Appendix A. Mono Lake Monthly Water Balance Model

The hydrology of Mono Lake has been analyzed by constructing a monthly water budget that includes inflow terms, a storage change term, and an outflow term. The monthly inflows are the gaged and ungaged monthly streamflows, groundwater inflows, and direct precipitation on the lake surface. Ungaged streamflow and groundwater inflows are called "unmeasured inflows". The monthly change in storage is calculated from the measured change in elevation and Mono Lake surface area. The outflow term is the unmeasured evaporation that is estimated from an assumed monthly evaporation rate and the lake surface area. The water budget method attempts to estimate each of these terms to provide a consistent description of Mono Lake hydrology.

Methods for Estimating Terms

The basic data needed to calculate an accurate monthly water budget for Mono Lake are:

- bathymetry (lake surface area and volume at each elevation),
- monthly water surface elevations,
- monthly lakewide average precipitation,
- monthly surface water and groundwater inflows, and
- monthly lakewide average evaporation.

Bathymetry data for this appendix were obtained from the combination of aerial photogrammetry by Pacific Western Aerial Surveys and a detailed bathymetric survey of Mono Lake conducted by Pelagos Corporation for LADWP in summer 1986, when Mono Lake elevation was approximately 6,380 feet. Raw data were obtained from 60,000 depth soundings throughout Mono Lake. The depth soundings were converted into 5-foot depth contours, and the area within each contour interval was estimated. Interpolation methods were used to obtain measurements of 1-foot area increments.

Monthly Mono Lake surface elevations were obtained from LADWP records of periodic (but not always end-of-month) elevation measurements, linearly interpolated to end-of-month estimates. LADWP records were adjusted by adding 0.37 foot (4.5 inches), so that the elevations are consistent with the U.S. Geological Survey (USGS) 1929 sea level datum.

Monthly lakewide average precipitation data are estimated from LADWP monthly Cain Ranch precipitation records. Because Mono Lake is in the "rain shadow" of the Sierra Nevada crest, it is reasonable to suppose that the lakewide average precipitation is less than the Cain Ranch (elevation 6,850 feet) average of 11 inches. A precipitation station at Simis Ranch on the eastern side of Mono Lake has an estimated (short-term record) average precipitation of 7.5 inches. Each of the previous water budgets for Mono Lake use Cain Ranch as an index of lakewide precipitation. Vorster (1985) and LADWP (1990) annual water balance models each assume an average lakewide precipitation of 8 inches (73% of Cain Ranch average). The variations in lakewide precipitation are assumed to follow the Cain Ranch pattern.

Monthly surface water and groundwater inflows can only be partially measured with streamflow gages on the major tributaries (Mill, Lee Vining, Walker, Parker, and Rush Creeks). Because of irrigation diversions downstream of the gages on each tributary, the available flow records are only approximate estimates of the total surface water and groundwater inflow to Mono Lake. Additional inflow may exist that is proportional to the measured runoff, or the additional inflow may be a constant term that does not depend on variations in surface runoff. Each of the previous water budgets for Mono Lake has used the measured runoff as an index for estimating the total inflow term.

Monthly lakewide evaporation can be estimated from local evaporation pan measurements, observed changes in lake elevation, assumed relationships with meteorological data (wind and humidity), or heat budget modeling of Mono Lake surface temperatures (Romero 1992). Because the lakewide evaporation cannot be measured directly, any of these methods can provide only assumed evaporation rates. Favorable comparison between these methods of estimation increases the confidence in the assumed monthly evaporation pattern for Mono Lake.

Available Hydrologic Data

The available hydrologic data for 1941-1989 are given in the basic data file MONOWB.WK1, available from SWRCB consultants. The year and month are followed by the end-of-month elevation (USGS datum). The surface area and monthly volume changes are calculated by interpolation of the 1-foot interval bathymetry data that is given in data file BATHY.WK1. The monthly Cain Ranch precipitation is provided in the next column. The precipitation volume estimate is calculated from the average lake area and the precipitation depth.

The available streamflow measurements are given in the next several columns. Previous water budget models used various sums and adjustments to arrive at an index of surface runoff into Mono Lake. Because the total runoff from the four diverted tributary creeks are used as the index of runoff-year types (wet, normal, or dry) for Mono Basin, flow measurements for these creeks are used for the monthly Mono Lake water budget runoff index. For the historical period of 1941-1989, LADWP measured the spill at Lee Vining Creek intake and the releases and spills from Grant Lake reservoir to Rush Creek. The sum of these values was taken as the surface inflow to Mono Lake from the four diverted creeks. Releases from Walker and Parker Creeks were generally used for irrigation and were not included in the surface inflow estimates, although in wet years some nonirrigation releases were made.

For a portion of the historical period, LADWP operated streamflow gages on Lee Vining Creek (1941-1969) and Rush Creek (1952-1967) near their mouths at Mono Lake. These records provide an indication of the portion of the creek flows that infiltrated or were evapotranspirated on irrigated pasture or in the riparian corridors. They cannot provide a better estimate of the inflow to Mono Lake because the infiltrated water would enter as groundwater flow.

The next column is the difference between the observed monthly change in Mono Lake volume and the estimated terms for measured inflow and precipitation. The missing terms, evaporation and unmeasured inflow, are more difficult to identify.

The average monthly evaporation pattern was estimated from the observed loss of water from Mono Lake. The observed monthly changes in Mono Lake volume are usually less than the estimated inflows (measured surface flows plus precipitation) and these differences are greatest in the warm summer months. These average differences were used to approximate the monthly evaporation rates.

Surface inflow from portions of Mono Basin without streamflow gages and groundwater inflow cannot be measured. Some reasonable estimate for these unmeasured inflows must be used; a constant long-term average and/or some fraction of measured precipitation or gaged runoff can be used.

Because both evaporation and unmeasured inflows must be estimated from the change in Mono Lake volume that is not explained by measured inflows and direct precipitation, the magnitude of one term must be assumed to calculate the magnitude of the other. An independent estimate of annual evaporation based on temperature modeling by the University of California, Santa Barbara (UCSB) (1992) was used to set the magnitude of annual Mono Lake evaporation at 48 inches. This allowed the magnitude of the unmeasured inflow to be estimated to complete the monthly Mono Lake water budget model.

Previous Mono Lake Water Balance Models

SWRCB staff evaluated two annual (runoff year) water budget models and determined that the historical accuracy of both models, when compared with recorded Mono Lake volume changes from 1937 to 1989, was essentially equivalent (Rich pers. comm.). Vorster (1985) had developed a model that included many separate hydrologic terms, although several could not be measured directly. LADWP

(1990) had developed a model with fewer terms that lumped many measured and unmeasured inflows into a single "runoff factor" regression equation. The following review of each model will explain the basic techniques of constructing a water balance model.

Vorster Model

Vorster (1985) summarized all previous water budgets for Mono Lake and analyzed all available hydrologic data to estimate terms for an annual water balance for Mono Lake. LADWP runoff and lake elevation data for 1937-1983 formed the basis for estimates of the annual water budget terms. Vorster attempted to separate each identifiable hydrologic term to provide an accurate and reliable water budget and sensitivity analysis. However, because data were not available for direct estimation of each term, several terms were based on assumptions and indirect evidence. The accuracy of each individual term is unknown, although the overall match with the historical Mono Lake elevation record is good.

Vorster's model is based on the following water budget terms:

- Precipitation at Mono Lake is assumed to average 8 inches and to fluctuate with Cain Ranch measurements.

- Evaporation is assumed to average 45 inches, to fluctuate with Long Valley evaporation pan data, and to be reduced slightly (3-5%) by Mono Lake salinity.

- Sierra Nevada runoff as measured at streamflow gages (150 thousand acre-feet per year [TAF/yr]) is increased by 11% to account for unmeasured Sierra runoff, with an additional 20 TAF assumed from non-Sierran areas, 9 TAF from precipitation on land around the lake, and 1.5 TAF from Virginia Creek diversions. The total average inflows are 197.5 TAF and can be estimated as 111% of measured runoff plus a constant of about 30.5 TAF.

