Texas Water Development Board

Technical Note 21-01

Evaporative Losses from Major Reservoirs in Texas

by
John Zhu, Ph.D., P.G., Nelun Fernando, Ph.D., Carla G. Guthrie, Ph.D.

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Table of Contents

Executive Summary

This report provides computed reservoir evaporation losses from 2001 through 2018 for 114 monitored major water supply and cooling reservoirs in Texas. A major reservoir in Texas is defined as to having original conservation storage greater than 5,000 acre-feet. The study period was set at 2001 through 2018 to ensure complete maximum data availability on reservoir water level. Total annual gross evaporation from these 114 reservoirs has been relatively stable during the period from 2001 to 2018, ranging from 5.85 to 7.96 million acre-feet with an average value of 6.88 million acre-feet. Annual net evaporation, which factors in precipitation over the lake, ranges from a net gain of approximately 115 thousand acre-feet in 2015 to a net loss of 5.42 million acre-feet in 2011 with an average net loss value of 1.91 million acre-feet per year. We extrapolated these results to the 188 major water supply reservoirs in Texas based on the proportional total surface area at the conservation pool level and found an average total annual gross evaporation of 7.38 million acre-feet per year and an average annual net evaporation loss of 2.04 million acre-feet per year. A key finding of the study is that annual reservoir evaporative loss in drought years, such as 2011, can exceed total annual municipal water use, highlighting the fact that reservoir evaporative loss should ideally factored into the regional water planning process either as a water demand factor or as a factor that affects future surface water availability. Further consideration to technologies for preventing reservoir evaporation loss as a future water management strategy in the regional water planning processes.

Introduction

Evaporation is a major source of water loss from Texas reservoirs. Evaporative loss rates are greater during summer than other seasons and are greater in the drier and hotter western half of the state than in the eastern half. Reservoir evaporation is an important factor to consider in reservoir operations and in the development of new water management strategies such as building new reservoirs. The drought of 2011 raised awareness about the significance of evaporative losses from Texas' water supply reservoirs. Because of this renewed awareness, and to quantify the magnitude of reservoir evaporation loss in Texas, we computed the volumetric loss due to evaporation for every monitored reservoir in the state and developed a statewide estimate of total volumetric loss for all major water supply reservoirs. In so doing, we specifically computed monthly gross reservoir evaporation volumetric loss and net reservoir evaporation volumetric loss or gain for 114 monitored reservoirs from 2001 through 2018 based on observed reservoir water level, evaporation data, and precipitation data. We then extrapolated evaporative losses for the 188 major water supply reservoirs (114 monitored reservoirs are included) listed in the State Water Plan (TWDB, 2012; 2017)[1] since the rest 74 reservoirs do not have water stage information.

Background

Historically, evaporation from reservoirs has been estimated by using pan evaporation data (Lowry 1960, Kane 1967, Dougherty 1975). The Texas Water Development Board (TWDB) has collected daily pan evaporation data through a cooperative program of approximately 18–50 evaporation stations (number of cooperators varies from year to year). In addition to cooperator data, TWDB staff acquires daily Class A pan evaporation data from the National Weather Service and National Centers for Environmental Information (NCEI) for another 60 to 80 stations in Texas and from four surrounding 4 states (Arkansas, Louisiana, New Mexico, and Oklahoma). The data are summed up to monthly dataset and subjected to quality assurance and quality control procedures. The monthly station data are used to

[1] There is no list of reservoirs in the 2017 State Water Plan [TWDB, 2017], but the default number for all water supply reservoirs is still 188 as shown in page 62.

produce monthly Thiessen polygons covering the entire territory of Texas and surrounding areas. The monthly data value for each polygon area is distributed to one-degree longitude by one-degree latitude quadrangle (grids) through an area-weighted method. Precipitation data are processed in the same way. The quadrangular monthly gross lake surface evaporation rate (after applying by pan-to-lake coefficient), precipitation rates, and net reservoir evaporation rates (i.e., gross evaporation minus precipitation) are published at: https://www.waterdatafortexas.org/lake-evaporation-rainfall.

Methodology

Out of 188 major water-supply reservoirs in Texas, 114 are monitored daily for water level or storage capacity. We computed volumetric evaporation loss for these 114 water-supply or cooling reservoirs (Figure 1 and Appendix A). Monthly volumetric reservoir evaporation loss is computed by multiplying the evaporation rate (gross or net) by a monthly mean reservoir surface area. The net evaporation rate equals gross evaporation rate less the precipitation rate. When an evaporation pan station is beside a lake, the station data (after applying pan-to-lake coefficient) is used in the computation for that reservoir, since it provides higher spatial accuracy than using quadrangular data; otherwise, quadrangular data are used. The reservoir's surface area is not directly measured but instead derived using the latest reservoir-specific elevation–area rating curve and a measured water level. In this study, monthly mean reservoir surface area is the average of daily surface areas for a month, which is derived from daily mean water level observations. When a reservoir's water level exceeds its conservation pool elevation, thus going beyond the regular range of the elevation-area rating curve, a linear extrapolation of the rating curve is applied for computing surface area. When there is no observed water level data for a (or a couple of) month, an average monthly water level is interpolated from observed data of nearest months. For reservoirs bordering other states (e.g., Lake Texoma and Toledo Bend Reservoir) or Mexico (e.g., Amistad and Falcon reservoirs), we used the entire surface area in the computation.

At conservation pool elevation, these 114 reservoirs represent approximately 93 percent of the total surface area and about 98 percent of the total conservation capacity of 188 major water supply reservoirs in Texas as listed in 2012 State Water Plan (TWDB, 2012). Therefore, the computed evaporation loss from the 114 reservoirs was extrapolated to that for the 188 major water-supply reservoirs by dividing by a factor of 0.93 – a factor corresponding to the surface area represented by the 114 reservoirs.

