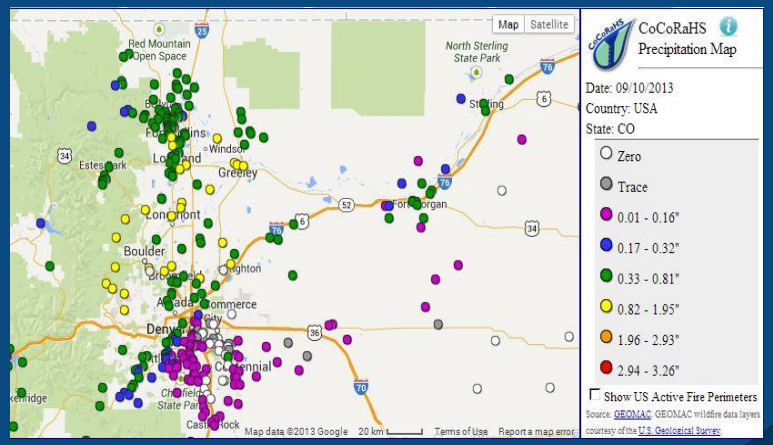
September 9-18, 2013 Floods

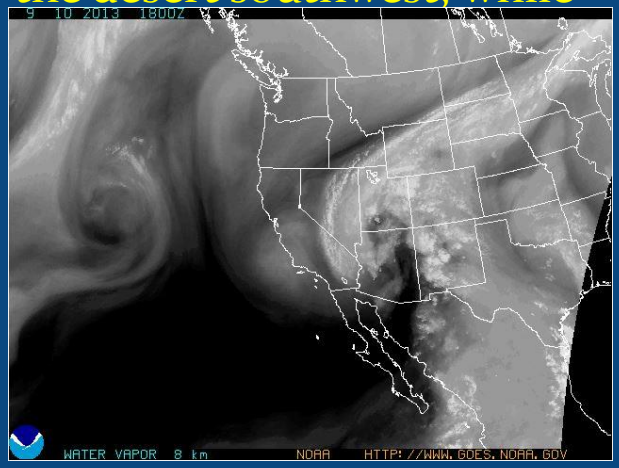
Antecedent Conditions:

- Record to Near Record Heat occurred across Northeast & North Central Colorado September 2-8.
- A cold front moved across Northeast Colorado the morning of the 9th, and deeper subtropical moisture advanced across the region as well.
- Storms with locally heavy rainfall occurred along and north of the I-76 corridor on the 9th (see image on right)

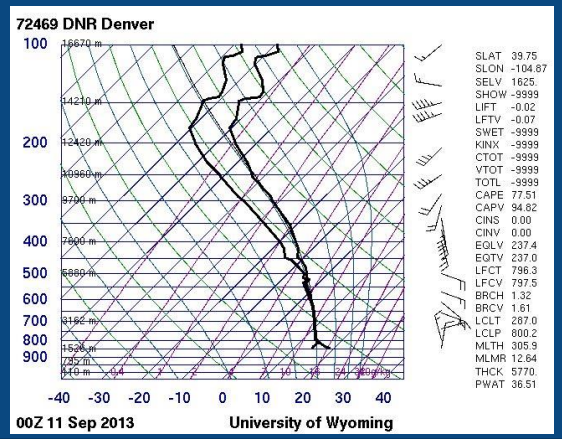


Tuesday, September 10:

- An upper level low remained over the desert southwest, while subtropical moisture moved north across Colorado.
  (water vapor imagery to right)

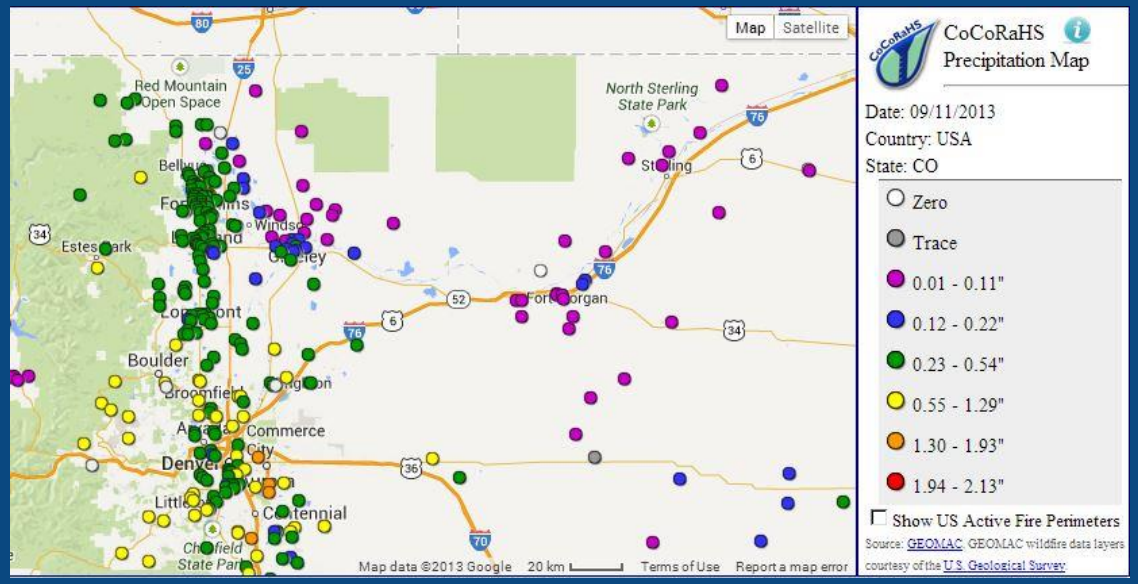


- The atmosphere was abnormally wet, with precipitable water of 36.5 mm (1.44 inches) on the 6 PM, Sep 10th Denver Sounding



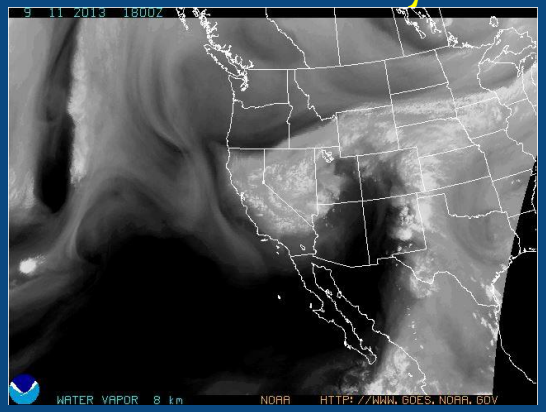
Tuesday, September 10 (cont.):

- While showers and a few storms developed in a very moist environment, generally moderate rainfall amounts occurred along the Front Range with 0.25" to 1.25" amounts common. Nearly 2" of rain fell with the strongest storms over the southeastern sections of Denver, as well as near Boulder.

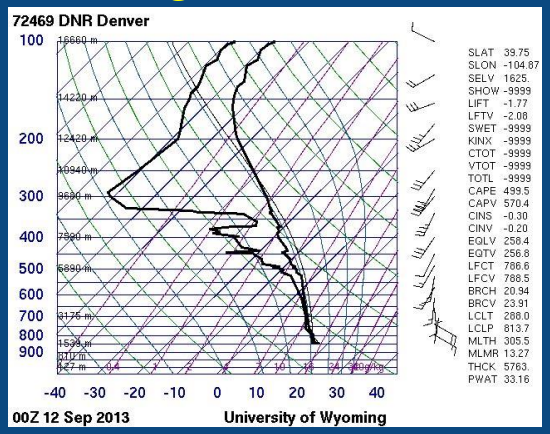


Wednesday, September 11:

- The upper level low in the desert southwest drifted slowly northward, with deeper subtropical moisture shifting north & east across eastern Colorado.
  (water vapor imagery to right)

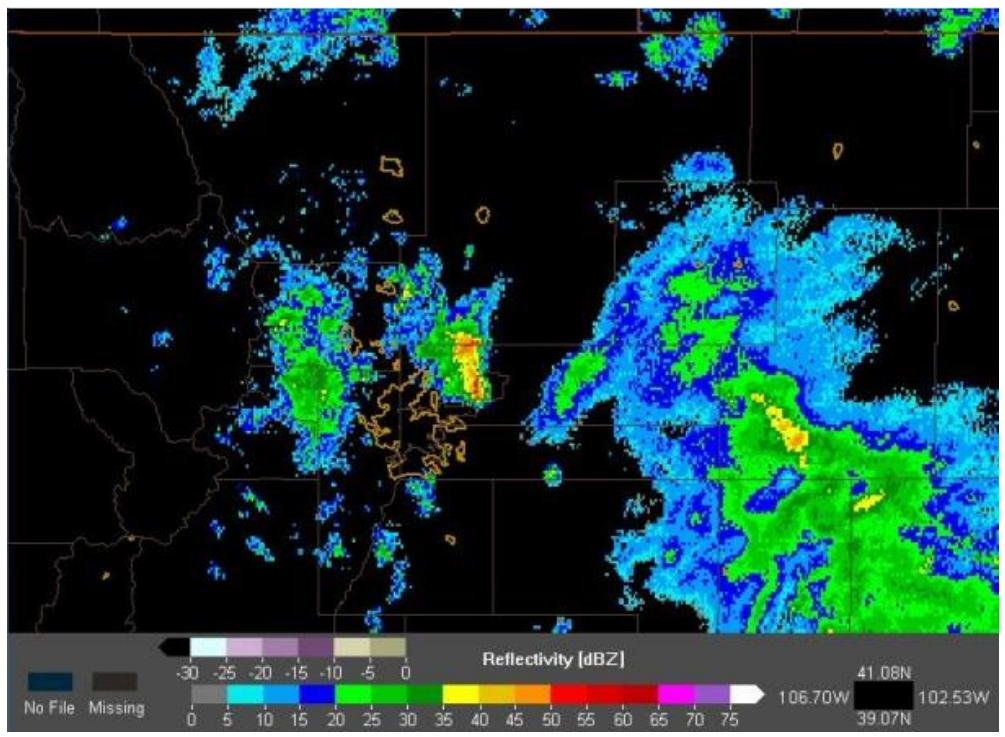


- The atmosphere remained quite moist, with the 6 AM and 6 PM Denver soundings indicating precipitable water values near 33 mm (1.30 inches).



