Parker, Colorado, July 30, 1998 - RAINFALL RECONSTITUTION

Prepared for:

Urban Drainage & Flood Control District
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1.0 Introduction

On July 30, 1999 a significant flash flood episode occurred during the late afternoon and early evening hours near Parker, Colorado. The event produced both stream and localized urban street flooding, especially on Sulphur Gulch, but also through a significant portion of the upper Cherry Creek basin. The flash flooding was caused by the runoff from an intense 30-90-minute period of heavy thunderstorm rainfall. The peak intensity of the storm produced a measured 0.96 inches of rain in 5 minutes 25 seconds in a District gauge which may have set a Colorado record.

Parker and the Cherry Creek basin is located in northeastern Douglas County just 5 miles south of Cherry Creek Reservoir and approximately 15 miles south-southeastt of downtown Denver. The area is shown in Figure 1 on a map provided by Urban Drainage & Flood Control District.

This brief technical report presents the highlights of the rainfall reconstruction requested by Urban Drainage & Flood Control District.

2.0 Rainfall Reconstitution

HMS has developed a standard technique for accomplishing radar-rainfall reconstitutions for the Urban Drainage & Flood Control District. This technique has been described in several publications, which are referenced at the conclusion of the report.

In general, HMS utilizes the standard Level III base reflectivity observations taken by the National Weather Service (NWS) at their WSR-88D located near Watkins, Colorado. This radar is within 40 miles of the entire basin and thus provides a clear radar picture of the storm. The observations used were taken at a 0.5-degree elevation angle, which is a standard observation mode.

HMS acquires the base reflectivity data through a satellite data feed from Kavouras, Inc a NIDS provider. Kavouras provides the data in an x-y co-ordinate system instead of the standard NWS polar coordinate format. The Kavouras format simplifies navigating the data into a MapInfo Pro GIS format, which HMS links to Microsoft Excel 7.0 spreadsheets.

HMS has created a workbook comprised of sheets of both radar reflectivity level data and radar-estimated rainfall. Maps of the basin have been superimposed over the spreadsheets and presented in a 0.5 by 0.5 mile square. This size grid approximates very closely the scale of each pixel of the NWS radar reflectivity observations.

A basin grid is prepared for each of the WSR-88D observations times and it is placed in a spreadsheet. A workbook of observation spreadsheets is prepared for each storm and summations of rainfall prepared from these estimations.

HMS follows a five-step process in assigning a rainfall value to each radar reflectivity value:

1. First, the radar data is navigated into the MapInfo Pro grid. The grid consists of 0.5 by 0.5 mile squares. The entire basin is then identified on the grids using boundaries supplied by the District.

2. Next, HMS calculates the atmospheric peak hourly rainfall rates using observations from the District Mesonet weather stations, the NWS atmospheric sounding and the equations below once an hour:

$$\textbf{Peak 60-minute rainfall} = \textbf{PWI* times } \frac{\textbf{(Depth of updraft warm layer)}}{\textbf{1.5km}} \textbf{ times 2**}$$

Peak 30-minute rainfall = 0.70 (Peak 60-min rain)
Peak 10-minute rainfall = 0.60 (Peak 30-min rain)

3. Next, these equations are used to atmosphere truth the peak radar reflectivity levels and rainfall rates observed in the 55 dBZ or greater portions of the storm. Lower reflectivity levels and rainfall rates are logarithmically assigned as seen in the table below:

Radar Z - Level	Peak 60-min 3.30"	Peak 30-min 2.31"	Peak 10-min 1.38"
2	0.10"/5min	0.22"/5min	0.30
3	0.20"/5min	0.30"/5min	0.40
4	0.30"/5min	0.41"/5min	0.55
5	0.40"/5min	0.55"/5min	0.70"
6	0.40"/5min	0.55"/5min	0.70"
7			Hail

4. Next, HMS takes the radar-estimated rainfall and compares it to observed District gauges. This step allows the data to be ground-truthed with actual gauge data and radar data within the atmospheric structure observed. Additionally, HMS ground-truths the radar reflectivity data to see if rainfall is actually observed when the radar would estimate rain are occurring. Frequently HMS is able to detect non-raining updraft areas of the storm using this technique. This knowledge is used to interpret the radar data and assign rain rates.