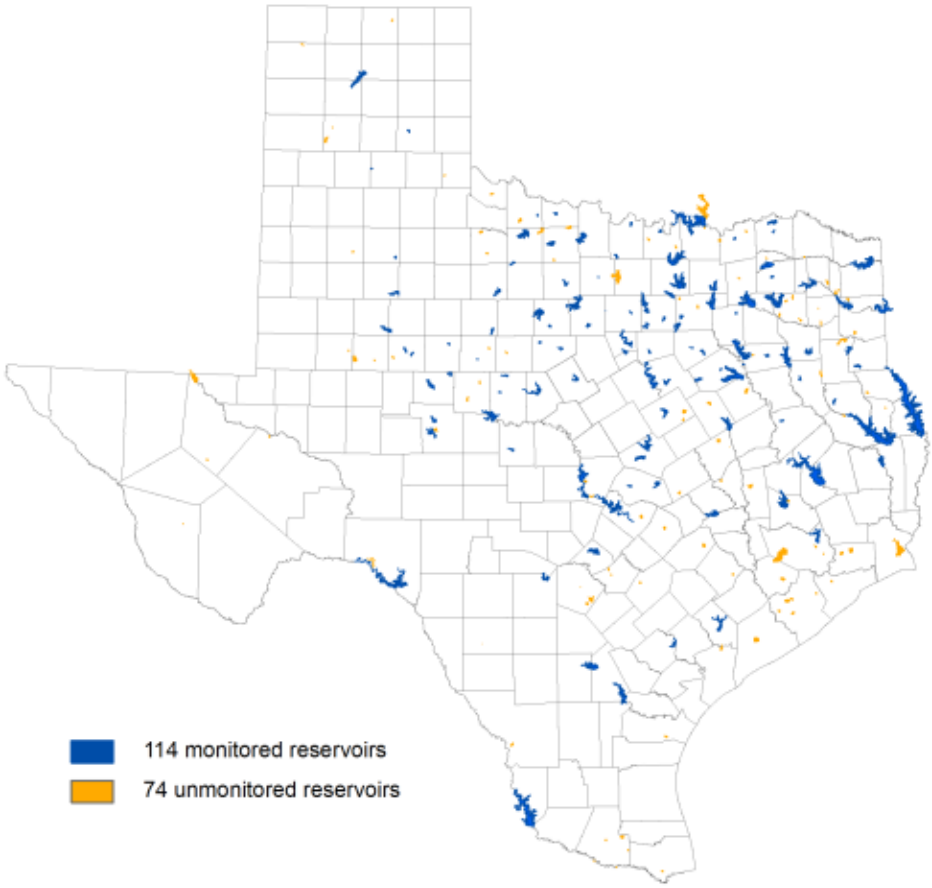

Figure 1. Location of 188 major reservoirs in Texas

Results

Evaporation Losses Computed from 114 Monitored Reservoirs

Total annual gross lake evaporation, precipitation, net lake evaporation, together with the reservoir surface area are computed (Table 1 and Figure 2). The annual gross lake evaporation, precipitation, and net lake evaporation from 114 monitored reservoirs during 2001–2018 period ranged from 5.85 to 7.96, 2.39 to 8.08, and -0.12 to 5.42, all in million acre-feet, respectively. The corresponding average annual gross evaporation, precipitation, and net evaporation are 6.88, 4.96, and 1.91, all in million acre-feet, respectively. Year 2011 has the second highest annual gross lake evaporation (7.81 million acre-feet), lowest annual precipitation (2.39 million acre-feet), therefore highest net evaporation, 5.42 million acre-feet. The net evaporation of 2011 is 3.51 million acre-feet greater than the average net evaporation of 1.91 million acre-feet. The result is consistent with reported record high temperature from March to November 2011 and record low rainfall from December 2010 through August 2011 from the State Climatologist (Nielsen-Gammon, 2011). Figure 3 presents the monthly gross evaporation, precipitation, and net evaporation in 2011 from our computation.

Table 1. Annual reservoir evaporation, precipitation, reservoir surface area, and evaporation rate for 114 Reservoirs

Year	Gross Reservoir Evaporation (million acre-feet)	Precipitation Over Reservoirs (million acre-feet)	Net Reservoir Evaporation (million acre-feet)	Average Monthly Total Surface Area (million acres)	Average Annual Gross Evaporation Rate (feet)
2001	6.36	5.57	0.79	1.48	4.31
2002	6.40	5.09	1.32	1.46	4.39
2003	6.42	3.97	2.45	1.46	4.42
2004	6.46	6.50	-0.03	1.51	4.29
2005	7.03	3.40	3.63	1.48	4.75
2006	7.00	3.95	3.04	1.35	5.19
2007	6.73	6.19	0.54	1.58	4.27
2008	7.31	4.47	2.84	1.52	4.82
2009	7.38	5.94	1.44	1.52	4.86
2010	7.47	4.23	3.23	1.53	4.88
2011	7.81	2.39	5.42	1.32	5.91
2012	6.44	4.28	2.16	1.32	4.86
2013	5.85	4.11	1.74	1.24	4.73
2014	5.96	3.53	2.43	1.26	4.59
2015	7.96	8.08	-0.12	1.61	4.96
2016	7.49	5.66	1.83	1.64	4.57
2017	7.05	5.40	1.65	1.51	4.67
2018	6.67	6.59	0.08	1.52	4.96
Average	**6.88**	**4.96**	**1.91**	**1.46**	**4.57**

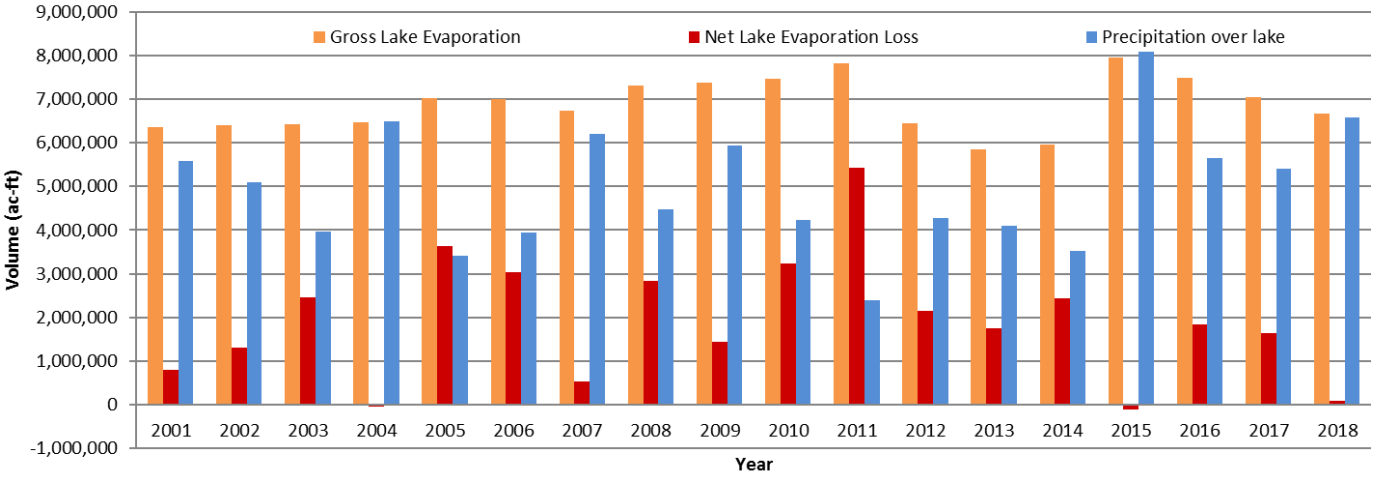

Figure 2. Annual reservoir gross and net evaporations and precipitation for the 114 monitored reservoirs

