USGS
science for a changing world

In cooperation with the Edwards Aquifer Authority

Water-Budget Analysis of Medina and Diversion Lakes and the Medina/Diversion Lake System, With Estimated Recharge to Edwards Aquifer, San Antonio Area, Texas

Scientific Investigations Report 2004–5209

U.S. Department of the Interior
U.S. Geological Survey

Cover:
Medina Lake, September 2001.

A Water-Budget Analysis of Medina and Diversion Lakes and the Medina/Diversion Lake System, With Estimated Recharge to Edwards Aquifer, San Antonio Area, Texas

By Richard N. Slattery and Lisa D. Miller

In cooperation with the Edwards Aquifer Authority

Scientific Investigations Report 2004–5209

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
Charles G. Groat, Director

U.S. Geological Survey, Reston, Virginia: 2004
For sale by U.S. Geological Survey, Information Services
Box 25286, Denver Federal Center
Denver, CO 80225

For more information about the USGS and its products:
Telephone: 1-888-ASK-USGS
World Wide Web: http://www.usgs.gov/

Suggested citation:

Slattery, R.N., and Miller, L.D., 2004, A water-budget analysis of Medina and Diversion Lakes and the Medina/Diversion Lake system, with estimated recharge to Edwards aquifer, San Antonio area, Texas: U.S. Geological Survey Scientific Investigations Report 2004–5209, 41 p.

Contents

Figures

Tables

Vertical Datum

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

A Water-Budget Analysis of Medina and Diversion Lakes and the Medina/Diversion Lake System, With Estimated Recharge to Edwards Aquifer, San Antonio Area, Texas

By Richard N. Slattery and Lisa D. Miller

Abstract

In January 2001, the U.S. Geological Survey—in cooperation with the Edwards Aquifer Authority—began a study to refine and, if possible, extend previously derived (1995–96) relations between the stage in Medina Lake and recharge to the Edwards aquifer to include the effects of reservoir stages below 1,018 feet and greater than 1,046 feet above National Geodetic Vertical Datum of 1929. The principal objective of this present (2001–02) study was to estimate ground-water outflow (seepage) from Medina Lake, Diversion Lake, and from the Medina/Diversion Lake system through the calculation of water budgets representing steady-state conditions over as wide a range as possible in the stages of Medina and Diversion Lakes. The water budgets were compiled for selected periods during which time the water-budget components were inferred to be relatively stable and the influence of precipitation, stormwater runoff, and changes in storage were presumably minimal.

Water budgets for the Medina/Diversion Lake system were compiled for 127 water-budget periods ranging from 8 to 78 days from daily hydrologic data collected during March 1955–September 1964, October 1995–September 1996, and February 2001–June 2002. Budgets for Medina and Diversion Lakes were compiled for 14 periods ranging from 8 to 23 days from daily hydrologic data collected only during October 1995–September 1996 and April 2001–June 2002.

Linear equations were developed to relate the stage in Medina Lake to ground-water outflow from Medina Lake, Diversion Lake, and the Medina/Diversion Lake system. The computed mean rates of outflow from Medina Lake ranged from about 18 to 182 acre-feet per day between stages of 1,019 and 1,064 feet above National Geodetic Vertical Datum of 1929. The computed rates of outflow from Diversion Lake ranged from about -85 to 52 acre-feet per day. The rates of outflow from the entire lake system ranged from about 5 to 178 acre-feet per day between Medina Lake stages of 963 to 1,064 feet. It is assumed that all outflow from the lake system enters the ground-water system as recharge to the Edwards aquifer.

During the time that the stage in Medina Lake was greater than about 1,040 feet, Diversion Lake gained more water than it lost to the ground-water system and the rate of ground-water outflow from Medina Lake increased sharply while its stage was between about 1,043 and 1,045 feet. The observed outflow from Diversion Lake during this time decreased sharply to the extent that a net gain resulted—indicating that a substantial amount of the additional outflow from Medina Lake returned to Diversion Lake. When the stage in Medina Lake is at the spillway elevation of 1,064 feet, Diversion Lake appears to gain as much as 40 percent of the concurrent ground-water outflow from Medina Lake.

An indication of water moving from the lake system into the ground-water system and back to the surface-water system was observed in the most downstream reach of the Medina River, between Diversion Lake and the Medina River near Riomedina. During conditions of no flow over Diversion Dam, this reach of the Medina River gained from about 32 to 94 acre-feet per day, with the gain increasing with increasing stage in Diversion Lake.

The average of the monthly recharge to the Edwards aquifer from the Medina/Diversion Lake system—as estimated by the present study for the October 1995–September 2002 period—is 3,083 acre-feet, or about 56 percent of recharge computed for this period with a previously used (Lowry) method. The present study's estimates of recharge for months with rising-lake stage conditions are about 44 percent of those computed with the previously used method, compared to about 60 percent for months with steady or falling-stage conditions. For stages greater than 1,045 feet, the present study estimated recharge to be about 52 percent of that computed with the previously used method, compared to about 64 percent at stages below 1,045 feet.

Introduction

Study Area

The Medina and Diversion Lakes study area (fig. 1) is located in northeastern Medina County and southeastern Bandera County, Texas, within the 650-square mile (mi^2) drainage area upstream from the U.S. Geological Survey (USGS) gaging station on the Medina River near Riomedina (fig. 2). Medina Lake straddles the Medina-Bandera County boundary and Diversion Lake lies behind Diversion Dam, about 5 river miles (mi) downstream from Medina Dam.

Constructed in 1912 to impound water for irrigation, Medina Dam has a conservation pool elevation (top of spillway) of 1,064.2 feet (ft) above NGVD 29. When full, Medina Lake holds nearly 255,000 acre-feet (acre-ft) of water, within a surface area of about 6,066 acres and about 71 mi of shoreline. The low-head Diversion Dam impounds an additional 2,555 acre-ft of water when filled to its spillway elevation of 919.0 ft. Part of the water from Diversion Lake can be diverted at Diversion Dam through the Medina Irrigation Canal to the Bexar-Medina-Atascosa Water Improvement District irrigation network, which provides irrigation water to about 33,000 acres of farmland in the Medina River Valley (Texas Water Development Board, 1996).

Hydrogeologic Setting

The Edwards aquifer is one of the most permeable and productive carbonate-rock (limestone and dolostone) aquifers in the United States and is the major source of public water supply for more than 1.6 million people in Bexar, Comal, Hays, Medina, and Uvalde Counties (U.S. Census Bureau, 2000). This aquifer supplies large quantities of water to agricultural, industrial, and recreational interests as well as to most businesses in the region. Spring discharge from the aquifer is vital to the area's tourism economy, the survival of several threatened or endangered plant and animal species, and the maintenance of downstream water supplies.

Recharge to the Edwards aquifer occurs mainly from streams that originate in the upgradient catchment area and flow across the outcrop (recharge zone) of the aquifer (fig. 1). Most runoff from the catchment area infiltrates updip, unconfined parts of the Edwards aquifer through faults, fractures, and sinkholes that characterize this recharge zone (Small and Clark, 2000).

The Edwards aquifer is recharged also by ground-water outflow (seepage) from Medina and Diversion Lakes, individually, as well as from the Medina/Diversion Lake system as a whole. Recharge from this system is estimated to contribute an average 62,700 acre-ft of recharge annually to the Edwards aquifer, accounting for about 9 percent of the estimated 698,500 acre-ft of average annual (1934–2003) recharge to the Edwards aquifer (Slattery, 2004).

Recharge to the Edwards aquifer in the study area is greatly influenced by the local hydrogeology (fig. 3; table 1, at end of report). Surface-water losses from the Medina/Diversion Lake system enter the aquifer indirectly through the Glen Rose Limestone of the Trinity Group or directly through porous outcrops of the Kainer Formation of the Edwards Group (Lambert and others, 2000). Medina Lake bottoms in the upper member of the Glen Rose Limestone (Small and Lambert, 1998, fig. 3), which comprises the relatively impermeable upper zone of the Trinity aquifer (Barker and Ardis, 1996, p. B42). Southern parts of Medina Lake abut the basal nodular member and possibly lower part of the dolomitic member of the Kainer Formation (T.A. Small, U.S. Geological Survey, retired, oral commun., 2000), the lowermost formation of the extraordinarily permeable Edwards aquifer. Because the relation between the hydrogeologic subdivisions in the study area and the associated zones of differing porosity and permeability are vertically controlled (Small and Lambert, 1998, table 4), recharge to the Edwards aquifer that occurs as seepage from the Medina/Diversion Lake system can be related to the stage in Medina Lake.

Whereas the contact between the upper member of the Glen Rose Limestone and the basal nodular member of the Kainer Formation is about 1,000 ft above NGVD 29, the contact between the basal nodular and dolomitic members of the Kainer Formation occurs at about 1,050 ft (Lambert and others, 2000). Because Medina Lake abuts the recharge zone of the Edwards aquifer between altitudes of about 1,000 and 1,064 ft (top of spillway), it is possible for water to seep from the lake into the aquifer so long as the stage exceeds about 1,000 ft. According to Lambert and others (2000, p. 17), "...the greatest losses from [Medina] lake to the ground-water system appear to result from lake stages that range from about 1,040 to 1,045 ft," a range that coincides with some of the more porous and permeable parts of the Kainer Formation on the southern side of Medina Lake (T.A. Small, U.S. Geological Survey, retired, oral commun., 2000).

From the bottom of the Medina Lake spillway to the approximate midpoint of Diversion Lake, where the Diversion Lake fault intersects Diversion Lake (fig. 3), the Medina River channel lies on the upper member of the Glen Rose Limestone, which corresponds to the upper zone of the Trinity aquifer. From the approximate midpoint of Diversion Lake downstream to the Haby Crossing fault—including the Medina River below Diversion Dam—the lake and river channel lie on a thin residuum of the basal nodular member, which corresponds to the lowermost part of the Edwards aquifer (Lambert and others, 2000).

Relation to Previous Studies

Lowry (1953) developed curves relating the storage (and therefore, stage) in Medina Lake to monthly seepage losses from the Medina/Diversion Lake system. Based on a substantial amount of estimated record, Lowry's curves originally were intended only as a tool for evaluating the design of a proposed

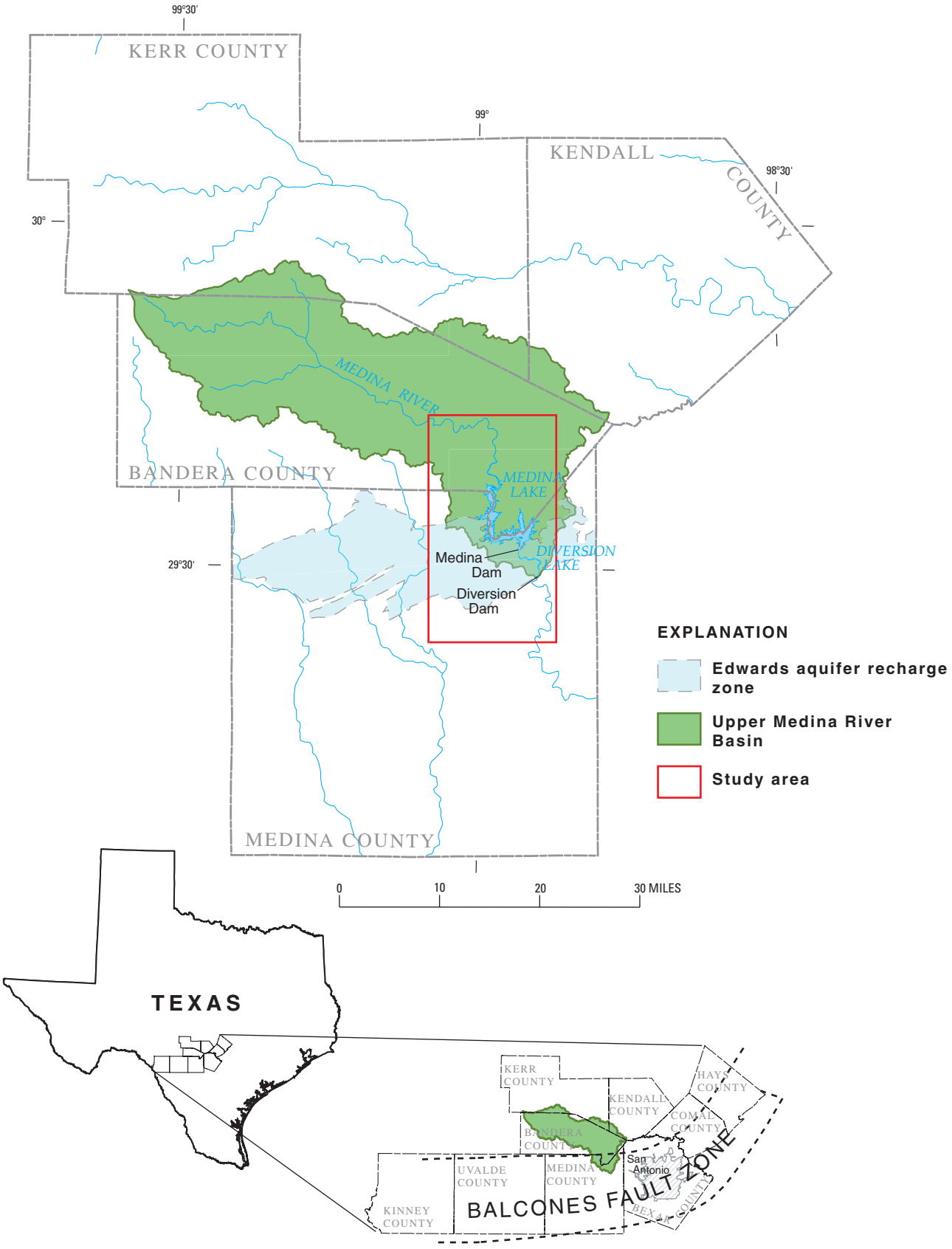

Figure 1. Location of the study area and upper Medina River Basin, San Antonio area, Texas.

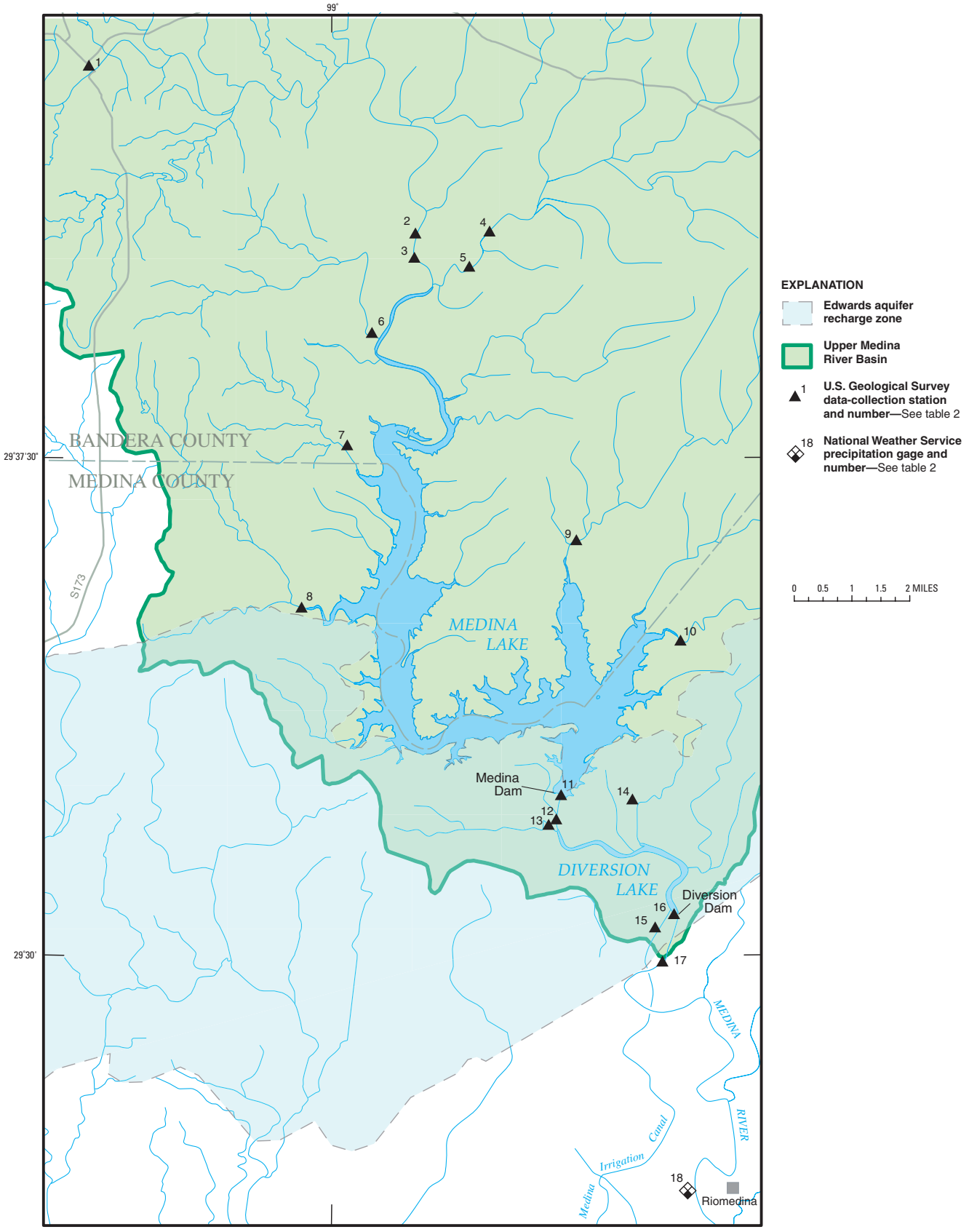

Figure 2. Southern part of the upper Medina River Basin and locations of data-collection sites in the study area.

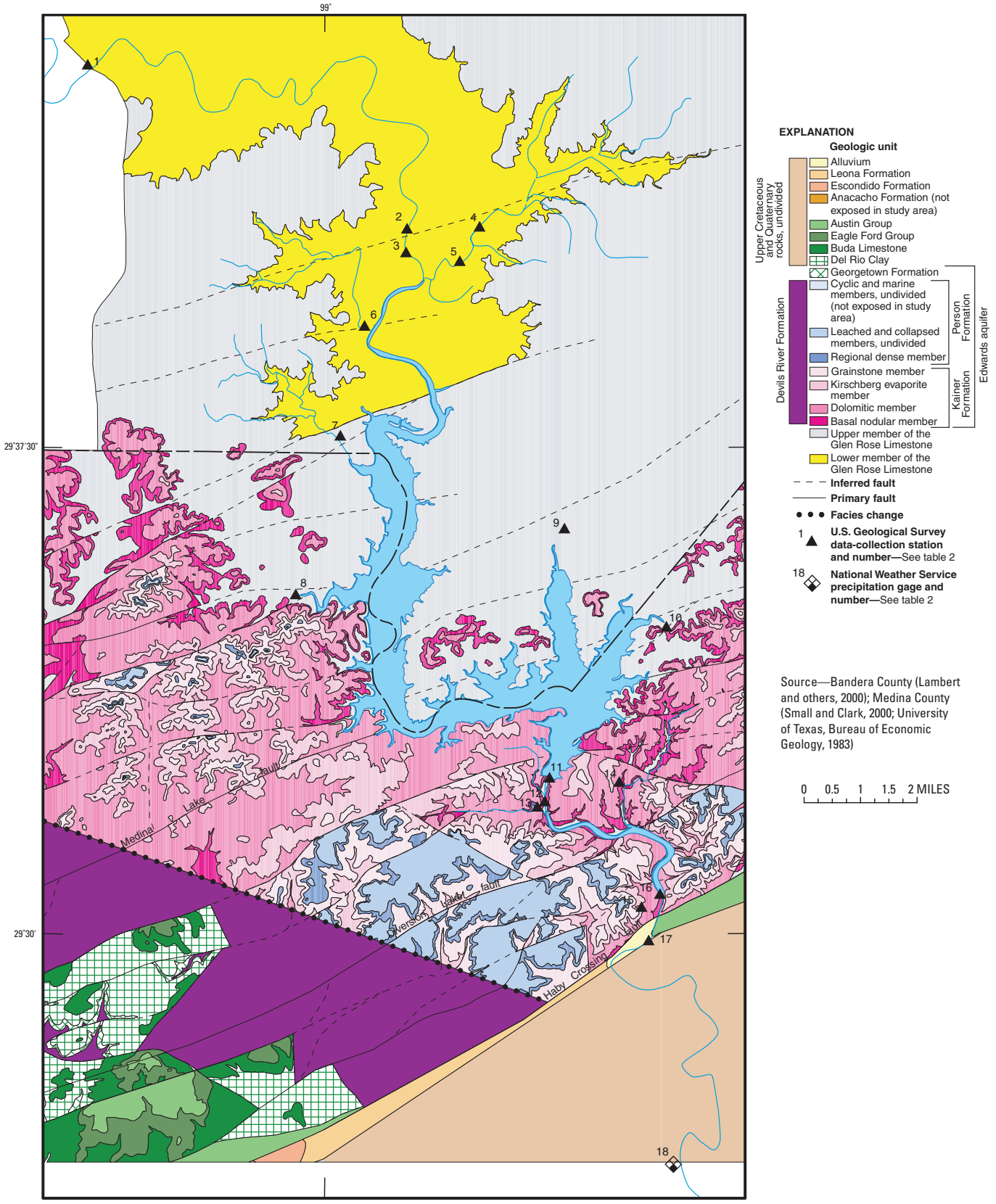

Figure 3. Surface and shallow subsurface geology of the study area.

reservoir in the lower part of the Medina River Basin. Lowry's work was adapted later by Puente (1978) to estimate annual recharge to the Edwards aquifer in that basin.

The USGS currently uses Puente's (1978) adaptation of the Lowry (1953) method to estimate annual recharge to the Edwards aquifer from the Medina/Diversion Lake system (Slattery, 2004). The USGS procedure sums estimates of monthly recharge (computed with the Lowry method) to estimate annual recharge, assuming that the short-term errors cancel over the course of a typical year.

During October 1995–September 1996, the USGS conducted a study (Lambert and others, 2000) with objectives to better define short-term rates of recharge and to reduce the error and uncertainty associated with estimates of monthly recharge from the Medina/Diversion Lake system. As part of that study, the USGS developed water budgets for Medina Lake, Diversion Lake, and the Medina/Diversion Lake system to derive the amount of ground-water outflow from each of these lakes as well as from the entire lake system. During that period of study, however, the stage in Medina Lake ranged from only about 1,018 to about 1,046 ft above NGVD 29. Consequently, the recharge estimates derived by the 1995–96 study (Lambert and others, 2000, p. 12) are considered "...valid only for a range in Medina Lake stage between about 1,018 and 1,046 ft above [NGVD 29]."

Therefore, the USGS—in cooperation with the Edwards Aquifer Authority (EAA)—began a study in January 2001 to refine and, if possible, extend the previously derived (1995–96) relations between Medina Lake stage and recharge to the Edwards aquifer to include the effects of reservoir stages below 1,018 ft and greater than 1,046 ft above NGVD 29. The principal objective of this present (2001–02) study was to estimate ground-water outflow from Medina Lake, Diversion Lake, and from the Medina/Diversion Lake system through the computation of water budgets representing steady-state conditions over as wide a range as possible in the stages of Medina and Diversion Lakes.

Purpose and Scope

The purpose of this report is to summarize precipitation, evaporation, and surface-water data collected during February 2001–June 2002 and provide updated water budgets for Medina and Diversion Lakes and the Medina/Diversion Lake system, including estimates of ground-water recharge from the lake system to the Edwards aquifer. These updated water budgets incorporate data collected during March 1955–September 1964 by the USGS, the National Weather Service (NWS), and the Texas Water Development Board (TWDB) in addition to data collected by the USGS during October 1995–September 1996 (Lambert and others, 2000).

Water-Budget Analysis

To estimate ground-water outflow from Medina and Diversion Lakes and from the Medina/Diversion Lake system, discrete water budgets were computed for selected periods over a range of stages in Medina and Diversion Lakes. The water-budget equation incorporates measurable components of inflow and outflow to solve for (or otherwise scientifically estimate) unknown gains or losses, or both, from a lake or the lake system. The measurable components include: surface-water inflow and outflow, precipitation, evaporation, and change in storage. The net effect of the unknown gains and losses is represented by the residual of all the measurable components—or water that is not accounted for, including errors associated with each of the measurable components.

The solution to the water-budget equation is obtained by balancing the contribution of each component of the water budget for any given budget period. The overall water-budget equation for Medina and Diversion Lakes and the Medina/Diversion Lake system can be written as follows:

$$GW_{out} \pm e_{GWout} = P \pm e_P - E \pm e_E + SW_{in} \pm e_{SWin} - SW_{out} \pm e_{SWout} - \Delta S \pm e_{\Delta S}, \quad (1)$$

where (all units in acre-feet per day)

GW_{out} is ground-water outflow (loss from the lake system, or selected part of the lake system, assumed to recharge the ground-water system) minus ground-water inflow (gain to the lake system, or selected part of the lake system, from the ground-water system);

P is precipitation on the lake;

E is evaporation from the lake surface;

SW_{in} is surface-water inflow to the lake;

SW_{out} is surface-water outflow from the lake;

ΔS is change in lake storage; and

e_i is the standard deviation around each measured term i.

