched, consists of unconsolidated clay, silt, sand, and gravel. The width of the flood plain varies from about $\frac{1}{2}$ mile to about 8 miles.

During a seepage study February 21-24, 1966, the river had a net loss of about 8 cfs (cubic feet per second) over an 18-mile reach from a release of 150 cfs. The normal release for this time of year is 86 cfs. Streamflow records show that at this lower release (86 cfs), the river increased in flow along the study reach. The purposely increased flow raised the river stage and created an imbalance between the river and the ground water in the alluvium. At the lower river stage the river received contributions from ground water, and at the higher stage the river lost water.

During a seepage study August 16-18, 1966, the river had a net gain of 4 cfs over an 18-mile reach with a release of 145 cfs. The floods between April and July 1966 apparently had recharged the alluvium along the river in sufficient quantities to satisfy the high evapotranspiration rates and still contribute ground water to the river. The supplementary discharge measurements of February 9, 1967, when the normal stage of the river was held constant by maintaining a flow of 80 cfs, showed that the river had a slight net gain along part of the study reach.

The shallow ground water in the alluvium is in hydraulic continuity with the river. The river loses water to the alluvium or gains water from the alluvium, depending mainly upon the stage of the river, which changes mostly in response to the seasonal demands for water in the Corpus Christi area. This relationship is also affected by water-table fluctuations due to evapotranspiration. When the river stage increases in relation to the water table, river water recharges the alluvium. When the river stage decreases in relation to the water table, water moves from the alluvium into the river. The exchanges of water between the river and the alluvium generally amount to several cfs, and the only appreciable natural and permanent losses from the river are from evaporation or transpiration by the dense vegetation along the river.

Results of the water-quality investigations show that the lower Nueces River water is well within those standards of water quality recommended by the U.S. Public Health Service for public supply. However, investigations have shown increases in mineralization along the study reach, particularly in the Calallen channel lake. Part of these increases are due to contamination by waste waters from oil-field and gravel-washing operations along the river, and part are due to contributions of poor quality ground water from the alluvium.

The quality of water from most of the wells in the alluvium does not meet the standards recommended by the U.S. Public Health Service. The generally poor quality of this water may be due largely to low permeability of the alluvial sediments, which restricts regional ground-water circulation, and to evapotranspiration, which increases the dissolved solids. Chemical analyses of water from test holes in the vicinity of Calallen Dam show highly mineralized water a short distance from the channel lake. Ground water in the area of estuarine conditions downstream from the dam is probably very saline.

INTRODUCTION

The water released from Lake Corpus Christi (impounded by Wesley E. Seale Dam near Mathis) flows down the lower Nueces River into a channel lake behind Calallen Dam, which is 35 river miles downstream from Lake Corpus Christi. Water in the channel lake is pumped for use by the city of Corpus Christi, Nueces County Water Control and Improvement District No. 3, San Patricio Municipal Water District, Celanese Chemical Company, Suntide Refining Company, and cabins along the channel lake. Previous studies have shown that water is lost along this reach of the river and that the water increases in mineralization, particularly in the channel lake.

Purpose and Scope

The purpose of this investigation was to determine the causes of losses or gains of water along the lower Nueces River between Lake Corpus Christi and the upper end of the Calallen channel lake and to determine the causes of changes in the mineralization of water in the Calallen channel lake.

This report is based on data collected from February 1966 to March 1967. During this period, two temporary low-flow stream-gaging stations installed along the study reach of the river supplemented streamflow data collected from the permanent stream-gaging station on the Nueces River near Mathis. Thirty-seven test holes were drilled by the U.S. Geological Survey to determine the

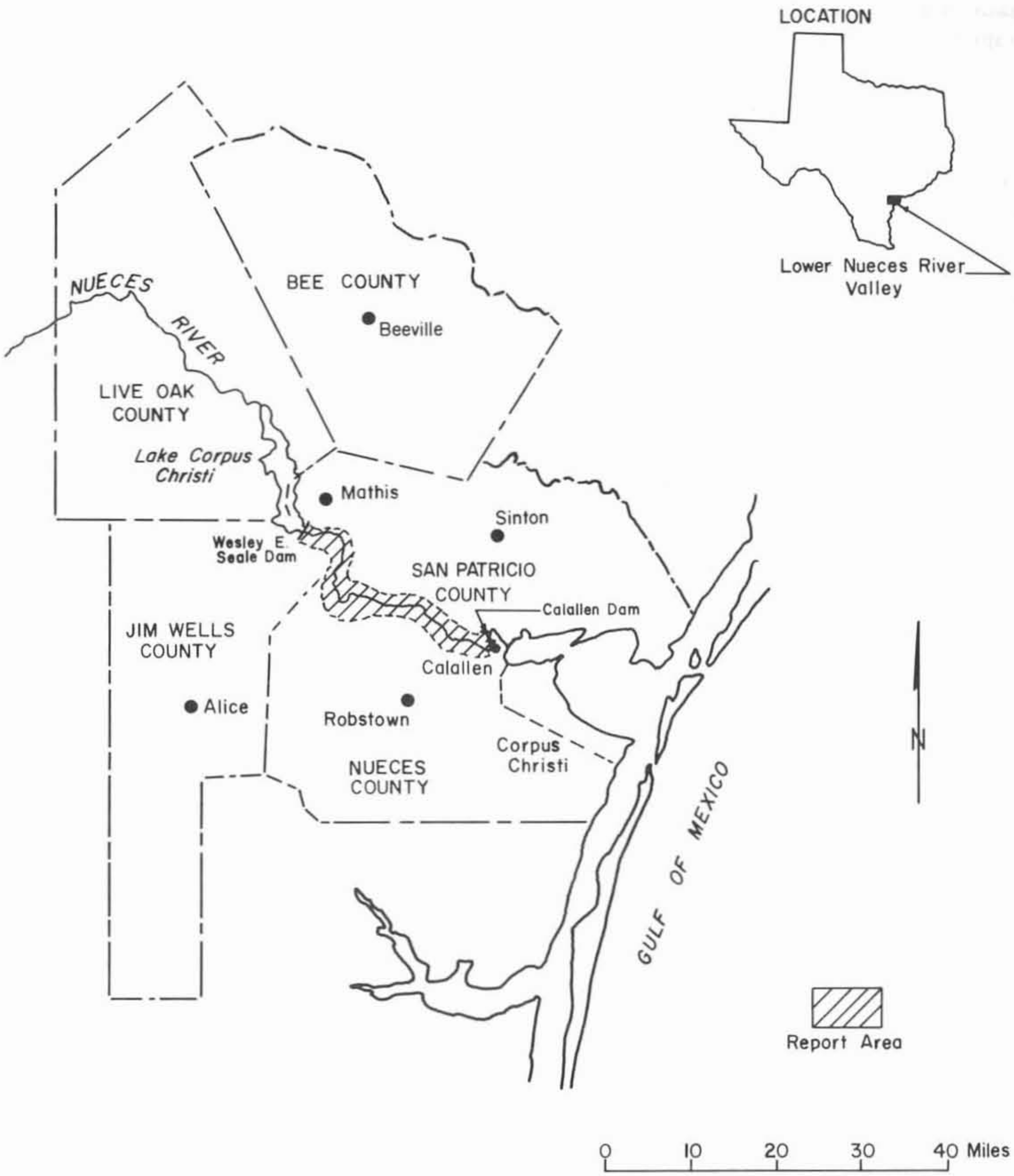

Figure 1

Location of the Lower Nueces River Valley

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

lithology of the sediments along the river and the quantity and quality of water in these sediments; automatic water-level recorders were placed on two of these test holes. To complete the water-level observation program, 13 private wells were added to the test-hole network. Two comprehensive investigations to determine gains, losses, and water quality along the study reach of the river were made in February and August 1966. A short gains-and-losses study between the temporary stream-gaging stations was made in February 1967.

Location and Physical Features

The area of study is that part of the lower Nueces River valley that approximately coincides with the flood plain of the river between Lake Corpus Christi and the dam near Calallen. The general area, which is part of the Gulf Coastal Plain in south Texas, includes parts of San Patricio, Jim Wells, and Nueces Counties (Figure 1).

The topography along the lower Nueces River valley is nearly flat, and most of the flood plain is covered with dense vegetation. Terrace deposits link the flood plain with the more elevated portions of the generally rolling Gulf Coastal Plain. The altitude along the flood plain ranges from about 60 feet above mean sea level immediately downstream from the Wesley E. Seale Dam to less than 10 feet above mean sea level near Calallen.

A few creeks tributary to the Nueces River drain flood waters from the area along the study reach of the river. The most important of these tributaries are Sixmile, Bayou, Sandy Hollow, and Cayamon Creeks.

Climate

According to Thornthwaite (1941, p. 2), the area of study has a dry subhumid climate. Temperatures usually are mild; the normal annual temperature at Corpus Christi (1931-60) is 71.8°F. The average annual precipitation at Sinton, 20 miles east of Mathis, for the period 1931-65 was 29.83 inches. The average annual gross lake-surface evaporation in San Patricio and Nueces Counties (1940-65) was about 60 inches (Kane, 1967). Evaporation is about double the precipitation.

Previous Investigations

In April 1948, the U.S. Geological Survey (1950) made a water-delivery study along the Nueces River between the streamflow station Nueces River near Mathis (0.6 mile downstream from Wesley E. Seale Dam) and a point 25.5 miles downstream. The Texas State Department of Health made studies (Craven, 1960; Classen, 1961) to determine the changes in the chemical quality of the Nueces River water between Lake Corpus Christi and Calallen. During August and October 1963, Sauer and Blakey (1965) made water-delivery and chemical-quality investigations along the Nueces River between the streamflow station near Mathis and the Calallen Dam. In 1966, Shafer (1968) completed a ground-water investigation of Nueces and San Patricio Counties.

Well-Numbering System

The well-numbering system used in this report, which is the system adopted by the Texas Water Development Board for use throughout the State, is based on the coordinates latitude and longitude. Each 1-degree quadrangle in the State is given a number consisting of two digits, which are the first two digits appearing in the well number. Each 1-degree quadrangle is divided into $7\frac{1}{2}$-minute quadrangles that are given 2-digit numbers from 01 to 64, which are the third and fourth digits of the well number. Each $7\frac{1}{2}$-minute quadrangle is subdivided into $2\frac{1}{2}$-minute quadrangles that are given single-digit numbers from 1 to 9. This is the fifth digit of the well number. Each well within a $2\frac{1}{2}$-minute quadrangle is given a 2-digit number, beginning with 01, assigned in the order in which the well is inventoried. These are the sixth and seventh digits of the well number. A 2-letter prefix is used with the well number to denote the county in which the well is found. For example, well WW-83-02-210 is in San Patricio County (WW), in the 1-degree quadrangle 83, in the $7\frac{1}{2}$-minute quadrangle 02, in the $2\frac{1}{2}$-minute quadrangle 2, and is the 10th well inventoried in the $2\frac{1}{2}$-minute quadrangle. Figure 2 shows the location and well numbers for all wells included in this report; Table 1 shows the records of these wells. The number at the well location on the map consists of the last three digits of the well number.

Acknowledgments

Appreciation is expressed to the many ranchers and landowners who allowed access to their properties and gave permission to drill test holes during this investigation. Special thanks are extended to officials of the Lower Nueces River Water Supply District and to personnel of the city of Corpus Christi Water Works, who gave general assistance with various phases of the water-delivery study.

GENERAL GEOLOGY

The lower Nueces River valley is underlain by sedimentary deposits of Pliocene, Pleistocene, and Recent ages. These deposits, from oldest to youngest, are the Goliad Sand of Pliocene age, Lissie Formation of Pleistocene age, Beaumont Clay of Pleistocene age, and the Pleistocene and Recent alluvium of the Nueces River (Figure 2).

The Goliad Sand is chiefly sand and sandstone, with interbedded gravel, clay, and silt. The Goliad is an important aquifer in parts of the Gulf Coastal region, but in the area of the lower Nueces River, much of the formation contains saline water (Wood, Gabrysch, and Marvin, 1963). In the northwestern quarter of the area of the report, the Goliad Sand directly underlies the alluvium of the Nueces River.

The Lissie Formation consists of alternating, thin to thick beds of light-colored sand, gravel, sandy clay, and clay. Extensive caliche deposits occur on the outcrop, and the sand and gravel beds are mostly discontinuous. Near the center of the area, the Lissie directly underlies the alluvium. Saline water in parts of the Lissie Formation make it a poor aquifer.

The Beaumont Clay is a varicolored calcareous clay which contains thin beds of silt and medium to fine sand. The formation is unimportant as an aquifer. In the lower half of the area of the report the Beaumont directly underlies the alluvium.

The alluvium of the Nueces River consists of unconsolidated deposits of black and white clay, fine to coarse sand, silt, and gravel. (See Table 2 for drillers' logs of test holes.) The surface material of the flood plain consists of silt and clay of low permeability. The underlying sand and gravel beds, which are more permeable than the silt and clay, are discontinuous over short distances.

Several short-term pumping tests of shallow wells tapping part of the alluvium have shown that the alluvium has generally low permeability. The thickness of the alluvium was not determined by the drilling program in this investigation. However, Ambursen Engineering Corporation and Myers and Noyes and Associates (1952) state that the thickness of the alluvium may vary from 80 to 160 feet. The alluvium of the Nueces River has been tapped by several small-capacity wells used chiefly to supply domestic and livestock water.

HYDROLOGY

River Gains and Losses

Results of Previous Investigations

During April 20-22, 1948, the U.S. Geological Survey (1950) completed a water-delivery study of the lower Nueces River. The reach studied was between the streamflow station Nueces River near Mathis (reference point 0.0 mile), which is 0.6 mile downstream from Wesley E. Seale Dam, and a point 25.5 miles downstream. Although a loss of 4.7 cfs (cubic feet per second) was noted in the first mile and another loss of 1.8 cfs between mile 10.9 and mile 13.4, the net loss in the study reach of the river was less than 1 cfs of 35.3 cfs passing the station near Mathis.

During August 28-31, 1963, Sauer and Blakey (1965) made a water-delivery study between the streamflow station near Mathis and Calallen Dam. Out of a release of 149 cfs from Lake Corpus Christi, about 15 cfs was lost between the station near Mathis and the upper end of the Calallen channel lake (mile 25.8). In this study there were two major losing reaches; the first was between mile 0.0 (stream-gaging station near Mathis) and mile 2.8 (loss of 8 cfs), and the second was between mile 10.8 and mile 13.4 (loss of 7 cfs). A high river stage plus a large evapotranspiration rate probably were the chief reasons for the water losses. Supplemental measurements were made during October 9-10, 1963, to confirm the losses. Only the second losing reach was substantiated (by measurements between mile 10.5 to mile 11.7) with a loss of 6 cfs out of 142 cfs measured at the station near Mathis. A decrease in the river losses of 9 cfs from August to October probably was due to the combination of decreases in both river stage and evapotranspiration.

Results of Current Investigation

The results of determining river gains and losses in this investigation are presented in Tables 3, 4, and 5. The accuracy of the discharge measurements is excellent, as each measurement is considered to have not more than $2\frac{1}{2}$ percent error. On this basis most of the apparent losses and gains are within the limits of error, but because measurements made during previous investigations gave similar results, the losses or gains recorded in this investigation are probably real.