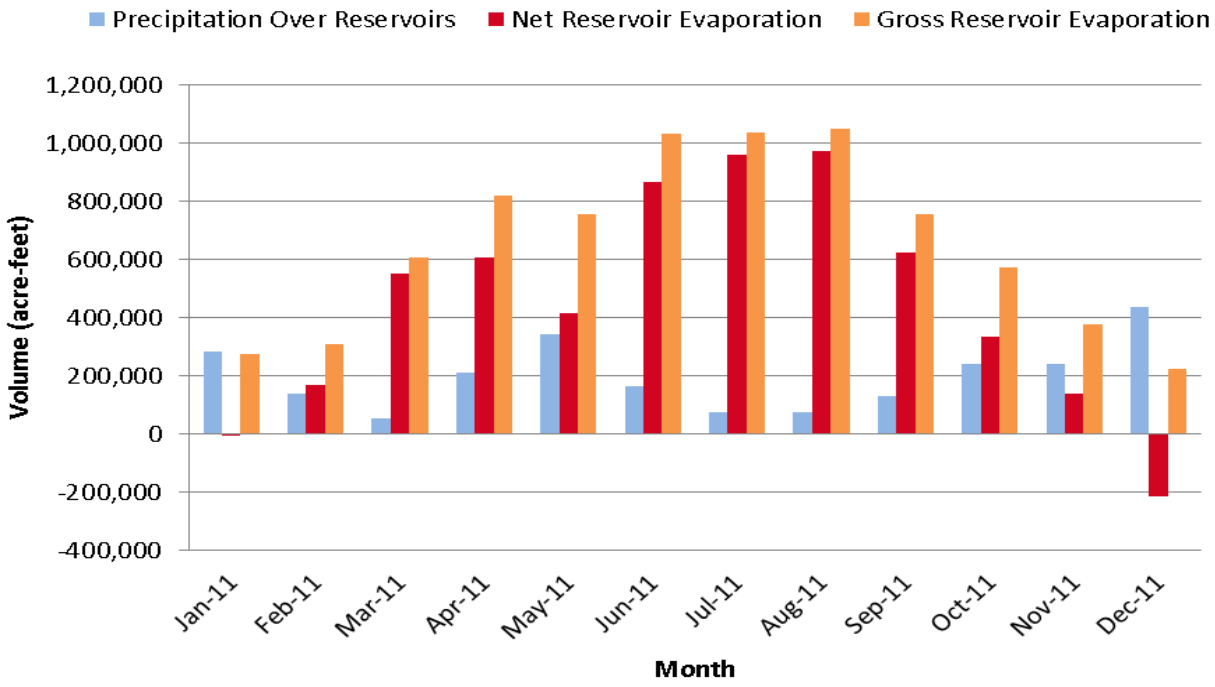

Figure 3. Monthly gross reservoir evaporation, net reservoir evaporation, and precipitation for 114 reservoirs in 2011 (negative net evaporation in December means net gain. This could be due to rainfall in December 2011 that ended the meteorological drought in most areas of the state).

Total monthly gross reservoir evaporation of these 114 reservoirs varies seasonally throughout a year with winter lows and summer highs (Figure 4 orange color). The minimum value was 198,637 acre-feet recorded in the winter of 2014 (December) and the maximum value was 1.34 million acre-feet recorded in summer of 2015 (June). The average monthly gross evaporation was approximately 573,131 acre-feet per month from January 2001 through December 2018. Total monthly reservoir precipitation on the 114 monitored reservoirs ranged from 54,988 acre-feet in March 2011 to 1.87 million acre-feet in May 2015 (Figure 5), with an average value of approximately 413,678 acre-feet per month. Precipitation has large interannual variability as depicted in Figure 5. Large values of rainfall over reservoirs (over a million acre-feet per month) were recorded in 2004, 2007, 2009, 2015, 2017, and 2018 (see peaks in figure 5). Total monthly net evaporation (dark-red line in figure 4) has a large monthly variability due to large intra-annual variations in rainfall. Large rainfall events as mentioned early led to large negative monthly net reservoir evaporation during those times (low drops of dark-red line in Figure 4). Total monthly net reservoir evaporation ranged from a net gain of 1.14 million acre-feet in May 2015 to a net loss of 1.11 million acre-feet in July 2015. The average total monthly net reservoir evaporation was approximately 159,453 acre-feet per month from 2001 through 2018.

