

2023

GROUNDWATER RECHARGE



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Recharge to the Edwards Aquifer originates as precipitation over the contributing and recharge zones of the aquifer, or as interformational flow from adjacent aquifers. The EAA maintains a joint funding agreement with the U.S. Geological Survey (USGS) to provide surface recharge estimates for eight of the nine major drainage basins with streams that flow on to the Edwards Aquifer recharge zone (Figure 1). Recharge is estimated using a water-balance method that relies on precipitation and streamflow measurements across the region. Based on the USGS methodology, the Guadalupe River Basin does not appear to provide significant recharge to the Edwards Aquifer, so recharge is not estimated for that drainage basin.

Table 1 lists estimated annual recharge by drainage basin for the period of record from 1934 through 2023 based on USGS calculations. Estimates of total annual recharge ranged from 43,700 acre-feet during the drought of record in 1956 to 2,486,000 acre-feet in 1992, as shown in Figure 2. In 2023, total estimated recharge was 147,000 acre-feet, which is below both the mean annual recharge of 683,000 acre-feet and the median annual recharge of 535,000 acre-feet for the period of record.

The EAA currently operates four recharge dams in Medina County on the Edwards Aquifer Recharge Zone (black triangles in Figure 1). The total amount of enhanced recharge for each site is estimated using data from stage recorders near these structures. Enhanced recharge refers to the estimated amount of additional recharge attributable to these structures

above the amount of recharge that would have occurred naturally in the absence of these structures. Table 2 shows the estimated annual enhanced recharge for each site starting in 2014. Recharge estimates in Table 2 prior to 2014 reflect total annual recharge at each dam site. The total estimated enhanced recharge recorded for these structures in 2023 was 0 acre-feet. Enhanced recharge is generally a small fraction of total recharge and tends to be greater in wet years when natural recharge is also high.

Recharge resulting from interformational flow in adjacent aquifers such as the Trinity Aquifer is not estimated annually. Estimates associated with interformational flow are variable and range from 5,000 to 100,000 acre-feet per year in different publications, but the actual value likely occurs in the middle of that range. Estimated interformational flow is not included in the recharge values provided in this report. Estimated recharge from interformational flow is included in modeling of the aquifer system. The Edwards Aquifer Authority is presently conducting an Interformational Flow study that may help to better quantify the amount of water that may enter the Edwards Aquifer from the Trinity Aquifer.

Figure 1. Major Drainage Basins and Edwards Aquifer Authority-Operated Recharge Structures in the San Antonio Segment of the Balcones Fault Zone Edwards Aquifer.