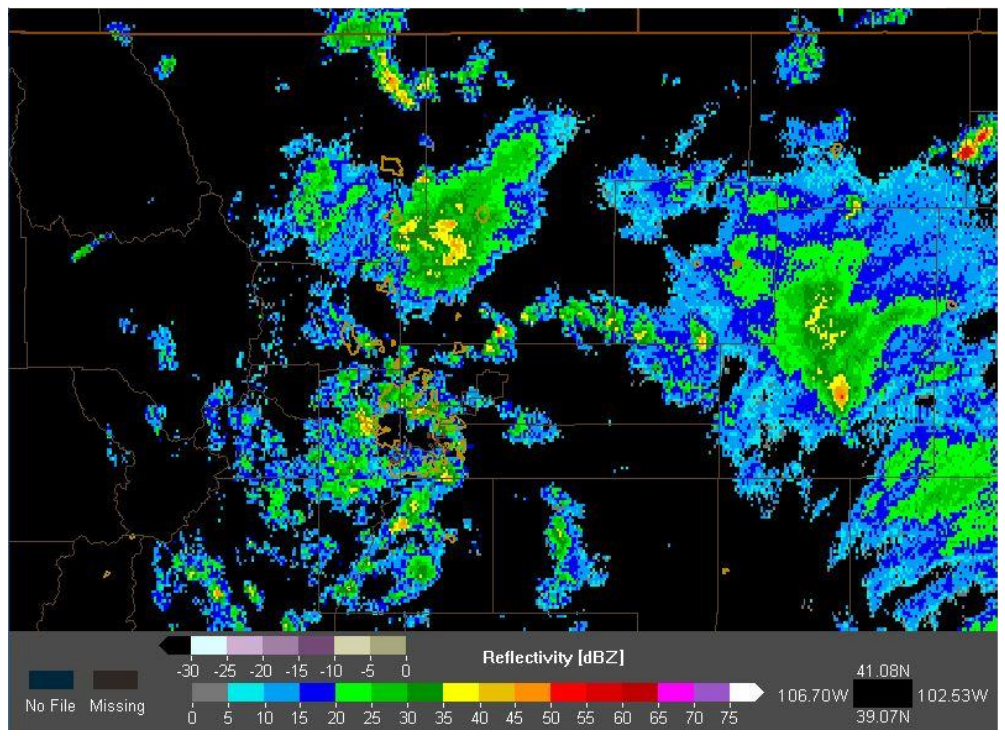
Wednesday, September 11:

- Initially, showers that developed in the afternoon were moving fast enough and were small enough to produce generally moderate rainfall amounts. (Front Range Radar imagery)



1 PM Sept 11

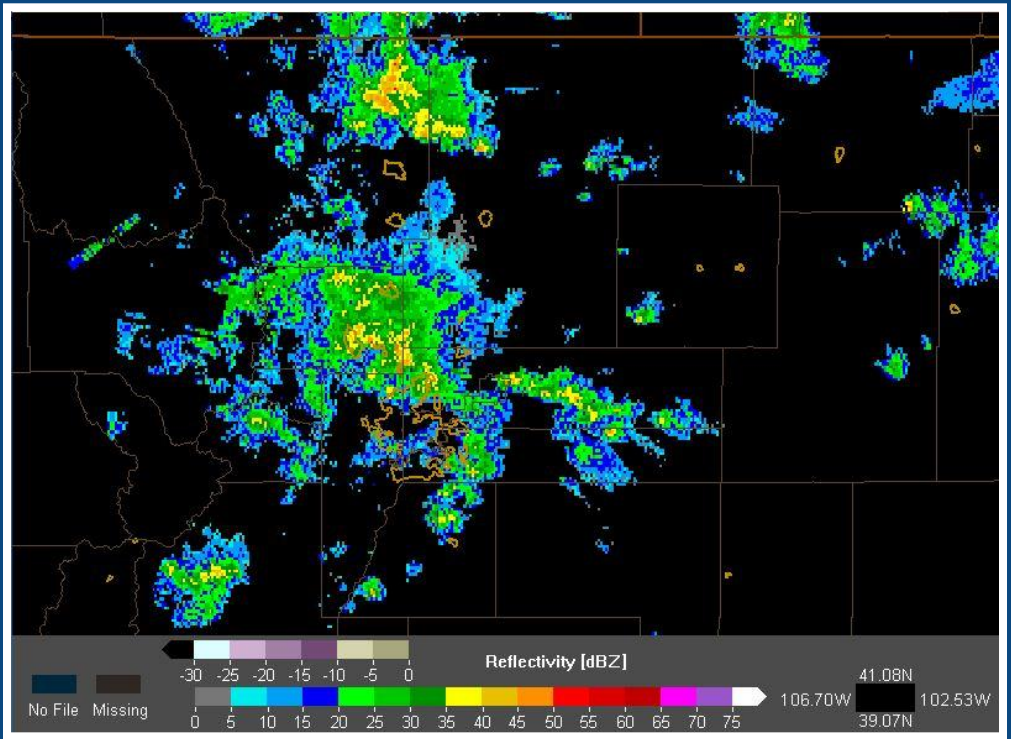
Wednesday, September 11:



3 PM
Sept 11

Wednesday, September 11:

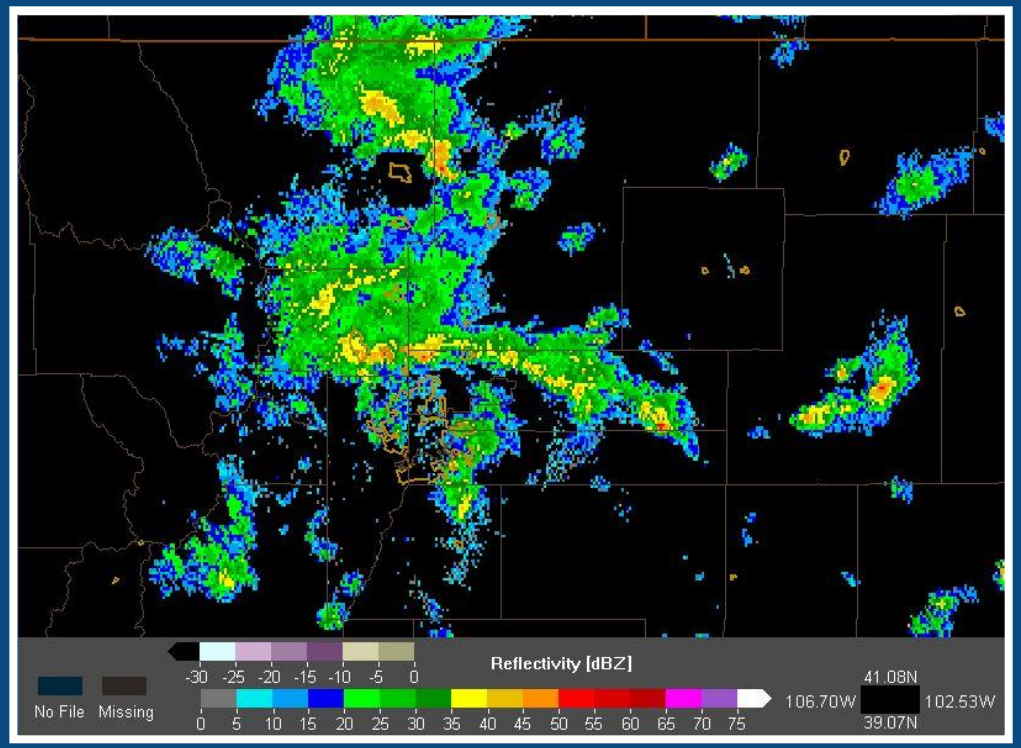
- However, rain along the Front Range began to intensify and become more widespread in the evening. (Front Range Radar imagery)



7 PM Sept 11

Wednesday, September 11:

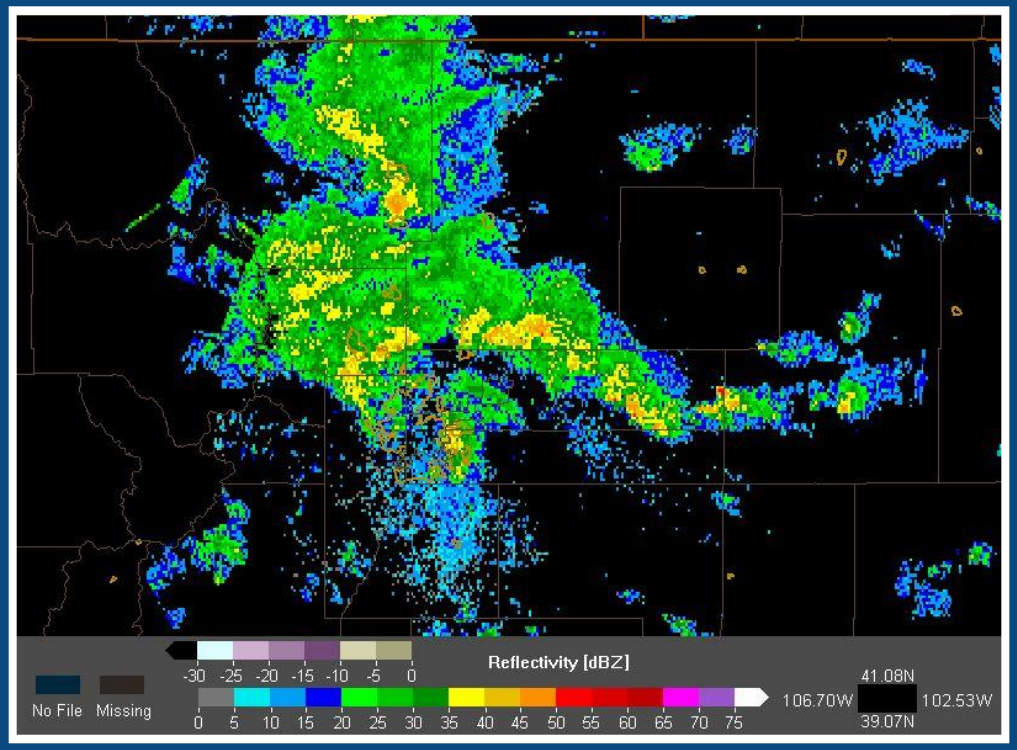
- A narrow band of very heavy rain began to organize just north of Denver and move westward toward the foothills.



8 PM Sept 11

Wednesday, September 11:

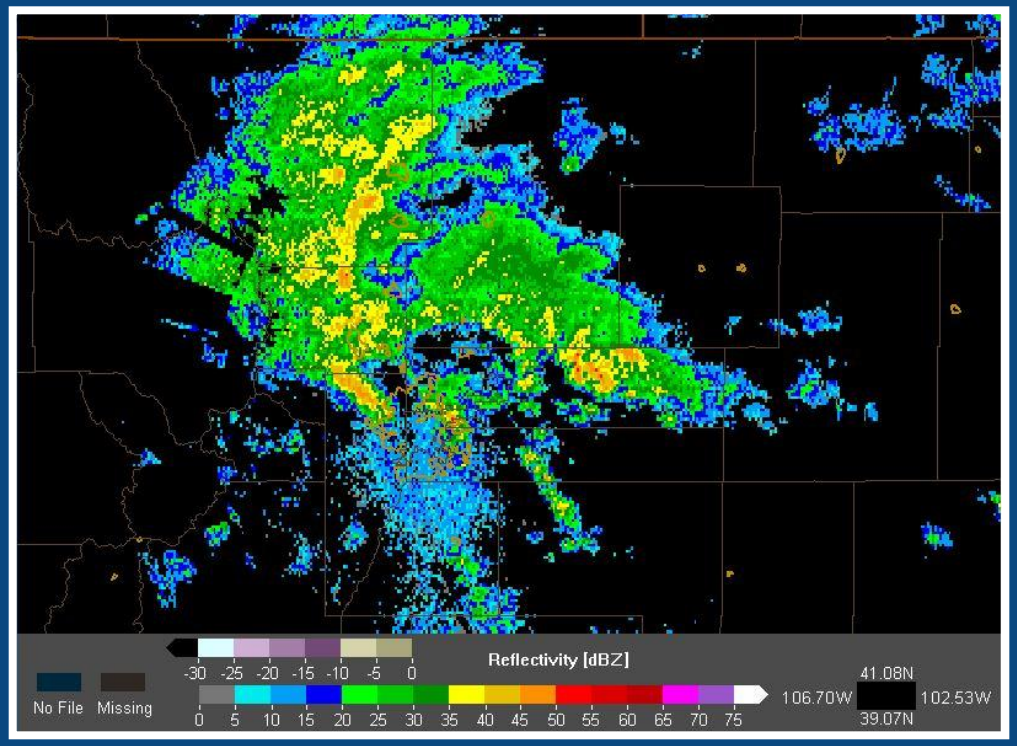
- By 9 PM, heavy rain was becoming more widespread, with rainfall rates near 2” per hour in the heaviest showers.