- Several water losses are assumed; bare ground ET around the lake perimeter averaged 5.5 TAF, Grant Lake reservoir evaporation averaged 1.5 TAF, phreatophytes around the lake account for 3 TAF, riparian ET averaged 1.5 TAF, irrigated pasture ET averaged 8 TAF, and the export of groundwater in the Mono Craters Tunnel accounts for about 7 TAF. These relatively constant losses total 26.5 TAF.

- The recorded LADWP exports from West Portal are subtracted from the available water.

- A final regression of unexplained lake volume changes with evaporation and runoff is used to correct the average 2.5 TAF/yr error in the modeled estimates of Mono Lake volume change during 1937-1983. The resulting estimates of Mono Lake elevation had an average error of 0.25 foot (3 inches).

The Vorster water balance includes many separate hydrologic terms that can be evaluated throughout the basin but does not provide validation of the individual estimates because hydrologic data are not collected for each identified term. The ability of the model to account accurately for the net water balance for Mono Lake suggests that the relative magnitude of the assumed inflows and losses is correct.

LADWP Model

LADWP developed a water balance with precipitation, evaporation, and a single net inflow term that used the available streamflow and diversion data to estimate the total releases toward Mono Lake. For an assumed evaporation rate, LADWP used a regression analysis to adjust the estimated inflows to match the historical fluctuations in Mono Lake volume for 1937-1989.

The LADWP-90RY model is based on the following water balance terms:

- Precipitation at Mono Lake is assumed to average 8 inches and to fluctuate with Cain Ranch measurements.

- Evaporation is assumed to average 41 inches, to fluctuate with Long Valley evaporation pan data, and to be reduced slightly (3-5%) by Mono Lake salinity.

- Sierra Nevada runoff as measured at streamflow gages (148 TAF/yr average) is decreased by irrigation diversions (7.5-12 TAF/yr), storage in Grant Lake reservoir, and West Portal exports. This is the measured portion of the estimated net inflow toward Mono Lake.

- A linear regression of unexplained historical lake volume changes with estimated releases to the lake is used to estimate the total inflow. The regression equation was estimated to be:

  Unmeasured inflow = 18.5 - .0585 x measured releases to Mono Lake

The LADWP formulation recognizes that the only available data are the measured streamflows, diversions, and lake level fluctuations. However, the regression equation for the unmeasured inflow could also be formulated in terms of the measured runoff, rather than the releases toward Mono Lake. Nevertheless, the historical match is comparable to the Vorster model, with an average error of 0.25 foot (3 inches).

Mono Lake Bathymetry

The bathymetric data for Mono Lake are summarized by the surface area and volume at 1-foot intervals from the lake bottom at elevations of 6,230-6,440 feet. The bathymetric data originated from a bottom depth-sounding survey conducted by Pelagos for LADWP in 1986 (Pelagos 1986) when the lake surface elevation was approximately 6,380 feet. The transects for the sounding equipment required at least 5 feet of depth. Aerial photogrammetry was used to estimate 5-foot elevation contours from 6,372 to 6,430 feet.

These basic data have been modified slightly in the elevation range of 6,365-6,430 feet and were extended to 6,440 by SWRCB consultants who mapped several contours based on visible benchmarks on aerial photographs (see Appendix G). The bathymetry data for elevations 6,300-6,440 feet are given in Table A-1. Estimates of salinity and specific gravity (density) are given for reference. The surface area of Mono Lake for elevations between 6,340 feet and 6,440 feet are shown in Figure A-1. The areas mapped by the SWRCB consultants are shown for comparison with the Pelagos bathymetry. The volume of Mono Lake for elevations between 6,340 and 6,440 feet is shown in Figure A-2.

The 1-foot incremental areas are the basic building block for the bathymetric data; the lake surface area is the sum of the incremental areas to that elevation, and the incremental volumes are calculated from the average area at the top and bottom of the increment. Review of the original Pelagos incremental area data showed that large incremental areas occurred near the 5-foot contour elevations, with much smaller increments midway between the 5-foot contours. This result is attributable to the SURFACE II graphics interpolation program used by Pelagos. SWRCB staff and consultants determined that this effect could be eliminated by 11-foot interval linear smoothing of the incremental area values (Rich pers. comm.).

Figure A-3 shows the original Pelagos and "smoothed" 1-foot incremental area values for Mono Lake between elevations of 6,350-6,420 feet. The largest incremental areas (more than 600 acres per foot of elevation) occur in the range of 6,365-6,375 feet because the shoreline slope is generally smallest at these elevations. The smallest incremental areas (about 200 acres per foot of elevation) occur between elevations 6,400 and 6,415 feet where the shoreline is steepest. The smoothing has relatively small effects on the lake surface and volume increments used in the water budget.

The bottom of Mono Lake is at about 6,230 feet elevation. At an elevation of 6,370 feet, the lake surface area is approximately 35,820 acres (56 square miles), and the lake volume is approximately 2.1 million af (MAF). At an elevation of 6,420 feet, the lake surface area is approximately 55,500 acres (87 square miles), and the lake volume is about 4.5 MAF. For the August 1989 point of reference for this EIR, Mono Lake surface elevation was 6,376.3 feet above sea level, with a surface area of about 41,000 acres and a volume of approximately 2.33 MAF.

In the water balance model, monthly volume changes of the lake were estimated from the surface areas interpolated from the 1-foot bathymetric data.

Evaporation and Precipitation

The monthly evaporation rates (inches/month) were assumed to be constants for each year. The monthly volume change from evaporation was estimated for the 1940-1989 historical period as the assumed evaporation rate multiplied by the surface area of the lake at the beginning of the month. The monthly precipitation contribution to the lake volume was estimated using the observed monthly Cain Ranch precipitation multiplied by the lake area. As previously noted, the average 1940-1989 Cain Ranch annual precipitation was approximately 11 inches. This is slightly higher than the estimated lakewide average precipitation of 8 inches based on maps of precipitation contours (Vorster 1985, LADWP 1990). This uncertainty in net evaporation (evaporation minus precipitation) is accounted for in the residual inflow estimate discussed in the next section.

The available hydrologic data were used to provide the initial estimate of monthly evaporation for Mono Lake. The monthly measured change in Mono Lake volume was compared with the estimated inflows from precipitation and measured surface inflows. This residual volume change was then divided by the surface area to give a residual elevation change in inches. These monthly estimates were averaged for each calendar month. The results provide an estimate of the minimum possible monthly average evaporation because any unmeasured inflows must be balanced by additional evaporation to match the historical surface elevation changes. Figure A-4 shows all the monthly estimates of "missing water", sorted by calendar months. These monthly residual estimates are scattered because of data errors and unmeasured inflows.

The monthly averages of these residual estimates of minimum evaporation rates are listed in Table A-2. The seasonal pattern is quite reasonable. The annual average sum of "missing water" is about 38 inches. This can be interpreted as the minimum possible evaporation because unmeasured inflows must be balanced by increased evaporation. This initial evaporation pattern can be confirmed with other estimates of evaporation for Mono Lake.

Two evaporation pan records for Mono Basin are available. A floating pan was maintained by LADWP in Grant Lake reservoir from 1942 to 1969, and a land pan replaced the floating pan in 1968 (elevation 7,200 feet). Measurements are only obtained in nonfreezing months, and Cain Ranch precipitation estimates are used to correct the actual pan data. Nevertheless, the average May-October Grant Lake reservoir evaporation measurements given in Table A-2 suggest a similar, but greater, seasonal pattern when compared to the residual monthly estimates.

The second evaporation pan record was collected at the Simis Ranch meteorological station from 1980 to 1983 (Vorster 1985). The monthly average values were higher than Grant Lake reservoir data but followed a similar seasonal pattern.

Temperature and salinity modeling of Mono Lake by UCSB staff independently estimated the evaporation for 1990 that provided the best match with biweekly surface temperature measurements. The annual value was approximately 48 inches (Romero 1992). This value was therefore selected for use in the Mono Lake monthly water budget model. Figure A-5 shows the sensitivity of modeled Mono Lake surface temperatures to the evaporation coefficient. The resulting annual evaporation rates are shown. The best estimate was determined to be 0.8 times the base estimate. UCSB staff plan to collect daily surface temperatures and complete local meteorological data in hopes of determining an even more accurate estimate of Mono Lake evaporation. However, some uncertainty will always remain in evaporation and all other terms of the water budget.