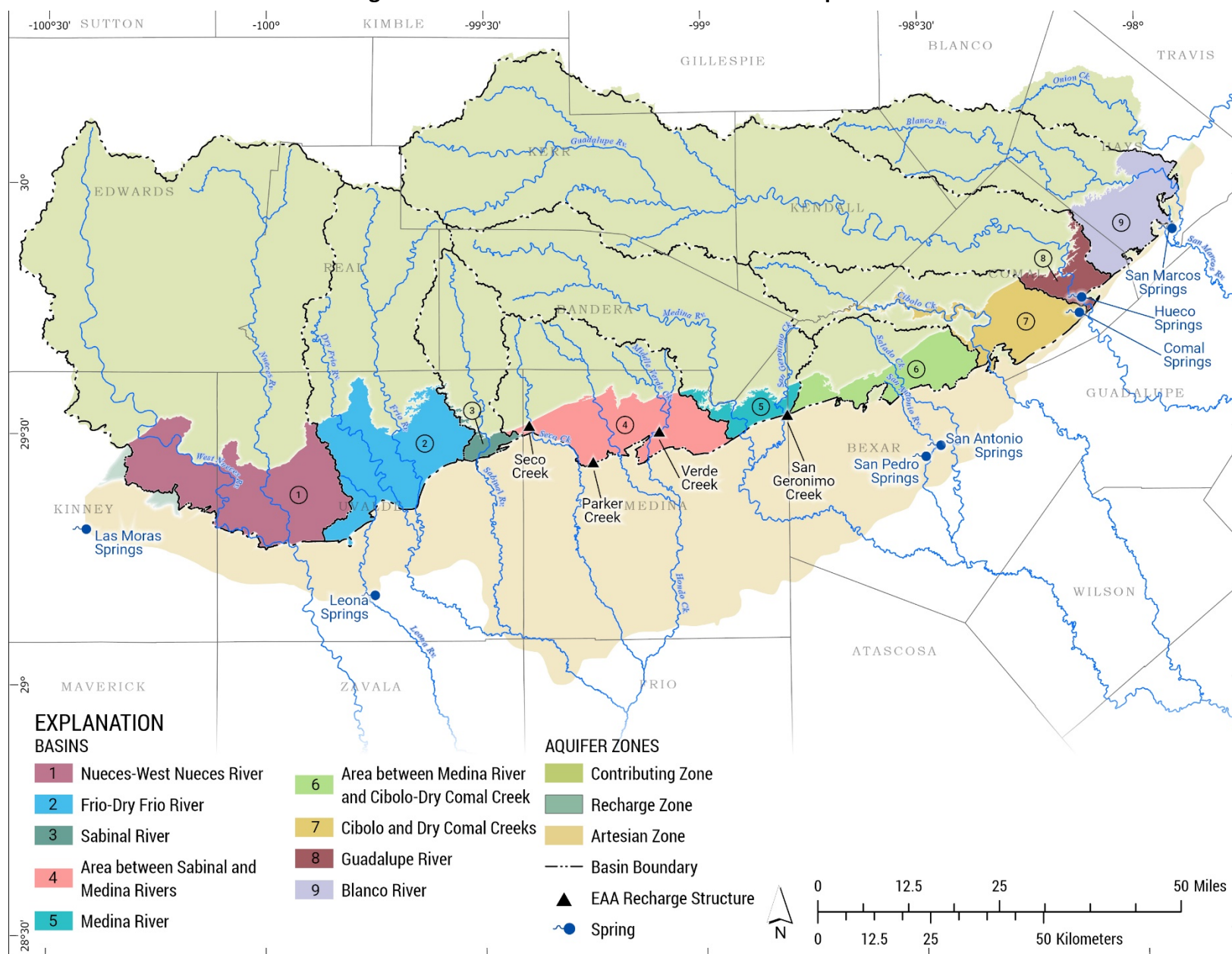


Table 1. Estimated Annual Groundwater Recharge to the San Antonio Segment of the Edwards Aquifer by Drainage Basin, 1934–2023 (in thousands of acre-feet)

Year	Nueces River/ West Nueces River Basin	Frio River/ Dry Frio River Basin	Sabinal River Basin	Area between Sabinal River and Medina River Basins	Medina River Basin	Area between Medina River and Cibolo Creek/ Dry Comal Creek Basins	Cibolo Creek/Dry Comal Creek Basin	Blanco River Basin	Total [†]
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	0.6	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

(Table 1. continued)

Year	Nueces River/ West Nueces River Basin	Frio River/ Dry Frio River Basin	Sabinal River Basin	Area between Sabinal River and Medina River Basins	Medina River Basin	Area between Medina River and Cibolo Creek/ Dry Comal Creek Basins	Cibolo Creek/Dry Comal Creek Basin	Blanco River Basin	Total†
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	197.7
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	226.9	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
2002	83.6	207.3	70.6	345.2	93.7	175.5	447.8	150.0	1,573.7
2003	149.8	112.2	31.7	67.4	86.6	56.2	105.0	59.9	669.0
2004	481.9	424.5	116.0	343.9	95.5	213.4	315.0	185.8	2,176.1
2005	105.5	147.2	50.1	79.1	82.8	84.8	140.4	74.1	764.0
2006	45.5	60.2	9.0	5.0	47.7	5.1	11.2	17.9	201.6
2007	471.8	474.4	104.0	406.4	75.2	227.6	306.1	96.9	2,162.3
2008	48.2	44.5	5.9	9.8	53.6	9.6	22.8	18.5	212.9
2009	58.5	30.3	1.8	13.5	45.6	7.3	26.4	27.5	210.9
2010	135.4	104.9	31.5	186.3	68.2	81.4	148.2	57.5	813.5
2011	15.3	13.7	1.0	2.0	43.3	3.0	15.3	18.3	112.0
2012	78.3	82.6	8.9	14.4	41.6	3.9	32.2	51.6	313.5
2013	67.7	26.7	0.5	2.8	10.8	3.3	28.7	42.1	182.6
2014	19.8	32.8	4.9	14.4	8.9	0.4	9.5	16.5	107.2
2015	343.8	281.9	42.2	218.4	54.6	131.6	177.3	108.3	1,358.1

