TEXAS WATER DEVELOPMENT BOARD

REPORT 104

WATER-LOSS STUDIES OF LAKE CORPUS CHRISTI NUECES RIVER BASIN, TEXAS, 1949-65

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

January 1970

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WATER-LOSS STUDIES OF LAKE CORPUS CHRISTI, NUECES RIVER BASIN, TEXAS, 1949-65

ABSTRACT

The changes in the hydrologic regimen for surface and ground water in the reach of a river inundated by a newly formed reservoir often present interesting but unexpected problems. Because numerous reservoirs are being planned in this time of increasing need for additional municipal, industrial, irrigation, and recreational water supplies, more analyses documenting these changes are needed in order that efficient use be made of the available water resources.

In April 1958 Lake Corpus Christi, which drains 16,656 square miles and is in south-central Texas on the Nueces River, was enlarged. This enlargement increased the elevation of the conservation pool by 20 feet and increased the potential inundated area by almost 30 square miles (old lake surface area was about 9 square miles). A cursory analysis of records of inflow to, change of contents in, and outflow from the lake after 1958 showed large losses of surface water in the reach studied. The accuracy of the surface-water records was suspect by some because the permeability of the sediments underlying the new reservoir was not considered to be great enough to account for the losses. A more detailed study resulted in the findings presented in this report.

The surface-water budget in the 57-mile reach of the Nueces River from Three Rivers downstream to Mathis was computed for the period 1949-65. The lower 33 miles of the reach is in Lake Corpus Christi. Past analyses of overbank flooding on the Nueces River much farther upstream have shown large water losses to the wide flood plain; however, an analysis of overbank flooding in the reach downstream from the Three Rivers stream-gaging station during the period 1949-65 indicated no positive loss due to this cause. Inflow to Lake Corpus Christi in the 8-month period following the beginning of enlarged impoundment in April 1958 raised the lake level by about 16 feet. The unaccounted for surface-water loss during 1958, most all of which occurred after April, was computed to be 193,200 acre-feet. In the period April 1958 to December 1961 an unaccounted for surface-water loss of 360,000 acre-feet was computed. For the entire period of study after impoundment, April 1958 to September 1965, a surface-water loss of 497,000 acre-feet was computed.

Intermittent water levels were obtained by the Texas Water Development Board at four ground-water wells near the lake from September 1956 to March 1965. The four wells were located 300, 500, 4,000, and 6,200 feet from the shoreline of the newly formed reservoir. All the wells were screened in the Goliad Sand. During the period 1958-61, the average rise in water level in the four wells was about 17 feet. After the large inflow to Lake Corpus Christi from May to September 1958, about 12,000 acres of alluvium was initially inundated. On the basis of a porosity of 0.30 for the alluvium and a change in saturated thickness equal to the difference between the old and the new lake levels, an infiltration to the alluvium of 32,000 acre-feet was computed. The recharge to the Goliad Sand for the period April 1958 to December 1961 was computed as 310,000 acre-feet by assuming a change in saturated thickness of 17 feet, a porosity of 0.25, a lake shoreline length of 75 miles, and an effective saturation distance normal to the lakeshore of 1½ miles. A total ground-water recharge to the alluvium and the Goliad Sand of 342,000 acre-feet was computed for the period April 1958 to December 1961. This ground-water gain compares closely with the computed surface-water loss of 360,000 acre-feet for the same period. Slight changes in the assumptions made to compute the ground-water recharge would give much closer agreement. For example, the saturation distance normal to the lakeshore (1½ miles) was based on the rise in water level in the well 6,200 feet from the shoreline (15 feet); obviously a somewhat greater distance could have been assumed.

A general recession of the lake level began in late 1961 and continued until May 1963. The four ground-water wells also reflected this general recession. In 1962 a gain was computed in the surface-water budget for Lake Corpus Christi, indicating that some of the ground water was returning to the reservoir. However, large volumes of inflow in 1963, 1964, and 1965 caused the lake level to again rise above the water table and more surface-water losses to occur.

The study points up the need for more intensive surface and ground-water data collection around major reservoirs before and after construction.

WATER-LOSS STUDIES OF LAKE CORPUS CHRISTI, NUECES RIVER BASIN, TEXAS, 1949-65

INTRODUCTION

In this time of increasing need for additional municipal, industrial, irrigation, and recreational water supplies, reservoirs are being planned and dams are being constructed at an accelerated rate. The changes in the hydrologic regimen for surface and ground water in the reach of a river inundated by a newly formed reservoir often present interesting but unusually mystifying problems. Sufficient hydrologic data to afford definition of the changes and isolation of the problems involved are usually lacking. Without isolation of the problems, optimum use of the reservoir can rarely be expected.