Table 3 shows the summary of the discharge measurements of the lower Nueces River and tributaries between Lake Corpus Christi and Calallen channel lake made during February 21-24, 1966. Twelve measurements of streamflow were made of the mainstream from the streamflow station near Mathis to a point about 20 miles below this station. Releases from Lake Corpus Christi were increased from the normal flow of about 86 cfs on February 19 to about 150 cfs on February 20, and measurements were made after the flow of the river had reached equilibrium at 150 cfs. Eight cfs was lost in the first 1.7 miles, but this loss was regained between mile 9.1 and mile 9.8. Between miles 10.8 and 12.7, the stream lost 7 cfs, but most of this loss was regained by mile 16.5. Measurements at miles 16.5 and 18.2 show that a loss of 6 cfs occurred between these points. The total net loss out of 150 cfs in the reach between miles 0.0 and 20.5 was 8 cfs.

A similar set of discharge measurements made during August 16-18, 1966 (Table 4), showed a net gain of 4 cfs in the reach between the streamflow station near Mathis, where 145 cfs was measured, and a point 10.8 miles downstream where 149 cfs was measured. No net losses or gains occurred between mile 10.8 and mile 18.2, a major losing reach during the February measurements.

Figure 12 (page 65) shows locations and results of all discharge measurements of the mainstream and tributaries during February and August 1966. Also shown are the location of the stream-gaging station Nueces River near Mathis, the location of the temporary stream-gaging stations Nueces River below Mathis (mile 9.8) and Nueces River above Calallen (mile 18.2 at Bluntzer Bridge), and partial results of the chemical analyses of surface-water samples at various sites.

Table 5 shows supplementary discharge measurements made between mile 9.8 and mile 18.2 on February 9, 1967. The daily mean discharge of 80 cfs at mile 9.8 (from temporary stream-gaging station record) increased to a mean of 83 cfs at mile 18.2 (from temporary stream-gaging station record).

Hydrographs of the daily mean discharges at the temporary stream-gaging stations are shown in Figure 3 for the period January 1966-February 1967. The monthly mean discharges at all three stream-gaging stations for the same period are shown in Figure 4.

The discharge measurements made during February 21-24, 1966, indicated a net loss between the temporary stream-gaging stations. Prior to increasing the stage by increasing the flow from 86 to 150 cfs, the stream made consistent gains in flow between the two stream-gaging stations. The monthly mean discharge (Figure 4) for February shows an increase of about 7 cfs between the two temporary stations and shows an increase of about 4 cfs between the station Nueces River near Mathis and the first downstream temporary station. The river stage for the period February 12-15 also was increased purposely for initiating

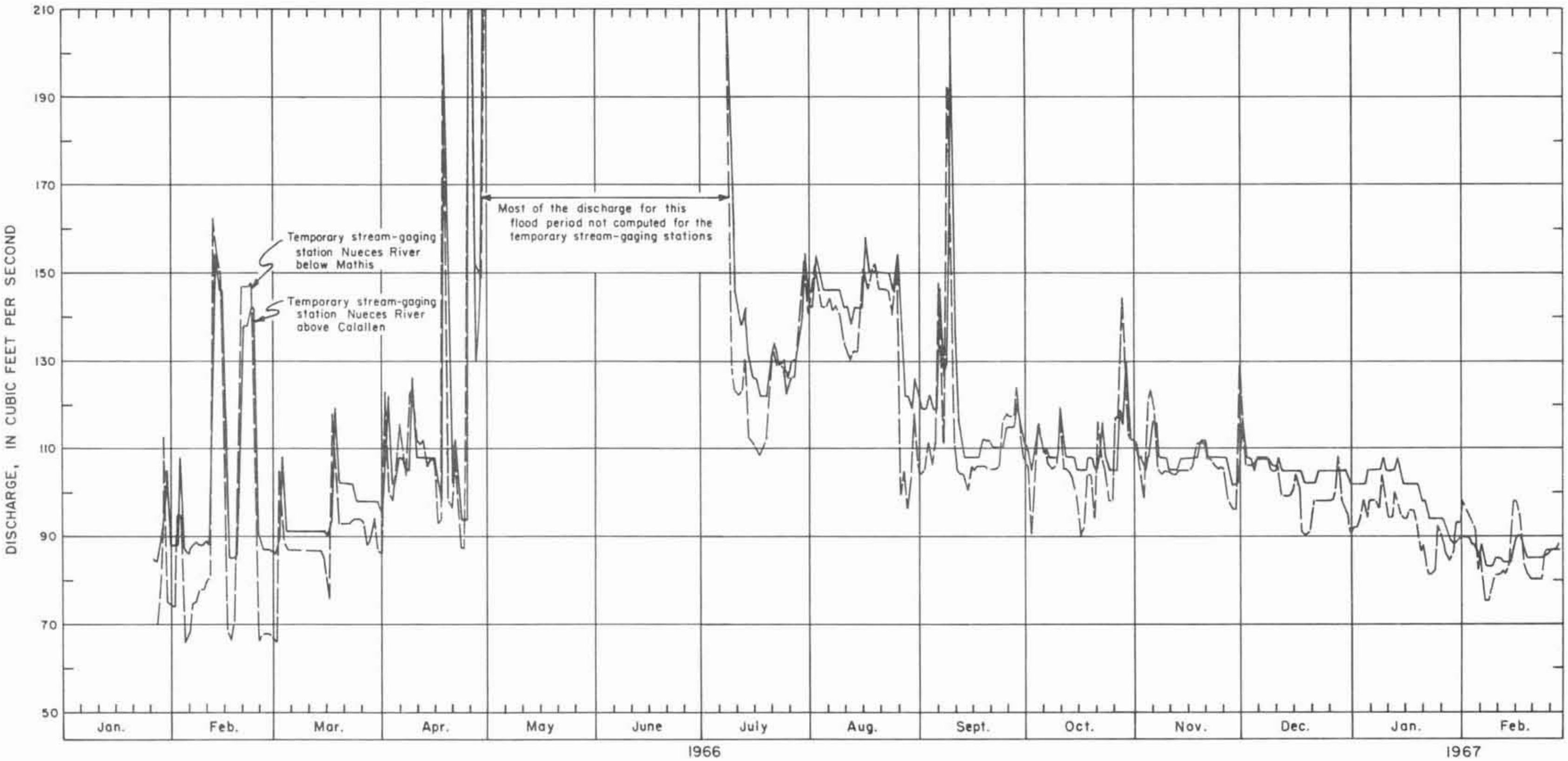

Figure 3

Daily Mean Discharge of the Lower Nueces River, January 1966 - February 1967

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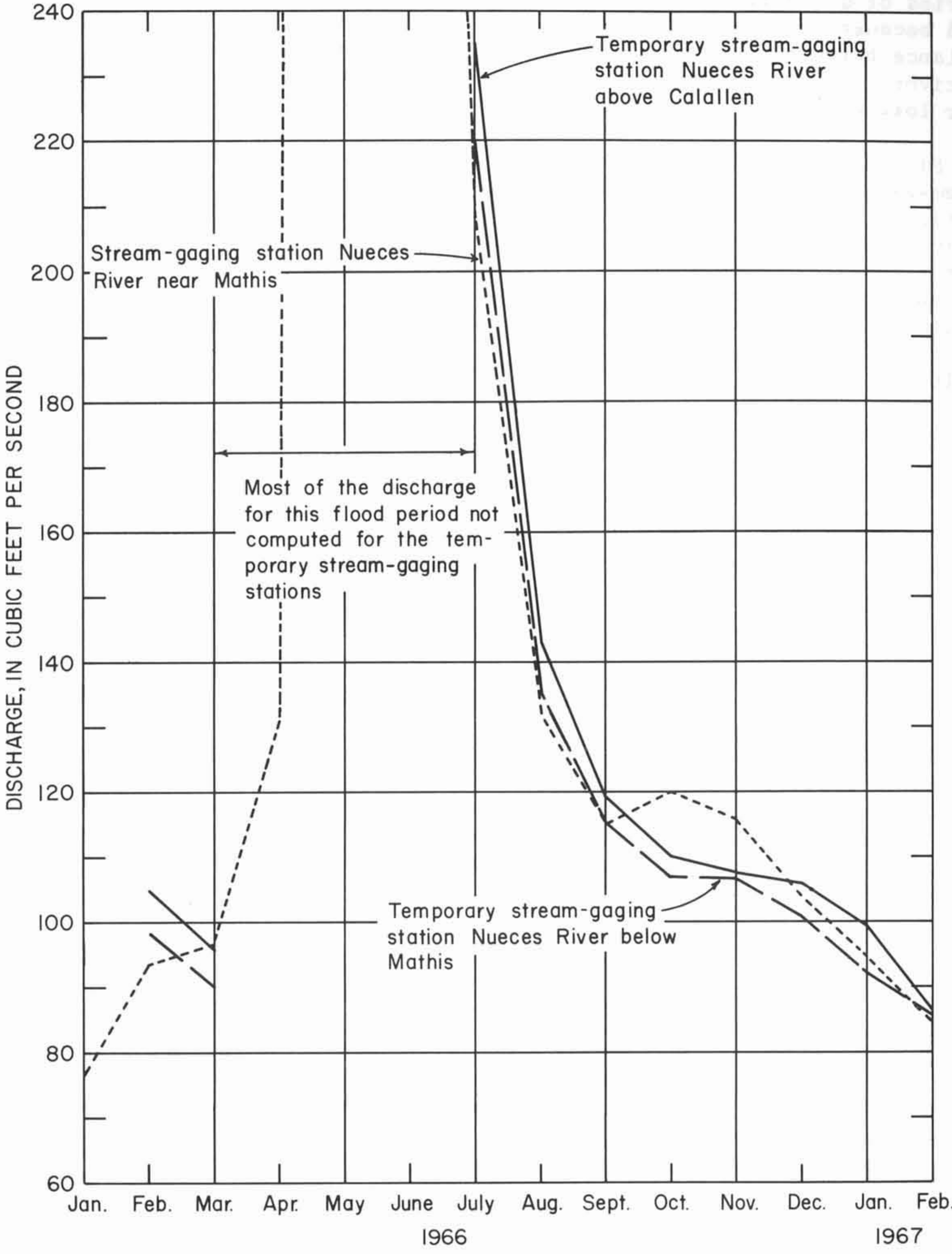

Figure 4

Monthly Mean Discharge of the Lower Nueces River, January 1966 - February 1967

U.S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

a series of discharge measurements, but the discharge measurements were postponed because of rain. The increase in river stage at this time created an imbalance between the river and ground-water storage. At the lower river stage the river received contributions from ground water, and at the higher stage the river lost water.

Figure 3 shows continued gains in river discharge between the temporary stream-gaging stations in March, but these gains decreased substantially during the first three weeks in April. This decrease probably is due to the increase in river stage plus the seasonal increase in evapotranspiration. For a particular river stage, gains may occur during the winter when evapotranspiration is low, and losses may occur during the spring and summer when evapotranspiration is high. These losses, if any, were not detected during this investigation because the temporary streamflow stations were installed for low-flow studies, precluding computation of flood flows during the period April 29-July 8, 1966.

During the rest of the period of record for this investigation, July 1966-February 1967, a net increase in discharge of several cfs occurred in the reach for almost every month (Figures 3 and 4). Ground-water storage apparently was recharged sufficiently during the floods so that ground water supplied most of the high evapotranspiration demand during part of this remaining period of record and still contributed water to the river. Except for October and November 1966, when several cfs for each month was lost between the regular station near Mathis and the last downstream temporary station, all data indicate net gains after the flood period throughout the study reach of the river (Figure 4). The net loss in October and November was due to an increase in the release of water from Lake Corpus Christi from a monthly mean of 115 cfs in September to a monthly mean of 120 cfs in October. The resulting increase in river stage was reflected by the immediate losses in the stretch of river between mile 0.0 and mile 9.8. These losses continued into November, but by December the releases were decreased to a river stage where the adjacent water table was contributing water instead of taking water, and the net effect throughout the reach was a gain in stream discharge. (See the discharges for the three streamflow stations in Figure 4.)

Ground Water in the Nueces River Alluvium

The alluvium which underlies the lower Nueces River flood plain, consisting of unconsolidated deposits of clay, silt, sand, and gravel, yields only small quantities of water to a few wells. Some of the test holes drilled into the alluvium by the U.S. Geological Survey were tested with low-capacity pumping equipment for periods of less than 1 hour. Yields varied from a fraction of a gallon per minute to about 2 gpm (gallons per minute), and specific capacities were all less than 1 gpm per foot of drawdown. The water in the alluvium is partly from direct infiltration of rain water in the small sandy outcrops along the river and partly from the infiltration of river water.

Relation to Nueces River

Figures 5, 6, and 7 show the altitude of water levels in wells tapping the alluvium along the lower Nueces River valley for April 4-6, June 6-7, and August 2-3, 1966, respectively. The areas of alluvium selected for most of the test drilling and water-level investigations were those adjacent to the river