(Table 1. continued)

Year	Nueces River/ West Nueces River Basin	Frio River/ Dry Frio River Basin	Sabinal River Basin	Area between Sabinal River and Medina River Basins	Medina River Basin	Area between Medina River and Cibolo Creek/ Dry Comal Creek Basins	Cibolo Creek/Dry Comal Creek Basin	Blanco River Basin	Total†
2016	275.7	247.8	52.4	184.1	77.5	110.9	186.4	86.3	1,221
2017	122.0	95.4	17.0	30.4	72.6	25.0	68.8	55.0	487
2018	360	316	57.3	168	66.8	22.8	71.1	42.9	1,100
2019	90.6	91.8	27.2	40.6	86.8	35.2	81.0	39.1	492
2020	32.0	24.7	3.74	4.49	54.5	4.57	27.4	32.9	184
2021	51.2	35.2	2.54	5.59	46.6	10.9	55.4	39.3	247
2022	78.3	15.6	0.27	1.96	37.3	0.86	5.25	16.6	156
2023	73.6	22.3	0.29	4.28	33.2	0.19	4.9	7.74	147
Recharge statistics for the period of record 1934–2023:									
Median	94.5	109	30.8	68.9	58.6	47.0	74.6	36.5	535
Mean	127	133	39.0	105	61.0	66.3	105	46.4	683
Recharge for the period of record 2014–2023 (last ten years):									
Median	84.4	62.3	11.0	22.4	54.6	16.9	62.1	39.2	366
Mean	145	116	20.8	67.2	54.3	34.3	68.7	44.5	550

Data source: USGS letter report (April 5, 2024).

†Totals may not exactly equal sum of all basins due to rounding. USGS began rounding all values to three significant digits in 2017.

Figure 2. Estimated Annual Recharge for the San Antonio Segment of the Balcones Fault Zone Edwards Aquifer, 1934–2023.