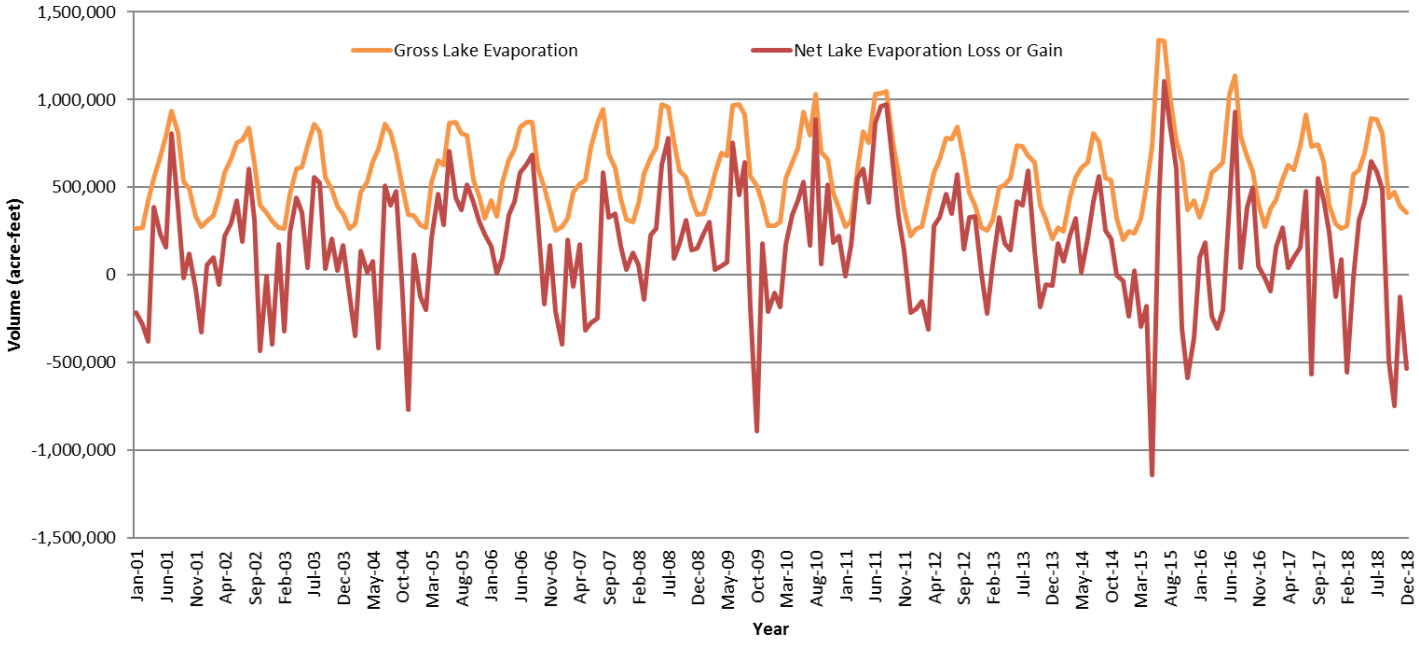

Figure 4. Monthly gross and net reservoir evaporation for 114 reservoirs

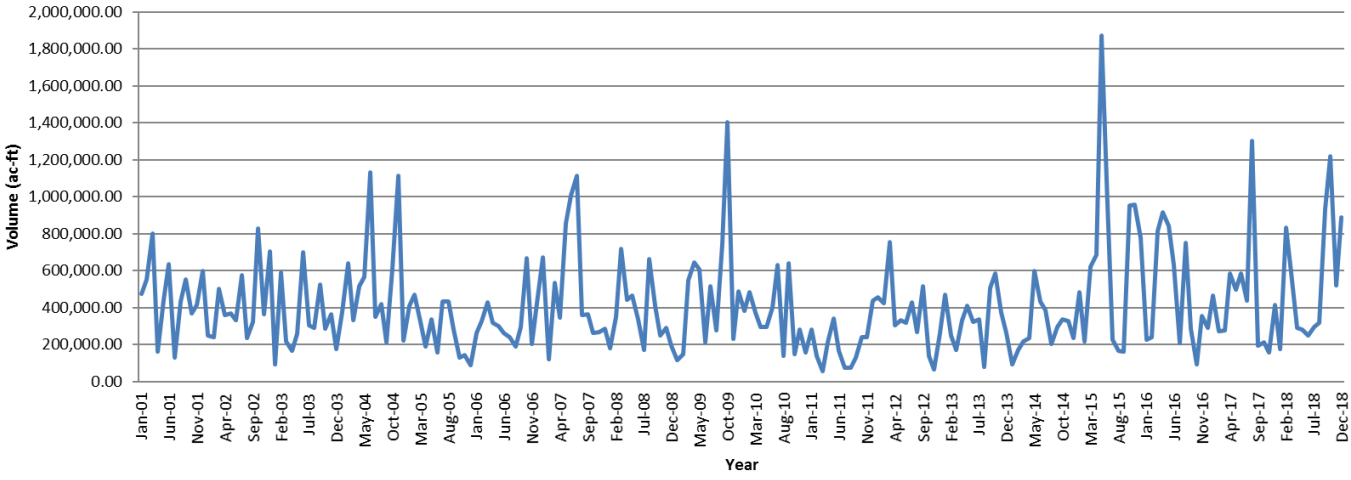

Figure 5. Monthly total precipitation over 114 reservoirs

Estimated Evaporation Losses from 188 Reservoirs

Extrapolated by the method discussed above (page 3), annual gross reservoir evaporation loss for all 188 reservoirs for the period from 2001 through 2018 are estimated to range from 6.29 to 8.56 million acre-feet per year with an average of 7.38 million acre-feet per year (Table 2). Annual estimated net evaporation loss ranged from a net gain of approximately 130,000 acre-feet (2015) to a net loss of 5.83 million acre-feet (2011) with an average net loss of approximately 2.04 million acre-feet per year. It should be noted that this estimation is to estimate the evaporative loss from those 74 unmonitored major water supply reservoirs. The computed loss for the 114 monitored reservoirs has not been revised.

Table 2. Estimated Annual Gross and Net Evaporation for 188 Reservoirs

Year	Gross Reservoir Evaporation (million acre-feet)	Net Reservoir Evaporation (million acre-feet)
2001	6.84	0.85
2002	6.88	1.42
2003	6.90	2.63
2004	6.95	-0.03
2005	7.56	3.90
2006	7.53	3.27
2007	7.24	0.58
2008	7.86	3.05
2009	7.94	1.55
2010	8.03	3.47
2011	8.40	5.83
2012	6.92	2.32
2013	6.29	1.87
2014	6.22	2.22
2015	8.56	-0.13
2016	8.05	1.97
2017	7.58	1.77
2018	7.17	0.09
Average	**7.38**	**2.04**

Discussion

In 2014, Wurbs and Ayala (2014) published a study on the statewide reservoir evaporation. They used the Texas Water Availability Model (WAM, Run 8) to estimate total net evaporation volumes from 3,435 major and minor reservoirs included in the WAM. The study simulates the evaporation from the water bodies as if the reservoirs existed during the period of 1940–1998 with a latest capacity before 2000. The model uses the maximum diversion during the 10-year period before 2000. They reported total average net evaporation to be between 5 to 6 million acre-feet per year during 1940s–1990s. This is a much larger number than our estimate of 2.04 million acre-feet per year from 188 major water supply reservoirs.

Several differences in methodology contribute to the difference in the two studies. First, our study is based on the observed evaporation, precipitation, and reservoir water level data from 2001–2018 while the Wurbs and Ayala (2014) study is based on WAM simulation for period of 1940s–1990s which include 1950s megadrought in Texas. Although our computation period includes a one-year recorded drought in Texas in 2011, there several wet years (2004, 2007, 2015, and 2018) are involved. Second, our study is for 188 major water supply reservoirs, while Wurbs and Ayala (2014) study includes many other minor reservoirs and water ponds, for a total of 3,435 water bodies. Therefore, the Wurbs and Ayala (2014) could have a higher estimate of total evaporation loss because they included all permitted surface water bodies in Texas.

