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THE LAS VEGAS FLASH FLOODS OF 8 JULY 1999: A POST-EVENT SUMMARY

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Introduction

Torrential rains produced severe, and in some cases, unprecedented flash-flooding across the Las Vegas valley on 8 July 1999. Much of the Las Vegas valley experienced from 35%-70% (1.5 to 3.0 inches) of its annual rainfall (4.13 inches) over the course of 60-90 minutes (1030-1200 LDT). The resulting runoff from these rains caused widespread street flooding and record flows in normally dry washes and flood control detention basins (Sutko, 1999). The floods caused over $20,000,000 in property damage and took two lives.

Streets and washes were overwhelmed by the tremendous amount of rain over such a short period of time. Motorists and pedestrians were also unprepared for the magnitude of these floods, as over 200 swift-water rescues were performed by the Las Vegas and Clark County Fire Departments. The floods also caused severe erosion of unlined sections of certain washes and damaged numerous roadways.

The Office of the Governor issued a Declaration of Emergency for the area and requested assistance from the Federal Emergency Management Agency on 15 July. President Clinton declared the city a disaster area on 19 July.

Flash floods are not unusual in the Las Vegas valley (Runk and Kosier, 1998), however, this event was extreme in its scope and intensity. The purpose of this Technical Attachment (TA) is to review the meteorological conditions that preceded this event and discuss how the unique orography and urbanization of the Las Vegas valley contributed to the flash-flood threat.

The Influence of Orography, Geology, Urbanization, and Flood Control Measures During the 8 July 1999 Flood Event

The Las Vegas valley is located in the Basin and Range Physiographic Province (Purkey, 1994). This region is characterized by a series of generally north-south trending mountain ranges and intervening valleys filled with eroded sediments. The eroded sediments disperse from the mountains that surround the Las Vegas valley in the form of alluvial fans. These fans, and the washes they contain, funneled water from the valley eastward into the Las Vegas Wash (Fig. 1). This wash then flows into Lake Mead which is part of the Colorado River system.

The Las Vegas valley is very prone to flash flooding due to its geologic and orographic composition. The Spring Mountains are located on the west side of the valley, while the Sheep Range borders the valley on the north. Smaller mountain ranges are located on the east and southeast sides of the valley. The Spring Mountains are composed primarily of limestone rock. The alluvial fans around the valley are coated with calcium carbonate which is part of the geologic composition of limestone. Calcium carbonate is better known as Caliche. Caliche is almost impervious, so when there is rainfall in the valley, almost 100% of it is runoff.

These factors, along with the amount of urban development in this area, can often increase the severity and impact of flash flooding in the Las Vegas Valley. Oftentimes, roadways placed on the surface of the alluvial fans can act as rivers, channeling away runoff and exacerbating urban flooding. Furthermore, many city streets are not equipped with storm drains or have storm drains that are incapable of handling runoff associated with moderate to heavy rainfall.

For the past two decades, the Clark County Regional Flood Control District has spearheaded the construction of flood control detention basins at strategic locations around the outskirts of the Las Vegas valley. This program has had a profound impact toward decreasing the severity of flooding in recent years. However, much of the rainfall on 8 July 1999 occurred downstream from these basins. Subsequently, much of the valley was vulnerable to flooding, though it is likely the flood damage would have been much more severe without the presence of the detention basins.

For all of these reasons, the amount of rainfall needed to produce flash flooding across the Las Vegas valley is quite small. Generally, only 0.50 to 1.0 inch of rainfall is needed in a short amount of time. During the floods of 8 July 1999, much of the Las Vegas valley received in excess of 1.5 inches of rainfall over a 60-90 minute period. Two automated rain gauges (one in the south and another in the west part of the valley) reported over 3.0 inches of rain (Fig. 2). Some of the flows in the washes exceeded the peak discharge of record (Fig. 1, Table 1). Additionally, many of the flood control detention basins stored impressive amounts of water (Table 2).

Synoptic Overview

The atmosphere over much of southern Nevada, northwest Arizona, and southeast California had experienced a tremendous increase in moisture levels prior to the flooding.

This was the first major surge of moisture over the area in 1999 associated with the Mexican monsoonal flow pattern. ETA model graphics for the 1200 UTC model run of 8 July 1999 are used in this TA since the model had the best initial analyses of the features in question.

The ETA model initial analysis of precipitable water at 1200 UTC showed values well in excess of 1 inch across much of southern Nevada (Fig. 3). The axis of highest moisture values extended from southeast California, through the Las Vegas valley, and up into southwest Utah. Similarly, Convectively Available Potential Energy (CAPE) values were in excess of 1000 J Kg^{-1} over much of extreme southern Nevada (Fig. 4). The moisture and instability were readily apparent on the 1200 UTC 8 July 1999 Desert Rock (DRA) sounding (Fig. 5), which is located about 60 miles northwest of Las Vegas.

What is notable about the sounding is that the deep, well-stratified moisture that is present suggests that the environmental relative humidity is high enough such that convective cold pools would not be strong enough to undercut the impinging storm-relative inflow to new updrafts. Thus, the mesoscale system could be maintained for an extended period of time. Also, extremely light winds throughout the depth of the troposphere, in concert with a rich moisture supply and deep layer of convective instability, provided the ingredients for very efficient rain rates.

A catalyst in bringing the abundant moisture into the region was a westward-moving inverted trough in the middle levels of the atmosphere. Meteorological studies done in the desert southwest have shown that although significant moisture is often necessary for large-scale severe weather or heavy monsoonal rainfall to occur (Wallace, 1998; Haro and Bruce, 1997), such events are much more apt to occur when a mesoscale or synoptic-scale feature is present to support such an episode (Haro, 1998).

The mid- and upper-level support provided by the inverted trough was strong enough to produce persistent nocturnal showers and thunderstorms over portions of northwest Arizona the night of 7 July 1999 and into the early morning hours of 8 July 1999. This persistent development immediately signaled that abundant daytime heating would not be necessary for showers and thunderstorms to develop over extreme southern Nevada.