As for the previous (1995–96) study (Lambert and others, 2000), domestic and municipal withdrawals from and discharges into Medina and Diversion Lakes were presumed negligible and are not accounted for in the water-budget analysis. As for the previous study, all components of ground-water inflow to the Medina/Diversion Lake system also were presumed negligible.

Daily precipitation, evaporation, streamflow, and reservoir storage were either measured directly or values were estimated on the basis of periodic on-site measurements. Table 2 (at end of report) lists the site number, USGS or NWS station number, station name, latitude, longitude, drainage area, station type, and period of record for the data-collection sites. Locations of the data-collection sites are shown in figure 2.

A water budget for the Medina/Diversion Lake system was computed using daily hydrologic data collected during March 1955–September 1964, October 1995–September 1996 (Lambert and others, 2000), and February 2001–June 2002

Figure 4. Weather station on Medina Lake, Texas, March 2001.

(present study). Water budgets for Medina and Diversion Lakes were computed using daily hydrologic data collected only during the 1995–96 and 2001–02 data-collection periods. Budgets for the individual lakes could not be computed from the 1955–64 data, because no streamflow data were available between the two lakes during that period.

The following sections describe how each component in the water budget (eq. 1) was derived for the 1955–64 and 2001–02 periods. Data from the 1995–96 study (Lambert and others, 2000) were used as published with the exception of some evaporation data, for which missing record was estimated as explained under "Evaporation," below.

Precipitation

Daily precipitation records from the NWS site at Riomedina (site 18) were used to estimate precipitation (P) on Medina and Diversion Lakes during 1955–64. No other sites from which to compute a weighted average were active within a reasonable proximity of the lakes during this time (fig. 2, table 2). For 2001–02, daily precipitation data from Medina River at Bandera (site 1) and Riomedina (site 18) were spatially weighted to estimate precipitation on Medina Lake (table 2). The weighting of the sites was based on the spatial proximity of the sites relative to Medina Lake. Using points of equal distance between sites 1 and 18 as the delineating boundary for each site, it was estimated that 30 percent of the Medina Lake surface area was within the area covered by site 1 and that 70 percent was covered by site 18. Therefore, the daily precipitation at site 1 was multiplied by 0.30 and the daily precipitation at site 18 by 0.70. The resulting values were summed to obtain estimates of daily precipitation on Medina Lake. Daily precipitation recorded at site 18 was used as an estimate of precipitation on Diversion Lake.

Evaporation

For 1955–64, daily evaporation (E) from Medina and Diversion Lakes was estimated from monthly evaporation totals for the Medina Lake area from the Texas Water Development Board (2004).

Daily evaporation data missing from the 1995–96 record (Lambert and others, 2000) were estimated using daily pan evaporation data from the NWS site at Sea World, San Antonio, Tex., located about 15 mi east-southeast of Medina Lake. Monthly pan coefficients for the Medina Lake area from the Texas Water Development Board (2003) were applied to the pan evaporation to compute the daily evaporation for Medina and Diversion Lakes. Periods for which the 1995–96 evaporation data were revised included October 11–November 12, 1995; January 19–24, and 27–28, 1996; February 7–9, 11–15, and 29, 1996; May 4, 13–15, and 19–24, 1996; August 4–19, and 21–22, 1996; and September 12–31, 1996.

For this report, lake evaporation (E) was estimated for 2001–02 from meteorological data collected at sites located on Medina and Diversion Lakes. Estimation of E also was made using evaporation data collected at the Texas A&M University (TAMU) meteorological data-collection site in San Antonio. The TAMU site is located about 27 mi east of Medina Lake (Texas A&M University, 2003).

Data collected at the Medina Lake weather station (site 11, fig. 4) included wind speed and direction, net radiation, vapor pressure, air temperature, and water temperature at selected depths. Data collected at the Diversion Lake weather station (site 16) included wind speed and direction, shortwave

radiation, vapor pressure, air temperature, and water temperature at the water surface.

Evaporation data for 2001–02 were calculated with the Bowen ratio-energy budget (BREB) (Bowen, 1926). To calculate evaporation using the BREB method, data-collection techniques and calculation methods were modified for open-water conditions as described by Laczniak and others (1999) and German (2000). Periods of missing BREB evaporation record were estimated using a relation between available BREB evaporation record and potential evaporation collected at the TAMU meteorological data-collection site.

Surface-Water Inflow and Outflow

For 1955–64, the surface-water inflow (SW_{in}) component to the Medina/Diversion Lake system was computed from records collected at two USGS continuous-record streamflow-gaging stations, Medina River near Pipe Creek (site 3) and Red Bluff Creek near Pipe Creek (site 4), and from streamflow estimates from the ungaged areas (fig. 2, table 2). The Red Bluff Creek gage (site 4) began operation in April 1956; therefore, from March 1955 through March 1956, the Red Bluff Creek drainage basin is included in the estimates of the ungaged area for that period.

For 1955–64, the surface-water outflow (SW_{out}) component for the Medina/Diversion Lake system was computed using estimated and continuous record from Medina Irrigation Canal, site 15 (fig. 5), and from continuous record collected at Medina River near Riomedina, site 17 (fig. 2, table 2). Site 15 began operation in July 1957. Prior to July 1957, flow at site 15 was estimated on the basis of periodic observations of the water level in Diversion Lake, behind Diversion Dam (fig. 6). From March 2 to April 29, 1955, Diversion Lake stage was reported as below the intake to Medina Irrigation Canal; from April 29, 1955, to April 3, 1957, Diversion Lake was reported as "dry." During these periods, flow at site 15 was estimated to be zero.

Streamflow was not measured at site 12 (Medina River below Medina Lake) during 1955–64; therefore, the SW_{in} and SW_{out} components were computed only for the Medina/Diversion Lake system and could not be derived for the individual lakes.

For 2001–02, the SW_{in} and SW_{out} components were computed from records collected at four continuous-record streamflow-gaging stations (sites 1, 12, 15, and 17), nine periodic streamflow measuring sites (sites 2, 5–10, 13, and 14), and from streamflow estimates from the ungaged areas that drain into Medina Lake (fig. 2, table 2). Mean daily streamflow and miscellaneous streamflow measurements made during 2001–02 are published in USGS Water-Data Reports (Gandara, 2002–03).

SW_{in} to Medina Lake and to the Medina/Diversion Lake system was computed by summing the estimated daily streamflows from seven periodic streamflow measuring sites (sites 2, 5–10) and the estimated daily streamflow from the ungaged areas that drain into Medina Lake (table 2). Daily streamflow at Medina River at English Crossing (site 2) during 2001–02 was estimated on the basis of a linear relation ($r^2 = 0.96$, p-value = 0) developed between continuous streamflow recorded at Medina River at Bandera (site 1) and 28 miscellaneous streamflow measurements made, primarily during lower flows, at site 2 between 1995–96 and 2001–02. The area upstream from site 2 accounts for about 75 percent of the Medina Lake drainage area.

The EAA recorded continuous stage at Red Bluff Creek at FM 1283 (site 5) for some periods during May 2000–February 2002. To determine streamflow at site 5, a stage-streamflow (discharge) relation was developed using stage values recorded by EAA and miscellaneous discharge measurements made at site 5 as part of the present (2001-02) study. Missing daily values at site 5 were estimated on the basis of periodic on-site measurements and a relation developed between continuous streamflow recorded at site 5 and at Seco Creek at Miller Ranch, USGS station 08201500. Daily streamflows for periodic measuring sites 6, 8, 9, 13, and 14 were estimated from the periodic measurements and continuous streamflow recorded at site 1. Daily streamflows for site 7 were estimated on the basis of periodic on-site measurements and continuous streamflow recorded at Helotes Creek at Helotes, USGS station 08181400. SW_{in} from the remaining ungaged area was estimated by multiplying the ungaged area (59 mi^2) by the average daily streamflow per square mile of the surrounding gaged watersheds. The Medina River watershed (upstream from site 1) was not included in this computation.

SW_{out} from Medina Lake and SW_{in} to Diversion Lake were computed by summing the daily streamflow recorded at the Medina River below Medina Lake gage (site 12) and the estimated daily discharge from Koenig Creek (site 13) and Nesbit Springs (site 14). Because the results of isotope analyses (Lambert and others, 2000, p. 33–34) indicate that Medina Lake is the source of most water discharging from Koenig Creek and Nesbit Springs, the estimated discharge from these sites (sites 13 and 14) was included in the computed SW_{out} from Medina Lake. SW_{out} from the Medina/Diversion Lake system and from Diversion Lake was computed by summing streamflow at the Medina Irrigation Canal (site 15) and Medina River near Riomedina (site 17).

For 1955–64, the Medina River contributed an average of about 94 percent of the total SW_{in} to Medina Lake, for 1995–96 about 96 percent, and for 2001–02 about 87 percent. The proportionately lower SW_{in} contribution from the Medina River during 2001–02 is attributed to the higher rainfall amounts during that time, which resulted in streamflow in the normally dry tributaries of Medina Lake. In contrast, no flow was recorded in most of the tributaries during most of the 1995–96 study (Lambert and others, 2000).

Reservoir Storage

Medina Lake storage for 1955–64 was obtained from published record of the USGS and stage from USGS observer

Figure 5. Medina Irrigation Canal near Riomedina, Texas, August 2004.

Figure 6. Diversion Dam near Riomedina, Texas, August 2004.

records that included daily to periodic stage measurements. For the same period, reservoir storage for Diversion Lake was estimated from periodic lake stage measurements using the TWDB stage-volume-area tables for Diversion Lake (Texas Water Development Board, 1996). Reservoir storage during the present study was computed from continuous lake stage recorded at Medina Lake and Diversion Lake, using the TWDB stage-volume-area tables for Medina and Diversion Lakes (Texas Water Development Board, 1996). Daily changes in lake storage (ΔS) were computed as the difference between the amount of current-day storage and the amount of previous-day storage.

Ground-Water Outflow

Ground-water outflow (GW_{out}) was computed as the residual of all other terms in the water-budget equation (eq. 1). GW_{out} represents water that is not accounted for by all other components, including any unrecognized errors. Positive values of GW_{out} represent losses from the lake system or selected part of the lake system (either of the two lakes and [or] the Medina River) to the ground-water system (Lambert and others, 2000). Negative GW_{out} values represent gains to the lake system or selected part of the lake system (including returns to the Medina River) from the ground-water system.

Equations with which to compute ground-water outflow as a function of reservoir stage were developed for selected periods during which time the water-budget components were inferred to be relatively stable and the influence of precipitation, stormwater runoff, and changes in storage were presumably minimal. These periods were chosen on the basis of three main criteria. First, periods were selected to exclude conditions affected by heavy rainfall or Medina Lake stages greater than 1,064.2 ft above NGVD 29 (top of spillway). During such conditions, error associated with high flows presumably would be eliminated, as would errors associated with estimates of stormwater runoff from ungaged watersheds. Second, periods of less than 7 days were not evaluated. Periods of less than 7 days would not adequately account for the travel time of the water through the system and would not provide a reasonable sample size for the computation of the mean daily GW_{out} on the basis of the variability of the data. Third, periods were selected that did not begin or end on days when Medina Irrigation Canal (fig. 2) was either beginning or ending a period of discharge.

Water budgets for Medina and Diversion Lakes and the lake system were selected also so that no budget period would begin or end on days when the Medina Dam gates were being opened or closed. The selection of such periods would presumably minimize error associated with disequilibrium within the system. Long periods of reasonably stable conditions with slow but steady decreases in lake stage were divided into approximately equal periods, with each representing approximately equal increments of changing stage. Tables 3–5 (at end of report) list the resulting mean daily GW_{out} values, as well as statistical summaries and errors computed for each of the selected water-budget periods.

The periods selected for the Medina Lake (table 3) and Diversion Lake (table 4) budgets ranged from 8 to 23 days. Fourteen budget periods during October 1995–September 1996, together equalling about 54 percent of the record, were selected for each lake. Fourteen budget periods also were selected from the April 2001–June 2002 data-collection interval, totalling 51 percent of the record (table 6, at end of report). Owing to heavy runoff resulting from above-average rainfall, slightly less of the total 2001–02 data were used for the water-budget computations.

For the Medina/Diversion Lake system, 127 water-budget periods (table 5) were selected that ranged from 8 to 78 days. Sixty-nine percent of the daily values during March 1955–September 1964 were included in the water-budget computations. For the October 1995–September 1996 period, 72 percent of the daily values were included. For the February 2001–June 2002 period, 38 percent of the daily values were included.

The contribution of the individual components of the water budget were computed as a percentage of the sum of the components for Medina and Diversion Lakes and for the Medina/Diversion Lake system. In general, the proportions of the individual components of the water budget reflect the effects of prevailing climatological influences of the period, operation of the lakes, and the fact that the selected periods exclude periods of heavy rainfall and stormwater runoff. The contribution of the individual budget components are summarized in tables 3–5 for selected budget periods and in table 6 for available periods of record.

For Medina Lake, ΔS, SW_{out}, and SW_{in} were the major components of the water budget, accounting for 29.1, 25.6, and 22.6 percent of the budget, respectively. GW_{out} accounted for 16.7 percent, evaporation for 4.9 percent, and precipitation for 1.1 percent. For Diversion Lake, SW_{in} and SW_{out} accounted for 47.2 and 40.7 percent of the budget, respectively. GW_{out} accounted for 8.5 percent, ΔS accounted for 3.0 percent, and evaporation and precipitation less than 1 percent. For the Medina/Diversion Lake system (observed between 1955 and 2002), ΔS had the greatest contribution (33.7 percent) and precipitation the least (1.3 percent). Whereas SW_{out} and GW_{out} accounted for 20.8 and 18.4 percent, respectively, of the total contribution, SW_{in} was 16.4 percent and E was 9.4 percent.

Linear equations were developed during the present study to relate the stage in Medina Lake to the computed mean rates of GW_{out} for Medina Lake (table 3), Diversion Lake (table 4), and the Medina/Diversion Lake system (table 5). The rates of GW_{out} from Medina and Diversion Lakes were plotted against the corresponding Medina Lake stages, which ranged from 1,019 to 1,064 ft above NGVD 29. Medina/Diversion Lake GW_{out} values were plotted against Medina Lake stages ranging from 963 to 1,064 ft. The resulting water-budget equations are:

Medina Lake GW_{out} =
2.3411 * MedLk Stage – 2,350.5

(r^2 = 0.60, p-value = <.001, standard error = 23.85), (2)

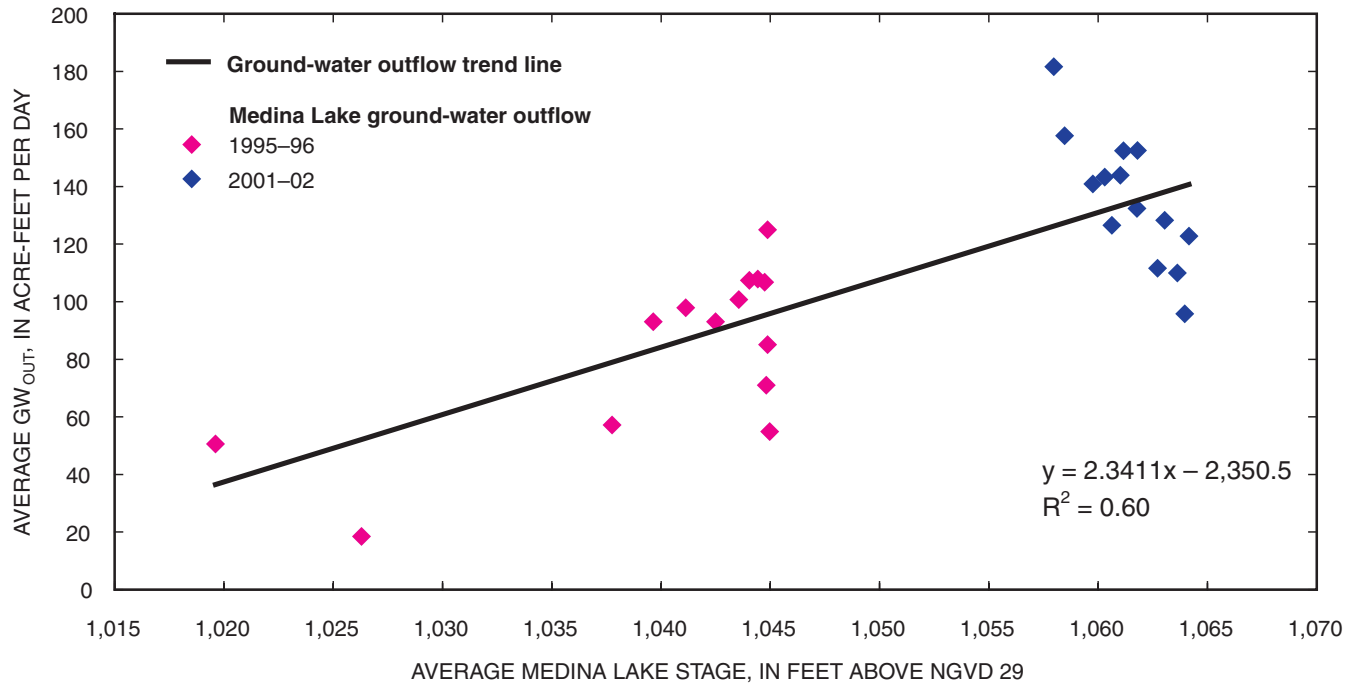

Figure 7. Relation between Medina Lake stage and ground-water outflow (GW_{out}) from Medina Lake during selected periods.

Diversion Lake GW_{out} =
-2.1776 * MedLk Stage + 2,261.2

(r^2 = 0.69, p-value = <.001, standard error = 18.19), and (3)

Medina/Diversion Lake system GW_{out} =
1.1019 * MedLk Stage – 1,057.2

(r^2 = 0.76, p-value = <.001, standard error = 21.79), (4)

where

MedLk Stage is Medina Lake stage in feet above NGVD 29.

The relation for equation 2 (fig. 7) indicates that Medina Lake GW_{out} increases as the stage in Medina Lake increases. The computed mean GW_{out} values for Medina Lake (table 3) range from 18.50 to 181.60 acre-feet per day (acre-ft/d). The end points of the trend line resulting from the regression of these GW_{out} values are 35.1 and 140.4 acre-ft/d at stages of 1,019 and 1,064 ft above NGVD 29, respectively.

Figure 8 (eq. 3) indicates that Diversion Lake GW_{out} decreases as the stage in Medina Lake increases. Whereas the mean GW_{out} values (table 4) range from -85.06 to 51.92 acre-ft/d, the trend line end points are -55.8 to 42.2 acre-ft/d, respectively. This relation indicates that Diversion Lake gains more water (indicated by negative GW_{out} values) than it loses through ground-water outflow when Medina Lake stages are greater than about 1,040 ft above NGVD 29.

Figure 7 indicates that when Medina Lake stages are between about 1,043 and 1,045 ft above NGVD 29, the outflow from Medina Lake increases sharply and exceeds the expected GW_{out} as determined by the ground-water outflow trend line—which indicates additional (greater-than-expected) loss between these elevations. During the time of this range of stage in Medina Lake, the ground-water outflow from Diversion Lake decreases sharply and drops below its expected GW_{out} as determined by the trend line in figure 8—which indicates additional gain of water in Diversion Lake. This additional gain in Diversion Lake represents a substantial amount of the concurrent, additional outflow from Medina Lake. The increase in Medina Lake GW_{out} between stages of about 1,043 and 1,045 ft corresponds to an interval within the lower part of the Kainer Formation that is recognized as one of the more permeable parts of the Edwards aquifer on the southern side of Medina Lake (Lambert and others, 2000).

During their 1995–96 study, Lambert and others (2000) observed a direct relation between the stage in Diversion Lake and ground-water outflow from Diversion Lake. In this relation (Lambert and others, 2000, fig. 7), the outflow from Diversion Lake increased with increasing stage. At the higher Medina Lake stages (1,057 to 1,064 ft above NGVD 29) observed during the present (2001–02) study, however, a substantial amount of the additional ground-water outflow from Medina Lake returned to Diversion Lake. Accordingly, the relation between Medina Lake stage and the outflow from Diversion Lake appears as an inverse relation in figure 9, as opposed to the direct relation between stage and ground-water outflow from Medina Lake.

The negative rates of ground-water outflow in figure 9 indicate a net gain of water in Diversion Lake from the adjacent

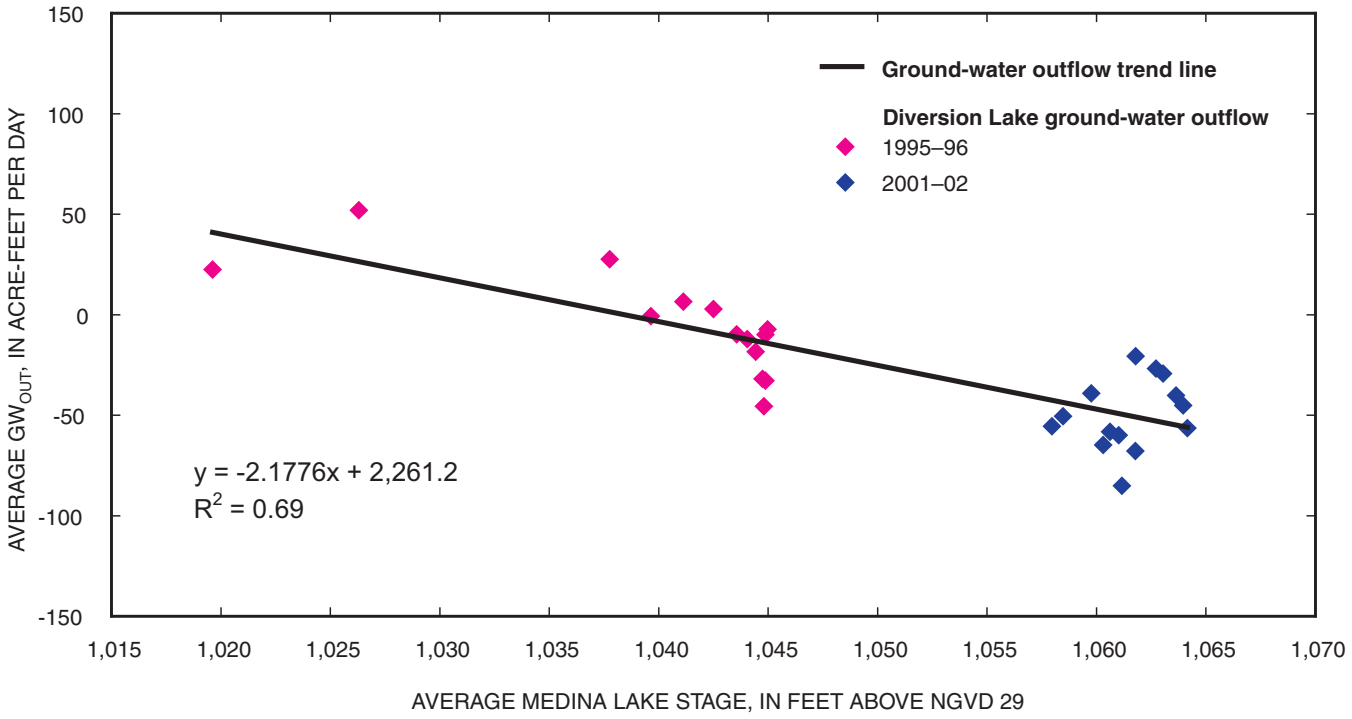

Figure 8. Relation between Medina Lake stage and ground-water outflow (GW_{out}) from Diversion Lake during selected periods.