9 PM Sept 11

Wednesday, September 11:

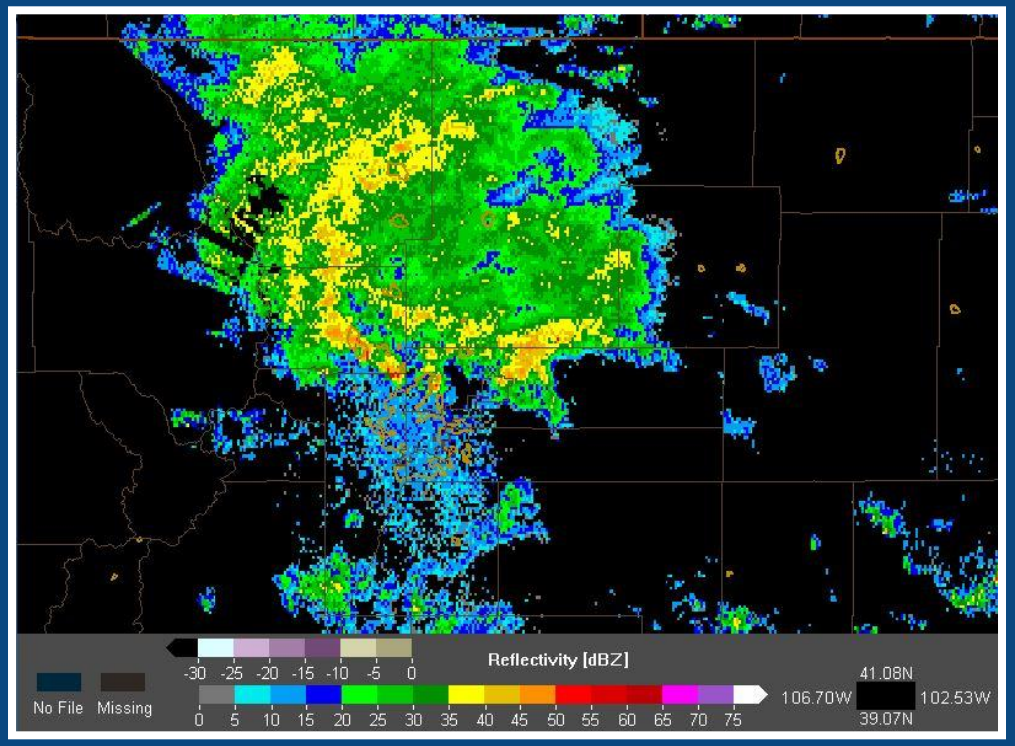
- 10 PM - Midnight, very heavy rain locked itself in against the Front Range!



10 PM Sept 11

Wednesday, September 11:

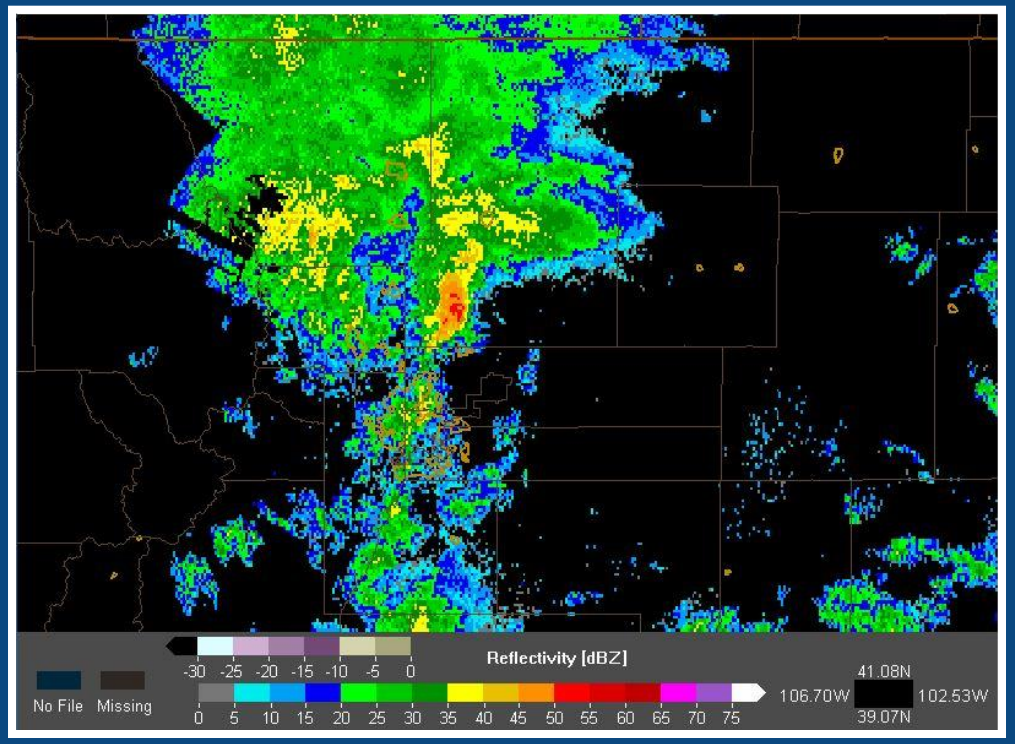
- 10 PM - Midnight, flash flooding became more widespread, with several road closures from northwest Jefferson county northward through Boulder & Larimer counties.



Midnight

Thursday, September 12 Early AM:

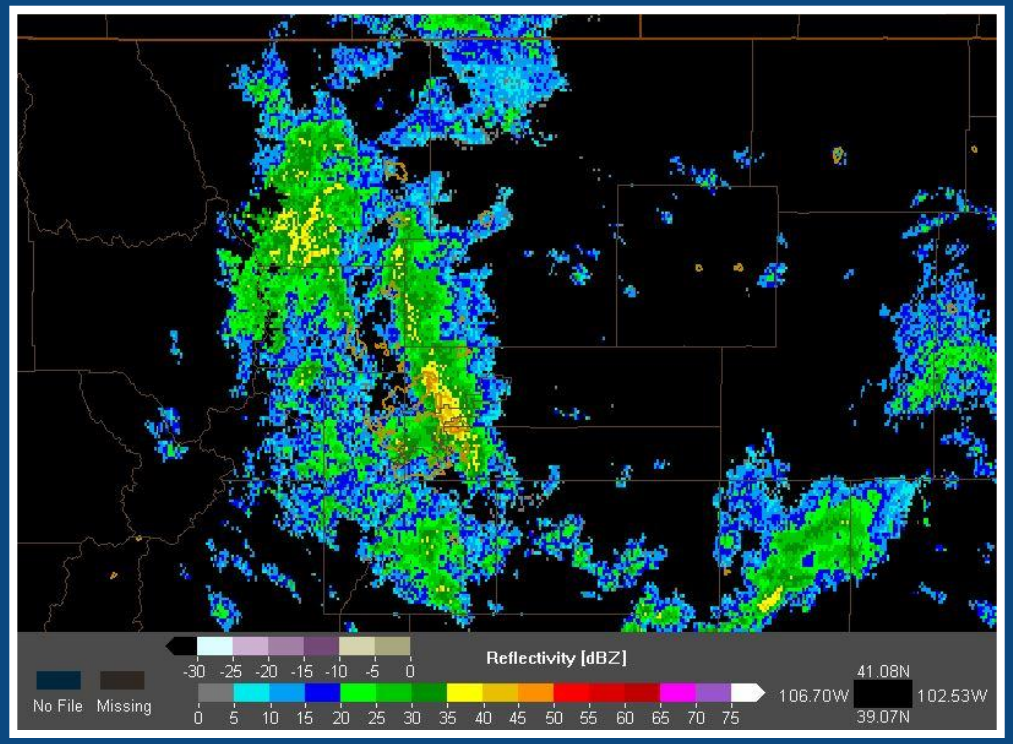
- The heaviest rain in the foothills of Boulder & Larimer counties finally began to abate, but widespread flash flooding continued due to the extremely heavy rainfall during the evening and early morning hours. Meanwhile, torrential rain redeveloped in southwest Weld county by 2 AM.



2 AM Sept 12

Thursday, September 12:

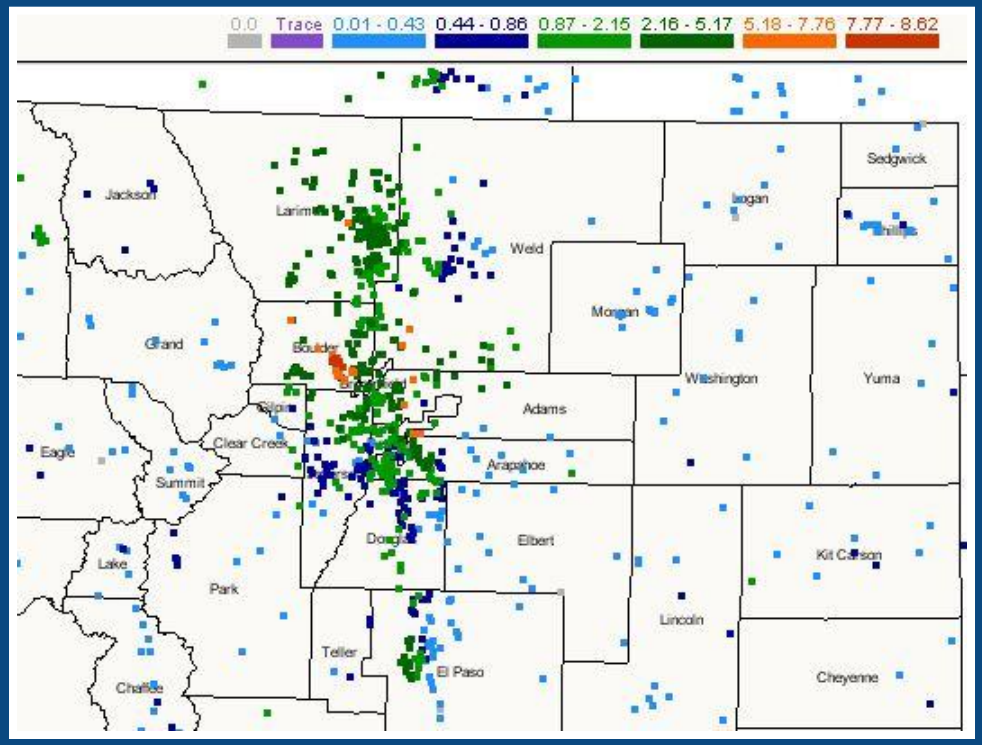
- Atypical for Colorado, the extremely heavy rain continued into the morning hours on Thursday. Now, torrential rain and flash flooding was developing in Aurora and northeast Denver.