Unmeasured Inflows

The monthly water balance model uses the monthly residual water estimates to determine the monthly fractions of an assumed total annual evaporation (Table A-2). A linear regression equation was then estimated between unmeasured inflows and monthly runoff to complete the monthly water budget. Both the constant and the fraction of runoff increase with the assumed evaporation. For the assumed evaporation of 48 inches, the constant term is 2,915 af/month (34,992 af/year), and the fraction of runoff is 22.8%. This 22.8% fraction of runoff regression term includes Mill and DeChambeau Creeks because the runoff term was selected to correspond to the diverted tributary creeks. Because the Mill and DeChambeau Creeks average 18% of the diverted creeks' runoff, unmeasured inflow is about 5% of diverted creeks' runoff, plus the constant term of about 35 TAF/yr.

This regression of unmeasured inflows is consistent with the assumed evaporation rate because the runoff from Mill and DeChambeau Creeks is about 18% of the diverted creeks' total runoff. If the runoff variable term is assumed to equal runoff from Mill and DeChambeau Creeks, then at least 44 inches of evaporation are required for an 18% runoff term in the unmeasured inflow regression. Alternatively, if the total unmeasured inflow term is assumed to equal runoff from Mill and DeChambeau Creeks, then at least 37 inches of evaporation are needed. The assumed 48 inches of evaporation are consistent with this unmeasured inflow regression estimate.

Model Calibration with Observed Lake-Level Fluctuations

The monthly water balance can be summarized as:

- assumed constant annual evaporation of 48 inches, distributed in constant monthly fractions;
- measured Cain Ranch monthly precipitation;
- monthly releases from Lee Vining, Walker, Parker, and Rush Creeks to Mono Lake; and

- additional monthly inflow of 2,916 af plus 22.8% of monthly runoff from the four diverted creeks; the total additional inflow averages 63,116 af per year.

These monthly estimated evaporation and additional inflow terms, together with the measured historical releases to Mono Lake from the diverted tributaries, provide an accurate simulation of the observed variations in lake volume and surface elevation. Figure A-6 shows the simulated and observed Mono Lake elevations for the 1941-1989 period. The average error for the 49-year period is 0.5 foot. However, the average absolute error since 1965 when the lake level declined below 6,390 feet is only 0.27 foot.

The calibration using the assumed 48 inches of evaporation and results for a 36 inch evaporation estimate are shown. Lower evaporation rates are balanced by smaller unmeasured inflows regressions, so that the resulting match with the historical Mono Lake elevation pattern is nearly identical. The simulated elevations remain consistently below the measured elevations from about 1950 to 1983, suggesting an error in the measured inflow terms.

The monthly water budget terms can be summarized with annual values for the historical period 1941-1989, as shown in Figure A-7. The terms are shown as cumulative annual values. The first term is the unmeasured inflows that fluctuate with runoff. The next term is precipitation on Mono Lake. The third inflow is the measured releases to Mono Lake from the four diverted creeks. These inflow terms have varied from about 50 TAF to more than 350 TAF. When the assumed 48 inches of evaporation are subtracted from these inflows, the final estimated change in Mono Lake volume is given. For calibration purposes, the actual observed changes in Mono Lake volume also are shown.

This monthly water budget for Mono Lake is considered adequate for purposes of this EIR and was used in the aqueduct simulation model (Auxiliary Reports 5 and 18) and, in modified form, in the extended drought analysis (Appendix H).

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Personal Communications

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Table A-1. Bathymetry of Mono Lake

	Original Pelagos Corporation Bathymetry				Smoothed Pelagos Corporation Bathymetry				Jones & Stokes Associates		
Elevation (ft)[a]	Surface Area (acres)	Area Increment (acres)	Lake Volume (af)	Volume Increment (af)	Surface Area (acres)	Area Increment[b] (acres)	Lake Volume (af)	Volume Increment (af)	Mapped Area (acres)[c]	Average Salinity (g/l)[d]	Specific Gravity[e]
6,300	14,786	360	301,744	14,606	14,776	395	302,324	14,579		693	1.530
6,301	15,150	364	316,712	14,968	15,162	386	317,293	14,969		661	1.506
6,302	15,502	352	332,036	15,324	15,536	374	332,642	15,349		630	1.482
6,303	15,892	390	347,728	15,692	15,903	367	348,362	15,719		602	1.461
6,304	16,335	443	363,840	16,112	16,259	356	364,443	16,081		575	1.441
6,305	16,698	363	380,361	16,521	16,609	350	380,877	16,434		550	1.422
6,306	17,027	329	397,223	16,862	16,952	343	397,657	16,780		527	1.404
6,307	17,354	327	414,418	17,195	17,289	337	414,777	17,121		505	1.388
6,308	17,674	320	431,923	17,505	17,623	333	432,233	17,456		485	1.372
6,309	17,977	303	449,753	17,830	17,949	326	450,019	17,786		466	1.357
6,310	18,271	294	467,877	18,124	18,264	315	468,126	18,106		448	1.344
6,311	18,561	290	486,289	18,412	18,574	310	486,544	18,419		431	1.331
6,312	18,862	301	504,999	18,710	18,882	308	505,272	18,728		415	1.319
6,313	19,169	307	524,013	19,014	19,189	307	524,308	19,036		400	1.307
6,314	19,482	313	543,339	19,326	19,498	309	543,651	19,344		386	1.296
6,315	19,799	317	562,978	19,639	19,808	310	563,304	19,653		372	1.286
6,316	20,106	307	582,929	19,951	20,117	309	583,267	19,962		359	1.277
6,317	20,417	311	603,187	20,258	20,424	307	603,537	20,270		347	1.267
6,318	20,735	318	623,762	20,575	20,727	303	624,113	20,576		336	1.259
6,319	21,070	335	644,659	20,897	21,025	298	644,989	20,876		325	1.250
6,320	21,384	314	665,886	21,227	21,319	294	666,161	21,172	21,639	315	1.243
6,321	21,672	288	687,420	21,534	21,609	290	687,625	21,464		305	1.235
6,322	21,939	267	709,222	21,802	21,895	286	709,378	21,752		295	1.228
6,323	22,196	257	731,293	22,071	22,179	283	731,415	22,037		287	1.221
6,324	22,449	253	753,614	22,321	22,455	276	753,732	22,317		278	1.215
6,325	22,716	267	776,197	22,583	22,723	268	776,321	22,589		270	1.209
6,326	22,990	274	799,052	22,855	22,986	263	799,175	22,854		262	1.203
6,327	23,253	263	822,173	23,121	23,246	261	822,291	23,116		255	1.197
6,328	23,534	281	845,564	23,391	23,505	259	845,667	23,376		248	1.192
6,329	23,774	240	869,221	23,657	23,766	261	869,302	23,635		241	1.187
6,330	24,017	243	893,118	23,897	24,029	263	893,199	23,897	24,251	235	1.182
6,331	24,272	255	917,263	24,145	24,292	263	917,360	24,161		228	1.177
6,332	24,538	266	941,668	24,405	24,557	265	941,785	24,425		223	1.173
6,333	24,786	248	966,332	24,664	24,826	268	966,476	24,692		217	1.168
6,334	25,067	281	991,260	24,928	25,094	268	991,436	24,960		211	1.164
6,335	25,343	276	1,016,469	25,209	25,366	272	1,016,666	25,230		206	1.160
6,336	25,609	266	1,041,941	25,472	25,643	277	1,042,171	25,505		201	1.156
6,337	25,909	300	1,067,699	25,758	25,926	283	1,067,955	25,785		196	1.153
6,338	26,206	297	1,093,760	26,061	26,215	288	1,094,026	26,070		192	1.149
6,339	26,483	277	1,120,102	26,342	26,509	295	1,120,388	26,362		187	1.146
6,340	26,767	284	1,146,732	26,630	26,805	296	1,147,045	26,657	26,928	183	1.142
6,341	27,068	301	1,173,645	26,913	27,101	295	1,173,998	26,953		179	1.139
6,342	27,382	314	1,200,872	27,227	27,398	298	1,201,247	27,250		174	1.136
6,343	27,711	329	1,228,422	27,550	27,695	296	1,228,794	27,547		171	1.133
6,344	28,030	319	1,256,294	27,872	27,987	292	1,256,635	27,841		167	1.130
6,345	28,320	290	1,284,467	28,173	28,277	291	1,284,767	28,132	28,595	163	1.127
6,346	28,592	272	1,312,923	28,456	28,565	288	1,313,188	28,421		160	1.125
6,347	28,886	294	1,341,664	28,741	28,848	283	1,341,895	28,707		156	1.122
6,348	29,166	280	1,370,691	29,027	29,124	276	1,370,881	28,986		153	1.120
6,349	29,420	254	1,399,982	29,291	29,391	267	1,400,138	29,258		150	1.117
6,350	29,681	261	1,429,532	29,550	29,650	259	1,429,659	29,521	29,880	147	1.115
6,351	29,931	250	1,459,339	29,807	29,904	254	1,459,436	29,777		144	1.113
6,352	30,184	253	1,489,396	30,057	30,158	253	1,489,467	30,031		141	1.110
6,353	30,413	229	1,519,696	30,300	30,409	251	1,519,750	30,283		138	1.108
6,354	30,651	238	1,550,227	30,531	30,662	253	1,550,286	30,536		135	1.106
6,355	30,875	224	1,580,989	30,762	30,920	258	1,581,077	30,791	31,080	133	1.104
6,356	31,119	244	1,611,984	30,995	31,182	262	1,612,128	31,051		130	1.102
6,357	31,379	260	1,643,234	31,250	31,449	267	1,643,443	31,315		128	1.100
6,358	31,652	273	1,674,745	31,511	31,720	271	1,675,028	31,584		125	1.099
6,359	31,951	299	1,706,543	31,798	31,998	279	1,706,886	31,859		123	1.097
6,360	32,258	307	1,738,649	32,106	32,283	285	1,739,027	32,141	32,340	121	1.095
6,361	32,559	301	1,771,058	32,409	32,575	292	1,771,456	32,429		118	1.093
6,362	32,864	305	1,803,775	32,717	32,873	298	1,804,180	32,724		116	1.092
6,363	33,165	301	1,836,790	33,015	33,182	309	1,837,207	33,027		114	1.090
6,364	33,478	313	1,870,113	33,323	33,517	336	1,870,557	33,350		112	1.089
6,365	33,787	309	1,903,745	33,632	33,869	352	1,904,250	33,693	33,831	110	1.087
6,366	34,086	299	1,937,684	33,939	34,224	355	1,938,297	34,047		108	1.086
6,367	34,392	306	1,971,918	34,234	34,593	369	1,972,705	34,409		106	1.084
6,368	34,777	385	2,006,491	34,573	35,070	477	2,007,537	34,832		104	1.083
6,369	35,345	568	2,041,538	35,047	35,619	549	2,042,882	35,345		103	1.081
6,370	35,819	474	2,077,137	35,599	36,266	647	2,078,825	35,943		101	1.080
6,371	36,165	346	2,113,131	35,994	36,970	704	2,115,443	36,618		99	1.079
6,372	36,619	454	2,149,503	36,372	37,688	717	2,152,772	37,329	36,859	97	1.077
6,373	38,113	1,494	2,186,471	36,968	38,409	721	2,190,820	38,048	37,592	96	1.076
6,374	39,203	1,090	2,225,300	38,829	39,127	718	2,229,588	38,768		94	1.075
6,375	40,590	1,387	2,264,835	39,535	39,915	789	2,269,109	39,521	39,418	92	1.074
6,376	41,535	945	2,306,053	41,218	40,724	809	2,309,428	40,320	40,323	91	1.072
6,377	41,976	441	2,347,827	41,774	41,531	807	2,350,556	41,128	40,876	89	1.071