The ETA 1200 UTC 8 July 1999 initial analysis of 500 hPa geopotential heights and winds (Fig. 6) shows the inverted trough over the Arizona/California border, with a well-defined deformation zone over southern Nevada. The influence of the trough was evident in the ETA 6 hour forecast of absolute vorticity at 600 hPa and omega in the 700-400 hPa layer (Fig. 7). In response to this deep-layered forcing, a well-defined surface convergence zone developed along the I-15 corridor from Mesquite, Nevada, through Las Vegas, to Barstow, California. This feature provided a focusing mechanism for initial convective development.

Satellite and WSR-88D Products Summary

Showers and thunderstorms began developing over northern portions of the Las Vegas valley by 1630-1700 UTC (0930-1000 LDT). The precipitation became more widespread after 1730 UTC and was oriented along the axis of greatest moisture and lift.

Between 1800-1900 UTC, heavy rainfall was affecting much of the western part of the valley. The Composite Reflectivity product from the Las Vegas (KESX) WSR-88D at 1832 UTC (Fig. 8) showed values well in excess of 50 dBZ across much of the area. Infrared satellite imagery of the storms at 1900 UTC (at 4 km resolution) showed that the coldest cloud top temperatures with these storms were near -70°C (Fig. 9). One-hour precipitation estimates from the KESX radar were well in excess of 1.5 inches in many locales (Fig. 10). These estimates corresponded well to what was occurring in real-time and proved reliable to the radar operators on shift.

Showers and thunderstorms gradually developed southwestward toward Barstow-Daggett, California along the axis of maximum moisture convergence. Storms eventually weakened and dissipated during the afternoon hours as the support provided by the inverted trough began to wane, and cold pool processes produced divergence in the boundary layer. It should be noted that although the most severe flooding occurred in the Las Vegas valley, flash-flooding also occurred over rural portions of northern Clark, southern Lincoln, and southern Nye Counties in Nevada, with minor flooding over southeast California.

Conclusions

Flooding of this magnitude across such a large swath of the Las Vegas valley was unprecedented in the eyes of many observers. This event fell between the 50 and 100-year flood criteria along portions of the Las Vegas Wash according to the U.S. Geological Survey (personal communication). Also, the extreme nature of this flood proved to be a stiff test for local emergency management officials, as well as to the flood control measures implemented by the Clark County Regional Flood Control District to deal with such events.

This event also illustrated the significant influence that kinematic features can have on the development of organized storms over the desert southwest during the summer monsoon. While much is made of the moisture that often accompanies this seasonal wind pattern, experience has clearly shown that when this moisture combines with well-defined kinematic features, devastating results can occur.

The response of the NWSO in Las Vegas during this event gave clear warning to local residents, media, and emergency management officials of the gravity of the weather situation. Most notably, an outlook statement was issued by the NWSO on 7 July 1999, specifically highlighting the possibility of flash floods the next day. A Flash Flood Watch was also issued at 0357 LDT that morning, warning of possible flash floods that day, a full 7 hours before the most severe flooding occurred. Short-term warnings were also issued efficiently and effectively.

Given the unique geology and orography of the Las Vegas valley, it will remain vulnerable to flash floods through the foreseeable future. More and more people will become susceptible to these devastating floods as the Las Vegas valley continues to grow at a rate of 5,000-6,000 people per month. Although no amount of prevention can spare everyone from the effects of such floods, these effects can be mitigated through the continued work and intervention of the Clark County Regional Flood Control District and the National Weather Service.

Acknowledgments

The authors thank the Clark County Regional Flood Control District and the U.S. Geological Survey for providing rainfall and streamflow data used in this TA.

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Table 1 Peak discharges on Las Vegas valley washes during the 8 July 1999 flash floods and previous maximum flows (data provided by the U.S. Geological Survey)

Location	Peak Discharge (cfs)	Previous Maximum (cfs)
1) Las Vegas Wash at Sahara	8,100	4,400 (9/11/98)
2) Las Vegas Wash below Flamingo	11,000	6,100 (9/11/98)
3) Las Vegas Wash below Three Kids	18,000	9,000 (9/11/98)
4) Flamingo Wash at Eastern	6,800	4,700 (8/10/83)
5) Duck Creek at Eastern	4,300	4,130 (8/19/84)

Table 2 Stored runoff in detention basins during the 8 July 1999 flash floods (data provided by the Clark County Regional Flood Control District)

Detention Basin	Acre-ft	Maximum Height of Water (ft)
1) Angel Park	200	13
2) Gowen South	325	22
3) Red Rock	200	7.25
4) Upper Flamingo	530	5.5

