

APPENDIX M

MILAN, MISSOURI – WATER SUPPLY STUDY

Missouri Water Supply Studies (2005)

Milan, Missouri
Water Supply Study
Elmwood Lake and Golf Course Lake

Milan is located in central Sullivan County Missouri with East Locust Creek flowing along the eastern boundary of the city.

Milan has two reservoirs that are available for use as water supply. The larger one is Elmwood Lake, which is located about 2 miles North of Milan on a tributary to East Locust Creek. Golf Course Lake is an older lake and is located near the city a short distance East of East Locust Creek.

At the time of this report, year 2000, Milan was experiencing severe water shortage. They had nearly emptied both lakes and were pumping from Locust Creek at a site west of Milan. They were using an average of 1.65 million gallon per day. A 3000-gallon per minute pump was used for pumping from Locust Creek. Pumping only occurred when flow in Locust Creek was sufficient to allow pumping plus allow flow to pass downstream for in-stream flow requirements.

Lake surveys of Elmwood Lake and Golf Course Lake were made by the NRCS in year 2000. The drainage area of Elmwood Lake is 6.41 square miles and Golf Course Lake's drainage area is 1.06 square miles.

Storage in Elmwood Lake has been increased in recent years to provide water to two meat processing plants in addition to the cities needs, a rural water district has been removed from the system to conserve water. Before The lake was modified, it had significant leakage. Leakage has now been greatly reduced.

The optimum demand from Lake Elmwood averages 737,500 gallon per day, and Golf Course Lake can be expected to yield and average of 115,930 gallon per day. The total for both lakes is 853,430 gallons per day. This is far short of the demand, 1.65 million gallon per day, placed on the system. Capacities of the lakes are 2503 acre-feet for Elmwood and 555 acre-feet for Golf Course Lake.

Following is the data and procedures for input to the "RESOP" program.

STO-AREA -- Elevation-Storage and Elevation-Area data were determined from May 2000 survey made by NRCS. Elmwood and Golf Course Lakes were surveyed

Elmwood Lake			Golf Course Lake		
Elevation (feet)	Area (acres)	Storage (ac-ft)	Elevation (feet)	Area (acres)	Storage (ac-ft)
842	0.25	0	64	0.21	0
844	0.93	1.19	66	2.61	2.82
846	1.60	3.72	68	4.89	10.31
848	4.58	9.91	70	7.95	23.16
850	20.04	34.53	72	11.00	42.11
852	32.17	86.75	74	14.67	67.77
854	46.45	165.37	76	17.88	100.32
856	63.37	275.19	78	20.97	139.17
858	78.34	416.91	80	25.02	185.15
860	94.06	589.32	82	29.54	239.70
862	113.13	796.51	84	34.70	303.94
864	137.94	1047.59	84.6	36.41	325.27
866	154.61	1340.14	86	38.63	377.80
868	170.09	1664.84	88	41.96	458.4
870	202.02	2036.95	90.1	50.24	555.21
872.2	221.85	2503.21			

	Elmwood Lake	Golf Course Lake
Normal Pool Elev.	= 872.2	= 90.1
May 25,2000 water elev.	= 864.0	May 2000 water elev. 84.6

LIMITS Elmwood Reservoir Max. Pool storage 2503 Ac.Ft.
Minimum Pool storage 417 Ac.Ft.

Minimum pool storage determination for Elmwood Reservoir.
e-mail from Steve McIntosh to Jerry Lane dated 4/24/2000.
Minimum storage from an old survey is 658 ac.ft. at elevation. 858.
At elev. 858 from new survey data, minimum storage is 417 Ac.Ft.

Golf Course Res. Maximum Pool storage 555 Ac.Ft.
Minimum Pool storage 162 Ac.Ft.

Minimum Pool Storage determination for Golf Course Reservoir.

E-mail from Steve McIntosh to Jerry Lane dated 4/24/2000.
Established storage of 176 acre feet as the minimum, this
is at assumed elevation 79. At elevation 79 from new survey data
minimum storage is 162 acre feet.

GENERAL Record period of drought is in the 1950's.
Analysis began in Jan. 1951 and ended December 1959

SEEPAGE For Elmwood Lake, seepage varied from 0 seepage near empty to a maximum of 3 inches per month when at full pool. Golf Course Lake allowed for seepage of 1.5 inches when full.

RAINFALL Rainfall data came from the Milan, Missouri rain gage.

RUNOFF This is the runoff into the lake from its drainage area. Monthly runoff volumes in watershed inches was determined at the Linneus gage on Locust creek. When runoff did not appear reasonable when compared to rainfall it was necessary to examine daily rainfall values for that month. Antecedent moisture was estimated for each rainfall event and adjustments to NRCS runoff curve number was made to arrive at runoff for each storm.

EVAP. Pan evaporation at the Lakeside gaging station was used as a base because it has data for year around evaporation. This data was updated with gage data from stations at Spickard, New Franklin, and Columbia. Depending on the latest data for the station nearest to Milan.

DEMAND This was determined by city records.
Break down of usage:
Determined from e-mail from Everett Baker to Deana Cash on Feb. 4, 2000.

Milan Production		
PWSD#1	300,000 GPD	= 0.92 Ac.Ft.
Con. Ag.	353,000 GPD	= 1.08 Ac.Ft.
City Use	297,000 GPD	= 0.91 Ac.Ft.
	-----	-----
Finished Water	950,000 GPD	= 2.91 Ac.Ft.
Raw Water to PSF	700,000 GPD	= 2.15 Ac.Ft.
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Total Use	1.65 MGD	5.06 Ac.Ft.
From Elmwood Res.	1.25 MGD	3.83 Ac.Ft.
From Golf Course	400,000 GPD	1.23 Ac.Ft.

When the Golf Course Reservoir water supply became depleted it was necessary to take all the water from Elmwood Reservoir. Golf Course Reservoir emptied rather quickly.

OTHER This refers to the volume of water pumped from Locust creek into Elmwood Reservoir.

Determination of the volume of water available for pumping was made using daily discharges at the stream gage at Linneus. The drainage area at Linneus is 550 square miles and the drainage area at the point of pumping is 225 square miles. The daily discharge rates at the point of pumping were reduced by a ratio of 225/550. Pumping was only planned for flows above 10 cfs. The maximum rate of pumping was 3000 gallons per minute or 6.68 cfs. It was necessary to have continuous pumping when enough flow was in Locust Creek

Milan, Missouri
Water Supply Study
Shatto Lake
Private Lake

Shatto Lake is a small private lake at the south side of Milan, in central Sullivan County, Missouri. It was investigated to determine the amount of emergency water supply that is available.

This lake 34-acre lake has a very small drainage area, 173 acres, too small to provide much water. This privately owned 35-acre lake is 40 feet deep and the owners have not been successful in sealing off a leak at the base of the dam.

Because there is no daily demand placed on this lake only an optimized run was made. The daily volume of water available is 83,000 gallon per day. By removing water at this rate the lake would be emptied and have no opportunity to refill until some time after the 1950's.

Shatto Lake analysis consisted of using the NRCS's computer program "RESOP". This program analyzes remaining stored water at the end of each month by summing gains and losses.

STO-AREA Elevation-Storage and Elevation-Area data were determined from May 2000 survey made by USGS.