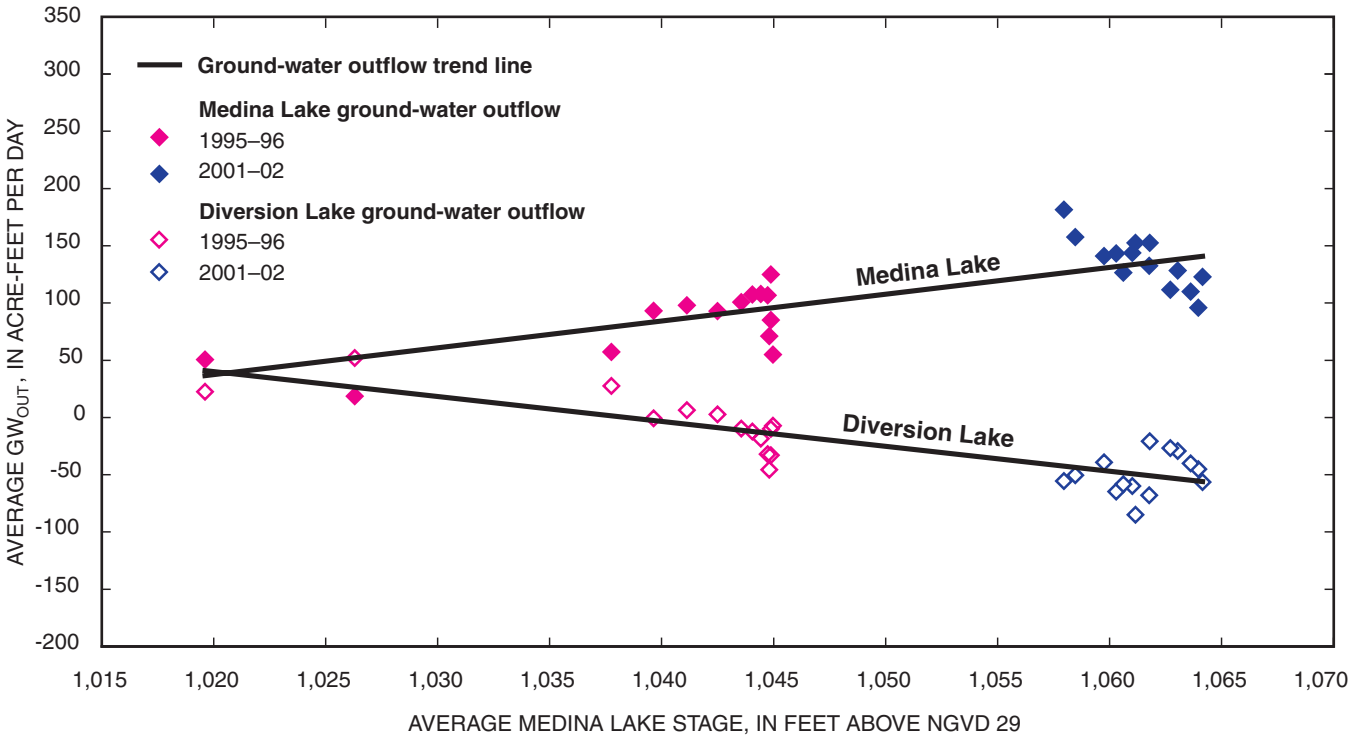

Figure 9. Relation between Medina Lake stage and ground-water outflow (GW_{out}) from Medina and Diversion Lakes during selected periods.

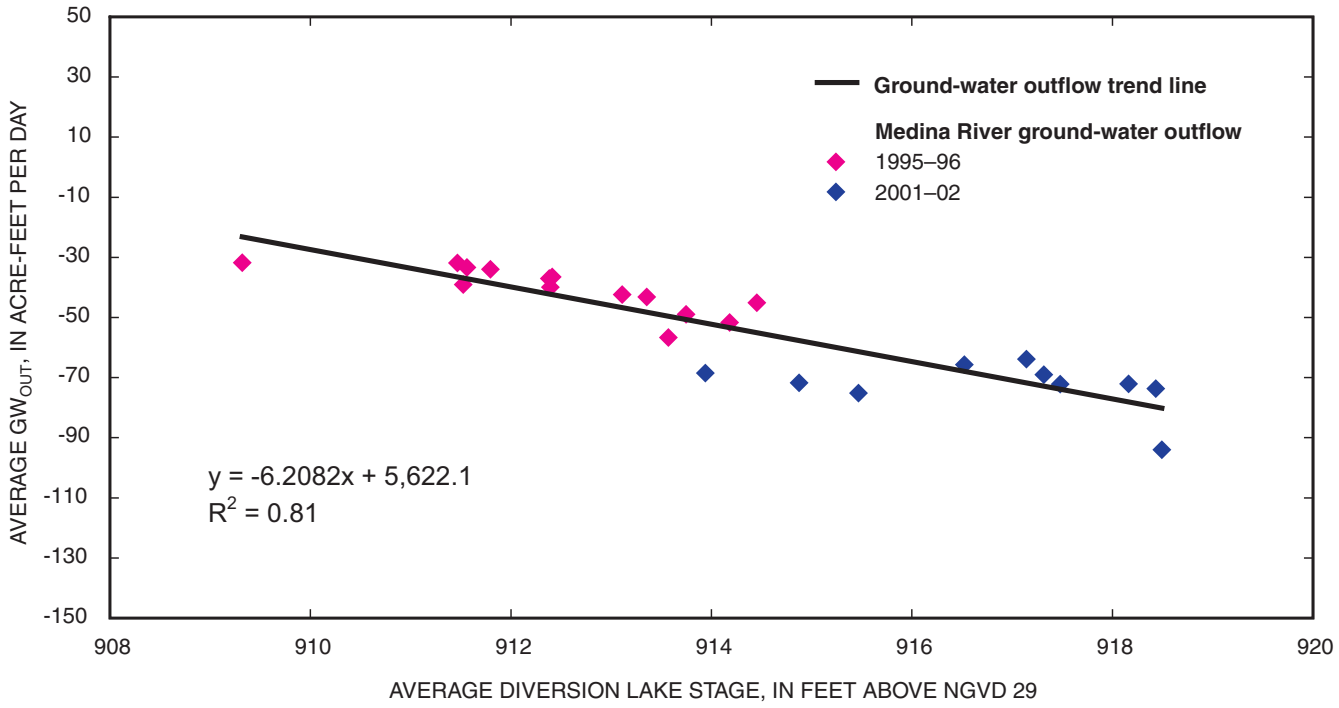

Figure 10. Relation between Diversion Lake stage and ground-water outflow (GW_{out}) to the Medina River between Diversion Dam and the Medina River near Riomedina during selected periods.

ground-water system. Because this gain was influenced by highly variable conditions of concurrent outflow from Medina Lake, a specific relation between the stage in Diversion Lake and the ground-water outflow from Diversion Lake could not be isolated from the data collected during 2001–02.

More study is required to better understand the specific relation between ground-water outflow from Medina Lake and the associated gain in Diversion Lake. However, from a net gain of zero in Diversion Lake when Medina Lake stages are below about 1,040 ft above NGVD 29, Diversion Lake appears to gain *on average* about 2.3 acre-ft/d of water for every 1 ft of Medina Lake stage above about 1,040 ft (fig. 8). The expected maximum gain (negative outflow) in Diversion Lake is about -56 acre-ft/d when the expected maximum outflow from Medina Lake is about 140 acre-ft/d (fig. 7). It can be deduced from these observations that—under optimum conditions (Medina Lake stage at its spillway elevation of 1,064 ft)—the gain of water in Diversion Lake could be as much as 40 percent of the concurrent ground-water outflow from Medina Lake.

An indication of water moving from the lake system into the ground-water system and back to the surface-water system was observed during the present study in the most downstream reach of the Medina River in the study area. The Medina River between sites 16 and 17 was analyzed for selected periods when the stage in Diversion Lake was less than 919 ft above NGVD 29 (top of Diversion Dam spillway). With no water spilling over the dam, streamflow between sites 16 and 17 is attributed to springflow into the streambed or seepage from adjacent canyon walls and hillsides that probably originates as outflow from Medina Lake or Diversion Lake, or both. The results of this analysis (eq. 5) showed that, between sites 16 and 17, the Medina River gained about 32 to 94 acre-ft/d and that this net gain (negative ground-water outflow) was dependent upon the stage in Diversion Lake, increasing as stage increases (fig. 10).

Gains to the Medina River =
-6.2082 * DivLk Stage + 5,622.1

$$(r^2 = 0.81), \quad (5)$$

where

DivLk Stage is Diversion Lake stage in feet above NGVD 29.

The water-budget equation (eq. 4) developed for the Medina/Diversion Lake system relates the stage in Medina Lake to the ground-water outflow from the entire system (fig. 11). The computed mean GW_{out} values range from 4.81 to 177.55 acre-ft/d between Medina Lake stages of 963 to 1,064 ft above NGVD 29 (table 5). The trend line end points for GW_{out} from the lake system are 3.9 to 115.2 acre-ft/d at these stages, respectively. The GW_{out} associated with this analysis reflects water loss from the lake system that is assumed to enter the ground-water system as recharge to the Edwards aquifer.

It should be noted that the sum of GW_{out} computed for Medina Lake (eq. 2) and for Diversion Lake (eq. 3) does not equal GW_{out} computed for the entire Medina/Diversion Lake

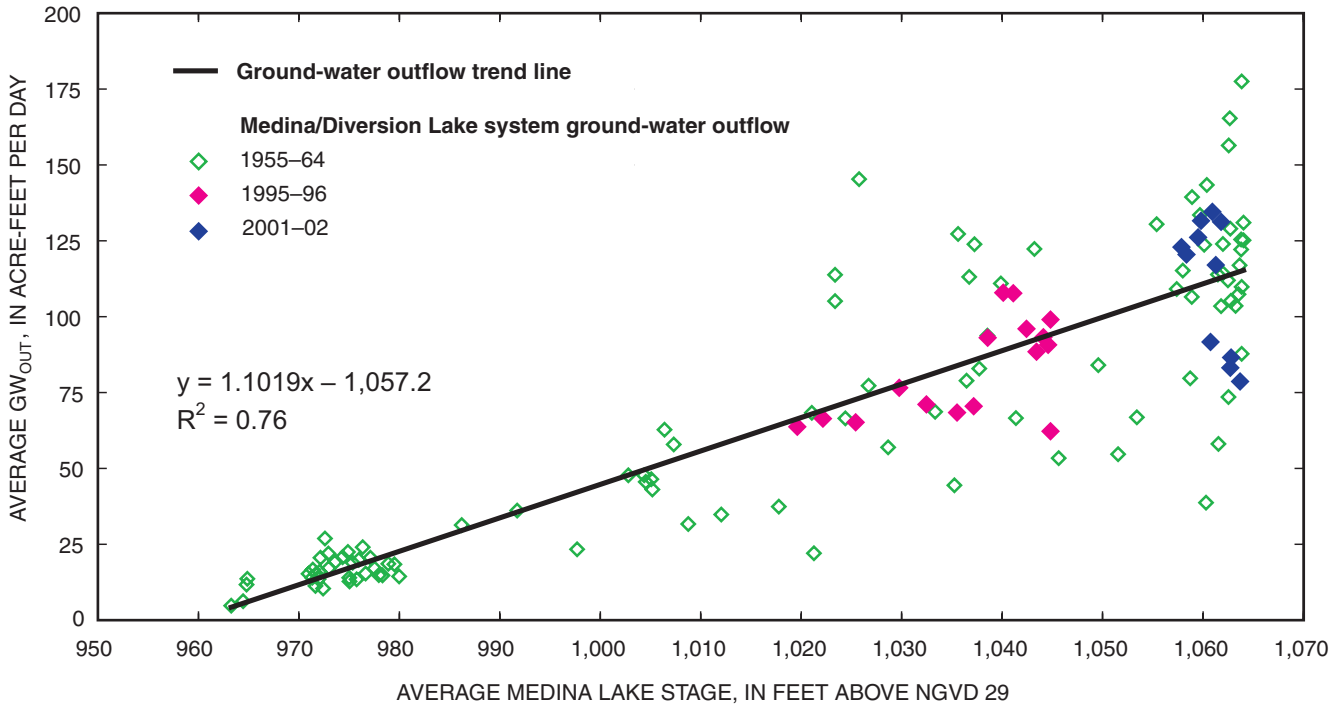

Figure 11. Relation between Medina Lake stage and ground-water outflow (GW_{out}) from the Medina/Diversion Lake system during selected periods.

system (eq. 4). Accordingly, equation 4 should not be used to estimate recharge to the Edwards aquifer without considering the effects of the (1) internal transfer of water among the two lakes and the Medina River, (2) computational error associated with the water-budget analysis, and (3) measurement error associated with components of the water budget. Measurement error is discussed in the following section.

Diversion Lake appears to gain more water than it loses during the time Medina Lake stages are greater than about 1,040 ft above NGVD 29 (fig. 8). Under such conditions, the level of Medina Lake would affect the level of Diversion Lake up to the spillway elevation of 919 ft. Because the level of Diversion Lake affects the outflow from Diversion Lake to the Medina River (fig. 10), it likely also affects the total ground-water outflow from the entire Medina/Diversion Lake system.

Errors associated with the computation of GW_{out} values that were used to derive equation 4 range from $\pm$1.5 to $\pm$78 acre-ft/d and average $\pm$35 acre-ft/d (table 5). The standard error associated with equation 4 is 21.8 acre-ft/d.

Measurement Error

The standard deviation around each measured term *i*, is considered to be the uncertainty or error in each term *i* (Lee and Swancar, 1997). To define the standard deviation around measured terms, errors (e) were assigned to each hydrologic budget component on the basis of the method of measurement, accuracy and precision of the instrumentation, and presumed quality of the hydrologic record. Records rated as good were assigned a percentage error ($\%e_i$) of $\pm$10 percent; records rated as fair were assigned a percentage error of $\pm$15 percent; and records rated as poor were assigned a percentage error of $\pm$20 (Novak, 1985, p. 65). Records for sites 1, 2, 3, 4, and 12 were rated good. Records for sites 13, 14, 15, 16, and 17 were rated fair. Records for the remaining surface-water sites and ungaged area were rated poor. Precipitation data were rated fair, and evaporation data were assigned a percentage error ($\%e_E$) of $\pm$25 percent (Novak, 1985, p. 65).

On the basis of the errors of the measured terms, the standard deviation ($\pm e_{GWout}$) of the residual term (GW_{out}) was calculated from the square root of the sum of the squared standard deviations of the measured terms (Lee and Swancar, 1997). The equation used to calculate $\pm e_{GWout}$ is:

$$\pm e_{GWout} = [(\%e_P * P)^2 + (\%e_E * E)^2 + (\%e_{SWin} * SW_{in})^2 + (\%e_{SWout} * SW_{out})^2 + (\%e_{\Delta S} * \Delta S)^2]^{.5}, \quad (6)$$

where

$\%e_P$ is fractional percentage error of daily P;
$\%e_E$ is fractional percentage error of daily E;
$\%e_{SWin}$ is fractional percentage error of daily SW_{in};
$\%e_{SWout}$ is fractional percentage error of daily SW_{out}; and
$\%e_{\Delta S}$ is fractional percentage error of daily ΔS.

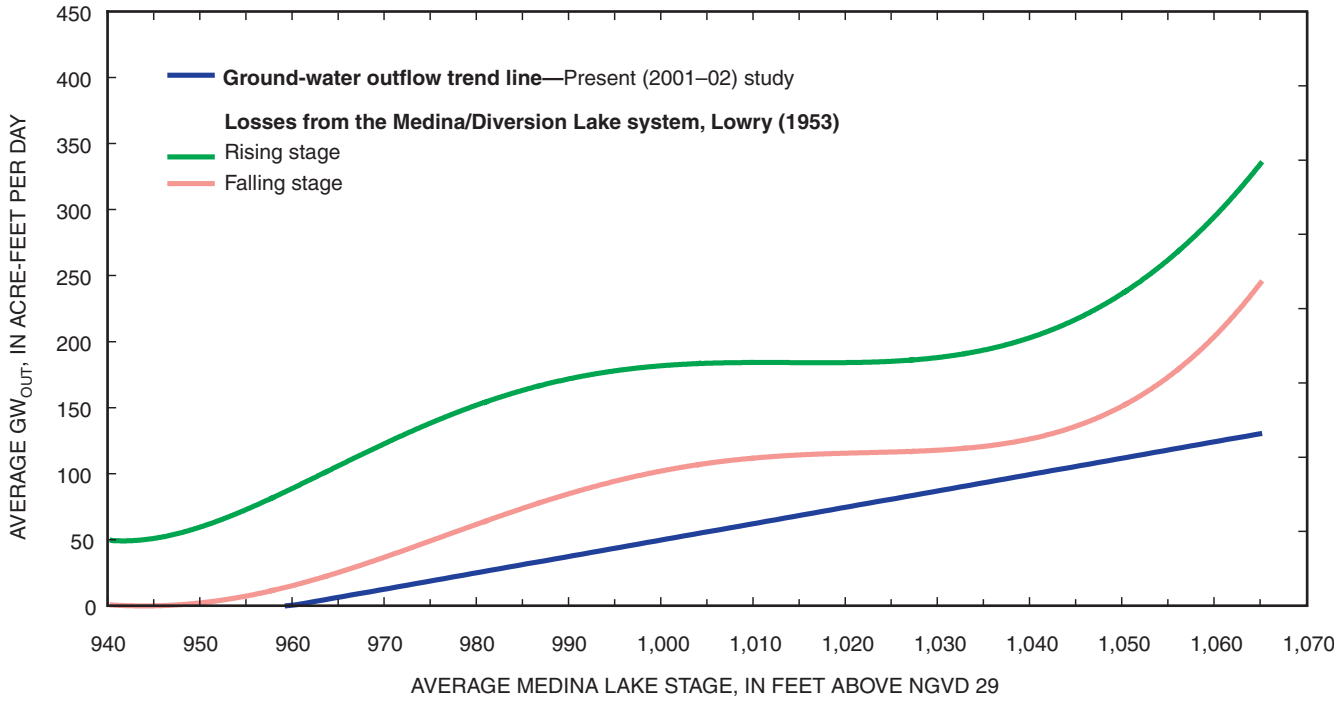

Figure 12. Ground-water outflow (GW_{out}) from the Medina/Diversion Lake system, as estimated by the present (2001–02) study, and losses computed with the Lowry (1953) method.

The daily $\pm e_{GWout}$ was calculated and averaged for each selected budget period. The average of the daily $\pm e_{GWout}$ for each budget period is presented in tables 3–5.

Estimated Recharge to Edwards Aquifer

Published estimates of recharge to the Edwards aquifer from the Medina River Basin during 1934–2003 range from 6,300 acre-ft (1956) to 104,000 acre-ft (1960) and average 62,700 acre-ft per year (Slattery, 2004). These estimates—based on methodology developed by Lowry (1953) and modified by Puente (1978)—currently (2004) are used by the USGS to estimate annual recharge to the Edwards aquifer.

To estimate recharge to the Edwards aquifer from the Medina/Diversion Lake system, Lowry (1953) performed a mass-balance (inflow minus outflow) analysis, in which he attempted to account for all inflow to and outflow from Medina Lake and the Medina/Diversion Lake system (including evaporation from lake surfaces). Using base-flow data collected during 1930 as part of a Medina River seepage investigation, Lowry estimated recharge to the Edwards aquifer from Diversion Lake. Lowry concluded that: (1) recharge from Diversion Lake was independent of the stage in Medina Lake, and (2) recharge from Diversion Lake was relatively constant—about 1,500 acre-ft per month—as long as water was stored in Diversion Lake. Lowry also developed a set of curves relating ground-water outflow from the Medina/Diversion Lake system to the "reservoir contents," or storage, in Medina Lake.

Figure 12 contains two curves modified from curves developed by Lowry (1953) by substituting Medina Lake stage for Lowry's "reservoir contents." Lowry reported that recharge during rising-lake stages (increasing storage) was greater than recharge during falling-stages (decreasing storage) and attributed the difference to bank-storage losses during rising-lake stages and to return flows from bank storage during falling stages. The ground-water outflow trend line in figure 12 was determined by equation 4 and duplicates the trend line in figure 11.

To compare the results of estimating recharge to the Edwards aquifer with the water-budget equations developed during the present study to those of the Lowry (1953) method, monthly losses from the Medina/Diversion Lake system were estimated with equation 4 and plotted in combination with those computed with the Lowry method (fig. 13). The October 1995–September 2002 period was chosen to compare the two methods, coinciding with the beginning of the initial 1996 study and the end of the present (2001–02) study. The average of the monthly recharge rates for October 1995–September 2002—estimated by equation 4 and plotted in figure 13—is 3,083 acre-ft, or about 56 percent of the 5,833 acre-ft computed with the Lowry method.

The greatest difference between recharge estimated by the present study and that computed with the Lowry method occurs during months with rising-lake stage conditions. The Lowry

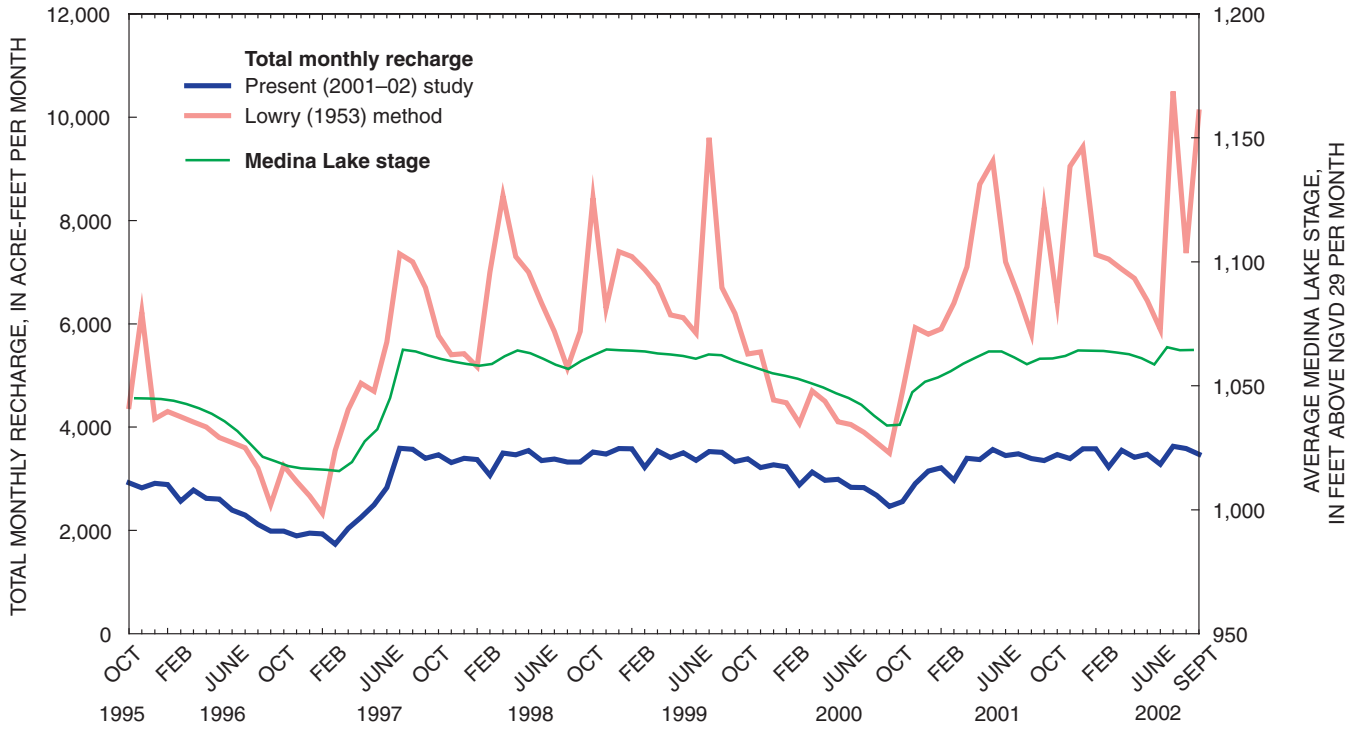

Figure 13. Comparison of monthly recharge to the Edwards aquifer in the study area during October 1995–September 2002, as estimated by the present (2001–02) study and computed with the Lowry (1953) method.

method assumes that about 2,200 acre-ft more recharge occurs during months with rising-stage conditions than during months with falling stage. The present study's estimates of recharge for months with rising-lake stage conditions are about 44 percent of those computed with the Lowry method, compared to about 60 percent for months with steady or falling-stage conditions. Large differences between the results of the different methods also occur at stages greater than about 1,045 ft above NGVD 29. For these stages, the present study estimated recharge to be about 52 percent of that computed with the Lowry method, compared to about 64 percent at stages below 1,045 ft.

Summary

Medina Lake and Diversion Lake are located on the Medina River in northeastern Medina County and southeastern Bandera County, Texas. The Edwards aquifer is recharged in part by ground-water outflow from Medina and Diversion Lakes, individually, as well as from the Medina/Diversion Lake system as a whole. This recharge is greatly influenced by the local hydrogeology; surface-water losses from the Medina/Diversion Lake system enter the aquifer indirectly through the Glen Rose Limestone of the Trinity Group or directly through the Kainer Formation of the Edwards Group. Because the relation between the hydrogeologic subdivisions in the study area and the associated zones of differing porosity and permeability are vertically controlled, recharge to the Edwards aquifer that occurs as outflow from the lake system can be related to the stage in Medina Lake.

The present (2001–02) Medina Lake study was done by the U.S. Geological Survey—in cooperation with the Edwards Aquifer Authority—to refine and, if possible, extend previously derived (1995–96) relations between Medina Lake stage and recharge to the Edwards aquifer to include the effects of reservoir stages below 1,018 ft and greater than 1,046 ft above NGVD 29. The principal objective of this study was to estimate ground-water outflow from Medina and Diversion Lakes and from the Medina/Diversion Lake system through the calculation of water budgets representing steady-state conditions over as wide a range as possible in the stages of Medina and Diversion Lakes.