6 AM Sept 12

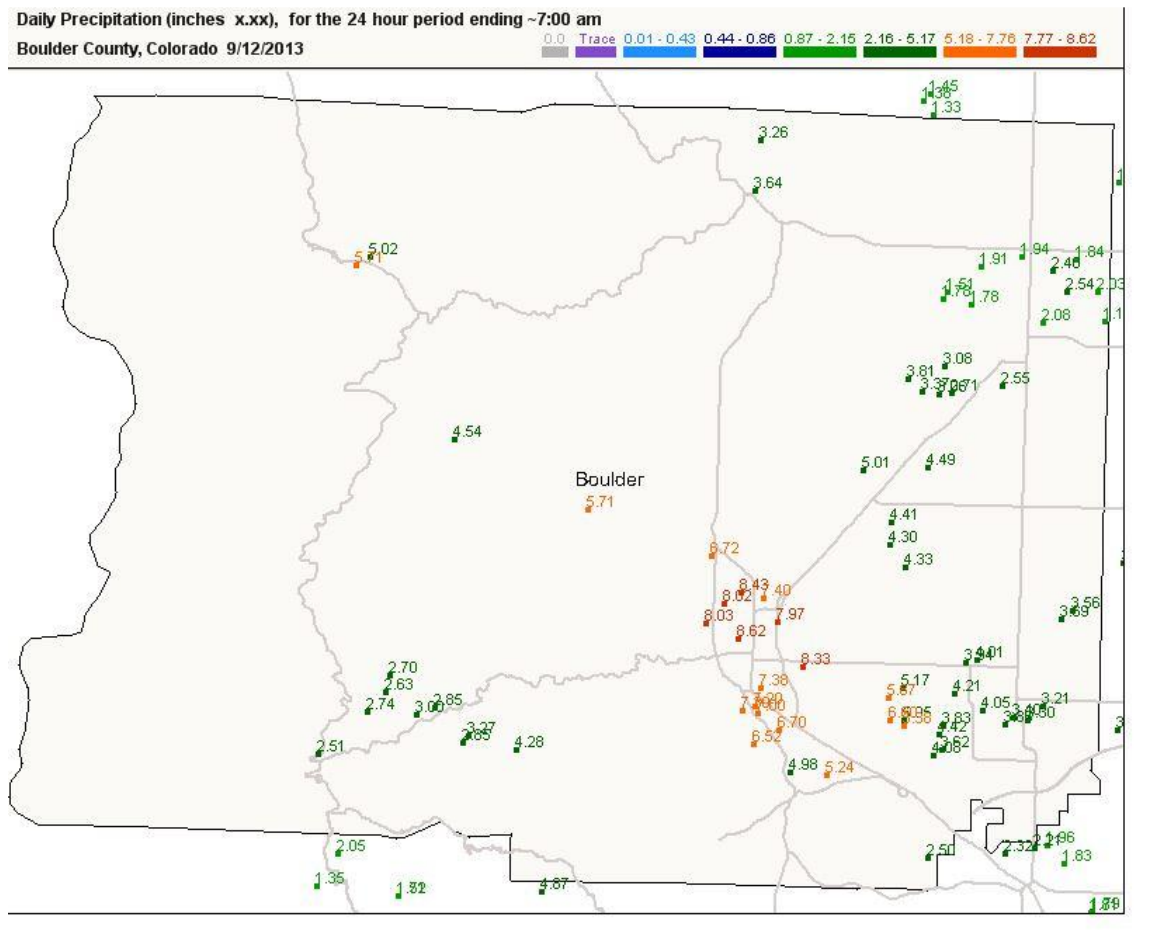
Thursday, September 12:

- 24 Hour Rain totals ending 7 AM, Thursday, September 12th
  - 6.5 to 8.6” in Boulder
  - 3-6.5” Larimer/Boulder county foothills & northeastern Denver Metro area into southwest Weld county.

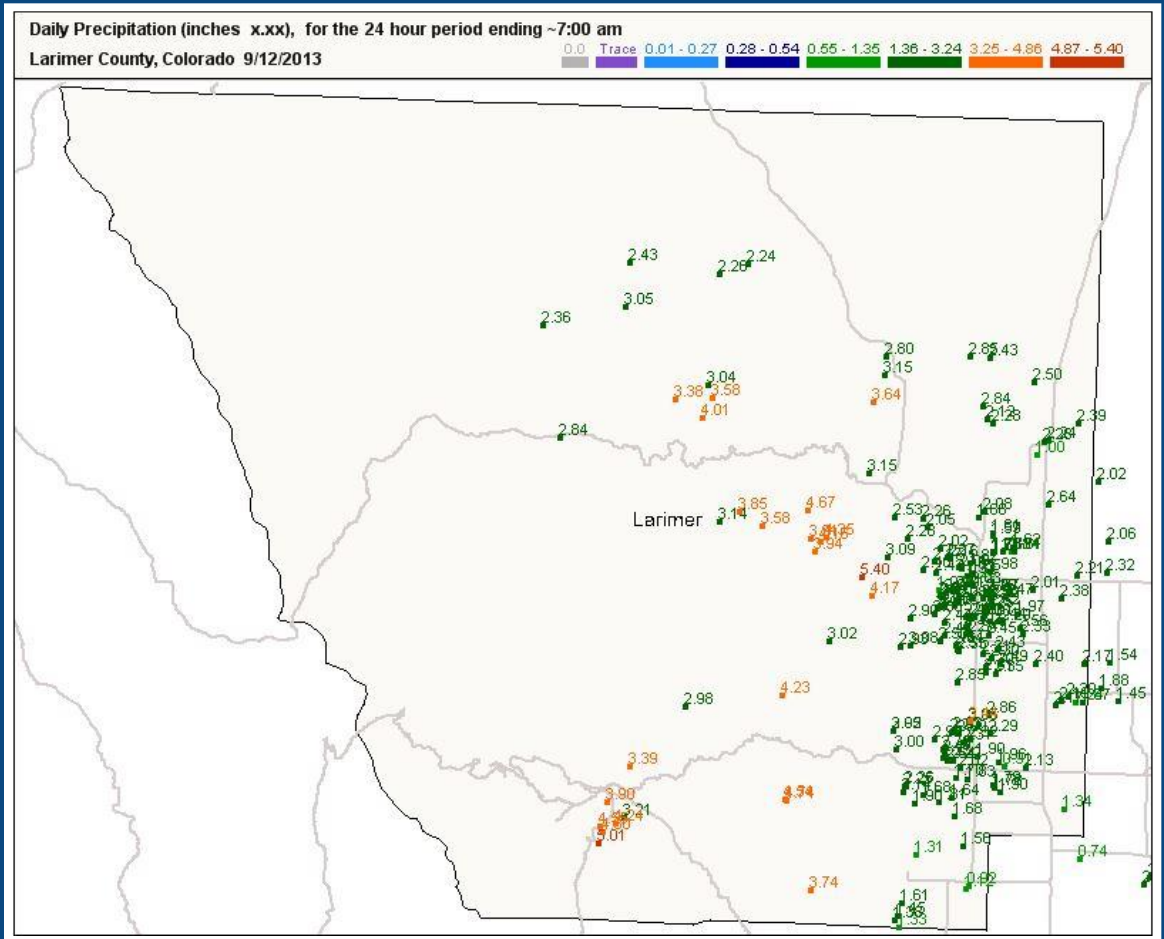


7 AM Sept 12

Thursday, September 12: Boulder county

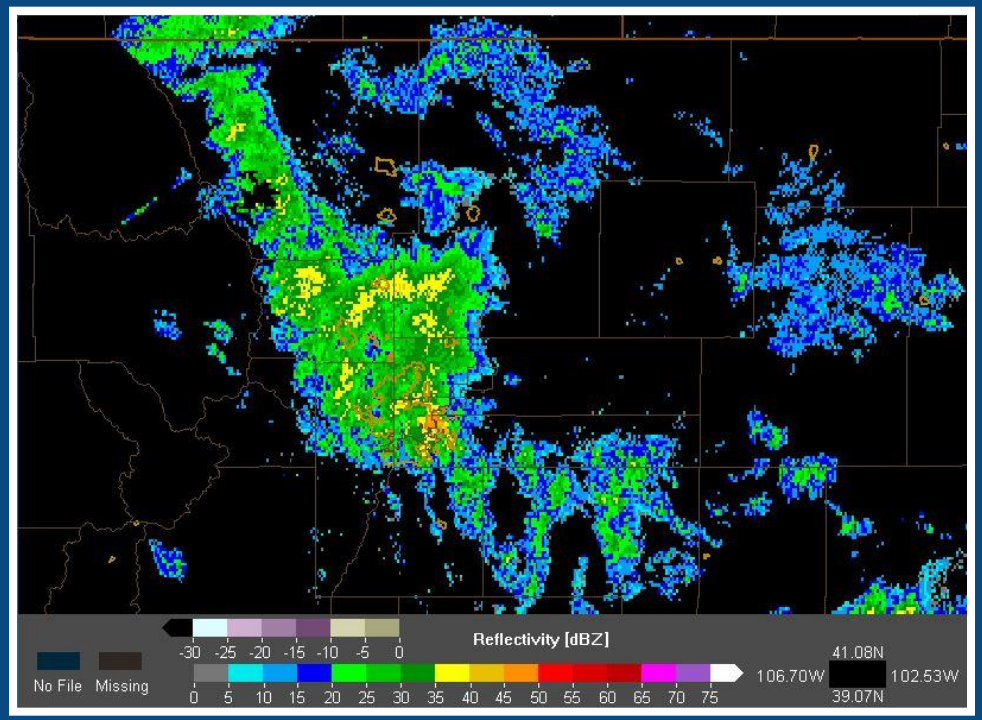


Thursday, September 12: Larimer county



Thursday, September 12:

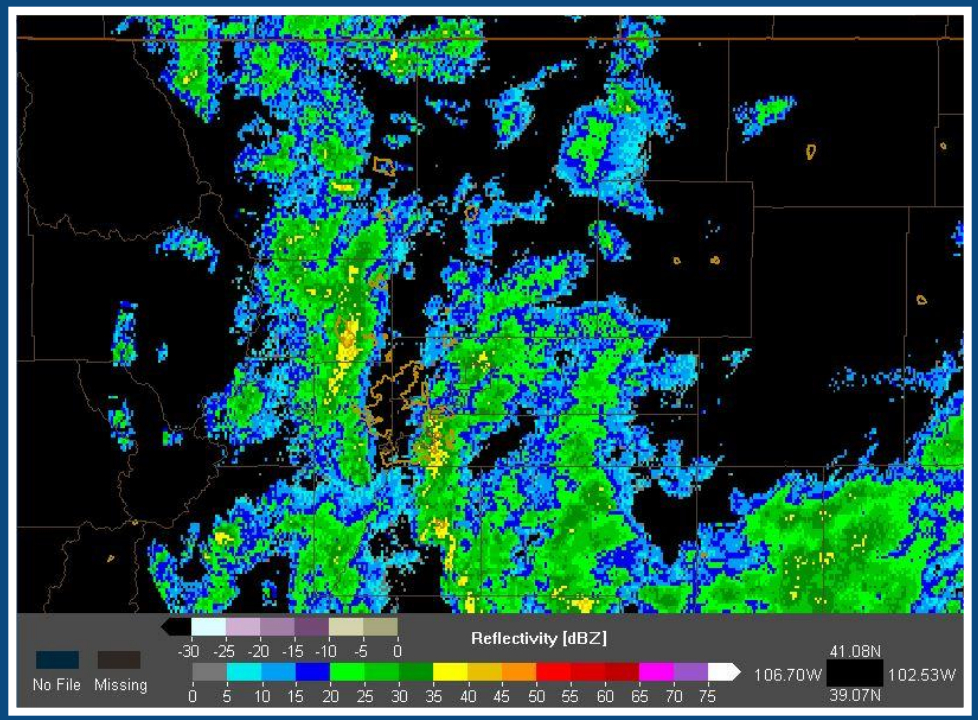
- Heavy Rain and considerable flash flooding continued through the morning in the Aurora area, with generally lighter rainfall elsewhere. Numerous streams remained at or above bankfull levels across Boulder, Larimer, and southwest Weld counties.