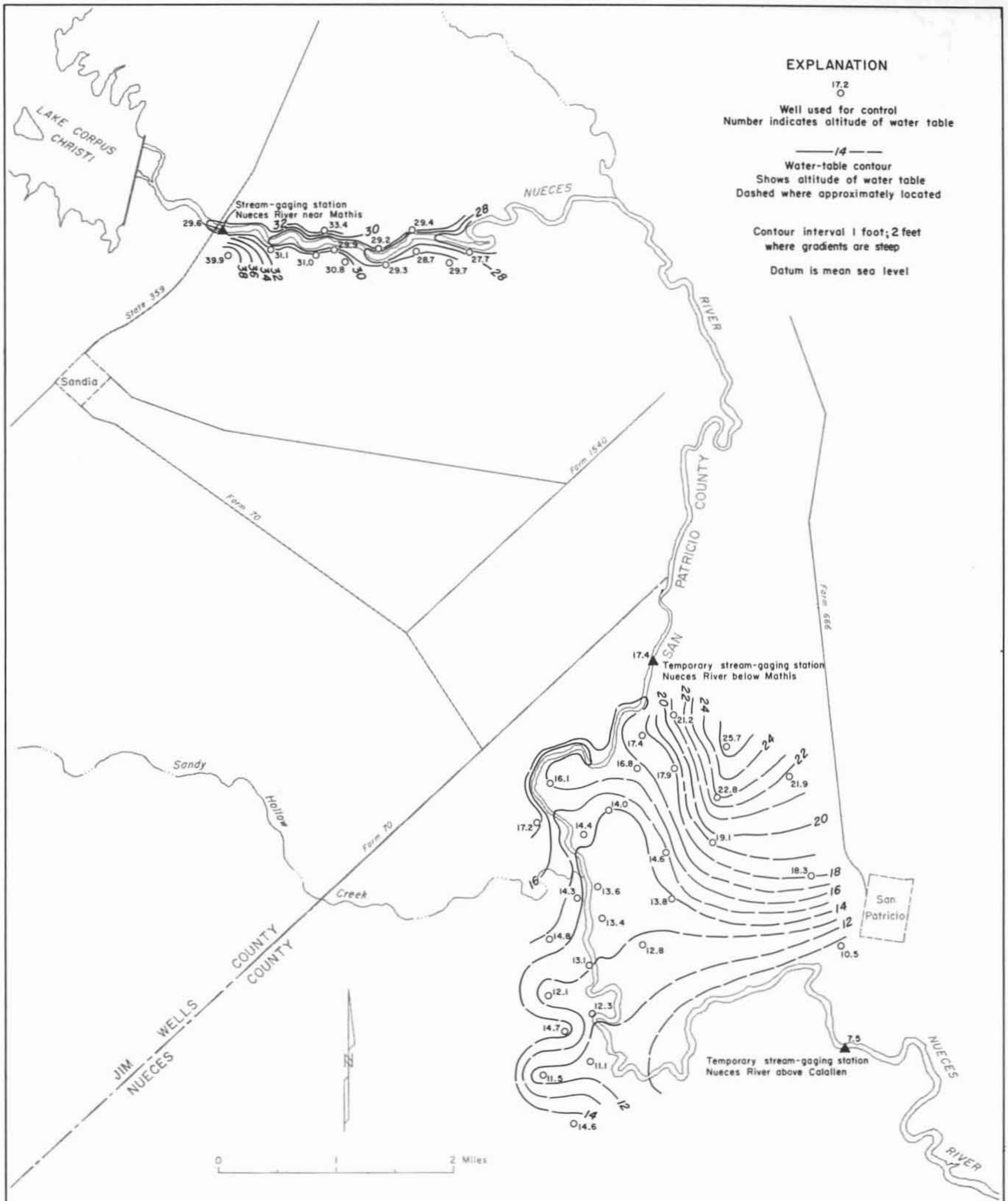

Figure 5

Altitude of the Water Table in the Alluvium, April 4-6, 1966

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

Base from U. S. Geological Survey topographic quadrangles

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

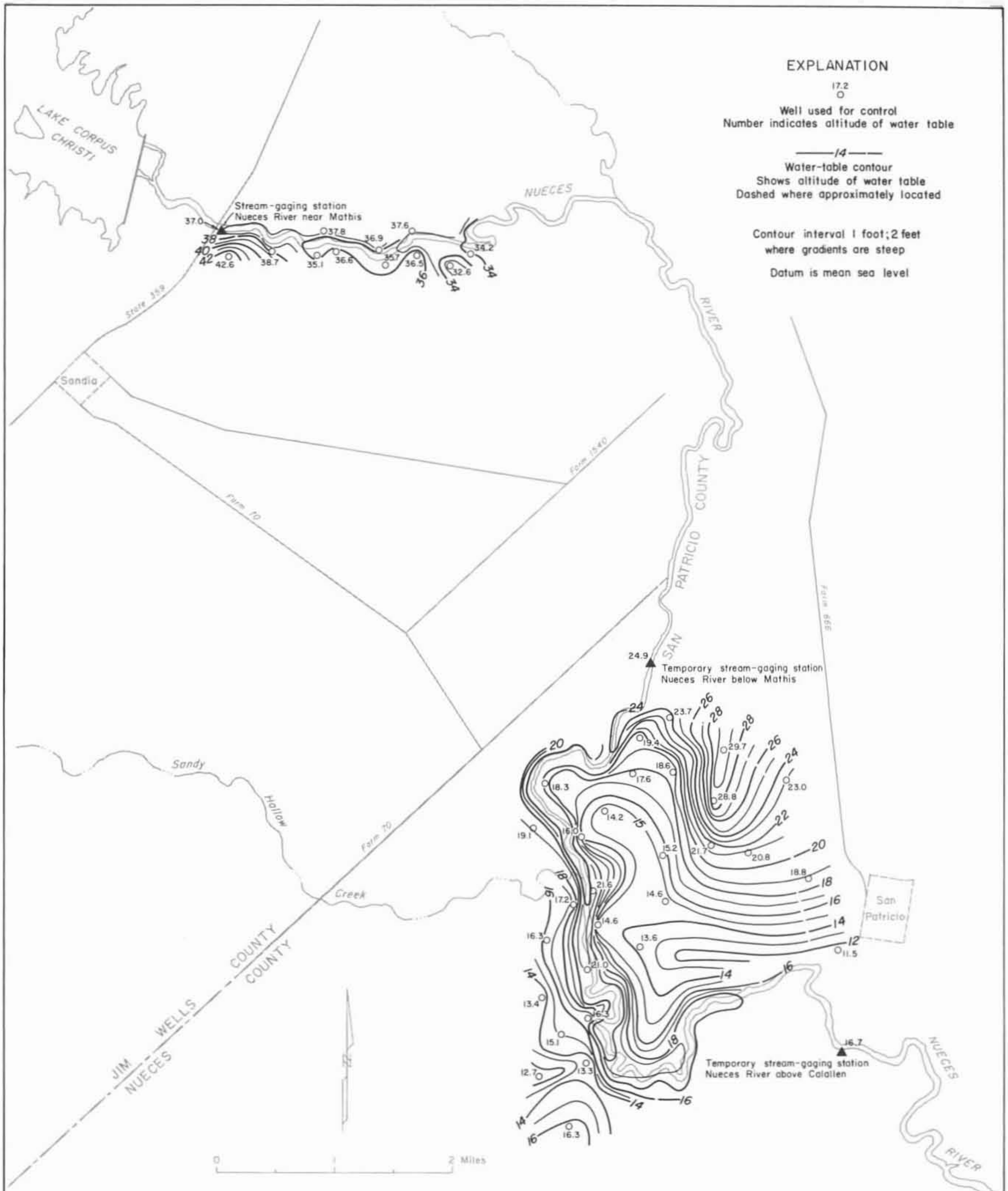

Figure 6

Altitude of the Water Table in the Alluvium, June 6-7, 1966

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

Base from U. S. Geological Survey topographic quadrangles

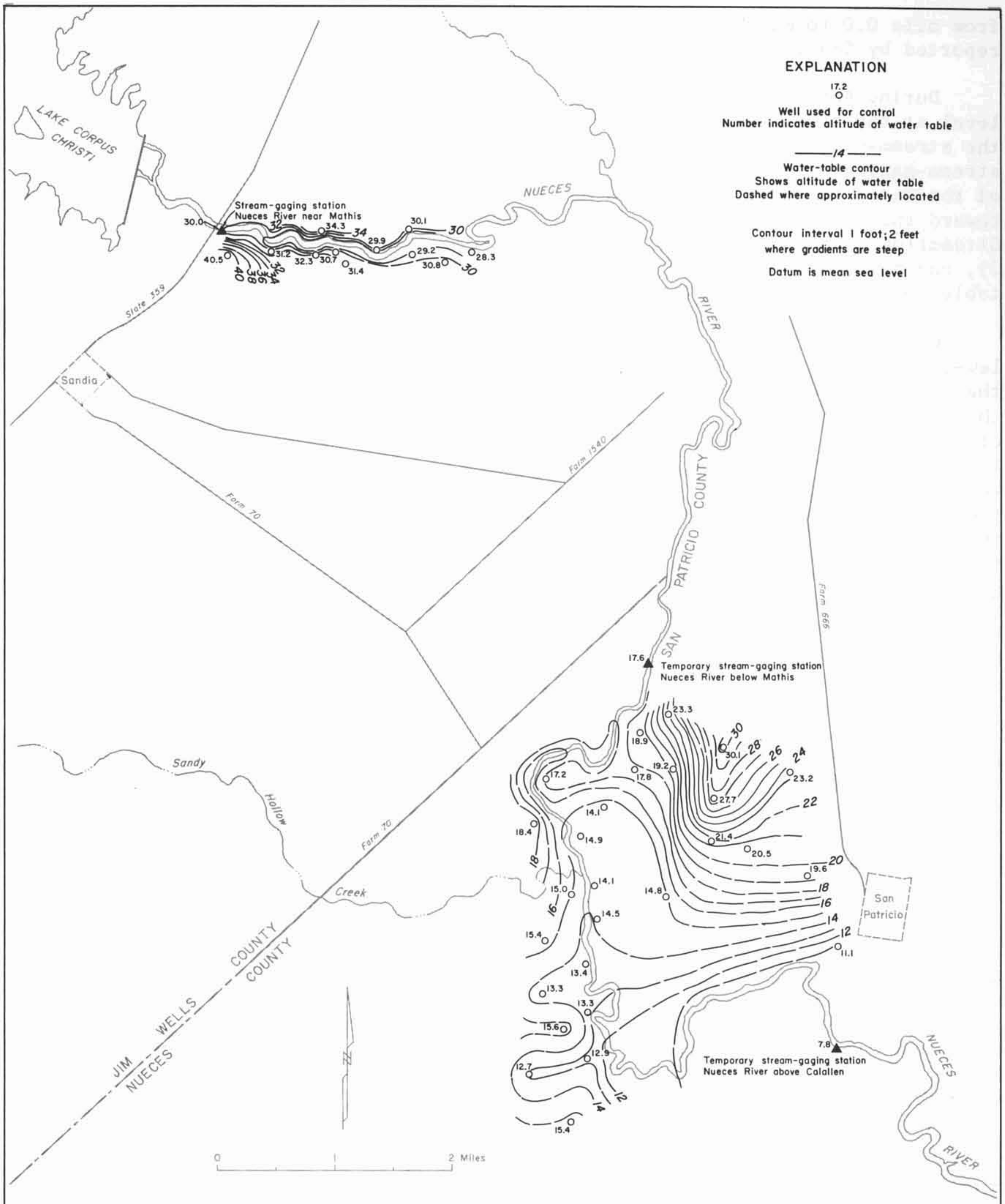

Figure 7

Altitude of the Water Table in the Alluvium, August 2-3, 1966

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

from mile 0.0 to mile 2.5 and from mile 10.8 to mile 18.2, which are the reaches reported by Sauer and Blakey (1965) to be the main losing reaches of the river.

During April 4-6, 1966, the river stage was nearly 30 feet above mean sea level at the stream-gaging station Nueces River near Mathis, over 17 feet at the stream-gaging station Nueces River below Mathis, and over 7 feet at the stream-gaging station Nueces River above Calallen. The general configuration of the water table (Figure 5) indicates that water in the alluvium was moving toward the river, although in places movement of water was away from the river. Streamflow records during early April show little net gains or losses (Figure 3), and probably the stage of the river was near equilibrium with the water table in the alluvium at that time.

During June 6-7, 1966, the river stage was about 37 feet above mean sea level at the stream-gaging station Nueces River near Mathis, about 25 feet at the stream-gaging station Nueces River below Mathis, and just under 17 feet at the stream-gaging station Nueces River above Calallen. At that time the stage of the river was higher than the water table adjacent to the river between the two temporary stream-gaging stations (Figure 8), and the configuration of the water table near the river in this area indicates that water was moving from the river into the alluvium (Figure 6). Ground water in the alluvium south of the river near the stream-gaging station Nueces River near Mathis was moving toward the river. The high water table in this area may be related to the high ground-water regimen near Lake Corpus Christi, or it may be a perched water table; in either case the water-level configuration shown in this area (Figure 6) may not be significant. The water table adjacent to the river in the area between the temporary stream-gaging stations had a relatively steep gradient away from the river. These relatively large losses in head over short distances illustrate the generally low permeability in some of the alluvial sediments along the river. The high water table more distant from the river, although probably affected by the general recharging of the alluvium adjacent to the river, was also partly the result of direct infiltration of rainfall. The direction of movement of water in this more distant area was, nevertheless, still toward the river. (See Figures 5 and 6 for comparison of direction of movement of ground water distant from the river in the area between the temporary streamflow stations.)

During August 2-3, 1966, the river stage was about 30 feet above mean sea level at the stream-gaging station Nueces River near Mathis, nearly 18 feet at the stream-gaging station Nueces River below Mathis, and nearly 8 feet at the stream-gaging station Nueces River above Calallen. At this time, after the river stage had receded from the recent flooding period, the general direction of ground-water movement in the alluvium was toward the river (Figure 7). Streamflow records for August 1966 substantiate this condition by indicating river gains between all three stream-gaging stations (Figure 4).

Fluctuations of Water Levels

Figure 8 shows hydrographs of the water levels in representative wells tapping the alluvium of the lower Nueces River valley. Locations of these wells are shown in Figure 2. Wells WW-83-02-218, WW-83-02-304, and UB-83-02-517 are about a mile from the river. The remainder of the wells represented on the hydrographs are generally within 1,000 feet of the river.

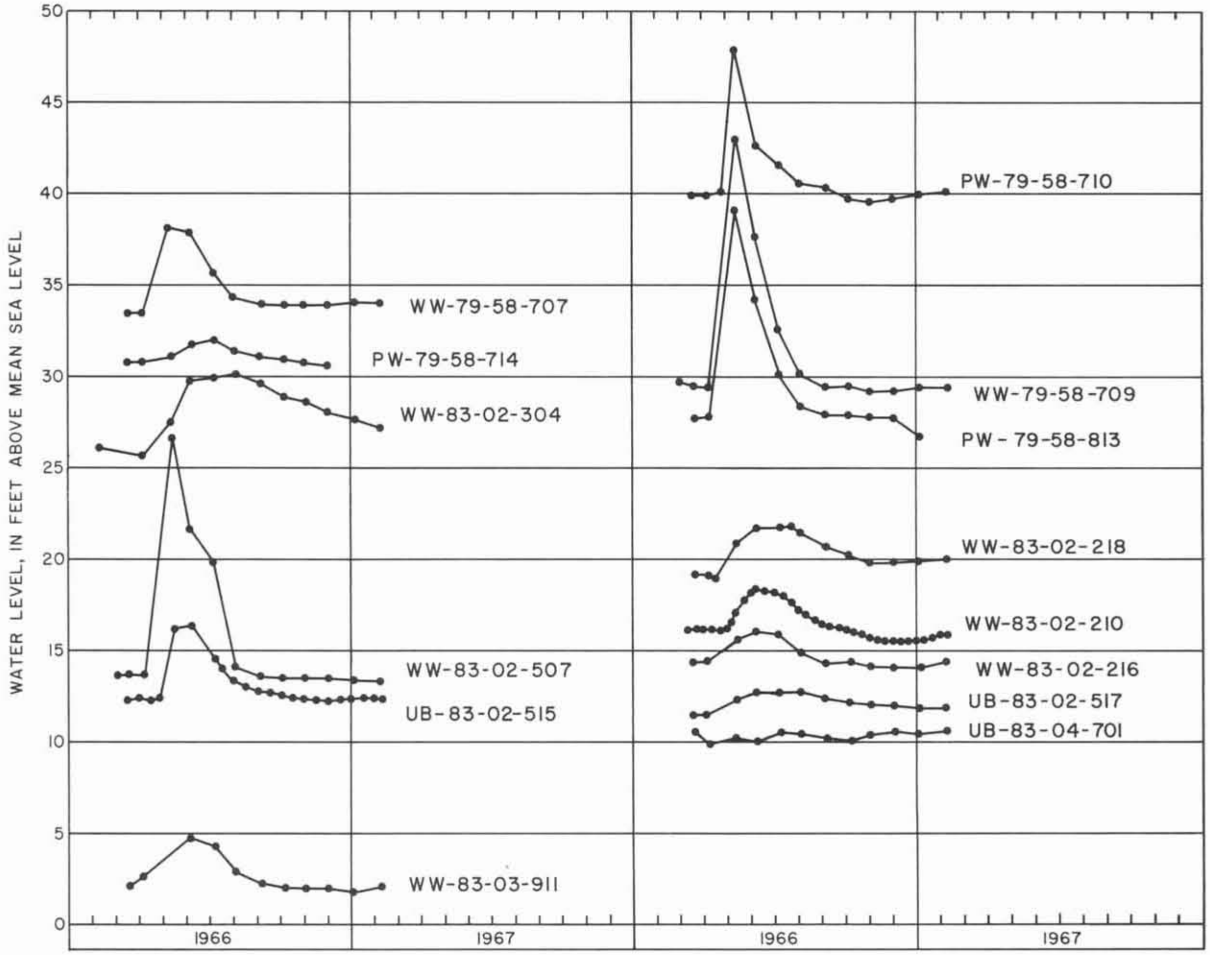

Figure 8

Hydrographs of Representative Wells in the Alluvium

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The water levels in those wells adjacent to the river had a wide range in fluctuation during 1966, rising rapidly during the April-July floods and receding to those levels prior to the floods by September or October (Figure 8). This was not entirely the case with the wells farther away from the river. Here the levels in wells fluctuated similarly during 1966, but in some of the wells the levels remained above the pre-flood levels during the receding period in late 1966 and early 1967. Overland flooding by the river during 1966 was confined to small low-lying areas, and therefore any recharge to the alluvium distant from the river was not from this overland flooding but, at least in part, by direct infiltration of rainfall. Seemingly, the water levels in wells adjacent to the river are controlled almost entirely by the stage of the river, whereas levels in wells more distant from the river are affected by both the river stage and infiltration from rainfall on the outcrop.