Water budgets were computed for the Medina/Diversion Lake system from daily hydrologic data collected during March 1955–September 1964, October 1995–September 1996, and February 2001–June 2002. Budgets for Medina and Diversion Lakes were computed from daily hydrologic data collected only during October 1995–September 1996 and April 2001–June 2002. Water budgets were compiled for selected periods (within these data-collection intervals) through a range of lake stages, during which time the water-budget components were inferred to be relatively stable and the influence of precipitation, storm-water runoff, and changes in storage were presumably minimal.

Linear equations were developed from the observed relations between the stage in Medina Lake and ground-water outflow from Medina Lake, Diversion Lake, and the Medina/Diversion Lake system. The computed mean rates of outflow from Medina Lake ranged from about 18 to 182 acre-ft/d between stages of 1,019 and 1,064 ft above NGVD 29. The computed rates of outflow from Diversion Lake ranged from about -85 to 52 acre-ft/d between these same Medina Lake stages. The rates of outflow from the entire lake system ranged from about 5 to 178 acre-ft/d between Medina Lake stages of 963 to 1,064 ft above NGVD 29. It is assumed that all outflow from the lake system enters the ground-water system as recharge to the Edwards aquifer.

During the time that the stage in Medina Lake was greater than about 1,040 ft, Diversion Lake gained more water than it lost to the ground-water system and the rate of outflow from Medina Lake increased sharply while its stage was between about 1,043 and 1,045 above NGVD 29. The observed outflow from Diversion Lake during this time decreased sharply to the extent that a net gain resulted—indicating that a substantial amount of the additional outflow from Medina Lake returned to Diversion Lake. When the stage in Medina Lake is at the spillway elevation of 1,064 ft, Diversion Lake appears to gain as much as 40 percent of the concurrent ground-water outflow from Medina Lake.

An indication of water moving from the lake system into the ground-water system and back to the surface-water system was observed in the most downstream reach of the Medina River, between Diversion Lake and the Medina River near Riomedina. During conditions of no flow over Diversion Dam, this reach of the Medina River gained from about 32 to 94 acre-ft/d, with the gain increasing with increasing stage in Diversion Lake.

To compare the results of estimating recharge to the Edwards aquifer with water-budget equations developed during the present study to those of a previously used (Lowry) method, monthly losses from the Medina/Diversion Lake system were estimated for the October 1995–September 2002 period. The average of the monthly recharge rates estimated for this period is 3,083 acre-ft, or about 56 percent of the monthly recharge computed with the previously used method.

The greatest difference between recharge estimated by the present study and that computed with the previously used method occurs during months with rising-lake stage conditions. (The previously used method assumes that about 2,200 acre-ft more recharge occurs during months with rising-stage conditions than during months with falling stage.) The present study's estimates of recharge for months with rising-lake stage conditions are about 44 percent of those computed with the previously used method, compared to about 60 percent for months with steady or falling-stage conditions. For stages greater than 1,045 ft above NGVD 29, the present study estimated recharge to be about 52 percent of that computed with the previously used method, compared to about 64 percent at stages below 1,045 ft.

References Cited

Ashworth, J.B., 1983, Ground-water availability of the Lower Cretaceous formations in the Hill Country of south-central Texas: Texas Department of Water Resources Report 273, 173 p.

Barker, R.A., and Ardis, A.F., 1996, Hydrogeologic framework of the Edwards-Trinity aquifer system, west-central Texas: U.S. Geological Survey Professional Paper 1421–B, 61 p.

Bowen, I.S., 1926, The ratio of heat losses by conduction and by evaporation from any water surface: Physics Review, v. 27, p. 779–787.

Choquette, P.W., and Pray, L.C., 1970, Geologic nomenclature and classification of porosity in sedimentary carbonates: American Association of Petroleum Geologists Bulletin, v. 54, no. 2, p. 207–250.

Dunham, R.J., 1962, Classification of carbonate rocks according to depositional texture, *in* Classification of Carbonate Rocks Symposium: American Association of Petroleum Geologists Memoir 1, p. 108–121.

Gandara, S.C., 2002, Water resources data, Texas, water year 2001—Volume 5. Guadalupe River Basin, Nueces River Basin, Rio Grande Basin, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX–01–5, 344 p.

Gandara, S.C., 2003, Water resources data, Texas, water year 2002—Volume 5. Guadalupe River Basin, Nueces River Basin, Rio Grande Basin, and intervening coastal basins: U.S. Geological Survey Water-Data Report TX–02–5, 382 p.

German, E.R., 2000, Regional evaluation of evapotranspiration in the Everglades: U.S. Geological Survey Water-Resources Investigations Report 00–4217, 48 p.

Holt, C.L.R., Jr., 1956, Geology and ground-water resources of Medina County, Texas: Texas Board of Water Engineers Bulletin 5601, 278 p.

Inden, R.F., 1974, Lithofacies and depositional model for a Trinity Cretaceous sequence, Central Texas, *in* Aspects of Trinity Division Geology, a Symposium on the Stratigraphy, Sedimentary Environments, and Fauna of the Comanche Cretaceous Trinity Division (Aptian and Albian) of Texas and Northern Mexico: Baton Rouge, La., School of Geoscience, Louisiana State University, Geoscience and Man, v. 8, p. 37–52.

Laczniak, R.J., DeMeo, G.A., Reiner, S.R., Smith, J.L., and Nylund, W.E., 1999, Estimates of ground-water discharge as determined from measurements of evapotranspiration, Ash Meadows area, Nye County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 99–4079, 70 p.

Lambert, R.B, Grimm, K.C., and Lee, R.W., 2000, Hydrology, hydrologic budget, and water chemistry of the Medina Lake area, Texas: U.S. Geological Survey Water-Resources Investigations Report 00–4148, 53 p.

Lee, T.M., and Swancar, Amy, 1997, Influence of evaporation, ground water, and uncertainty in the hydrologic budget of

Lake Lucerne, a seepage lake in Polk County, Florida: U.S. Geological Survey Water-Supply Paper 2439, 61 p.

Lowry, R.L., Jr., 1953 Hydrologic report—Medina River above the Applewhite Dam site: Unpublished report prepared for San Antonio City Water Board, 43 p.

Maclay, R.W., and Small, T.A., 1976, Progress report on geology of the Edwards aquifer, San Antonio area, Texas, and preliminary interpretation of borehole geophysical and laboratory data on carbonate rocks: U.S. Geological Survey Open-File Report 76–627, 65 p.

Novak, C.E., 1985, WRD data reports preparation guide: U.S. Geological Survey, 199 p.

Puente, Celso, 1978, Method of estimating natural recharge to the Edwards aquifer in the San Antonio area, Texas: U.S. Geological Survey Water-Resources Investigations Report 78–10, 34 p.

Rose, P.R., 1972, Edwards Group, surface and subsurface, central Texas: Austin, University of Texas, Bureau of Economic Geology Report of Investigations 74, 198 p.

Slattery, R.N., 2004, Recharge to and discharge from the Edwards aquifer in the San Antonio area, Texas, 2003: accessed August 26, 2004, at URL http://tx.usgs.gov/reports/dist/dist-2004-01/

Small, T.A., and Clark, A.K., 2000, Geologic framework and hydrogeologic characteristics of the Edwards aquifer outcrop, Medina County, Texas: U.S. Geological Survey Water-Resources Investigations Report 00–4195, 10 p.

Small, T.A., and Lambert, R.B., 1998, Geologic framework and hydrogeologic characteristics of the outcrops of the Edwards and Trinity aquifers, Medina Lake area, Texas: U.S. Geological Survey Water-Resources Investigations Report 97–4290, 17 p.

Stricklin, F.L., Smith, C.I., and Lozo, F.E., 1971, Stratigraphy of Lower Cretaceous Trinity deposits of central Texas: Austin, Tex., University of Texas, Bureau of Economic Geology Report of Investigations 71, 63 p.

Texas A&M University, 2003, Agriculture program, TexasET, San Antonio weather station: accessed September 22, 2003, at URL http://texaset.tamu.edu/

Texas Water Development Board, 1996, Volumetric survey of Medina Lake and Diversion Lake: Texas Water Development Board publication prepared for Bexar-Medina-Atascosa Counties Water Control and Improvement District No. 1, 14 p.

Texas Water Development Board, 2003, Monthly pan coefficients used in ThEvap, quadrangle 809: accessed October 6, 2003, at URL http://hyper20.twdb.state.tx.us/Evaporation/pancoef.txt

Texas Water Development Board, 2004, Monthly lake surface evaporation in inches, annual total evaporation in inches, quadrangle 809: accessed March 1, 2004, at URL http://hyper20.twdb.state.tx.us/Evaporation/evap.html

U.S. Census Bureau, 2000, State and county quickfacts—Bexar, Comal, Hays, Medina, and Uvalde Counties, Texas, population, 2000: accessed October 4, 2004, at URL http://quickfacts.census.gov/qfd/states/48000.html

University of Texas, Bureau of Economic Geology, 1983, Geologic atlas of Texas, San Antonio sheet: Austin, Tex., scale 1:250,000.

Table 1. Summary of the lithologic and hydrologic properties of the hydrogeologic subdivisions of the Edwards and Trinity aquifers, San Antonio area, Texas (modified from Lambert and others, 2000).

[Hydrogeologic subdivisions modified from Maclay and Small (1976); groups, formations, members, and thicknesses modified from Holt (1956), Stricklin and others (1971), Rose (1972), Inden (1974), and Ashworth (1983); lithology modified from Dunham (1962); and porosity type modified from Choquette and Pray (1970). AQ, aquifer; CU, confining unit; *, not exposed in the study area; gal/min, gallons per minute]

Hydrogeologic subdivision			Group, formation, or member				Hydrologic function	Thickness (feet)	Lithology	Field identification	Cavern development	Porosity/permeability and well yields
Lower Cretaceous	I	Edwards aquifer	Georgetown Formation				Karst AQ; not karst CU	2–20	Reddish-brown, gray to light-tan, marly limestone	Red-brown to gray marly limestone; *Kingena wacoensis*	None	Low porosity/low permeability
	II		Devils River Formation	Edwards Group	Person Formation	Cyclic and marine members, undivided	AQ	0–10	Mudstone to packstone; *miliolid* grainstone; chert	*	Many subsurface; might be associated with earlier karst development	Laterally extensive; both fabric and not fabric/ water-yielding
	III					Leached and collapsed members, undivided	AQ	70–90	Crystalline limestone; mudstone to grainstone; chert; collapsed breccia	Bioturbated iron-stained beds separated by massive limestone beds; stromatolitic limestone	Extensive lateral development; large rooms	Majority not fabric/one of the most porous and permeable
	IV					Regional dense member	CU	16–20	Dense, argillaceous mudstone	Wispy iron-oxide stains	Very few; only vertical fracture enlargement	Not fabric/low permeability; vertical barrier
	V				Kainer Formation	Grainstone member	AQ	50–60	*Miliolid* grainstone; mudstone to wackestone; chert	White crossbedded grainstone	Few caves	Not fabric/recrystallization reduces permeability
	VI					Kirschberg evaporite member	AQ	50–60	Highly altered crystalline limestone; chalky mudstone; chert	Boxwork voids, with neospar and travertine frame	Probably extensive cave development	Majority fabric/one of the most porous and permeable
	VII					Dolomitic member	AQ	110–140	Mudstone to grainstone; crystalline limestone; chert	Massively bedded, light gray; *Toucasia* abundant	Caves related to structure or bedding planes	Mostly not fabric; some bedding-plane fabric/ water-yielding
	VIII					Basal nodular member	Karst AQ; not karst CU	50–60	Shaly, fossiliferous, nodular limestone; mudstone; *miliolid* grainstone	Massive, nodular, and mottled; abundant gastropods and *Exogyra texana*	Large lateral caves at surface	Fabric; stratigraphically controlled/large conduit flow at surface; no permeability in subsurface
	Upper zone Trinity aquifer		Trinity Group		Glen Rose Limestone	Upper member	CU; evaporite beds AQ	350–500	Yellowish-tan, thinly bedded limestone and marl	Stair-step topography; alternating limestone and marl; *Orbitolina minuta*	Some surface cave development	Some water production at evaporite beds/relatively impermeable (0–20 gal/ min)

Table 2. Hydrologic budget data-collection sites in the study area, San Antonio area, Texas.

[mi^2, square miles; GW_{out}, ground-water outflow; SW_{in}, surface-water inflow site; **P**, precipitation measurement site; c, continuous record site; p, periodic measurement site; FM, Farm to Market; ΔS, change in storage measurement site; E, evaporation measurement site; SW_{out}, surface-water outflow site; e, estimated record; --, not applicable]

Site number (fig. 1)	Station number	Station name	Latitude	Longitude	Drainage area (mi^2)	Station type	Period of record available for GW_{out} computation
			U.S. Geological Survey				
1	08178880	Medina River at Bandera	29°43'25"	99°04'11"	328	SW_{in}, **P**, c	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
2	08178990	Medina River at English Crossing	29°40'53"	98°58'32"	474	SW_{in}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
3	08179000	Medina River near Pipe Creek	29°40'31"	98°58'33"	474	SW_{in}, c	Mar. 1955–Sept. 1964
4	08179100	Red Bluff Creek near Pipe Creek	29°40'51"	98°57'19"	56.3	SW_{in}, c	Apr. 1956–Sept. l964
5	08179110	Red Bluff Creek at FM 1283	29°40'23"	98°57'36"	57.9	SW_{in}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
6	08179240	Bruins Creek near Pipe Creek	29°39'23"	98°59'17"	8.76	SW_{in}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
7	08179260	Rocky Creek near Pipe Creek	29°37'15"	98°59'57"	5.22	SW_{in}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
8	08179280	Cypress Creek near Riomedina	29°35'14"	99°00'30"	11	SW_{in}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
9	08179300	Elm Creek near Pipe Creek	29°36'15"	98°55'45"	12.7	SW_{in}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
10	08179320	Unnamed tributary at FM 1283	29°34'44"	98°53'57"	5.44	SW_{in}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
11	08179500	Medina Lake near San Antonio	29°32'24"	98°56'01"	634	ΔS, E	Mar. 1955–Sept. 1964[1]; Oct. 1995–Sept. 1996; Jan. 2001–June 2002
12	08179520	Medina River below Medina Lake	29°32'02"	98°56'06"	635	SW_{in}, SW_{out}, c	Oct. 1995–Sept. 1996; Apr. 2001–June 2002
13	08179530	Koenig Creek near Riomedina	29°31'57	98°56'14"	3.64	SW_{in}, SW_{out}, p	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
14	08179700	Nesbit Springs near Mico	29°32'20	98°54'47"	--	SW_{in}, p SW_{out}, p	Jan. 2001–June 2002
15	08180000	Medina Irrigation Canal near Riomedina	29°30'19"	98°54'11"	--	SW_{out}, c, e[2]	Mar. 1955–Sept. 1964; Oct. 1995–Sept. 1996; Feb. 2001–June 2002
16	08180010	Diversion Lake near Riomedina	29°30'36"	98°54'04"	649	ΔS, E	Mar. 1955–Sept. 1964[1]; Oct. 1995–Sept. 1996[1]; Feb. 2001–June 2002
17	08180500	Medina River near Riomedina	29°29'53"	98°54'16"	650	SW_{out}, c	Mar. 1955–Sept. 1964; Oct. 1995–Sept. 1996; Jan. 2001–June 2002
--	--	Ungaged area	--	--	160	SW_{in}, e	Mar. 1955–Mar. 1956
--	--	Ungaged area	--	--	103.7	SW_{in}, e	Apr. 1956–Sept. 1964
--	--	Ungaged area	--	--	59.0	SW_{in}, e	Oct. 1995–Sept. 1996; Jan. 2001–June 2002
			National Weather Service				
18	417628	Riomedina	29°26'25"	98°53'50"	--	**P**	Mar. 1955–Sept. 1964; Jan. 2001–June 2002

[1] Evaporation estimated for this period, no data collected at site.
[2] Streamflow estimated March 1955–April 1957.

Table 3. Summary of selected water-budget periods and associated components of the water budget for Medina Lake, San Antonio area, Texas.

[In acre-feet per day except as indicated. GW_{out}, ground-water outflow; SW_{in}, surface-water inflow; SW_{out}, surface-water outflow; ΔS, change in storage]

Water-budget period	Number of days in budget period	Medina Lake stage, average (feet above NGVD 29)	GW_{out}, mean	GW_{out}, standard deviation	GW_{out}, minimum	25th per-centile	Median	75th per-centile	GW_{out}, maximum	GW_{out}, ±error
10/12/1995 to 10/25/1995	14	1,044.88	124.97	67.63	48.57	87.26	107.20	153.05	301.14	48.84
11/05/1995 to 11/16/1995	12	1,044.81	71.03	53.89	-13.47	51.69	64.45	86.69	205.63	25.09
11/19/1995 to 11/27/1995	9	1,044.97	54.87	29.18	2.48	33.06	65.31	68.45	103.18	23.02
11/30/1995 to 12/10/1995	11	1,044.88	85.09	63.44	-32.36	63.27	89.00	95.11	236.12	23.44
12/11/1995 to 12/21/1995	11	1,044.74	106.78	58.94	-33.34	90.79	109.35	127.18	192.87	23.62
12/28/1995 to 01/09/1996	13	1,044.43	107.83	67.15	7.73	60.73	101.78	143.25	246.36	24.53
01/10/1996 to 01/22/1996	13	1,044.05	107.43	87.39	-49.81	67.76	103.02	122.58	347.95	27.92
01/23/1996 to 02/04/1996	13	1,043.56	100.73	55.62	11.08	49.10	123.49	138.35	172.71	32.30
02/08/1996 to 02/28/1996	21	1,042.50	93.02	70.62	-82.27	71.99	94.04	124.29	287.61	44.76
03/02/1996 to 03/24/1996	23	1,041.13	97.91	64.01	-36.38	72.19	86.13	123.51	288.60	41.00
03/29/1996 to 04/08/1996	11	1,039.64	93.07	68.37	-32.86	50.80	91.06	143.76	203.57	47.29
04/15/1996 to 05/06/1996	22	1,037.76	57.17	95.10	-117.40	-15.89	45.45	112.14	300.84	65.17
07/16/1996 to 07/23/1996	8	1,026.30	18.50	42.31	-39.97	-6.70	23.79	43.51	81.79	71.61
09/08/1996 to 09/22/1996	15	1,019.61	50.55	48.15	-15.76	25.73	42.40	62.31	151.30	18.05
07/05/2001 to 07/20/2001	16	1,061.77	132.41	63.76	-2.33	100.05	121.05	196.17	220.91	84.69
07/21/2001 to 08/05/2001	16	1,060.30	143.30	46.25	76.37	109.07	138.87	175.43	219.00	80.48
08/08/2001 to 08/25/2001	18	1,058.47	157.67	172.75	-228.78	101.70	136.81	199.99	559.93	83.30
09/26/2001 to 10/06/2001	11	1,061.16	152.41	188.34	-80.61	-9.89	135.06	290.36	495.80	50.97
10/18/2001 to 10/31/2001	14	1,061.02	143.88	200.30	-63.21	-9.39	81.85	282.98	541.03	46.95
11/01/2001 to 11/14/2001	14	1,060.62	126.58	241.62	-89.14	-40.90	-25.95	296.72	560.44	42.61
01/25/2002 to 02/07/2002	14	1,064.15	122.80	172.58	-252.45	66.82	87.89	160.12	473.73	43.78
02/12/2002 to 02/27/2002	16	1,063.96	95.83	124.50	-54.18	.73	69.86	197.50	376.06	42.10
02/28/2002 to 03/14/2002	15	1,063.63	109.95	185.43	-234.32	.87	118.46	236.49	395.33	41.30
03/21/2002 to 04/06/2002	17	1,063.04	128.28	166.09	-112.07	2.20	109.23	223.52	558.68	52.44
04/09/2002 to 04/27/2002	19	1,062.71	111.64	146.69	-110.38	16.03	100.51	223.16	430.68	43.06
04/28/2002 to 05/16/2002	19	1,061.79	152.55	112.57	-61.89	100.41	140.40	240.79	327.13	73.81
05/27/2002 to 06/12/2002	17	1,059.76	140.91	119.68	-24.46	18.05	147.68	217.83	343.78	80.72
06/13/2002 to 06/29/2002	17	1,057.96	181.60	109.81	50.92	93.87	166.22	260.58	396.60	88.25

Table 3. Summary of selected water-budget periods and associated components of the water budget for Medina Lake, San Antonio area, Texas—Continued.

Water-budget period	Precipitation, mean	Precipitation, standard deviation	Precipitation, minimum	Precipitation, maximum	Precipitation, ±error	Sw_{in}, mean	Sw_{in}, standard deviation	Sw_{in}, minimum	Sw_{in}, maximum	SW_{in}, ±error
10/12/1995 to 10/25/1995	0	0	0	0	0	132.62	19.88	103.44	163.29	13.77
11/05/1995 to 11/16/1995	0	0	0	0	0	175.54	34.41	134.24	237.20	18.24
11/19/1995 to 11/27/1995	0	0	0	0	0	170.65	26.44	135.21	202.79	18.00
11/30/1995 to 12/10/1995	3.05	10.12	0	33.57	.46	138.20	6.12	129.29	149.75	14.50
12/11/1995 to 12/21/1995	11.20	26.87	0	84.09	1.68	152.57	10.18	138.80	172.87	15.83
12/28/1995 to 01/09/1996	2.34	8.45	0	30.47	.35	119.81	12.52	104.27	140.96	12.36
01/10/1996 to 01/22/1996	0	0	0	0	0	103.75	3.80	98.90	112.17	10.70
01/23/1996 to 02/04/1996	2.00	7.21	0	26.00	.30	94.58	6.05	87.77	104.84	9.76
02/08/1996 to 02/28/1996	.93	4.28	0	19.62	.14	88.95	7.86	79.87	103.65	9.12
03/02/1996 to 03/24/1996	0	0	0	0	0	81.64	12.13	65.24	106.25	8.34
03/29/1996 to 04/08/1996	18.01	59.74	0	198.13	2.70	87.77	24.39	65.93	143.15	9.00
04/15/1996 to 05/06/1996	10.21	41.76	0	195.05	1.53	56.55	10.86	43.20	86.76	5.83
07/16/1996 to 07/23/1996	0	0	0	0	0	7.23	1.04	6.00	8.83	.75
09/08/1996 to 09/22/1996	13.45	39.28	0	151.73	2.02	96.63	52.24	43.20	210.47	9.95
07/05/2001 to 07/20/2001	0	0	0	0	0	120.75	28.40	88.40	185.58	12.44
07/21/2001 to 08/05/2001	0	0	0	0	0	65.49	10.67	52.60	85.91	6.76
08/08/2001 to 08/25/2001	12.38	48.77	0	207.25	1.86	40.44	3.68	35.85	47.37	4.16
09/26/2001 to 10/06/2001	2.65	8.77	0	29.10	.40	200.25	21.47	177.48	237.50	22.23
10/18/2001 to 10/31/2001	0	0	0	0	0	216.61	29.93	181.67	273.34	23.47
11/01/2001 to 11/14/2001	22.76	66.22	0	246.39	3.41	168.63	5.78	162.07	178.31	17.70
01/25/2002 to 02/07/2002	13.75	41.45	0	155.09	2.06	277.75	6.63	264.56	286.56	29.90
02/12/2002 to 02/27/2002	.57	2.27	0	9.08	.09	220.93	13.79	194.97	238.70	23.59
02/28/2002 to 03/14/2002	2.34	7.26	0	27.62	.35	179.74	8.59	168.69	194.29	18.74
03/21/2002 to 04/06/2002	46.64	156.37	0	635.09	7.00	175.15	12.98	162.07	197.57	18.55
04/09/2002 to 04/27/2002	12.82	37.37	0	120.81	1.92	170.78	20.91	141.57	207.77	18.00
04/28/2002 to 05/16/2002	0	0	0	0	0	110.46	15.42	91.24	138.77	11.39
05/27/2002 to 06/12/2002	5.19	16.82	0	69.71	.78	100.45	8.36	83.54	115.59	10.39
06/13/2002 to 06/29/2002	22.63	49.81	0	151.18	3.39	61.26	8.35	52.60	80.92	6.34

Table 3. Summary of selected water-budget periods and associated components of the water budget for Medina Lake, San Antonio area, Texas—Continued.