SHATTO LAKE

Elevation (feet)	Area (acres)	Volume (acre-ft)
846.0	0.19	0.18
848.0	0.47	0.74
850.0	1.15	2.44
852.0	1.89	5.48
854.0	2.59	9.96
856.0	3.24	15.78
858.0	4.27	23.28
860.0	5.45	33.01
862.0	6.86	45.26
864.0	8.42	60.51
866.0	10.03	78.93
868.0	11.57	100.56
870.0	13.08	125.19
872.0	14.62	152.90
874.0	16.40	183.80
876.0	18.60	218.80
878.0	20.56	258.00
880.0	22.38	300.92
882.0	24.22	347.55
884.0	25.75	397.51
886.0	27.33	450.55
888.0	29.00	506.92
890.0	30.49	566.41
890.3	30.76	575.59
892.0	32.02	628.98
893.0	32.80	661.37
894.0	33.51	694.53
895.6	34.68	749.08

LIMITS	Maximum Pool storage	661 Ac.Ft.
	Minimum Pool storage	80 Ac.Ft.
	Starting storage was considered full pool.	
	The drainage area of the lake is 0.27 square miles.	
GENERAL	Record period of drought is in the 1950's. Analysis began in January 1951 and ended December 1959.	
SEEPAGE	For Shatto Lake, seepage is high. For this study, seepage varied from 0 near empty to a maximum of 3 inches per month when at full pool.	
RAINFALL	Rainfall data came from the Milan, Missouri rain gage.	
RUNOFF	This is the runoff into the lake from its drainage area. Monthly runoff volumes in watershed inches was determined at the Linneus gage on Locust Creek. When runoff did not appear reasonable compared to rainfall it was necessary to examine daily rainfall values for that month. Antecedent moisture was estimated for each rainfall event and adjustments to NRCS runoff curve number was made to arrive at runoff for each storm.	
EVAP.	Pan evaporation at the Lakeside gaging station was used as a base because it has data for year around evaporation. This data was updated with gage data from stations at Spickard, New Franklin, and Columbia. Depending on the latest data for the station nearest to Milan.	
DEMAND	This control word was only used to establish a monthly distribution because the purpose of this analysis was to determine the optimum yield.	
OTHER	This control word was not used because no other inflows were considered.	

