



EDWARDS AQUIFER
AUTHORITY

Hydrologic Data Report 2016 Recharge

GROUNDWATER RECHARGE

Recharge to the Edwards Aquifer originates as precipitation over the drainage area and recharge zone 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 2016 based on USGS calculations. Estimates of total annual recharge ranged from 43,700 acre-feet at the height of the drought of record in 1956 to 2,486,000 acre-feet in 1992, as shown in Figure 2. In 2016, total estimated recharge was 1,221,100 acre-feet, which is significantly greater than the mean annual recharge of 706,500 acre-feet. The median annual recharge for the period of record is 557,800 acre-feet. The median value represents the amount of annual recharge that has a 50-percent chance of being exceeded in any given year.

In an effort to enhance recharge, the EAA operates four recharge structures in Medina County on the Edwards Aquifer Recharge Zone (yellow 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 annual enhanced recharge for each site starting in 2014_. Recharge estimates for prior dates reflect total annual recharge at each site. The total estimated enhanced recharge for these structures in 2016 was 8,799 acre-feet.

Historical median and mean annual recharge attributed to the recharge structures is based on a period of record that reflects the date of construction through 2014. The approximate historical median annual enhanced recharge from the combined structures is

1,028 acre-feet; the historical mean annual enhanced recharge from the combined structures is 4,903 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. Estimated interformational recharge is not included in recharge values provided in this report. 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 Trinity Aquifer formations to the north.

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

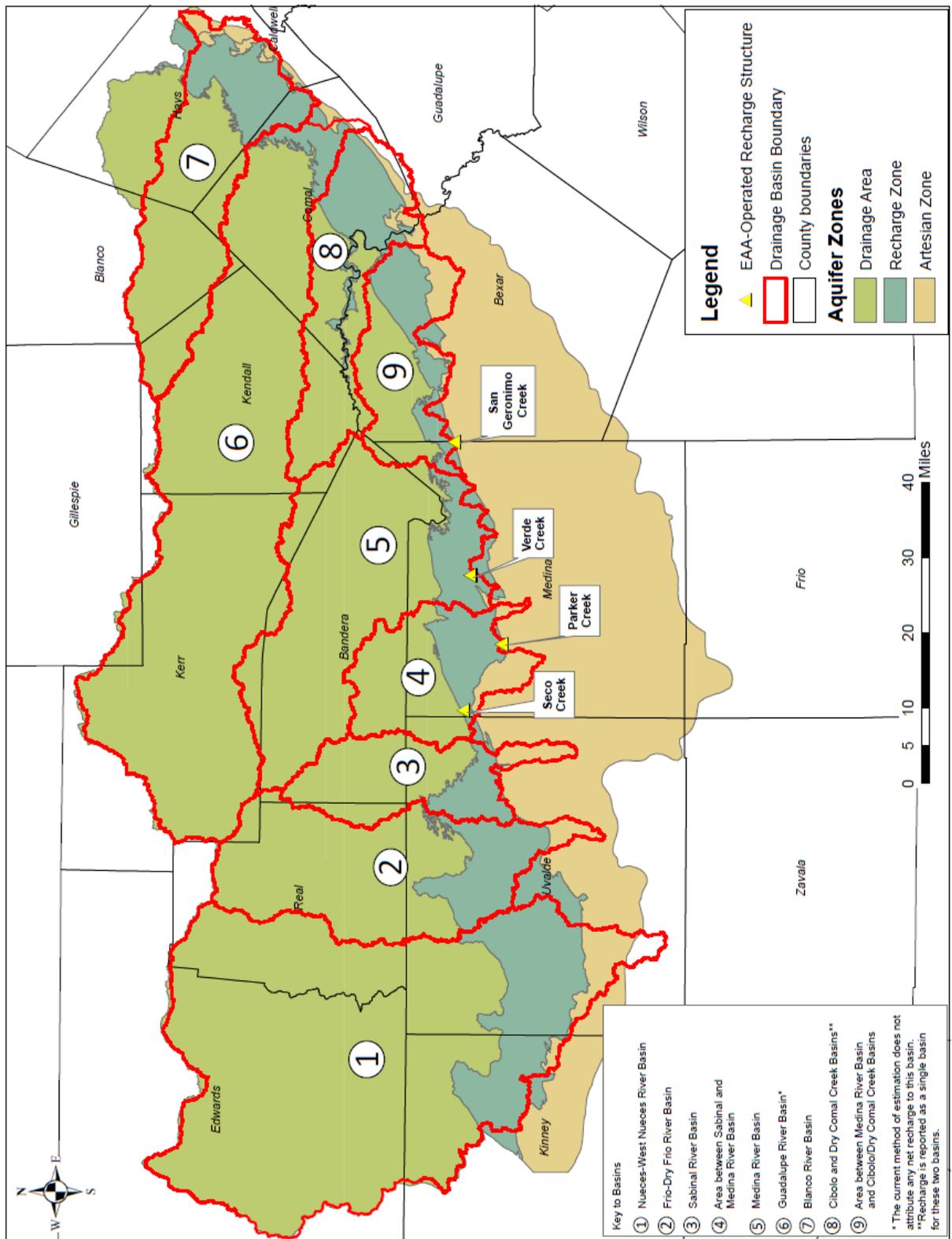


Table 1. Estimated Annual Groundwater Recharge to the San Antonio Segment of the Balcones Fault Zone Edwards Aquifer by Drainage Basin, 1934–2016 (in thousands of acre-feet).