9 AM Sept 12

Thursday, September 12:

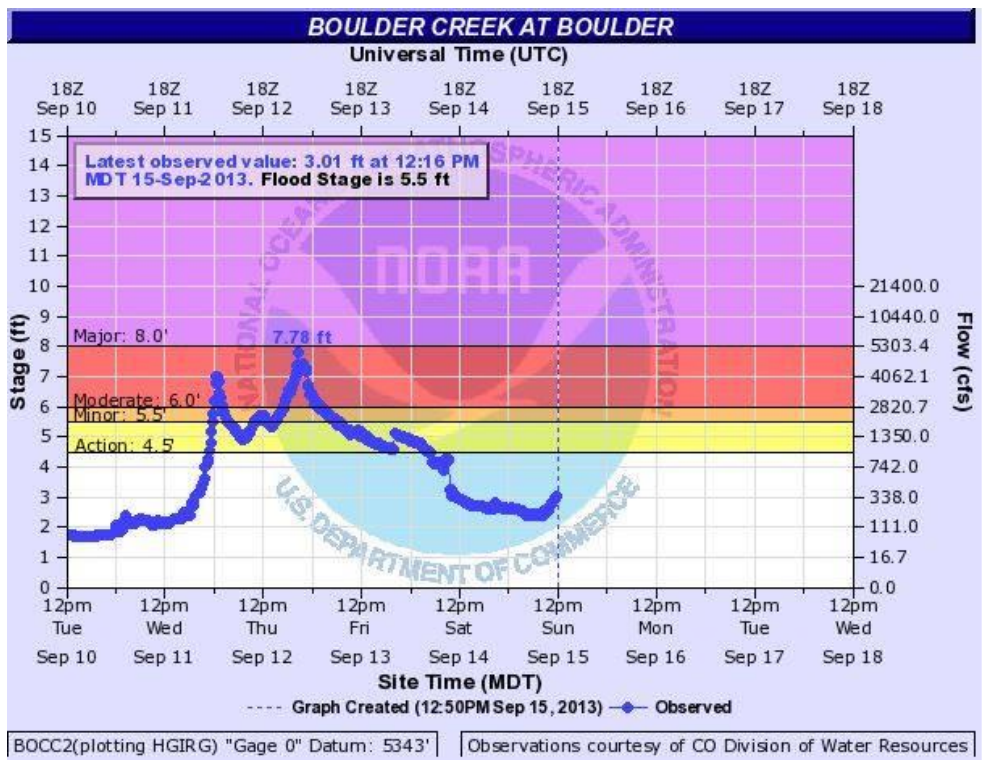
- While flooding continued in many areas, the severity of flooding would only increase on the evening of September 12th. Heavy rain, while not as widespread as the previous day, had a greater impact on stream levels as streams were already elevated and the ground was completely saturated. Rainfall rates still approached 1.5" per hour in the heaviest cells.



5 PM Sept 12

Thursday, September 12:

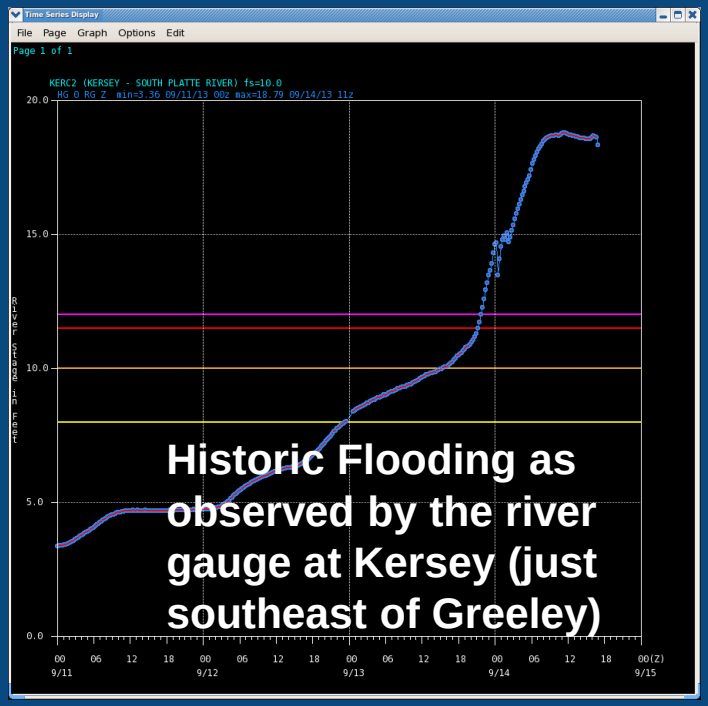
- The image below shows the two peaks of flows on Boulder Creek near downtown. The peak flow on the evening of September 12th surpassed the 1969 Boulder flood, but fell short of the 1938 and 1894 floods.



Boulder Stream Gauge – peak flows occurred near 1 AM on Sep 12, and 9 PM Sep 12

Thursday, September 12:

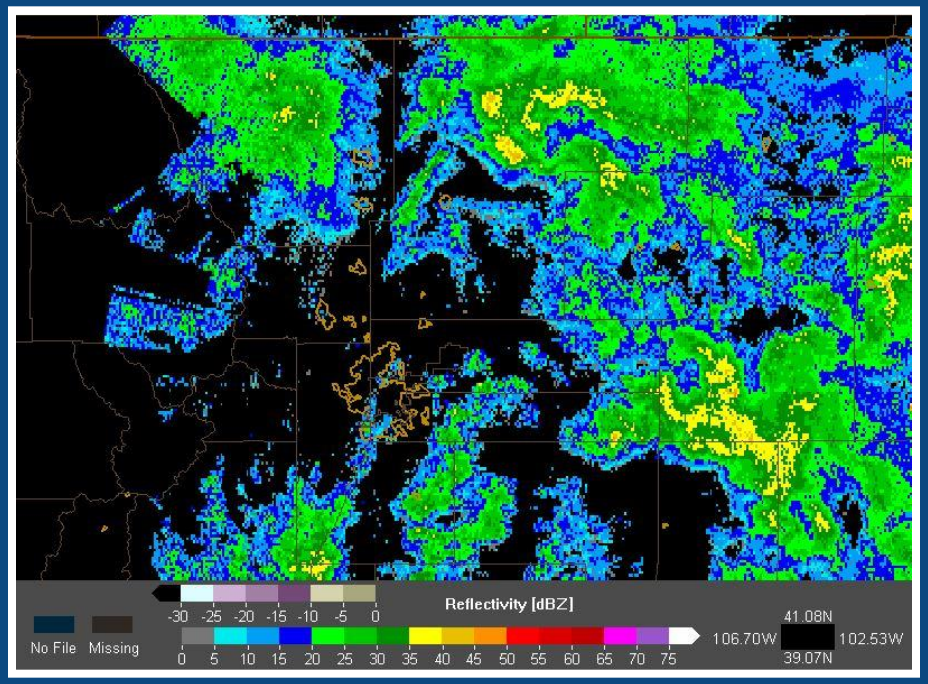
- Similar massive stream flows occurred on many other creeks and rivers up and down the Front Range, including;
  - Big Thompson River
  - Lefthand Creek
  - Little Thompson
  - Cache la Poudre
  - St Vrain Creek
  - Coal Creek
  - South Boulder Creek
  - Sand Creek



Historic Flooding as observed by the river gauge at Kersey (just southeast of Greeley)

Friday, September 13:

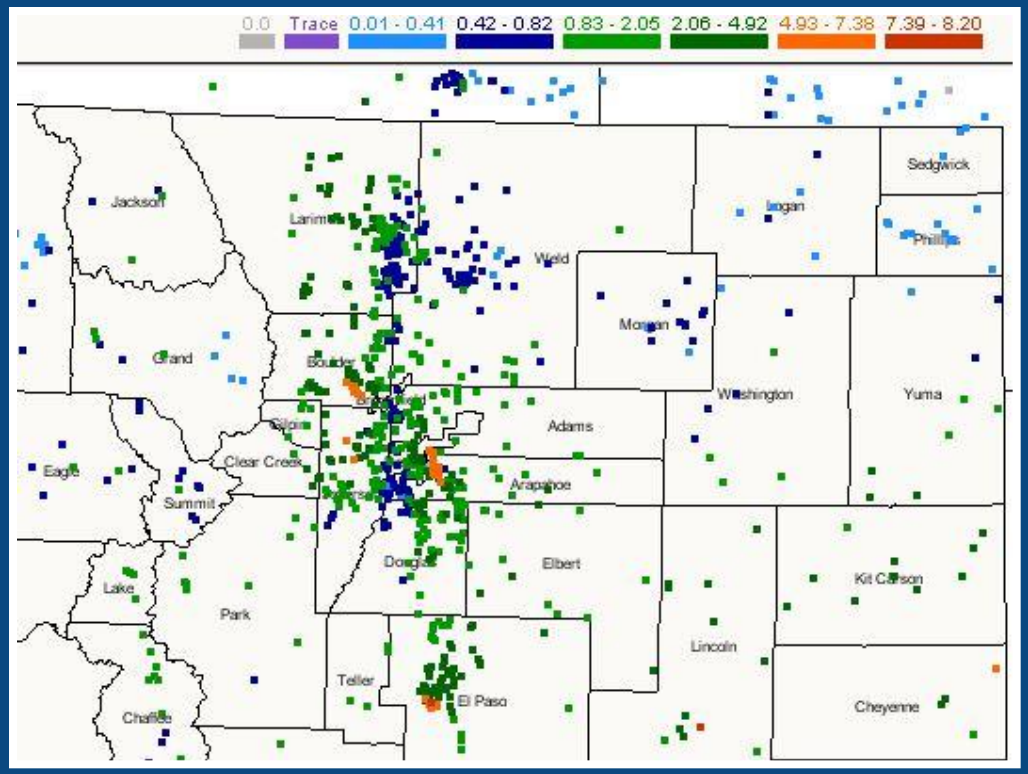
- Rain finally decreased during the early morning hours of Friday, September 13th. But floodwaters were now rushing downstream from the foothills eastward onto the plains including Weld county.



6 AM Sept 13

Friday, September 13:

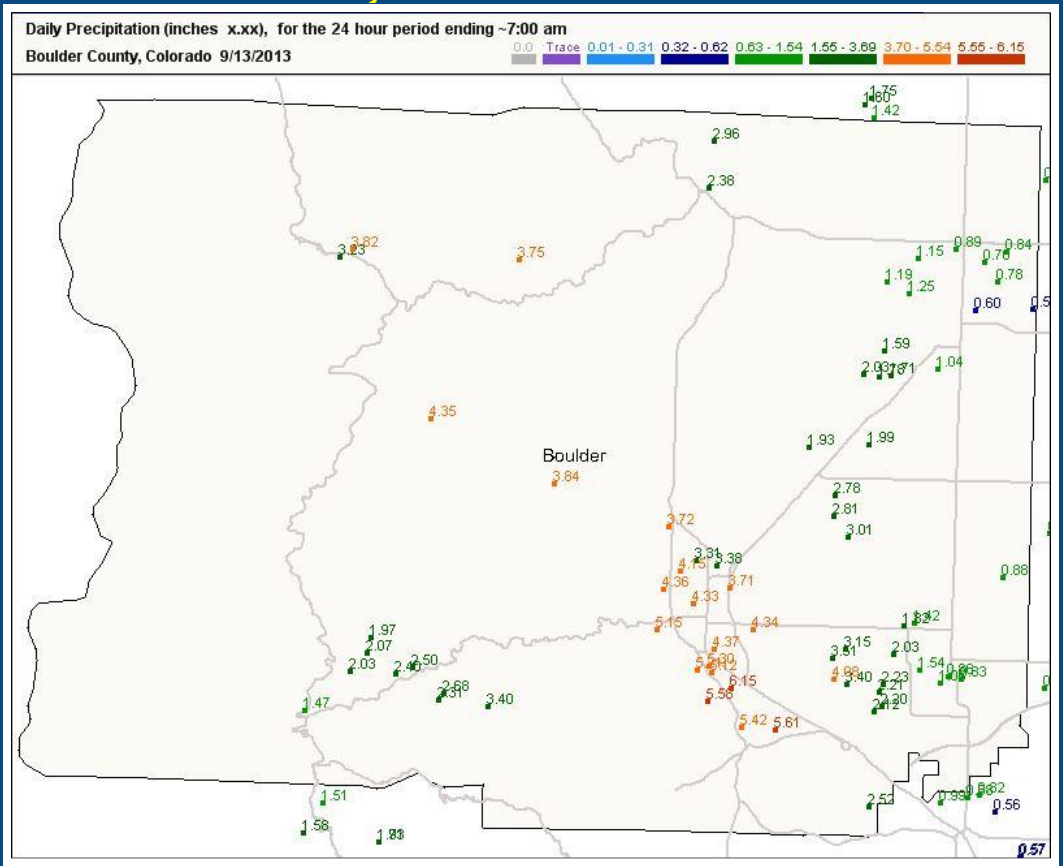
- 24 Hour Rain totals ending 7 AM, Friday, September 13th
  - ~2-6" in/near foothills of Boulder/Larimer/Nrn Jefferson counties, & Aurora/eastern Denver area