The water levels in well UB-83-04-701, near the Calallen channel lake (Figure 2), do not correlate with any levels of other wells in the immediate area. This well is located in what appears to be a ground-water mound. Here the water table is several feet higher than the level of the channel lake and also higher than the water table in other places adjacent to the lake. (See differences in levels between wells UB-83-04-701 and WW-83-03-911 in Figure 8.) The source of water to this ground-water mound is probably waste water disposed from plant operations which treat the water supply for the city of Corpus Christi. The lack of any large water-level fluctuations in well UB-83-04-701 suggests that the waste water may be infiltrating at a relatively regular and steady rate.

All water levels in test holes and other wells measured during this investigation are presented in Table 6.

QUALITY OF WATER

Lower Nueces River

Table 7 shows the results of the chemical analyses of water from the lower Nueces River and its tributaries between Lake Corpus Christi and the Calallen Dam during February 21-24, 1966. Table 8 shows the results of the analyses of the sampling during August 16-18, 1966. The location of the sampling sites along the river and partial results of the analyses are shown in Figure 12. During the sampling in February and August, supplemental samples were taken at other sites along the river to determine chloride content and specific conductance. Results of these determinations are shown in Tables 9 and 10, which also include locations of sampling sites, time of sampling, and temperature of the sampled water.

Results of the water-quality investigations of the river show that the lower Nueces River water is well within the standards of water quality recommended by the U.S. Public Health Service (1962, p. 7) for public water supplies. However, chemical analyses of the samples taken during February and August from throughout the study reach show increases in mineralization in the downstream direction (Tables 7 and 8). In February, the chloride content increased from 35 ppm (parts per million) at the upstream end of the reach to 72 ppm at the downstream end. During August, the increase in the same reach was from 25 to 67 ppm. Investigations by the Texas State Department of Health (Craven, 1960;

Classen, 1961) have shown slightly greater increases in river-water mineralization throughout the same reach during January 1960 and from December 1961 to January 1962; average flows during these periods were 91 cfs and 97 cfs, respectively. The Texas State Department of Health concluded that the increase in mineralization is caused by waste waters discharging into the river from oil-field and gravel-washing operations along the river. Sauer and Blakey (1965) reported less increase in mineralization during their investigation in August 1963, when the flow was between 133 and 149 cfs, than that which occurred in either the present investigation or in the Texas State Department of Health study.

All of the above investigations showed increases in the mineralization of the river water between Lake Corpus Christi and Calallen Dam that varied in magnitude from one time to another. The differences may be explained partly by the fact that the greater the quantity of water released from Lake Corpus Christi, the less the percentage of increase in mineralization. Contributions of ground water from the alluvium to the river, which normally occur during the winter but which do occur any time that the water table is higher than the river stage, add to the mineralization of the river water. Also, the probably irregular disposal of waste waters into the river by oil-field and gravel-washing operations may cause irregular increases in mineralization of the water.

Figure 9 shows the chloride content of the lower Nueces River water along the study reach during the February and August investigations in 1966. The overall chloride content during August was less than during February, probably because of the effects of the April-July flooding conditions. (See Tables 7 and 8 for comparison of general quality of water.) Generally, slight net increases in chloride content may be noted between mile 0.0 and about mile 22 during both investigations. The Cayamon Creek tributary at mile 23.7 added 1.41 cfs of water (1,310 ppm chloride) during February to the Nueces River flow, and the chloride content increased by a few ppm at mile 24 (Figure 9). Approximately the same condition occurred during August.

The largest increases in chlorides during both investigations were from about mile 33 to Calallen Dam at mile 34.4 (Figure 9). All large pumping facilities for water supply are along this stretch of the river. Although the cause of these increases could not be determined during the study, two factors, which under different hydrologic conditions could account for large salinity increases, can be ruled out. These are inflow into the lake of highly saline ground water in the alluvium adjacent to the lake and increase in mineralization of the lake water by concentration from evaporation.

Test drilling near the dam has shown that the lake surface is higher than the adjacent water table in the alluvium, and for this reason, the saline ground water is not entering the lake. A similar relationship between lake water and ground water probably exists at least for several miles upstream from the dam. Although evaporation tends to increase the mineralization of the lake water, the exposure of the water to evaporation is not sufficient to cause the sharp increases near the lower end of the lake.

Definite conclusions have not been reached therefore regarding all causes of increases in mineralization of the water in the Calallen channel lake. However, these increases are small and the quality of the water is well within the standards of the U.S. Public Health Service. The results of this investigation will serve as a guide to more comprehensive studies in this area, if necessary.

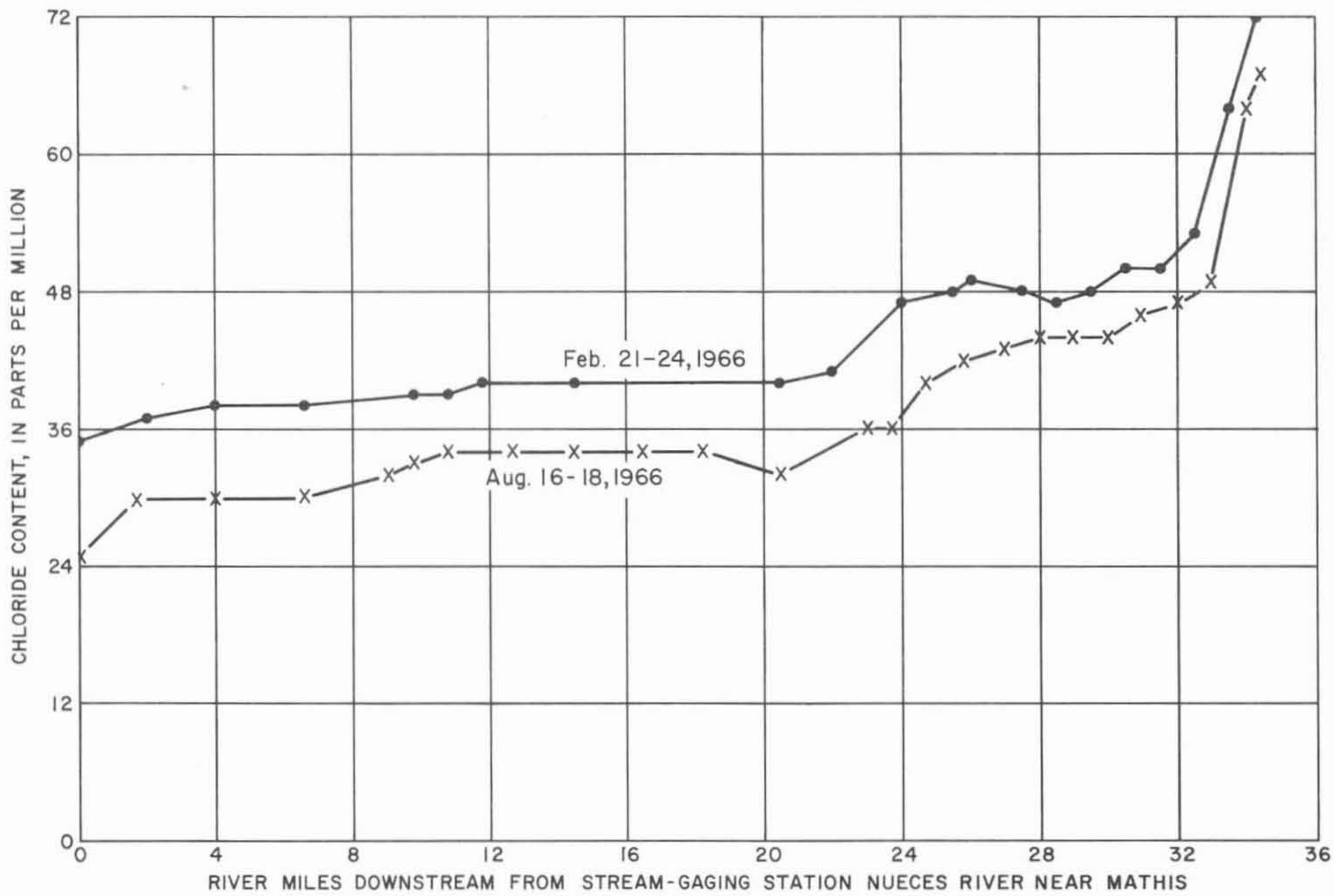

Figure 9

Chloride Content of the Lower Nueces River Water, February 21-24 and August 16-18, 1966

U. S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

Nueces River Alluvium

Area Near the Losing Reaches of the River

Figure 10 shows the dissolved-solids and chloride content in April 1966 and the chloride content in July 1966 in water from wells tapping the alluvium of the lower Nueces River valley. Generally, the chemical quality of the ground water in the alluvium near the losing reaches of the river (mile 0 to mile 2.5 and mile 10.8 to mile 18.2) is poor. The quality of water from most of the test holes in the alluvium does not meet the standards recommended by the U.S. Public Health Service for public supplies. Although the water in the alluvium may be contaminated by industrial wastes in certain places, the generally poor quality may be largely due to the low permeability of the alluvial sediments, which restricts regional ground-water circulation. Transpiration by the dense vegetation in the valley affects the quality of the water because this process removes very little of the dissolved solids, increasing the concentration in the reduced volume of water that remains.

The chemical quality of water from the alluvium in some test wells improved from April to July 1966, but was degraded in others during the same period (Figure 10). Those areas having quality-of-water improvement were probably recharged by the river or by direct rainfall during the flooding between April and July. The quality of water in the alluvium varies from place to place and time to time as a result of changes in the patterns of circulation. All chemical analyses of water collected during this investigation from wells tapping the alluvium are shown in Table 11.

Area Near Calallen Dam

Five test holes were drilled in the alluvium a short distance from the channel lake near Calallen Dam. Chemical analyses of the water from these test holes indicate the presence of highly mineralized water (Figure 10). Estuarine conditions exist a short distance downstream from the dam, and most of the ground water in this general vicinity probably is very saline.

Figure 11 illustrates the approximate relation between ground water and the Calallen channel lake at a point just upstream from the dam. The chloride content in both the lake water and ground water is shown for various times during 1966 and 1967. Under the conditions illustrated in Figure 11, lowering of the lake level below the water table would cause ground water to enter the lake and would endanger the quality of the water in the lake. During 1966, the lake level fluctuated between 5 and 6 feet above mean sea level and was several feet higher during the flooding period between April and July. Part of the water table west of the lake had a slight gradient toward the lake in the winter of 1967. This probably is due to equilibrium conditions established by the evapotranspiration demands. During spring and summer when evapotranspiration demands are maximum, the gradient of the water table toward the wooded area along the lake probably is greater.

The chemical quality of the water from test hole UB-83-04-701, which is north of Calallen, on the east side of the channel lake, and near the water-treatment plant of the city of Corpus Christi, indicates relatively good ground water in this area (Figure 10). Water levels in this well, compared with the levels in other wells in this vicinity, show evidence of a ground-water mound (Figure 8). The source of water to this mound appears to be waste water from the treatment plant. Part of this waste water is placed in an earthen tank north of the plant, and part is disposed through a drainage ditch that discharges the water into the channel lake 200 feet upstream from Calallen Dam. Some waste water from the tank and ditch probably infiltrates the land surface and, in the course of time, has built up the ground-water mound. Because the mound is normally higher than the lake level, ground water from the mound is probably migrating westward and discharging into the lake. The relative quantities of these additions to the lake are unknown. However, the 1966 annual statistical report by the city of Corpus Christi Water Division (1966) on the Corpus Christi Water Works indicates an average waste-water (washwater) production of less than 1 cfs. (The average annual production of washwater for the period 1961-66 was about 230 million gallons.) The maximum rate of disposing part of this washwater through the drainage ditch appears to be not more than a few cfs.

CONCLUSIONS

The shallow ground water in the alluvium along the lower Nueces River is in hydrologic continuity with the river. The river loses water to the alluvium or gains water from the alluvium depending primarily upon the river's stage. This relationship is affected also by water-table changes due to seasonal evapotranspiration demands. When the stage of the river increases in relation to the water table, as from winter to summer, water from the river moves into the alluvium. When the stage of the river decreases in relation to the water table, as from summer to winter, water from the alluvium moves into the river.

The quantity of water exchanged between the alluvium and the river depends on the permeability and porosity of the alluvial sediments and on the hydraulic gradient established by differences between river and water-table stages. The exchanges usually amount to only several cfs, but maximum rates, which normally occur for only short periods, could be as much as 15 to 20 cfs. The only appreciable natural and permanent losses from the river appear to be associated with evapotranspiration. Losses of water from the alluvium by pumping wells and by leakage to underlying aquifers probably are very small.

Part of the increases in mineralization of the lower Nueces River water between Lake Corpus Christi and Calallen Dam is due to contamination from waste waters from oil-field and gravel-washing operations along the river and in part to contributions of ground water of inferior chemical quality from the alluvium. The largest increase in mineralization occurs along the stretch of the Calallen channel lake where the major pumping for water supply is located. Nevertheless, the total increases in mineralization are small and the quality of the water in the Calallen channel lake is well within the standards established by the U.S. Public Health Service.