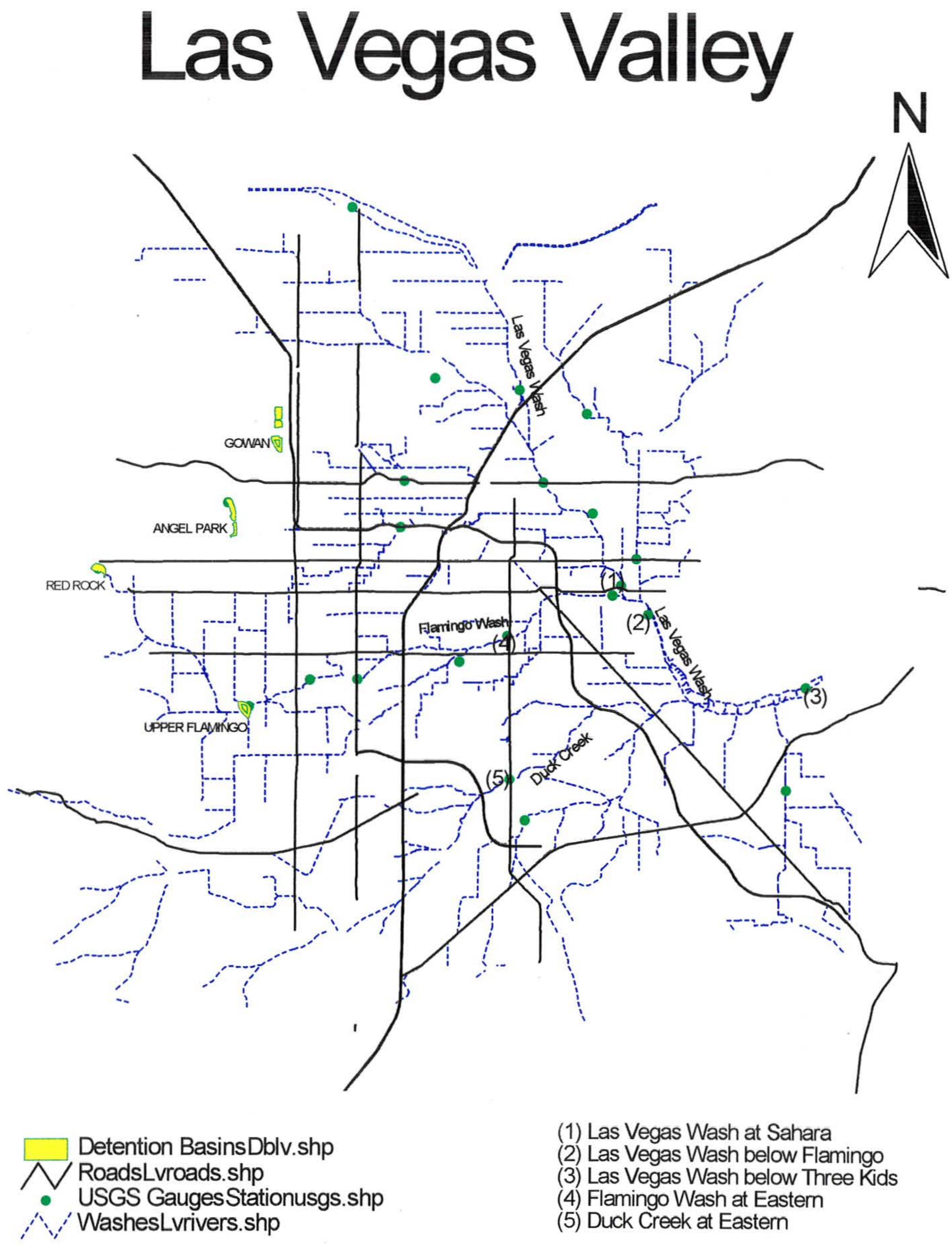

Fig 1. Las Vegas valley washes and flood control detention basins affected by the flash floods of 8 July 1999.

Las Vegas Rainfall

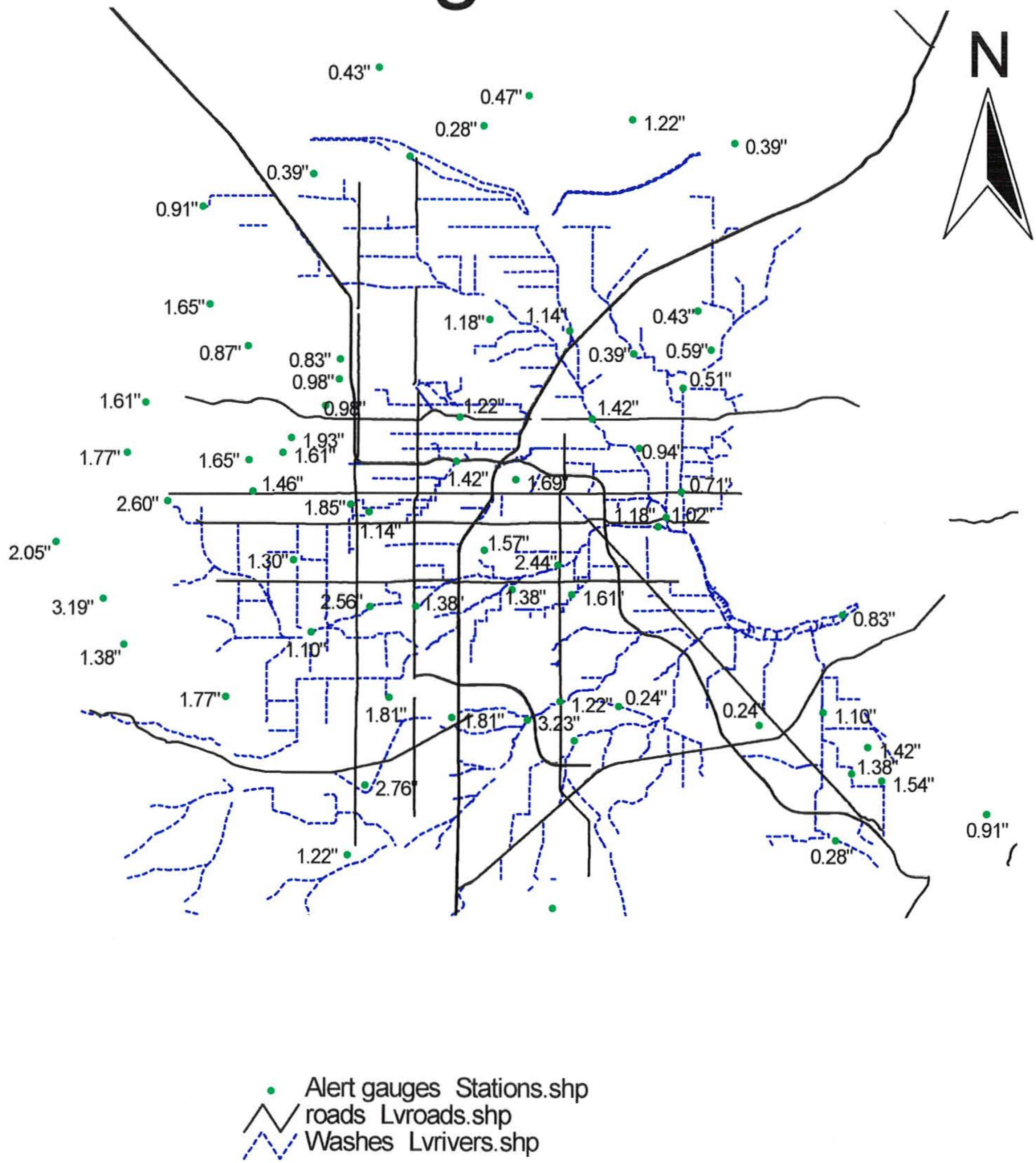

Fig 2. Las Vegas valley rainfall distribution.

