Recharge to and Discharge from the Edwards Aquifer in the San Antonio Area, Texas, 2001

The Edwards aquifer is the sole source of public water supply for more than 1 million people in the San Antonio area and supplies large quantities of water for agriculture, industry, and the military. The dissolutioned, faulted limestone aquifer is the major source of water for Bexar, Comal, Hays, Medina, and Uvalde Counties. The annual compilation of estimates of recharge to and discharge from the Edwards aquifer is part of a continuing program of the U.S. Geological Survey (USGS) in cooperation with the Edwards Aquifer Authority (EAA).

Annual recharge estimates (table 1) are based on data collected from a network of streamflow- and rainfall-gaging stations (operated by the USGS and National Oceanic and Atmospheric Administration) and on assumptions that the runoff characteristics of gaged areas relate to ungaged areas (Puente, 1978). Annual discharge estimates (table 2) are compiled from spring-discharge data collected by the USGS and from annual water well use reports submitted to the EAA by Edwards aquifer users. Unreported water use was estimated by the EAA.

Recharge

Recharge to the Edwards aquifer is derived mainly from seepage into the aquifer from streams that cross the outcrop of the aquifer and direct infiltration of precipitation on the outcrop. The watershed areas used for estimating recharge to the Edwards aquifer in the San Antonio area (fig. 1) have been modified slightly from the areas described by Puente (1978) to reflect existing data-collection sites. Recharge in the Guadalupe River Basin is not included because the net recharge to the aquifer in this basin is negligible (Puente, 1978). The watershed areas are based on surface- and ground-water divides.

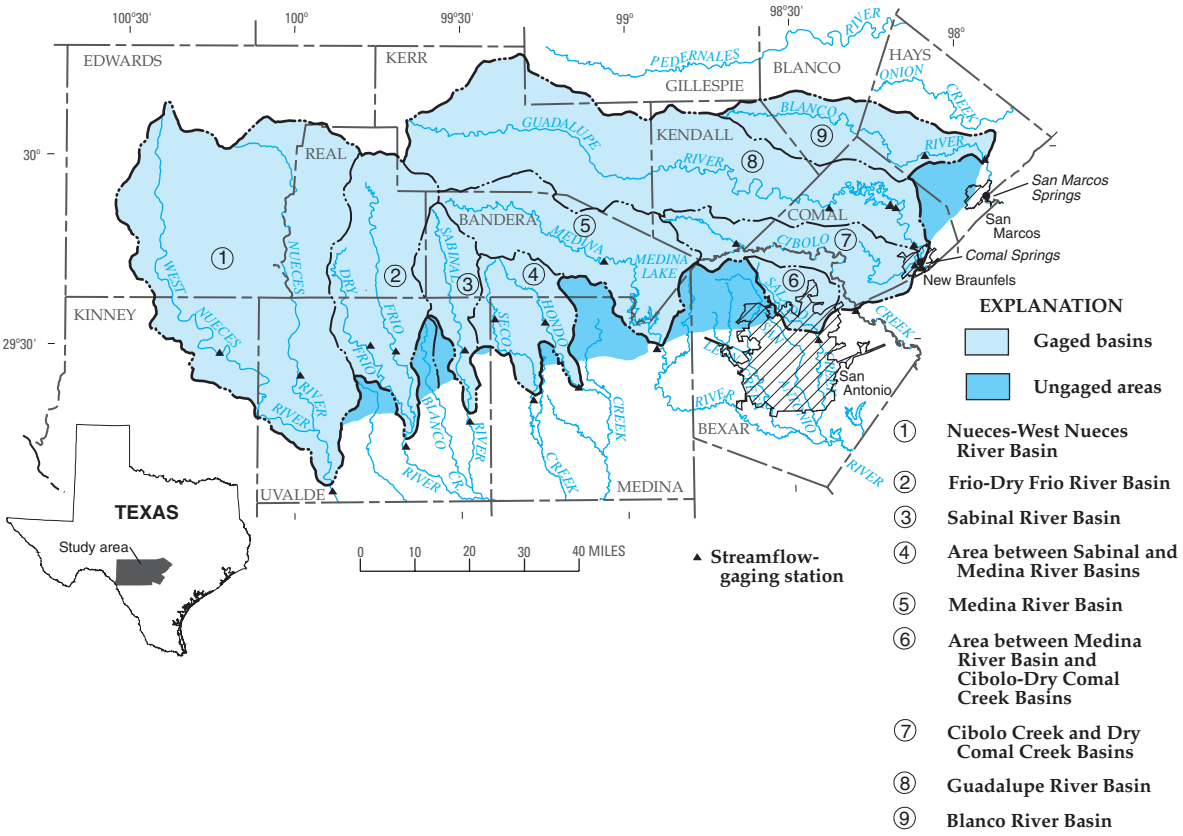

Figure 1. Map showing gaged basins and ungaged areas (modified from Puente, 1978, fig. 1).

