# An Example of a Heavy Precipitation (HP) Supercell Producing Record Rainfall Rates in Downtown Sacramento, CA

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## Introduction

On 19 September 2004, the Sacramento, California area experienced a short-lived but very intense convective rainfall event that produced historic rainfall rates. The National Weather Service rain gauge located at the California State University, Sacramento (CSUS) campus recorded a storm total of 1.93 inches in 71 minutes. Rainfall from this Heavy Precipitation (HP) supercell overwhelmed drainage and the sewer systems. Localized flooding due to the excessive rainfall rates resulted, including the flooding of part of the State Capitol. The heavy rain also contributed to the collapse of a section of a grocery store roof. Small hail accumulated to a depth of several inches in one neighborhood. California State Climatologist Bill Mork calculated the hourly rainfall rates from the storm to be a 1 in 51,000 year event!

## Synoptic Situation

An unseasonably deep upper level trough, originating in the Gulf of Alaska, migrated over California on 19 September 2004. Note the broad area of less than -22 degree Celsius temperatures at 500 mbs over northern California (Figure 1).

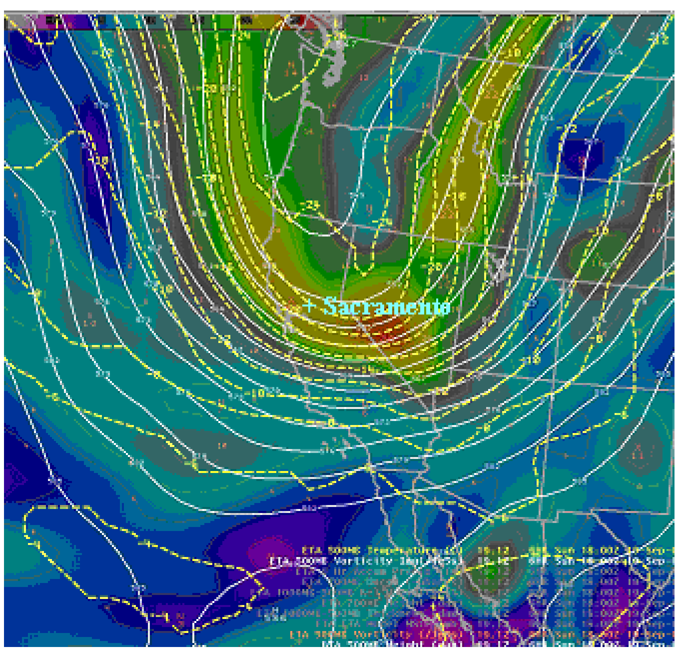



**Figure 1. 18Z Eta 500mb Heights, Vorticity, and Temperatures**

In addition, a strong vorticity maximum associated with the upper trough enhanced upward vertical motion and helped steepen mid level lapse rates. A lifted index of -2.9 degs C was indicated on the 12Z 19 September 2004 Oakland, California (KOAK) sounding, illustrating the instability of the air mass. A strong upper level jet with wind speeds in excess of 130 knots approached the coast of northern California during the day. Upper level divergence, from the left front exit region of this feature, enhanced upward vertical motion over northern California (Figure 2). The amount of moisture available was abundant with the 12Z KOAK sounding showing a precipitable water value of .76 inches, which was 125% of normal.