Purpose and Scope of Study

The purpose of this study is to show the magnitude of surface-water losses which can occur from impoundment of water in a new reservoir.

The study presents results of hydrologic analyses made to define the interchange of surface water and ground water in the reach of the Nueces River valley inundated by Lake Corpus Christi in south-central Texas. Streamflow, lake-content, and ground-water level data were available before and after enlargement of Lake Corpus Christi in April 1958. This enlargement increased the elevation of the conservation pool by 20 feet and increased the potential inundated area by almost 30 square miles. A cursory analysis of the inflow to and outflow from the lake after 1958 showed sizeable losses which prompted this more detailed analysis.

Location and Physical Features

Lake Corpus Christi is formed by Wesley E. Seale Dam on the Nueces River 40 miles northwest of Corpus Christi. The Wesley E. Seale Dam was completed and storage began on April 26, 1958. The dam was constructed a short distance downstream from Mathis Dam, completed July 24, 1934, which impounded water to form the old Lake Corpus Christi and which was submerged by the new lake. Information on significant features of the two dams and reservoirs is given in the following table:

	MATHIS DAM			WESLEY E. SEALE DAM		
	ELEVATION (FEET)	CAPACITY[1] (AC-FT)	SURFACE AREA[1] (ACRES)	ELEVATION (FEET)	CAPACITY[2] (AC-FT)	SURFACE AREA[2] (ACRES)
Crest of gates	74.5	39,400	5,480	94.0	302,100	22,050
Crest of regulated spillways	54.5	1,000	260	88.0	185,900	16,700
Invert of sluice gate	43.55	0	0	55.5	140	310

1/Based on 1948 sediment survey by U.S. Soil Conservation Service.

2/Based on 1956 topographic survey by Reagan & McCaughan, Consulting Engineers.

The specific area involved in this water-budget study is the 1,056 square-mile drainage of the Nueces River downstream from the stream-gaging station located 2 miles south of Three Rivers and upstream from the stream-gaging station located 0.6 mile downstream from Wesley E. Seale Dam (Figure 1). The Nueces River meanders through a distance of 57 miles in this reach with 33 miles being in backwater from Wesley E. Seale Dam. Major tributaries in the reach are: Sulphur Creek, La Para Creek, Spring Creek, Ramirena Creek, and Lagarto Creek.

Most of the area is rolling to moderately hilly, although some small areas are nearly flat. Elevations range from about 500 feet above mean sea level at the headwaters of Sulphur and Lagarto Creeks to about 30 feet in the Nueces River channel below Wesley E. Seale Dam. The Nueces River channel at the Three Rivers gaging station is at an elevation of about 100 feet above mean sea level.

Water Use

The city of Corpus Christi has permits from the Texas Water Rights Commission for diverting 500,000 acre-feet of water annually from Lake Corpus Christi and the Nueces River downstream. The distribution of these diversions with regard to use is as follows: Municipal, 220,000 acre-feet; industrial, 180,000 acre-feet; irrigation, 50,000 acre-feet; mining, 20,000 acre-feet; and recreation, 30,000 acre-feet. Over 99 percent of the water diverted under these permits is diverted from the pool formed by the low-head Calallen Dam 35 miles downstream from Wesley E. Seale Dam. Two other permits for a total annual diversion of 936 acre-feet are in force in the study area. The average annual discharge at the stream-gaging station 0.6 mile downstream from Lake Corpus Christi for the 26-year period October 1939 to September 1965 is 559,600 acre-feet.

The major purchasers of raw water for industrial use are Celanese Chemical Company and Suntide Refining Company.

Climatic Conditions

The 68-year average annual temperature at Beeville, 20 miles east of the study area, is 70.9°F. The monthly average temperature ranged from 55.7°F. for January to 84.3°F. for July. During the period covered by this report, January 1949 through September 1965, the annual temperature averaged about 72°F. Frost is infrequent in the area. At George West, near the center of the study area, the 49-year average annual rainfall is 26.77 inches. Monthly average rainfall ranges from 1.48 inches for March to 3.51 inches for September. The influence of tropical storms is indicated by September being the wettest month. During the period covered by this report, the annual rainfall averaged 25.28 inches. The 12.16 inches for 1955 was the second lowest annual rainfall measured at the George West station. In only 4 years during the period covered by this report was the annual rainfall greater than the 49-year average.