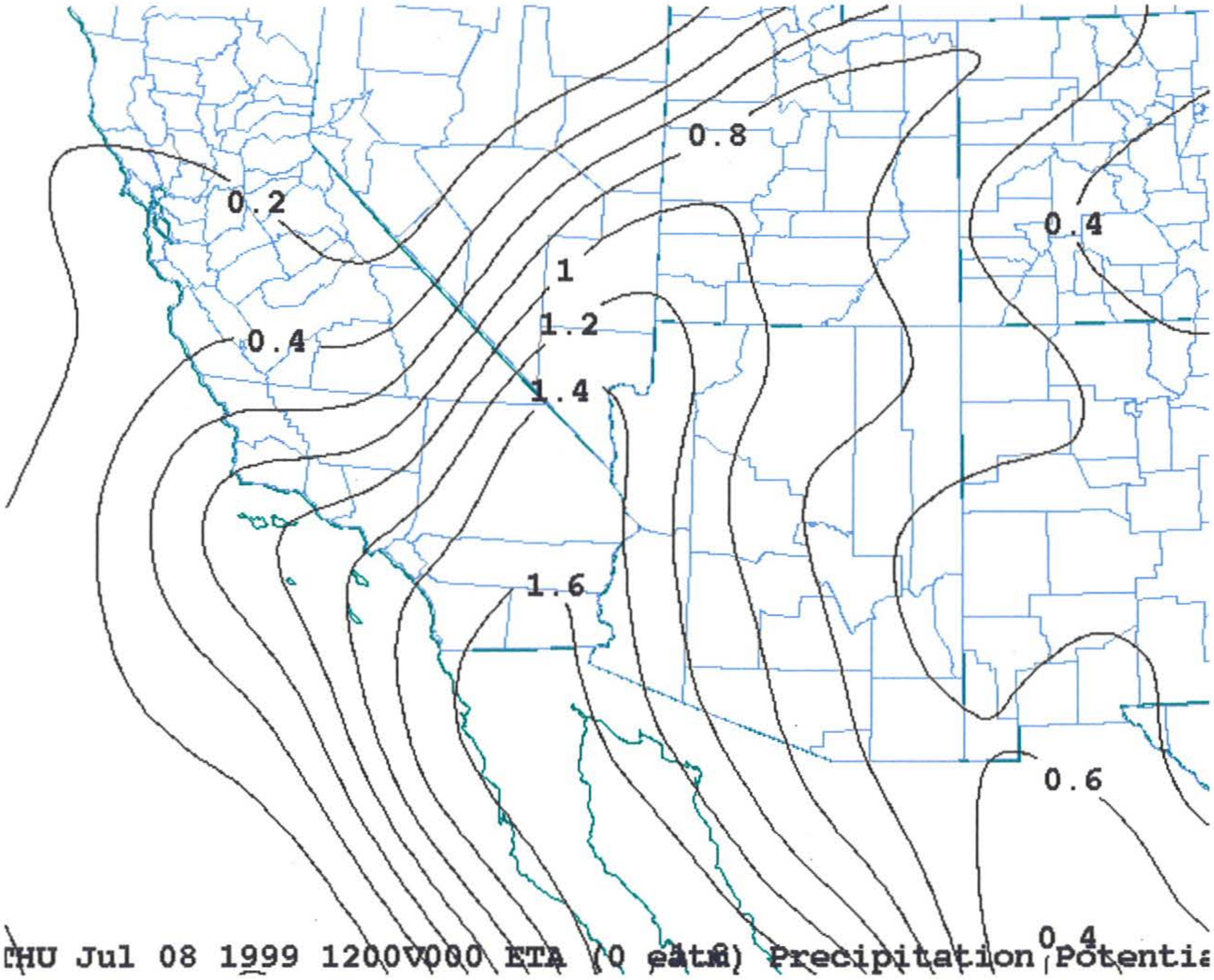

Fig 3. ETA model initial analysis of precipitable water at 1200 UTC 8 July 1999

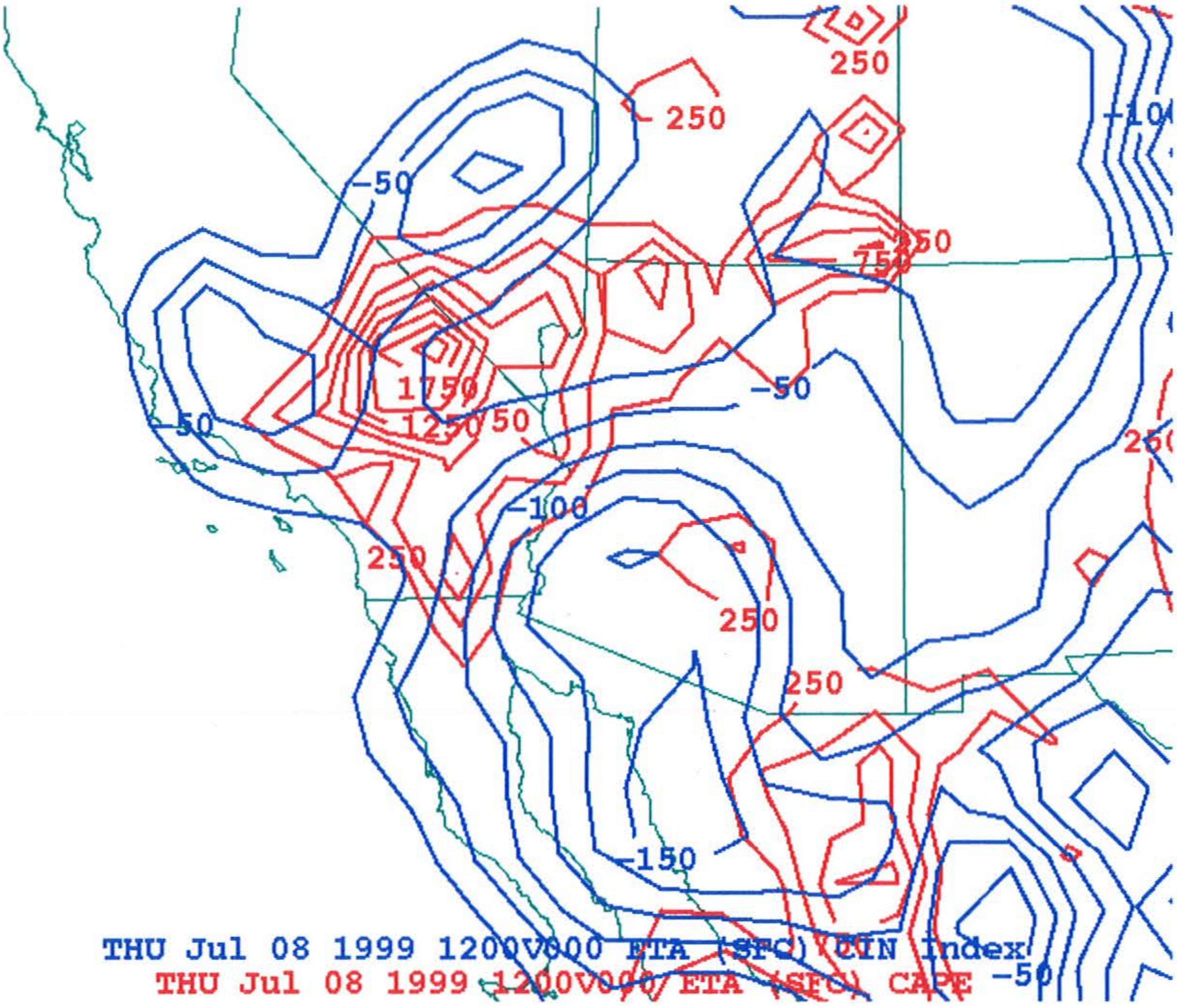

Fig 4. ETA model initial analysis of