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 Creek Basins	Cibolo Comal Creek/ Dry Creek Basin	Blanco River Basin	Total
1974	91.1	135.7	36.1	115.3	96.2	68.1	76.9	39.1	2
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	1,221.1

Recharge statistics for the period of record 1934–2016:

Median	101.4	117.9	31.5	78.2	59.9	50.1	77.9	36.4	557.8
Mean	128.0	137.5	41.0	110.6	61.4	70.7	109.8	47.5	706.5

Recharge for the period of record 2007–2016 (last ten years):

Median	73	63.6	7.4	14.4	49.6	8.5	30.5	46.9	263.2
Mean	151.5	134.0	25.3	105.2	47.9	57.9	95.3	52.4	669.4

Data source: USGS unpublished report (April 2017).

Figure 2. Estimated Annual Recharge for the San Antonio Segment of the Balcones Fault Zone Edwards Aquifer, 1934–2016

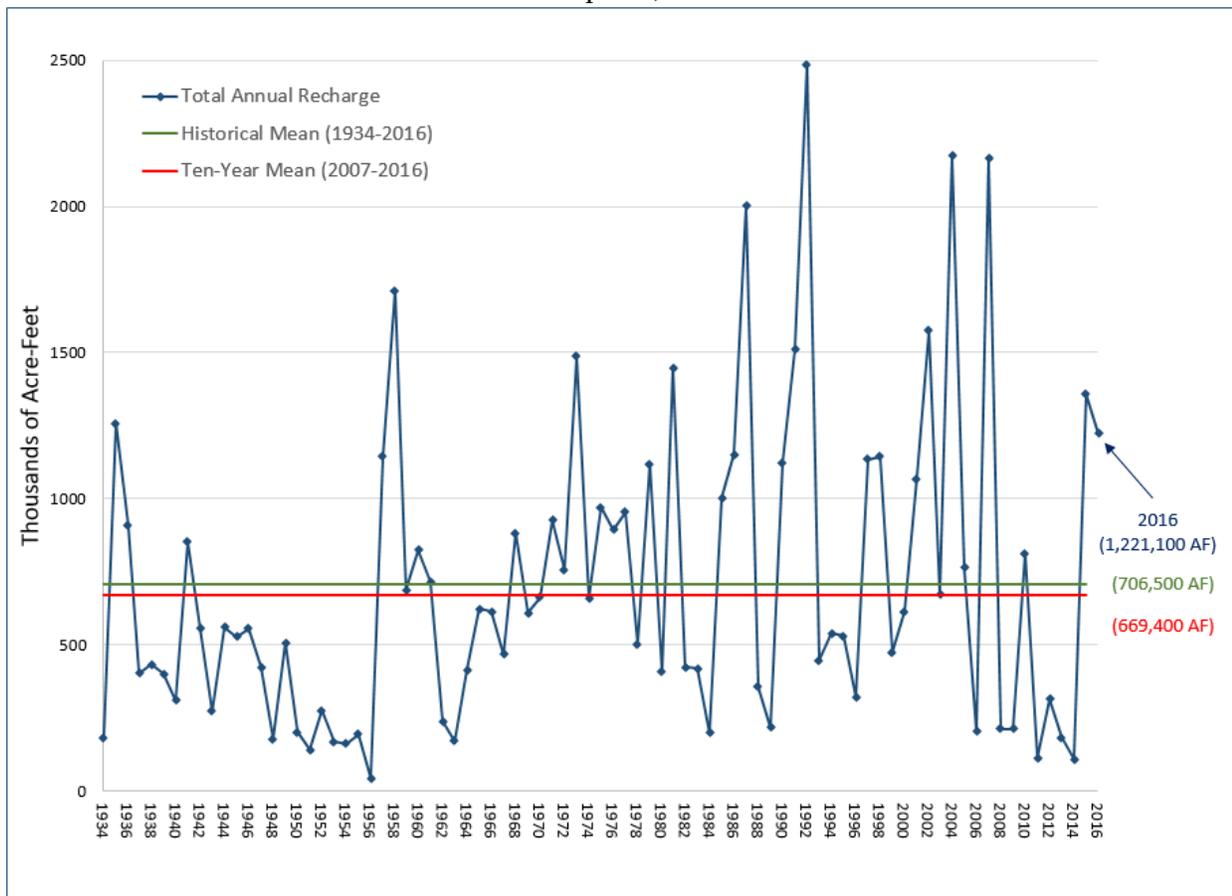


Table 2. Estimated Annual Enhanced Recharge from Edwards Aquifer Authority-Operated Recharge Structures (measured in acre-feet).

Year	Parker (April 1974)	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	630.3	30.5	0.1	27.5	688.4
2010	1,356.4	1,324	4,375.1	6,170.7	13,226.2
2011	10.1	4.5	1.0	0	15.6
2012	1.0	51.2	0	97.5	149.7
2013	0.6	0	0	0.4	1.0
2014	759	38.0	0	319.4	1,116.4
2015	418.5	815.8	1,162.8	4,682.1	7,079.2
2016	2,257.2	747.4	1,776.2	4,018.0	8,798.8
Total	33,297	26,559	38,854	108,307	210,812
Median	251	184	71	472	1,028
Mean	774	681	1,022	3,185	4,903

Data source: Unpublished Edwards Aquifer Authority files (2014).

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.



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