Water-budget period	Sw_{out}, mean	Sw_{out}, standard deviation	Sw_{out}, minimum	Sw_{out}, maximum	Sw_{out}, ±error	Evaporation, mean	Evaporation, standard deviation	Evaporation, minimum	Evaporation, maximum	Evaporation, ±error
10/12/1995 to 10/25/1995	226.83	41.94	148.72	258.85	34.41	53.60	20.35	22.05	83.51	13.40
11/05/1995 to 11/16/1995	68.87	1.50	67.26	70.73	10.75	42.47	24.27	10.23	96.49	10.62
11/19/1995 to 11/27/1995	68.30	1.39	67.13	70.34	10.66	27.92	16.39	6.60	62.31	6.98
11/30/1995 to 12/10/1995	66.82	.67	64.88	67.29	10.40	42.07	41.33	1.42	140.60	10.52
12/11/1995 to 12/21/1995	66.00	.92	64.98	67.04	10.28	36.54	37.39	0	119.01	9.13
12/28/1995 to 01/09/1996	64.69	.19	64.45	65.04	10.07	50.32	39.20	4.75	135.74	12.58
01/10/1996 to 01/22/1996	118.55	10.38	101.97	145.63	18.13	27.92	18.72	0	62.71	6.98
01/23/1996 to 02/04/1996	138.56	20.86	111.69	178.87	21.12	42.44	19.96	5.94	92.18	10.61
02/08/1996 to 02/28/1996	225.15	22.56	174.93	251.73	34.09	25.48	27.15	0	96.39	6.37
03/02/1996 to 03/24/1996	191.10	56.97	140.63	302.80	28.97	34.76	36.06	0	151.38	8.69
03/29/1996 to 04/08/1996	239.05	47.91	182.05	281.30	36.16	26.76	20.09	2.78	57.34	6.69
04/15/1996 to 05/06/1996	337.58	27.14	280.90	377.44	50.91	41.51	34.43	2.56	145.70	10.38
07/16/1996 to 07/23/1996	360.23	26.82	325.36	394.62	54.26	64.62	8.58	48.98	75.60	16.15
09/08/1996 to 09/22/1996	52.97	25.37	34.68	93.51	8.26	33.36	10.35	14.14	48.35	8.34
07/05/2001 to 07/20/2001	328.02	8.47	317.68	337.15	49.77	172.82	11.54	141.20	186.12	43.21
07/21/2001 to 08/05/2001	294.12	16.48	281.40	317.64	44.64	159.31	25.13	109.78	191.90	39.83
08/08/2001 to 08/25/2001	315.62	2.18	312.79	320.87	47.84	140.64	41.47	52.05	223.54	35.16
09/26/2001 to 10/06/2001	139.06	1.06	136.80	141.45	21.48	120.53	42.08	14.55	161.46	30.13
10/18/2001 to 10/31/2001	142.43	1.28	140.29	143.89	22.00	94.60	25.99	38.01	129.49	23.65
11/01/2001 to 11/14/2001	142.36	.86	140.76	142.88	21.96	72.45	22.80	31.23	115.44	18.11
01/25/2002 to 02/07/2002	149.13	8.53	138.63	164.33	23.06	55.29	22.12	15.15	99.45	13.82
02/12/2002 to 02/27/2002	135.66	.20	135.28	135.92	20.99	90.01	28.70	15.13	148.30	22.50
02/28/2002 to 03/14/2002	134.29	1.07	132.93	135.28	20.76	77.85	41.07	15.08	140.54	19.46
03/21/2002 to 04/06/2002	155.55	31.45	130.86	200.67	23.94	102.66	57.34	3.09	173.76	25.66
04/09/2002 to 04/27/2002	134.88	.34	134.41	135.51	20.84	89.71	63.29	0	226.24	22.43
04/28/2002 to 05/16/2002	330.67	106.59	132.34	486.53	50.16	85.13	42.93	25.87	161.16	21.28
05/27/2002 to 06/12/2002	346.64	93.87	203.07	475.99	52.54	118.09	54.41	32.69	232.79	29.52
06/13/2002 to 06/29/2002	385.09	25.25	374.46	471.99	58.28	105.44	38.87	37.85	188.27	26.36

Table 3. Summary of selected water-budget periods and associated components of the water budget for Medina Lake, San Antonio area, Texas—Continued.

Water-budget period	ΔS, mean	ΔS, standard deviation	ΔS, minimum	ΔS, maximum	ΔS, ±error	GW_{out}, percent of hydrologic budget	Precipitation, percent of hydrologic budget	Sw_{in}, percent of hydrologic budget	Sw_{out}, percent of hydrologic budget	Evaporation, percent of hydrologic budget	ΔS, percent of hydrologic budget
10/12/1995 to 10/25/1995	-273	86	-445	-121	27.3	16.1	0	17.1	29.2	2.6	35.1
11/05/1995 to 11/16/1995	-7	71	-189	79	4.9	20.5	0	50.7	19.9	7.0	2.0
11/19/1995 to 11/27/1995	20	51	-60	93	4.6	16.6	0	51.7	20.7	5.0	5.9
11/30/1995 to 12/10/1995	-53	70	-249	14	5.6	22.0	.8	35.7	17.3	10.7	13.6
12/11/1995 to 12/21/1995	-46	61	-134	81	6.0	25.5	2.7	36.4	15.7	8.9	10.9
12/28/1995 to 01/09/1996	-101	76	-259	-3	10.1	24.8	.5	27.6	14.9	9.0	23.2
01/10/1996 to 01/22/1996	-150	86	-392	0	15.0	21.5	0	20.8	23.8	3.8	30.1
01/23/1996 to 02/04/1996	-185	67	-269	-56	18.5	18.6	.4	17.5	25.6	3.7	34.2
02/08/1996 to 02/28/1996	-254	70	-444	-99	25.4	13.5	.1	12.9	32.7	3.9	36.8
03/02/1996 to 03/24/1996	-242	89	-392	-38	24.2	15.1	0	12.6	29.5	5.6	37.3
03/29/1996 to 04/08/1996	-253	86	-373	-114	25.3	13.1	2.5	12.3	33.6	2.8	35.6
04/15/1996 to 05/06/1996	-370	77	-620	-220	37.0	6.6	1.2	6.5	39.0	4.0	42.7
07/16/1996 to 07/23/1996	-436	41	-510	-392	43.6	2.2	0	.9	43.4	1.0	52.5
09/08/1996 to 09/22/1996	-27	49	-118	71	4.6	20.2	5.4	38.5	21.1	4.1	10.7
07/05/2001 to 07/20/2001	-513	72	-600	-400	51.3	12.0	0	10.9	29.7	1.0	46.4
07/21/2001 to 08/05/2001	-531	48	-600	-500	53.1	13.5	0	6.2	27.8	2.4	50.2
08/08/2001 to 08/25/2001	-561	158	-1,000	-200	56.1	14.0	1.1	3.6	28.0	3.7	49.7
09/26/2001 to 10/06/2001	-209	187	-600	0	20.9	20.4	.4	26.9	18.7	5.6	28.0
10/18/2001 to 10/31/2001	-164	210	-600	0	16.4	20.8	0	31.2	20.5	3.7	23.7
11/01/2001 to 11/14/2001	-150	235	-600	0	15.0	20.0	3.6	26.6	22.5	3.6	23.7
01/25/2002 to 02/07/2002	-36	165	-400	300	9.3	19.8	2.2	44.7	24.0	3.6	5.7
02/12/2002 to 02/27/2002	-100	126	-400	0	10.0	16.5	.1	38.0	23.3	4.9	17.2
02/28/2002 to 03/14/2002	-140	192	-500	200	18.0	18.1	.4	29.6	22.1	6.8	23.0
03/21/2002 to 04/06/2002	-165	237	-600	400	21.2	17.6	6.4	24.1	21.4	7.9	22.6
04/09/2002 to 04/27/2002	-153	168	-500	0	15.3	17.3	2.0	26.4	20.9	9.8	23.6
04/28/2002 to 05/16/2002	-458	198	-700	0	45.8	13.9	0	10.1	30.2	3.9	41.8
05/27/2002 to 06/12/2002	-500	162	-700	-200	50.0	12.3	.5	8.8	30.2	4.7	43.6
06/13/2002 to 06/29/2002	-588	117	-900	-400	58.8	14.2	1.8	4.8	30.1	3.0	46.0

Table 4. Summary of selected water-budget periods and associated components of the water budget for Diversion Lake, San Antonio area, Texas.

[In acre-feet per day except as indicated. GW_{out}, ground-water outflow; SW_{in}, surface-water inflow; SW_{out}, surface-water outflow; ΔS, change in storage]

Water-budget period	Number of days in budget period	Diversion Lake stage, average (feet above NGVD 29)	GW_{out}, mean	GW_{out}, standard deviation	GW_{out}, minimum	25th per-centile	Median	75th per-centile	GW_{out}, maximum	GW_{out}, ±error
10/12/1995 to 10/25/1995	14	912.39	-9.95	8.65	-22.88	-12.85	-9.34	-6.94	9.18	48.21
11/05/1995 to 11/16/1995	12	914.18	-45.57	6.69	-56.58	-50.37	-46.01	-41.56	-33.77	22.50
11/19/1995 to 11/27/1995	9	914.45	-7.27	4.84	-15.19	-9.24	-4.94	-3.78	-3.08	13.40
11/30/1995 to 12/10/1995	11	913.75	-32.89	7.81	-45.50	-35.13	-32.79	-30.31	-17.05	22.85
12/11/1995 to 12/21/1995	11	911.53	-31.94	5.11	-41.52	-33.28	-30.06	-28.56	-26.12	20.08
12/28/1995 to 01/09/1996	13	911.56	-18.42	2.63	-23.34	-19.91	-17.77	-16.77	-14.41	17.31
01/10/1996 to 01/22/1996	13	911.47	-12.13	8.46	-22.62	-15.83	-14.57	-12.55	11.84	26.14
01/23/1996 to 02/04/1996	13	911.79	-9.76	7.15	-24.15	-14.53	-9.12	-6.17	5.23	30.32
02/08/1996 to 02/28/1996	21	912.38	2.77	6.31	-11.40	-.14	4.31	6.86	13.29	47.40
03/02/1996 to 03/24/1996	23	912.41	6.49	23.65	-30.61	-4.68	.10	5.94	59.94	39.73
03/29/1996 to 04/08/1996	11	913.35	-.71	18.83	-26.27	-19.32	7.58	13.99	23.27	52.04
04/15/1996 to 05/06/1996	22	913.11	27.57	7.84	12.80	22.16	27.28	33.76	42.25	68.45
07/16/1996 to 07/23/1996	8	913.57	51.92	9.16	39.30	47.28	49.89	56.63	66.37	71.39
09/08/1996 to 09/22/1996	15	909.32	22.44	10.02	11.50	14.96	17.37	31.49	41.86	10.17
07/05/2001 to 07/20/2001	16	915.47	-67.88	7.79	-83.53	-71.38	-67.99	-63.98	-54.09	77.04
07/21/2001 to 08/05/2001	16	914.87	-64.75	10.71	-87.70	-68.20	-64.36	-59.41	-47.84	70.78
08/08/2001 to 08/25/2001	18	913.94	-50.46	12.94	-71.87	-59.53	-49.57	-42.35	-27.74	72.47
09/26/2001 to 10/06/2001	11	918.49	-85.06	12.34	-99.68	-95.52	-84.97	-76.68	-63.63	40.65
10/18/2001 to 10/31/2001	14	919.10	-59.97	8.56	-72.99	-66.95	-58.65	-56.43	-46.96	37.55
11/01/2001 to 11/14/2001	14	918.16	-58.20	13.98	-85.87	-63.31	-55.83	-53.82	-26.21	39.65
01/25/2002 to 02/07/2002	14	919.13	-56.43	3.92	-62.63	-59.27	-57.23	-52.95	-50.92	38.38
02/12/2002 to 02/27/2002	16	918.43	-45.19	16.56	-76.65	-52.70	-45.50	-30.38	-24.71	35.77
02/28/2002 to 03/14/2002	15	917.32	-40.19	9.30	-58.98	-45.57	-40.54	-32.13	-27.80	34.02
03/21/2002 to 04/06/2002	17	918.87	-29.23	11.33	-53.67	-32.84	-28.20	-21.91	-12.20	35.40
04/09/2002 to 04/27/2002	19	918.96	-26.78	12.04	-56.47	-26.82	-22.35	-19.18	-16.10	33.08
04/28/2002 to 05/16/2002	19	917.14	-20.66	25.28	-57.15	-33.25	-26.53	-12.10	38.32	73.46
05/27/2002 to 06/12/2002	17	916.52	-39.17	26.36	-111.42	-48.35	-40.42	-25.17	13.57	78.07
06/13/2002 to 06/29/2002	17	917.48	-55.50	12.32	-84.44	-59.72	-56.63	-47.04	-37.30	89.15

Table 4. Summary of selected water-budget periods and associated components of the water budget for Diversion Lake, San Antonio area, Texas—Continued.

Water-budget period	Precipitation, mean	Precipitation, standard deviation	Precipitation, minimum	Precipitation, maximum	Precipitation, ±error	Sw_{in}, mean	Sw_{in}, standard deviation	Sw_{in}, minimum	Sw_{in}, maximum	Sw_{in}, ±error
10/12/1995 to 10/25/1995	0	0	0	0	0	226.83	41.94	148.72	258.85	34.41
11/05/1995 to 11/16/1995	.11	.37	0	1.27	.02	68.87	1.50	67.26	70.73	10.75
11/19/1995 to 11/27/1995	0	0	0	0	0	68.30	1.39	67.13	70.34	10.66
11/30/1995 to 12/10/1995	.08	.26	0	.85	.01	66.82	.67	64.88	67.29	10.40
12/11/1995 to 12/21/1995	.37	.90	0	2.88	.06	66.00	.92	64.98	67.04	10.28
12/28/1995 to 01/09/1996	0	0	0	0	0	64.69	.19	64.45	65.04	10.07
01/10/1996 to 01/22/1996	0	0	0	0	0	118.55	10.38	101.97	145.63	18.13
01/23/1996 to 02/04/1996	0	0	0	0	0	138.56	20.86	111.69	178.87	21.12
02/08/1996 to 02/28/1996	0	0	0	0	0	225.15	22.56	174.93	251.73	34.09
03/02/1996 to 03/24/1996	0	0	0	0	0	191.10	56.97	140.63	302.80	28.97
03/29/1996 to 04/08/1996	.75	2.48	0	8.21	.11	239.05	47.91	182.05	281.30	36.16
04/15/1996 to 05/06/1996	.26	1.21	0	5.70	.04	337.58	27.14	280.90	377.44	50.91
07/16/1996 to 07/23/1996	0	0	0	0	0	360.23	26.82	325.36	394.62	54.26
09/08/1996 to 09/22/1996	.65	2.26	0	8.75	.10	52.97	25.37	34.68	93.51	8.26
07/05/2001 to 07/20/2001	0	0	0	0	0	328.02	8.47	317.68	337.15	49.77
07/21/2001 to 08/05/2001	0	0	0	0	0	294.12	16.48	281.40	317.64	44.64
08/08/2001 to 08/25/2001	.14	.59	0	2.51	.02	315.62	2.18	312.79	320.87	47.84
09/26/2001 to 10/06/2001	0	0	0	0	0	139.06	1.06	136.80	141.45	21.48
10/18/2001 to 10/31/2001	0	0	0	0	0	142.43	1.28	140.29	143.89	22.00
11/01/2001 to 11/14/2001	.68	2.54	0	9.49	.10	142.36	.86	140.76	142.88	21.96
01/25/2002 to 02/07/2002	.40	1.20	0	4.42	.06	149.13	8.53	138.63	164.33	23.06
02/12/2002 to 02/27/2002	0	0	0	0	0	135.66	.20	135.28	135.92	20.99
02/28/2002 to 03/14/2002	.06	.23	0	.88	.01	134.29	1.07	132.93	135.28	20.76
03/21/2002 to 04/06/2002	1.49	5.01	0	20.38	.22	155.55	31.45	130.86	200.67	23.94
04/09/2002 to 04/27/2002	.26	.80	0	3.15	.04	134.88	.34	134.41	135.51	20.84
04/28/2002 to 05/16/2002	0	0	0	0	0	330.67	106.59	132.34	486.53	50.16
05/27/2002 to 06/12/2002	0	0	0	0	0	346.64	93.87	203.07	475.99	52.54
06/13/2002 to 06/29/2002	.64	1.81	0	5.59	.10	385.09	25.25	374.46	471.99	58.28

Table 4. Summary of selected water-budget periods and associated components of the water budget for Diversion Lake, San Antonio area, Texas—Continued.

Water-budget period	Sw_{out}, mean	Sw_{out}, standard deviation	Sw_{out}, minimum	Sw_{out}, maximum	Sw_{out}, ±error	Evaporation, mean	Evaporation, standard deviation	Evaporation, maximum	Evaporation, minimum	Evaporation, ±error
10/12/1995 to 10/25/1995	224.31	41.47	150.48	265.32	33.65	2.02	0.39	2.58	1.16	0.50
11/05/1995 to 11/16/1995	127.71	25.75	81.18	164.34	19.16	1.42	.84	3.43	.26	.36
11/19/1995 to 11/27/1995	45.10	1.92	43.56	47.52	6.77	1.29	.98	3.44	.37	.32
11/30/1995 to 12/10/1995	131.22	8.99	116.82	148.50	19.68	1.91	2.02	6.76	.28	.48
12/11/1995 to 12/21/1995	113.40	12.05	99.00	132.66	17.01	1.54	1.35	4.73	.05	.39
12/28/1995 to 01/09/1996	93.06	4.20	87.12	99.00	13.96	1.22	.91	3.72	.15	.30
01/10/1996 to 01/22/1996	124.74	10.81	93.06	132.66	18.71	1.65	1.18	4.33	.62	.41
01/23/1996 to 02/04/1996	144.39	12.46	124.74	164.34	21.66	.78	.56	1.70	0	.20
02/08/1996 to 02/28/1996	219.50	17.76	186.12	243.54	32.92	1.04	.78	2.75	0	.26
03/02/1996 to 03/24/1996	180.18	32.09	138.60	225.72	27.03	1.09	1.28	5.44	0	.27
03/29/1996 to 04/08/1996	247.14	13.34	231.66	269.28	37.07	1.34	1.08	3.52	.17	.34
04/15/1996 to 05/06/1996	304.92	23.48	249.48	334.62	45.74	1.40	1.01	4.27	.31	.35
07/16/1996 to 07/23/1996	309.13	16.55	285.12	332.64	46.37	2.75	.62	3.56	1.48	.69
09/08/1996 to 09/22/1996	32.60	4.48	29.70	47.52	4.89	1.44	.62	3.02	.69	.36
07/05/2001 to 07/20/2001	391.79	11.74	364.32	403.92	58.77	3.48	.23	3.74	2.85	.87
07/21/2001 to 08/05/2001	365.68	13.85	338.58	382.14	54.85	3.19	.53	3.89	2.18	.80
08/08/2001 to 08/25/2001	362.34	21.76	310.86	394.02	54.35	2.77	.81	4.38	1.02	.69
09/26/2001 to 10/06/2001	228.42	31.52	194.04	263.34	34.26	2.98	.99	3.91	.38	.74
10/18/2001 to 10/31/2001	202.67	6.14	194.04	211.86	30.40	2.58	.72	3.54	1.04	.65
11/01/2001 to 11/14/2001	218.65	19.19	178.20	247.50	32.80	1.88	.64	3.04	.75	.47
01/25/2002 to 02/07/2002	204.51	10.97	190.08	225.72	30.68	1.45	.58	2.61	.40	.36
02/12/2002 to 02/27/2002	189.46	39.72	128.70	279.18	28.42	2.26	.75	3.85	.40	.56
02/28/2002 to 03/14/2002	179.39	8.43	168.30	192.06	26.91	1.81	.95	3.24	.36	.45
03/21/2002 to 04/06/2002	168.30	21.16	140.58	213.84	25.25	2.67	1.47	4.39	.08	.67
04/09/2002 to 04/27/2002	168.51	28.93	138.60	251.46	25.28	2.35	1.62	5.69	0	.59
04/28/2002 to 05/16/2002	351.92	61.67	174.24	405.90	52.79	2.04	1.05	3.94	.58	.51
05/27/2002 to 06/12/2002	378.88	34.88	308.88	459.36	56.83	2.81	1.29	5.65	.76	.70
06/13/2002 to 06/29/2002	449.11	21.50	419.76	487.08	67.37	2.71	1.00	4.89	.96	.68

Table 4. Summary of selected water-budget periods and associated components of the water budget for Diversion Lake, San Antonio area, Texas—Continued.

Water-budget period	ΔS, mean	ΔS, standard deviation	ΔS, minimum	ΔS, maximum	ΔS, ±error	GW_{out}, percent of hydrologic budget	Precipitation, percent of hydrologic budget	Sw_{in}, percent of hydrologic budget	Sw_{out}, percent of hydrologic budget	Evaporation, percent of hydrologic budget	ΔS, percent of hydrologic budget
10/12/1995 to 10/25/1995	10.46	10.67	-1.00	34.50	1.59	2.1	0	47.4	47.9	0.4	2.2
11/05/1995 to 11/16/1995	-14.58	27.06	-54.10	27.50	4.11	17.6	0	49.4	26.7	.6	5.6
11/19/1995 to 11/27/1995	29.18	7.20	22.00	41.60	4.38	4.8	0	29.8	45.2	.9	19.3
11/30/1995 to 12/10/1995	-33.34	7.54	-49.50	-24.70	5.00	12.4	0	49.3	25.1	.7	12.5
12/11/1995 to 12/21/1995	-16.64	8.23	-32.10	-7.30	2.50	13.9	.2	49.3	28.7	.7	7.2
12/28/1995 to 01/09/1996	-11.17	3.37	-18.20	-5.60	1.68	9.8	0	49.4	34.3	.6	5.9
01/10/1996 to 01/22/1996	4.29	10.62	-6.90	35.90	.89	4.6	0	47.7	45.4	.6	1.6
01/23/1996 to 02/04/1996	3.15	9.56	-15.60	18.40	1.21	3.3	0	48.7	46.7	.3	1.1
02/08/1996 to 02/28/1996	1.85	3.78	-5.20	9.00	.49	.6	0	48.7	50.0	.2	.4
03/02/1996 to 03/24/1996	3.33	8.95	-14.50	17.00	1.13	1.7	0	47.1	50.0	.3	.9
03/29/1996 to 04/08/1996	-7.98	19.50	-37.40	15.40	2.48	.1	.2	49.7	48.1	.3	1.6
04/15/1996 to 05/06/1996	3.95	6.53	-5.70	15.70	.89	4.1	0	45.1	50.0	.2	.6
07/16/1996 to 07/23/1996	-3.56	4.81	-12.50	0	.53	7.1	0	42.5	49.5	.4	.5
09/08/1996 to 09/22/1996	-2.85	18.64	-24.50	28.10	2.51	19.9	.6	28.9	46.9	1.3	2.5
07/05/2001 to 07/20/2001	.63	10.63	-10.00	30.00	.84	8.6	0	49.5	41.4	.4	.1
07/21/2001 to 08/05/2001	-10.00	13.17	-30.00	20.00	1.88	8.8	0	49.6	39.9	.4	1.4
08/08/2001 to 08/25/2001	1.11	13.23	-20.00	40.00	1.17	6.9	0	49.5	43.1	.4	.2
09/26/2001 to 10/06/2001	-7.27	22.84	-30.00	20.00	3.27	18.4	0	49.4	30.0	.6	1.6
10/18/2001 to 10/31/2001	-2.86	6.11	-10.00	10.00	.64	14.6	0	49.4	34.7	.6	.7
11/01/2001 to 11/14/2001	-19.29	12.07	-50.00	-10.00	2.89	13.2	.2	49.6	32.3	.4	4.4
01/25/2002 to 02/07/2002	0	3.92	-10.00	10.00	.21	13.7	.1	49.6	36.2	.4	0
02/12/2002 to 02/27/2002	-11.25	28.95	-70.00	30.00	3.56	11.8	0	49.4	35.3	.6	2.9
02/28/2002 to 03/14/2002	-6.67	6.17	-20.00	0	1.00	11.1	0	49.5	37.1	.5	1.8
03/21/2002 to 04/06/2002	15.29	32.62	-20.00	70.00	3.35	7.8	.4	45.2	41.8	.7	4.1
04/09/2002 to 04/27/2002	-8.95	26.44	-70.00	50.00	2.13	7.8	.1	49.3	39.5	.7	2.6
04/28/2002 to 05/16/2002	-2.63	44.33	-90.00	80.00	4.50	2.9	0	49.7	46.7	.3	.4
05/27/2002 to 06/12/2002	4.12	46.38	-90.00	80.00	5.21	5.1	0	49.1	44.9	.4	.5
06/13/2002 to 06/29/2002	-10.59	16.38	-30.00	30.00	2.47	6.1	.1	49.7	42.6	.3	1.2

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas.