HYDROLOGIC AND CLIMATIC DATA

Inflow to Lake Corpus Christi

The stream-gaging station, Nueces River near Three Rivers, located about 25 miles upstream from Lake Corpus Christi, has been operated by the U.S. Geological Survey since July 1, 1915 (Figure 1). The station is presently operated in cooperation with the Texas Water Development Board. The drainage area of the Nueces River upstream from this station is 15,600 square miles. Except for the 3-month period November 1919 to January 1920, daily records of stream discharges are available since establishment. Records for the station were used in this study to determine the major inflow term in the water-budget analysis for Lake Corpus Christi.

The drainage area to Lake Corpus Christi below the Three Rivers stream-gaging station is 1,056 square miles. Runoff from this area was estimated on the basis of: (1) runoff gaged at the stream-gaging station Mission River at Refugio, draining 690 square miles about 30 miles east of the study area; and (2) rainfall measured at Goliad, Beeville, and George West (see inset of Figure 1). The stream-gaging station at Refugio has been operated by the Geological Survey in cooperation with the Texas Water Development Board since July 1939. Records of daily discharge are available for the station, and records of daily rainfall have been collected and published by the U.S. Weather Bureau at Goliad since 1913; at Beeville since 1896; and at George West since 1916. Unit runoff from the 1,056-square-mile area was estimated to have occurred as it did in the Mission River drainage and was adjusted for differences in watershed rainfall. Watershed rainfall used for the Mission River drainage was based on the average precipitation measured at Goliad and Beeville. Watershed rainfall used for the 1,056-square-mile drainage below the Three Rivers stream-gaging station was based on the precipitation measured at George West. Rainfall on the lake surface was assumed to be equal to that measured at George West.

The three elements of inflow, (1) runoff past the Three Rivers stream-gaging station, (2) runoff from the ungaged 1,056 square miles below Three Rivers, and (3) rainfall on the lake surface, were considered to provide all of the surface inflow to Lake Corpus Christi in this water-budget analysis.

Area and Contents of Lake Corpus Christi

Records of daily lake contents have been computed and published by the Geological Survey from elevations furnished by the city of Corpus Christi since September 10, 1948. This data-collection and dissemination program is presently carried out in cooperation with the Texas Water Development Board. Area and capacity tables used in computations were furnished by the city of Corpus Christi. The tables used prior to the lake enlargement, April 26, 1958, were based on a sediment survey made in December 1948 by the U.S. Soil Conservation Service. The tables used after enlargement were prepared from data furnished by Reagan & McCaughan, Consulting Engineers, and were based on a topographic survey made in 1956.

The average annual lake-surface area used in computing rainfall on the lake surface and evaporation from the lake surface was computed as the average of the average monthly areas. Annual change in lake contents was computed as the difference in the December 31 contents for succeeding years.

Outflow From Lake Corpus Christi

The stream-gaging station, Nueces River near Mathis, located 0.6 mile downstream from Wesley E. Seale Dam, has been operated by the Geological Survey since August 1939, and records of daily discharge are available since this date. Present operation of the station is in cooperation with the U.S. Army Corps of Engineers and Texas Water Development Board. Ninety-nine percent of the water released from Lake Corpus Christi for municipal or other purposes flows past the Mathis gaging station. Surface inflow from the 4-square-mile drainage below the dam and upstream from the gaging station was not considered in this water-budget analysis.

Beginning in October 1964, the Alice Water Authority diverted water directly from Lake Corpus Christi for municipal supply. For the period October 1964 to September 1965, the city of Corpus Christi reported that 3,280 acre-feet were diverted by the Alice Water Authority.

Evaporation from the lake surface was computed from data published by the U.S. Weather Bureau for the Beeville evaporation station, which is located about 25 miles northeast of Wesley E. Seale Dam. The Beeville station had a 72-inch sunken pan (Bureau of Plant Industry type) prior to March 1955 and a 24-inch screened sunken pan thereafter. Annual evaporation was computed using a pan coefficient of 1.00. Studies by Kohler (1954) indicate that the annual pan-to-lake coefficient for the Bureau of Plant Industry (BPI) pan is slightly above 0.9 if the annual pan-to-lake coefficient of a Class A pan is accepted as 0.7. This study also showed that the pan-to-pan ratio for BPI and screened sunken pans was near 1.00. However, more recent studies by Gilbert, Commons, Koberg, and Kennon (1964, p. F 48-61) using mass-transfer evaporation data indicate that the annual pan-to-lake coefficient for screened sunken pans could be greater than 1.00.