This process insures reasonable radar-rainfall estimation and accounts for most of the errors commonly observed in such calculations.

3.0 Observed Rainfall Characteristics

The user of this rainfall data will find the data in standard Excel 7.0 workbook formats on the attached 3.5-inch diskette. Rainfall observations are provided for each radar observation with a standard observation interval of about 6 minutes, the time it takes the radar dish to rotate about its axis one time.

HMS has prepared four tables of information on this storm exclusive from this workbook. Each table is a colorized map of rainfall or radar reflectivity for the event.

Table 1 shows the period of intense thunderstorm rainfall, which fell across northeastern Douglas County from 210PM until 333PM. During this period an intense line of thunderstorms formed in the circulation of a Denver cylone which was spinning just north of Parker at 2PM. The heavy rainfall centered in two areas: one over Sulphur Gulch and the town of Parker and the other over portions of the Cherry Creek basin between Castle Rock and Parker. Note the large area of over three inches of rain that targeted the Sulphur Gulch area. Most of this rain fell in 30-40 minutes. It should be noted that copious amounts of hail of up to 1.00 inch in diameter was reported to the south of Parker.

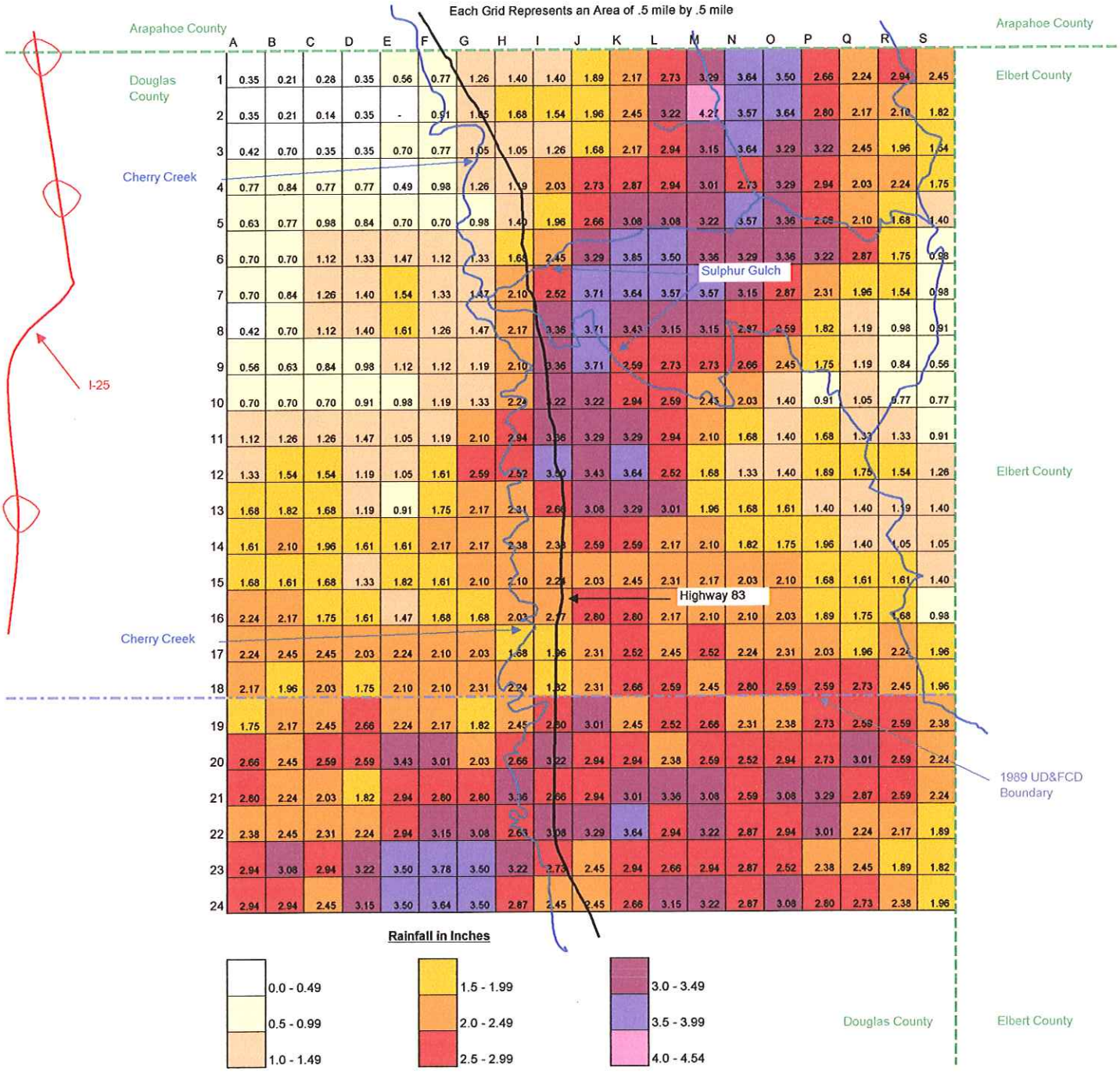
Table 2 shows the rainfall from 339PM until 500PM, MDT that fell as light rain shower period in the extreme eastern border of the county. This rain-free period was followed by another more general period of light rain which fell across the basins between 506PM and 611PM as shown in Table 3. This portion of the rainfall was very light and did not have a major impact.