Other factors that may contribute to the discrepancy include:

1. The reservoir surface areas in Wurbs and Ayala (2014) are calculated from area-capacity rating curves developed before 2000 that have large incremental intervals of water elevation, and do not include storage above the conservation pool. We used the latest and detailed elevation-area rating curves available that report on all observed water levels, including beyond the conservation pool. Therefore, it is not surprising that the average total surface area for water bodies in the Wurbs and Ayala (2014) study is less than the average total surface area for the monitored 114 major reservoirs included in our study.
2. The reservoir storage in the Wurbs and Ayala (2014) study was simulated using an unchanged maximum annual diversion target, based on 1990–2000 values rather than actual recorded diversion values. Using the maximum diversion target may cause simulated storage to be lower than observed storage.
3. According to U.S. Census Bureau unpublished data from the MAF/TIGER database (http://www.census.gov/geo/reference/state-area.html), the total surface area of perennially open water bodies (excluding bays and estuaries) in Texas is approximately 4.46 million acres. If we extrapolate our average annual net evaporation from 114 reservoirs to all water bodies with 4.46 million acres of surface area, the total will be 5.83 million acre-feet (1.914 * 4.46/1.46). Based on this information, it seems that the result from Wurbs and Ayala (approximately 5-6 million acre-feet per year) might be a slight over-estimate on per area basis, because the number of permitted water bodies may be much less than the perennial open water bodies from the U. S. Census Bureau (some may not have water permit).
4. The difference may also be largely be due to the difference of time periods we considered. It also should be noted that the net reservoir evaporation rate from the 1940s through 1953 in the WAM models are no longer supported by the TWDB. This is because these rates were derived from observations taken at multiple types of evaporation pans and are considered to over-estimate the evaporation rate (TWDB, 1998, internal report, page 13) for that period. TWDB no longer publishes reservoir evaporation rate data prior to 1954.

To quantify the scale of evaporation losses from major reservoirs in Texas for audience, we compared net reservoir evaporation loss with the total municipal water use in Texas. The TWDB estimated that annual statewide municipal water use (from all types of source including groundwater) from 2001 through 2018 was less than five million acre-feet per year (Table 3, average was 4.32 million acre-feet). This value is typically greater than the statewide net reservoir evaporation of 188 reservoirs (average was 2.04 million acre-feet) for the same period. During the period of 2001–2018, statewide total municipal use as a percentage of net evaporation ranged from -3 percent to 117.3 percent, or an average of 47.1 percent.

Of interest is the fact that the net reservoir evaporation loss in 2011 (5.83 million acre-feet) was higher than the municipal water use (4.97 million acre-feet) in 2011, although the maximum annual water use was recorded in 2011. This result highlights the fact that during drought years evaporative water loss from reservoirs is significant in Texas.

Table 3. Comparison of Reservoir Evaporation Loss and Municipal Water Use (million acre-feet).

Year	Total Municipal Water Use	Net Reservoir Evaporation	Net Reservoir Evaporation as Percent of Municipal Water Use (%)
2001	4.19	0.85	20.3
2002	4.12	1.42	34.5
2003	4.03	2.63	65.3
2004	3.99	-0.03	-0.8
2005	4.53	3.90	86.1
2006	4.81	3.27	68.0
2007	4.35	0.58	13.3
2008	4.17	3.05	73.1
2009	4.18	1.55	37.1
2010	4.21	3.47	82.4
2011	4.97	5.83	117.3
2012	4.47	2.32	51.9
2013	4.22	1.87	44.3
2014	4.01	2.22	55.4
2015	4.28	-0.13	-3.0
2016	4.41	1.97	44.7
2017	4.42	1.77	40.0
2018	4.44	0.09	2.0
Average	**4.32**	**2.04**	**47.1**

(Statewide municipal water use data available for up to 2018
https://www3.twdb.texas.gov/apps/reports/WU/SumFinal_BasinReport and
https://www3.twdb.texas.gov/apps/reports/WU/SumFinal_BasinReportWithReuse

Conclusions

This study reports on gross and net reservoir evaporation loss for 114 monitored major water supply and cooling reservoirs in Texas for the period 2001 through 2018 using observed water level, evaporation, and precipitation data. Further, the study extrapolates the evaporation losses from the 114 reservoirs to all 188 major water supply reservoirs in Texas.

Total annual gross evaporation loss from the 114 reservoirs ranges from 5.85 to 7.96 million acre-feet per year with an average of 6.88 million acre-feet per year from 2001 through 2018. Total annual gross reservoir evaporation estimated for the 188 reservoirs ranges from 6.29 to 8.56 million acre-feet per year, with an average loss of 7.38 million acre-feet per year for the same period. Total annual net evaporation loss for the same period and for the 114 reservoirs ranges from a net gain of approximately 115,000 acre-feet in 2015 to a net loss of 5.42 million acre-feet in 2011, with an average loss of 1.91 million acre-feet per year for the same period.

Total annual estimated net evaporation loss from the 188 major water supply reservoirs ranges from a gain of 130,000 acre-feet in 2015 to a loss of 5.83 million acre-feet in 2011, with an average loss of 2.04 million acre-feet per year for the same period.
The result of this study reveals that a significant volume of water evaporates from our reservoirs, especially during droughts, such as seen in 2011. The net reservoir evaporation loss (5.83 million acre-feet) in 2011 was higher than municipal water use (4.97 million acre-feet) that year, even though 2011 had the maximum recorded annual water use.

We have demonstrated that reservoir evaporation is a source of major water loss from surface water sources. This loss is currently not accounted for as a water demand factor or as a factor leading to a reduction in future available reservoir supply in the regional water planning process in Texas. We draw attention to the need to factor evaporative loss when estimating future available surface water in Texas. Such accounting for evaporative loss can guide decisions on whether investments to reduce reservoir evaporation as a potential water management strategy will be needed in the future.

Acknowledgements

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Appendix A: List of 114 Monitored Reservoirs Used in the Analysis

USGS Gage ID	Reservoir Name	Year of Completion	Conservation Capacity (acre-feet)	Surface Area at Top of Conservation Pool (acres)
8083270	Abilene	1921	6,099	595
8079700	Alan Henry	1994	94,808	2,741
8888888	Amistad	1969	3,275,532	65,597
8043700	Amon G Carter	1956	27,500	1,489
8093350	Aquilla	1983	44,566	3,066
8049200	Arlington	1957	40,188	1,926
7314800	Arrowhead	1966	235,997	14,506
8031290	Athens	1963	29,475	1,799
8154900	Austin	1939	24,644	1,589
8040000	B.A. Steinhagen	1951	66,972	10,235
8063700	Bardwell	1965	46,472	3,138
8102000	Belton	1954	435,225	12,135
8046500	Benbrook	1950	85,648	3,635
7344489	Bob Sandlin	1978	201,733	8,703
7332610	Bonham	1969	11,038	1,012
8144900	Brady Creek	1963	30,430	2,020
8043000	Bridgeport	1931	366,236	11,712
8143000	Brownwood	1933	131,429	6,814
8148000	Buchanan	1938	883,308	22,137
7346310	Caddo	1968	129,000	26,800
8167700	Canyon	1964	378,852	8,308
8063010	Cedar Creek	1966	644,785	32,873
8123600	Champion Creek	1959	42,500	1,560
8206900	Choke Canyon	1982	695,271	25,438
8086215	Cisco	1923	26,000	1,050
8140770	Coleman	1966	38,094	1,811
8177400	Coleto Creek	1980	31,040	3,100
8123000	Colorado City	1949	31,085	1,612
8067600	Conroe	1973	416,228	19,640
8210500	Corpus Christi	1958	257,260	18,700
7335600	Crook	1923	9,210	1,060
7344484	Cypress Springs	1971	66,756	3,252
8086600	Daniel	1948	9,515	924
8123950	E.V. Spence	1969	517,272	14,640
8045000	Eagle Mountain	1932	179,880	8,494