A coefficient of 1.00 was used in the Lake Corpus Christi study with the realization that it could be slightly high; but, through its use, some accounting for the evapotranspiration by the contiguous vegetation could be accomplished. No other attempt was made to isolate or account for evapotranspiration.

The three elements of outflow, (1) discharge from Lake Corpus Christi as gaged at the Mathis stream-gaging station, (2) direct diversion from the lake by the Alice Water Authority beginning October 1964, and (3) evaporation from the lake surface, were the only ones initially accounted for in this study.

Contiguous Ground-Water Levels

In 1956, the Geological Survey started extensive ground-water studies in Live Oak County in cooperation with the Texas Board of Water Engineers (a predecessor of the Texas Water Development Board). In these studies by Anders and Baker (1961), many water wells were inventoried in 1956 and 1957. At the conclusion of the ground-water studies, some of the wells were put into an observation-well program operated by the Texas Water Development Board, and water levels were measured for the next several years. Four of these observation wells were located near enough to Lake Corpus Christi to yield data of value in this water-loss analysis (Figure 1). Anders and Baker (1961) found that these four wells derive water from the Goliad Sand.

Well N-2 is 80 feet deep and located about 300 feet from the lakeshore. Water-level observations were obtained periodically from September 1956 to March 1964.

Well N-18 is 93 feet deep and located about 500 feet from the lakeshore. Water-level observations have been made periodically since 1956 and are continuing at this time.

Well N-28 is 160 feet deep and located about 6,200 feet from the lakeshore. Water-level observations were obtained periodically from February 1957 to March 1964.

Well N-29 is 270 feet deep and located about 4,000 feet from the lakeshore. Periodic water-level observations have been made since February 1957 and are continuing at this time.

While the data from these four wells are not considered adequate for detailed studies of ground-water movement away from Lake Corpus Christi, they are sufficient to provide hypothetical, but logical, conclusions in this water-loss analysis.

WATER BUDGET OF LAKE CORPUS CHRISTI

In this study the water budget for Lake Corpus Christi was evaluated by use of annual values for terms in the basic equation

$$Q_i = Q_o \pm \Delta S + L \text{ (all terms in acre-feet)},$$

Q_i = the inflow to the lake or reach, considered here to be the sum of streamflow gaged at the Three Rivers station and estimated inflow from ungaged drainage below the Three Rivers station (rainfall on lake surface is accounted for as an inflow term by using net evaporation as an outflow term);

Q_o = the outflow from the lake or reach, considered here to be the sum of streamflow gaged at the Mathis station, all known diversions in the reach of river studied, and net evaporation from the lake surface;

ΔS = the net change in lake contents; and

L = the water loss in the lake or reach.

The results of the water-budget evaluation are given in Table 1.

Accuracy of the data used as terms in the above equation is variable. The annual streamflow records at the Three Rivers and Mathis stream-gaging stations are considered to be within 5 percent accuracy. The annual change in lake contents also is considered accurate within 5 percent. Although some error in the values of lake contents and surface area may exist, values of net change in contents tend to average these errors. Net evaporation from the lake surface hopefully is within a 10-percent limit of accuracy. As stated, use of a pan coefficient of 1.00 is believed to facilitate at least a partial accounting of unmeasured evapotranspiration. Diversions in the study area, other than those by the Alice Water Authority, are considered negligible. Of the items included in the water budget, the one most subject to error is the estimate of inflow from the 1,056-square-mile drainage below the Three Rivers stream-gaging station. As discussed in the section "Hydrologic and Climatic Data," the estimate is based on annual runoff and rainfall in the adjacent Mission River watershed. Although the watersheds are similar in climate and physiography, the variability of storm patterns always injects doubt into an estimate of adjacent runoff. For the period January 1958 to September 1965, the estimate of ungaged inflow was 561,600 acre-feet or only 13 percent of the 4,356,000 acre-feet for the total inflow term of the water-budget equation (Table 1). Because the annual estimates should tend to have compensating errors when totaled for this period, the estimate is considered sufficiently accurate for this analysis.