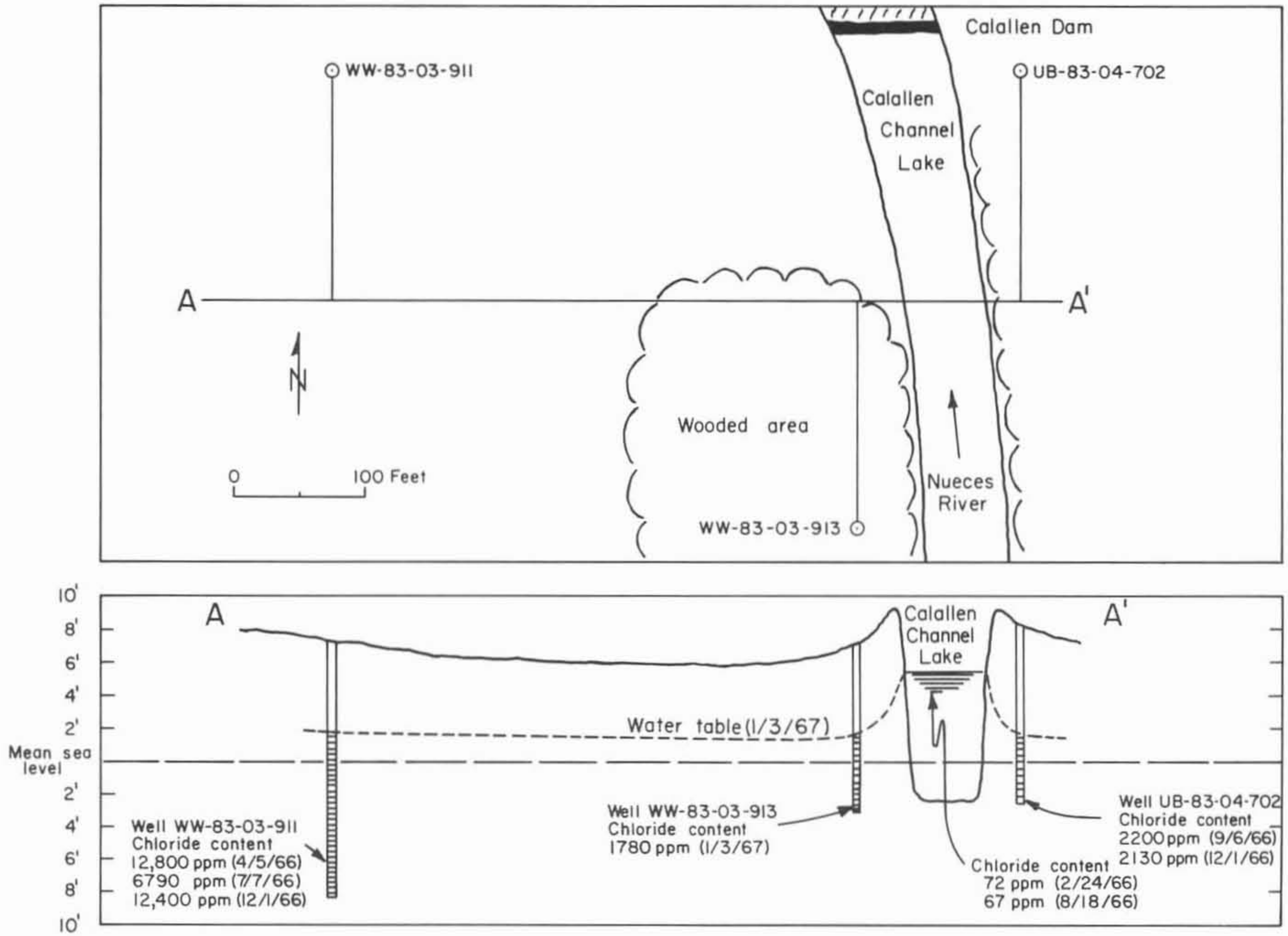

Figure 11

Calallen Dam Area and Section Showing Relation Between Ground Water and the Calallen Channel Lake Near Calallen Dam

U.S. Geological Survey in cooperation with the Texas Water Development Board and the Lower Nueces River Water Supply District

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Table 1.--Records of test holes and wells in the lower Nueces River valley

All U.S. Geological Survey test holes are machine-bored into the alluvium except where noted in Remarks. All other wells are drilled and tap the alluvium unless otherwise noted in Remarks.

Method of lift and type of power: C, cylinder; E, electric; N, none; S, submergible; T, turbine; W, windmill. Number indicates horsepower.
Use of water : D, domestic; Irr, irrigation; N, none; S, livestock.

Well	Owner	Driller	Date completed	Depth of well (ft)	Diameter of well (in.)	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
						Jim Wells County					
PW-79-58-702	Brumme Estate	-- White	1958	174	--	105	72.8	Feb. 8, 1967	C,E	S	Well taps Goliad Sand.
710	Dan Meany	USGS	1966	37	4	52.1	12.0	do	N	N	USGS test hole 17.
711	do	do	1966	37	4	54.5	23.5	do	N	N	USGS test hole 18.
712	Brumme Estate	do	1966	37	4	51.8	20.9	do	N	N	USGS test hole 24.
713	do	do	1966	37	4	50.8	20.1	Aug. 2, 1966	N	N	USGS test hole 22.
714	do	do	1966	37	4	56.6	26.0	Dec. 1, 1966	N	N	USGS test hole 23.
715	J. McGlaugherty	do	1966	32	4	46.9	17.9	do	N	N	USGS test hole 26.
716	B. W. Cox	do	1966	37	4	45.8	17.3	Feb. 8, 1967	N	N	USGS test hole 21.
812	J. Martinez (-- Tucker)	do	1966	37	4	43.3	14.4	Jan. 4, 1967	N	N	USGS test hole 20.
813	do	do	1966	37	4	48.2	21.5	do	N	N	USGS test hole 19.
						Nueces County					
UB-83-02-204	State of Texas	--	--	58	4	69.9	53.3	Feb. 8, 1967	C,W	D	Fort Lipantitlan well.
214	Bluntzer Estate	--	--	100	4	65	51.8	June 6, 1966	C,W	D,S	
215	do	-- Welty	1952	100	4	68.4	51.5	Feb. 8, 1967	C,W	S	
504	--	--	--	40	8	40.2	29.0	do	C,W	D,S	Dug well. Casing: 8 inches and 4 inches.
505	Dougherty Estate	--	--	--	--	32.6	17.7	do	C,W	S	Old well.
509	Frank Bluntzer	USGS	1966	37	4	36.7	22.7	do	N	N	USGS test hole 31.
511	do	do	1966	35	4	33.8	19.0	do	N	N	USGS test hole 32.

Table 1.--Records of test holes and wells in the lower Nueces River valley--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Diameter of well (in.)	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	Remarks
UB-83-02-513	Frank Bluntzer	USGS	1966	37	4	32.8	20.0	Feb. 8, 1967	N	N	USGS test hole 30.
514	do	do	1966	37	4	36.7	24.1	do	N	N	USGS test hole 29.
515	E. C. Dunn	do	1966	37	5	32.0	19.7	Feb. 9, 1967	N	N	USGS test hole 28. Continuous water-level recorder on well.
516	do	-- Welty	1957	98	4	38.7	23.9	do	S,E, 1-1/2	S	
517	A. Frazier	USGS	1966	37	4	35.1	23.3	do	N	N	USGS test hole 27.
04-701	State of Texas	do	1966	16	4	12.0	1.4	Feb. 8, 1967	N	N	USGS test hole 33.
702	do	do	1966	11	4	8.2	6.0	do	N	N	USGS test hole 35. Hand augered.
						San Patricio County					
WW-79-58-707	B. W. Cox	USGS	1966	37	4	54.1	20.2	Feb. 8, 1967	N	N	USGS test hole 15.
708	do	do	1966	37	4	50.1	21.1	do	N	N	USGS test hole 16.
709	C. S. Brown	do	1966	42	4	53.4	24.1	do	N	N	USGS test hole 2.
83-02-203	C. E. Caddell	H. S. Well Service	1963	310	12	51.1	29.0	Sept. 5, 1966	T,E, 60	Irr	Cased to bottom. Perforated from 142-162, 181-209, 220-242, and 270-310 feet. Well taps Lissie Formation and Goliad Sand.
207	Dougherty Estate	--	--	--	4	42.7	18.9	Feb. 9, 1967	N	N	Formerly equipped with hand pump. Unused. Old well.
209	McGloin Estate	USGS	1966	37	4	43.4	23.9	do	N	N	USGS test hole 3.
210	Dougherty Estate	do	1966	37	5	33.7	17.9	Feb. 8, 1967	N	N	USGS test hole 14. Continuous water-level recorder on well.
211	McGloin Estate	do	1966	37	4	45.3	28.1	Feb. 9, 1967	N	N	USGS test hole 4.
212	do	do	1966	37	4	41.2	22.6	do	N	N	USGS test hole 1.
213	Dougherty Estate	do	1966	37	4	36.1	22.2	Feb. 8, 1967	N	N	USGS test hole 12.
216	do	do	1966	37	4	34.0	19.6	do	N	N	USGS test hole 13.
217	Carl Bluntzer	do	1966	35	4	39.3	24.0	do	N	N	USGS test hole 6.

Table 1.--Records of test holes and wells in the lower Nueces River valley--Continued

Well	Owner	Driller	Date completed	Depth of well (ft)	Diameter of well (in.)	Altitude of land surface (ft)	Water level: Below land-surface datum (ft)	Water level: Date of measurement	Method of lift	Use of water	
WW-83-02-218	McCown Estate	USGS	1966	38	4	36.7	16.8	Feb. 8, 1967	N	N	USGS test hole 5.
302	M. D. Wright	--	--	--	4	48.8	26.6	do	C,W	D	Reported water not used for drinking purposes.
303	Marie McCown	Burl Sikes	--	150	4	46.1	26.0	do	C,W	D,S	Pump set at 72 feet.
304	C. E. Caddell	--	--	100	8	52.4	25.2	do	N	N	
306	McCown Estate	--	1966	35	4	38.1	18.6	do	N	N	Drilled for supplying water to oil-drilling rig. Unused.
507	Carl Bluntzer	USGS	1966	35	4	36.8	23.5	do	N	N	USGS test hole 7.
508	do	do	1966	40	4	41.1	26.4	do	N	N	USGS test hole 9.
510	do	do	1966	42	4	33.7	20.6	do	N	N	USGS test hole 8.
512	Harold McCown	do	1966	37	4	40.1	26.2	do	N	N	USGS test hole 10.
602	W. Brown	--	--	--	--	--	23.8	do	C,W	D	
03-911	Welder Heirs	USGS	1966	16	4	7.3	5.2	do	N	N	USGS test hole 34.
912	do	do	1966	10	4	5.4	3.9	do	N	N	USGS test hole 36. Hand augered.
913	do	do	1966	10	4	7	5.4	Feb. 9, 1967	N	N	USGS test hole 37. Hand augered.

Table 2.--Drillers' logs of test holes

[Test holes drilled by U.S. Geological Survey.]

Jim Wells County

	Thickness (feet)	Depth (feet)
Test hole PW-79-58-710 Owner: Dan Meany		
Clay	7	7
Clay, and sand	5	12
Sand, fine (wet)	11	23
Gravel	14	37
Test hole PW-79-58-711 Owner: Dan Meany		
Clay, and sand	37	37
Test hole PW-79-58-712 Owner: Brumme Estate		
Clay, black	2	2
Sand, and clay	18	20
Sand, and small gravel	17	37
Test hole PW-79-58-713 Owner: Brumme Estate		
Sand, fine, and clay	37	37
Test hole PW-79-58-714 Owner: Brumme Estate		
Sand, fine, and clay	37	37
Test hole PW-79-58-715 Owner: J. McGlaugherty		
Clay, black	3	3
Clay, sandy	29	32
Test hole PW-79-58-716 Owner: B. W. Cox		
Sand, fine, and clay	37	37
Test hole PW-79-58-812 Owner: -- Tucker		
Sand, fine, and clay	37	37
Test hole PW-79-58-813 Owner: -- Tucker		
Sand, fine, and clay	37	37

Nueces County

	Thickness (feet)	Depth (feet)
Test hole UB-83-02-509 Owner: Brumme Estate		
Clay, black	10	10
Sand	23	33
Clay, white	4	37
Test hole UB-83-02-511 Owner: Frank Bluntzer		
Clay, black	20	20
Sand	11	31
Clay, white	4	35

Table 2.--Drillers' logs of test holes--Continued

Nueces County

Test hole UB-83-02-513
Owner: Frank Bluntzer

	Thickness (feet)	Depth (feet)
Clay, black	15	15
Sand	15	30
Clay	7	37

Test hole UB-83-02-514
Owner: Frank Bluntzer

	Thickness (feet)	Depth (feet)
Sand	37	37

Test hole UB-83-02-515
Owner: E. C. Dunn

	Thickness (feet)	Depth (feet)
Sand	1	1
Clay, black	22	23
Sand	14	37

Test hole UB-83-02-517
Owner: E. C. Dunn

	Thickness (feet)	Depth (feet)
Clay, black	2	2
Sand, and clay	18	20
Sand	17	37

Test hole UB-83-04-701
Owner: State of Texas

	Thickness (feet)	Depth (feet)
Clay, black, and sandy	16	16

Test hole UB-83-04-702
Owner: State of Texas

	Thickness (feet)	Depth (feet)
Clay, black	3	3
Clay, sandy	3	6
Sand	5	11

San Patricio County

Test hole WW-79-58-707
Owner: B. W. Cox

	Thickness (feet)	Depth (feet)
Clay, black	8	8
Sand, fine	22	30
Clay	7	37

Test hole WW-79-58-708
Owner: B. W. Cox

	Thickness (feet)	Depth (feet)
Clay, black	27	27
Sand, fine, and clay	10	37

Test hole WW-79-58-709
Owner: C. S. Brown

	Thickness (feet)	Depth (feet)
Clay, black	18	18
Sand, and coarse gravel	4	22
Gravel	2	24
Clay, and fine sand	18	42

Table 2.--Drillers' logs of test holes--Continued

San Patricio County

	Thickness (feet)	Depth (feet)
Test hole WW-83-02-209 **Owner: McGloin Estate**		
Clay, black	5	5
Sand, fine	2	7
Sand, fine to medium	15	22
Sand, coarse	10	32
Clay	5	37
Test hole WW-83-02-210 **Owner: Dougherty Estate**		
Clay, black	5	5
Clay	5	10
Sand, fine	10	20
Sand, fine, and coarse gravel	17	37
Test hole WW-83-02-211 **Owner: McGloin Estate**		
Clay, black, and sand	3	3
Clay	13	16
Sand	21	37
Test hole WW-83-02-212 **Owner: McGloin Estate**		
Clay, black	22	22
Sand, and gravel	10	32
Clay, white and yellow	5	37
Test hole WW-83-02-213 **Owner: Dougherty Estate**		
Clay, black	4	4
Sand, and clay	33	37
Test hole WW-83-02-216 **Owner: Dougherty Estate**		
Clay, black	4	4
Sand, and clay	26	30
Clay, white	7	37
Test hole WW-83-02-217 **Owner: Carl Bluntzer**		
Sand, fine	25	25
Sand, coarse	8	33
Clay, white, sandy	2	35
Test hole WW-83-02-218 **Owner: McCown Estate**		
Sand, fine	16	16
Gravel, and sand	9	27
Clay, white, sandy	11	38
Test hole WW-83-02-507 **Owner: Carl Bluntzer**		
Clay	3	3
Clay, black and sand	16	19
Clay, white and sand	13	32
Clay, yellow and hard	3	35

Table 2.--Drillers' logs of test holes--Continued

San Patricio County

	Thickness (feet)	Depth (feet)
Test hole WW-83-02-508 Owner: Carl Bluntzer		
Sand and gravel	40	40
Test hole WW-83-02-510 Owner: Carl Bluntzer		
Clay, black -----------	2	2
Sand ------------------	5	7
Sand, gravel and clay ----------------	31	38
Clay, white and hard --	4	42
Test hole WW-83-02-512 Owner: H. McCown		
Clay, sandy -----------	22	22
Sand and gravel -------	2	24
Sand, fine ------------	13	37
Test hole WW-83-03-911 Owner: Welder Heirs		
Clay, black ----------	3	3
Clay, sandy ----------	2	5
Sand -----------------	4	9
Clay, sandy ----------	7	16
Test hole WW-83-03-912 Owner: Welder Heirs		
Clay, black ----------	4	4
Clay and sand --------	6	10
Test hole WW-83-03-913 Owner: Welder Heirs		
Clay and sand --------	10	10

Table 3.--Summary of discharge measurements, lower Nueces River and tributaries between Lake Corpus Christi and Calallen channel lake, February 21-24, 1966

Site	Date (1966)	Stream	River mile below gaging station[a]	Water temp. °F	Air temp. °F	Discharge (cfs)		Streambed material	Remarks
						Main stream	Tributary		
1	Feb. 21	Nueces River	0.0	56	64	150	--	Sand and gravel	At stream-gaging station 8-2110.
2	21	do	1.7	56	61	142	--	Sand	50 feet above site T-1.
T-1	21	Unnamed Tributary	1.7	60	--	--	0.28	Sandy loam	Estimated at 50 feet above mouth.
3	21	Nueces River	4.0	56	61	146	--	Sand	
T-2	22	Sixmile Creek	4.6	--	--	--	.01	Sandy loam	Estimated at 300 feet above mouth.
T-3	22	Bayou Creek	4.8	--	--	--	.001	Clay and sandy loam	Estimated at 1,000 feet above mouth.
4	22	Nueces River	6.6	53	46	144	--	Sand	
5	22	do	9.1	53	47	141	--	do	
6	22	do	9.8	53	47	149	--	do	At temporary stream-gaging station 8-2111.
7	22	do	10.8	54	62	149	--	Sand and gravel	
T-4	22	Sandy Hollow	12.6	--	--	--	0	Sandy loam	
8	22	Nueces River	12.7	54	41	142	--	Clay	

See footnote at end of table.

