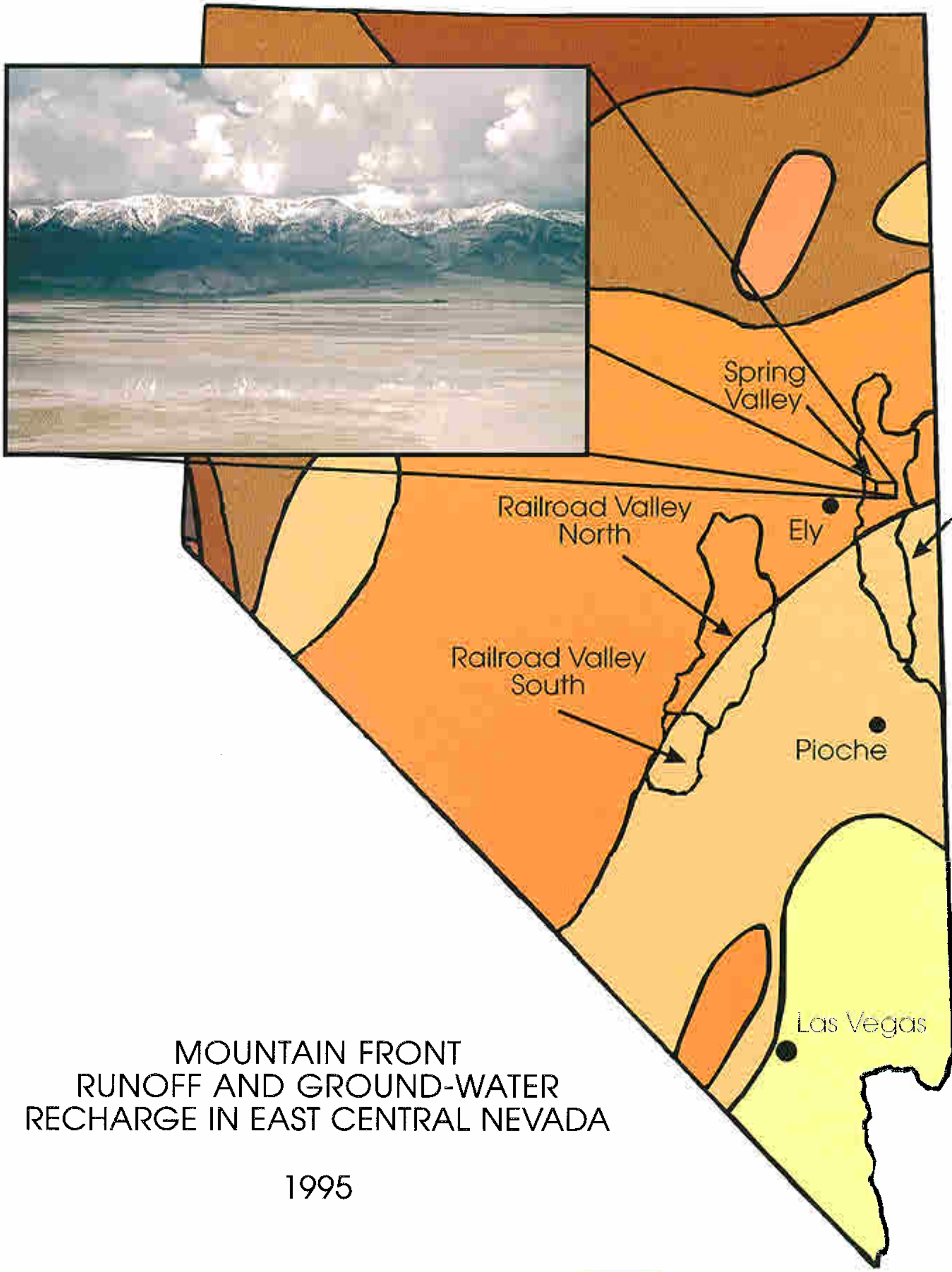

MOUNTAIN FRONT RUNOFF AND GROUND-WATER RECHARGE IN EAST CENTRAL NEVADA

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INTRODUCTION

In October 1989, the Las Vegas Valley Water District (District) filed for water rights in 28 hydrologic basins in eastern and southern Nevada. Consultants, retained by the District, were directed to evaluate all available hydrologic data for each basin and to develop computer models to represent the ground-water hydrology; one basin was evaluated primarily for surface water. Numerous reports were prepared which present the hydrology of the basins.