Unaccounted Water Loss

An inspection of the computed water-loss (L) values shown in Table 1 brings immediate attention to the large losses in and subsequent to 1958. The logical assumption relative to these losses would be to relate them in some way to the initial filling of the new lake which began in April 1958. An analysis of these losses is made in a later section of this report. However, other questions can be raised concerning the water loss (or gain) values shown; e.g., the large gain in 1949 and the loss shown for 1952. The most plausible explanation for the large gain in 1949 is that heavy scattered showers occurred in the area in April, June, and July, and some apparently without adding to the rainfall total at the index station used at George West. The reverse of this hypothesis appears to be the most plausible explanation for the loss in 1952.

Analyses of Water Losses

Loss to Overbank Flooding

Records for stream-gaging stations on the Nueces River upstream from Three Rivers show very large losses of streamflow that were attributed to overbank flooding. For this reason, an analysis was made of possible losses to overbank flooding downstream from Three Rivers.

The analysis consisted of a simple graphical comparison of the computed water loss (L) from Table 1 with the annual accumulated depth of overbank flooding immediately downstream from the Three Rivers stream-gaging station (Figure 2). The graph shows that there was no relation between loss and overbank flooding prior to 1958. However, a relation is indicated for the period 1958-65. Actually, the relation is indicated because water loss is related to runoff (inflow to Lake Corpus Christi) during this period, and runoff is related to overbank flooding. If there had been any direct relation between the losses found and overbank flooding, some of the years with extensive overbank flooding prior to 1958 would have also shown losses. The analysis seems to show that water loss to overbank flooding in the study area is negligible.

Loss to Alluvium and Contiguous Aquifers

The large water losses indicated after 1957 were logically attributed to some aspect of the initial filling of the enlarged Lake Corpus Christi. Small errors in computed change in contents as determined from new capacity tables could not have accounted for the large volume of water lost. Except for the upper 5 miles, Lake Corpus Christi is underlain by alluvium and the Goliad Sand. Use of coefficients of transmissibility derived by Anders and Baker (1961) in the generally used equations for computing ground-water movement and recharge did not yield values which would account for the large losses.

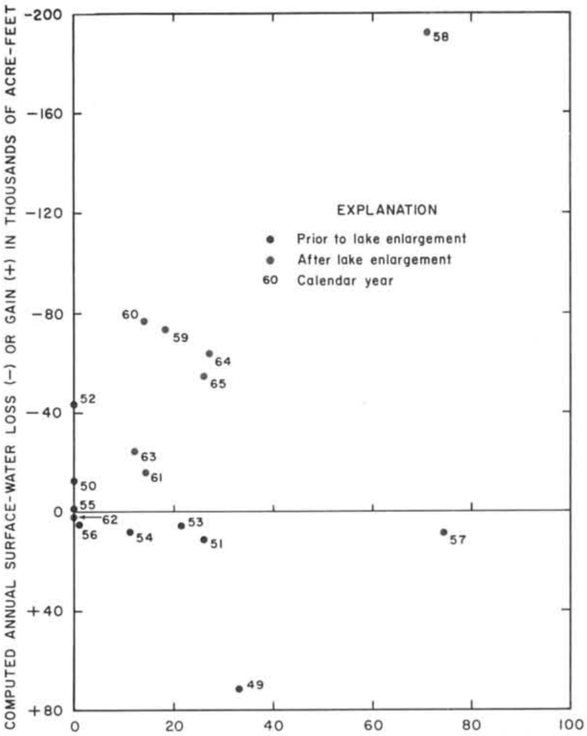

Figure 2.—Relation Between Annual Overbank Flooding and Surface-Water Loss in Nueces River, Three Rivers Gaging Station to Mathis Gaging Station, 1949-65

A graph of the monthly average lake level of Lake Corpus Christi for the period January 1957 to September 1965 is shown on Figure 3. At the time of initial impoundment for the enlarged reservoir, April 26, 1958, the surface area of the lake was about 5,500 acres. After the large inflow from May through September, the surface area was about 17,600 acres. Assuming that all of the newly inundated area was underlain by alluvium, and assuming that the unsaturated zone in the alluvium began at the elevation of the lake at the beginning of impoundment (74 feet), the volume of water in the newly saturated alluvium was computed by using a porosity of 0.30. The computed volume of water loss to the alluvium was 32,000 acre-feet.