7 AM Sept 13

Friday, September 13:

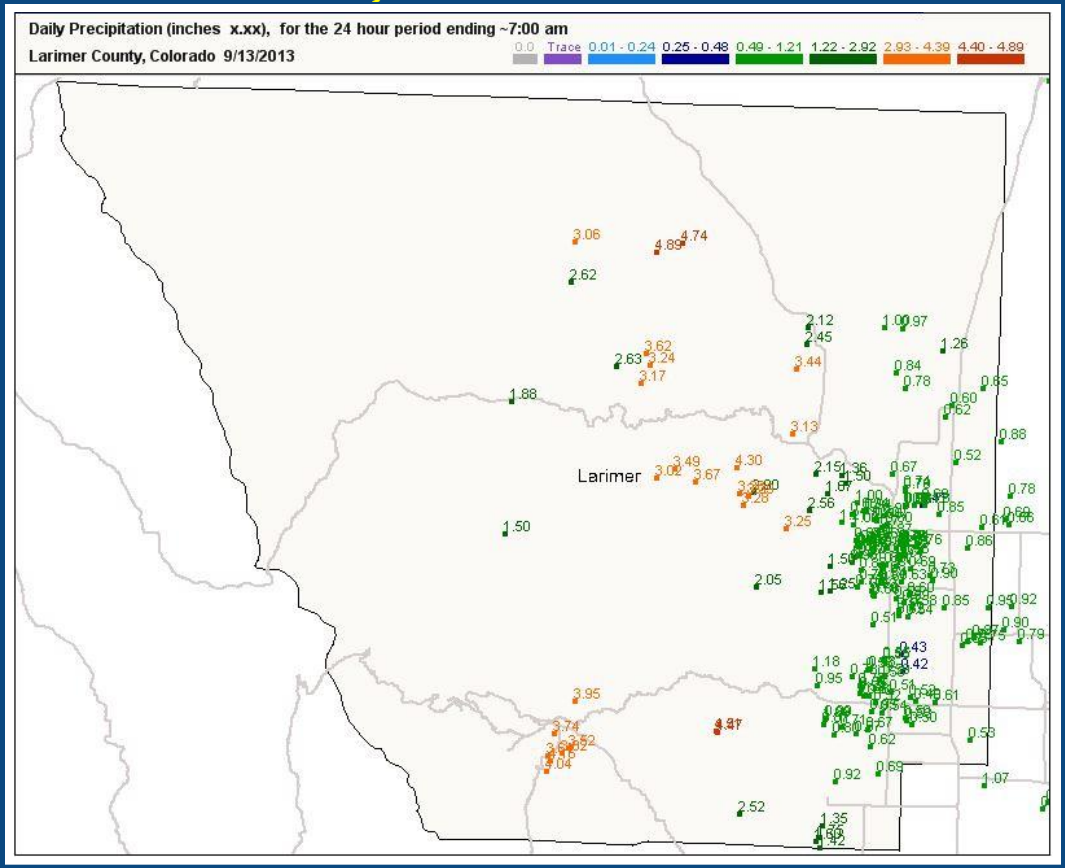
- 24 Hour Rain totals ending 7 AM, Friday, September 13th
  - Boulder County



7 AM Sept 13

Friday, September 13:

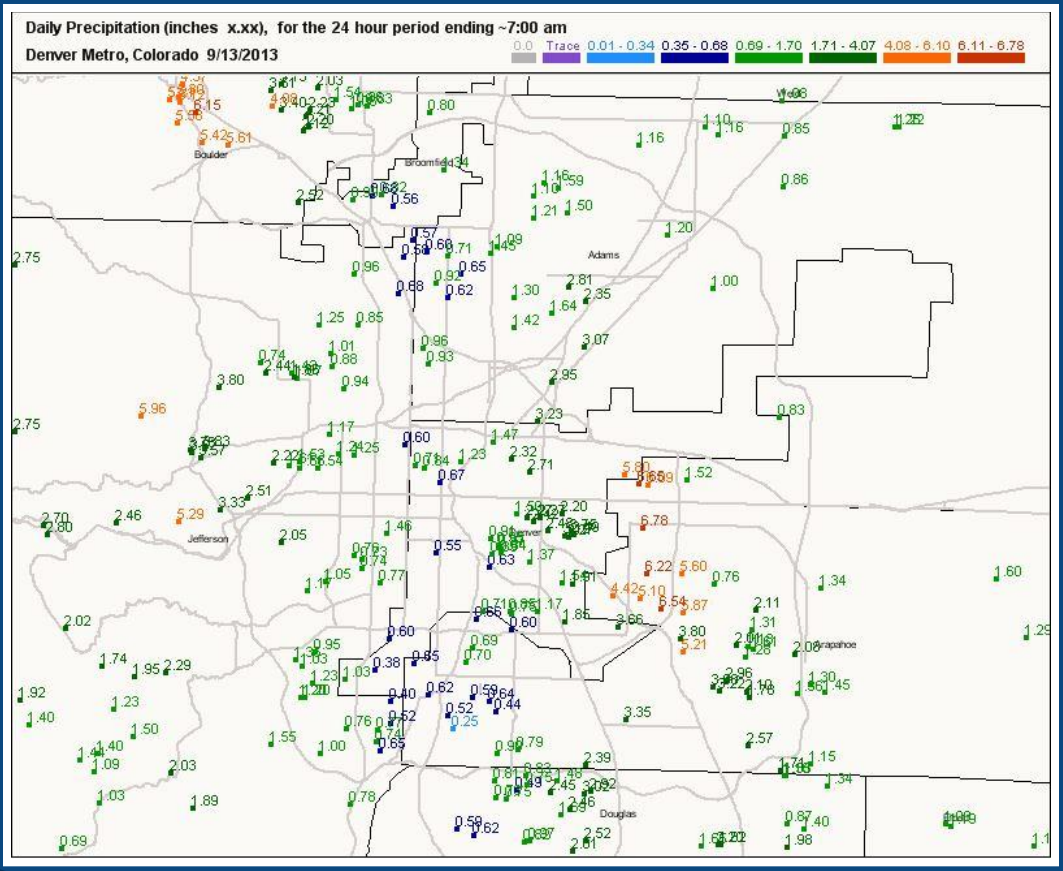
- 24 Hour Rain totals ending 7 AM, Friday, September 13th
  - Larimer County



7 AM Sept 13

Friday, September 13:

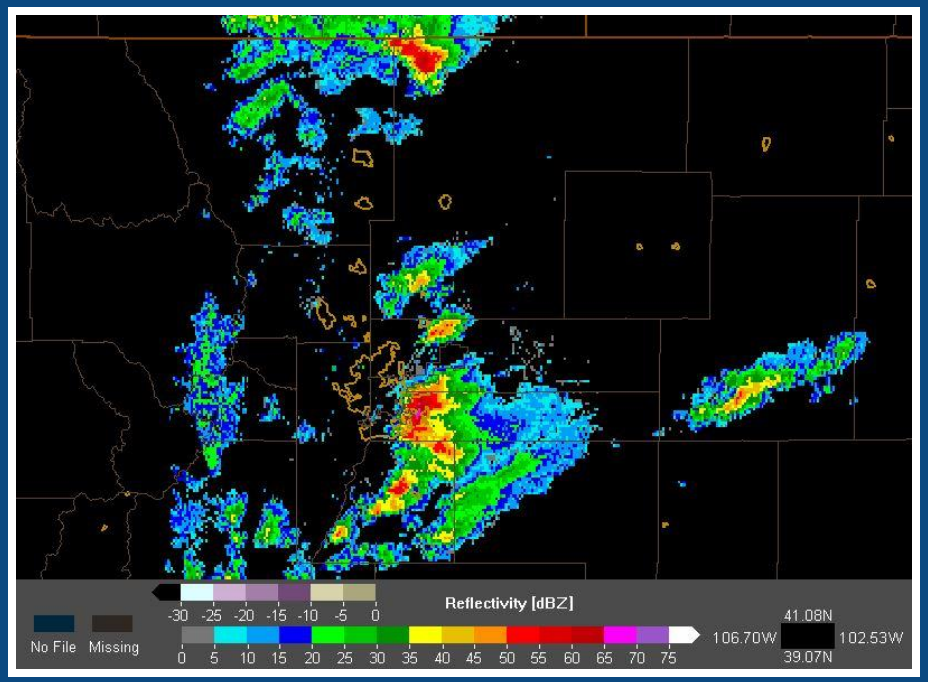
- 24 Hour Rain totals ending 7 AM, Friday, September 13th
  - Denver Metro area



7 AM Sept 13

Saturday, September 14:

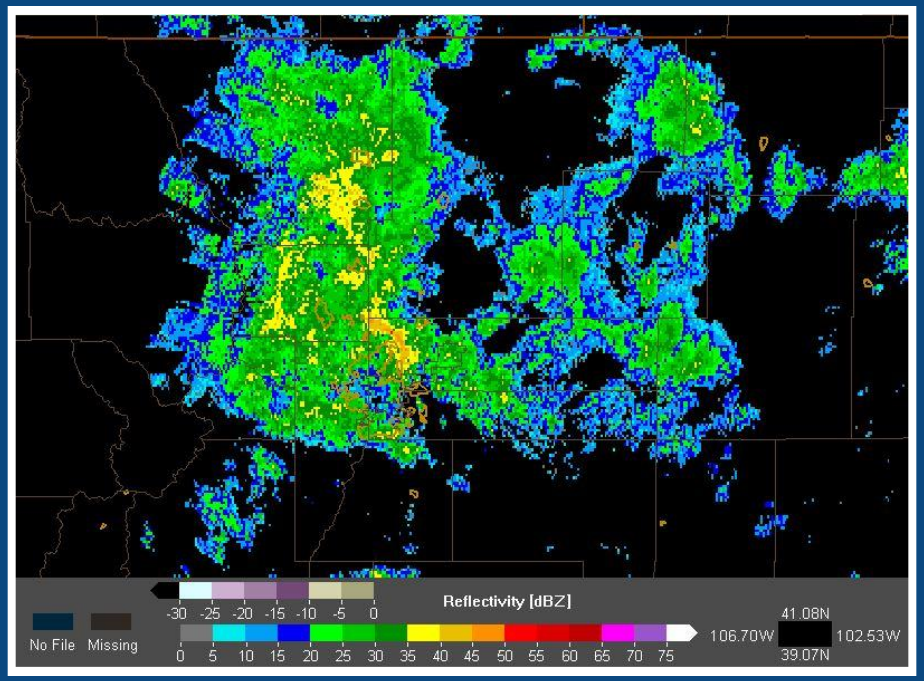
- After little rainfall on Friday, September 13th, the flash flood threat returned for Saturday. This time, storms with heavy rainfall occurred in Douglas county, but also extended northeast into the Aurora area once again. Up to 3" of rain fell in 1 hour. Plum Creek and other small creeks and streams flooded, along with significant street flooding.