Milan, Missouri
Water Supply Study
Elmwood Reservoir
Storage Volume

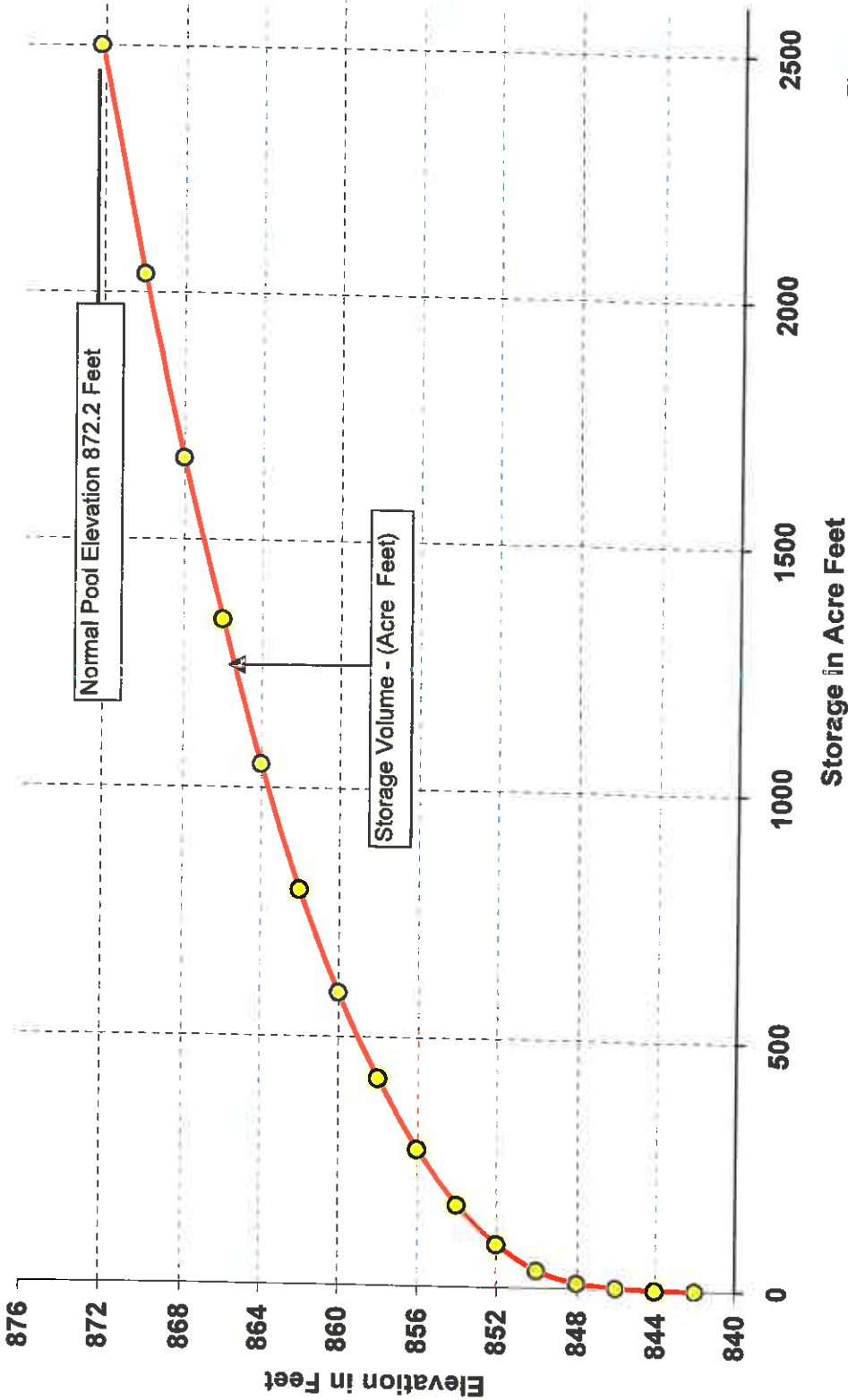


Figure 22.1.a

**Milan, Missouri
Water Supply Supply
Elmwood Lake
Surface Area**

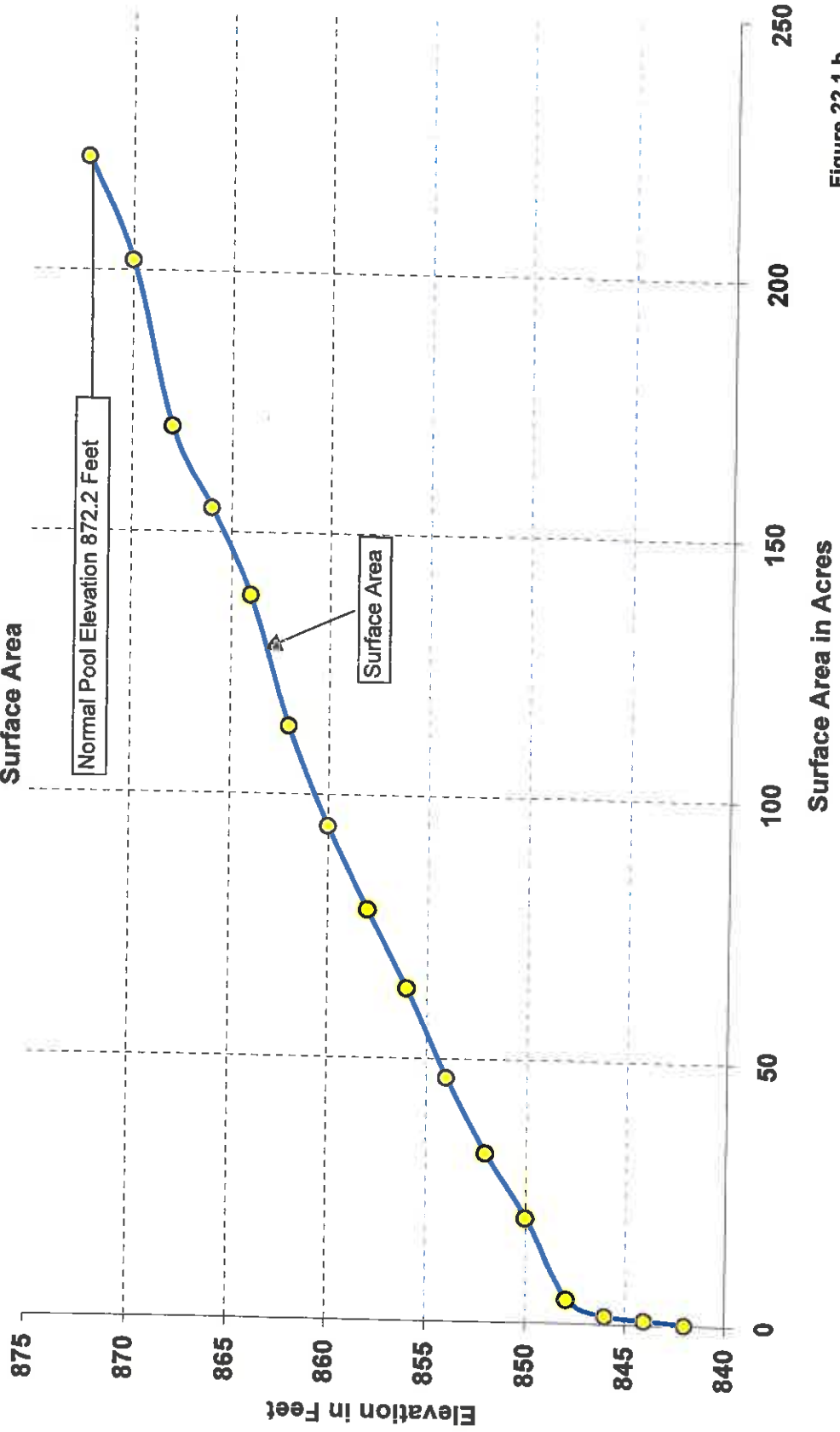


Figure 22.1.b

Milan, Missouri
Water Supply Study
Golf Course Lake
Storage Volume