Table A-1. Continued

Elevation (ft)[a]	Original Pelagos Corporation Bathymetry: Surface Area (acres)	Area Increment (acres)	Lake Volume (af)	Volume Increment (af)	Smoothed Pelagos Corporation Bathymetry: Surface Area (acres)	Area Increment[b] (acres)	Lake Volume (af)	Volume Increment (af)	Jones & Stokes Associates Mapped Area (acres)[c]	Average Salinity (g/l)[d]	Specific Gravity[e]
6,378	42,323	347	2,389,985	42,158	42,325	794	2,392,484	41,928		88	1.070
6,379	42,677	354	2,432,473	42,488	43,012	687	2,435,153	42,669		86	1.069
6,380	44,021	1,344	2,475,351	42,878	43,670	658	2,478,494	43,341		85	1.068
6,381	44,715	694	2,519,878	44,527	44,256	585	2,522,457	43,963	43,895	83	1.067
6,382	45,039	324	2,564,761	44,883	44,783	527	2,566,976	44,519		82	1.066
6,383	45,356	317	2,609,959	45,198	45,295	512	2,612,015	45,039	44,886	80	1.064
6,384	45,668	312	2,655,465	45,506	45,799	505	2,657,562	45,547	45,323	79	1.063
6,385	46,445	777	2,701,320	45,855	46,310	511	2,703,617	46,055		78	1.062
6,386	47,028	583	2,748,135	46,815	46,734	424	2,750,139	46,522		76	1.061
6,387	47,335	307	2,795,323	47,188	47,112	378	2,797,062	46,923	46,597	75	1.060
6,388	47,607	272	2,842,794	47,471	47,492	380	2,844,364	47,302		74	1.060
6,389	47,873	266	2,890,535	47,741	47,865	373	2,892,042	47,679		72	1.059
6,390	48,294	421	2,938,554	48,019	48,245	379	2,940,097	48,055	48,295	71	1.058
6,391	48,685	391	2,987,074	48,520	48,584	339	2,988,512	48,414		70	1.057
6,392	48,870	185	3,035,910	48,836	48,893	309	3,037,250	48,739		69	1.056
6,393	49,224	354	3,085,012	49,102	49,194	301	3,086,294	49,044	49,402	68	1.055
6,394	49,461	237	3,134,354	49,342	49,491	297	3,135,637	49,343		67	1.054
6,395	49,841	380	3,183,957	49,603	49,796	304	3,185,280	49,644		66	1.054
6,396	50,178	337	3,233,993	50,036	50,093	297	3,235,225	49,944		65	1.053
6,397	50,426	248	3,284,298	50,305	50,375	282	3,285,459	50,234		64	1.052
6,398	50,649	223	3,334,837	50,539	50,660	284	3,335,976	50,518		63	1.051
6,399	50,875	226	3,385,597	50,760	50,930	270	3,386,771	50,795		62	1.051
6,400	51,220	345	3,436,601	51,004	51,204	274	3,437,838	51,067	51,635	61	1.050
6,401	51,566	346	3,488,019	51,418	51,469	265	3,489,175	51,336		60	1.049
6,402	51,789	223	3,539,698	51,679	51,720	252	3,540,769	51,595		59	1.048
6,403	51,999	210	3,591,595	51,897	51,967	246	3,592,613	51,844		58	1.048
6,404	52,199	200	3,643,691	52,096	52,208	241	3,644,700	52,087		58	1.047
6,405	52,472	273	3,696,012	52,321	52,451	243	3,697,030	52,329		57	1.047
6,406	52,753	281	3,748,642	52,630	52,685	235	3,749,598	52,568		56	1.046
6,407	52,948	195	3,801,493	52,851	52,904	218	3,802,392	52,794		55	1.045
6,408	53,135	187	3,854,536	53,043	53,117	214	3,855,403	53,011		54	1.045
6,409	53,304	169	3,907,754	53,218	53,326	208	3,908,624	53,221		54	1.044
6,410	53,544	240	3,961,154	53,400	53,534	209	3,962,054	53,430	53,626	53	1.044
6,411	53,800	256	4,014,845	53,691	53,741	207	4,015,692	53,638		52	1.043
6,412	53,968	168	4,068,730	53,885	53,939	197	4,069,532	53,840		52	1.043
6,413	54,140	172	4,122,788	54,058	54,134	196	4,123,568	54,036	54,115	51	1.042
6,414	54,289	149	4,177,003	54,215	54,327	193	4,177,799	54,231		50	1.042
6,415	54,495	206	4,231,376	54,373	54,527	200	4,232,226	54,427		50	1.041
6,416	54,751	256	4,286,015	54,639	54,730	203	4,286,854	54,628		49	1.041
6,417	54,922	171	4,340,854	54,839	54,924	194	4,341,681	54,827	54,698	48	1.040
6,418	55,099	177	4,395,865	55,011	55,120	196	4,396,703	55,022		48	1.040
6,419	55,256	157	4,451,041	55,176	55,318	199	4,451,922	55,219		47	1.039
6,420	55,504	248	4,506,394	55,353	55,534	215	4,507,348	55,426		46	1.039
6,421	55,772	268	4,562,055	55,661	55,756	223	4,562,993	55,645		46	1.038
6,422	55,939	167	4,617,912	55,857	55,976	220	4,618,859	55,866		45	1.038
6,423	56,123	184	4,673,940	56,028	56,205	229	4,674,950	56,091		45	1.038
6,424	56,324	201	4,730,163	56,223	56,450	245	4,731,278	56,328		44	1.037
6,425	56,656	332	4,786,612	56,449	56,760	310	4,787,883	56,605		44	1.037
6,426	56,945	289	4,843,440	56,828	57,066	305	4,843,440	55,557		43	1.036
6,427	57,170	225	4,900,496	57,056	57,365	299	4,900,496	57,056		43	1.036
6,428	57,443	273	4,957,793	57,297	57,668	303	4,957,793	57,297	56,433	42	1.036
6,429	57,794	351	5,015,397	57,604	57,972	304	5,015,397	57,604		42	1.035
6,430	58,662	868	5,073,424	58,027	58,276	304	5,073,424	58,027	57,004	41	1.035
6,431	58,864	202	5,132,187	58,763	58,569	293	5,132,187	58,763		41	1.035
6,432	59,066	202	5,191,152	58,965	58,853	285	5,191,152	58,965		40	1.034
6,433	59,268	202	5,250,319	59,167	59,136	283	5,250,319	59,167		40	1.034
6,434	59,470	202	5,309,688	59,369	59,412	276	5,309,688	59,369		39	1.033
6,435	59,672	202	5,369,259	59,571	59,675	263	5,369,259	59,571		39	1.033
6,436	59,874	202	5,429,032	59,773	59,920	245	5,429,032	59,773		39	1.033
6,437	60,076	202	5,489,007	59,975	60,150	230	5,489,007	59,975		38	1.033
6,438	60,278	202	5,549,184	60,177	60,365	215	5,549,184	60,177		38	1.032
6,439	60,480	202	5,609,563	60,379	60,565	200	5,609,563	60,379		37	1.032
6,440	60,682	202	5,670,144	60,581	60,750	185	5,670,144	60,581	60,674	37	1.032