Convectively Available Potential Energy (CAPE) and Convective Inhibition (CIN) for 1200 UTC 8 July 1999

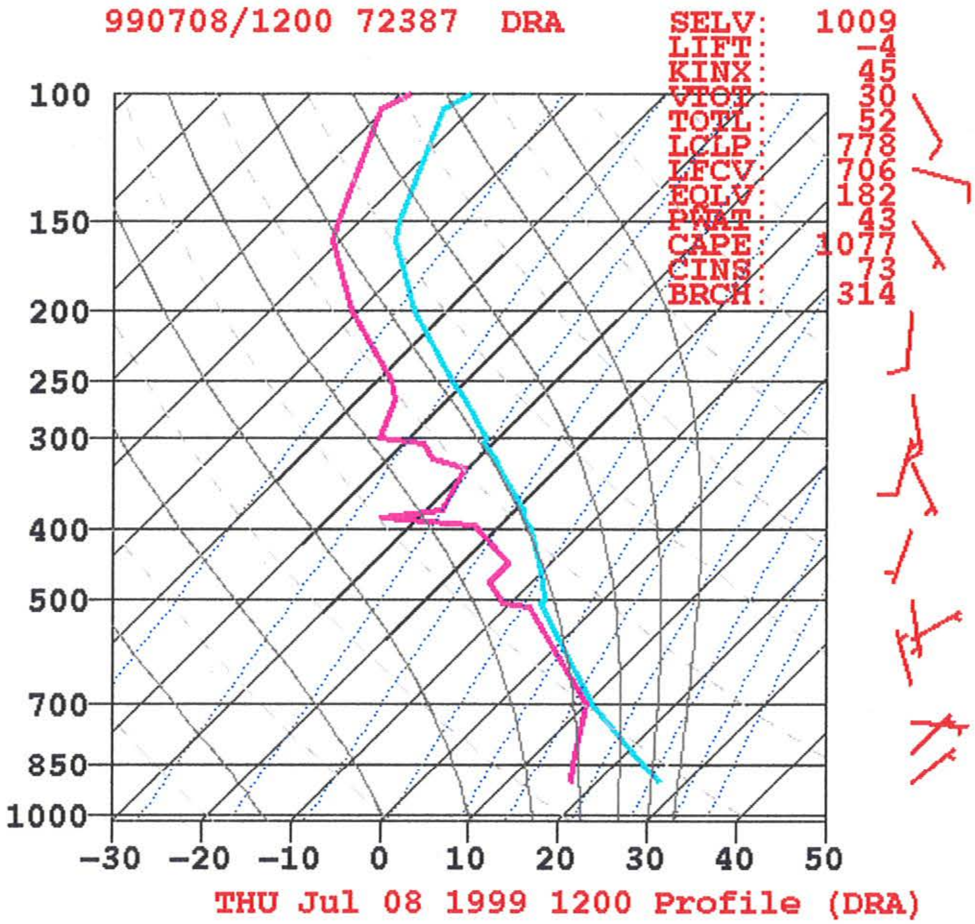

Fig 5. 1200 UTC 8 July 1999 sounding for Desert Rock (DRA)