Graphs of water levels in the four wells used in this study are shown for the period 1957-65 on Figure 3. These graphs show a water-level rise of over 24 feet between June 1958 and September 1960 in the well nearest the lakeshore (N-2). The average maximum rise in water level in the four wells during the 4-year period January 1958 to December 1961 was about 17 feet. Using this average rise to represent the depth of the newly saturated zone in the Goliad Sand, and assuming a porosity of 0.25, a shoreline length of 75 miles, and an effective saturation distance normal to the lakeshore of 1½ miles, a water loss of 310,000 acre-feet to the Goliad Sand during the period April 1958 to December 1961 was computed. Because a rise in water level of about 15 feet occurred in well N-28, which is 6,200 feet from the lakeshore, the use of 1½ miles as the lateral extent of saturation is considered to yield a conservative estimate of water loss to the aquifer.

If the lag in ground water level rise relative to lake-level rise as shown in Figure 3 is correct, the data almost preclude any consideration that some of the ground-water rise might be attributable to load effect from the impounded water. However, in the absence of more ground-water observations in these wells during and immediately after filling of the new reservoir, some reservations should be made relative to the loading effect that could be in the water levels. Only a small amount of recharge to the Goliad Sand from the heavy rainfall in April and May 1957 (about 12 inches) is indicated by the limited ground-water data. This lack of data emphasizes the need for a record of the adjacent ground-water level during the filling of any major reservoir.

The total volume of water filling voids of the newly saturated alluvium and the Goliad Sand was computed to be 342,000 acre-feet for the period of initial filling from about April 1958 to December 1961. Results of the water-budget analysis given in Table 1 show a water loss of about 360,000 acre-feet during this period. If the water table in the adjacent aquifers had been assumed to be 5 feet lower than the lake surface at the beginning of filling, an additional 20,000 acre-feet of infiltration could be computed. Unmeasured evapotranspiration also could probably account for some of the 18,000 acre-feet difference during the 4-year period of comparison.

A water loss of 193,200 acre-feet was found for 1958 (Table 1). Presumably, saturation (loss of 32,000 acre-feet) of the newly inundated alluvium would take place during 1958; however, a filling of voids in the Goliad Sand in the amount of 161,000 acre-feet during the 8-month period following initial reservoir impoundment is not apparent from the ground-water levels. If over half of the 310,000 acre-feet computed initial water loss to the aquifer occurred in 1958, it would follow that over half the maximum water-level rise in the penetrating wells should also occur. An inspection of Figure 3 shows only the water level in well N-2 to have risen in this manner. However, if more ground-water observations had been available, possibly the graphs for wells N-18 and N-29 would have shown that more than half the maximum rise took place in 1958.

The unaccounted gain of 1,800 acre-feet in 1962 reflects an apparent return of ground water from the contiguous aquifers. During years of general decline in lake level, a gain should be expected. It is probable, however, that much of the ground water returned in this manner is lost to evapotranspiration. Because of a lack