The U. S. Geological Survey (USGS) in conjunction with the Nevada Department of Conservation and Natural Resources conducted reconnaissance studies regarding the water resources for a number of hydrographic basins in Nevada during the 1960's and 1970's. These studies defined the basin's hydrologic budget, ground-water recharge and discharge, and estimated mountain front runoff for some basins.

The estimation of ground-water recharge, occurring in the mountain block, is based on an empirical technique first described by Maxey and Eakin (1949). This technique now referred to as the Maxey-Eakin method was further described by Eakin (1951) and has been reviewed by numerous investigators, most recently Avon and Durbin (1992). Avon and Durbin (1992) performed a statistical analyses of the Maxey-Eakin method and compared Maxey-Eakin estimates with other independent estimates of recharge. They found the Maxey-Eakin method to be a fairly reliable predictor of recharge. Briefly, the Maxey-Eakin method estimates the percentage of precipitation which will reach the ground-water system for various precipitation zones within the mountain block which are defined by altitude. These percentages were arrived at by estimating the discharge of a basin from evapotranspiration and then balancing the amount entering the basin (recharge) with the amount leaving the basin (discharge).

The reconnaissance studies also included an estimation of the amount of runoff occurring at the bedrock-alluvial contact, referred to as mountain front runoff, for basins surrounded by high mountain ranges receiving significant snowpack. While the studies estimated the overall volume of mountain front runoff for these basins, the role of the mountain front runoff in the overall water budget was not specifically addressed. In many basins this mountain front runoff provides water for agriculture and phreatophytes in the spring and summer months when it is available. The reconnaissance report for Spring Valley (Rush and Kazmi, 1965) termed this runoff rejected recharge and implied that some was probably entering the ground-water system past the bedrock-alluvial contact. Brothers et al. (1994) concluded that in water rich valleys, such as Spring Valley, the shallow depths to water and extensive surface water regime suggest the application of the Maxey-Eakin method may underestimate the percentage of ground-water recharge.

The Maxey-Eakin method was developed about fifty years ago, and has provided estimates of annual ground-water recharge for basins in Nevada that the Nevada State Engineer has used to evaluate and allocate ground-water resources. Recent studies (Nichols, 1992) regarding evapotranspiration rates of various phreatophytes indicate that some rates might be as much as 3.5 times higher than rates used in the USGS reconnaissance studies. This could also indicate

CONCLUSIONS

The annual estimated mountain front runoff is much lower than expected in Snake Valley and Railroad Valley and to a lesser extent in Spring Valley. Mountain front runoff estimates are based on an altitude-runoff relation which is calibrated using available stream flow information which accounts for local differences in geology, precipitation, vegetation, and land use. Workers in these three valleys all suggested that the mountain front runoff estimates for these valleys were low,when compared with many other valleys, due to the presence of high permeability carbonate rocks which cause a high percent of precipitation and runoff to infiltrate into the carbonate rocks before reaching the mountain front.

This anomaly leads to the question of where does this infiltrated water go and how does it fit in to the basin water budget? Van Denburgh and Rush (1974) suggested that the low value of mountain front runoff may indicate that recharge from precipitation in Railroad Valley is higher than the value calculated using the Maxey-Eakin method. The Maxey-Eakin method of calculating ground-water recharge is similar to the Moore (1968) method of calculating mountain front runoff in that both are based on a relation to altitude. However, the altitude-mountain front runoff relation is adjusted for local differences in geologic and geographic conditions, whereas the altitude-recharge relationship is not.