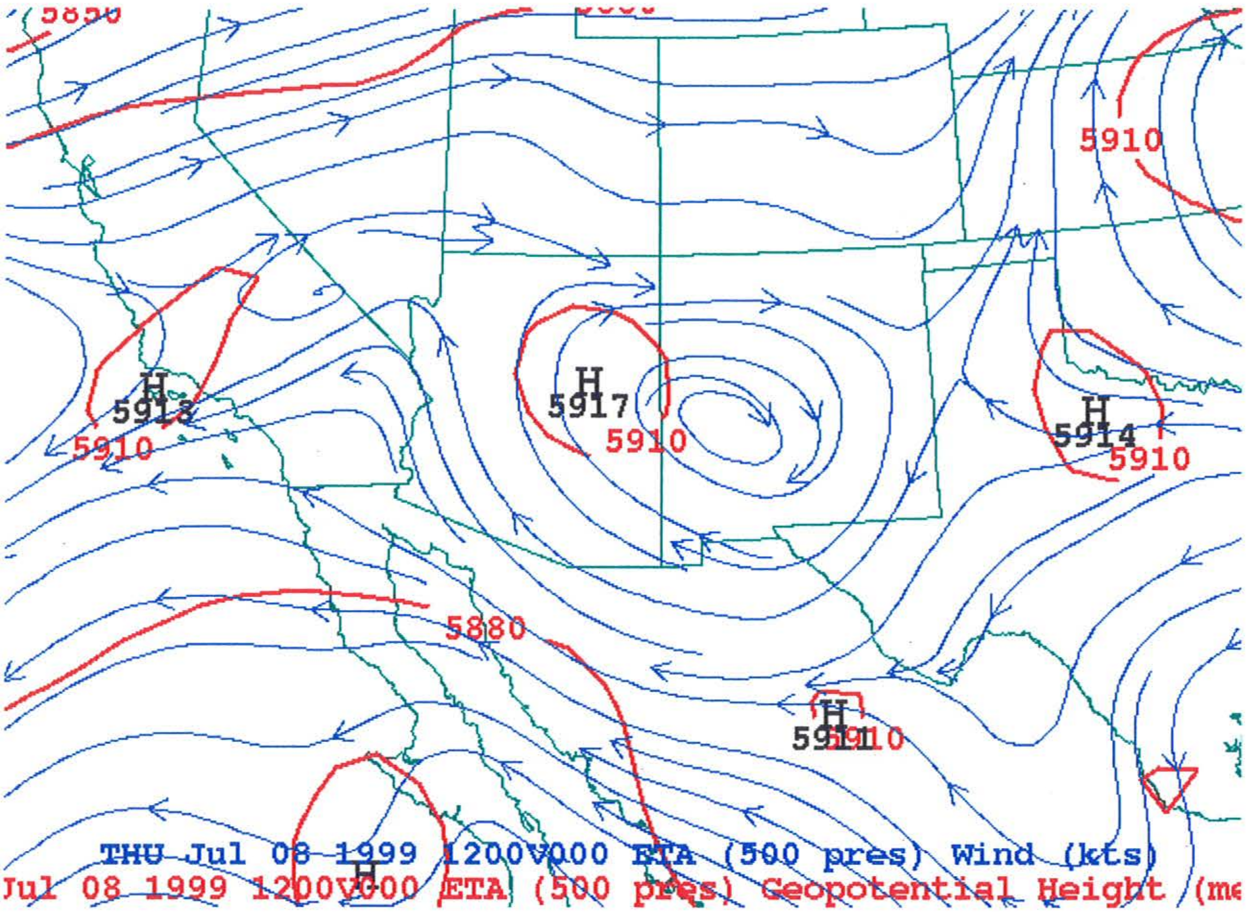

Fig 6. ETA model initial analysis of 500 hPa geopotential heights and streamlines of winds at 1200 UTC 8 July 1999

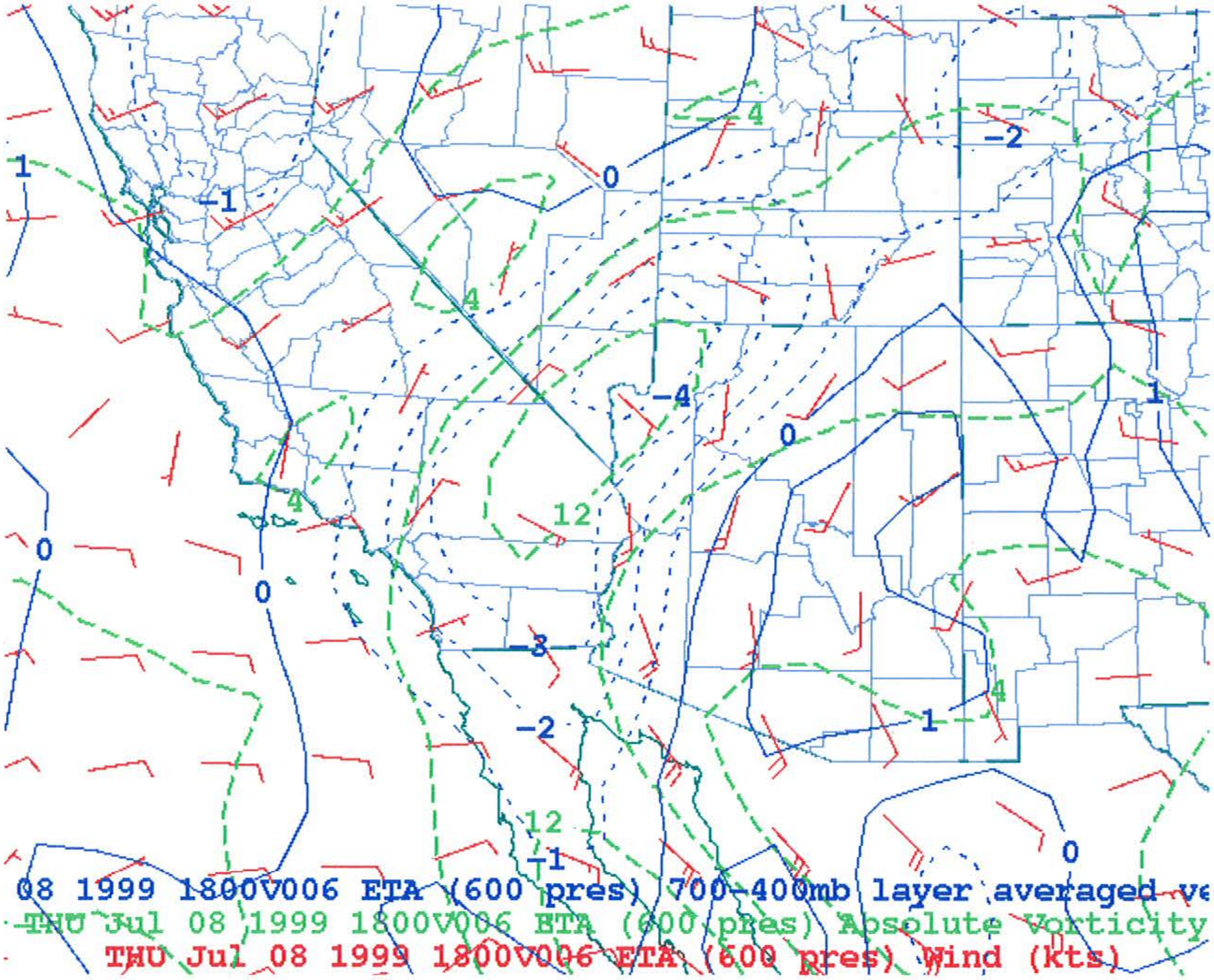

Fig 7. ETA model 6 hour forecast of 600 hPa absolute vorticity and wind, and layered omega between 700-400 hPa