Finally, Table 4 shows the summed rainfall for the event. Clearly the storm focused in the northeastern portion of the county. It is impressive that the heaviest rainfall was concentrated during a 30-45 minute period between 200PM and 300PM, MDT. The heavy rainfall was observed to occur in the northeastern quadrant of a Denver Cyclone feature that remained stationary over the area for almost an hour. This same feature was present over the basin for two hours before the heavy rainfall began stressing the importance of the prediction of the Denver Cyclone to the Flash Flood Prediction Program (F2P2).

4.0 Conclusion

A radar estimated rainfall study was completed for Parker, Colorado flash flood of August 4, 1999. Basin average rainfall of almost 3.50 inches was noted with a peak point rainfall of 4.27 inches. A Denver Cyclone low level circulation feature was observed to intensify the thunderstorms and may have contributed to the unusually high, short duration rainfall observed.

Table 1. Rainfall, Parker, CO, July 30, 1998
2:10 PM to 3:33 PM, MST



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	0.35	0.21	0.28	0.35	0.56	0.77	1.26	1.40	1.40	1.89	2.17	2.73	3.29	3.64	3.50	2.66	2.24	2.94	2.45
2	0.35	0.21	0.14	0.35	-	0.91	1.85	1.68	1.54	1.96	2.45	3.22	4.27	3.57	3.64	2.80	2.17	2.10	1.82
3	0.42	0.70	0.35	0.35	0.70	0.77	1.05	1.05	1.26	1.68	2.17	2.94	3.15	3.64	3.29	3.22	2.45	1.96	1.54
4	0.77	0.84	0.77	0.77	0.49	0.98	1.26	1.19	2.03	2.73	2.87	2.94	3.01	2.73	3.29	2.94	2.03	2.24	1.75
5	0.63	0.77	0.98	0.84	0.70	0.70	0.98	1.40	1.96	2.66	3.08	3.08	3.22	3.57	3.36	2.66	2.10	1.68	1.40
6	0.70	0.70	1.12	1.33	1.47	1.12	1.33	1.68	2.45	3.29	3.85	3.50	3.36	3.29	3.36	3.22	2.87	1.75	0.98
