Chapter IV: CONCLUSIONS

SUMMARY OF MODEL DEVELOPMENT AND RESULTS

The quantity of runoff, precipitation, evaporation, evapotranspiration, diversions, and storage changes in the Mono Basin and their annual change over the 1937-83 period is systematically analyzed and formulated as a Mono Lake level water balance forecast model. The model is based on the Mono Groundwater Basin (MGWB), a fixed free-body, because the inflows and outflows are easier to estimate than those of a free-body that only includes the fluctuating lake. Most of the previously developed models used the fluctuating lake as the free-body and as a consequence determined all or part of the inflow as a residual, This report's model is considered to be more accurate than previously developed models because it independently quantifies the identified components and it isolates some of the component uncertainty into a relatively small overall error which is partially explained in an explicit model calibration, Verification of the model confirms that it can predict Mono Lake levels with reasonable accuracy, The model is also more useful than previous models because it determines the fluctuations of Mono Lake levels and salinities in response to variable hydroclimatic conditions and LADWP export scenarios.

The model shows that:

a. In an average runoff year 84% of the total surface and subsurface inflow into the (MGWB) is from the Sierra Nevada; about 76% of the runoff is measured at gaging stations,

b. About 9% of the inflow comes from the mountains to the north, east, and south of Mono Lake, and flows into the MGWB mainly via the subsurface.

c. The remaining 7% of the inflow is derived from precipitation surplus to that consumptively used by vegetation in the MGWB.

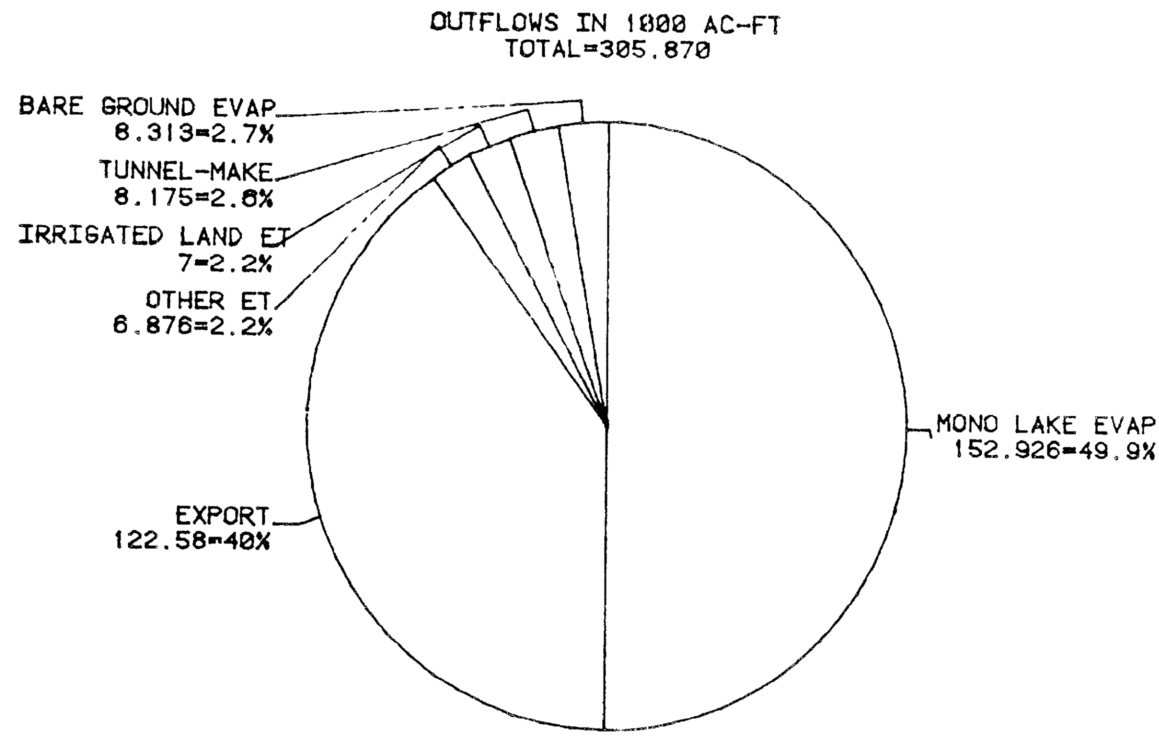
d. Under LADWP's current operational policies, nearly 65% of the runoff into the MGWB is exported by LADWP in an average runoff year; about 7% of the runoff is diverted for in-basin irrigation, half of which is consumptively used; less than 0.1% is used consumptively for in-basin municipal purposes.