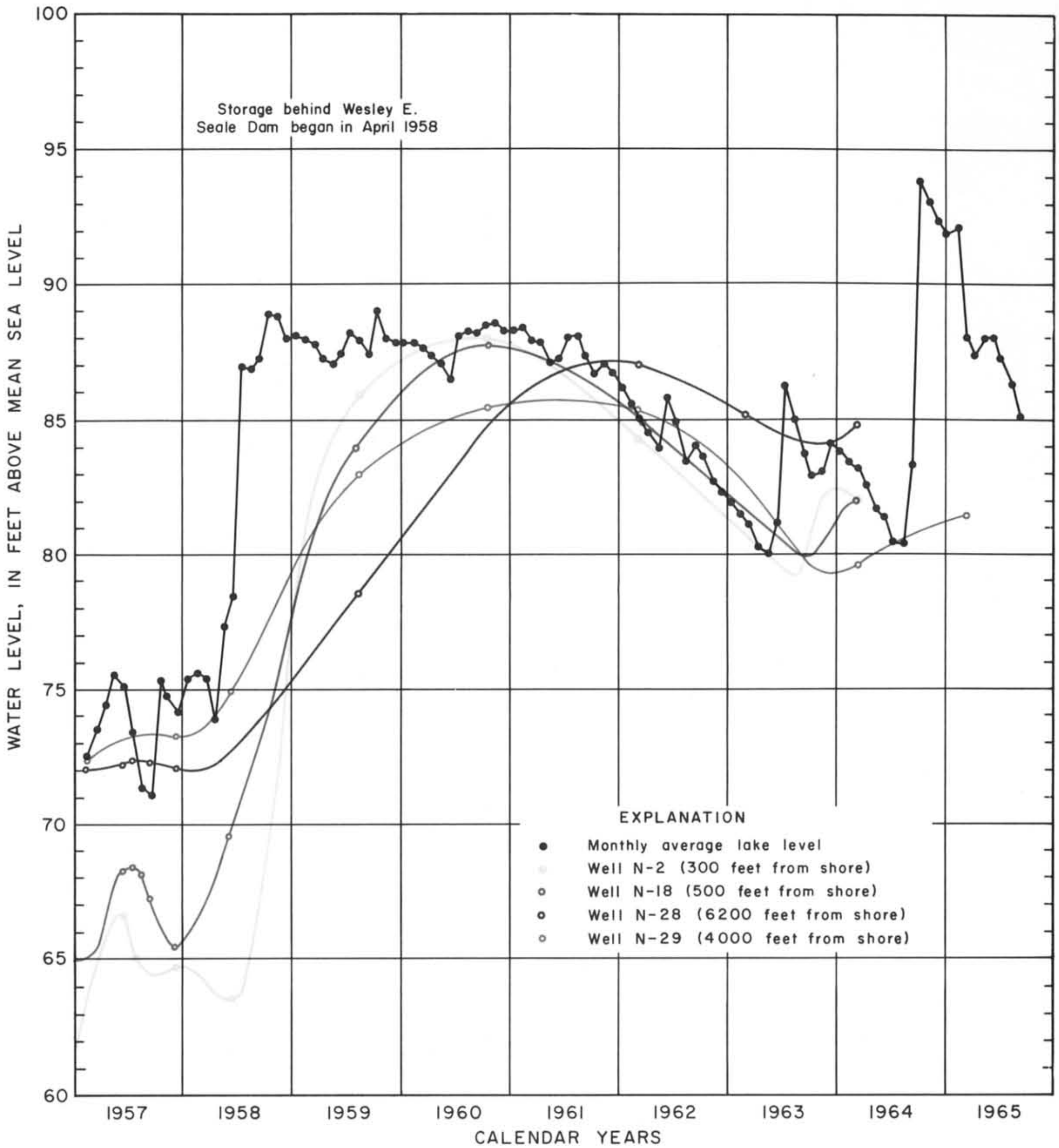

Figure 3.—Water Levels in Lake Corpus Christi and in the Contiguous Aquifers, 1957-65

of ground-water data, the rather large losses in 1964 and 1965 could not be compared with changes in ground-water storage. Logic would dictate that a higher ground-water level also occurred because the lake level in 1964 was 5 feet higher than at any previous time.

Table 1 shows that the total unaccounted water loss for the period January 1958 to September 1965 was 497,000 acre-feet. Lack of data on the continued movement of ground water away from the locally high water table near the reservoir precludes a discussion of how long the large water losses to the aquifer will continue. Presumably a condition of near equilibrium eventually should be attained. However, when large rises in lake level occur, sizeable losses will probably result.

Studies by Brown, Jones, and Rogers (1948) found that after the original Lake Corpus Christi was filled, the water level in local wells within one-quarter of a mile rose about 30 feet.

SUMMARY AND CONCLUSIONS

During initial filling of the enlarged Lake Corpus Christi, large quantities of lake water percolated into the underlying alluvium and Goliad Sand. From the beginning of impoundment, April 26, 1958 to December 31, 1958, 193,000 acre-feet of water in storage was estimated to have been lost in this manner. Of this amount, about 161,000 acre-feet percolated into the Goliad Sand and the remainder into the alluvium. For the period January 1958 to September 1965, a total water loss of 497,000 acre-feet was computed. All of the 497,000 acre-feet, except the original loss to the alluvium (about 32,000 acre-feet), is estimated to have percolated into the Goliad Sand. Analyses showed that no measurable losses from overbank flooding occur in the reach of the Nueces River covered by this report.

Analyses indicated that during periods of continued lake-level recession, some return of ground-water storage can be expected; however, due to the physical limitation imposed by the specific yield of the aquifer and the continuing action of evapotranspiration, this return flow probably will be small. At the end of the period covered by this report, large losses were still occurring with large rises in lake level. The available data do not permit analyses for defining the probable future losses.