USGS Gage ID	Reservoir Name	Year of Completion	Conservation Capacity (acre-feet)	Surface Area at Top of Conservation Pool (acres)
7312180	Electra	1950	5,626	731
9999999	Falcon	1954	2,645,693	85,195
7315600	Farmers Creek	1960	21,749	1,362
8018800	Fork	1980	636,504	26,889
8083500	Fort Phantom Hill	1938	70,036	4,213
8104650	Georgetown	1979	36,904	1,287
8088400	Graham	1958	45,302	2,444
8090900	Granbury	1969	129,011	7,945
8105600	Granger	1979	50,779	4,159
8054500	Grapevine	1952	164,703	6,707
7299840	Greenbelt	1968	60,400	2,025
8064510	Halbert	1921	6,033	603
8141000	Hords Creek	1948	8,112	510
8065330	Houston County	1966	17,665	1,330
8072000	Houston	1954	133,990	10,160
8086400	Hubbard Creek	1962	324,983	14,922
7315950	Hubert H. Moss	1966	24,155	1,140
8148100	Inks	1938	14,074	793
8118000	J.B. Thomas	1952	200,604	7,282
8032200	Jacksonville	1957	25,732	1,164
7342495	Jim Chapman	1991	298,930	17,958
8049800	Joe Pool	1991	176,895	7,470
7312000	Kemp	1923	245,434	15,357
7314000	Kickapoo	1945	85,825	5,864
8060500	Lavon	1953	456,526	20,559
8099000	Leon	1954	27,290	1,590
8052800	Lewisville	1955	598,902	27,175
8110470	Limestone	1978	208,017	12,486
8066190	Livingston	1969	1,741,900	83,277
8042820	Lost Creek	1991	11,950	413
8152500	Lyndon B. Johnson	1951	133,090	6,273
7298100	Mackenzie	1974	46,454	896
8022060	Martin	1974	75,116	4,981
8179500	Medina	1913	254,823	6,066
7227900	Meredith	1965	817,970	16,411
8082800	Millers Creek	1974	29,171	2,212
8090700	Mineral Wells	1920	7,065	440

USGS Gage ID	Reservoir Name	Year of Completion	Conservation Capacity (acre-feet)	Surface Area at Top of Conservation Pool (acres)
7344488	Monticello	1973	34,740	2,001
8050050	Mountain Creek	1936	22,840	2,710
8022200	Murvaul	1958	38,285	3,507
8036700	Nacogdoches	1977	39,523	2,212
8063050	Navarro Mills	1963	49,827	4,736
8062730	New Terrell City	1955	8,594	849
7312380	North Fork Buffalo Creek	1964	15,400	1,500
8134500	O.C. Fisher	1951	115,743	5,440
8136600	O.H. Ivie	1989	554,340	19,149
7345900	O the Pines	1958	241,363	17,638
8125500	Oak Creek	1952	39,360	2,375
8031400	Palestine	1971	373,204	22,656
7233550	Palo Duro	1991	61,239	2,413
8090300	Palo Pinto	1964	27,215	2,176
8091900	Pat Cleburne	1964	26,008	1,568
7335390	Pat Mayse	1967	117,844	5,638
8088500	Possum Kingdom	1941	540,340	16,716
8099400	Proctor	1963	55,457	4,615
8061550	Ray Hubbard	1969	452,040	20,963
8051100	Ray Roberts	1987	788,490	28,646
8064550	Richland-Chambers	1987	1,112,764	43,384
8039300	Sam Rayburn	1965	2,876,032	112,590
8109900	Somerville	1967	147,104	11,395
8091730	Squaw Creek	1977	151,418	3,169
8084500	Stamford	1953	51,573	5,124
8104050	Stillhouse Hollow	1968	227,825	6,484
7343460	Sulphur Springs	1973	17,838	1,340
8083200	Sweetwater	1930	11,582	630
8017400	Tawakoni	1960	871,693	37,325
8164525	Texana	1981	159,845	9,676
7331500	Texoma	1944	2,384,823	74,686
8025350	Toledo Bend	1969	4,477,000	181,600
8154500	Travis	1942	1,134,863	19,297
8131200	Twin Buttes	1963	186,200	9,082
8034000	Tyler	1967	80,198	4,737
8095550	Waco	1965	199,277	8,190
8063600	Waxahachie	1956	11,386	656

USGS Gage ID	Reservoir Name	Year of Completion	Conservation Capacity (acre-feet)	Surface Area at Top of Conservation Pool (acres)
8045800	Weatherford	1957	17,812	1,112
8080910	White River	1963	31,846	1,642
8092500	Whitney	1951	554,203	23,220
8045400	Worth	1914	33,495	3,458
7344200	Wright Patman	1954	308,020	18,247

Appendix B: Minimum, Average, and Maximum Annual Gross Evaporation Loss from 114 Monitored Reservoirs

USGS Gage ID	Reservoir Name	Minimum Annual Gross Evaporation Loss (acre-feet)	Average Annual Gross Evaporation Loss (acre-feet)	Maximum Annual Gross Evaporation Loss (acre-feet)
8083270	Abilene	69	1,665	3,056
8079700	Alan Henry	9,707	14,940	21,676
8888888	Amistad	160,482	292,180	466,064
8043700	Amon G Carter	5,172	6,717	7,930
8093350	Aquilla	11,765	14,031	16,170
8049200	Arlington	7,714	8,685	10,339
7314800	Arrowhead	31,853	60,425	77,267
8031290	Athens	6,821	7,861	8,713
8154900	Austin	5,430	6,539	8,227
8040000	B.A. Steinhagen	15,841	32,368	43,149
8063700	Bardwell	13,321	14,848	16,727
8102000	Belton	49,996	58,347	68,323
8046500	Benbrook	14,059	15,277	17,299
7344489	Bob Sandlin	31,045	34,998	39,743
7332610	Bonham	3,983	4,345	4,872
8144900	Brady Creek	4,826	7,518	9,571
8043000	Bridgeport	38,133	51,179	61,326
8143000	Brownwood	25,255	31,880	40,103
8148000	Buchanan	52,299	79,284	102,380
7346310	Caddo	52,145	91,551	131,833
8167700	Canyon	29,671	37,977	56,726
8063010	Cedar Creek	135,307	148,578	170,775
8123600	Champion Creek	299,018	365,287	482,404
8206900	Choke Canyon	62,607	104,849	134,326
8086215	Cisco	2,099	2,651	3,285
8140770	Coleman	4,823	7,791	10,760
8177400	Coleto Creek	7,803	9,708	14,834
8123000	Colorado City	3,496	6,334	8,905
8067600	Conroe	74,725	82,944	94,407
8210500	Corpus Christi	37,626	73,151	95,430
7335600	Crook	3,755	4,365	5,321
7344484	Cypress Springs	12,137	13,691	16,065
8086600	Daniel	80	2,017	4,656