[In acre-feet per day except as indicated. GW_{out}, ground-water outflow; SW_{in}, surface-water inflow; SW_{out}, surface-water outflow; DS, change in storage]

Water-budget period	Number of days in budget period	Medina Lake stage, average (feet above NGVD 29)	Diversion Lake stage, average (feet above NGVD 29)	GW_{out}, mean	GW_{out}, standard deviation	GW_{out}, minimum	25th per-centile	Median	75th per-centile	GW_{out}, maximum	GW_{out}, ±error
03/02/1955 to 03/19/1955	18	963.27	879.55	4.81	6.95	-12.94	2.66	5.95	7.07	15.77	2.45
03/22/1955 to 04/05/1955	15	964.45	872.94	6.22	7.02	-14.37	4.44	5.27	10.29	15.29	2.28
04/06/1955 to 04/20/1955	15	964.80	869.53	11.68	4.84	2.77	7.24	12.63	16.03	17.84	2.05
04/21/1955 to 05/05/1955	15	964.87	866.44	13.60	5.34	6.48	9.90	11.40	17.61	22.78	1.60
05/25/1955 to 06/20/1955	27	975.03	865.89	13.98	29.58	-82.46	8.04	17.14	31.44	57.52	3.68
06/23/1955 to 07/16/1955	24	975.05	865.89	12.75	22.55	-84.59	11.02	15.72	25.98	29.09	3.35
08/23/1955 to 09/12/1955	21	979.99	865.89	14.40	13.15	-15.67	14.57	21.20	21.60	26.51	3.35
09/13/1955 to 10/02/1955	20	979.50	865.89	18.42	17.85	-.63	.76	17.09	31.67	50.29	3.24
10/03/1955 to 10/22/1955	20	978.91	865.89	18.54	24.11	-2.15	.47	12.04	24.89	99.38	3.31
10/23/1955 to 11/11/1955	20	978.32	865.89	14.79	29.24	-44.88	-4.88	11.88	22.07	83.20	3.34
11/12/1955 to 12/01/1955	20	977.97	865.89	14.80	14.70	-1.36	-.48	14.11	21.38	42.00	2.30
12/02/1955 to 12/21/1955	20	977.53	865.89	17.03	12.38	1.73	3.17	15.89	26.25	42.50	1.95
12/22/1955 to 01/10/1956	20	977.11	865.89	20.58	14.57	3.17	5.54	18.41	30.24	50.65	2.16
01/11/1956 to 01/30/1956	20	976.65	865.89	15.35	10.70	4.02	6.80	11.00	23.24	40.67	1.78
01/31/1956 to 02/19/1956	20	976.36	865.89	24.06	51.35	-118.56	7.72	28.13	41.40	135.97	4.18
02/20/1956 to 03/10/1956	20	975.96	865.89	19.89	9.57	7.51	9.39	21.18	26.60	36.05	2.23
03/11/1956 to 03/30/1956	20	975.76	865.89	13.42	11.70	6.34	6.34	7.53	13.86	39.71	2.18
03/31/1956 to 04/19/1956	20	975.37	865.89	18.91	11.14	.61	11.18	20.60	29.27	35.77	2.74
04/20/1956 to 05/09/1956	20	974.89	865.89	22.52	16.59	-2.50	6.76	25.38	36.23	51.67	3.15
05/10/1956 to 05/29/1956	20	974.37	865.89	20.73	11.74	-4.10	14.10	19.39	25.98	47.41	3.04
05/30/1956 to 06/18/1956	20	973.65	865.89	19.31	10.79	-.56	13.94	20.98	25.51	41.87	2.94
06/19/1956 to 07/08/1956	20	972.98	865.89	17.08	12.19	-5.22	10.02	18.22	25.89	35.27	3.13
07/09/1956 to 07/28/1956	20	972.17	865.89	20.55	11.77	5.11	11.46	14.90	29.04	44.63	3.82
07/29/1956 to 08/17/1956	20	971.39	865.89	16.69	9.92	2.37	12.29	12.51	20.13	42.74	3.25
09/08/1956 to 09/27/1956	20	972.61	865.89	26.87	18.32	9.47	15.88	18.20	34.81	62.99	3.45
09/28/1956 to 10/15/1956	18	971.98	865.89	13.53	26.35	-50.41	9.60	16.36	20.64	56.25	3.09
10/16/1956 to 11/02/1956	18	971.73	865.89	15.30	17.04	-23.33	6.19	13.96	23.89	47.29	2.71
11/07/1956 to 11/26/1956	20	972.94	865.89	21.92	14.73	-.21	10.96	20.57	29.96	46.83	2.42
11/27/1956 to 12/16/1956	20	972.42	865.89	10.46	12.92	-1.32	-.37	7.49	19.60	45.35	1.54
12/17/1956 to 01/05/1957	20	972.08	865.89	15.95	11.79	-.37	7.34	14.21	26.31	39.69	1.88
01/06/1957 to 01/25/1957	20	971.67	865.89	11.32	20.87	-29.97	.36	10.20	21.94	50.00	1.98
01/26/1957 to 02/14/1957	20	971.35	865.89	14.01	9.56	-2.92	7.97	14.71	20.75	30.36	1.58
02/15/1957 to 03/10/1957	24	970.98	865.89	15.27	9.16	3.20	8.11	13.59	22.59	38.68	1.78
07/01/1957 to 07/15/1957	15	1,028.67	909.42	56.94	63.23	-46.06	19.64	47.35	98.12	166.21	28.61
07/26/1957 to 08/13/1957	19	1,025.76	913.30	145.28	27.22	101.68	125.64	153.20	165.11	188.21	50.13
08/14/1957 to 09/01/1957	19	1,023.39	913.14	113.82	36.52	48.40	86.40	120.17	140.82	188.60	49.15
09/02/1957 to 09/20/1957	19	1,021.07	913.12	68.32	77.47	-42.65	9.96	62.46	136.53	192.52	41.75
09/28/1957 to 10/08/1957	11	1,023.37	913.16	105.16	69.81	75.27	85.83	91.57	122.24	161.68	17.27
12/01/1957 to 12/19/1957	19	1,035.63	912.56	127.29	166.56	-399.89	97.56	136.54	230.94	291.09	63.46
12/28/1957 to 01/04/1958	8	1,036.74	913.76	113.08	66	11.25	69.30	113.04	152.10	225.13	43.62
05/21/1958 to 06/16/1958	27	1,060.12	916.14	123.70	124.91	-242.03	64.24	135.17	177.90	386.95	56.66
07/16/1958 to 08/03/1958	19	1,063.84	917.69	177.55	101.56	27.84	96.82	183.64	260.92	326.09	64.03

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Number of days in budget period	Medina Lake stage, average (feet above NGVD 29)	Diversion Lake stage, average (feet above NGVD 29)	GW_{out}, mean	GW_{out}, standard deviation	GW_{out}, minimum	25th per-centile	Median	75th per-centile	GW_{out}, maximum	GW_{out}, ±error
08/04/1958 to 08/23/1958	20	1,062.66	916.68	165.39	88.41	-11.16	105.78	169.09	209.29	375.56	69.09
08/26/1958 to 09/05/1958	11	1,061.49	917.87	113.92	79.32	-23.21	57.82	120.43	184.46	222.79	51.57
01/22/1959 to 02/12/1959	22	1,064.04	919.15	130.95	95.91	-113.33	95.85	111.40	145.33	419.22	36.84
02/16/1959 to 03/09/1959	22	1,064.04	919.09	125.20	104	6.05	68.71	93.13	163.16	425.92	37.45
03/10/1959 to 03/30/1959	21	1,063.65	917.51	116.95	77.33	-53.30	73.88	114.13	154.61	293.61	39.65
04/14/1959 to 04/30/1959	17	1,063.80	915.18	125.48	121.80	-128.04	56.86	80.85	226.02	328.97	49.10
05/03/1959 to 06/04/1959	33	1,063.79	916.67	122.10	120.42	-81.50	21.82	116.28	196.85	316.89	43.82
07/28/1959 to 08/22/1959	26	1,063.53	916.93	107.42	104.87	-103.73	65.96	110.07	154.57	368.08	56.00
08/29/1959 to 09/17/1959	20	1,061.98	916.94	123.99	129.58	-25.59	6.67	122.55	207.44	357.85	53.98
11/17/1959 to 12/14/1959	28	1,062.73	918.36	129.00	125.69	-116.03	34.20	136.52	199.24	413.26	34.25
01/03/1960 to 03/20/1960	78	1,062.50	919.06	111.98	109.82	-184.99	52.13	85.24	155.70	597.57	35.86
05/20/1960 to 06/05/1960	17	1,061.53	918.71	58.08	117.80	-158.40	-6.48	54.02	115.49	282.58	56.88
06/06/1960 to 06/23/1960	18	1,060.29	918.64	38.70	32.58	-8.93	17.62	33.22	52.49	109.61	78.06
06/30/1960 to 07/14/1960	15	1,058.74	917.93	79.65	86.31	-51.33	32.33	75.58	110.07	283.63	51.65
07/24/1960 to 08/10/1960	18	1,058.88	918.16	106.52	133.26	-169.38	9.74	141.89	185.80	361.06	44.89
09/01/1960 to 09/23/1960	23	1,062.56	917.81	156.40	93.18	4.10	89.52	137.92	178.27	334.18	58.45
09/24/1960 to 10/15/1960	22	1,061.79	917.08	103.48	86.22	-12.12	42.19	70.28	159.60	286.39	48.02
11/06/1960 to 12/05/1960	30	1,063.26	919.16	103.59	113.88	-145.12	28.09	132.66	172.58	324.38	57.70
04/17/1961 to 05/12/1961	26	1,063.86	918.52	87.78	145.32	-105.10	-15.13	55.88	122.96	422.10	61.74
05/13/1961 to 06/07/1961	26	1,062.54	917.91	73.52	58.77	-27.30	36.86	69.32	115.08	182.83	66.80
07/29/1961 to 08/16/1961	19	1,063.85	917.70	109.78	91.08	-67.02	65.90	111.57	146.92	353.17	47.74
08/25/1961 to 09/11/1961	18	1,062.76	916.51	105.23	150.25	-79.01	-36.92	99.15	210.00	383.50	53.17
09/12/1961 to 10/01/1961	20	1,061.98	916.37	114.36	159.56	-50.81	49.65	82.81	119.03	754.64	52.18
10/27/1961 to 11/13/1961	18	1,060.39	917.39	143.38	87.31	-20.58	95.09	143.07	183.92	348.38	28.21
11/14/1961 to 12/13/1961	30	1,059.70	918.00	133.49	69.48	-29.38	102.37	127.45	161.81	295.11	26.92
12/27/1961 to 01/09/1962	27	1,058.91	917.57	139.44	94.59	-54.19	85.99	135.58	202.04	327.00	28.50
01/13/1962 to 01/22/1962	10	1,058.00	917.39	115.16	82.67	-47.29	87.38	133.27	170.18	206.39	40.35
01/23/1962 to 02/12/1962	21	1,057.39	917.59	109.14	130.46	-129.31	56.05	101.92	179.22	312.58	34.17
03/10/1962 to 04/01/1962	23	1,055.39	917.53	130.49	127.98	-70.16	43.27	104.99	204.46	421.91	47.51
05/04/1962 to 05/27/1962	24	1,053.43	916.31	66.85	139.31	-164.44	-37.74	58.86	164.17	331.46	58.82
06/04/1962 to 06/27/1962	24	1,051.56	915.96	54.67	133.83	-200.51	-24.32	20.04	130.30	358.47	58.54
06/28/1962 to 07/18/1962	21	1,049.58	915.84	84.07	246.91	-271.50	8.32	64.04	103.77	1,068.31	72.75
08/01/1962 to 08/26/1962	26	1,045.63	915.98	53.39	180.40	-427.85	-1.69	69.47	138.18	618.48	74.53
08/27/1962 to 09/17/1962	22	1,043.21	916.13	122.35	180.11	-175.67	51.11	96.13	136.24	744.53	60.48
09/18/1962 to 10/12/1962	25	1,041.38	915.96	66.56	117.93	-153.32	-4.26	110.22	130.69	242.50	43.50
11/03/1962 to 11/25/1962	23	1,039.89	915.64	110.98	87.40	-30.26	48.84	102.59	173.60	305.30	36.36
12/03/1962 to 12/17/1962	15	1,038.55	915.45	93.78	55.77	-16.69	65.84	116.91	124.66	179.93	30.27
12/26/1962 to 01/12/1963	18	1,037.72	915.51	82.87	117.63	-106.93	8.73	91.09	145.50	362.99	16.70
01/13/1963 to 01/30/1963	18	1,037.27	915.65	123.90	80.81	18.00	84.72	87.98	172.65	340.33	16.80
01/31/1963 to 02/15/1963	16	1,036.47	915.79	78.90	70.85	-8.71	30.78	60.31	102.76	286.94	41.18
03/12/1963 to 03/26/1963	15	1,035.25	916.10	44.43	31.52	-28.14	29.45	36.56	61.92	94.53	35.22
04/14/1963 to 04/26/1963	13	1,033.34	916.35	68.67	29.62	10.71	59.30	72.92	79.05	111.97	41.21
06/24/1963 to 07/14/1963	21	1,026.72	916.28	77.27	88.68	-134.12	30.64	79.80	110.42	237.61	43.33

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Number of days in budget period	Medina Lake stage, average (feet above NGVD 29)	Diversion Lake stage, average (feet above NGVD 29)	GW_{out}, mean	GW_{out}, standard deviation	GW_{out}, minimum	25th per-centile	Median	75th per-centile	GW_{out}, maximum	GW_{out}, ±error
07/16/1963 to 07/29/1963	14	1,024.40	915.84	66.50	32.88	5.39	41.91	66.79	88.04	126.17	68.10
07/30/1963 to 08/20/1963	22	1,021.27	915.39	22.02	67.95	-118.87	-6.60	5.33	52.92	162.96	72.38
08/21/1963 to 09/11/1963	22	1,017.77	914.89	37.44	46.37	-86.17	16.40	48.95	69.45	99.51	62.52
10/03/1963 to 10/23/1963	21	1,012.04	914.36	34.81	51.80	-92.44	-2.92	30.12	73.00	112.79	44.21
11/11/1963 to 11/25/1963	15	1,008.76	914.88	31.68	55.14	-73.65	5.69	47.36	59.52	132.43	27.51
11/28/1963 to 12/17/1963	20	1,007.32	914.33	57.90	100.52	-243.09	22.83	67.27	103.90	233.31	18.24
12/18/1963 to 01/03/1964	17	1,006.39	913.81	62.79	31.43	11.50	45.03	54.90	81.69	134.75	15.36
01/10/1964 to 01/27/1964	18	1,004.38	914.94	47.77	59.15	-53.69	5.50	29.21	87.23	144.12	22.15
02/05/1964 to 02/28/1964	24	1,005.10	914.85	46.44	87.48	-72.63	-10.81	28.12	88.25	316.61	18.05
03/24/1964 to 04/16/1964	24	1,005.18	913.69	43.05	45.21	-41.76	21.45	38.62	70.25	143.09	24.33
04/19/1964 to 05/03/1964	15	1,004.53	913.30	45.61	30.35	-28.74	33.31	45.30	62.04	94.59	18.76
05/05/1964 to 05/28/1964	24	1,002.79	913.05	47.71	79.82	-97.41	14.25	57.65	101.15	168.15	42.84
06/17/1964 to 07/10/1964	24	997.70	913.86	23.31	55.18	-105.53	1.11	15.65	57.29	148.97	45.65
07/11/1964 to 07/30/1964	20	991.73	913.74	36.12	244.41	-324.63	-53.70	23.00	161.18	650.67	65.72
08/02/1964 to 08/15/1964	14	986.21	913.74	31.33	63.91	-97.03	-6.37	28.73	74.53	132.18	47.46
10/11/1995 to 10/28/1995	18	1,044.82	912.38	99.01	71.74	-25.62	52.01	96.37	122.49	294.62	35.40
11/30/1995 to 12/17/1995	18	1,044.83	912.97	62.23	56.63	-63.99	38.64	60.86	78.38	210.51	19.19
12/18/1995 to 01/04/1996	18	1,044.58	911.62	90.70	60.52	-74.13	65.18	94.62	123.61	184.74	20.63
01/05/1995 to 01/22/1996	18	1,044.13	911.39	93.22	88.85	-65.64	54.89	84.46	121.41	342.80	22.08
01/23/1996 to 02/09/1996	18	1,043.44	911.88	88.45	50.18	-1.24	48.35	93.43	123.05	163.60	26.23
02/10/1996 to 02/28/1996	19	1,042.44	912.40	96.03	75.78	-84.84	73.61	98.53	132.70	292.21	33.72
03/07/1996 to 03/20/1996	14	1,041.13	912.31	107.76	69.24	-5.03	70.61	88.36	138.19	284.63	32.54
03/21/1996 to 04/03/1996	14	1,040.12	913.22	107.87	67.94	-33.56	75.35	111.46	147.93	208.59	39.58
04/11/1996 to 04/24/1996	14	1,038.56	912.78	93.08	67.74	-16.21	59.43	100.51	133.60	188.01	42.38
04/25/1996 to 05/07/1996	13	1,037.19	913.29	70.50	107.79	-153.45	51.91	72.44	87.58	332.76	49.05
05/12/1996 to 05/26/1996	15	1,035.53	913.24	68.38	85.96	-89.40	18.50	83.17	131.94	195.88	47.24
06/04/1996 to 06/19/1996	16	1,032.47	913.70	71.13	75.53	-75.76	46.46	61.38	92.40	280.03	61.50
06/20/1996 to 07/05/1996	16	1,029.76	913.86	76.53	76.28	-15.20	21.03	60.76	117.54	271.55	62.95
07/16/1996 to 08/02/1996	18	1,025.43	913.57	65.17	50.37	-27.10	33.43	72.46	93.65	175.60	56.74
08/03/1996 to 08/19/1996	17	1,022.16	913.66	66.44	89.03	-145.58	30.16	59.98	88.54	260.93	59.32
09/06/1996 to 09/23/1996	18	1,019.62	909.47	63.75	49.08	-10.84	46.02	57.66	84.52	168.68	15.03
03/30/2001 to 04/14/2001	16	1,060.94	919.16	134.51	169.59	-218.23	58.36	151.51	280.77	361.65	59.00
06/22/2001 to 07/08/2001	17	1,062.80	915.21	86.52	108.71	-217.44	60.74	89.91	126.32	321.43	68.22
07/09/2001 to 07/27/2001	19	1,061.27	915.37	117.05	140.35	-84.55	38.62	128.61	210.80	375.49	74.80
07/28/2001 to 08/09/2001	13	1,059.79	914.43	131.58	132.31	-88.88	68.55	131.58	176.28	434.10	72.06
08/10/2001 to 08/25/2001	16	1,058.36	913.92	120.49	176.90	-273.57	58.60	100.51	161.45	516.95	74.58
10/26/2001 to 11/11/2001	17	1,060.75	918.61	91.66	261.32	-176.58	-108.45	-84.53	381.27	494.66	41.81
02/22/2002 to 03/14/2002	21	1,063.70	917.48	78.64	176.95	-295.06	-40.06	76.97	226.47	353.57	35.50
04/09/2002 to 04/27/2002	19	1,062.71	918.96	83.13	144.64	-128.60	-12.40	73.67	200.83	379.81	36.95
04/28/2002 to 05/16/2002	19	1,061.79	917.14	131.24	114.59	-102.19	61.22	120.71	221.63	324.21	62.63
05/30/2002 to 06/14/2002	16	1,059.52	916.67	126.15	115.09	-68.24	71.81	124.37	232.11	303.91	75.46
06/15/2002 to 06/29/2002	15	1,057.85	917.36	122.90	118.81	-.62	24.68	84.42	210.48	353.53	75.85

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Precipitation, mean	Precipitation, standard deviation	Precipitation, minimum	Precipitation, maximum	Precipitation, ±error	Sw_{in}, mean	Sw_{in}, standard deviation	Sw_{in}, minimum	Sw_{in}, maximum	Sw_{in}, ±error
03/02/1955 to 03/19/1955	0	0	0	0	0	19.32	0.40	19.01	19.80	1.93
03/22/1955 to 04/05/1955	0	0	0	0	0	18.64	2.68	17.42	27.72	1.86
04/06/1955 to 04/20/1955	.13	.49	0	1.88	.02	18.16	1.51	15.84	19.80	1.82
04/21/1955 to 05/05/1955	.06	.24	0	.94	.01	13.03	1.99	9.50	15.84	1.30
05/25/1955 to 06/20/1955	1.40	4.52	0	20.28	.21	13.49	5.05	7.52	27.72	1.35
06/23/1955 to 07/16/1955	.22	.85	0	4.09	.03	9.02	5.11	4.36	19.80	.90
08/23/1955 to 09/12/1955	.26	.82	0	2.97	.04	12.53	4.75	7.52	25.74	1.25
09/13/1955 to 10/02/1955	1.99	6.90	0	30.52	.30	7.74	.67	6.73	9.50	.77
10/03/1955 to 10/22/1955	.94	2.99	0	13.08	.14	6.25	1.82	2.97	8.32	.62
10/23/1955 to 11/11/1955	4.77	16.82	0	73.00	.72	3.29	.52	2.97	5.15	.33
11/12/1955 to 12/01/1955	1.74	7.77	0	34.76	.26	4.36	.63	3.56	5.94	.44
12/02/1955 to 12/21/1955	.15	.68	0	3.03	.02	5.78	.49	5.15	6.73	.58
12/22/1955 to 01/10/1956	0	0	0	0	0	6.97	.82	5.94	8.32	.70
01/11/1956 to 01/30/1956	2.13	6.75	0	26.36	.32	8.59	1.48	6.73	10.69	.86
01/31/1956 to 02/19/1956	1.55	3.42	0	13.46	.23	11.88	1.09	10.69	13.07	1.19
02/20/1956 to 03/10/1956	.31	1.40	0	6.25	.05	12.53	.61	11.88	13.07	1.25
03/11/1956 to 03/30/1956	.33	1.46	0	6.53	.05	12.12	.49	11.88	13.07	1.21
03/31/1956 to 04/19/1956	0	0	0	0	0	8.85	1.07	6.73	10.69	.89
04/20/1956 to 05/09/1956	2.41	7.94	0	35.37	.36	14.16	10.90	4.36	31.68	1.42
05/10/1956 to 05/29/1956	.37	1.20	0	4.94	.06	8.49	5.01	2.97	19.01	.85
05/30/1956 to 06/18/1956	.38	1.04	0	4.25	.06	1.89	.37	1.58	2.97	.19
06/19/1956 to 07/08/1956	.70	3.15	0	14.10	.11	1.49	.24	.99	1.98	.15
07/09/1956 to 07/28/1956	0	0	0	0	0	.84	.11	.59	.99	.08
07/29/1956 to 08/17/1956	0	0	0	0	0	.65	.09	.59	.79	.07
09/08/1956 to 09/27/1956	.50	1.70	0	7.27	.07	5.68	3.06	1.98	13.07	.57
09/28/1956 to 10/15/1956	1.14	4.83	0	20.48	.17	1.73	.19	1.58	1.98	.17
10/16/1956 to 11/02/1956	2.13	6.31	0	22.76	.32	7.55	5.20	3.56	25.74	.75
11/07/1956 to 11/26/1956	0	0	0	0	0	5.35	2.81	2.97	11.88	.53
11/27/1956 to 12/16/1956	0	0	0	0	0	2.41	.13	2.38	2.97	.24
12/17/1956 to 01/05/1957	1.08	3.61	0	15.09	.16	2.41	.13	2.38	2.97	.24
01/06/1957 to 01/25/1957	0	0	0	0	0	2.14	.24	1.58	2.38	.21
01/26/1957 to 02/14/1957	.64	1.37	0	4.26	.10	3.47	.94	2.38	5.15	.35
02/15/1957 to 03/10/1957	2.40	6.04	0	22.00	.36	7.44	2.13	3.56	13.07	.74
07/01/1957 to 07/15/1957	0	0	0	3.56	0	133.75	19.70	104.23	172.46	14.29
07/26/1957 to 08/13/1957	1.78	7.78	0	33.91	.27	51.88	14.00	31.68	79.48	5.25
08/14/1957 to 09/01/1957	6.41	19.22	0	64.23	.96	22.76	4.48	17.42	29.70	2.28
09/02/1957 to 09/20/1957	9.89	24.56	0	86.08	1.48	19.03	3.34	17.42	29.70	1.90
09/28/1957 to 10/08/1957	0	0	0	0	0	127.27	26.92	97.09	182.42	13.79
12/01/1957 to 12/19/1957	1.39	4.21	0	14.71	.21	482.88	80.36	383.33	627.62	53.70
12/28/1957 to 01/04/1958	0	0	0	0	0	345.27	21.68	321.01	378.25	38.22
05/21/1958 to 06/16/1958	5.10	20.73	0	103.45	.76	250.12	78.89	156.15	413.24	27.32
07/16/1958 to 08/03/1958	0	0	0	0	0	285.45	61.41	199.59	389.39	31.33