RECOMMENDATIONS

Although meaningful analyses and results were possible with the hydrologic and climatic data available for this study, with only a minor additional expense for data collection, many of the uncertainties in the analyses could be eliminated or greatly minimized. The writer recommends that stream-gaging stations should be located on Sulphur Creek, Ramirena Creek, and Lagarto Creek, to provide data needed to define runoff from the 1,056 square-mile ungaged drainage immediately upstream from Lake Corpus Christi. These stream-gaging stations would not only provide the data needed for accurate water-budget studies of Lake Corpus Christi, but would also provide much needed data on runoff from smaller watersheds which is lacking in this general locality.

Also, a more extensive and systematic ground-water observation well network around the lake would permit analyses to define the future changes in ground-water storage and movement attributable to lake impoundment. A network of eight observation wells with water-level recorders should be established around the lake in the Goliad Sand. The wells should be located in pairs with northwest-southeast alignment, one about 500 feet from shore and one about 1½ miles from shore, on both the east and west sides of the lake. Data collected from this recommended observation-well network and data on aquifer characteristics obtained from pumping tests would define the effects of Lake Corpus Christi on the contiguous ground-water regimen. In light of the large number of reservoirs to be constructed in the near future in this and other areas of the State, definition of the surface and ground-water interchange is prerequisite to sound water management.

SELECTED REFERENCES

Anders, R. B., and Baker, E. T., Jr., 1961, Ground-water geology of Live Oak County, Texas: Texas Board Water Engineers Bull. 6105.

Brown, C. B., Jones, V. H., and Rogers, R. E., 1948, Report on sedimentation in Lake Corpus Christi and the water supply of Corpus Christi, Texas: U.S. Soil Conservation Service Tech. Pub. 74.

Gilbert, C. R., Commons, G. G., Koberg, G. E., and Kennon, F. W., 1964, Hydrologic studies of small watersheds, Honey Creek basin, Collin and Grayson Counties, Texas, 1953-59: U.S. Geol. Survey Water-Supply Paper 1779-F, p. F48-61.

Kohler, M. A., 1954, Lake and pan evaporation, *in* Water-loss investigations, Lake Hefner studies, technical report: U.S. Geol. Survey Prof. Paper 269, p. 127-148.

Needs a line drafted

Table 1.--Annual Surface-Water Budget for Lake Corpus Christi, 1949-65

BUDGET ITEM (Runoff in thousands of acre-feet)	CALENDAR YEARS 1949	1950	1951	1952	1953	1954	1955	1956	1957	1958[1]	1959	1960	1961	1962	1963	1964	1965[2]	PERIOD 1958-65
Runoff, Three Rivers gaging station	810.6	219.8	408.1	149.4	588.5	244.6	149.8	145.0	1,477.0	1,555.0	499.0	410.2	321.9	45.0	165.3	513.3	284.8	3,794.5
Ungaged runoff below Three Rivers	37.5	4.0	33.2	66.1	60.9	7.1	3.2	12.4	75.7	214.0	43.9	173.7	47.9	29.7	7.0	9.7	35.7	561.6
Total lake inflow (Q_I)	848.1	223.8	441.3	215.5	649.4	251.7	153.0	157.4	1,552.7	1,769.0	542.9	583.9	369.8	74.7	172.3	523.0	320.5	4,356.1
Runoff, Mathis gaging station	907.5	204.5	428.2	160.3	636.9	242.7	129.5	136.7	1,546.0	1,413.0	416.6	455.1	320.8	76.4	79.9	276.6	352.3	3,390.7
Net evaporation from lake	10.3	20.8	13.9	17.8	12.5	20.2	26.2	17.6	14.9	15.0	57.6	36.6	67.4	58.0	44.8	48.6	39.7	367.7
Alice Water Authority diversions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.7	2.6	3.3
Total known lake outflow (Q_O)	917.8	225.3	442.1	178.1	649.4	262.9	155.7	154.3	1,560.9	1,428.0	474.2	491.7	388.2	134.4	124.7	325.9	394.6	3,761.7
Change in lake contents (ΔS)	+ 5.5	-14.0	+ 9.4	- 6.1	+ 6.6	- 2.3	- 3.1	+ 9.0	- 0.3	+ 147.8	- 5.0	+15.2	-34.3	-57.9	+23.4	+134.6	-126.4	+ 97.4
Net unaccounted (L)	-75.2	12.5	-10.2	43.5	- 6.6	- 8.9	0.4	- 5.9	- 7.9	193.2	73.7	77.0	15.9	- 1.8	24.2	62.5	52.3	497.0

1/ Impoundment of water in enlarged Lake Corpus Christi began April 26, 1958.
2/ Nine-month period through September.