e. Most of the remaining runoff flows into Mono Lake where it is evaporated; a small amount is transpired by phreatophytes or evaporated from bare ground exposed around Mono Lake.

f. In the 1937-83 base period there was a net imbalance in the groundwater basin inflow and outflow. As a consequence there was a 43% decrease in the volume of water stored in Mono Lake and a small decrease in the water stored in the aquifers of the groundwater basin,

Figure 4-l shows the proportional component values for water year 1975, a nearly normal runoff year which had an average lake elevation similar to the current level of 6380 ft.

In an effort to ascertain the impact of LADWP's exports on the historic and future lake levels and salinity, the model is applied with the sequences of 1937-83 hydroclimatic conditions and a range of export scenarios. Without LADWP exports the Lake



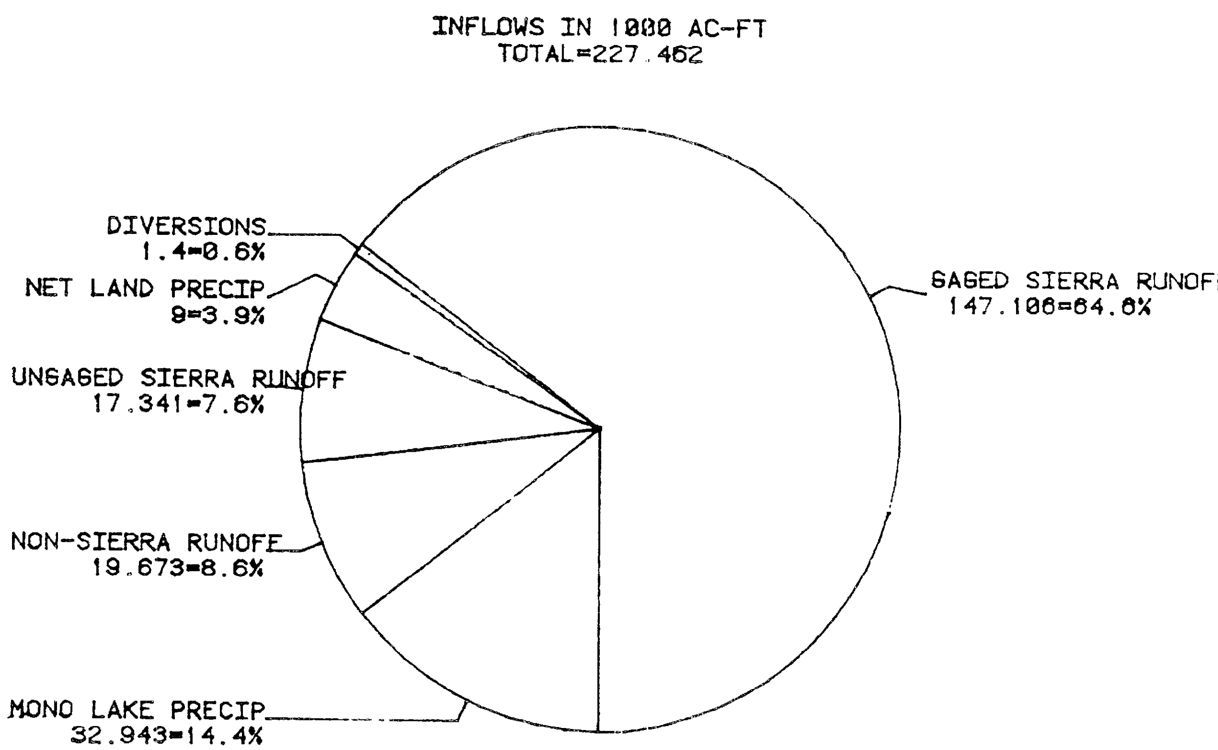


Figure 4-1 Inflows and Outflows to the Mono Groundwater Basin in 1975 Water Year

would have fluctuated in the 1937-83 period between 6416 ft and 6420 ft until the last few years, when the wettest four-year period in the historical record would have elevated the lake close to 6426 ft.

The magnitude and timing of future lake fluctuations wall depend on the nature and variability of future climate and, to an even greater degree, on the amount of water exported by LADWP. Should surface water exports cease, and the hydroclimatic conditions of the past 47 years continue indefinitely into the future, the lake will rise, then fluctuate between elevations of approximately 6428 ft and 6438 ft as it achieves a dynamic equilibrium with the climate (the lake elevation of 6428 ft postulated for 1983 in the preceding paragraph does not reflect a climatic equilibrium level), If, on the other hand, surface water exports continue into the future at rates approximating those of the 1970's (averaging about l00,000 ac-ft/yr), the lake will decline and, given a repetition of 1937-83 hydroclimatic conditions, fluctuate between elevations of approximately 6330 ft and 6346 ft. Thus, if the hydroclimatic conditions of the 1937-83 period persist indefinitely the unrestricted trans-basin export of Mono Lake's two largest tributary streams would result in a difference of nearly 100 ft in lake surface elevation, 33,000 ac of lake surface area, and 4 million ac-ft of water storage (see Figure 4-2).

It should be borne in mind that, with or without continued exports, Mono Lake will in the future fluctuate widely in