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Precipitation, mean	Precipitation, standard deviation	Precipitation, minimum	Precipitation, maximum	Precipitation, ±error	Sw_{in}, mean	Sw_{in}, standard deviation	Sw_{in}, minimum	Sw_{in}, maximum	Sw_{in}, ±error
08/04/1958 to 08/23/1958	0	0	0	0	0	159.61	13.66	140.32	190.75	17.19
08/26/1958 to 09/05/1958	13.70	45.44	0	150.70	2.05	122.83	19.91	104.39	169.49	13.03
01/22/1959 to 02/12/1959	18.73	40.12	0	177.25	2.81	263.70	16.59	235.43	294.10	28.18
02/16/1959 to 03/09/1959	12.57	30.29	0	104.40	1.89	238.29	18.56	210.78	265.85	25.73
03/10/1959 to 03/30/1959	9.37	32.32	0	139.49	1.41	181.03	13.09	161.62	207.13	19.29
04/14/1959 to 04/30/1959	8.83	20.19	0	62.10	1.32	352.72	60.15	276.78	449.22	38.82
05/03/1959 to 06/04/1959	24.68	69.46	0	243.82	3.70	227.65	45.73	150.70	343.51	24.79
07/28/1959 to 08/22/1959	0	0	0	0	0	132.23	32.09	90.82	205.34	14.12
08/29/1959 to 09/17/1959	20.75	47.87	0	161.85	3.11	77.14	5.49	68.76	88.80	8.01
11/17/1959 to 12/14/1959	13.56	60.30	0	318.16	2.03	197.73	16.42	176.21	231.82	21.50
01/03/1960 to 03/20/1960	20.77	67.03	0	398.22	3.12	232.92	25.44	189.29	301.96	25.08
05/20/1960 to 06/05/1960	31.83	87.86	0	339.77	4.77	129.72	21.87	96.31	172.04	13.86
06/06/1960 to 06/23/1960	0	0	0	0	0	65.07	16.98	41.58	91.63	6.72
06/30/1960 to 07/14/1960	0	0	0	0	0	42.25	17.22	29.70	100.71	4.46
07/24/1960 to 08/10/1960	0	0	0	0	0	161.10	56.94	98.58	283.70	18.00
09/01/1960 to 09/23/1960	271.31	72.53	0	271.31	40.70	487.36	87.38	211.07	487.36	53.44
09/24/1960 to 10/15/1960	7.38	24.47	0	111.79	1.11	194.24	38.59	154.90	279.30	20.81
11/06/1960 to 12/05/1960	18.08	48.14	0	175.94	2.71	421.51	61.44	335.14	535.58	46.69
04/17/1961 to 05/12/1961	7.01	25.04	0	104.12	1.05	266.61	50.07	178.20	343.79	27.96
05/13/1961 to 06/07/1961	1.18	6.03	0	30.74	.18	138.81	24.03	99.00	174.24	13.97
07/29/1961 to 08/16/1961	12.31	53.67	0	233.95	1.85	181.50	37.40	130.68	251.40	18.91
08/25/1961 to 09/11/1961	0	0	0	0	0	137.39	20.21	110.88	172.83	14.05
09/12/1961 to 10/01/1961	42.75	153.62	0	671.85	6.41	115.38	24.85	87.12	175.15	11.56
10/27/1961 to 11/13/1961	31.37	75.61	0	276.79	4.70	111.10	3.71	104.94	120.78	11.11
11/14/1961 to 12/13/1961	15.41	40.57	0	146.85	2.31	114.77	5.21	108.90	124.74	11.48
12/27/1961 to 01/09/1962	3.97	14.57	0	63.41	.60	106.92	10.83	97.02	130.68	10.69
01/13/1962 to 01/22/1962	14.34	29.01	0	90.74	2.15	102.37	1.88	99.00	104.94	10.24
01/23/1962 to 02/12/1962	4.32	17.74	0	81.19	.65	84.57	9.39	71.28	104.94	8.46
03/10/1962 to 04/01/1962	23.30	52.69	0	195.51	3.50	71.80	5.95	65.34	87.12	7.18
05/04/1962 to 05/27/1962	0	0	0	0	0	54.45	12.66	39.60	79.20	5.45
06/04/1962 to 06/27/1962	1.06	5.18	0	25.36	.16	49.01	29.09	21.78	146.52	4.90
06/28/1962 to 07/18/1962	60.86	258.22	0	1,185.23	9.13	16.68	5.86	11.09	27.72	1.67
08/01/1962 to 08/26/1962	2.16	11.01	0	56.16	.32	7.58	1.24	6.14	11.88	.76
08/27/1962 to 09/17/1962	67.56	206.47	0	771.15	10.13	5.47	1.89	3.96	11.09	.55
09/18/1962 to 10/12/1962	10.08	31.27	0	140.82	1.51	6.71	3.71	3.37	19.01	.67
11/03/1962 to 11/25/1962	27.64	61.16	0	239.63	4.15	55.35	5.86	47.52	67.32	5.54
12/03/1962 to 12/17/1962	9.72	37.64	0	145.79	1.46	73.00	8.66	63.36	91.08	7.30
12/26/1962 to 01/12/1963	6.17	17.21	0	69.71	.93	62.81	4.49	57.42	69.30	6.28
01/13/1963 to 01/30/1963	18.53	42.64	0	151.28	2.78	50.49	2.65	47.52	55.44	5.05
01/31/1963 to 02/15/1963	8.15	28.90	0	115.64	1.22	44.18	2.87	39.60	47.52	4.42
03/12/1963 to 03/26/1963	1.36	5.28	0	20.46	.20	49.24	1.81	47.52	51.48	4.92
04/14/1963 to 04/26/1963	1.07	3.88	0	13.97	.16	51.48	3.61	47.52	57.42	5.15
06/24/1963 to 07/14/1963	6.10	27.97	0	128.18	.92	18.86	4.38	9.50	25.74	1.89

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Precipitation, mean	Precipitation, standard deviation	Precipitation, minimum	Precipitation, maximum	Precipitation, ±error	Sw_{in}, mean	Sw_{in}, standard deviation	Sw_{in}, minimum	Sw_{in}, maximum	Sw_{in}, ±error
07/16/1963 to 07/29/1963	0	0	0	0	0	5.15	1.22	3.37	7.52	0.51
07/30/1963 to 08/20/1963	0	0	0	0	0	8.02	12.06	2.18	53.46	.80
08/21/1963 to 09/11/1963	0	0	0	0	0	5.00	1.47	3.37	8.71	.50
10/03/1963 to 10/23/1963	1.21	5.56	0	25.47	.18	2.37	.24	2.18	2.97	.24
11/11/1963 to 11/25/1963	1.17	4.53	0	17.53	.18	10.08	2.76	8.12	17.82	1.01
11/28/1963 to 12/17/1963	8.35	17.72	0	62.74	1.25	27.01	9.21	14.65	43.56	2.70
12/18/1963 to 01/03/1964	1.96	8.07	0	33.27	.29	39.48	2.84	37.62	45.54	3.95
01/10/1964 to 01/27/1964	4.44	18.82	0	79.84	.67	33.22	2.10	31.68	39.60	3.32
02/05/1964 to 02/28/1964	7.85	25.73	0	114.50	1.18	103.37	17.08	79.20	142.56	10.34
03/24/1964 to 04/16/1964	2.11	7.70	0	34.98	.32	110.80	22.31	85.14	168.30	11.08
04/19/1964 to 05/03/1964	3.89	10.26	0	29.86	.58	96.62	16.85	71.28	126.72	9.66
05/05/1964 to 05/28/1964	10.91	26.38	0	119.30	1.64	51.98	11.72	35.64	69.30	5.20
06/17/1964 to 07/10/1964	11.44	56.06	0	274.62	1.72	13.93	4.68	8.12	25.74	1.39
07/11/1964 to 07/30/1964	.60	2.70	0	12.07	.09	5.52	1.37	3.96	7.52	.55
08/02/1964 to 08/15/1964	3.45	10.50	0	38.89	.52	3.38	.36	2.97	3.96	.34
10/11/1995 to 10/28/1995	0	0	0	0	0	130.77	22.75	103.44	175.17	6.86
11/30/1995 to 12/17/1995	6.58	20.97	0	84.09	.99	141.75	7.15	129.29	152.74	7.49
12/18/1995 to 01/04/1996	4.09	11.52	0	40.23	.61	136.05	16.33	114.21	172.87	7.09
01/05/1995 to 01/22/1996	0	0	0	0	0	104.88	3.91	98.90	112.17	5.46
01/23/1996 to 02/09/1996	1.44	6.13	0	26.00	.22	95.44	6.06	87.77	104.84	4.97
02/10/1996 to 02/28/1996	1.03	4.50	0	19.62	.15	87.41	6.49	79.87	103.65	4.52
03/07/1996 to 03/20/1996	0	0	0	0	0	81.00	8.81	70.79	106.25	4.18
03/21/1996 to 04/03/1996	6.41	18.24	0	65.81	.96	72.32	6.80	65.24	83.16	3.76
04/11/1996 to 04/24/1996	2.12	7.92	0	29.62	.32	74.98	20.47	53.12	115.43	3.88
04/25/1996 to 05/07/1996	15.44	55.68	0	200.75	2.32	49.51	4.20	43.20	55.10	2.59
05/12/1996 to 05/26/1996	0	0	0	0	0	39.01	10.48	26.61	52.83	2.03
06/04/1996 to 06/19/1996	0	0	0	0	0	20.24	4.44	14.08	30.25	1.04
06/20/1996 to 07/05/1996	13.74	42.52	0	164.55	2.06	15.17	4.02	10.22	24.31	.79
07/16/1996 to 08/02/1996	0	0	0	0	0	6.93	1.25	5.48	9.88	.37
08/03/1996 to 08/19/1996	.26	1.06	0	4.37	.04	4.91	.28	4.44	5.37	.27
09/06/1996 to 09/23/1996	11.75	38.06	0	160.48	1.76	96.97	48.06	43.20	210.47	5.03
03/30/2001 to 04/14/2001	3.89	13.46	0	54.17	.58	674.08	83.33	567.33	813.62	40.61
06/22/2001 to 07/08/2001	11.80	30.97	0	121.83	1.77	184.44	31.70	144.00	239.96	9.78
07/09/2001 to 07/27/2001	0	0	0	0	0	95.23	20.13	68.03	135.82	4.96
07/28/2001 to 08/09/2001	0	0	0	0	0	53.53	7.09	44.50	65.54	2.81
08/10/2001 to 08/25/2001	14.09	52.33	0	209.76	2.11	39.68	3.52	35.65	47.10	2.08
10/26/2001 to 11/11/2001	15.90	61.94	0	255.88	2.39	175.10	10.90	160.77	199.38	9.48
02/22/2002 to 03/14/2002	1.72	6.35	0	28.49	.26	185.37	14.10	167.51	215.03	9.91
04/09/2002 to 04/27/2002	13.07	38.13	0	122.53	1.96	169.05	20.56	140.35	205.69	9.09
04/28/2002 to 05/16/2002	0	0	0	0	0	109.81	15.20	90.76	137.59	5.75
05/30/2002 to 06/14/2002	5.16	17.37	0	69.71	.77	96.64	11.59	73.02	114.85	5.07
06/15/2002 to 06/29/2002	26.37	54.29	0	156.52	3.96	58.74	6.03	52.30	70.53	3.10

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Sw_{out}, mean	Sw_{out}, standard deviation	Sw_{out}, minimum	Sw_{out}, maximum	Sw_{out}, ±error	Evaporation, mean	Evaporation, standard deviation	Evaporation, minimum	Evaporation, maximum	Evaporation, ±error
03/02/1955 to 03/19/1955	0	0	0	0	0	1.90	0.02	1.87	1.95	0.48
03/22/1955 to 04/05/1955	0	0	0	0	0	2.41	.42	2.09	3.01	.60
04/06/1955 to 04/20/1955	0	0	0	0	0	3.05	.02	3.02	3.08	.76
04/21/1955 to 05/05/1955	0	0	0	0	0	2.98	.12	2.76	3.07	.75
05/25/1955 to 06/20/1955	0	0	0	0	0	8.07	.88	6.62	8.72	2.02
06/23/1955 to 07/16/1955	0	0	0	0	0	8.98	.19	8.72	9.25	2.25
08/23/1955 to 09/12/1955	0	0	0	0	0	9.66	1.62	8.22	11.53	2.41
09/13/1955 to 10/02/1955	0	0	0	0	0	8.14	.08	7.97	8.28	2.04
10/03/1955 to 10/22/1955	0	0	0	0	0	8.14	.10	7.99	8.28	2.03
10/23/1955 to 11/11/1955	0	0	0	0	0	6.27	1.49	4.93	7.96	1.57
11/12/1955 to 12/01/1955	0	0	0	0	0	4.79	.32	3.45	4.92	1.20
12/02/1955 to 12/21/1955	0	0	0	0	0	3.40	.03	3.36	3.44	.85
12/22/1955 to 01/10/1956	0	0	0	0	0	3.05	.29	2.74	3.36	.76
01/11/1956 to 01/30/1956	0	0	0	0	0	2.71	.01	2.70	2.74	.68
01/31/1956 to 02/19/1956	0	0	0	0	0	3.71	.24	2.70	3.81	.93
02/20/1956 to 03/10/1956	0	0	0	0	0	4.63	.96	3.68	5.60	1.16
03/11/1956 to 03/30/1956	0	0	0	0	0	5.53	.03	5.47	5.54	1.38
03/31/1956 to 04/19/1956	0	0	0	0	0	6.94	.36	5.47	7.12	1.74
04/20/1956 to 05/09/1956	0	0	0	0	0	7.38	.61	6.81	8.09	1.84
05/10/1956 to 05/29/1956	0	0	0	0	0	7.80	.10	7.66	7.96	1.95
05/30/1956 to 06/18/1956	0	0	0	0	0	6.45	.41	6.21	7.63	1.61
06/19/1956 to 07/08/1956	0	0	0	0	0	7.62	1.90	6.01	9.96	1.90
07/09/1956 to 07/28/1956	0	0	0	0	0	9.45	.19	9.20	9.76	2.36
07/29/1956 to 08/17/1956	0	0	0	0	0	8.30	.37	7.96	9.16	2.07
09/08/1956 to 09/27/1956	0	0	0	0	0	6.97	.14	6.80	7.23	1.74
09/28/1956 to 10/15/1956	0	0	0	0	0	5.63	.53	5.30	6.79	1.41
10/16/1956 to 11/02/1956	0	0	0	0	0	5.11	.62	3.40	5.39	1.28
11/07/1956 to 11/26/1956	0	0	0	0	0	3.78	.05	3.71	3.88	.95
11/27/1956 to 12/16/1956	0	0	0	0	0	2.95	.39	2.74	3.70	.74
12/17/1956 to 01/05/1957	0	0	0	0	0	2.54	.31	2.02	2.74	.63
01/06/1957 to 01/25/1957	0	0	0	0	0	1.99	.02	1.95	2.02	.50
01/26/1957 to 02/14/1957	0	0	0	0	0	2.43	.32	1.95	2.66	.61
02/15/1957 to 03/10/1957	0	0	0	0	0	3.32	.89	2.58	4.39	.83
07/01/1957 to 07/15/1957	1.73	.95	.79	3.56	.26	74.34	.19	73.97	74.65	18.58
07/26/1957 to 08/13/1957	199.67	4.44	194.04	207.90	29.95	67.81	2.81	64.95	72.20	16.95
08/14/1957 to 09/01/1957	202.79	7.53	184.14	209.88	30.42	62.32	4.37	44.65	64.78	15.58
09/02/1957 to 09/20/1957	190.77	13.93	164.34	203.94	28.62	43.46	.66	42.47	44.55	10.86
09/28/1957 to 10/08/1957	17.68	9.83	13.46	47.12	2.65	32.38	8.58	27.33	45.75	8.10
12/01/1957 to 12/19/1957	66.17	46.37	21.78	126.72	9.93	19.94	.18	19.63	20.16	4.99
12/28/1957 to 01/04/1958	25.74	1.06	23.76	27.72	3.86	19.05	2.13	17.02	21.07	4.76
05/21/1958 to 06/16/1958	206.07	52.42	122.76	263.34	30.91	90.41	9.95	78.59	99.13	22.60
07/16/1958 to 08/03/1958	192.06	16.87	146.52	225.72	28.81	151.74	3.77	143.17	153.76	37.94
08/04/1958 to 08/23/1958	251.96	8.32	229.68	263.34	37.79	141.75	0.79	140.56	143.04	35.44

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Sw_{out}, mean	Sw_{out}, standard deviation	Sw_{out}, minimum	Sw_{out}, maximum	Sw_{out}, ±error	Evaporation, mean	Evaporation, standard deviation	Evaporation, minimum	Evaporation, maximum	Evaporation, ±error
08/26/1958 to 09/05/1958	176.58	5.93	172.26	194.04	26.49	109.72	34.79	73.31	140.23	27.43
01/22/1959 to 02/12/1959	137.25	10.14	126.72	158.40	20.59	28.05	1.17	27.00	29.30	7.01
02/16/1959 to 03/09/1959	135.42	14.90	112.86	164.34	20.31	46.09	23.45	27.03	73.75	11.52
03/10/1959 to 03/30/1959	153.31	15.31	130.68	178.20	23.00	73.20	.20	72.86	73.52	18.30
04/14/1959 to 04/30/1959	117.75	23.47	97.02	146.52	17.66	71.11	.06	70.97	71.20	17.78
05/03/1959 to 06/04/1959	130.86	51.95	43.56	233.64	19.63	83.07	11.61	78.65	113.98	20.77
07/28/1959 to 08/22/1959	203.41	25.44	160.38	223.74	30.51	123.83	2.66	117.77	125.82	30.96
08/29/1959 to 09/17/1959	187.11	7.34	176.22	209.88	28.07	113.24	4.36	110.58	123.37	28.31
11/17/1959 to 12/14/1959	117.95	12.71	102.96	146.52	17.69	41.76	5.36	36.44	47.08	10.44
01/03/1960 to 03/20/1960	129.55	11.77	74.05	156.42	19.43	41.59	13.29	24.77	54.37	10.40
05/20/1960 to 06/05/1960	254.02	42.04	186.12	308.88	38.10	103.33	21.84	89.33	136.35	25.83
06/06/1960 to 06/23/1960	351.78	29.59	308.88	394.02	52.77	134.38	.91	132.87	135.77	33.60
06/30/1960 to 07/14/1960	177.67	43.47	124.74	233.64	26.65	110.60	6.00	108.40	132.23	27.65
07/24/1960 to 08/10/1960	152.68	35.79	108.90	188.10	22.90	94.34	14.10	81.80	109.81	23.59
09/01/1960 to 09/23/1960	225.72	11.55	194.04	225.72	33.86	101.56	.26	100.82	101.56	25.39
09/24/1960 to 10/15/1960	212.04	1.21	209.88	215.82	31.81	77.05	16.49	65.83	100.78	19.26
11/06/1960 to 12/05/1960	181.83	22.44	156.42	229.68	27.27	36.30	6.25	22.56	39.20	9.08
04/17/1961 to 05/12/1961	290.22	29.19	255.42	326.70	43.53	86.96	2.04	84.41	88.88	21.74
05/13/1961 to 06/07/1961	332.49	6.67	320.76	342.54	49.87	87.57	6.31	83.15	98.04	21.89
07/29/1961 to 08/16/1961	174.97	21.36	148.50	215.82	26.25	105.70	1.23	104.96	108.50	26.43
08/25/1961 to 09/11/1961	215.38	26.53	172.26	239.58	32.31	100.02	3.37	97.06	104.36	25.01
09/12/1961 to 10/01/1961	203.64	16.99	156.42	215.82	30.55	94.47	10.03	51.90	97.22	23.62
10/27/1961 to 11/13/1961	90.86	19.45	61.38	106.92	13.63	44.06	4.61	41.19	51.31	11.02
11/14/1961 to 12/13/1961	99.82	29.15	58.21	154.44	14.97	35.45	6.52	28.05	41.18	8.86
12/27/1961 to 01/09/1962	110.66	39.56	73.26	176.22	16.60	28.77	1.18	27.83	30.44	7.19
01/13/1962 to 01/22/1962	196.02	31.98	160.38	251.46	29.40	30.13	.06	30.04	30.22	7.53
01/23/1962 to 02/12/1962	132.94	19.64	85.14	154.44	19.94	48.22	16.19	29.87	62.07	12.06
03/10/1962 to 04/01/1962	209.19	22.95	158.40	241.56	31.38	53.67	5.20	52.05	77.48	13.42
05/04/1962 to 05/27/1962	250.80	68.71	170.28	352.44	37.62	95.34	.83	93.85	96.48	23.83
06/04/1962 to 06/27/1962	257.98	121.19	100.98	399.96	38.70	87.03	.89	85.37	88.16	21.76
06/28/1962 to 07/18/1962	288.51	74.11	184.14	390.06	43.28	106.96	9.22	84.90	112.12	26.74
08/01/1962 to 08/26/1962	321.52	31.32	265.32	366.30	48.23	108.60	2.00	105.52	111.90	27.15
08/27/1962 to 09/17/1962	233.19	24.68	198.00	261.36	34.98	74.19	16.94	64.31	105.23	18.55
09/18/1962 to 10/12/1962	177.88	38.76	91.08	237.60	26.68	61.39	2.27	58.42	64.16	15.35
11/03/1962 to 11/25/1962	162.02	23.86	118.80	211.86	24.30	32.77	.38	32.27	33.43	8.19
12/03/1962 to 12/17/1962	146.52	13.78	132.66	168.30	21.98	16.78	.20	16.40	17.04	4.19
12/26/1962 to 01/12/1963	49.72	2.79	45.54	55.44	7.46	18.60	1.54	16.40	19.68	4.65
01/13/1963 to 01/30/1963	43.04	2.14	40.19	47.52	6.46	19.45	.11	19.31	19.61	4.86
01/31/1963 to 02/15/1963	200.97	58.62	77.22	257.40	30.15	29.64	2.83	19.31	31.06	7.41
03/12/1963 to 03/26/1963	166.32	10.32	132.66	180.18	24.95	47.57	.38	46.96	48.24	11.89
04/14/1963 to 04/26/1963	187.80	43.83	124.74	233.64	28.17	53.89	.30	53.40	54.29	13.47
06/24/1963 to 07/14/1963	171.41	46.31	97.02	233.64	25.71	67.93	1.92	65.13	70.21	16.98
07/16/1963 to 07/29/1963	321.33	17.73	310.86	358.38	48.20	66.30	0.94	64.80	67.74	16.58