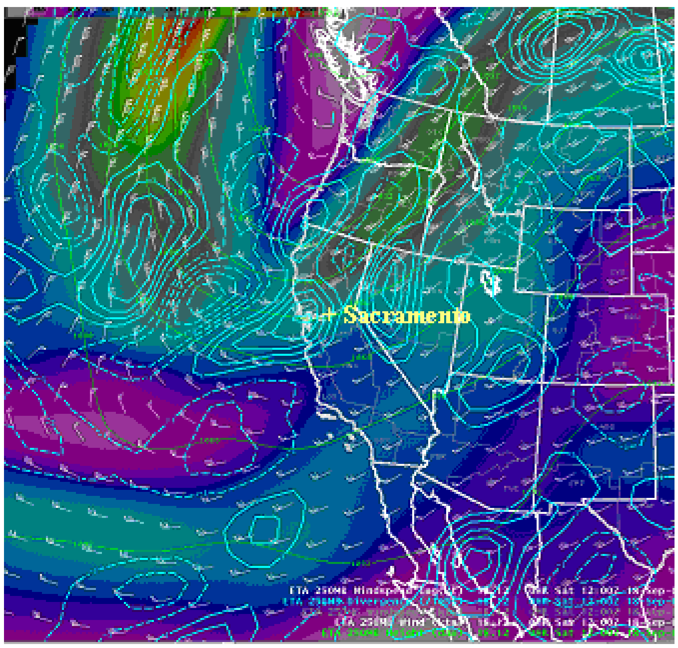



**Figure 2. 12Z Eta 250 mb Heights, Winds, and Divergence**

A significant surface reflection of the deep upper level trough was identifiable in the surface wind field. By early afternoon, pronounced convergence of the surface winds from the East Bay through the Sacramento area was evident (Figure 3) from the LAPS data along with a mesoscale area of low pressure just west of Sacramento. Staudenmaier (1995) and Tardy (2002) discussed how convection is often focused and enhanced along such convergence boundaries in the Sacramento valley. Low level moisture became focused or "pooled" along this boundary during the afternoon (Figure 3).

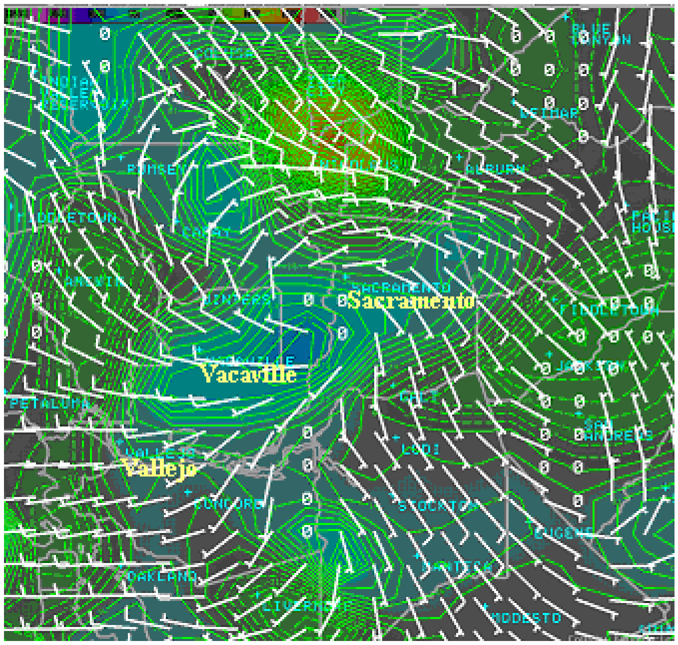



**Figure 3. 20Z LAPS Surface Winds and Moisture Flux Divergence**

Radar images from the Davis, California (KDAX) site showed deep, moist convection developing and intensifying along this convergence line (Figure 4). The strongest cells developed just east of the mesoscale circulation, over downtown Sacramento. This area also saw a cell merger which aided in storm intensification.

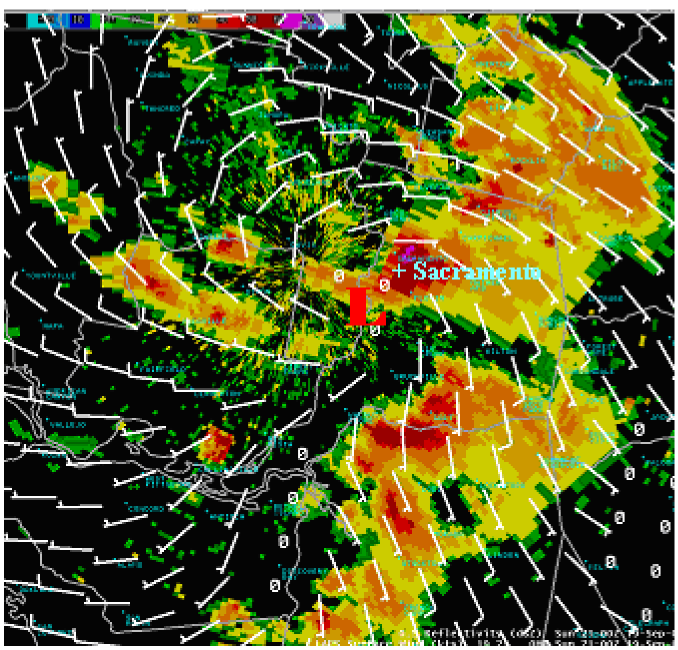



**Figure 4. 21Z KDAX 0.5 Degree Reflectivity and LAPS Surface Winds**

A veering wind profile resulted in a broadly looping hodograph. Helicity values from the 18Z Eta model (via BUFKIT) were 107 $m^2/s^2$ around the time of convective initiation, but later climbed as high as 158 $m^2/s^2$ on the 00Z initialization. These values would be coincident with low-topped supercell storms as described by Davies-Jones, et al. (1990).