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Table 1. Estimated annual recharge to the Edwards aquifer by basin, 1934–2001

[thousands of acre-feet]

Calendar year	Nueces-West Nueces River Basin	Frio-Dry Frio River Basin[1]	Sabinal River Basin[1]	Area between Sabinal and Medina River Basins[1]	Medina River Basin[2]	Area between Medina River Basin and Cibolo-Dry Comal Creek Basins[1]	Cibolo Creek and Dry Comal Creek Basins	Blanco River Basin[1]	Total[3]
1934	8.6	27.9	7.5	19.9	46.5	21.0	28.4	19.8	179.6
1935	411.3	192.3	56.6	166.2	71.1	138.2	182.7	39.8	1,258.2
1936	176.5	157.4	43.5	142.9	91.6	108.9	146.1	42.7	909.6
1937	28.8	75.7	21.5	61.3	80.5	47.8	63.9	21.2	400.7
1938	63.5	69.3	20.9	54.1	65.5	46.2	76.8	36.4	432.7
1939	227.0	49.5	17.0	33.1	42.4	9.3	9.6	11.1	399.0
1940	50.4	60.3	23.8	56.6	38.8	29.3	30.8	18.8	308.8
1941	89.9	151.8	50.6	139.0	54.1	116.3	191.2	57.8	850.7
1942	103.5	95.1	34.0	84.4	51.7	66.9	93.6	28.6	557.8
1943	36.5	42.3	11.1	33.8	41.5	29.5	58.3	20.1	273.1
1944	64.1	76.0	24.8	74.3	50.5	72.5	152.5	46.2	560.9
1945	47.3	71.1	30.8	78.6	54.8	79.6	129.9	35.7	527.8
1946	80.9	54.2	16.5	52.0	51.4	105.1	155.3	40.7	556.1
1947	72.4	77.7	16.7	45.2	44.0	55.5	79.5	31.6	422.6
1948	41.1	25.6	26.0	20.2	14.8	17.5	19.9	13.2	178.3
1949	166.0	86.1	31.5	70.3	33.0	41.8	55.9	23.5	508.1
1950	41.5	35.5	13.3	27.0	23.6	17.3	24.6	17.4	200.2
1951	18.3	28.4	7.3	26.4	21.1	15.3	12.5	10.6	139.9
1952	27.9	15.7	3.2	30.2	25.4	50.1	102.3	20.7	275.5
1953	21.4	15.1	3.2	4.4	36.2	20.1	42.3	24.9	167.6
1954	61.3	31.6	7.1	11.9	25.3	4.2	10.0	10.7	162.1
1955	128.0	22.1	.6	7.7	16.5	4.3	3.3	9.5	192.0
1956	15.6	4.2	1.6	3.6	6.3	2.0	2.2	8.2	43.7
1957	108.6	133.6	65.4	129.5	55.6	175.6	397.9	76.4	1,142.6
1958	266.7	300.0	223.8	294.9	95.5	190.9	268.7	70.7	1,711.2
1959	109.6	158.9	61.6	96.7	94.7	57.4	77.9	33.6	690.4
1960	88.7	128.1	64.9	127.0	104.0	89.7	160.0	62.4	824.8
1961	85.2	151.3	57.4	105.4	88.3	69.3	110.8	49.4	717.1
1962	47.4	46.6	4.3	23.5	57.3	16.7	24.7	18.9	239.4
1963	39.7	27.0	5.0	10.3	41.9	9.3	21.3	16.2	170.7
1964	126.1	57.1	16.3	61.3	43.3	35.8	51.1	22.2	413.2