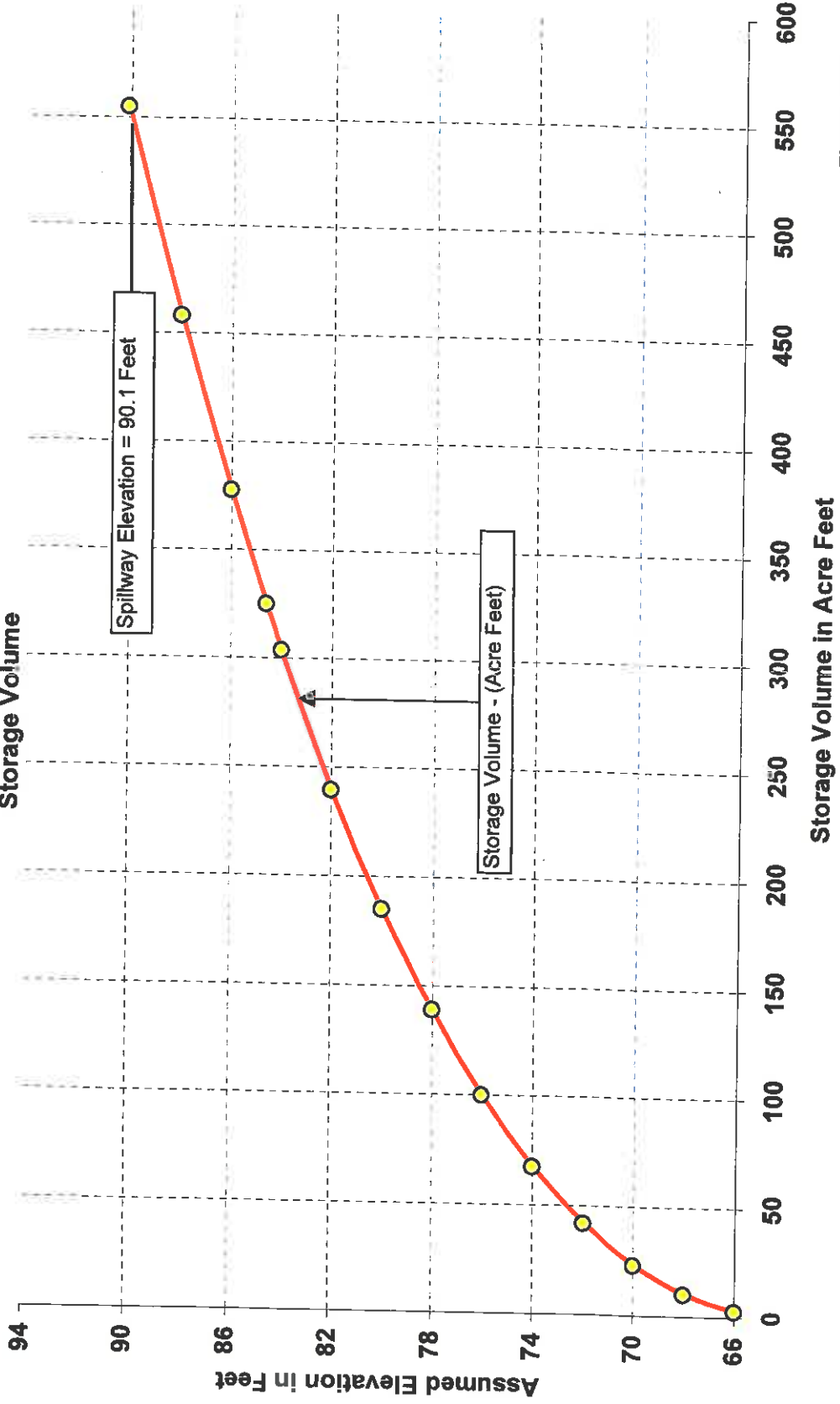


Figure 22.1.c

Milan, Missouri
Water Supply Study
Golf Course Lake
Surface Area

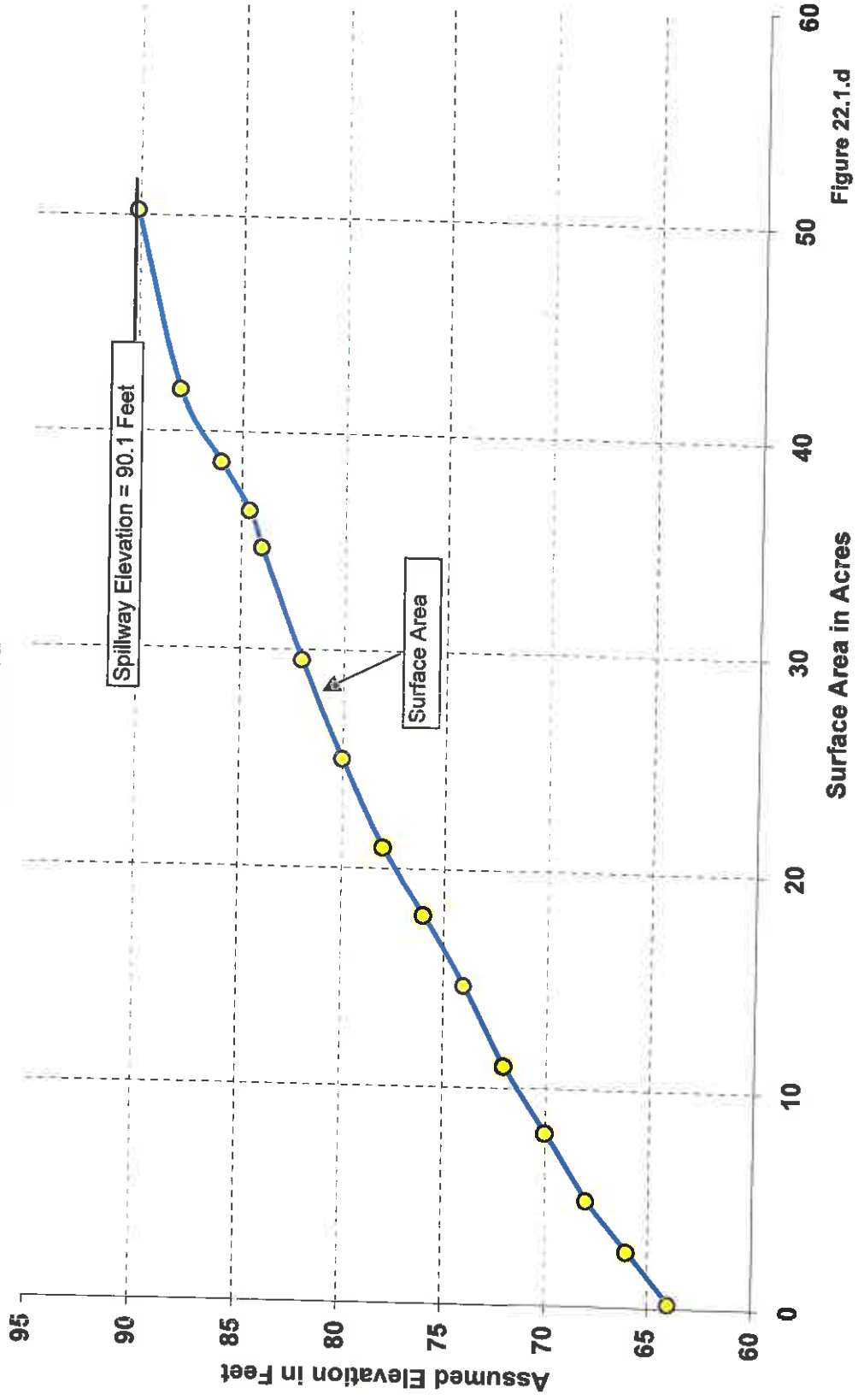


Figure 22.1.d

Milan, Missouri
Water Supply Study
Shatto Lake
Storage Volume

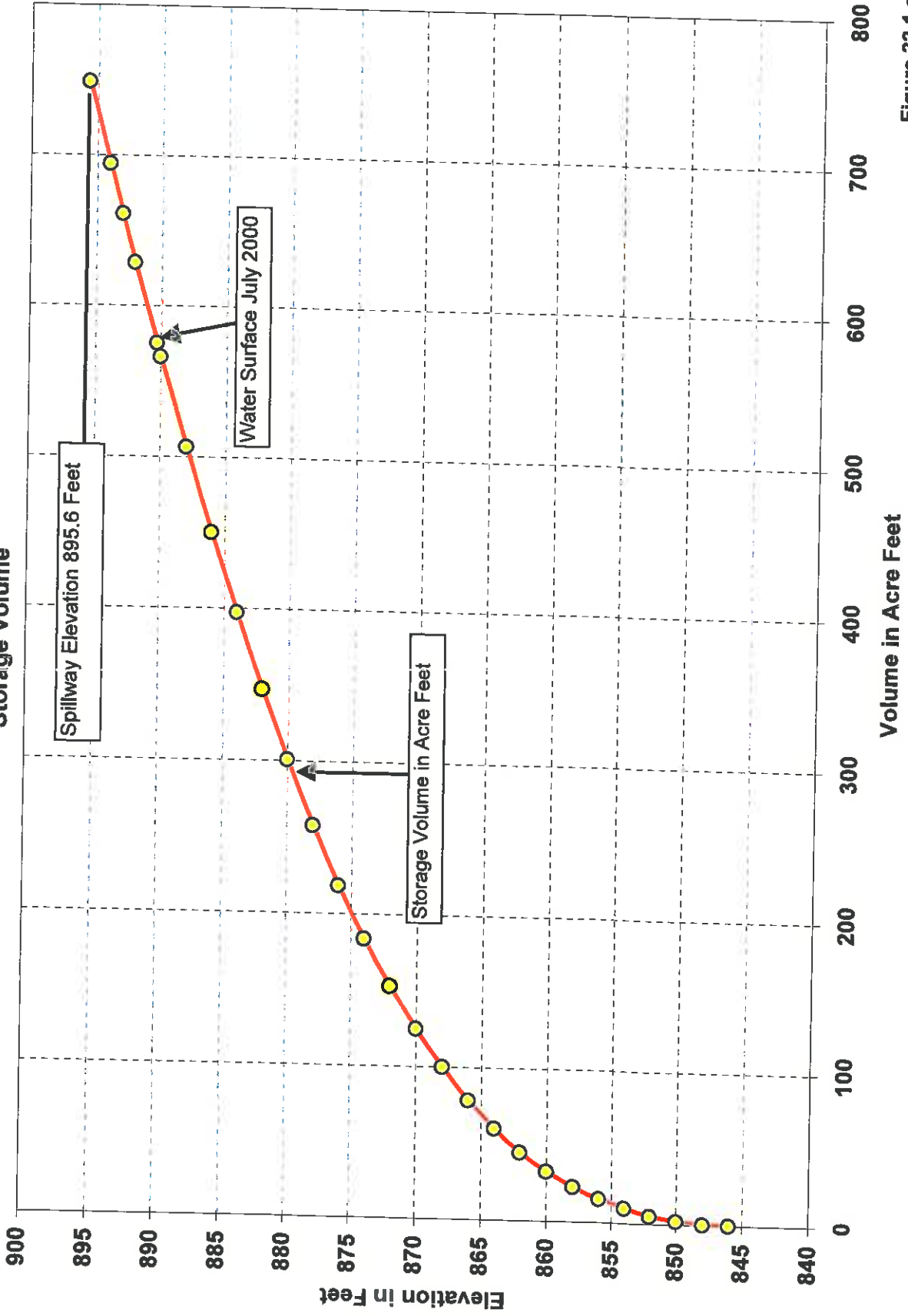


Figure 22.1.e

**Milan, Missouri
Water Supply Study