Table 3.--Summary of discharge measurements, lower Nueces River and tributaries between Lake Corpus Christi and Calallen channel lake, February 21-24, 1966--Continued

Site	Date (1966)	Stream	River mile below gaging station[a]	Water temp. °F	Air temp. °F	Discharge (cfs) Main stream	Discharge (cfs) Tributary	Streambed material	Remarks
9	Feb. 22	Nueces River	14.5	54	41	144	--	Sand and clay	
10	23	do	16.5	50	39	148	--	Sand and gravel	
11	24	do	18.2	44	41	142	--	Sand and rock	At temporary stream-gaging station 8-2112.
12	23	do	20.5	51	40	142	--	Sand and silt	
T-5A	23	Cayamon Creek	--	46	39	--	1.04	Sand	Discharge estimated at Farm Road 666 crossing.
T-5B	23	do	23.7	45	40	--	1.41	Sand and gravel	Estimated at 1,000 feet above mouth.

[a] Stream-gaging station: Nueces River near Mathis, 0.6 mile downstream from Wesley E. Seale Dam.

Table 4.--Summary of discharge measurements, lower Nueces River and tributaries between Lake Corpus Christi and Calallen channel lake, August 16-18, 1966

Site	Date (1966)	Stream	River mile below gaging station[a]	Water temp. °F	Air temp. °F	Discharge (cfs)		Streambed material	Remarks
						Main stream	Tributary		
1	Aug. 16	Nueces River	0.0	82	80	145	--	Sand and gravel	At stream-gaging station 8-2110.
2	16	do	1.7	82	84	147	--	Sand	
T-1	16	Unnamed Tributary	1.7	78	82	--	0.08	Sandy loam	Estimated at mouth.
3	16	Nueces River	4.0	84	87	149	--	Sand	
T-2	16	Sixmile Creek	4.6	--	--	--	0	Sandy loam	At mouth.
T-3	16	Bayou Creek	4.8	88	90	--	.04	Sandy loam	Estimated 1,000 feet above mouth.
4	16	Nueces River	6.6	86	90	148	--	Sand	
5	16	do	9.1	86	84	151	--	do	
6	16	do	9.8	86	85	149	--	do	At temporary stream-gaging station 8-2111.
7	16	do	10.8	84	86	149	--	Sand and gravel	
T-4	17	Sandy Hollow Creek	12.6	--	--	--	0	--	At mouth.

See footnote at end of table.

Table 4.--Summary of discharge measurements, lower Nueces River and tributaries between Lake Corpus Christi and Calallen channel lake, August 16-18, 1966--Continued

Site	Date (1966)	Stream	River mile below gaging station[a]	Water temp. °F	Air temp. °F	Discharge (cfs)		Streambed material	Remarks
						Main stream	Tributary		
T-8	Aug. 17	Nueces River	12.7	85	89	149	--	Clay	
9	17	do	14.5	84	100	148	--	Sand and gravel	
10	17	do	16.5	84	96	152	--	Sand and gravel	
11	18	do	18.2	83	--	149	--	Sand and rock	Atetemporary stream-gaging station 8-2112.
T-5A	18	Cayamon Creek	--	93	--	--	1.76	Sand	Discharge estimated at Farm Road 66 crossing.
T-5B	18	do	23.7	80	--	--	1.05	Sand and gravel	Estimated 1,000 feet above mouth.

[a] Stream-gaging station: Nueces River near Mathis, 0.6 mile downstream from Wesley E. Seale Dam.

Table 5.--Summary of supplementary discharge measurements, lower Nueces River and tributaries between Lake Corpus Christi and Calallen channel lake, February 9, 1967

Site	Date (1967)	Stream	River mile below gaging station[a]	Discharge (cfs)		Streambed material	Remarks
				Main stream	Tributary		
1	Feb. 9	Nueces River	9.8	[b] 80	--	Sand	At temporary stream-gaging station 8-2111.
2	9	do	11.7	79.1	--	Sand and gravel	
T-4	9	Sandy Hollow Creek	12.6	--	0	--	At mouth.
3	9	Nueces River	12.7	81.5	--	Sand	
4	9	do	14.2	81.0	--	Sand and gravel	
5	9	do	18.2	[b] 83	--	Rock and sand	At temporary stream-gaging station 8-2112.

[a] Stream-gaging station: Nueces River near Mathis, 0.6 mile downstream from Wesley E. Seale Dam.
[b] Daily mean discharge for February 9 from recorder at temporary stream-gaging station.

Table 6.--Water levels in test holes and wells
[Water level, in feet, below land surface]

Date	Water level	Date	Water level	Date	Water level

Jim Wells County

Well PW-79-58-702

Owner: Brumme Estate

Date	Water level	Date	Water level	Date	Water level
Apr. 4, 1966	72.70	Aug. 2, 1966	72.00	Dec. 1, 1966	72.53
May 11	71.98	Sept. 6	72.35	Jan. 4, 1967	72.45
June 6	71.66	Oct. 4	72.30	Feb. 8	72.76
July 5	71.65	Nov. 1	72.46		

Test hole PW-79-58-710

Owner: Dan Meany

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	12.28	July 5, 1966	10.58	Dec. 1, 1966	12.41
Apr. 6	12.24	Aug. 2	11.62	Jan. 3, 1967	12.14
Apr. 22	12.01	Sept. 6	11.89	Feb. 8	12.02
May 11	4.30	Oct. 4	12.48		
June 6	9.54	Nov. 1	12.66		

Test hole PW-79-58-711

Owner: Dan Meany

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	23.17	July 5, 1966	20.01	Nov. 1, 1966	23.34
Apr. 6	23.35	Aug. 2	23.28	Dec. 1	23.47
Apr. 22	23.47	Sept. 6	22.99	Jan. 3, 1967	23.43
June 6	15.73	Oct. 5	26.17	Feb. 8	23.46

Table 6.--Water levels in test holes and wells--Continued

Jim Wells County

Date	Water level	Date	Water level	Date	Water level

Test hole PW-79-58-712

Owner: Brumme Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	20.80	Aug. 2, 1966	19.44	Dec. 1, 1966	20.90
Apr. 6	20.74	Sept. 6	20.20	Jan. 4, 1967	20.88
June 6	16.62	Oct. 5	20.50	Feb. 8	20.86
July 5	18.19	Nov. 1	20.77		

Test hole PW-79-58-713

Owner: Brumme Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	21.04	May 12, 1966	12.35	July 5, 1966	18.17
Apr. 6	20.92	June 6	14.19	Aug. 2	20.10

Test hole PW-79-58-714

Owner: Brumme Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	25.82	July 5, 1966	24.57	Nov. 1, 1966	25.90
Apr. 6	25.80	Aug. 2	25.14	Dec. 1	26.05
May 12	25.50	Sept. 5	25.48		
June 6	24.85	Oct. 5	25.61		

Test hole PW-79-58-715

Owner: J. McGlaugherty

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	17.65	July 5, 1966	15.00	Oct. 5, 1966	17.64
Apr. 6	17.57	July 7	15.08	Nov. 1	17.82
May 12	0.71	Aug. 2	16.95	Dec. 1	17.91
June 6	11.26	Sept. 6	17.53		

Table 6.--Water levels in test holes and wells--Continued

Jim Wells County

Date		Water level	Date		Water level	Date		Water level
			Test hole PW-79-58-716					
Owner: B. W. Cox								
Mar.	18, 1966	17.14	July	5, 1966	14.04	Nov.	1, 1966	17.53
Apr.	6	17.11	Aug.	2	16.62	Dec.	1	17.48
May	11	1.20	Sept.	6	17.25	Jan.	4, 1967	17.41
June	6	9.34	Oct.	5	17.35	Feb.	8	17.28
			Test hole PW-79-58-812					
Owner: -- Tucker								
Mar.	18, 1966	13.74	July	5, 1966	11.66	Nov.	1, 1966	13.70
Apr.	6	13.69	Aug.	2	12.58	Dec.	1	13.76
May	11	11.40	Sept.	6	12.30	Jan.	4, 1967	14.43
June	6	10.80	Oct.	5	13.43			
			Test hole PW-79-58-813					
Owner: -- Tucker								
Mar.	18, 1966	20.49	July	5, 1966	18.06	Nov.	1, 1966	20.40
Apr.	6	20.46	Aug.	2	19.84	Dec.	1	20.41
May	11	9.16	Sept.	6	20.26	Jan.	4, 1967	21.46
June	6	13.94	Oct.	5	20.32			

Table 6.--Water levels in test holes and wells--Continued

Date	Water level	Date	Water level	Date	Water level

Nueces County

Well UB-83-02-204

Owner: State of Texas

Feb. 14, 1966	52.80	Aug. 2, 1966	51.78	Dec. 1, 1966	53.23
Apr. 4	52.59	Sept. 5	52.30	Feb. 8, 1967	53.27
July 6	51.10	Oct. 5	52.89		

Well UB-83-02-214

Owner: Bluntzer Estate

June 6, 1966	51.83				

Well UB-83-02-215

Owner: Paul Bluntzer

Apr. 4, 1966	51.23	Aug. 2, 1966	50.00	Dec. 1, 1966	51.61
May 11	49.71	Sept. 5	51.16	Jan. 3, 1967	51.69
June 6	49.35	Oct. 5	51.33	Feb. 8	51.45
July 6	49.75	Nov. 1	51.73		

Well UB-83-02-504

Owner: E. C. Dunn

Feb. 14, 1966	29.63	July 6, 1966	26.51	Nov. 1, 1966	28.80
Apr. 4	29.09	Aug. 2	27.27	Dec. 1	29.40
May 11	28.80	Sept. 5	27.95	Feb. 9, 1967	29.03
June 6	26.89	Oct. 5	28.35		

Table 6.--Water levels in test holes and wells--Continued

Nueces County

Well UB-83-02-505

Owner: Dougherty Estate

Date	Water level	Date	Water level	Date	Water level
Feb. 14, 1966	17.72	July 6, 1966	16.46	Nov. 1, 1966	17.67
Apr. 4	17.99	Aug. 2	17.17	Dec. 1	17.85
May 11	16.75	Sept. 5	18.35	Jan. 3, 1967	18.56
June 6	16.32	Oct. 7	18.14	Feb. 8	17.72

Test hole UB-83-02-509

Owner: Frank Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	22.56	July 7, 1966	20.65	Nov. 3, 1966	22.95
Apr. 5	22.49	Aug. 2	21.70	Dec. 1	23.03
May 11	19.60	Sept. 5	22.44	Jan. 5, 1967	22.91
June 6	19.54	Oct. 5	22.68	Feb. 8	22.65

Test hole UB-83-02-511

Owner: Frank Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	18.99	July 7, 1966	17.42	Nov. 3, 1966	19.55
Apr. 5	18.92	Aug. 2	18.39	Dec. 1	19.58
May 11	18.42	Sept. 5	19.05	Jan. 5, 1967	19.29
June 6	17.47	Oct. 5	19.29	Feb. 8	19.01

Table 6.--Water levels in test holes and wells--Continued

Nueces County

Date	Water level	Date	Water level	Date	Water level

Test hole UB-83-02-513

Owner: Frank Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	19.87	Aug. 2, 1966	19.37	Dec. 1, 1966	19.80
Apr. 5	19.74	Sept. 5	19.76	Jan. 5, 1967	19.90
June 6	11.84	Oct. 5	19.82	Feb. 8	20.01
July 7	17.07	Nov. 3	19.89		

Test hole UB-83-02-514

Owner: Frank Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 17, 1966	24.71	July 7, 1966	23.01	Nov. 3, 1966	24.23
Apr. 5	24.65	Aug. 2	23.40	Dec. 1	24.38
May 11	23.90	Sept. 5	23.87	Jan. 5, 1967	24.20
June 6	23.31	Oct. 5	24.02	Feb. 8	24.11

Well UB-83-02-516

Owner: E. C. Dunn

Date	Water level	Date	Water level	Date	Water level
Feb. 14, 1966	30.98	July 6, 1966	22.51	Nov. 1, 1966	24.00
Apr. 4	24.00	Aug. 2	23.10	Dec. 1	23.93
May 11	22.70	Sept. 5	24.12	Jan. 5, 1967	24.20
June 6	23.58	Oct. 5	24.10	Feb. 9	23.85

Table 6.--Water levels in test holes and wells--Continued

Nueces County

Test hole UB-83-02-517

Owner: A. Frazier

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	23.67	July 6, 1966	22.41	Nov. 1, 1966	23.07
Apr. 4	23.60	Aug. 2	22.45	Dec. 1	23.17
May 11	22.80	Sept. 5	22.77	Jan. 5, 1967	23.28
June 6	22.43	Oct. 5	22.92	Feb. 9	23.29

Test hole UB-83-04-701

Owner: State of Texas

Date	Water level	Date	Water level	Date	Water level
Mar. 18, 1966	1.59	July 7, 1966	1.48	Nov. 2, 1966	1.65
Apr. 5	2.00	Aug. 3	1.68	Dec. 1	1.44
May 11	1.70	Sept. 5	1.87	Jan. 3, 1967	1.61
June 6	1.95	Oct. 7	1.97	Feb. 8	1.40

Test hole UB-83-04-702

Owner: State of Texas

Date	Water level	Date	Water level	Date	Water level
Sept. 6, 1966	6.46	Nov. 2, 1966	6.50	Feb. 9, 1967	6.04
Oct. 5	6.57	Dec. 1	6.59		
Oct. 7	6.64	Jan. 3, 1967	6.60		