1965	97.9	83.0	23.2	104.0	54.6	78.8	115.3	66.7	623.5
1966	169.2	134.0	37.7	78.2	50.5	44.5	66.5	34.6	615.2
1967	82.2	137.9	30.4	64.8	44.7	30.2	57.3	19.0	466.5
1968	130.8	176.0	66.4	198.7	59.9	83.1	120.5	49.3	884.7
1969	119.7	113.8	30.7	84.2	55.4	60.2	99.9	46.6	610.5
1970	112.6	141.9	35.4	81.6	68.0	68.8	113.8	39.5	661.6
1971	263.4	212.4	39.2	155.6	68.7	81.4	82.4	22.2	925.3
1972	108.4	144.6	49.0	154.6	87.9	74.3	104.2	33.4	756.4
1973	190.6	256.9	123.9	286.4	97.6	237.2	211.7	82.2	1,486.5
1974	91.1	135.7	36.1	115.3	96.2	68.1	76.9	39.1	658.5
1975	71.8	143.6	47.9	195.9	93.4	138.8	195.7	85.9	973.0
1976	150.7	238.6	68.2	182.0	94.5	47.9	54.3	57.9	894.1
1977	102.9	193.0	62.7	159.5	77.7	97.9	191.6	66.7	952.0
1978	69.8	73.1	30.9	103.7	76.7	49.6	72.4	26.3	502.5
1979	128.4	201.4	68.6	203.1	89.4	85.4	266.3	75.2	1,117.8
1980	58.6	85.6	42.6	25.3	88.3	18.8	55.4	31.8	406.4
1981	205.0	365.2	105.6	252.1	91.3	165.0	196.8	67.3	1,448.4
1982	19.4	123.4	21.0	90.9	76.8	22.6	44.8	23.5	422.4
1983	79.2	85.9	20.1	42.9	74.4	31.9	62.5	23.2	420.1
1984	32.4	40.4	8.8	18.1	43.9	11.3	16.9	25.9	197.9
1985	105.9	186.9	50.7	148.5	64.7	136.7	259.2	50.7	1,003.3
1986	188.4	192.8	42.2	173.6	74.7	170.2	267.4	44.5	1,153.7
1987	308.5	473.3	110.7	405.5	90.4	229.3	270.9	114.9	2,003.6
1988	59.2	117.9	17.0	24.9	69.9	12.6	28.5	25.5	355.5
1989	52.6	52.6	8.4	13.5	46.9	4.6	12.3	23.6	214.4
1990	479.3	255.0	54.6	131.2	54.0	35.9	71.8	41.3	1,123.2
1991	325.2	421.0	103.1	315.2	52.8	84.5	109.7	96.9	1,508.4
1992	234.1	586.9	201.1	566.1	91.4	290.6	286.6	228.9	2,485.7
1993	32.6	78.5	29.6	60.8	78.5	38.9	90.9	37.8	447.6
1994	124.6	151.5	29.5	45.1	61.1	34.1	55.6	36.6	538.1
1995	107.1	147.6	34.7	62.4	61.7	36.2	51.1	30.6	531.3
1996	130.0	92.0	11.4	9.4	42.3	10.6	14.7	13.9	324.3
1997	176.9	209.1	57.0	208.4	63.3	193.4	144.2	82.3	1,134.6
1998	141.5	214.8	72.5	201.4	80.3	86.2	240.9	104.7	1,142.3
1999	101.4	136.8	30.8	57.2	77.1	21.2	27.9	21.0	473.5
2000	238.4	123.0	33.1	55.2	53.4	28.6	48.6	34.1	614.5
2001	297.5	126.7	66.2	124.1	90.0	101.5	173.7	89.7	1,069.4
Average	121.2	134.1	42.2	107.2	61.9	69.9	105.0	43.1	684.7