4 PM
Sept 14

Sunday, September 15:

- The last day of this prolonged period of very heavy rainfall was on Sunday, September 15th. Another weak front had pushed through the area Saturday night, leaving the atmosphere unseasonably moist and unstable. Heavy rain developed by mid morning and then became more widespread and peaked in intensity by the noon hour. This time, flash flooding was most significant in the northern portions of the Denver metro area from Northglenn to around Broomfield. Rain finally tapered off during the late afternoon and evening.



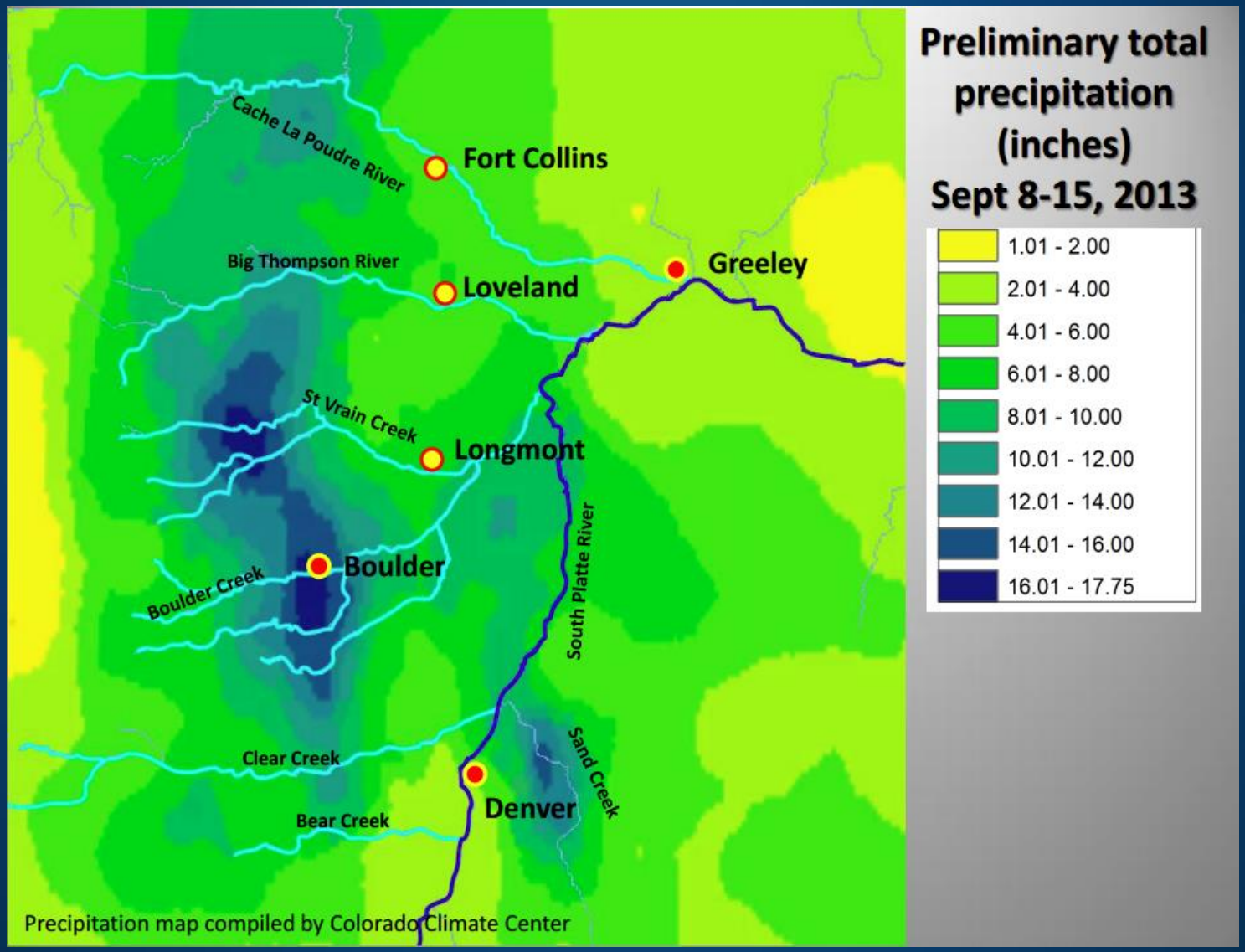
12 Noon Sept 15

Precipitation Records:

- Boulder
  - Daily record (24 hr) of 9.08", previous record was 4.80" set on July 31, 1919
  - Monthly record for September of 17.18", previous record was 5.50" set on September 30, 1940
  - Monthly record for rainfall in any month of 17.18" so far in September 2013, previous record was 9.60" set in May 1995
  - Annual record of 30.14" so far in 2013, previous record was 29.47" in 1995

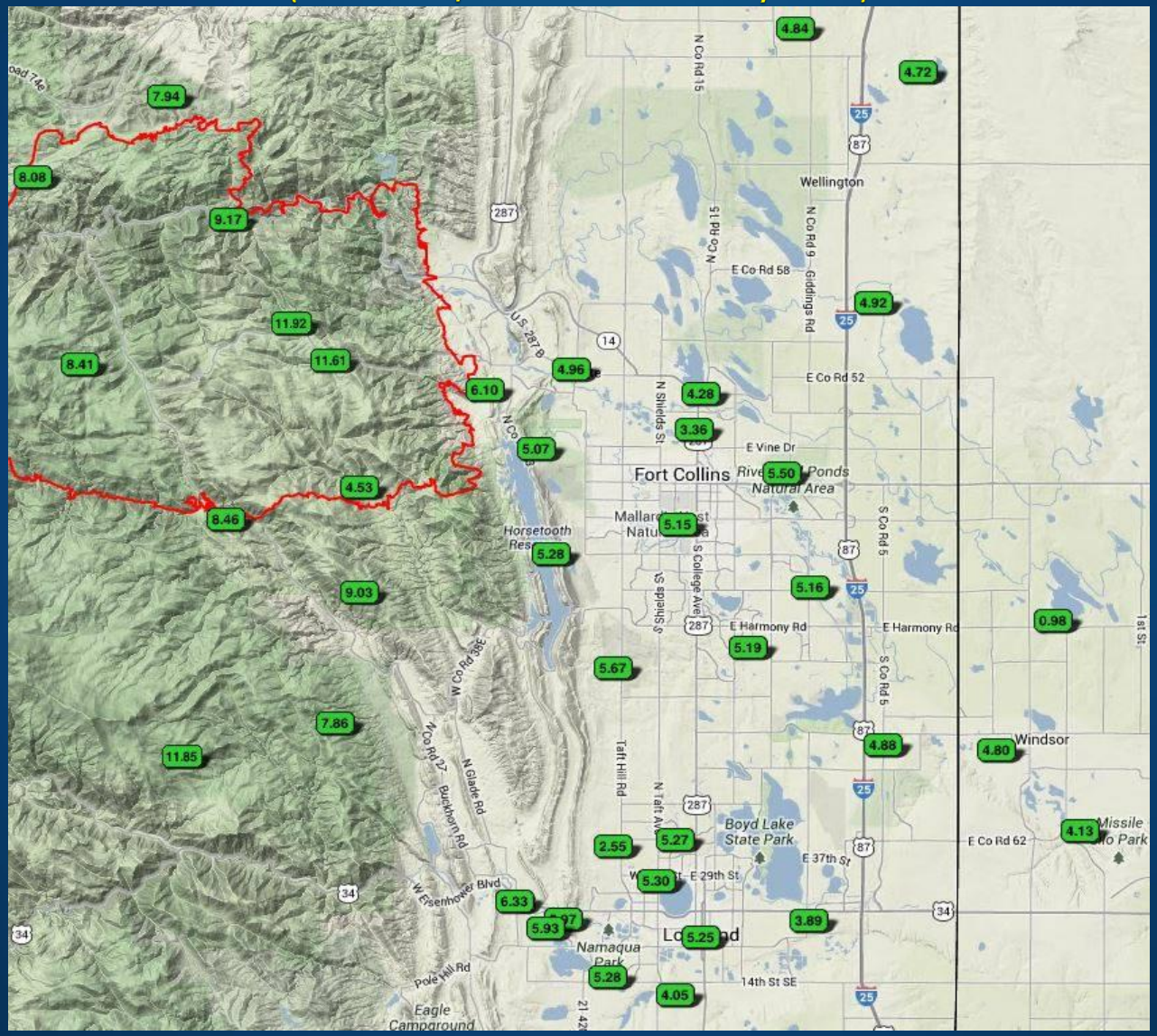
- DIA
  - 24 hr rainfall for September 14, 2013 of 2.01", previous record was 1.48" set back on September 26, 2012

Rainfall Analysis



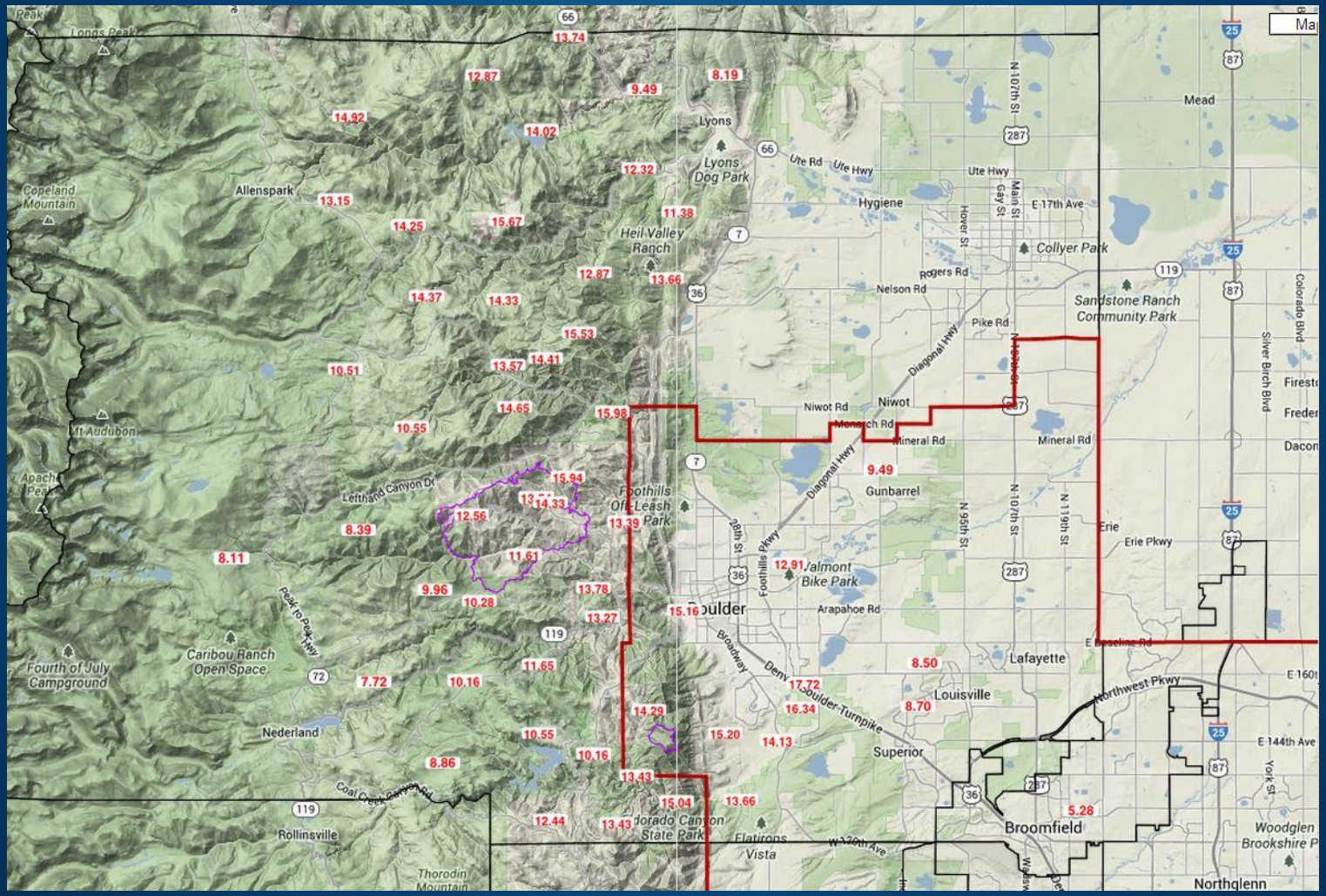
Rainfall Analysis

(Fort Collins/Loveland area – 7 day totals)