Shatto Lake
Surface Area**

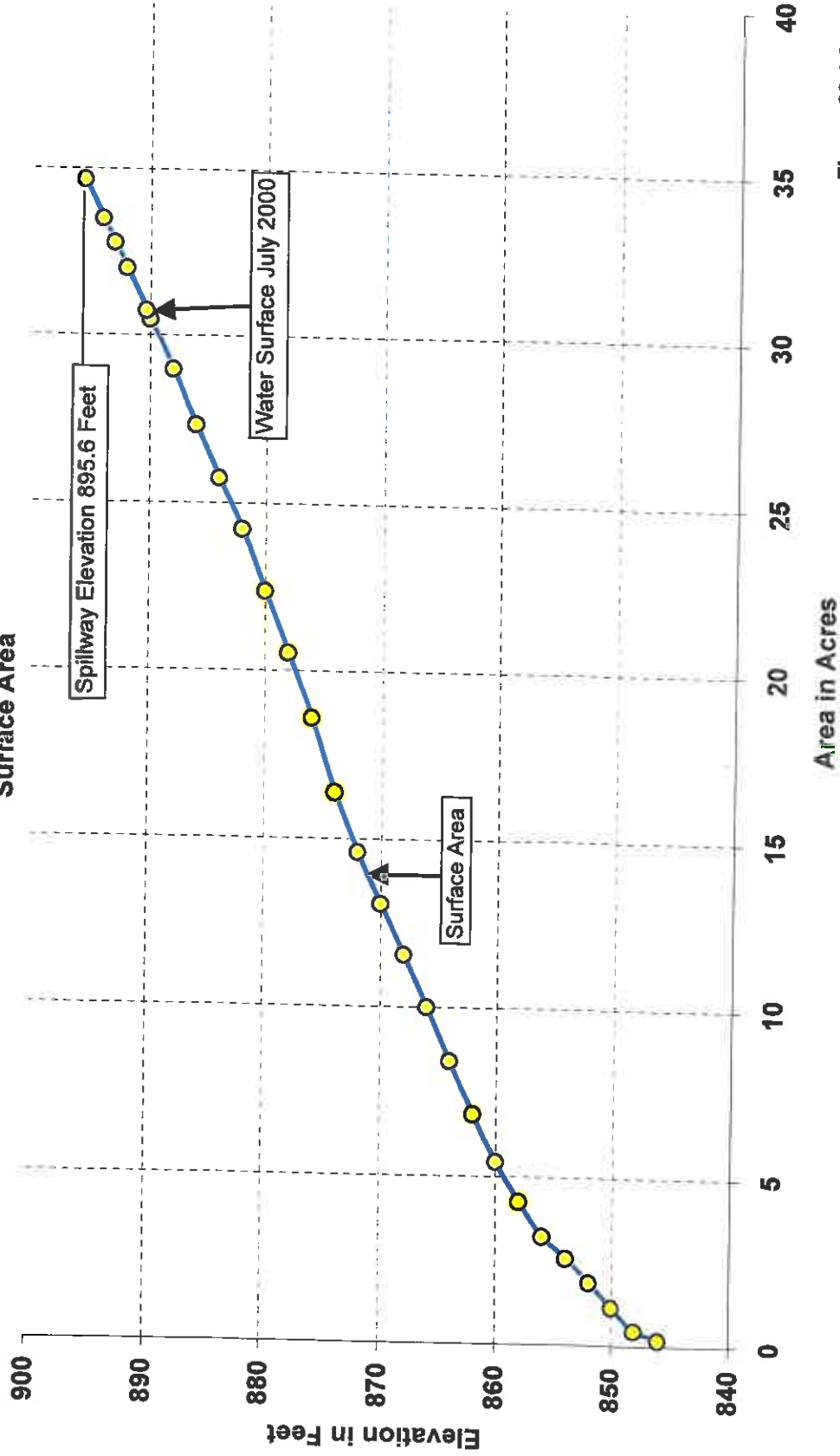


Figure 22.1.f

**Milan, Missouri
Water Supply Study
Elmwood Reservoir
Lake Storage**

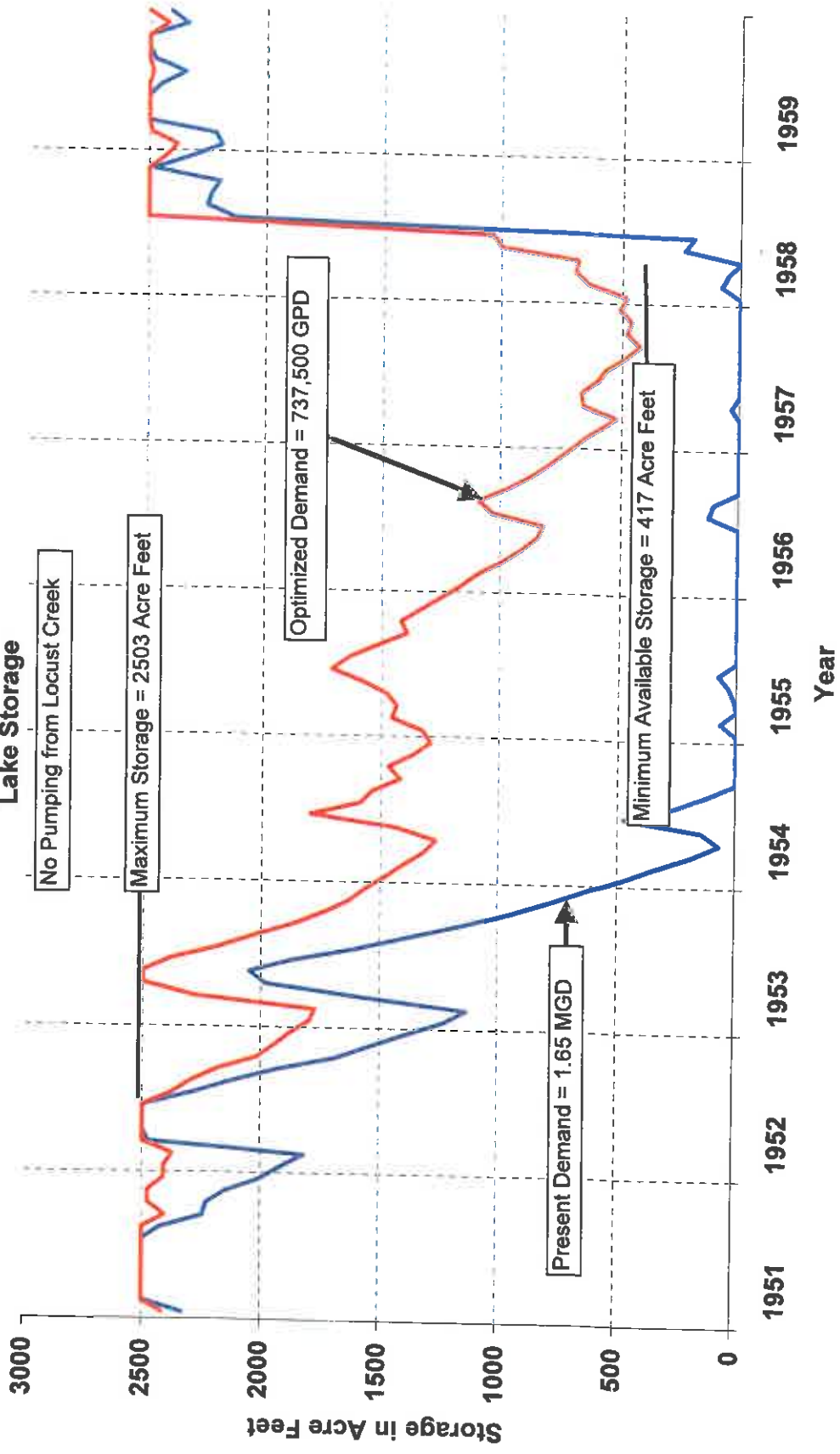


Figure 22.2.a

Milan, Missouri
Water Supply Study
Elmwood Lake
Lake Storage

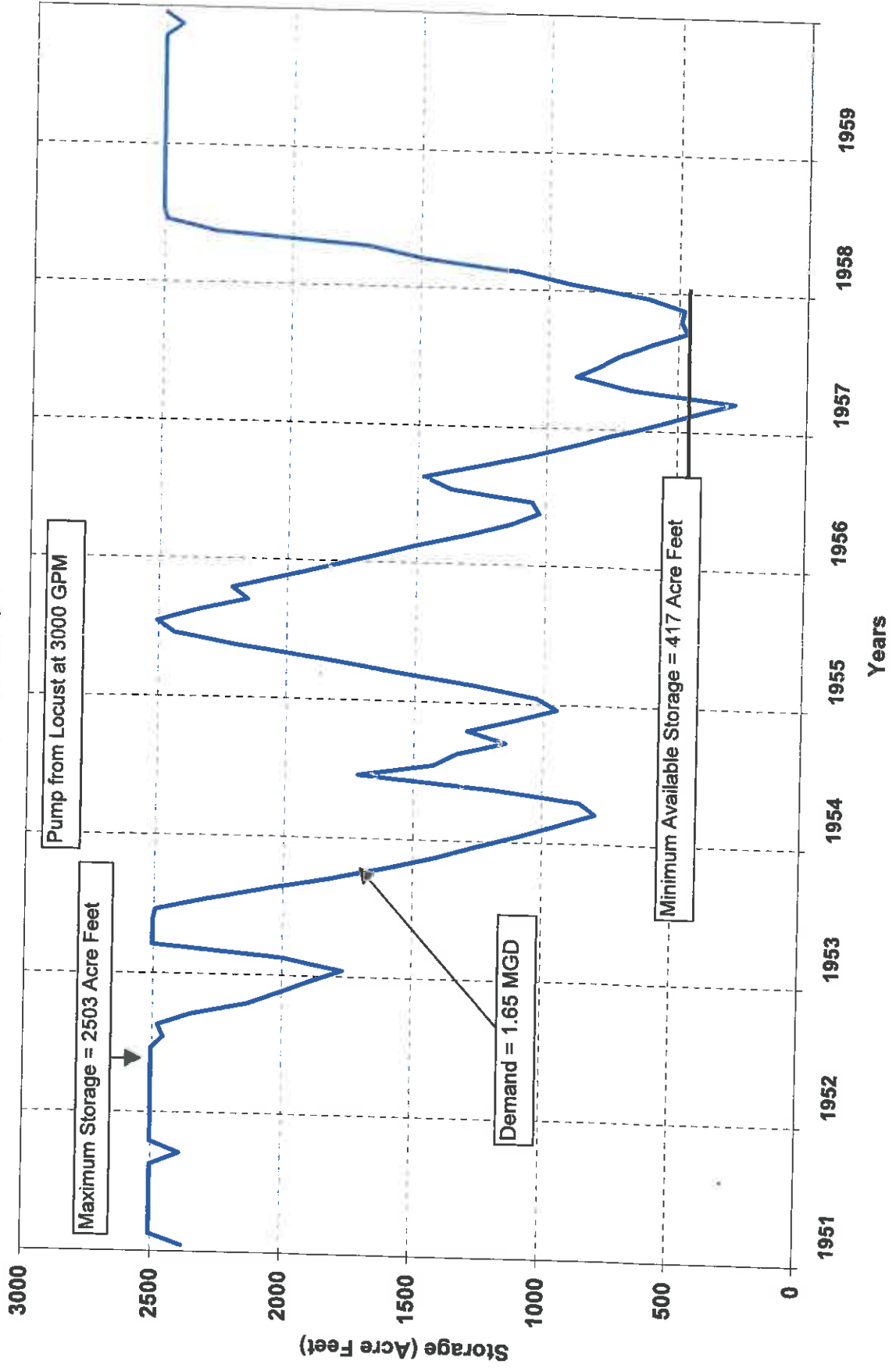