Date	Water level	Date	Water level	Date	Water level

San Patricio County

Test hole WW-79-58-707

Owner: B. W. Cox

Mar. 17, 1966	20.76	July 7, 1966	18.48	Dec. 1, 1966	20.18
Apr. 5	20.70	Aug. 2	19.81	Jan. 4, 1967	20.10
May 11	16.03	Sept. 6	20.15	Feb. 8	20.18
June 6	16.28	Oct. 5	20.18		
July 6	18.46	Nov. 1	20.27		

Test hole WW-79-58-708

Owner: B. W. Cox

Mar. 17, 1966	20.98	July 7, 1966	17.96	Nov. 1, 1966	21.05
Apr. 5	20.84	Aug. 2	20.18	Dec. 1	21.02
May 11	9.10	Sept. 6	20.79	Jan. 4, 1967	21.02
June 6	13.18	Oct. 5	20.91	Feb. 8	21.06

Test hole WW-79-58-709

Owner: C. S. Brown

Feb. 28, 1966	23.73	July 5, 1966	20.86	Dec. 1, 1966	24.20
Mar. 17	24.01	Aug. 2	23.29	Jan. 5, 1967	24.07
Apr. 5	24.00	Sept. 6	23.97	Feb. 8	24.08
May 11	10.43	Oct. 5	24.05		
June 6	15.81	Nov. 1	24.30		

Table 6.--Water levels in test holes and wells--Continued

San Patricio County

Well WW-83-02-203

Owner: C. E. Caddel

Date	Water level	Date	Water level	Date	Water level
Feb. 9, 1966	29.18	June 7, 1966	27.43	Sept. 5, 1966	29.02
Apr. 5	29.95	July 7	27.51		
May 12	28.93	Aug. 3	27.82		

Well WW-83-02-207

Owner: J. R. Dougherty Estate

Date	Water level	Date	Water level	Date	Water level
Feb. 14, 1966	19.32	July 6, 1966	14.04	Nov. 1, 1966	17.43
Apr. 5	19.84	Aug. 3	14.98	Dec. 2	18.06
May 11	13.59	Sept. 5	16.05	Jan. 5, 1967	18.55
June 7	13.89	Oct. 4	16.69	Feb. 9	18.86

Test hole WW-83-02-209

Owner: R. B. McGloin Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	25.94	July 6, 1966	24.03	Nov. 1, 1966	25.59
Apr. 5	26.02	Aug. 3	24.55	Dec. 2	25.68
May 12	25.46	Sept. 5	25.12	Jan. 5, 1967	25.73
June 7	24.07	Oct. 4	25.34	Feb. 9	25.69

Test hole WW-83-02-211

Owner: R. B. McGloin Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	28.63	May 12, 1966	28.10	July 6, 1966	27.30
Apr. 5	28.50	June 7	27.69	Aug. 3	27.46

(Continued on next page)

San Patricio County

Test hole WW-83-02-211--Continued

Date	Water level	Date	Water level	Date	Water level
Sept. 5, 1966	27.87	Nov. 1, 1966	28.11	Feb. 9, 1967	28.10
Oct. 4	27.98	Dec. 2	28.30		

Test hole WW-83-02-212

Owner: R. B. McGloin Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	23.34	July 6, 1966	22.16	Nov. 1, 1966	22.48
Apr. 5	23.35	Aug. 3	21.98	Dec. 2	22.58
May 11	23.10	Sept. 5	22.15	Jan. 5, 1967	22.65
June 7	22.57	Oct. 4	22.28	Feb. 9	22.64

Test hole WW-83-02-213

Owner: Dougherty Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	22.05	July 6, 1966	21.78	Nov. 1, 1966	22.61
Apr. 5	22.10	Aug. 3	22.96	Dec. 2	22.66
May 12	21.97	Sept. 5	22.36	Jan. 6, 1967	22.50
June 7	21.88	Oct. 4	22.41	Feb. 8	22.20

Test hole WW-83-02-216

Owner: Dougherty Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	19.60	July 6, 1966	18.09	Nov. 1, 1966	19.86
Apr. 5	19.54	Aug. 3	19.06	Dec. 2	19.94
May 12	18.33	Sept. 5	19.69	Jan. 7, 1967	19.87
June 7	17.92	Oct. 4	19.62	Feb. 8	19.60

Table 6.--Water levels in test holes and wells--Continued

San Patricio County

Date	Water level	Date	Water level	Date	Water level

Test hole WW-83-02-217

Owner: Carl Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	24.80	July 6, 1966	23.75	Nov. 2, 1966	24.89
Apr. 5	24.67	Aug. 2	24.05	Dec. 2	24.74
May 12	24.31	Sept. 5	24.63	Jan. 5, 1967	24.33
June 7	24.05	Oct. 4	24.70	Feb. 8	24.00

Test hole WW-83-02-218

Owner: McCown Estate

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	17.60	July 6, 1966	15.06	Nov. 1, 1966	16.95
Apr. 5	17.69	July 19	15.00	Dec. 2	16.92
Apr. 14	17.86	Aug. 3	15.34	Jan. 5, 1967	16.87
May 12	15.92	Sept. 5	16.07	Feb. 8	16.79
June 7	15.06	Oct. 4	16.53		

Well WW-83-02-302

Owner: M. P. Wright

Date	Water level	Date	Water level	Date	Water level
Feb. 14, 1966	26.80	July 7, 1966	25.46	Jan. 5, 1967	27.88
Apr. 5	26.96	Aug. 3	25.61	Feb. 8	26.62
May 12	26.14	Sept. 5	26.54		
June 7	25.88	Nov. 1	26.19		

Table 6.--Water levels in test holes and wells--Continued

San Patricio County

Well WW-83-02-303

Owner: Marie McCown

Date	Water level	Date	Water level	Date	Water level
Apr. 5, 1966	27.84	July 19, 1966	24.84	Dec. 2, 1966	25.91
May 12	25.74	Aug. 3	26.53	Feb. 8, 1967	26.04
June 7	27.37	Sept. 5	25.49		

Well WW-83-02-304

Owner: C. E. Caddel

Date	Water level	Date	Water level	Date	Water level
Feb. 9, 1966	26.24	July 7, 1966	22.49	Nov. 3, 1966	23.82
Apr. 5	26.70	Aug. 3	22.28	Dec. 2	24.29
May 12	24.91	Sept. 5	22.80	Jan. 5, 1967	24.78
June 7	22.70	Oct. 4	23.61	Feb. 8	25.20

Well WW-83-02-306

Owner: McCown Estate

Date	Water level	Date	Water level	Date	Water level
May 12, 1966	17.98	Sept. 5, 1966	18.92	Jan. 5, 1967	18.93
June 7	17.32	Oct. 4	18.55	Feb. 8	18.55
July 6	17.30	Nov. 1	18.62		
Aug. 3	17.68	Dec. 2	18.36		

Test hole WW-83-02-507

Owner: Carl Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 2, 1966	23.21	Apr. 5, 1966	23.15	June 7, 1966	15.19
Mar. 16	23.20	May 12	10.15	July 6	16.97

(Continued on next page)

Table 6.--Water levels in test holes and wells--Continued

San Patricio County

Date	Water level	Date	Water level	Date	Water level
Test hole WW-83-02-507--Continued					
Aug. 3, 1966	22.67	Nov. 2, 1966	23.40	Feb. 8, 1966	23.51
Sept. 5	23.24	Dec. 2	23.41		
Oct. 4	23.33	Jan. 5, 1967	23.43		

Test hole WW-83-02-508

Owner: Carl Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	27.41	July 6, 1966	26.09	Nov. 2, 1966	27.04
Apr. 5	27.33	Aug. 3	26.30	Dec. 2	26.90
May 12	26.84	Sept. 5	26.81	Jan. 5, 1967	26.60
June 7	26.40	Oct. 4	26.84	Feb. 8	26.40

Test hole WW-83-02-510

Owner: Carl Bluntzer

Date	Water level	Date	Water level	Date	Water level
Mar. 2, 1966	20.47	July 6, 1966	18.48	Nov. 2, 1966	20.80
Mar. 16	20.42	Aug. 3	19.64	Dec. 2	20.97
Apr. 5	20.35	Sept. 5	20.26	Jan. 5, 1967	20.89
June 7	19.14	Oct. 4	20.52	Feb. 8	20.56

Test hole WW-83-02-512

Owner: Harold McCown

Date	Water level	Date	Water level	Date	Water level
Mar. 16, 1966	27.38	July 6, 1966	25.59	Nov. 2, 1966	26.05
Apr. 5	27.37	Aug. 3	25.65	Dec. 2	26.19
May 12	27.18	Sept. 5	26.16	Jan. 5, 1967	26.23
June 7	26.58	Oct. 4	25.79	Feb. 8	26.25

San Patricio County

Date	Water level	Date	Water level	Date	Water level

Well WW-83-02-602

Owner: Willie Brown

Apr. 5, 1966	23.52	July 6, 1966	22.22	Oct. 4, 1966	25.28
May 12	22.09	Aug. 3	22.92	Nov. 2	25.65
June 7	22.58	Sept. 5	23.65	Feb. 8, 1967	23.81

Test hole WW-83-03-911

Owner: Welder Heirs

Mar. 18, 1966	5.14	Aug. 3, 1966	4.48	Nov. 2, 1966	5.36
Apr. 5	4.72	Sept. 6	5.11	Dec. 1	5.41
June 6	2.64	Oct. 5	5.29	Jan. 3, 1967	5.55
July 7	3.03	Oct. 7	5.30	Feb. 8	5.25

Test hole WW-83-03-912

Owner: Welder Heirs

Sept. 6, 1966	3.76	Nov. 2, 1966	4.58	Jan. 3, 1967	4.02
Oct. 7	4.40	Dec. 1	4.64	Feb. 8	3.93

Test hole WW-83-03-913

Owner: Welder Heirs

Jan. 3, 1967	5.44	Feb. 9, 1967	5.38		

Table 7.--Chemical analyses of surface water, lower Nueces River between Lake Corpus Christi and Calallen Dam, February 21-24, 1966

[Analyses given are in parts per million except specific conductance, pH, percent sodium, and SAR.]

Site	Date (1966)	River mile below gaging station[a]	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3-NO_2)		Phosphate (PO_4)	Boron (B)	Dissolved solids	Total hardness as ($CaCO_3$)	NCH [b]	Percent sodium	SAR [c]	Specific conductance (micromhos at 25°C)	pH
1	Feb. 21	0.0	150	17	0.01	0.02	60	5.0	34	7.5	217	26	35	0.3	0.2	0.12	0.21	0.15	292	170	0	29	1.1	506	7.3
2	21	1.7	142	--	.01	--	--	--	--	--	216	--	37	--	.2	.02	--	--	--	172	0	--	--	520	7.6
T-1	21	1.7	.28	19	--	--	64	7.4	49	7.8	250	31	46	.4	0.	--	--	--	--	190	0	35	1.5	598	7.5
3	21	4.0	146	--	.01	--	--	--	--	--	217	--	38	--	.2	.05	--	--	--	172	0	--	--	523	7.3
T-2	22	4.6	.01	32	--	--	38	22	214	11	336	43	232	1.2	1.5	--	--	--	760	186	0	70	6.8	1,340	7.7
4	22	6.6	144	18	.02	--	61	5.1	37	7.4	217	27	38	.3	0	.07	--	--	301	173	0	31	1.2	526	7.2
5	22	9.1	141	--	.02	--	--	--	--	--	218	--	38	--	0	--	--	--	--	175	0	--	--	527	7.4
7	22	10.8	149	--	.02	--	--	--	--	--	219	--	39	--	.2	.01	--	--	--	178	0	--	--	531	7.3
8	22	12.7	142	--	.03	--	--	--	--	--	221	--	40	--	0	--	--	--	--	174	0	--	--	532	7.3
9	22	14.5	144	--	.07	--	--	--	--	--	219	--	40	--	0	0	--	--	--	176	0	--	--	534	7.2
10	23	16.5	148	--	.10	--	--	--	--	--	220	--	40	--	0	--	--	--	--	175	0	--	--	532	7.2
11	24	18.2	142	--	.10	--	--	--	--	--	220	--	40	--	.2	--	--	--	--	175	0	--	--	532	7.2
12	23	20.5	142	17	.10	.02	662	5.0	37	7.6	220	27	40	.3	0	0	.20	.16	304	175	0	30	1.2	532	7.2
T-5A	23	--	1.04	40	--		178	70	865	12	280	466	1,320	--	6.5	--	--	--	3,100	730	500	72	14	5,210	7.4
T-5B	23	23.7	1.41	--	--		--	--	--	--	234	--	1,310	--	--	--	--	--	--	685	493	--	--	5,090	7.3
P-41	24	28.5	--	17	--		62	6.4	43	7.4	226	29	47	.3	0	--	--	--	323	181	0	33	1.4	549	7.4
P-43	24	30.5	--	--	--		--	--	--	--	223	--	50	--	--	--	--	--	--	185	2	--	--	575	7.2
P-44	24	31.5	--	--	--		--	--	--	--	223	--	50	--	--	--	--	--	--	180	0	--	--	571	7.7
P-47	24	34.3	--	18	--		68	7.4	52	7.5	230	36	72	.3	.2	--	--	--	374	200	12	35	1.6	665	7.3

[a] Stream-gaging station: Nueces River near Mathis, 0.6 mile downstream from Wesley E. Seale Dam.
[b] Non-carbonate hardness.
[c] Sodium-adsorption ratio.

Table 8.--Chemical analyses of surface water lower Nueces River between Lake Corpus Christi and Calallen Dam, August 16-18, 1966

[Analyses given are in parts per million except specific conductance, pH, percent sodium, and SAR.]

Site	Date (1966)	River mile below gaging station[a]	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Flouride (F)	Nitrate (NO_3-NO_2)		Phosphate (PO_4)	Boron (B)	Dissolved solids	Total hardness as ($CaCO_3$)	NCH [b]	Percent sodium	SAR [c]	Specific conductance (micromhos at 25°C)	pH
1	Aug. 16	0.0	145	20	0.08	0.02	51	3.8	28	7.9	187	20	25	0.3	0.2	--	0.43	0.17	249	143	0	28	1.0	420	7.5
2	16	1.7	147	--	.06	.02	--	--	--	--	--	--	330	--	--	--	--	--	--	--	--	--	--	435	--
T-1	16	1.7	.08	28	--	--	48	7.9	184	8.8	331	31	187	1.0	.2	--	.24	1.0	660	152	0	71	6.5	1,150	7.6
3	16	4.0	149	20	.02	.02	52	4.0	31	7.8	189	21	30	.3	.2	--	.44	.17	260	146	0	30	1.1	442	7.6
T-3	16	4.8	.04	36	--	--	90	11	70	5.8	274	51	112	.4	0	--	.07	.29	512	270	45	35	1.9	867	7.3
4	16	6.6	148	20	.14	.05	52	4.1	31	7.8	191	22	30	.3	0	--	.43	.17	262	147	0	30	1.1	444	7.7
5	16	9.1	151	20	.21	.06	52	3.8	31	7.8	191	22	32	.3	.2	--	.44	.16	264	145	0	30	1.1	445	7.7
6	16	9.8	149	--	.24	.08	--	--	--	--	--	--	33	--	--	--	--	--	--	--	--	--	--	450	--
7	16	10.8	149	20	.22	.08	52	4.0	32	8.1	191	22	34	.3	.2	--	.44	.20	267	146	0	31	1.2	450	7.6
8	17	12.7	146	--	.03	.04	--	--	--	--	--	--	34	--	--	--	--	--	--	--	--	--	--	452	--
9	17	14.5	148	20	.11	.02	53	4.0	33	7.8	192	22	34	.3	.2	--	.42	.18	269	149	0	31	1.2	453	7.8
10	17	16.5	152	21	.02	.02	53	4.0	33	7.8	193	22	34	.3	.2	--	.43	.18	271	149	0	31	1.2	454	7.7
11	18	18.2	148	21	.03	.02	52	4.1	32	8.2	193	22	34	.3	0	--	.43	.16	269	147	0	31	1.1	455	7.7
12	17	20.5	141	20	.03	.02	52	3.9	32	7.7	192	22	32	.3	.2	--	.44	.19	265	146	0	31	1.2	447	7.8
T-5A	18	--	1.76	55	--	--	90	38	459	12	234	248	680	.9	.8	--	.08	2.0	1,700	381	189	72	10	2,910	7.6
T-5B	18	23.7	1.05	51	--	--	108	49	586	12	237	318	880	--	.8	--	.35	2.6	2,120	471	277	72	12	3,640	7.4

[a] Stream-gaging station: Nueces River near Mathis, 0.6 mile downstream from Wesley E. Seale Dam.
[b] Non-carbonate hardness.
[c] Sodium-adsorption ratio.