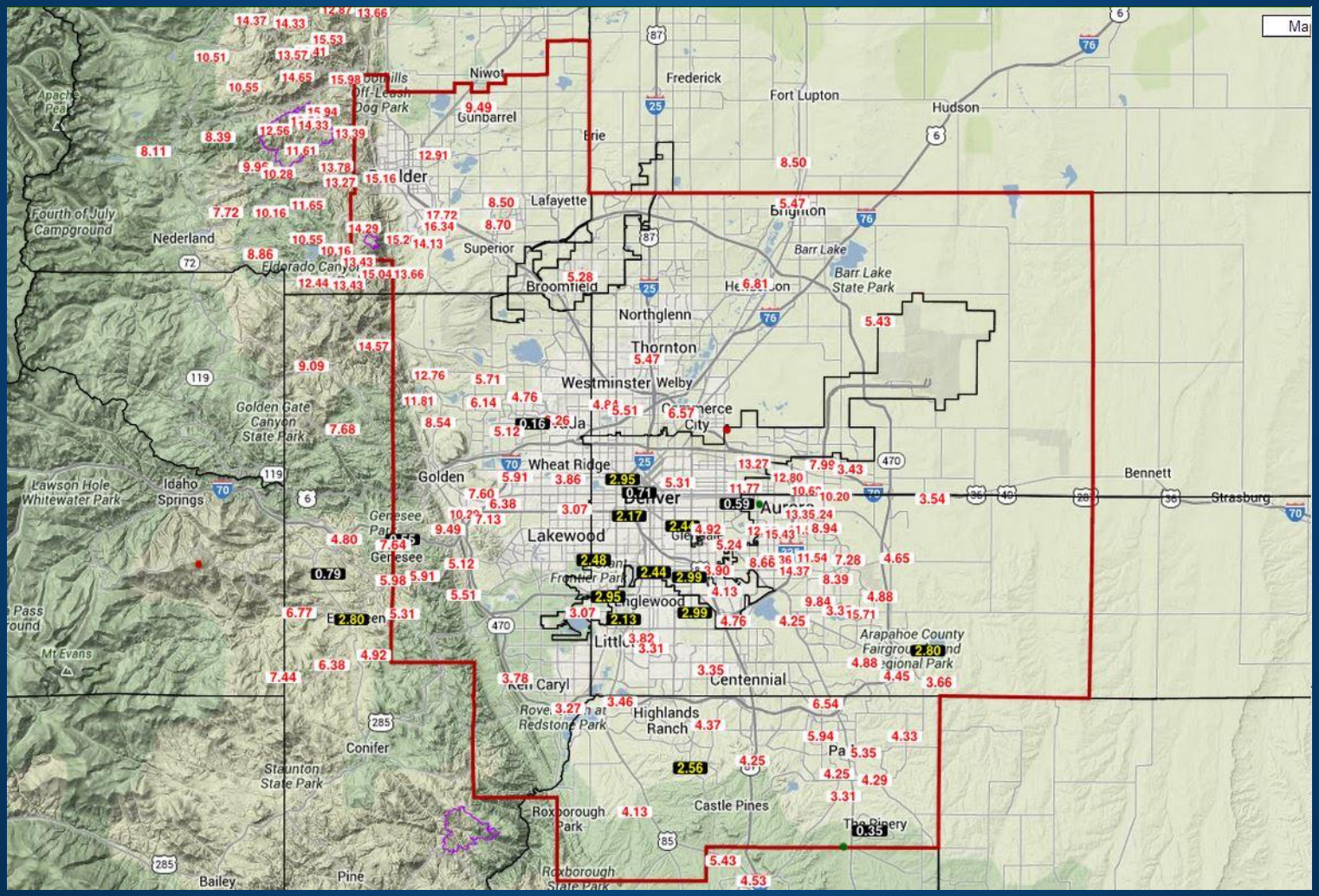
Rainfall Analysis

(Boulder County – 7 day totals)



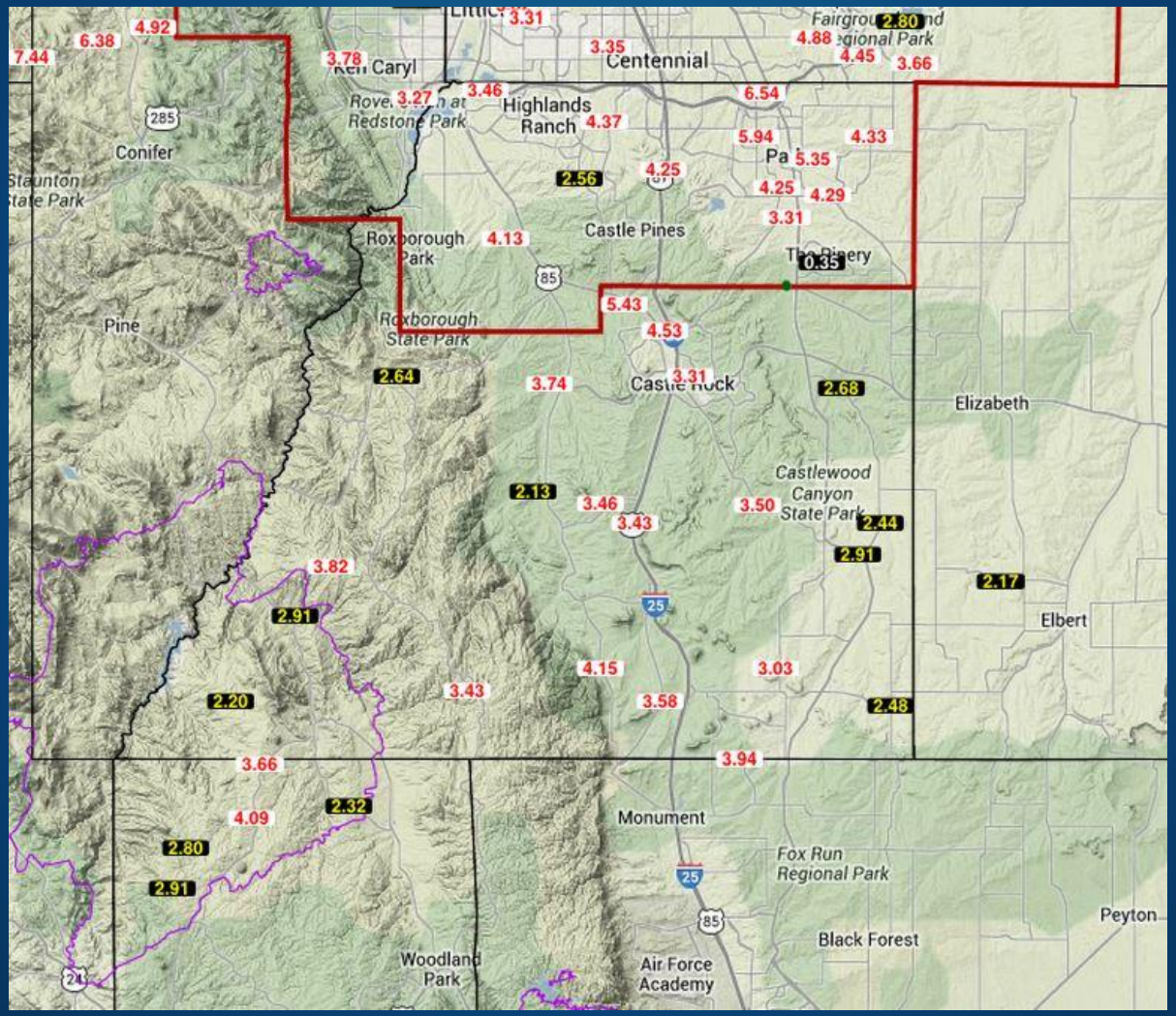
Rainfall Analysis

(Denver Metro area – 7 day totals)



Rainfall Analysis

(Douglas County – 7 day totals)



How Historic was the Rainfall?

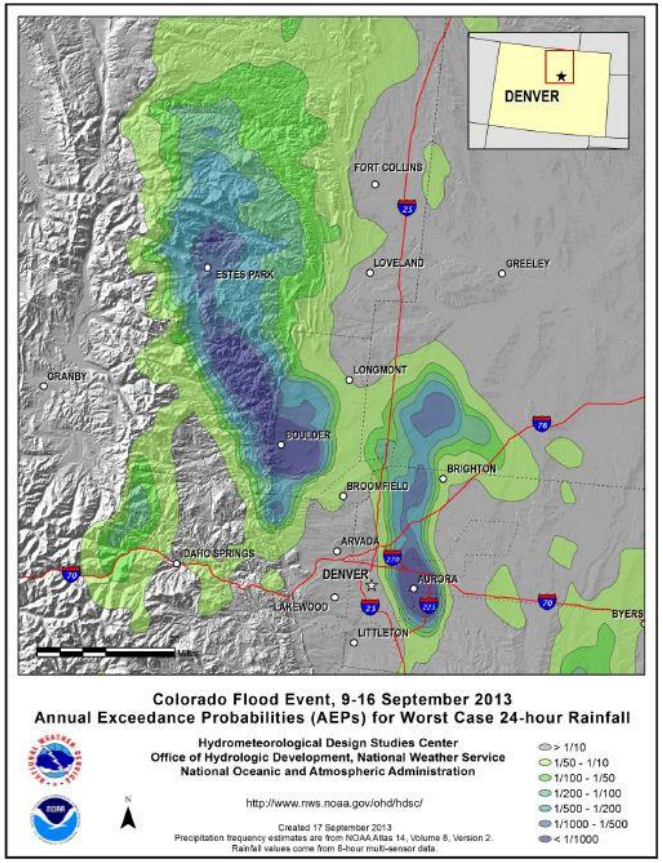


Figure 2. Annual exceedance probabilities for the worst case 24-hour rainfall.

Annual Exceedence Probabilities for 24 Hour Rainfall Suggests this was a 1 in 1000+ year event for some locales

More information can be found at http://www.nws.noaa.gov/oh/hdsc/aep_storm_analysis/index.html

Impact Summary

- Flood Area over 1918 square miles (18 Counties)
- Damage Estimate: Near $4 Billion
- FEMA Disaster Declarations – 15 Counties
- 9 Fatalities
- Over 19,000 persons evacuated
- 2,006 Homes Destroyed…26,000 Damaged (Major & Minor)
- 200 Business Destroyed…750 Damaged
- 200 Miles of Road Damaged…50 Major bridges Damaged
- 65 Flash Flood Warnings Issued for Event
- 38 Flood Warning Products