The thunderstorm over Sacramento exhibited supercell characteristics around 2045Z as a flanking line and apparent rear flank downdraft (RFD) formed. It was at this time that a severe thunderstorm warning was issued for the Sacramento area due to the increased potential for large hail from the intensifying updraft evident by a V-notch (Figure 5). In subsequent scans, a bounded weak echo region (BWER) was identified.

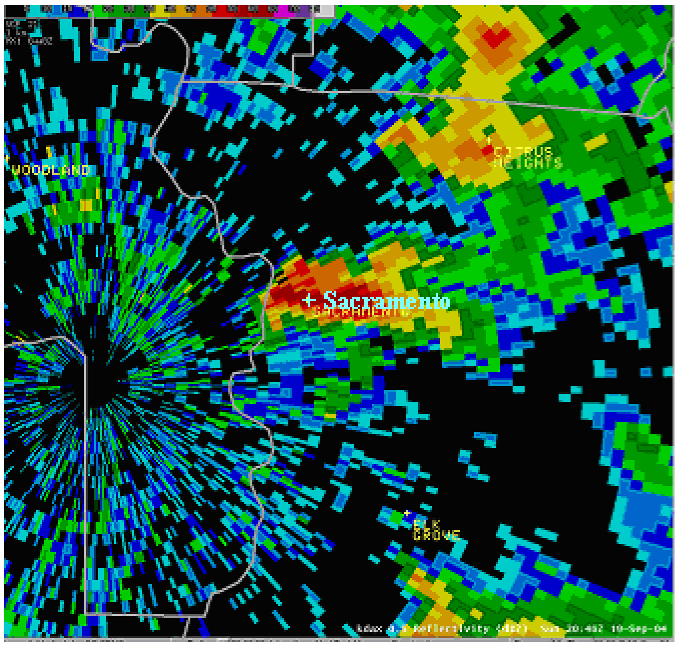



**Figure 5. 2046Z KDAX 0.5 Degree Reflectivity**

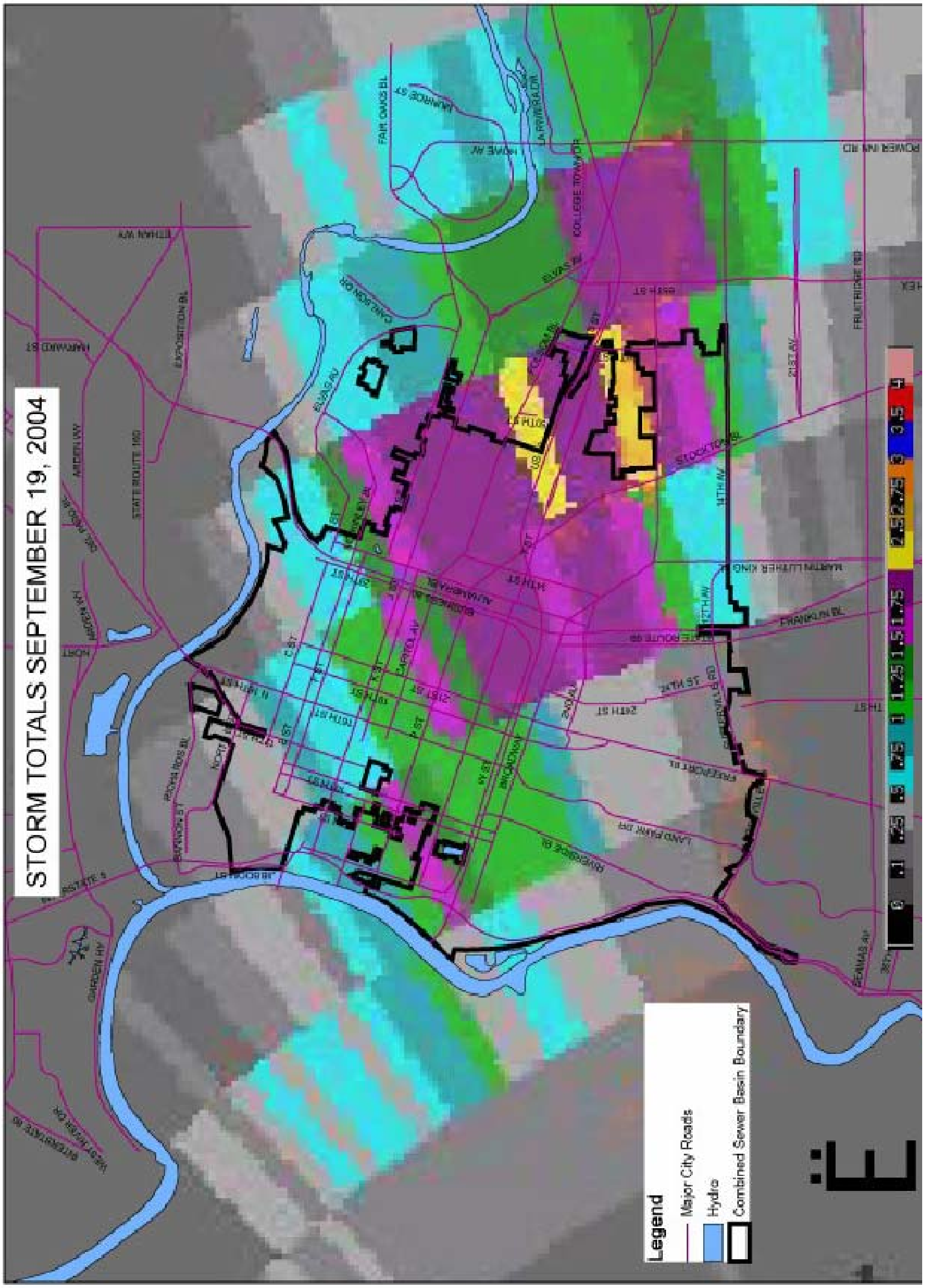
The severe thunderstorm warning issued at 2051Z identified the potential for localized flooding. Although the estimated rainfall was likely inflated due to the presence of a significant amount of small hail, the Storm Total Precipitation (STP) product from the KDAX radar estimated a maximum of 2.6 inches in the Sacramento area. After the severe thunderstorm warning expired, an urban and small stream flood advisory was issued to heighten awareness of the localized flooding with this storm. A damage assessment conducted by the City of Sacramento identified that all of the flooding was confined to the southwest quadrant of the city (Attachments 1 and 2).