[1] Includes recharge from ungaged areas (fig. 1).

[2] Recharge to Edwards aquifer from the Medina River Basin consists entirely of losses from Medina Lake (Puente, 1978, p. 23).

[3] Total might not equal sum of basin values due to rounding.

Table 2. Estimated annual discharge from the Edwards aquifer by county, 1934–2001

[thousands of acre-feet]

Calendar year	Kinney-Uvalde Counties	Medina County	Bexar County	Comal County	Hays County	Total[1]	Well discharge	Spring discharge
1934	12.6	1.3	109.3	229.1	85.6	437.9	101.9	336.0
1935	12.2	1.5	171.8	237.2	96.9	519.6	103.7	415.9
1936	26.6	1.5	215.2	261.7	93.2	598.2	112.7	485.5
1937	28.3	1.5	201.8	252.5	87.1	571.2	120.2	451.0
1938	25.2	1.6	187.6	250.0	93.4	557.8	120.1	437.7
1939	18.2	1.6	122.5	219.4	71.1	432.8	118.9	313.9
1940	16.1	1.6	116.7	203.8	78.4	416.6	120.1	296.5
1941	17.9	1.6	197.4	250.0	134.3	601.2	136.8	464.4
1942	22.5	1.7	203.2	255.1	112.2	594.7	144.6	450.1
1943	19.2	1.7	172.0	249.2	97.2	539.3	149.1	390.2
1944	11.6	1.7	166.3	252.5	135.3	567.4	147.3	420.1
1945	12.4	1.7	199.8	263.1	137.8	614.8	153.3	461.5
1946	6.2	1.7	180.1	261.9	134.0	583.9	155.0	428.9
1947	13.8	2.0	193.3	256.8	127.6	593.5	167.0	426.5
1948	9.2	1.9	159.2	203.0	77.3	450.6	168.7	281.9
1949	13.2	2.0	165.3	209.5	89.8	479.8	179.4	300.4
1950	17.8	2.2	177.3	191.1	78.3	466.7	193.8	272.9
1951	16.9	2.2	186.9	150.5	69.1	425.6	209.7	215.9
1952	22.7	3.1	187.1	133.2	78.8	424.9	215.4	209.5
1953	27.5	4.0	193.7	141.7	101.4	468.3	229.8	238.5
1954	26.6	6.3	208.9	101.0	81.5	424.3	246.2	178.1
1955	28.3	11.1	215.2	70.1	64.1	388.8	261.0	127.8
1956	59.6	17.7	229.6	33.6	50.4	390.9	321.1	69.8
1957	29.0	11.9	189.4	113.2	113.0	456.5	237.3	219.2
1958	23.7	6.6	199.5	231.8	155.9	617.5	219.3	398.2
1959	43.0	8.3	217.5	231.7	118.5	619.0	234.5	384.5
1960	53.7	7.6	215.4	235.2	143.5	655.4	227.1	428.3
1961	56.5	6.4	230.3	249.5	140.8	683.5	228.2	455.3
1962	64.6	8.1	220.0	197.5	98.8	589.0	267.9	321.1
1963	51.4	9.7	217.3	155.7	81.9	516.0	276.4	239.6
1964	49.3	8.6	201.0	141.8	73.3	474.0	260.2	213.8
1965	46.8	10.0	201.1	194.7	126.3	578.9	256.1	322.8
1966	48.5	10.4	198.0	198.9	115.4	571.2	255.9	315.3
1967	81.1	15.2	239.7	139.1	82.3	557.4	341.3	216.1
1968	58.0	9.9	207.1	238.2	146.8	660.0	251.7	408.3
1969	88.5	13.6	216.3	218.2	122.1	658.7	307.5	351.2
1970	100.9	16.5	230.6	229.2	149.9	727.1	329.4	397.7
1971	117.0	32.4	262.8	168.2	99.1	679.5	406.8	272.7
1972	112.6	28.8	247.7	234.3	123.7	747.1	371.3	375.8
1973	96.5	14.9	273.0	289.3	164.3	838.0	310.4	527.6
1974	133.3	28.6	272.1	286.1	141.1	861.2	377.4	483.8
1975	112.0	22.6	259.0	296.0	178.6	868.2	327.8	540.4
1976	136.4	19.4	253.2	279.7	164.7	853.4	349.5	503.9
1977	156.5	19.9	317.5	295.0	172.0	960.9	380.6	580.3
1978	154.3	38.7	269.5	245.7	99.1	807.3	431.8	375.5
1979	130.1	32.9	294.5	300.0	157.0	914.5	391.5	523.0
1980	151.0	39.9	300.3	220.3	107.9	819.4	491.1	328.3
1981	104.2	26.1	280.7	241.8	141.6	794.4	387.1	407.3
1982	129.2	33.4	305.1	213.2	105.5	786.4	453.1	333.3
1983	107.7	29.7	277.6	186.6	118.5	720.1	418.5	301.6
1984	151.1	46.9	309.7	108.9	85.7	702.3	529.8	172.5
1985	156.9	59.2	295.5	200.0	144.9	856.5	522.5	334.0
1986	[2]91.7	41.9	294.0	229.3	160.4	[2]817.3	429.3	[2]388.1
1987	[2]95.1	15.9	326.6	286.2	198.4	[2]922.0	364.1	[2]558.0
1988	[2]156.7	82.2	317.4	236.5	116.9	[2]909.7	540.0	[2]369.8
1989	156.9	70.5	305.6	147.9	85.6	766.6	542.4	224.1
1990	118.1	69.7	276.8	171.3	94.1	730.0	489.4	240.6
1991	76.6	25.6	315.5	221.9	151.0	790.6	436.3	354.3
1992	76.5	9.3	370.5	412.4	261.3	1,130.2	327.3	802.8
1993	107.5	17.8	371.0	349.5	151.0	996.7	407.3	589.4
1994	95.5	41.1	297.7	269.8	110.6	814.8	424.6	390.2
1995	90.8	35.2	272.1	235.0	127.8	761.0	399.6	361.3
1996	117.6	66.3	286.8	150.2	84.7	705.6	493.6	212.0
1997	[3]29.9	[3]7.0	[3]255.3	243.3	149.2	[3]684.7	[3]300.7	384.0
1998	113.1	51.3	312.8	271.4	169.2	915.9	451.7	464.1
[4]1999	[5]99.8	48.3	298.3	295.2	142.3	884.0	427.8	456.2
2000	89.1	45.1	283.6	226.1	108.4	752.3	414.8	337.5
2001	68.7	33.9	291.6	327.4	175.3	896.9	367.7	529.1