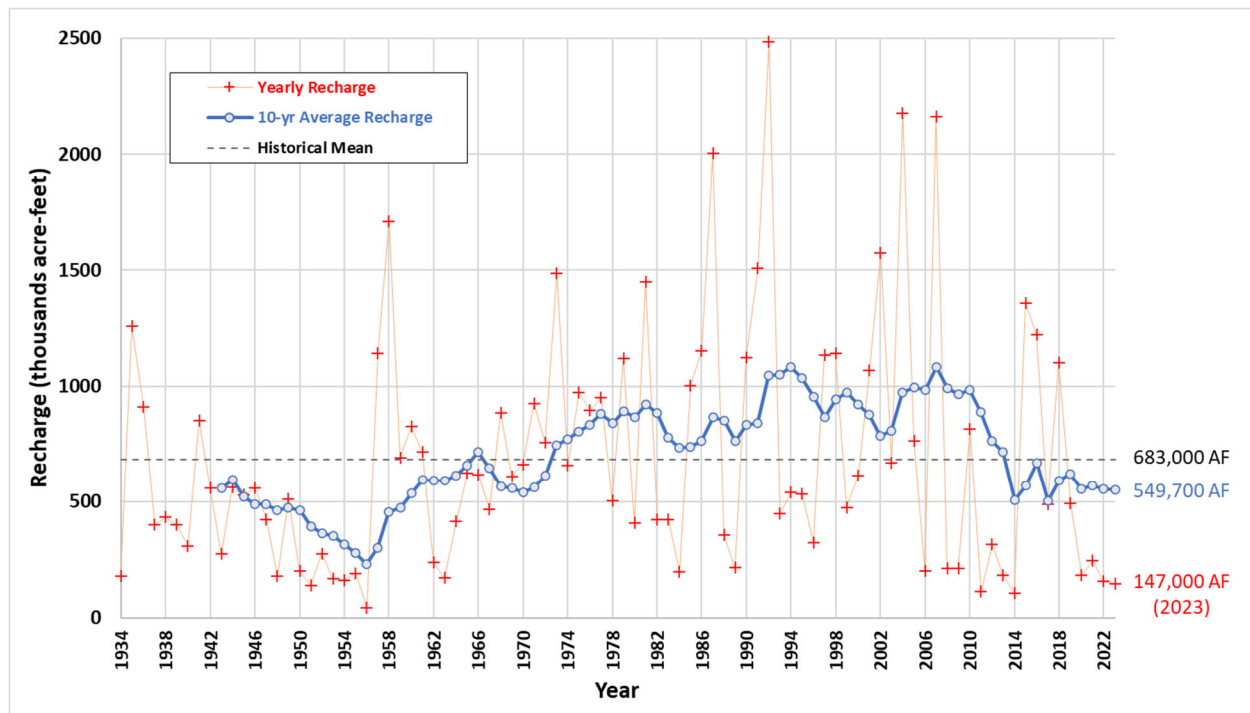


Table 2. Estimated Annual Enhanced Recharge from Edwards Aquifer Authority-Operated Recharge Structures from 1974 to 2023 (measured in acre-feet)

Year	Parker (April 1974)	Middle Verde (April 1978)	San Geronimo (November 1979)	Seco (October 1982)	Annual Total
1974	160	---	---	---	160
1975	620	---	---	---	620
1976	2,018	---	---	---	2,018
1977	6	---	---	---	6
1978	98	150	---	---	248
1979	2,315	1,725	0	---	4,040
1980	0	371	903	---	1,274
1981	772	1,923	1,407	---	4,102
1982	3	112	91	0	206
1983	0	254	0	0	254
1984	251	246	0	143	640
1985	232	440	1,097	643	2,412
1986	217	889	963	1,580	3,649
1987	2,104	4,141	1,176	12,915	20,336
1988	0	0	0	0	0
1989	0	0	0	0	0
1990	49	176	41	479	745
1991	647	966	1,647	2,160	5,420
1992	723	2,775	2,874	14,631	21,003
1993	0	0	334	508	842
1994	159	0	0	5	164
1995	18	79	51	880	1,028
1996	0	0	0	0	0
1997	2,941 ^a	2,154 ^b	1,579 ^b	7,515 ^b	14,189 ^b
1998	1,469 ^{a,b}	1,160 ^b	872 ^b	3,796 ^b	7,297 ^b
1999	0 ^b	0 ^b	0 ^b	50 ^c	50 ^{b,c}
2000	901 ^b	1,371 ^b	1,023 ^b	4,606 ^b	7,901 ^b
2001	526 ^b	657 ^{b,d}	1,085 ^{b,d}	2,154 ^{b,d}	4,422 ^{b,d}
2002	1,811	1,511	4,350	18,872	26,544
2003	665	184	0	465	1,314
2004	2,363	170	4,778	14,682	21,993
2005	795	0	0	58	853
2006	0	0	0	0	0
2007	5,998	2,091	7,268	10,645	26,002
2008	2.6	2.5	0	0	5
2009	630	31	0.1	28	688
2010	1,356	1,324	4,375	6,171	13,226
2011	10	4.5	1.0	0	16
2012	1.0	51	0	98	150
2013	0.6	0	0	0.4	1.0
2014	759	38.0	0	319	1,116
2015	419	816	1,163	4,682	7,079
2016	2,257	747	1,776	4,018	8,799
2017	35	0	0	0	0
2018	756	1,333	4,056	5,838	11,983
2019	0	0	14.7	76.2	90.9
2020	0	0	0	0	0
2021	50.9	6.5	199.3	0	256.7
2022	0	0	0	0	0
2023	0	0	0	0	0

Data source: Unpublished Edwards Aquifer Authority files (2024).

a = Written communication from USGS, San Antonio Subdistrict Office.

b = Determined by linear-regression analysis using rainfall data and historical recharge data.

c = Linear-regression analysis indicates zero recharge; however, one recharge event was observed that was estimated to have recharged 50 acre-feet.

d = Part of 2001 recharge estimate provided by HDR Engineering, Inc. (unpublished report).

---= Years prior to construction of recharge structure.