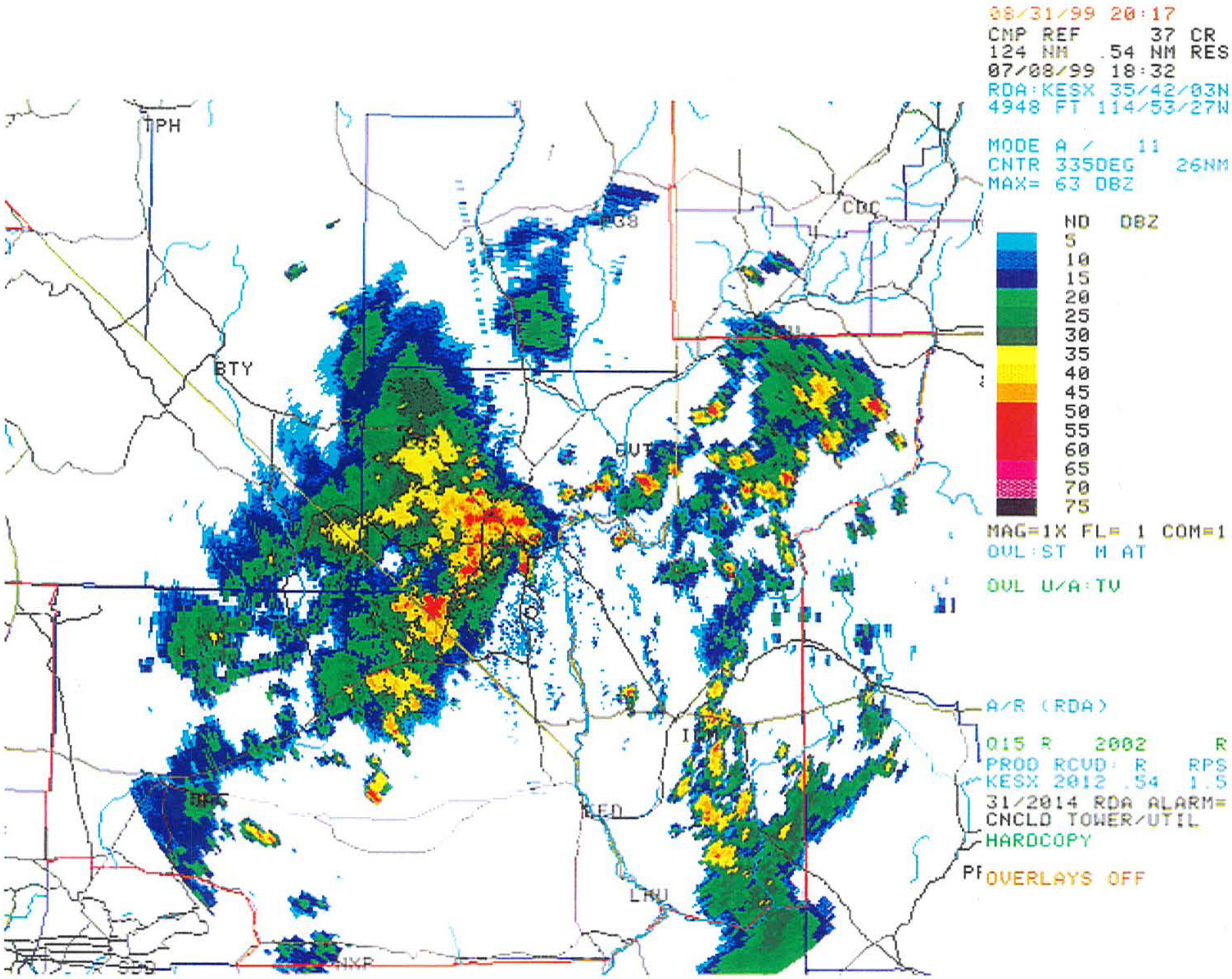

Fig 8. Las Vegas (KESX) Composite Reflectivity Image valid at 1832 UTC 8 July 1999