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	Sw_{out}, mean	Sw_{out}, standard deviation	Sw_{out}, minimum	Sw_{out}, maximum	Sw_{out}, ±error	Evaporation, mean	Evaporation, standard deviation	Evaporation, minimum	Evaporation, maximum	Evaporation, ±error
07/30/1963 to 08/20/1963	364.59	21.20	340.56	397.98	54.69	63.32	1.43	60.90	65.67	15.83
08/21/1963 to 09/11/1963	310.50	10.92	283.14	320.76	46.58	50.53	9.80	40.13	62.01	12.63
10/03/1963 to 10/23/1963	219.87	9.32	211.86	237.60	32.98	28.78	.64	27.73	29.77	7.19
11/11/1963 to 11/25/1963	131.87	44.26	89.10	201.96	19.78	20.54	.23	20.12	20.86	5.13
11/28/1963 to 12/17/1963	73.06	2.15	71.28	78.80	10.96	10.56	4.06	8.79	20.03	2.64
12/18/1963 to 01/03/1964	65.32	2.63	62.17	70.29	9.80	9.22	1.17	8.61	11.68	2.30
01/10/1964 to 01/27/1964	101.74	34.57	59.80	150.48	15.26	11.18	.10	11.07	11.39	2.79
02/05/1964 to 02/28/1964	69.19	36.23	49.50	196.02	10.38	12.29	.07	12.20	12.40	3.07
03/24/1964 to 04/16/1964	111.29	54.31	39.60	162.36	16.69	19.96	2.88	15.94	22.28	4.99
04/19/1964 to 05/03/1964	85.34	28.53	49.50	122.76	12.80	22.29	1.40	21.56	25.01	5.57
05/05/1964 to 05/28/1964	224.73	62.84	132.66	352.44	33.71	23.55	.55	22.75	24.56	5.89
06/17/1964 to 07/10/1964	226.89	81.98	66.53	322.74	34.03	33.45	1.55	31.57	36.03	8.36
07/11/1964 to 07/30/1964	327.29	53.73	211.86	372.24	49.09	31.74	1.30	29.64	34.01	7.94
08/02/1964 to 08/15/1964	241.56	66.96	126.72	336.60	36.23	27.05	.76	25.74	28.14	6.76
10/11/1995 to 10/28/1995	217.25	40.72	148.50	265.32	16.46	52.87	22.23	9.65	85.52	13.22
11/30/1995 to 12/17/1995	126.17	12.01	102.96	148.50	9.56	34.31	35.69	.99	141.35	8.58
12/18/1995 to 01/04/1996	79.53	28.49	31.68	110.88	6.03	50.16	36.30	5.41	136.76	12.54
01/05/1995 to 01/22/1996	115.61	17.84	87.12	132.66	8.76	36.88	27.39	.85	121.09	9.22
01/23/1996 to 02/09/1996	153.12	19.96	124.74	188.10	11.60	37.66	23.01	3.59	93.20	9.41
02/10/1996 to 02/28/1996	223.01	14.61	196.02	243.54	16.89	28.88	27.63	.14	96.87	7.22
03/07/1996 to 03/20/1996	176.22	28.50	142.56	221.76	13.35	45.93	41.64	3.76	151.38	11.48
03/21/1996 to 04/03/1996	238.02	17.26	215.82	269.28	18.03	34.52	25.83	4.62	91.18	8.63
04/11/1996 to 04/24/1996	272.53	27.25	229.68	304.92	20.65	38.50	28.95	9.68	109.80	9.62
04/25/1996 to 05/07/1996	322.44	10.69	304.92	338.58	24.43	41.32	37.71	5.15	146.75	10.33
05/12/1996 to 05/26/1996	274.96	59.53	213.84	370.26	20.83	60.51	8.82	44.07	77.43	15.13
06/04/1996 to 06/19/1996	400.95	8.91	392.04	423.72	30.38	56.50	13.29	40.14	86.59	14.13
06/20/1996 to 07/05/1996	429.04	3.29	423.72	435.60	32.50	41.33	8.56	30.70	58.39	10.33
07/16/1996 to 08/02/1996	348.92	40.35	285.12	407.88	26.43	62.21	13.18	30.08	81.49	15.55
08/03/1996 to 08/19/1996	374.10	40.25	302.94	409.86	28.34	57.80	12.18	29.77	81.96	14.45
09/06/1996 to 09/23/1996	37.40	12.45	29.70	73.26	2.83	37.49	12.96	16.07	69.98	9.37
03/30/2001 to 04/14/2001	150.23	6.50	138.60	162.36	11.38	69.48	33.51	23.90	129.35	17.37
06/22/2001 to 07/08/2001	399.73	17.42	356.40	415.80	30.28	151.76	28.68	70.01	183.30	37.94
07/09/2001 to 07/27/2001	312.25	128.73	77.22	403.92	23.66	177.07	14.30	144.05	195.79	44.27
07/28/2001 to 08/09/2001	294.44	108.73	61.38	382.14	22.31	160.58	26.42	111.95	194.51	40.14
08/10/2001 to 08/25/2001	362.71	23.14	310.86	394.02	27.48	138.70	42.52	53.07	227.92	34.67
10/26/2001 to 11/11/2001	215.00	17.13	194.04	247.50	16.29	86.69	22.48	49.23	121.02	21.67
02/22/2002 to 03/14/2002	185.55	15.21	168.30	237.60	14.06	81.47	36.45	15.44	143.78	20.37
04/09/2002 to 04/27/2002	168.51	28.93	138.60	251.46	12.77	92.06	64.91	0	231.83	23.02
04/28/2002 to 05/16/2002	351.92	61.67	174.24	405.90	26.66	87.18	43.98	26.45	165.11	21.79
05/30/2002 to 06/14/2002	401.07	39.94	364.32	487.08	30.38	113.94	56.95	33.45	238.44	28.49
06/15/2002 to 06/29/2002	444.71	18.66	419.76	481.14	33.69	112.84	40.07	38.80	193.16	28.21

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	ΔS, mean	ΔS, standard deviation	ΔS, minimum	ΔS, maximum	ΔS, ±error	GW_{out}, percent of hydrologic budget	Precipitation, percent of hydrologic budget	Sw_{in}, percent of hydrologic budget	Sw_{out}, percent of hydrologic budget	Evaporation, percent of hydrologic budget	ΔS, percent of hydrologic budget
03/02/1955 to 03/19/1955	9.62	7.47	-2.41	30.00	1.34	13.5	0	54.2	0	5.3	27.0
03/22/1955 to 04/05/1955	10.00	9.26	0	40.00	1.00	16.7	0	50.0	0	6.5	26.8
04/06/1955 to 04/20/1955	3.56	4.45	-3.33	10.00	.40	31.9	.3	49.7	0	8.3	9.7
04/21/1955 to 05/05/1955	-3.62	4.40	-10.00	0	.37	40.8	.2	39.1	0	9.0	10.9
05/25/1955 to 06/20/1955	-7.16	30.28	-46.67	83.33	2.15	31.7	3.2	30.6	0	18.3	16.2
06/23/1955 to 07/16/1955	-12.50	22.42	-30.00	80.00	1.92	29.3	.5	20.7	0	20.7	28.8
08/23/1955 to 09/12/1955	-11.27	15.86	-20.00	20.00	1.89	29.9	.5	26.0	0	20.1	23.4
09/13/1955 to 10/02/1955	-16.83	18.30	-50.00	0	1.68	34.7	3.7	14.6	0	15.3	31.7
10/03/1955 to 10/22/1955	-19.50	24.55	-100.00	0	1.95	34.7	1.8	11.7	0	15.3	36.5
10/23/1955 to 11/11/1955	-13.00	24.61	-66.67	40.00	1.90	35.1	11.3	7.8	0	14.9	30.9
11/12/1955 to 12/01/1955	-13.50	14.12	-43.33	0	1.35	37.8	4.4	11.1	0	12.2	34.4
12/02/1955 to 12/21/1955	-14.50	12.25	-40.00	0	1.45	41.7	.4	14.1	0	8.3	35.5
12/22/1955 to 01/10/1956	-16.67	14.75	-46.66	0	1.67	43.5	0	14.7	0	6.5	35.3
01/11/1956 to 01/30/1956	-7.33	10.90	-36.67	0	.73	42.5	5.9	23.8	0	7.5	20.3
01/31/1956 to 02/19/1956	-14.33	50.81	-126.67	126.67	3.47	43.3	2.8	21.4	0	6.7	25.8
02/20/1956 to 03/10/1956	-11.67	9.52	-26.67	0	1.17	40.6	.6	25.6	0	9.4	23.8
03/11/1956 to 03/30/1956	-6.50	11.92	-33.33	0	.65	35.4	.9	32.0	0	14.6	17.2
03/31/1956 to 04/19/1956	-17.00	11.39	-33.33	0	1.70	36.6	0	17.1	0	13.4	32.9
04/20/1956 to 05/09/1956	-13.33	11.39	-36.67	0	1.33	37.7	4.0	23.7	0	12.3	22.3
05/10/1956 to 05/29/1956	-19.67	10.86	-50.00	0	1.97	36.3	.6	14.9	0	13.7	34.5
05/30/1956 to 06/18/1956	-23.50	11.05	-46.67	-3.33	2.35	37.5	.7	3.7	0	12.5	45.6
06/19/1956 to 07/08/1956	-22.50	11.54	-40.00	0	2.25	34.6	1.4	3.0	0	15.4	45.5
07/09/1956 to 07/28/1956	-29.17	11.84	-53.33	-13.33	2.92	34.2	0	1.4	0	15.8	48.6
07/29/1956 to 08/17/1956	-24.33	9.92	-50.00	-10.00	2.43	33.4	0	1.3	0	16.6	48.7
09/08/1956 to 09/27/1956	-27.67	17.74	-63.33	-6.67	2.77	39.7	.7	8.4	0	10.3	40.9
09/28/1956 to 10/15/1956	-16.30	25.15	-60.00	46.67	2.59	35.3	3.0	4.5	0	14.7	42.5
10/16/1956 to 11/02/1956	-10.74	21.71	-46.67	46.67	1.81	37.5	5.2	18.5	0	12.5	26.3
11/07/1956 to 11/26/1956	-20.00	13.64	-40.00	0	2.00	42.9	0	10.5	0	7.4	39.2
11/27/1956 to 12/16/1956	-11.00	13.03	-46.67	0	1.10	39.0	0	9.0	0	11.0	41.0
12/17/1956 to 01/05/1957	-15.00	12.16	-40.00	0	1.50	43.1	2.9	6.5	0	6.9	40.6
01/06/1957 to 01/25/1957	-11.17	20.89	-50.00	30.00	1.78	42.5	0	8.0	0	7.5	42.0
01/26/1957 to 02/14/1957	-12.33	9.86	-30.00	3.33	1.27	42.6	1.9	10.6	0	7.4	37.5
02/15/1957 to 03/10/1957	-8.75	8.33	-26.67	0	.88	41.1	6.4	20.0	0	8.9	23.5
07/01/1957 to 07/15/1957	.74	65.14	-108.08	74.85	15.11	21.3	0	50.0	.6	27.8	.3
07/26/1957 to 08/13/1957	-359.10	20.85	-381.20	-291.21	35.97	17.6	.2	6.3	24.2	8.2	43.5
08/14/1957 to 09/01/1957	-349.77	39.12	-431.20	-259.77	35.04	15.0	.8	3.0	26.8	8.2	46.2
09/02/1957 to 09/20/1957	-273.63	83.83	-389.77	-149.77	27.42	11.3	1.6	3.1	31.5	7.2	45.2
09/28/1957 to 10/08/1957	-27.95	47.41	-99.77	33.57	3.46	33.9	0	41.0	5.7	10.4	9.0
12/01/1957 to 12/19/1957	270.87	199.51	97.46	897.43	27.72	13.1	.1	49.9	6.8	2.1	28.0
12/28/1957 to 01/04/1958	187.40	68.48	79.02	312.61	19.36	16.4	0	50.0	3.7	2.8	27.1
05/21/1958 to 06/16/1958	-164.96	199.20	-419.15	446.00	24.87	14.7	.6	29.8	24.5	10.8	19.6
07/16/1958 to 08/03/1958	-235.90	156.50	-477.72	-11.59	24.16	17.0	0	27.4	18.4	14.6	22.6
08/04/1958 to 08/23/1958	-399.49	86.27	-610.67	-219.20	41.86	14.8	0	14.3	22.5	12.7	35.7

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	ΔS, mean	ΔS, standard deviation	ΔS, minimum	ΔS, maximum	ΔS, ±error	GW_{out}, percent of hydrologic budget	Precipitation, percent of hydrologic budget	Sw_{in}, percent of hydrologic budget	Sw_{out}, percent of hydrologic budget	Evaporation, percent of hydrologic budget	ΔS, percent of hydrologic budget
08/26/1958 to 09/05/1958	-263.69	87.35	-418.30	-117.98	30.14	14.2	1.7	15.3	22.1	13.7	32.9
01/22/1959 to 02/12/1959	-13.81	73.20	-200.15	199.77	3.21	22.1	3.2	44.5	23.2	4.7	2.3
02/16/1959 to 03/09/1959	-55.85	108.35	-400.23	-.23	5.73	20.4	2.0	38.8	22.1	7.5	9.1
03/10/1959 to 03/30/1959	-153.05	74.86	-318.13	-17.48	16.21	17.0	1.4	26.4	22.3	10.7	22.3
04/14/1959 to 04/30/1959	47.21	149.40	-190.50	409.26	12.07	17.4	1.2	48.8	16.3	9.8	6.5
05/03/1959 to 06/04/1959	-83.70	154.51	-469.57	209.96	13.04	18.2	3.7	33.9	19.5	12.4	12.5
07/28/1959 to 08/22/1959	-302.42	125.60	-601.13	-1.14	30.30	12.4	0	15.2	23.4	14.2	34.8
08/29/1959 to 09/17/1959	-326.46	131.69	-564.82	-198.12	33.12	14.6	2.4	9.1	22.0	13.3	38.5
11/17/1959 to 12/14/1959	-77.42	109.81	-285.71	133.54	12.55	22.3	2.3	34.2	20.4	7.2	13.4
01/03/1960 to 03/20/1960	-29.43	83.24	-300.00	300.14	4.24	19.8	3.7	41.1	22.9	7.3	5.2
05/20/1960 to 06/05/1960	-253.88	100.53	-400.53	-34.70	25.44	7.0	3.8	15.6	30.6	12.4	30.6
06/06/1960 to 06/23/1960	-459.79	46.52	-500.53	-400.53	46.01	3.7	0	6.2	33.5	12.8	43.8
06/30/1960 to 07/14/1960	-325.67	81.37	-478.11	-198.01	33.10	10.8	0	5.7	24.1	15.0	44.3
07/24/1960 to 08/10/1960	-192.44	140.61	-497.99	2.02	19.75	15.1	0	22.8	21.6	13.3	27.2
09/01/1960 to 09/23/1960	-.74	126.05	-406.52	-.74	40.98	12.6	21.8	39.2	18.2	8.2	.1
09/24/1960 to 10/15/1960	-190.96	75.05	-406.38	-73.00	20.30	13.2	.9	24.7	27.0	9.8	24.3
11/06/1960 to 12/05/1960	117.87	115.16	1.24	301.25	11.90	11.8	2.1	47.9	20.7	4.1	13.4
04/17/1961 to 05/12/1961	-191.35	166.11	-603.63	-4.35	19.34	9.4	.8	28.7	31.2	9.4	20.6
05/13/1961 to 06/07/1961	-353.58	62.70	-470.17	-203.63	35.54	7.4	.1	14.1	33.7	8.9	35.8
07/29/1961 to 08/16/1961	-196.65	74.70	-310.49	-10.88	20.20	14.1	1.6	23.2	22.4	13.5	25.2
08/25/1961 to 09/11/1961	-283.24	148.28	-601.75	-101.76	28.41	12.5	0	16.3	25.6	11.9	33.7
09/12/1961 to 10/01/1961	-254.34	71.47	-401.74	-101.75	25.89	13.9	5.2	14.0	24.7	11.5	30.8
10/27/1961 to 11/13/1961	-135.84	63.09	-228.34	4.95	14.81	25.8	5.6	20.0	16.3	7.9	24.4
11/14/1961 to 12/13/1961	-138.57	55.86	-228.19	5.16	14.70	24.8	2.9	21.4	18.6	6.6	25.8
12/27/1961 to 01/09/1962	-167.97	102.60	-370.69	-3.97	17.01	25.0	.7	19.2	19.8	5.2	30.1
01/13/1962 to 01/22/1962	-224.61	62.45	-297.95	-131.33	22.98	16.9	2.1	15.0	28.7	4.4	32.9
01/23/1962 to 02/12/1962	-201.40	136.49	-433.39	2.09	20.59	18.8	.7	14.6	22.9	8.3	34.7
03/10/1962 to 04/01/1962	-298.25	115.31	-566.79	-136.97	29.95	16.6	3.0	9.1	26.6	6.8	37.9
05/04/1962 to 05/27/1962	-358.54	167.32	-736.53	-103.18	36.00	8.1	0	6.6	30.4	11.5	43.4
06/04/1962 to 06/27/1962	-349.61	150.68	-667.70	-101.01	35.01	6.8	.1	6.1	32.3	10.9	43.7
06/28/1962 to 07/18/1962	-402.00	152.31	-600.05	-1.00	40.22	8.8	6.3	1.7	30.1	11.2	41.9
08/01/1962 to 08/26/1962	-473.78	177.51	-1,000.05	2.00	47.84	5.5	.2	.8	33.2	11.2	49.0
08/27/1962 to 09/17/1962	-356.70	111.33	-564.67	-134.36	35.79	14.2	7.9	.6	27.1	8.6	41.5
09/18/1962 to 10/12/1962	-289.05	101.32	-401.05	-101.05	28.96	10.9	1.6	1.1	29.1	10.0	47.3
11/03/1962 to 11/25/1962	-222.77	90.79	-401.03	-101.03	22.33	18.1	4.5	9.1	26.5	5.4	36.4
12/03/1962 to 12/17/1962	-174.36	53.75	-267.72	-101.02	17.49	18.2	1.9	14.2	28.5	3.3	33.9
12/26/1962 to 01/12/1963	-82.20	113.33	-365.57	101.13	11.47	27.4	2.0	20.8	16.4	6.2	27.2
01/13/1963 to 01/30/1963	-117.38	58.54	-232.16	-32.16	12.02	33.2	5.0	13.5	11.5	5.2	31.5
01/31/1963 to 02/15/1963	-257.18	82.10	-398.85	-65.55	26.01	12.7	1.3	7.1	32.5	4.8	41.5
03/12/1963 to 03/26/1963	-207.72	38.77	-265.53	-132.24	21.06	8.6	.3	9.5	32.2	9.2	40.2
04/14/1963 to 04/26/1963	-257.80	65.48	-332.22	-132.22	26.07	11.1	.2	8.3	30.3	8.7	41.5
06/24/1963 to 07/14/1963	-291.65	102.40	-510.45	-101.29	29.30	12.2	1.0	3.0	27.1	10.7	46.1
07/16/1963 to 07/29/1963	-448.98	36.54	-500.41	-380.43	45.08	7.3	0	0.6	35.4	7.3	49.4

Table 5. Summary of selected water-budget periods and associated components of the water budget for the Medina/Diversion Lake system, San Antonio area, Texas—Continued.

Water-budget period	ΔS, mean	ΔS, standard deviation	ΔS, minimum	ΔS, maximum	ΔS, ±error	GW_{out}, percent of hydrologic budget	Precipitation, percent of hydrologic budget	Sw_{in}, percent of hydrologic budget	Sw_{out}, percent of hydrologic budget	Evaporation, percent of hydrologic budget	ΔS, percent of hydrologic budget
07/30/1963 to 08/20/1963	-441.91	83.19	-617.01	-300.33	44.36	2.4	0	.9	40.5	7.0	49.1
08/21/1963 to 09/11/1963	-393.46	47.15	-469.82	-286.53	39.50	4.7	0	.6	39.0	6.3	49.4
10/03/1963 to 10/23/1963	-279.88	48.17	-351.36	-170.71	28.25	6.1	.2	.4	38.8	5.1	49.4
11/11/1963 to 11/25/1963	-172.83	66.48	-282.16	-87.32	17.85	8.6	.3	2.7	35.8	5.6	46.9
11/28/1963 to 12/17/1963	-106.17	97.86	-265.31	184.68	12.78	20.5	3.0	9.5	25.8	3.7	37.5
12/18/1963 to 01/03/1964	-95.89	28.31	-141.84	-48.49	10.61	22.9	.7	14.4	23.8	3.4	34.9
01/10/1964 to 01/27/1964	-123.04	90.22	-272.25	7.86	14.28	14.9	1.4	10.3	31.7	3.5	38.3
02/05/1964 to 02/28/1964	-16.70	82.38	-186.63	89.87	7.34	18.2	3.1	40.4	27.0	4.8	6.5
03/24/1964 to 04/16/1964	-61.39	98.30	-224.46	112.21	10.20	12.3	.6	31.8	31.9	5.7	17.6
04/19/1964 to 05/03/1964	-52.73	52.74	-122.74	-2.72	5.41	14.9	1.3	31.5	27.8	7.3	17.2
05/05/1964 to 05/28/1964	-233.10	112.07	-423.22	-76.51	23.84	8.1	1.8	8.8	38.0	4.0	39.4
06/17/1964 to 07/10/1964	-258.28	138.10	-430.94	50.26	26.48	4.1	2.0	2.5	40.0	5.9	45.5
07/11/1964 to 07/30/1964	-389.03	251.38	-1,033.11	-49.78	38.95	4.6	.1	.7	41.4	4.0	49.2
08/02/1964 to 08/15/1964	-293.11	107.52	-416.45	-143.11	29.37	5.2	.6	.6	40.3	4.5	48.9
10/11/1995 to 10/28/1995	-238.36	99.81	-443.00	-27.40	26.15	13.4	0	17.7	29.4	7.2	32.3
11/30/1995 to 12/17/1995	-74.37	58.42	-273.70	-15.80	9.03	14.0	1.5	31.8	28.3	7.7	16.7
12/18/1995 to 01/04/1996	-80.26	66.52	-216.50	72.70	11.42	20.6	.9	30.9	18.0	11.4	18.2
01/05/1995 to 01/22/1996	-140.82	86.79	-398.90	-3.60	15.17	19.0	0	21.3	23.5	7.5	28.7
01/23/1996 to 02/09/1996	-182.33	55.80	-256.90	-53.00	20.02	15.8	.3	17.1	27.4	6.7	32.7
02/10/1996 to 02/28/1996	-259.48	69.70	-443.00	-93.50	26.69	13.8	.1	12.6	32.0	4.1	37.3
03/07/1996 to 03/20/1996	-248.91	78.72	-395.30	-136.50	25.57	16.3	0	12.3	26.7	7.0	37.7
03/21/1996 to 04/03/1996	-301.69	59.02	-407.00	-194.40	33.15	14.2	.8	9.5	31.3	4.5	39.7
04/11/1996 to 04/24/1996	-327.01	63.66	-438.60	-217.50	34.64	11.5	.3	9.3	33.7	4.8	40.5
04/25/1996 to 05/07/1996	-386.45	78.12	-622.00	-318.10	39.06	8.0	1.7	5.6	36.4	4.7	43.6
05/12/1996 to 05/26/1996	-364.84	123.22	-583.60	-158.90	39.03	8.5	0	4.8	34.0	7.5	45.2
06/04/1996 to 06/19/1996	-508.34	82.48	-734.10	-355.50	51.35	6.7	0	1.9	37.9	5.3	48.1
06/20/1996 to 07/05/1996	-517.99	76.41	-724.70	-436.30	52.29	7.0	1.3	1.4	39.2	3.8	47.4
07/16/1996 to 08/02/1996	-469.37	50.05	-576.50	-402.00	47.52	6.8	0	.7	36.6	6.5	49.3
08/03/1996 to 08/19/1996	-493.16	94.97	-695.10	-285.10	49.75	6.7	0	.5	37.5	5.8	49.5
09/06/1996 to 09/23/1996	-29.92	47.68	-130.60	67.10	7.87	23.0	4.2	35.0	13.5	13.5	10.8
03/30/2001 to 04/14/2001	323.75	187.54	0	600.00	33.06	9.9	.3	49.7	11.1	5.1	23.9
06/22/2001 to 07/08/2001	-441.76	110.18	-600.00	-90.00	45.50	6.8	.9	14.5	31.3	11.9	34.6
07/09/2001 to 07/27/2001	-540.53	60.41	-610.00	-400.00	54.24	9.4	0	7.7	25.1	14.3	43.5
07/28/2001 to 08/09/2001	-533.08	60.33	-620.00	-400.00	54.50	11.2	0	4.6	25.1	13.7	45.4
08/10/2001 to 08/25/2001	-568.13	162.61	-1,000.00	-200.00	58.09	9.7	1.1	3.2	29.2	11.2	45.7
10/26/2001 to 11/11/2001	-202.35	259.07	-650.00	0	20.94	11.7	2.0	22.3	27.3	11.0	25.7
02/22/2002 to 03/14/2002	-158.57	185.24	-500.00	200.00	19.26	11.4	.2	26.8	26.8	11.8	22.9
04/09/2002 to 04/27/2002	-161.58	168.66	-530.00	0	17.39	12.1	1.9	24.6	24.5	13.4	23.5
04/28/2002 to 05/16/2002	-460.53	172.55	-650.00	-20.00	50.29	11.5	0	9.6	30.9	7.6	40.4
05/30/2002 to 06/14/2002	-539.38	113.64	-670.00	-320.00	60.22	9.8	.4	7.5	31.3	8.9	42.1
06/15/2002 to 06/29/2002	-595.33	125.52	-930.00	-410.00	60.30	9.0	1.9	4.3	32.7	8.3	43.7

Table 6. Relative contribution of each component of the water budget and relative part of record used for each water-budget computation for Medina Lake, Diversion Lake, and the Medina/Diversion Lake system, San Antonio area, Texas.

[GW_{out}, ground-water outflow; P, precipitation; SW_{in}, surface-water inflow; SW_{out}, surface-water outflow; E, evaporation; ΔS, change in storage]

	GW_{out} period of record	Percentage of water budget[1] components of total water budget						Percentage of days in period budgeted[2]
		GW_{out}	P	SW_{in}	SW_{out}	E	ΔS	
Medina Lake	10/01/1995 to 09/30/1996	16.9	1.0	24.4	26.2	5.2	26.5	53.6
	04/20/2001 to 06/30/2002	16.5	1.3	20.8	25.0	4.6	31.8	51.0
	Average	16.7	1.1	22.6	25.6	4.9	29.1	52.3
Diversion Lake	10/01/1995 to 09/30/1996	7.3	.1	45.2	42.5	.5	4.4	53.6
	04/20/2001 to 06/30/2002	9.8	.1	49.2	39.0	.5	1.6	51.0
	Average	8.5	.1	47.2	40.7	.5	3.0	52.3
Medina/Diversion Lake System	03/01/1955 to 04/18/1957	36.3	1.9	18.4	0	11.7	31.7	84.0
	06/30/1957 to 09/30/1964	14.4	1.8	17.9	25.8	8.5	31.6	54.9
	10/01/1995 to 09/30/1996	12.8	.7	13.3	30.4	6.8	36.1	72.1
	02/26/2001 to 06/30/2002	10.2	.8	15.9	26.8	10.6	35.6	38.4
	Average	18.4	1.3	16.4	20.8	9.4	33.7	62.4

[1] Percentage of sum of all water-budget components.
[2] Percentage of total GW_{out} period of record.

Prepared by the Texas District Office:
U.S. Geological Survey
8027 Exchange Drive
Austin, TX 78754–4733

Information regarding water resources in Texas is available at URL
http: //tx.usgs.gov/

125 years of science for America

1879–2004

Printed on recycled paper