7	0.70	0.84	1.26	1.40	1.54	1.33	1.47	2.10	2.52	3.71	3.64	3.57	3.57	3.15	2.87	2.31	1.96	1.54	0.98
8	0.42	0.70	1.12	1.40	1.61	1.26	1.47	2.17	3.36	3.71	3.43	3.15	3.15	2.87	2.59	1.82	1.19	0.98	0.91
9	0.56	0.63	0.84	0.98	1.12	1.12	1.19	2.10	3.36	3.71	2.59	2.73	2.73	2.66	2.45	1.75	1.19	0.84	0.56
10	0.70	0.70	0.70	0.91	0.98	1.19	1.33	2.24	3.22	3.22	2.94	2.59	2.45	2.03	1.40	0.91	1.05	0.77	0.77
11	1.12	1.26	1.26	1.47	1.05	1.19	2.10	2.94	3.36	3.29	3.29	2.94	2.10	1.68	1.40	1.68	1.33	1.33	0.91
12	1.33	1.54	1.54	1.19	1.05	1.61	2.59	2.52	3.50	3.43	3.64	2.52	1.68	1.33	1.40	1.89	1.75	1.54	1.26
13	1.68	1.82	1.68	1.19	0.91	1.75	2.17	2.31	2.66	3.08	3.29	3.01	1.96	1.68	1.61	1.40	1.40	1.19	1.40
14	1.61	2.10	1.96	1.61	1.61	2.17	2.17	2.38	2.38	2.59	2.59	2.17	2.10	1.82	1.75	1.96	1.40	1.05	1.05
15	1.68	1.61	1.68	1.33	1.82	1.61	2.10	2.10	2.24	2.03	2.45	2.31	2.17	2.03	2.10	1.68	1.61	1.61	1.40
16	2.24	2.17	1.75	1.61	1.47	1.68	1.68	2.03	2.17	2.80	2.80	2.17	2.10	2.10	2.03	1.89	1.75	1.68	0.98
17	2.24	2.45	2.45	2.03	2.24	2.10	2.03	1.68	1.96	2.31	2.52	2.45	2.52	2.24	2.31	2.03	1.96	2.24	1.96
18	2.17	1.96	2.03	1.75	2.10	2.10	2.31	2.24	1.82	2.31	2.66	2.59	2.45	2.80	2.59	2.59	2.73	2.45	1.96
19	1.75	2.17	2.45	2.66	2.24	2.17	1.82	2.45	2.80	3.01	2.45	2.52	2.66	2.31	2.38	2.73	2.59	2.59	2.38
20	2.66	2.45	2.59	2.59	3.43	3.01	2.03	2.66	3.22	2.94	2.94	2.38	2.59	2.52	2.94	2.73	3.01	2.59	2.24
21	2.80	2.24	2.03	1.82	2.94	2.80	2.80	3.36	2.66	2.94	3.01	3.36	3.08	2.59	3.08	3.29	2.87	2.59	2.24
22	2.38	2.45	2.31	2.24	2.94	3.15	3.08	2.63	3.08	3.29	3.64	2.94	3.22	2.87	2.94	3.01	2.24	2.17	1.89
23	2.94	3.08	2.94	3.22	3.50	3.78	3.50	3.22	2.73	2.45	2.94	2.66	2.94	2.87	2.52	2.38	2.45	1.89	1.82
24	2.94	2.94	2.45	3.15	3.50	3.64	3.50	2.87	2.45	2.45	2.66	3.15	3.22	2.87	3.08	2.80	2.73	2.38	1.96