**Summary and Conclusions**

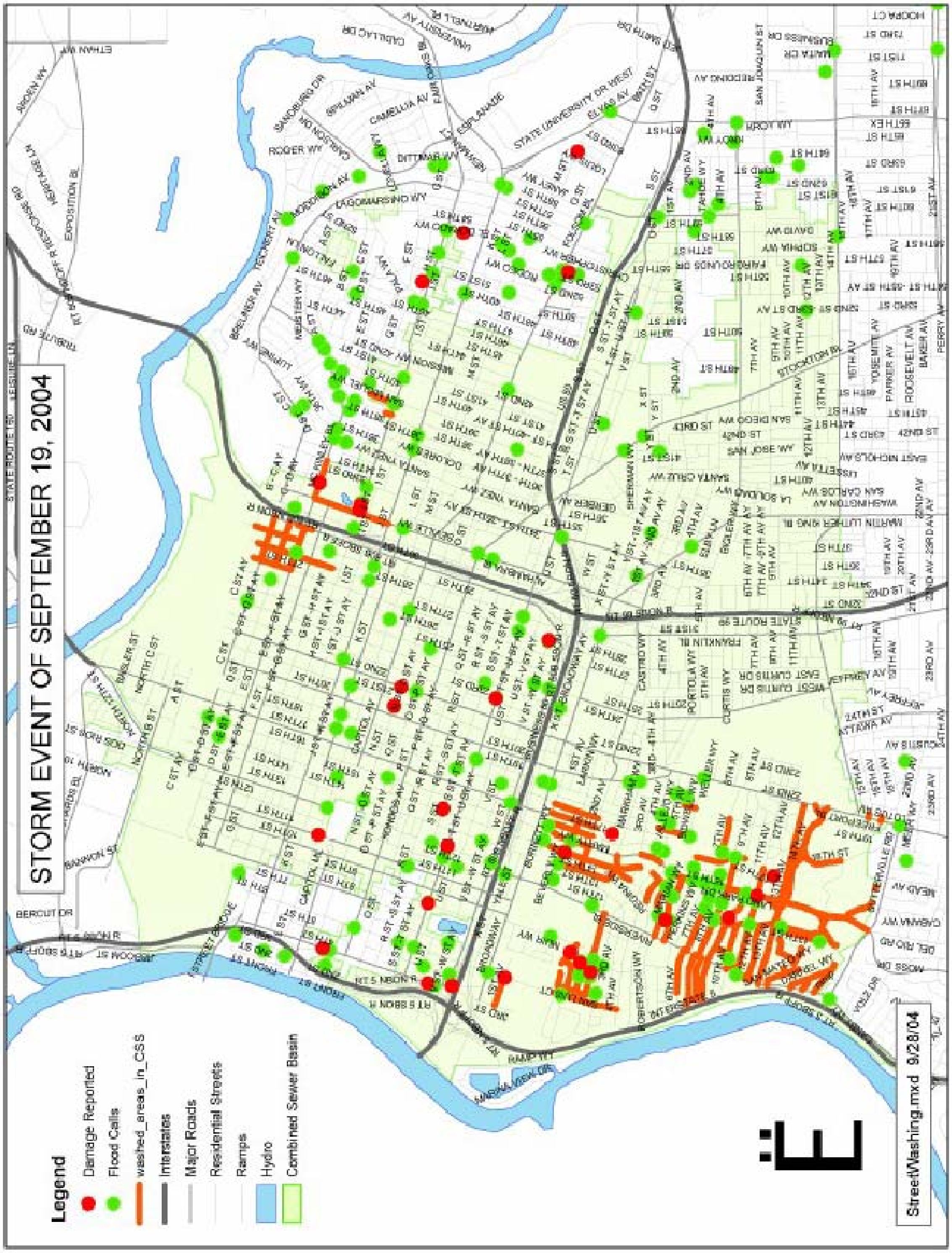
On 19 September 2004, an HP supercell produced a record-setting rainfall event over portions of the City of Sacramento. The official National Weather Service rain gauge for downtown Sacramento recorded 1.93 inches of rain in just over an hour. According to the California State Climatologist, this was a 1 in 51,000 year event, and resulted in six new rainfall records for downtown Sacramento (Attachment 3). Flooding and flood-related damage was confined to a relatively small portion of the city. One fatality occurred, but this was associated with a lightning strike from another cluster of thunderstorms north of Sacramento.

While an unseasonably strong upper level trough provided the synoptic scale dynamics to produce such an event, the development of a low-level convergence boundary appeared to be the most important mechanism for focusing convection over the downtown Sacramento area. The end result was the development of a slow-moving HP supercell which produced the historic rainfall.

**Attachment 1. KDAX Storm Total Precipitation and Street Map (courtesy City of Sacramento)**



**Attachment 2. Damage Map and Flood Calls (courtesy City of Sacramento)**



**Attachment 3. Resultant Rainfall Records From 9/19/2004 Storm**

| | New Record | Old Record |
|---|---|---|
| **Maximum 10 Minute Rainfall For September** | **0.38 inches** | **0.33 inches – set on 9/23/1904** |
| **Maximum 30 Minute Rainfall For September** | **1.08 inches** | **0.69 inches – set on 9/23/1904** |
| **Maximum 1 Hour Rainfall For September** | **1.81 inches** | **0.71 inches – set on 9/23/1904** |
| **Maximum 2 Hour Rainfall For September** | **1.93 inches** | **0.96 inches – set on 9/23/1904** |
| **Maximum 24 Hour Rainfall For September 19th** | **1.93 inches** | **0.80 inches – set in 1956** |
| **Maximum Annual (any month) 1 Hour Rainfall** | **1.81 inches** | **1.65 inches – set on 4/7/1935** |

## References

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