[1] Total might not equal sum of county values due to rounding.

[2] Differs from value in Edwards Underground Water District Bulletins 46–48, table 3, due to correction of an error in the method of computing the Leona Formation underflow.

[3] Does not include irrigation discharge (Bexar, Medina, and Uvalde Counties).

[4] Does not include discharges for domestic supply, stock, and miscellaneous use.

[5] Does not include discharge from Kinney County.

The estimated annual recharge for 2001 is 1,069,400 acre-feet (acre-ft). The estimated annual recharge for 1934–2001 (table 1) ranges from 43,700 acre-ft in 1956 to 2,486,000 acre-ft in 1992. The average and median estimated annual recharge for 1934–2001 are 684,700 and 556,950 acre-ft, respectively.

Discharge

Discharge from the Edwards aquifer is by wells and springs. The major discharge from wells primarily is in Bexar, Medina, and Uvalde Counties. Most of the well discharge in Bexar County in 2001 was for public water supply and the military. Some well discharge in Bexar County and most of the well discharge in Medina and Uvalde Counties was for irrigation. The remaining discharge (primarily from wells in Bexar County) in 2001 supplied industry, domestic uses, stock, and miscellaneous uses.

The estimated annual discharge from wells and springs during 2001 is 896,900 acre-ft. The estimated annual discharge from wells and springs for 1934–2001 (table 2) ranges from 388,800 acre-ft in 1955 to 1,130,000 acre-ft in 1992. The 1934–2001 estimated annual discharge from wells ranges from 101,900 acre-ft in 1934 to 542,400 acre-ft in 1989.

Discharge from San Marcos and Comal Springs (414,800 acre-ft) accounted for about 78 percent of spring discharge during 2001. The remaining spring discharge was from Hueco Springs in Comal County, San Pedro and San Antonio Springs in Bexar County, and Leona Springs in Uvalde County. Discharge from Leona Springs includes underflow from the Edwards aquifer into gravels of the Leona Formation along the stream. The 1934–2001 estimated annual discharge from springs ranged from 69,800 acre-ft in 1956 to 802,800 acre-ft in 1992; the average for the period is 368,600 acre-ft and the median is 375,700 acre-ft.

Table 3. Computed average daily and total annual discharge from the Edwards aquifer by county and by water use, 2001

[Totals might not equal sums of components due to rounding]

County	Springs	Municipal supply and military use	Irrigation	Industrial use	Domestic supply, stock, and miscellaneous uses	Total (million gallons per year)	Total (thousand acre-feet per year)
	(million gallons per day)						
Kinney	0	1.0	0.5	0	0.3	645	2.0
Uvalde	13.9	4.3	38.5	.8	2.1	21,730	66.7
Medina	0	5.7	23.0	.7	.8	11,040	33.9
Bexar	26.2	201	8.3	17.2	7.9	95,020	291.6
Comal	282	3.5	.04	6.1	.3	106,680	327.4
Hays	150	4.4	.05	1.5	.7	57,130	175.3
Total (million gallons per year)	172,400	80,160	25,720	9,589	4,366	292,240	
Total (thousand acre-feet per year)	529	246	78.9	29.4	13.4		897

Reference

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.

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Information on technical reports and hydrologic data related to this and other studies can be obtained from:

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