[a] USGS datum.

[b] Jones & Stokes Associates smoothed with 11-foot moving average, as described in text.

[c] GIS results using aerial photographs of previous shorelines.

[d] Estimated from lake volume assuming 285 million tons of dissolved salt; TDS (g/l) = 2.096 x 10^8/Volume (af).

[e] Estimated from LADWP experiments with Mono Lake water (see Chapter 3B); SG = 1.004 + 0.00072 x Salinity (g/l).

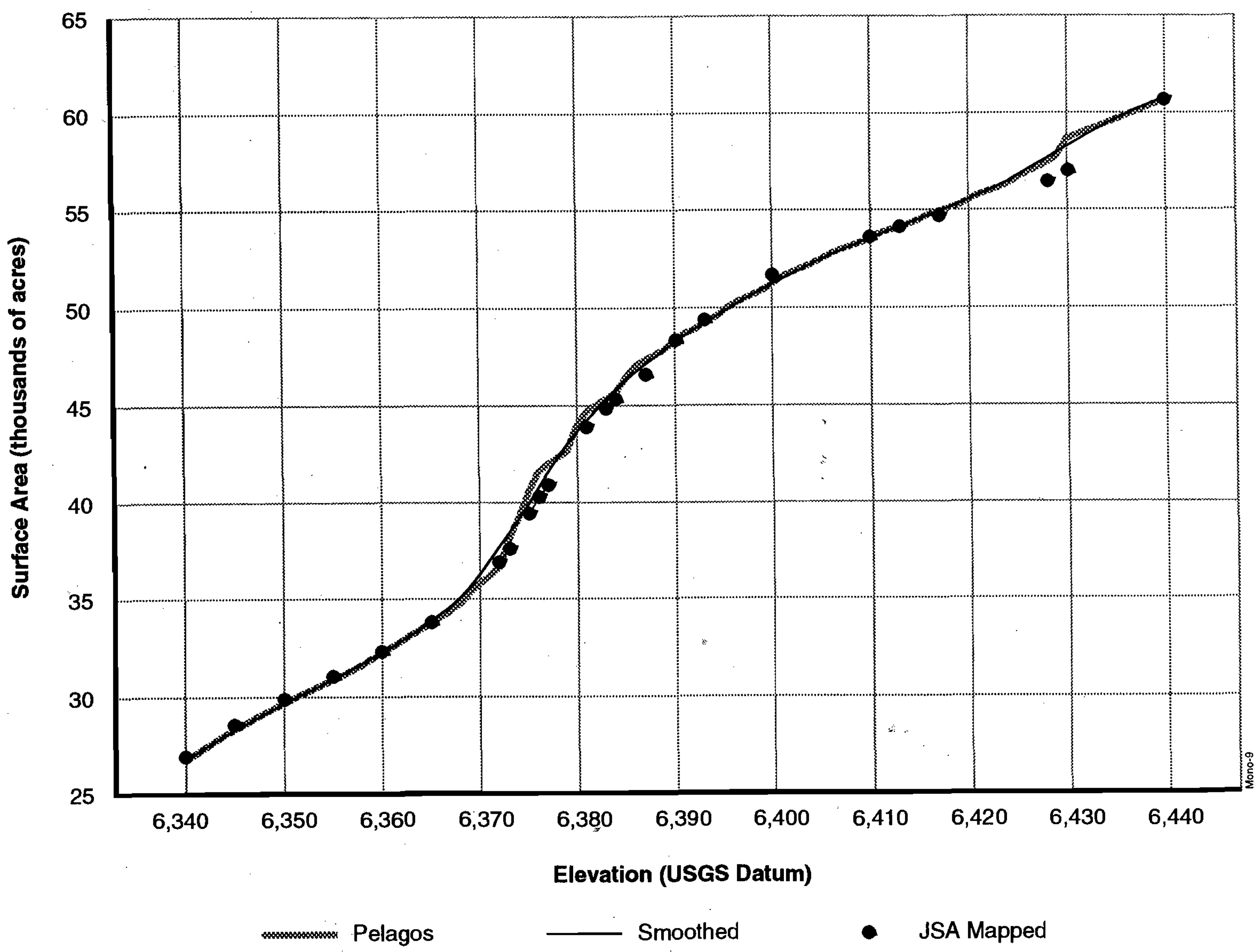
Table A-2. Monthly Evaporation Estimates for Mono Lake

Month	Monthly Water Budget[a]	Grant Pan[b]	Simis Ranch[c]
January	1.1	--	--
February	0.6	--	--
March	1.0	--	--
April	1.9	--	--
May	3.2	6.0	8.7
June	4.7	7.1	9.5
July	5.5	8.2	10.6
August	6.2	8.0	9.4
September	5.1	6.3	7.1
October	3.8	4.6	4.3
November	3.1	--	--
December	1.8	--	--
Annual	38.0	--	--

[a] Estimated as residual of lake volume change/area.

[b] LADWP land pan (1968-1989) and floating pan (1942-1969) data.