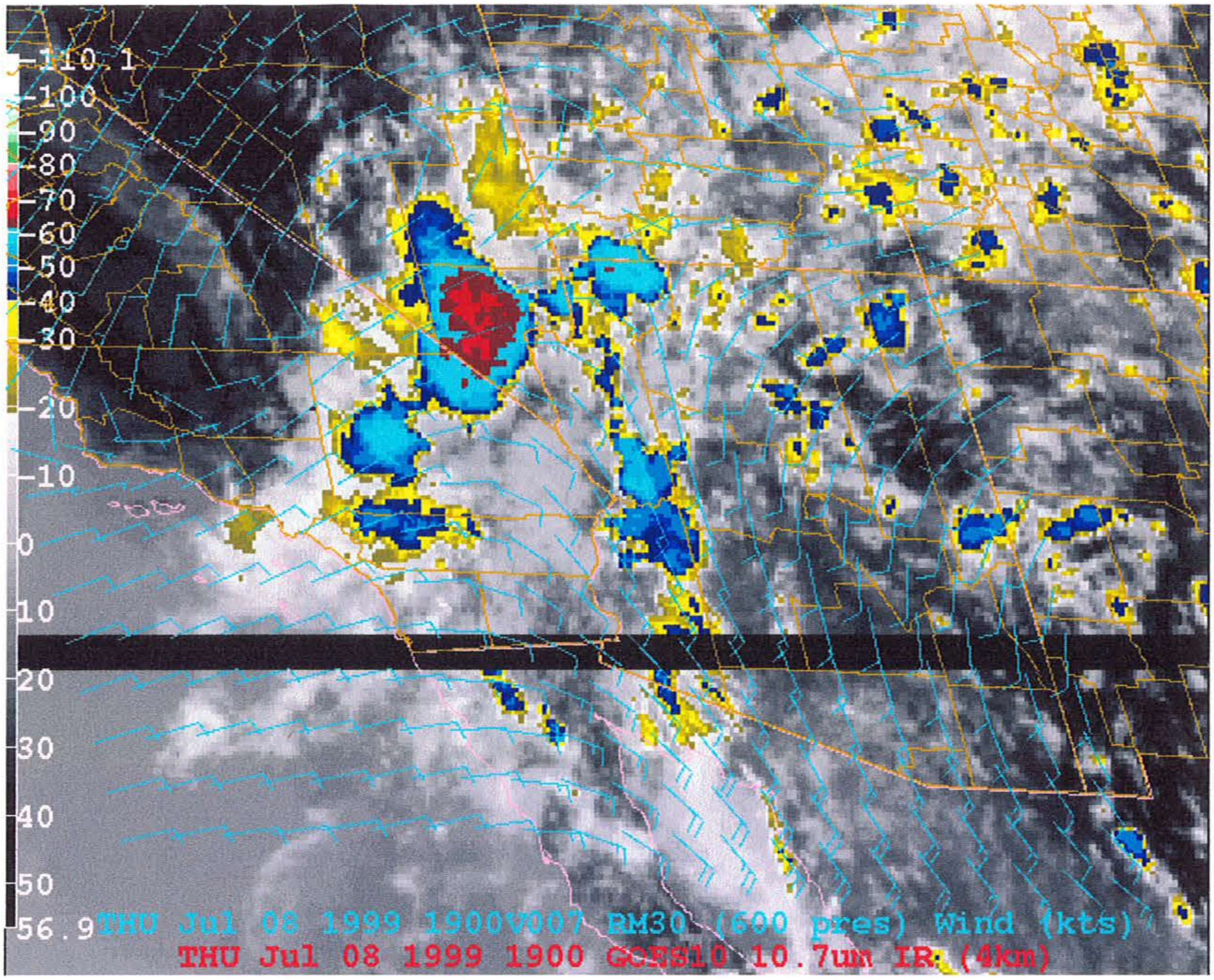

Fig 9. GOES 10 4 km IR satellite image valid at 1900 UTC 8 July 1999 and RAMS model 600 hPa winds

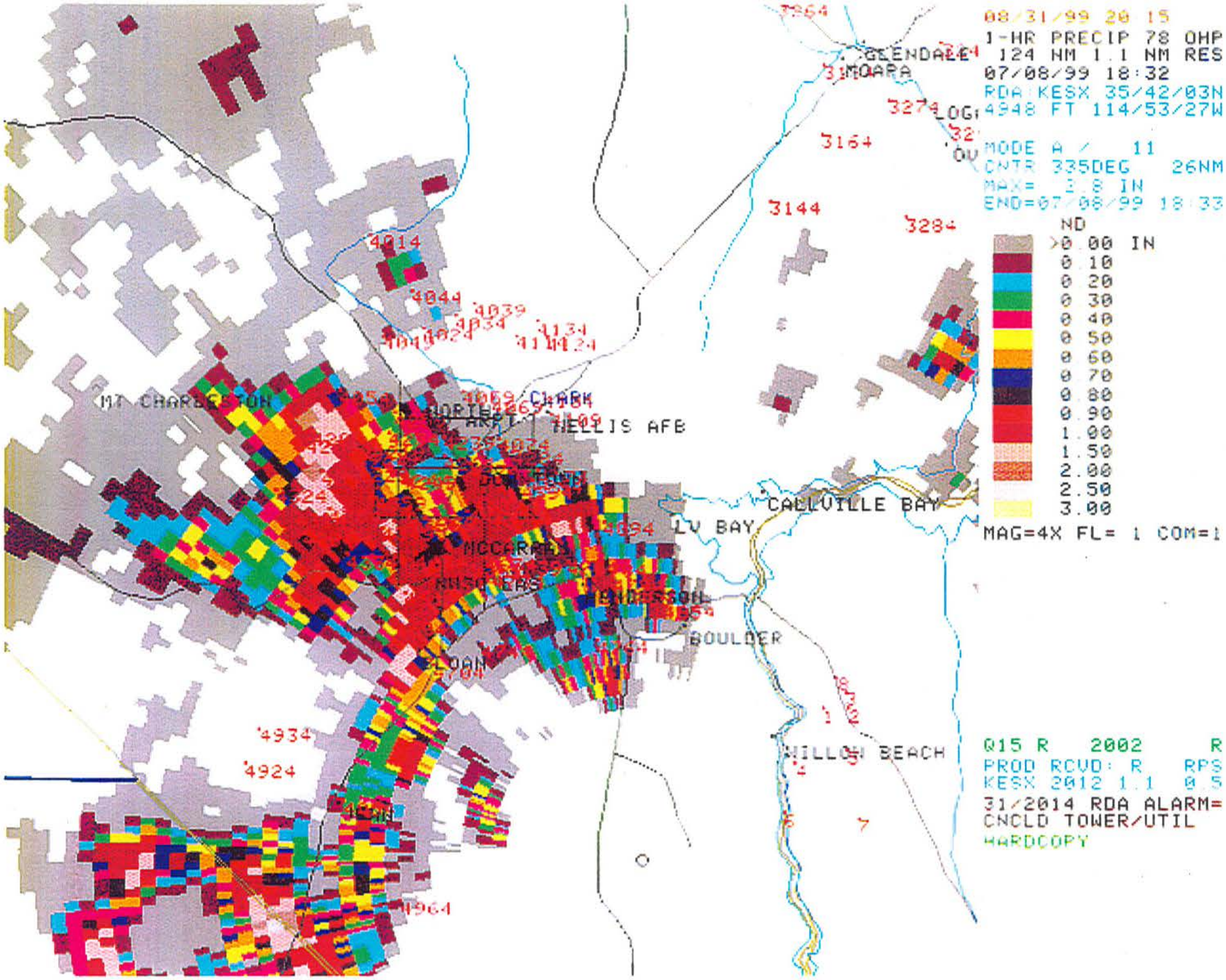

Fig 10. Las Vegas (KESX) 1-HR precipitation product valid at 1832 UTC 8 July 1999