Figure 22.2.b

Milan, Mo.
Water Supply Study
Golf Course Lake
Lake Storage

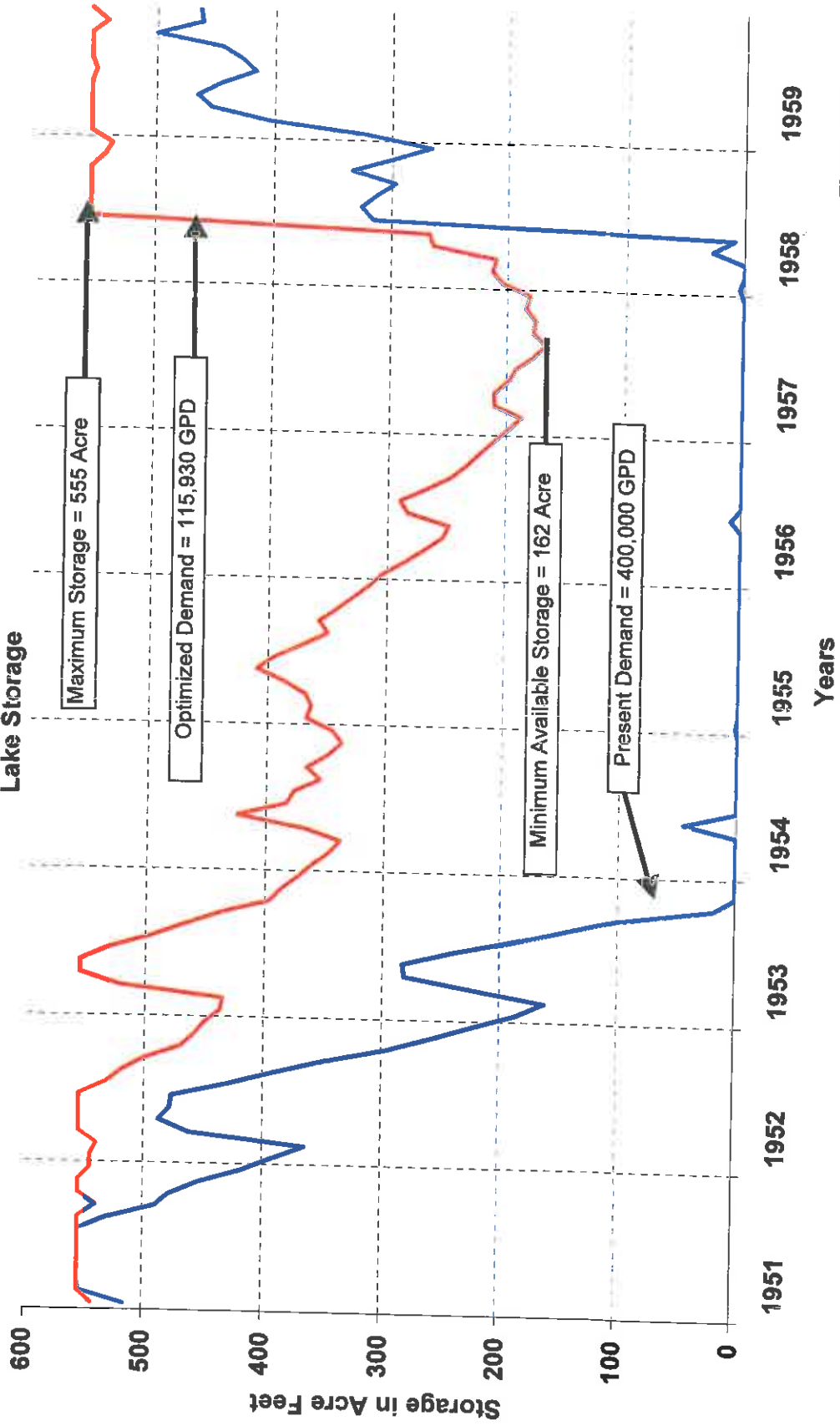


Figure 22.2.c

Miian, Missouri
Water Supply Study
Shatto Lake
Lake Storage

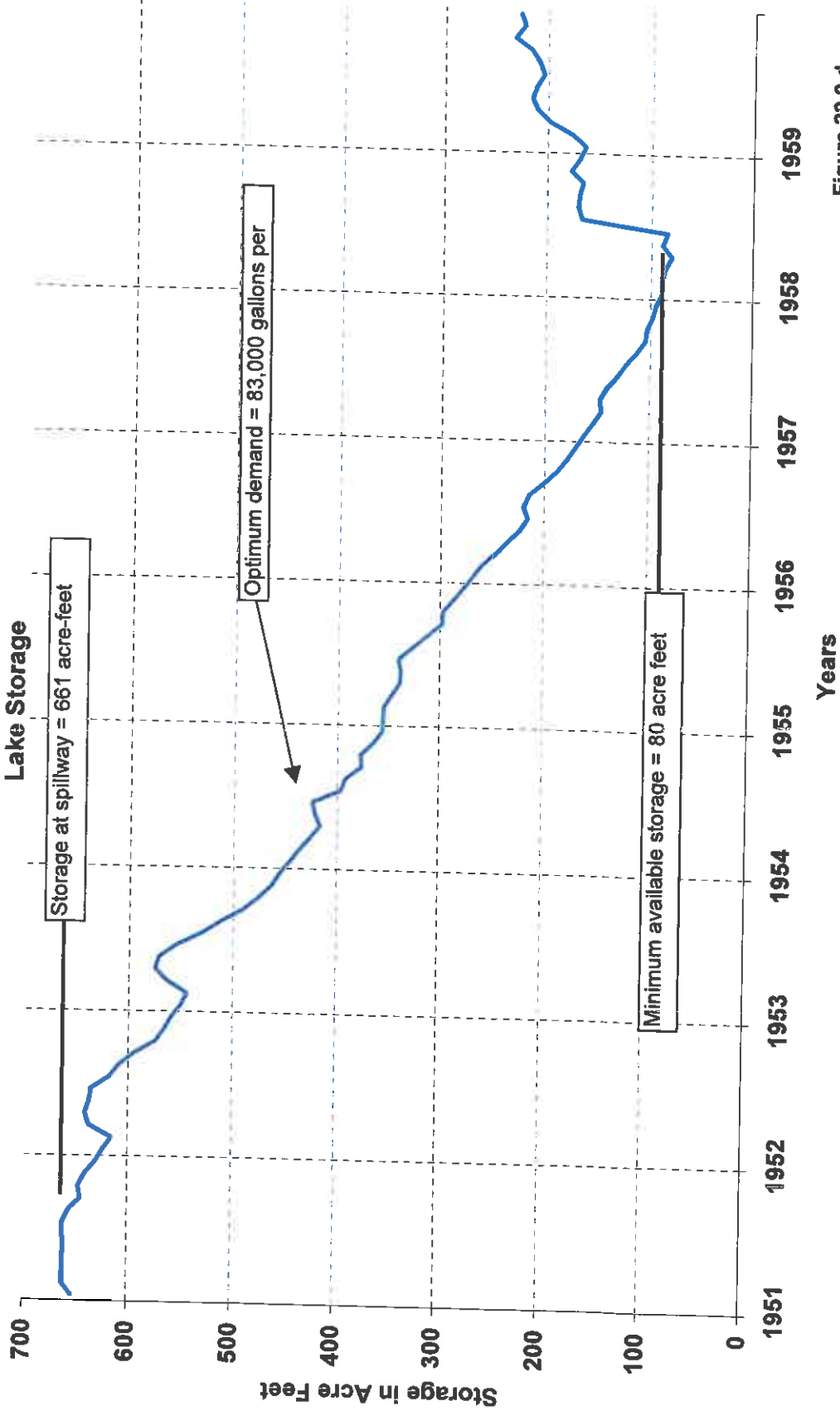


Figure 22.2.d

Milan, Missouri Water Supply Study Water Use