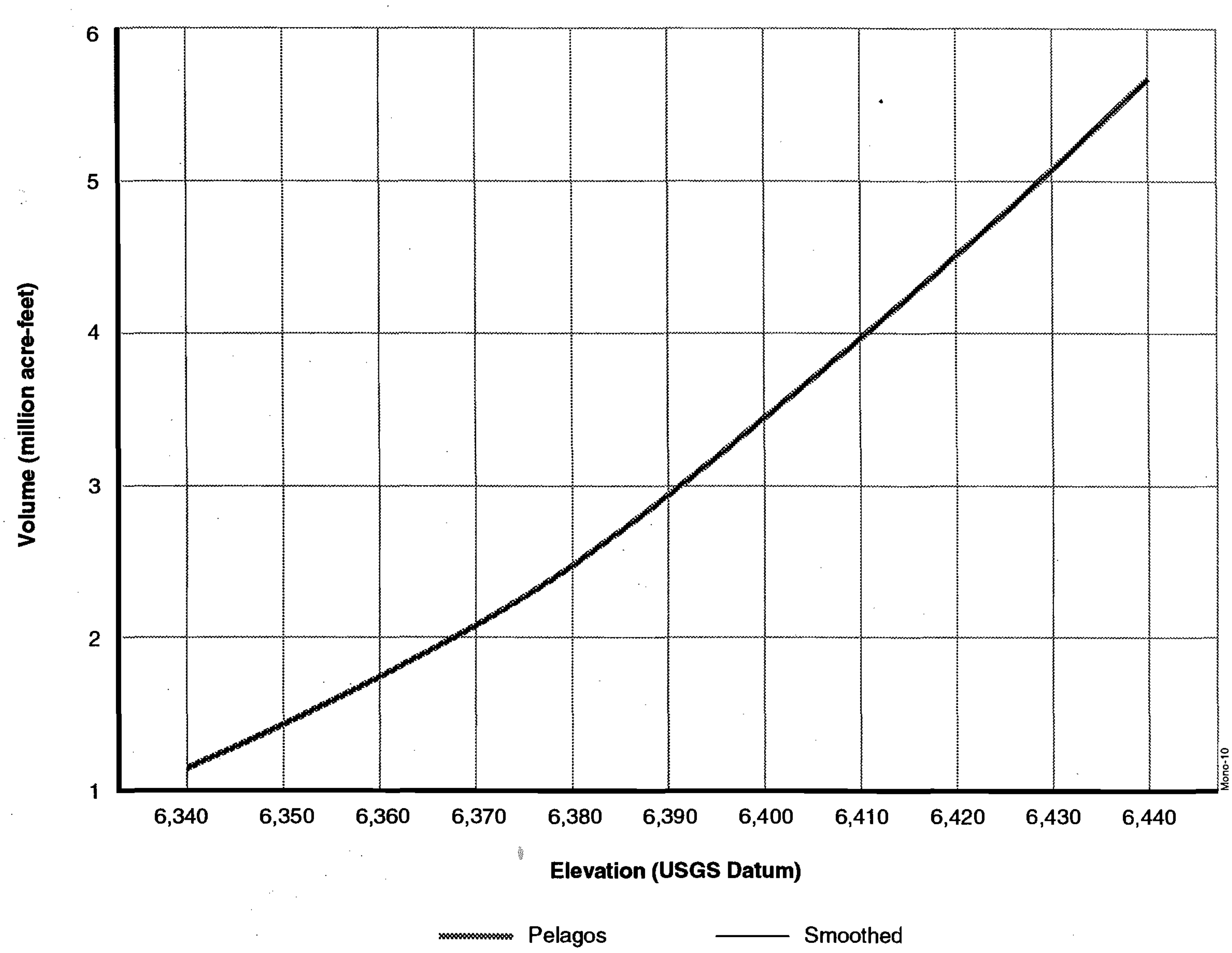
[c] Source: Data from 1980-1983 from Vorster 1985.



Source: Pelagos (1986) bathymetric survey and Pacific Western Aerial Surveys (1986) terrestrial photogrammetric survey for JSA - mapped data, see Appendix G

Figure A-1.
Lake Surface Area - Elevation Relationship for Mono Lake

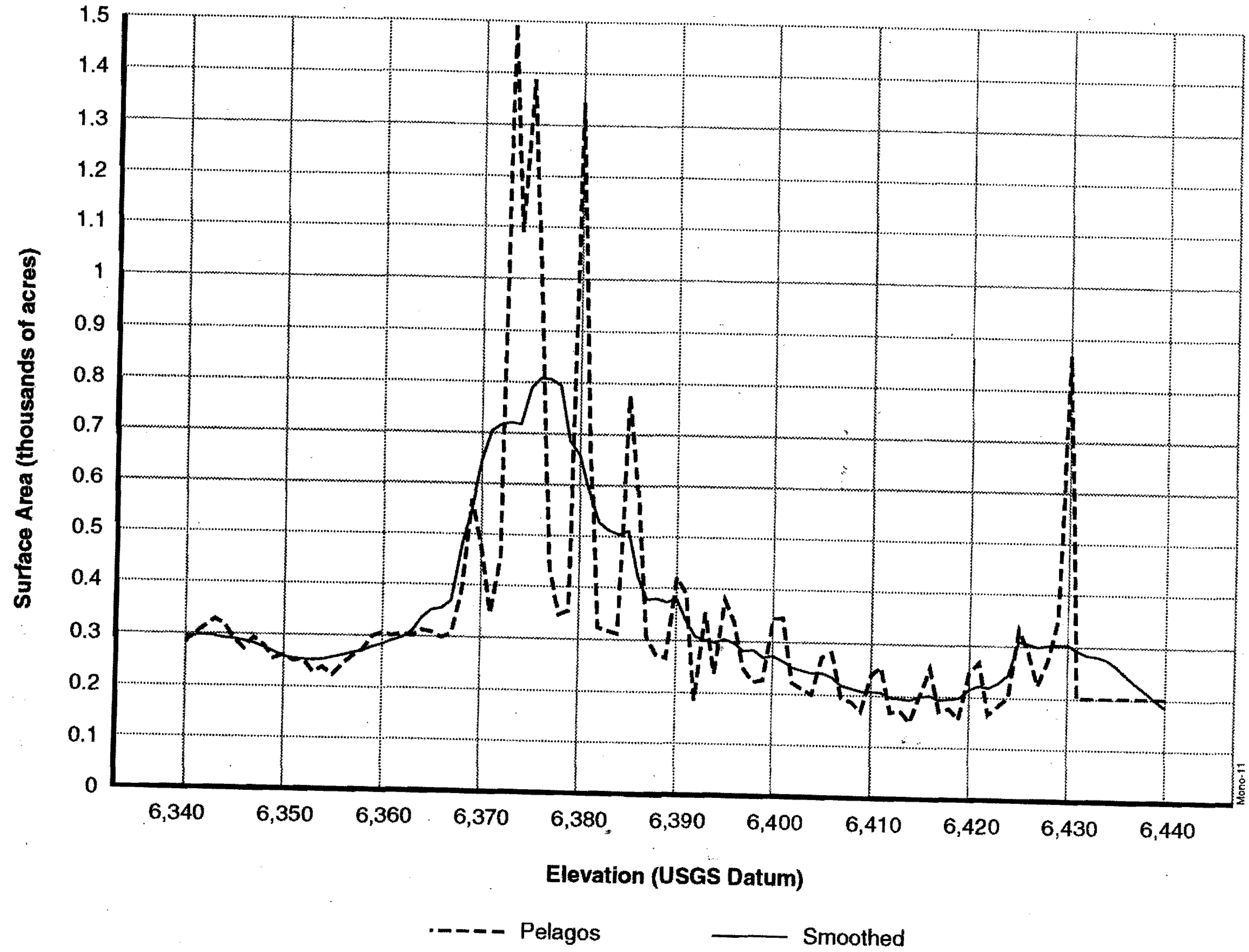
MONO BASIN EIR
Prepared by Jones & Stokes Associates



Source: Pelagos (1986) bathymetric survey and Pacific Western Aerial Surveys (1986) terrestrial photogrammetric survey