USGS Gage ID	Reservoir Name	Minimum Annual Gross Evaporation Loss (acre-feet)	Average Annual Gross Evaporation Loss (acre-feet)	Maximum Annual Gross Evaporation Loss (acre-feet)
8123950	E.V. Spence	3,915	15,338	27,601
8045000	Eagle Mountain	33,001	37,517	45,691
7312180	Electra	7	686	1,536
9999999	Falcon	97,254	270,461	437,423
7315600	Farmers Creek	4,051	6,010	6,932
8018800	Fork	105,677	117,589	134,244
8083500	Fort Phantom Hill	10,684	16,052	23,824
8104650	Georgetown	3,212	4,270	5,785
8088400	Graham	8,504	11,717	14,608
8090900	Granbury	22,829	32,552	39,992
8105600	Granger	17,015	21,799	45,685
8054500	Grapevine	24,599	32,871	56,668
7299840	Greenbelt	3,060	4,917	5,987
8064510	Halbert	1,954	2,342	2,601
8141000	Hords Creek	101,007	127,779	160,213
8065330	Houston County	5,753	6,114	7,003
8072000	Houston	32,333	42,991	51,344
8086400	Hubbard Creek	25,630	47,736	75,895
7315950	Hubert H. Moss	4,482	5,381	6,029
8148100	Inks	2,814	3,402	4,071
8118000	J.B. Thomas	2,851	10,806	20,129
8032200	Jacksonville	4,755	5,202	6,125
7342495	Jim Chapman	46,707	63,125	75,045
8049800	Joe Pool	30,749	34,743	42,993
7312000	Kemp	23,901	54,415	85,245
7314000	Kickapoo	14,277	23,943	30,566
8060500	Lavon	60,892	84,424	97,023
8099000	Leon	5,351	6,421	8,074
8052800	Lewisville	94,207	111,420	129,760
8110470	Limestone	52,577	58,085	62,620
8066190	Livingston	230,901	339,530	374,933
8042820	Lost Creek	1,337	1,614	1,920
8152500	Lyndon B. Johnson	21,710	26,587	32,035
7298100	Mackenzie	888	1,535	1,928
8022060	Martin	16,431	18,367	20,371
8179500	Medina	2,240	15,319	22,659

USGS Gage ID	Reservoir Name	Minimum Annual Gross Evaporation Loss (acre-feet)	Average Annual Gross Evaporation Loss (acre-feet)	Maximum Annual Gross Evaporation Loss (acre-feet)
7227900	Meredith	10,701	27,841	54,259
8082800	Millers Creek	2,948	7,540	11,712
8090700	Mineral Wells	1,503	2,547	3,251
7344488	Monticello	7,204	8,571	10,762
8050050	Mountain Creek	12,098	13,203	15,129
8022200	Murvaul	13,312	14,506	15,910
8036700	Nacogdoches	7,483	8,640	10,771
8063050	Navarro Mills	19,636	23,669	26,868
8062730	New Terrell City	1,938	3,472	4,324
7312380	North Fork Buffalo Creek	344	2,224	4,379
8134500	O C. Fisher	1,175	3,243	6,350
8136600	O H. Ivie	27,383	57,689	94,222
7345900	O the Pines	63,882	83,093	115,637
8125500	Oak Creek	2,136	6,212	13,640
8031400	Palestine	89,859	101,571	115,074
7233550	Palo Duro	914	2,112	5,209
8090300	Palo Pinto	3,428	8,765	11,618
8091900	Pat Cleburne	6,381	6,970	8,308
7335390	Pat Mayse	0	21,810	26,406
8088500	Possum Kingdom	54,303	72,051	88,775
8099400	Proctor	7,860	17,216	22,438
8061550	Ray Hubbard	79,030	95,882	112,966
8051100	Ray Roberts	104,569	138,086	155,020
8064550	Richland-Chambers	183,209	208,382	252,569
8039300	Sam Rayburn	411,792	446,758	551,510
8109900	Somerville	44,997	55,012	87,553
8091730	Squaw Creek	12,939	14,942	18,374
8084500	Stamford	6,504	20,560	30,764
8104050	Stillhouse Hollow	23,636	30,581	52,975
7343460	Sulphur Springs	208,708	277,750	332,027
8083200	Sweetwater	681	1,806	3,517
8017400	Tawakoni	126,492	160,689	193,291
8164525	Texana	27,737	34,835	40,341
7331500	Texoma	272,934	338,238	475,729
8025350	Toledo Bend	631,322	716,278	833,781

USGS Gage ID	Reservoir Name	Minimum Annual Gross Evaporation Loss (acre-feet)	Average Annual Gross Evaporation Loss (acre-feet)	Maximum Annual Gross Evaporation Loss (acre-feet)
8154500	Travis	37,425	60,452	76,091
8131200	Twin Buttes	3,642	9,505	22,745
8034000	Tyler	17,343	20,653	23,845
8095550	Waco	32,917	42,645	51,817
8063600	Waxahachie	2,740	2,968	3,278
8045800	Weatherford	4,084	4,548	5,341
8080910	White River	2,381	3,847	6,708
8092500	Whitney	75,189	87,645	102,697
8045400	Worth	13,530	15,044	18,187
7344200	Wright Patman	88,748	108,547	130,835

Appendix C: Minimum, Average, and Maximum Annual Net Evaporation Loss / Gain[2] from 114 Monitored Reservoirs Used in the Analysis