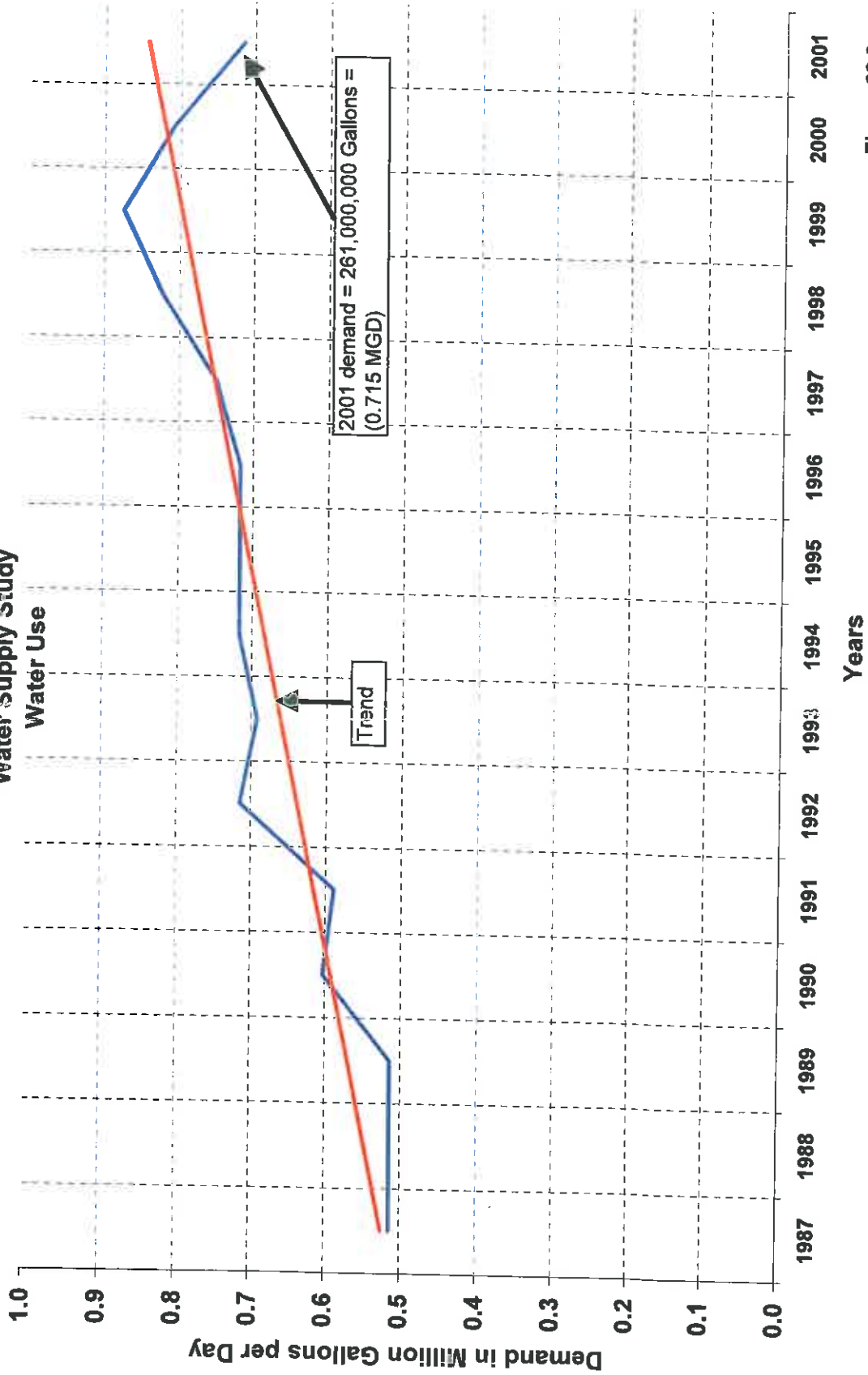


Figure 22.3

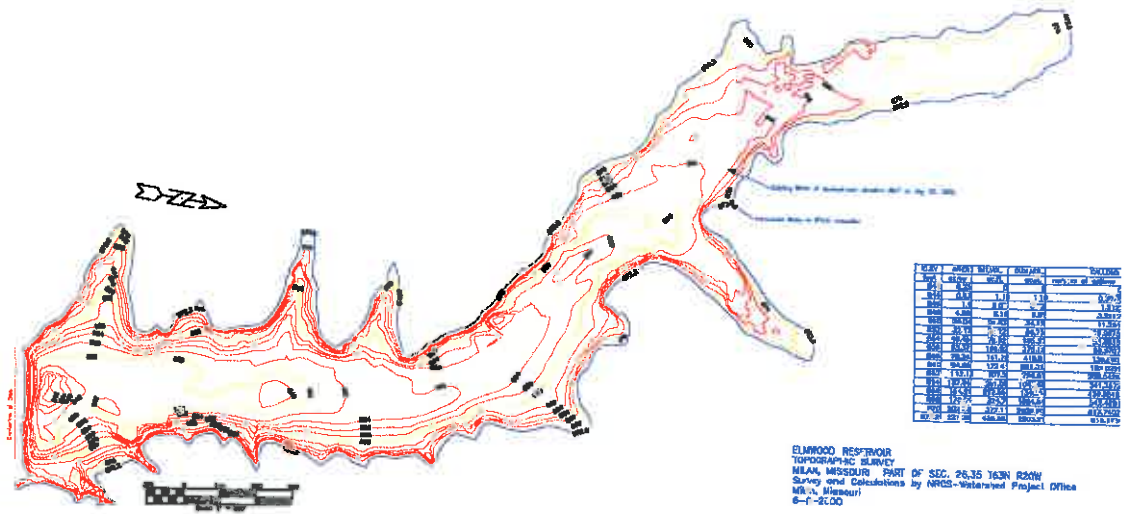


Figure 22.4.a Bathymetric map and area/volume table of Elmwood Reservoir, Milan, Missouri.

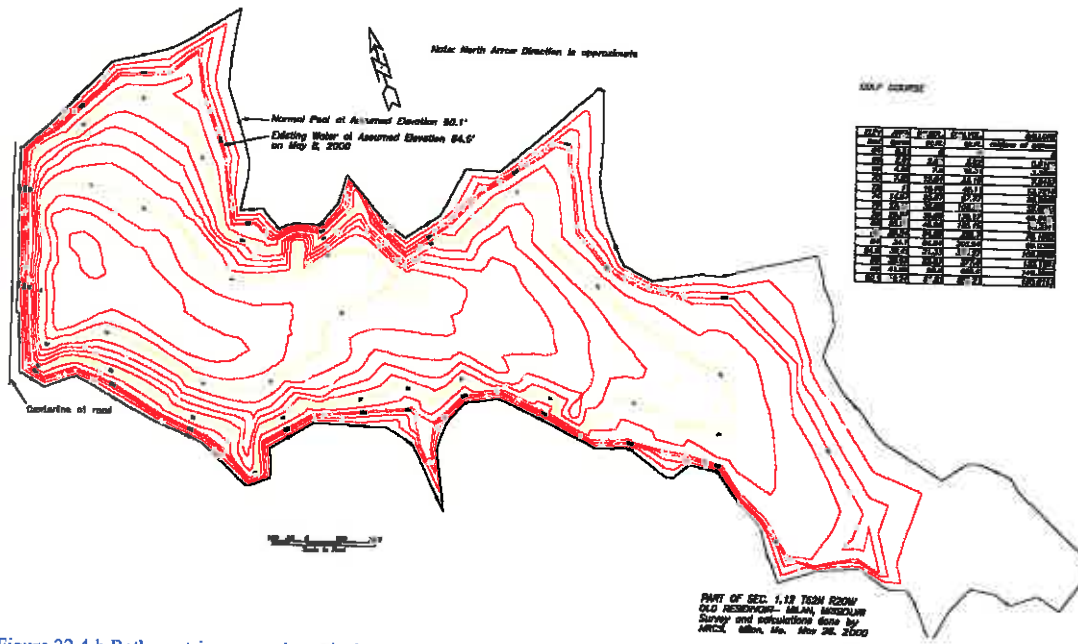


Figure 22.4.b Bathymetric map and area/volume table of Golf Course Reservoir, Milan, Missouri.