Figure A-2.
Lake Volume - Elevation Relationship for Mono Lake

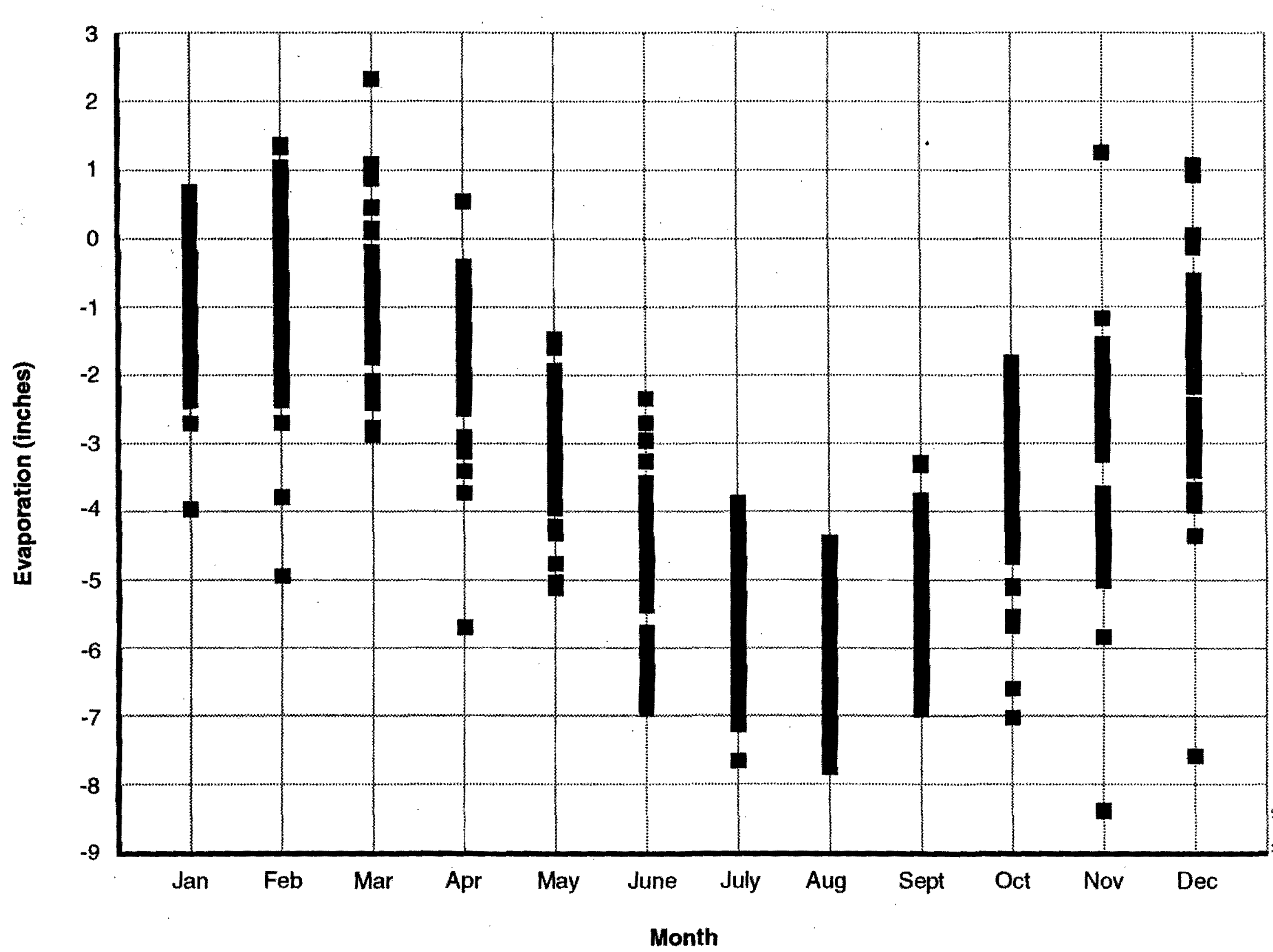
MONO BASIN EIR
Prepared by Jones & Stokes Associates



Source: Pelagos (1986) bathymetric survey and Pacific Western Aerial Surveys (1986) terrestrial photogrammetric survey