Therefore a basin with surrounding mountains comprised of high permeability carbonate rocks will probably have a low amount of runoff which is measured and reflected in a lower than expected estimated mountain front runoff. The estimated value of ground-water recharge does not take into account differences in geology or geography, therefore basins with mountains composed of high permeability carbonate rock will have a relatively low ratio of mountain front runoff to recharge. This could indicate that the Maxey-Eakin method of estimating recharge may underestimate recharge in these basins. Recharge could be entering the deep carbonate aquifer, the alluvial basin aquifer, or both. It is possible that in these basins the actual recharge of precipitation is near the value that would result if the recharge estimate were increased by the value that would be added to runoff to get a more normal runoff : recharge ratio. For example in Railroad Valley the estimated recharge of precipitation is 51,000 acre-feet per year and the estimated runoff is 26,000 acre-feet per year. A runoff value of 78,000 acre-feet per year would yield the average runoff : recharge ratio of 1.5 : 1. If the difference between the 78,000 value and the estimated value of 26,000 were assumed to be all an increase in recharge, the estimated recharge value of 51,000 acre feet per year would be adjusted to 104,000 acre-feet per year. Van Denburgh and Rush (1974) adjusted the recharge to Railroad Valley to 75,000 acre-feet per year to near the estimated basin discharge.

The assumption that the entire quantity of mountain front runoff below the average value of runoff, based on the runoff : recharge ratio, is accounted for by an equal increase in recharge is probably not correct. A percentage of mountain front runoff recharges the ground-water system via infiltration through alluvial fan deposits. Therefore some of the runoff lost to infiltration in the carbonate rocks in the mountains would probably have infiltered in the alluvial fans at below the mountain front had it not recharged the carbonate rocks. However, evaporation losses should be lower when precipitation runoff infiltrates rapidly below the zone effected by evapotranspiration. Therefore, it seems reasonable to assume that basins with lower than average mountain front runoff will have a higher than average recharge to the ground-water system when carbonate mountains are involved. The Maxey-Eakin method is based on an average altitude: recharge relation derived by trial and error in 13 valleys (Eakin et al. 1951, pg 78-80). Since it does not account for differences in geology or geography the method probably underestimates recharge in basins with carbonate rock mountains with low runoff : recharge ratios.

Van Denburgh and Rush (1974) recognized this possibility in Railroad Valley. Rush and Kazmi (1965) in their study of Spring Valley thought the anomalous quantity of runoff infiltrating on the western side of the Snake Range might be flowing eastward through the Snake Range and contributing to spring flow and runoff on the east side of the Snake Range. However since the runoff : recharge ratio on the east side of the Snake Range and Snake Valley is also very low, the infiltrated runoff could be recharging the deep carbonate aquifer, Spring Valley, or Snake Valley alluvial aquifer. Hood and Rush (1965) calculated Snake Valley mountain front runoff and recharge, but did not comment on the values or the runoff : recharge ratio. However they did comment that "Water from Snake and Hamlin Valleys may enter the carbonate rocks from precipitation and from the valley fill and be transmitted northeastward and northward to the Great Salt Lake Desert."(Hood & Rush, 1965, p. 21). Carlton (1985) calculated the runoff : recharge ratio for Snake Valley at 0.58 : 1 and noted that it was less than the average value for 54 Great Basin carbonate valleys and 111 Great Basin noncarbonate valleys that he examined. It is possible that the infiltrated runoff in the Snake Range is recharging the deep carbonate aquifer and flowing toward the great Salt Lake Desert.

The lower than expected mountain front runoff in Railroad Valley, Spring Valley, and Snake Valley suggests a significant percent of runoff is infiltrating into the carbonate rocks that comprise the mountains. This phenomena may be causing ground-water recharge of precipitation in excess to the amount predicted using the Maxey-Eakin methodology described in Eakin et al. (1951). This recharge may be contributing to the alluvial basin aquifers or the deep carbonate aquifer. There is little available data on the alluvial basin aquifers and almost no data available for the deep carbonate system, therefore it is not possible to state with certainty whether recharge is greater than the value predicted using the Maxey-Eakin method. However, the available information suggests that recharge of precipitation may be greater than previously predicted in these areas, but it will not be possible to evaluate with certainty until ground water in these areas is more fully developed and monitored.