SHATTO LAKE

Elevation (feet)	Area (acres)	Volume (acre-ft)	Elevation (feet)	Area (acres)	Volume (acre-ft)
846.0	0.2	0.2	874.0	16.4	183.8
848.0	0.5	0.7	876.0	18.6	218.8
850.0	1.2	2.4	878.0	20.6	258.0
852.0	1.9	5.5	880.0	22.4	300.9
854.0	2.6	10.0	882.0	24.2	347.5
856.0	3.2	15.8	884.0	25.8	397.5
858.0	4.3	23.3	886.0	27.3	450.6
860.0	5.4	33.0	888.0	29.0	506.9
862.0	6.9	45.3	890.0	30.5	566.4
864.0	8.4	60.5	890.3	30.8	575.6
866.0	10.0	78.9	892.0	32.0	629.0
868.0	11.6	100.6	893.0	32.8	661.4
870.0	13.1	125.2	894.0	33.5	694.5
872.0	14.6	152.9	895.6	34.7	749.1

Table 1. Lake elevations and respective surface areas and volumes. Elevation of top of dam is approximately 895.6 feet. Datum is sea level.

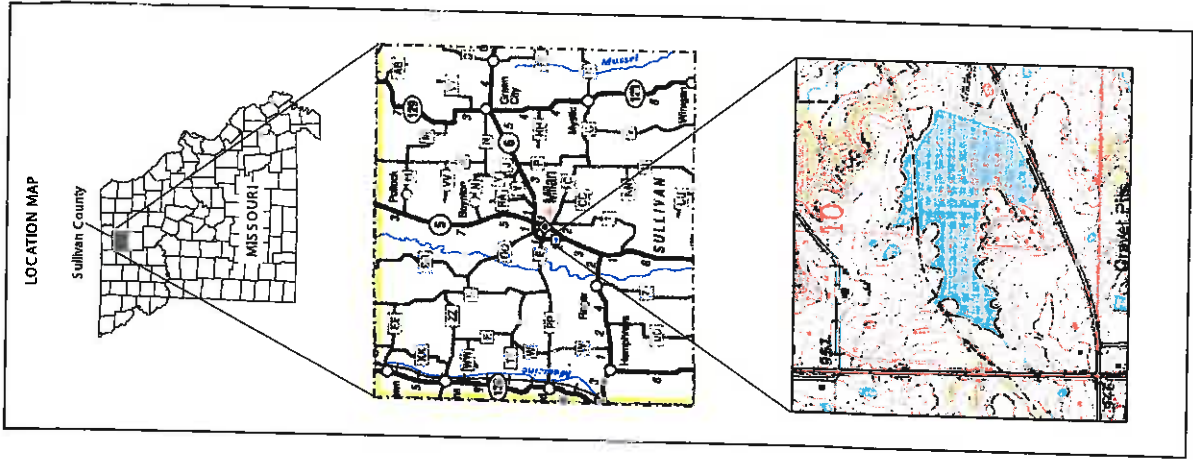
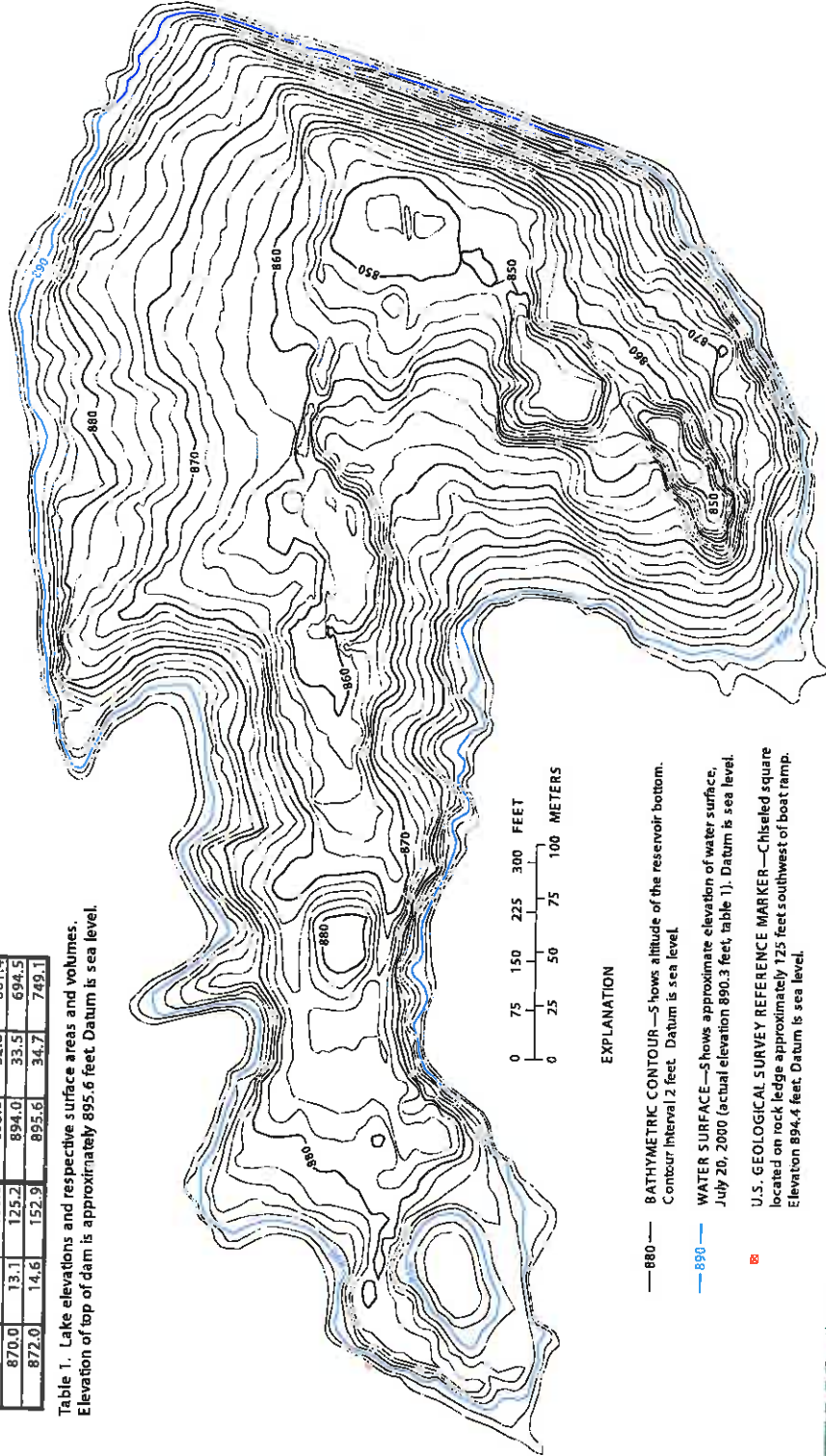


Figure 22.4c Bathymetric map and area/volume table for Shatto Lake near Milan, Missouri.