Figure A-3.
Lake Area Increments by Elevation for Mono Lake

MONO BASIN EIR
Prepared by Jones & Stokes Associates



Source: Based on LADWP monthly streamflow and lake level data, 1941-1989

Figure A-4.
Evaporation Estimates for Mono Lake

MONO BASIN EIR
Prepared by Jones & Stokes Associates

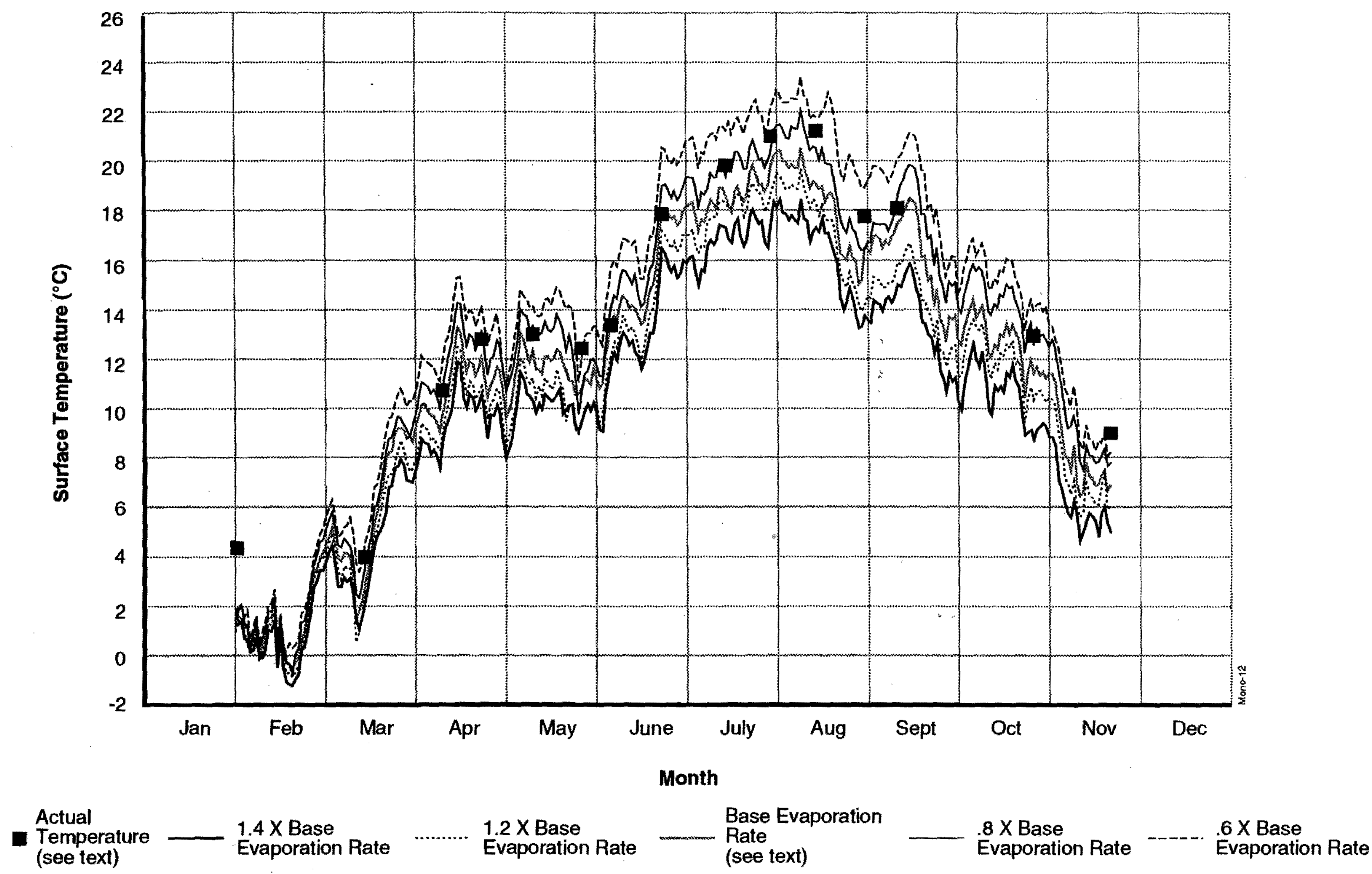


Figure A-5.
Effect of Evaporation Rate on Seasonal Temperature

MONO BASIN EIR
Prepared by Jones & Stokes Associates

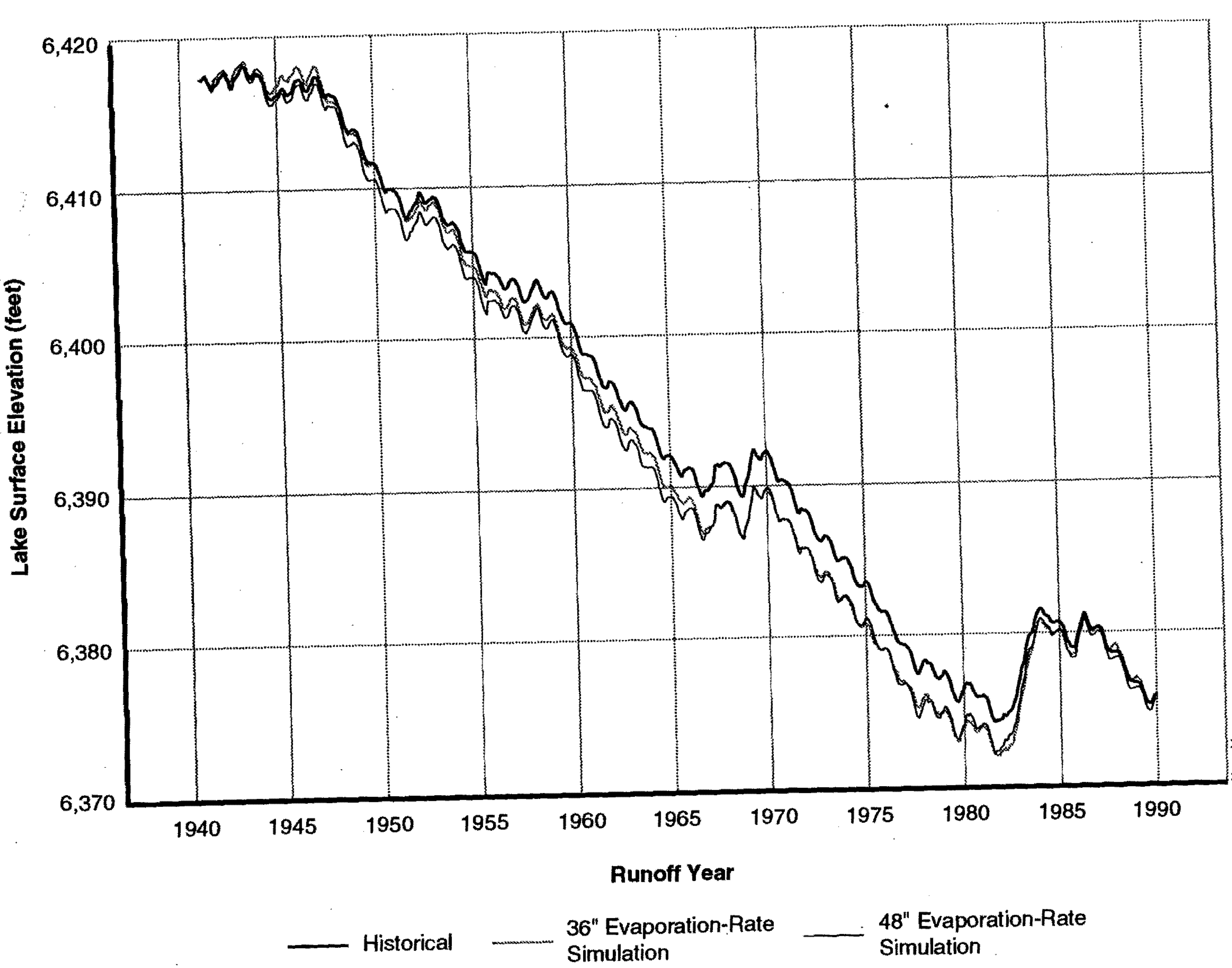


Figure A-6.
Historical and Simulated Lake Surface Elevation Changes for Various Evaporation Rates

MONO BASIN EIR
Prepared by Jones & Stokes Associates

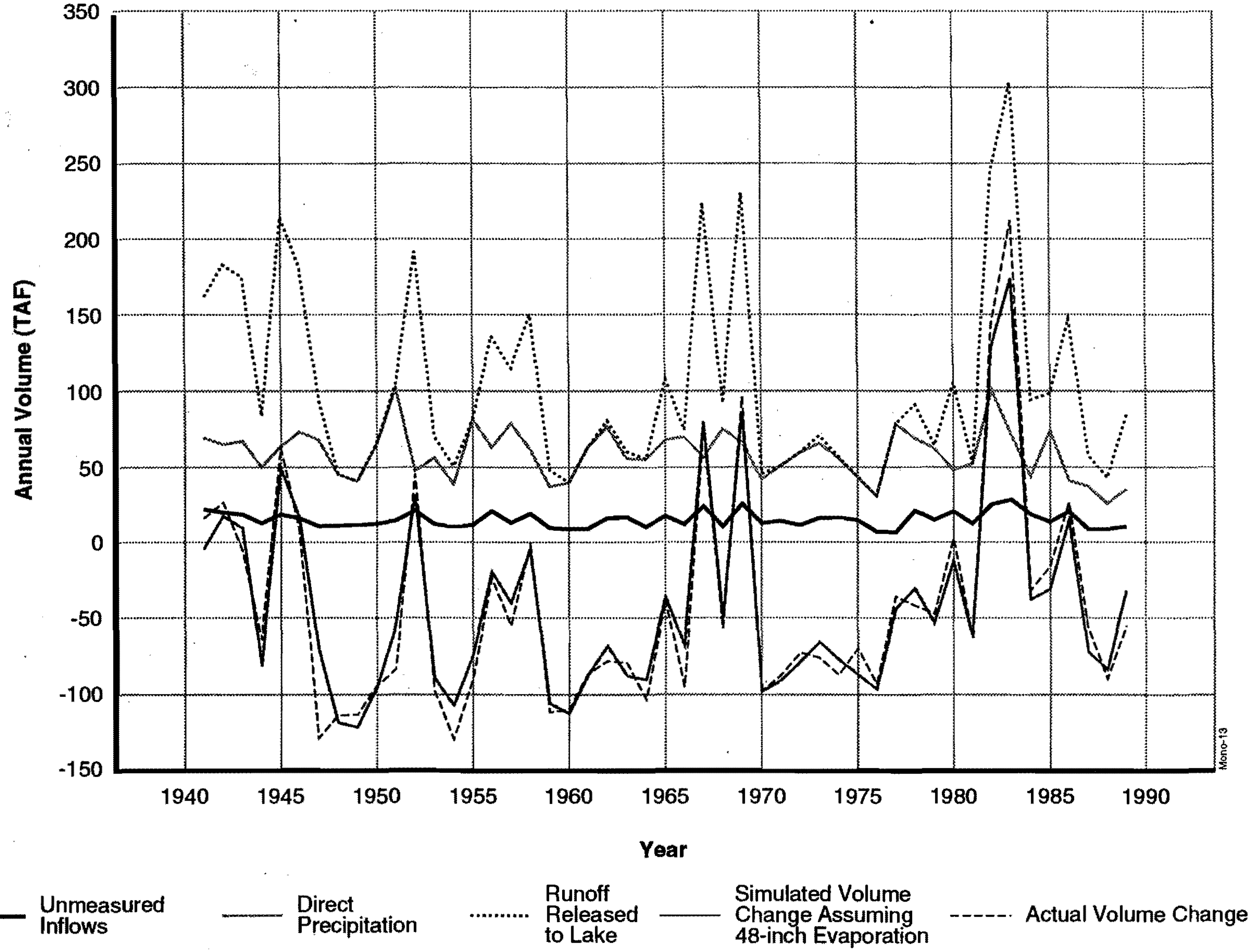


Figure A-7.
Annual Average Water Budget Terms