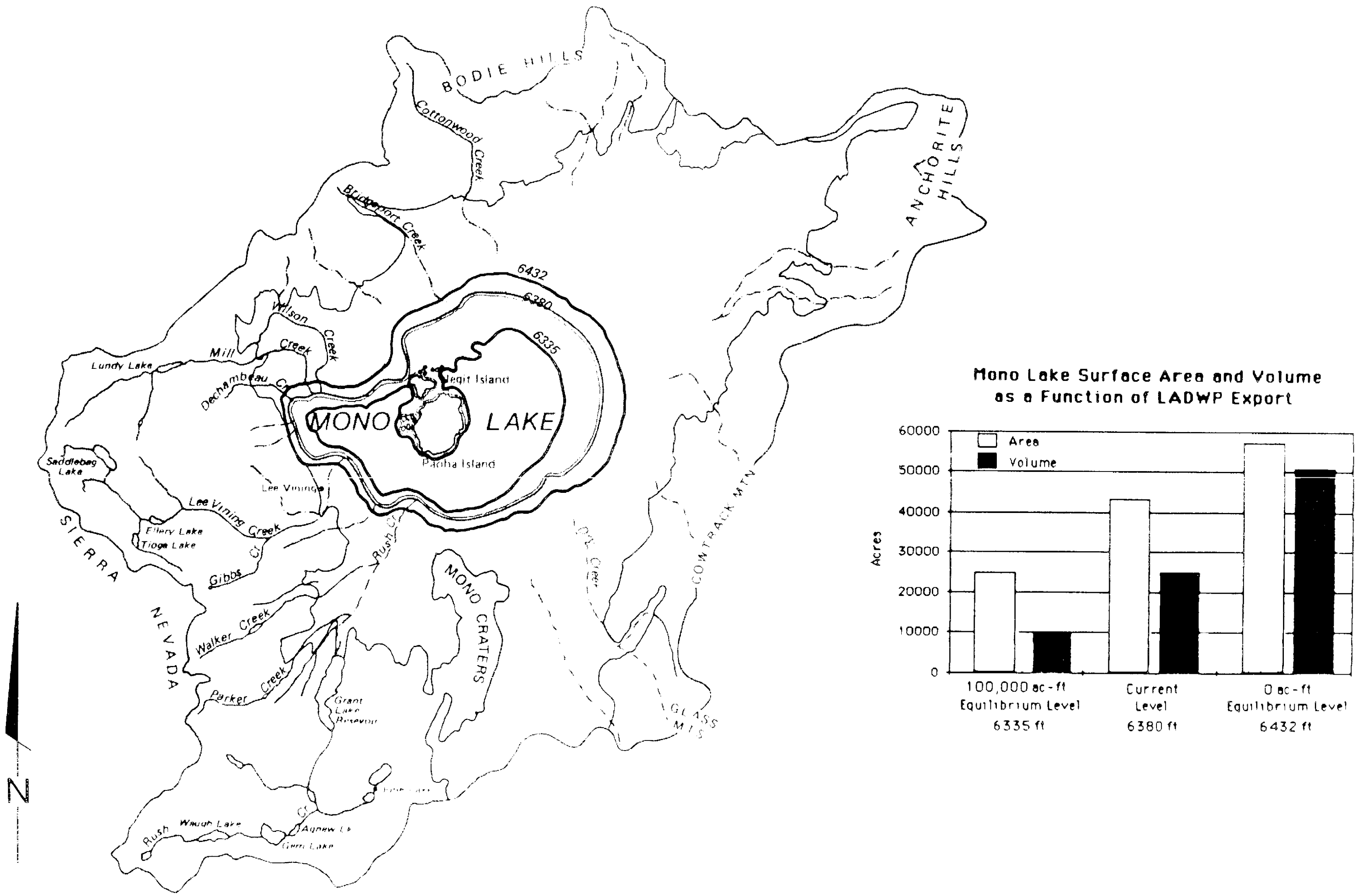


Figure 4-2
Comparison of Current and Projected Lake Levels, Areas, and Volumes

surface elevation in response to both short-term and long-term variations in climate, The sensitivity of Mono Lake to future variations in climate is illustrated by the way the lake responds to two sets of sequences that differ by 5% in average runoff and precipitation. Over the long-term the Lake levels could differ by as much as 17 ft in response to these two sets of conditions,

USEFULNESS OF THE MODEL

At the the present time the model is useful for making reasonably accurate year-to-year forecasts of Mono Lake levels. The forecast procedure requires testing several different values for the hydroclimatic variables and export levels or the use of projections based on long-range forecasts such as those that would be available following the April 1 snow surveys- Shorter time forecasts (e.g. monthly or bi-annual) can be made but the uncertainty in estimating Mono Lake's monthly evaporation rate decreases the forecast accuracy. Multi-year forecasts must assume a sequence of values for the hydroclimatic variables which in turn would determine the export rate. Basing the future sequences on the past record is standard practice although the future climate may be more or less variable (more or fewer fluctuations from wet to dry) than that of the last SO years. In other parts of the earth, much of the time (mid 1930's to mid 1970's) covered by the base period used in this model was a time of reduced climatic variability. Who could have guessed at the end of 1975 that in the next ten years runoff would swing from the lowest two years on record to the wettest seven year period on record, including the apparent highest one year runoff (1983) in this century?

Because of swings In climate one cannot make a deterministic forecast of future Mono Lake levels even if one knew the future annual LADWP export rates. To be of any use, every forecast must explicitly state what hydroclimatic assumptions are being used and what period in the past these assumptions are based upon. Thus the results showing the dynamic or static equilibrium levels as a function of export rates are only valid within the very narrow confines of the model assumptions. These results, however, can be interpreted to indicate what amounts of inflow (given the calculated amounts of outflow:) to the Mono Groundwater Basin are needed in order maintain Mono lake levels within a given elevational range.