Table 9.--Chloride concentration, specific conductance, and temperature of surface water, lower Nueces River and tributaries between Lake Corpus Christi and Calallen Dam, February 21-24, 1966

Site[a]	Date (1966)	Time (hours)	River mile below gaging station[b]	Chloride (ppm)	Specific conductance (micromhos at 25° C)	Water temperature (°F)
1	Feb. 21	1320	0.0	35	506	56
P- 1	21	--	1.0	37	516	56
P- 2	21	--	1.5	37	514	56
T- 1	21	--	1.7	46	598	60
2	21	1430	1.7	37	520	56
P- 3	21	--	2.0	37	520	56
P- 4	21	--	3.3	38	524	56
P- 5	21	--	3.9	--	519	56
3	21	1630	4.0	38	523	56
P- 6	22	0850	4.5	38	520	53
T- 2	21	1815	4.6	232	1,340	--
P- 7	22	0930	5.0	38	524	53
P- 8	22	0945	5.5	--	520	53
P- 9	22	0950	6.0	--	519	53
4	22	1015	6.6	38	526	53
P-10	22	--	7.0	--	522	54
P-11	22	1120	7.5	--	522	53
P-12	22	1130	8.0	--	524	53
5	22	1200	9.1	38	527	53
P-13	22	--	9.8	39	531	53
P-14	22	--	10.2	--	523	54
7	22	1500	10.8	39	531	53

Table 9.--Chloride concentration, specific conductance, and temperature of surface water, lower Nueces River and tributaries between Lake Corpus Christi and Calallen Dam, February 21-24, 1966--Continued

Site[a]	Date (1966)	Time (hours)	River mile below gaging station[b]	Chloride (ppm)	Specific conductance (micromhos at 25° C)	Water temperature (°F)
P-15	Feb. 22	1535	11.3	39	527	53
P-16	22	1550	11.8	40	532	54
P-17	22	1600	12.3	40	535	54
8	22	1615	12.7	40	532	54
P-18	22	1740	13.2	--	529	54
P-19	22	1756	13.7	--	531	54
9	22	1815	14.5	40	534	54
P-20	22	1905	15.2	39	527	54
P-21	23	1130	16.0	--	526	50
10	23	1100	16.5	40	532	50
P-22	23	1200	17.0	--	532	50
P-23	23	1210	17.5	--	526	50
11	23	0930	18.2	40	532	48
P-24	23	1235	18.7	--	524	50
P-25	23	1240	19.2	--	525	50
P-26	23	1250	19.7	40	535	50
12	23	1300	20.5	40	532	50
P-27	23	1455	21.0	--	535	51
P-28	23	1500	21.5	--	537	51
P-29	23	1510	22.0	41	539	50
P-30	23	1515	22.5	--	534	51
P-31	23	--	23.0	--	536	51

Table 9.--Chloride concentration, specific conductance, and temperature of surface water, lower Nueces River and tributaries between Lake Corpus Christi and Calallen Dam, February 21-24, 1966--Continued

Site[a]	Date (1966)	Time (hours)	River mile below gaging station[b]	Chloride (ppm)	Specific conductance (micromhos at 25° C)	Water temperature (°F)
T-5A	Feb. 23	1735	--	1,320	5,210	46
P-32	23	1600	23.5	--	530	51
T-5B	23	1530	23.7	1,310	5,090	48
P-33	23	1605	24.0	47	555	51
P-34	23	1615	24.5	47	564	51
P-35	23	1620	25.0	--	559	52
P-36	23	1625	25.5	48	561	52
P-37	23	1635	26.0	49	565	53
P-38	23	1640	26.5	--	558	53
P-39	23	1650	27.0	--	554	54
P-40	23	1655	27.5	48	568	54
P-41	24	0945	28.5	47	549	51
P-42	24	--	29.5	48	565	52
P-43	24	1013	30.5	50	575	52
P-44	24	1025	31.5	50	571	52
P-45	24	1038	32.5	53	584	53
P-46	24	1054	33.5	64	622	55
P-47	24	--	34.3	72	665	55

[a] Prefix P denotes sites on main stream where supplemental quality-of-water samples were collected; prefix T denotes tributary sites.
[b] Stream-gaging station: Nueces River near Mathis, 0.6 mile downstream from Wesley E. Seale Dam.

Table 10.--Chloride concentration, specific conductance, and temperature of surface water, lower Nueces River and tributaries between Lake Corpus Christi and Calallen Dam, August 16-18, 1966

Site[a]	Date (1966)	Time (hours)	River mile below gaging station[b]	Chloride (ppm)	Specific conductance (micromhos at 25° C)	Water temperature (°F)
1	Aug. 16	0755	0.0	25	420	83
T- 1	16	0910	1.7	187	1,150	78
2	16	0925	1.7	30	435	82
3	16	1105	4.0	30	442	83
T- 3	16	--	4.8	112	867	88
4	16	1340	6.6	30	444	86
5	16	1530	9.1	32	445	86
6	16	1645	9.8	33	450	86
7	16	1805	10.8	34	450	85
8	17	1050	12.7	34	452	85
9	17	1310	14.5	34	453	85
10	17	--	16.5	34	454	84
11	18	0710	18.2	34	455	83
12	17	1635	20.5	32	447	85
T-5A	18	1445	--	680	2,910	93
P- 1	18	--	23.0	36	469	83
T-5B	18	0920	23.7	880	3,640	80
P- 2	18	--	23.7	36	466	83
P- 3	18	1030	24.7	40	482	83
P- 4	18	1100	25.8	42	493	84
P- 5	18	1125	27.0	43	490	86

Table 10.--Chloride concentration, specific conductance, and temperature of surface water, lower Nueces River and tributaries between Lake Corpus Christi and Calallen Dam, August 16-18, 1966--Continued

Site[a]	Date (1966)	Time (hours)	River mile below gaging station[b]	Chloride (ppm)	Specific conductance (micromhos at 25° C)	Water temperature (°F)
P- 6	Aug. 18	1130	28.0	44	495	86
P- 7	18	1150	29.0	44	497	86
P- 8	18	1200	30.0	44	496	86
P- 9	18	1212	31.0	46	504	86
P-10	18	1225	32.0	47	511	88
P-11	18	1255	33.0	49	521	88
P-12	18	1310	34.0	64	567	88
P-13	18	1325	34.4	67	573	90

[a] Prefix P denotes sites on main stream where supplemental quality-of-water samples were collected; prefix T denotes tributary sites.

[b] Stream-gaging station: Nueces River near Mathis, 0.6 mile downstream from Wesley E. Seale Dam.

Table 11.--Chemical analyses of ground water

[Analyses given are in parts per million except specific conductance, pH, and percent sodium.]

Well	Owner	Depth of well (ft.)	Date of collection	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
Jim Wells County														
PW-79-58-710	Dan Meany	37	Apr. 6, 1966	102	5.5	68	340	45	69	483	277	33	819	6.8
			July 5	--	--	--	346	40	66	--	300	--	800	7.1
711	do	37	Apr. 6	116	11	52	438	17	64	497	334	23	868	6.8
			July 5	--	--	--	424	54	99	--	392	--	1,010	6.9
			Dec. 1	--	--	--	430	25	97	--	452	--	981	7.0
715	J. McGlaugherty	32	Apr. 6	762	84	832	432	476	2,300	4,730	2,250	44	7,710	6.2
			July 5	--	--	--	418	292	1,700	--	2,060	--	5,930	6.5
716	B. W. Cox	37	Apr. 6	318	46	271	632	66	750	1,800	982	36	3,210	6.5
			July 5	--	--	--	432	75	113	--	434	--	1,130	7.0
			Dec. 1	--	--	--	542	53	325	--	705	--	1,870	6.9
812	J. Martinez (-- Tucker)	37	Apr. 6	114	16	394	378	264	445	1,460	350	70	2,420	7.0
			July 5	--	--	--	332	105	180	--	222	--	1,310	7.1
813	do	37	Apr. 6	109	12	276	480	256	212	1,160	322	64	1,830	7.0
			July 5	--	--	--	480	232	260	--	288	--	1,970	7.2
			Dec. 1	--	--	--	474	245	210	--	318	--	1,800	7.2
Nueces County														
UB-83-02-215	Paul Bluntzer	100	Apr. 4, 1966	90	23	264	400	95	358	1,070	319	63	1,900	6.9
			Dec. 2	--	--	--	348	109	430	--	356	--	2,050	7.0
504	-- Frazier	--	Apr. 4	142	16	133	320	99	240	834	420	38	1,440	6.9
			July 6	--	--	--	328	94	255	--	440	--	1,510	6.9
509	Frank Bluntzer	37	Apr. 5	121	19	292	630	126	280	1,200	380	62	1,960	6.8
			July 7	--	--	--	618	85	212	--	360	--	1,710	6.9
			Dec. 1	--	--	--	614	83	205	--	362	--	1,660	7.0

Table 11.--Chemical analyses of ground water--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Cal-cium (Ca)	Magne-sium (Mg)	Sodium and potassium (Na + K)	Bicar-bonate (HCO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Dis-solved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
UB-83-02-511	Frank Bluntzer	37	Apr. 5, 1966	137	20	155	534	91	165	879	424	43	1,460	6.7
			July 7	--	--	--	454	76	101	--	340	--	1,120	7.3
513	do	37	Apr. 5	352	25	68	765	20	360	1,270	981	12	2,190	6.6
			July 7	--	--	--	746	47	440	--	1,180	--	2,460	6.6
515	E. C. Dunn	37	Apr. 4	169	22	420	668	172	550	1,720	512	63	2,880	6.7
			July 6	--	--	--	1,200	86	1,270	--	1,180	--	5,270	6.9
			Dec. 1	--	--	--	682	112	760	--	660	--	3,340	7.2
517	A. Frazier	37	Apr. 4	48	18	200	390	94	140	749	194	68	1,280	7.2
			July 6	--	--	--	304	35	68	--	176	--	769	7.4
			Dec. 1	--	--	--	358	50	73	--	218	--	913	7.4
04-701	State of Texas	16	Apr. 5	74	15	240	725	45	101	864	246	67	1,400	7.0
			July 7	--	--	--	584	86	78	--	308	--	1,220	7.1
702	do	11	Sept. 6	--	--	--	1,160	745	2,200	--	425	--	9,120	7.2
			Dec. 1	--	--	--	1,160	754	2,130	5,400*	395	--	8,920	7.5

San Patricio County

Well	Owner	Depth of well (ft.)	Date of collection	Cal-cium (Ca)	Magne-sium (Mg)	Sodium and potassium (Na + K)	Bicar-bonate (HCO_3)	Sul-fate (SO_4)	Chlo-ride (Cl)	Dis-solved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
WW-79-58-707	B. W. Cox	37	Apr. 5	299	56	380	321	170	960	2,110	976	44	3,710	6.6
			July 7	--	--	--	348	137	540	--	508	--	2,460	6.9
			Dec. 1	--	--	--	320	152	860	--	870	--	3,370	6.8
708	do	37	Apr. 5	342	24	462	572	292	858	2,330	952	51	3,860	6.6
			July 7	--	--	--	642	374	1,140	--	1,340	--	4,790	6.7
			Dec. 1	--	--	--	578	320	890	--	1,030	--	3,960	6.7
709	C. S. Brown	42	Apr. 5	140	7.8	77	393	51	137	650	382	28	1,100	6.8
			Oct. 5	--	--	--	310	29	51	--	258	--	686	7.1

* Estimated

Table 11.--Chemical analyses of ground water--Continued

Well	Owner	Depth of well (ft.)	Date of collection	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
WW-79-58-210	Dougherty Estate	42	Apr. 5, 1966	250	20	469	505	237	745	2,020	706	58	3,430	6.7
			July 6	--	--	--	508	193	650	--	628	--	3,080	6.8
			Dec. 2	--	--	--	504	183	630	--	600	--	2,970	6.9
83-02-212	R. B. McGloin	37	Apr. 5	158	19	403	548	174	519	1,580	472	64	2,710	7.1
			July 6	--	--	--	468	54	342	--	316	--	1,890	7.1
213	Dougherty Estate	37	Apr. 5	335	27	545	401	196	1,110	2,430	947	55	4,400	6.7
			July 6	--	--	--	382	306	1,320	--	1,270	--	5,010	6.9
216	do	37	Apr. 5	167	17	217	527	18	265	1,080	486	48	1,980	6.9
			July 6	--	--	--	610	32	115	--	306	--	1,280	7.1
			Dec. 2	--	--	--	634	25	80	--	262	--	1,210	6.9
218	McCown Estate	38	Apr. 5	107	14	42	302	15	109	495	324	21	846	6.9
			July 6	--	--	--	296	14	44	--	280	--	643	7.1
			Dec. 2	--	--	--	320	13	40	--	254	--	635	7.1
507	Carl Bluntzer	35	Apr. 5	300	33	125	820	24	330	1,280	884	22	2,290	6.6
			July 6	--	--	--	1,050	78	340	--	1,100	--	2,560	6.6
			Dec. 2	--	--	--	962	16	285	--	895	--	2,200	6.7
510	do		Apr. 5	114	14	388	712	100	375	1,410	342	70	2,360	6.8
			July 6	--	--	--	672	147	400	--	328	--	2,460	7.0
03-911	Welder Heirs	16	Apr. 5	926	503	6,982	390	1,300	12,800	22,700	4,380	77	36,000	6.5
			July 7	--	--	--	560	735	6,790	--	2,620	--	20,200	7.0
			Dec. 1	--	--	--	686	1,200	12,400	--	4,740	--	34,900	7.3
912	do	10	Sept. 6	--	--	--	950	302	675	--	545	--	3,840	6.8
			Dec. 1	--	--	--	1,030	270	1,120	3,100*	655	--	5,200	7.0
913	do	10	Jan. 3, 1967	--	--	--	944	1,580	1,780	5,000*	2,620	--	8,210	6.5

* Estimated