USGS Gage ID	Reservoir Name	Minimum Annual Net Evaporation Loss/Gain (acre-feet)	Average Annual Net Evaporation Loss/Gain (acre-feet)	Maximum Annual Net Evaporation Loss (acre-feet)
8083270	Abilene	61	1,048	2,142
8079700	Alan Henry	6,115	10,642	20,349
8888888	Amistad	117,059	225,833	440,437
8043700	Amon G Carter	431	2,980	4,772
8093350	Aquilla	-806	5,636	11,825
8049200	Arlington	-311	3,523	7,412
7314800	Arrowhead	12,641	34,896	64,226
8031290	Athens	-597	2,003	5,165
8154900	Austin	-967	2,342	6,292
8040000	B.A. Steinhagen	-25,270	-5,550	19,732
8063700	Bardwell	-488	5,250	10,262
8102000	Belton	-2,055	23,898	47,470
8046500	Benbrook	-910	5,916	12,450
7344489	Bob Sandlin	-14,307	6,875	21,056
7332610	Bonham	-634	1,155	2,961
8144900	Brady Creek	2,477	4,752	7,126
8043000	Bridgeport	3,156	22,989	37,379
8143000	Brownwood	11,080	20,001	29,751
8148000	Buchanan	-3,749	34,169	68,588
7346310	Caddo	-43,274	7,056	70,794
8167700	Canyon	-17,077	12,756	32,989
8063010	Cedar Creek	-7,064	53,190	108,304
8123600	Champion Creek	136,304	254,591	449,658
8206900	Choke Canyon	7,263	58,269	114,606
8086215	Cisco	186	1,345	2,107
8140770	Coleman	2,698	4,716	7,692
8177400	Coleto Creek	-4,255	2,118	5,973
8123000	Colorado City	2,594	4,311	6,569
8067600	Conroe	-27,517	9,368	63,347
8210500	Corpus Christi	4,477	33,602	79,880
7335600	Crook	-1,800	857	2,589

[2] Negative value in table means water gain in reservoir when precipitation exceeds evaporation.

USGS Gage ID	Reservoir Name	Minimum Annual Net Evaporation Loss/Gain (acre-feet)	Average Annual Net Evaporation Loss/Gain (acre-feet)	Maximum Annual Net Evaporation Loss (acre-feet)
7344484	Cypress Springs	-5,787	2,618	8,154
8086600	Daniel	78	1,008	2,918
8123950	E.V. Spence	3,183	10,211	21,544
8045000	Eagle Mountain	-764	15,422	32,914
7312180	Electra	4	437	1,077
9999999	Falcon	68,455	188,967	397,242
7315600	Farmers Creek	429	2,652	4,214
8018800	Fork	-10,732	30,043	79,391
8083500	Fort Phantom Hill	3,531	9,897	16,728
8104650	Georgetown	-1,886	935	2,901
8088400	Graham	2,309	6,797	12,087
8090900	Granbury	-2,248	13,193	29,213
8105600	Granger	-5,829	6,684	16,014
8054500	Grapevine	-226	13,737	25,679
7299840	Greenbelt	2,121	3,328	4,341
8064510	Halbert	-100	802	1,444
8141000	Hords Creek	30,668	79,486	119,615
8065330	Houston County	-1,377	1,166	4,402
8072000	Houston	-21,742	-1,771	25,822
8086400	Hubbard Creek	6,103	24,169	47,634
7315950	Hubert H. Moss	331	2,347	3,841
8148100	Inks	-236	1,508	3,194
8118000	J.B. Thomas	2,353	7,745	15,421
8032200	Jacksonville	-997	1,097	3,854
7342495	Jim Chapman	-34,703	10,187	37,010
8049800	Joe Pool	-2,157	11,905	26,829
7312000	Kemp	16,183	34,899	59,875
7314000	Kickapoo	5,390	13,863	25,491
8060500	Lavon	-8,314	23,951	59,164
8099000	Leon	239	3,211	5,033
8052800	Lewisville	-16,680	28,699	78,451
8110470	Limestone	-3,463	20,543	41,244
8066190	Livingston	-110,165	37,287	260,873
8042820	Lost Creek	-276	561	1,455
8152500	Lyndon B. Johnson	-1,715	11,832	24,939
7298100	Mackenzie	598	1,115	1,645

USGS Gage ID	Reservoir Name	Minimum Annual Net Evaporation Loss/Gain (acre-feet)	Average Annual Net Evaporation Loss/Gain (acre-feet)	Maximum Annual Net Evaporation Loss (acre-feet)
8022060	Martin	-6,504	1,500	9,010
8179500	Medina	-2,647	5,837	14,357
7227900	Meredith	7,972	20,486	43,518
8082800	Millers Creek	1,968	4,864	8,716
8090700	Mineral Wells	90	1,237	1,873
7344488	Monticello	-3,349	1,741	5,259
8050050	Mountain Creek	-670	4,594	9,023
8022200	Murvaul	-5,420	1,011	8,209
8036700	Nacogdoches	-4,770	355	5,744
8063050	Navarro Mills	-1,095	8,283	17,787
8062730	New Terrell City	-85	1,212	2,681
7312380	North Fork Buffalo Creek	87	1,295	3,239
8134500	O.C. Fisher	750	2,183	4,982
8136600	O.H. Ivie	17,773	37,345	69,969
7345900	O the Pines	-55,881	2,779	46,483
8125500	Oak Creek	1,417	4,418	9,873
8031400	Palestine	-8,558	25,770	68,011
7233550	Palo Duro	701	1,651	3,850
8090300	Palo Pinto	436	4,380	7,964
8091900	Pat Cleburne	-259	2,834	5,992
7335390	Pat Mayse	-9,948	4,098	13,854
8088500	Possum Kingdom	2,947	36,294	58,624
8099400	Proctor	696	7,771	15,076
8061550	Ray Hubbard	-4,922	34,117	69,906
8051100	Ray Roberts	6,332	60,759	98,479
8064550	Richland-Chambers	-7,627	78,582	171,405
8039300	Sam Rayburn	-221,027	24,104	297,250
8109900	Somerville	-28,569	10,828	35,895
8091730	Squaw Creek	-467	6,155	13,171
8084500	Stamford	4,344	13,231	27,689
8104050	Stillhouse Hollow	-2,101	10,869	21,825
7343460	Sulphur Springs	-45,330	76,015	168,087
8083200	Sweetwater	429	1,297	2,989
8017400	Tawakoni	-16,217	40,512	114,721
8164525	Texana	-13,964	6,278	21,533

USGS Gage ID	Reservoir Name	Minimum Annual Net Evaporation Loss/Gain (acre-feet)	Average Annual Net Evaporation Loss/Gain (acre-feet)	Maximum Annual Net Evaporation Loss (acre-feet)
7331500	Texoma	-72,362	83,172	213,635
8025350	Toledo Bend	-326,054	5,578	452,721
8154500	Travis	-14,015	19,273	44,262
8131200	Twin Buttes	1,391	6,459	16,890
8034000	Tyler	-1,400	5,351	14,138
8095550	Waco	1,233	19,415	38,955
8063600	Waxahachie	-230	1,019	2,038
8045800	Weatherford	-116	1,849	3,839
8080910	White River	1,510	2,784	6,306
8092500	Whitney	-5,808	33,835	58,516
8045400	Worth	-517	6,108	13,054
7344200	Wright Patman	-106,900	-12,949	50,475