SUGGESTED FUTURE RESEARCH

The ability to model the hydrologic cycle in the Mono Basin has outstripped the data base. For example we know that evaporation from Mono Lake is a major component, but our knowledge of the rates of evaporation over time and space is unacceptably limited because of the paucity of reliable and representative data, Additional data would substantially improve the accuracy of the component estimates and allow a refinement of component variables into more realistic parameters. Analysis of the component derivation as well as the relative significance of the component error to the model suggests that the following components need the most additional research: Mono Lake evaporation, non-Sierra runoff, bare ground evaporation from the exposed Mono Lake bottom, and groundwater storage change, Table 4-1 lists some recommended actions that would provide data and benefit the most components for the least cost, A costly but highly beneficial program would be to do thorough two to three year energy budget study of Mono Lake in order to provide more accurate evaporation estimates and greater understanding of the thermal cycle of the lake.

Methodological refinements and further application of the model would increase its usefulness as a tool for planning for the optimal utilization of Mono Lake's tributary water for LADWP export anti lake level maintenance. Suggested refinements include:

1. Develop a monthly forecast model, This would require a substantially better data base for Mono Lake evaporation and ungaged runoff. If a monthly model is not feasible, the model should be developed for the runoff year (April-March) in order to tie it into LADWP's export planning,
2. Develop a stochastic (probabilistic) runoff, evaporation rate, and precipitation rate simulation model. The synthetic sequences generated by a stochastic model would provide input to the water balance forecast model to project equally likely traces of future lake levels. A frequency analysis of the lake level traces provides probability information on various levels. It Is doubtful, however, if a valid stochastic model of the Lake evaporation rate can be developed from the existing inadequate

TABLE 4-1. Recommendations To Improve Accuracy of Component Estimates

	Recommendation	Purpose	Component(s) Benefited
1.	install automatic lake stage recorders on opposite shores	reduce interpolation and measurement error, measure seiching and wave height	MLSC, BGE
2.	develop more detailed topographic and bathymetric maps of lake basin[1]	improve stage/area/volume relationship	MLSC, GWSC, BGE
3.	monitor evaporation pan, pan water temperature, wind, relative humidity at south shore and Paoha Island site (would require automatic recorders)	improve pan coefficient estimate, facilitate mass-transfer method of estimating evaporation; determine spatial variation of evaporation	MLE, BGE, PHREB
4.	install water level recorder (staff gage adequate) and intermittent current meter measurements or calibrated flume on Post Office Creek, Log Cabin Creek, Dry Creek, Virginia Creek diversion	measure runoff from current ungaged areas and Virgina Creek diversion	USR, NSR, VCI
5.	supplement network of year round precipitation stations around lakeshore and mountains south and east of Mono Lake; probably require 3 to 4 new stations	improve isohyetal map; establish precipitation distribution in eastern part of basin	MLP, USR, NSR, NLSP
6.	drill and monitor shallow wells around lake shore	estimate ground water storage change and relationship to lake level change; estimate ground water evaporation by plants and soil	BGE, GWSC, PETA, PETB

	Recommendation	Purpose	Component(s) Benefited
7.	monitor water levels in existing wells in the groundwater basin; do pump tests	estimate magnitude of groundwater flow	USR, NSR, GWSC
8.	re-establish stream gages at Lee Vining Creek and Rush Creek county road crossing	quantify gain or loss in stream reach within groundwater basin	GWSC, USR
9.	install lysimeters in irrigated pasture and phreatophytes areas above and below 6428 feet	improve ET. estimates	ILET, RET, PHREA, PREB

[1] In late 1984 the USGS issued in preliminary form a series of 7 1/2 minute topographic maps for the Mono Basin. The entire near-shore area except for a small portion of the western shoreline area is mapped from aerial photos taken in August 1982. Also in late 1984 Pacific and Western Aerial Surveys made a topographic map of the near-shore area from elevations 6372 ft to 6435 ft. This map was made for the parties in United States vs. California lawsuit over the ownership of the exposed lake bottom.

data base.

3. Tie the model into a LADWP export model that incorporates Los Angeles Aqueduct runoff and storage, efficient Los Angeles water use, and alternative water supplies availability.

4. Reconstruct past Mono Basin climates from the Stine's (1984) prehistoric lake level fluctuation curve in order to project different plausible climatic conditions into the future.