Table 2. Rainfall, Parker, CO, July 30, 1998
3:39 PM to 5:00 PM, MST

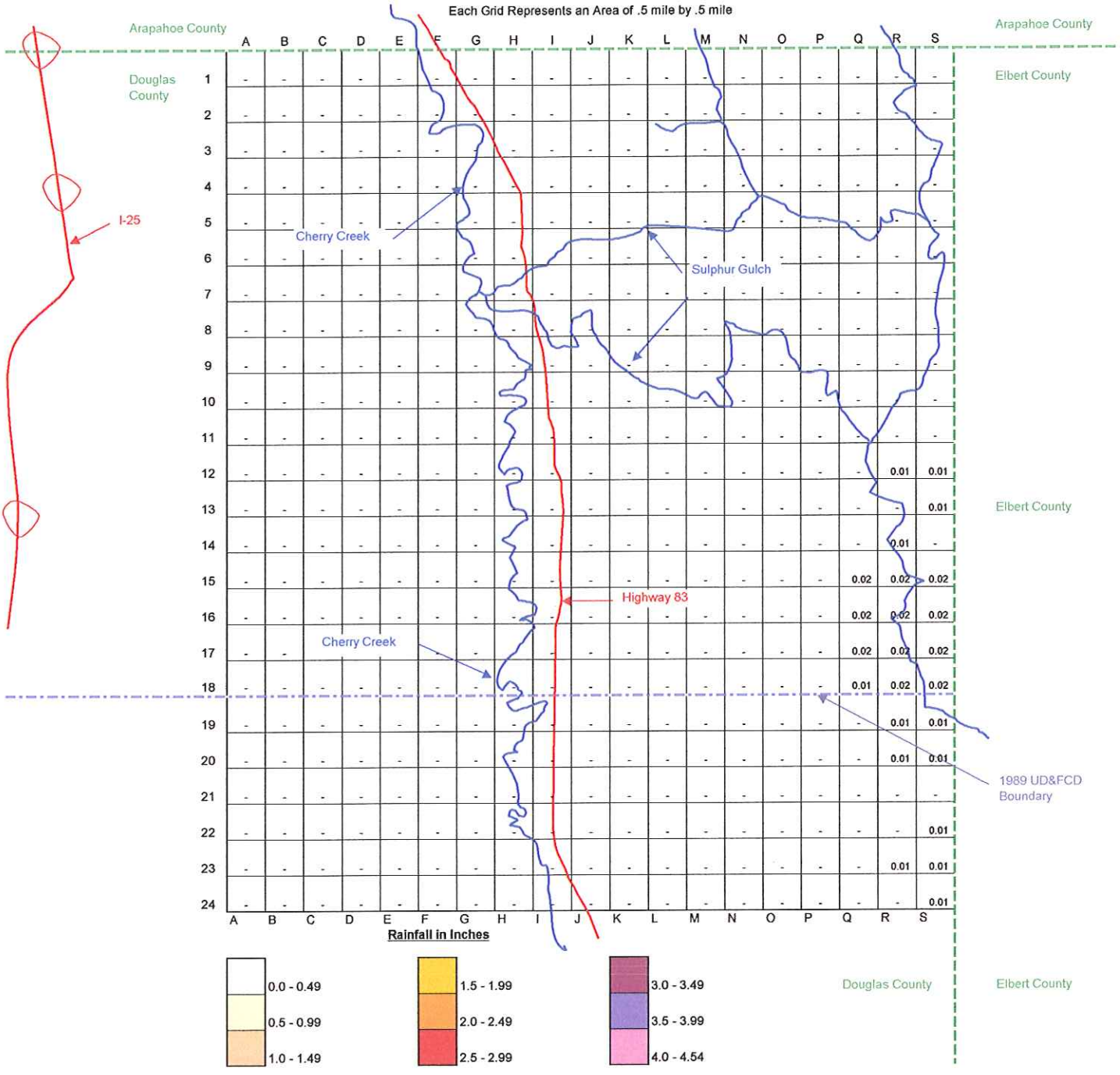
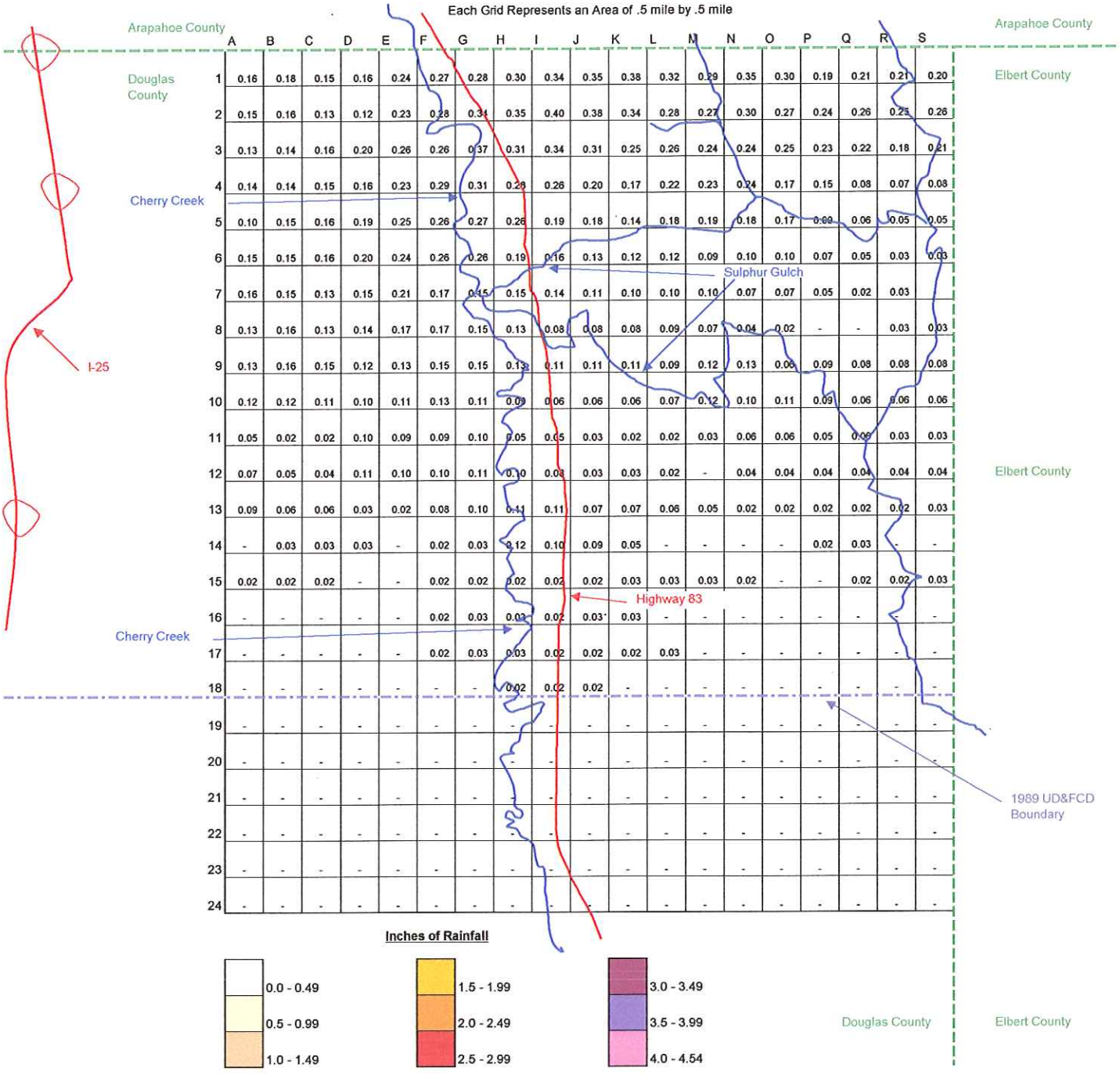
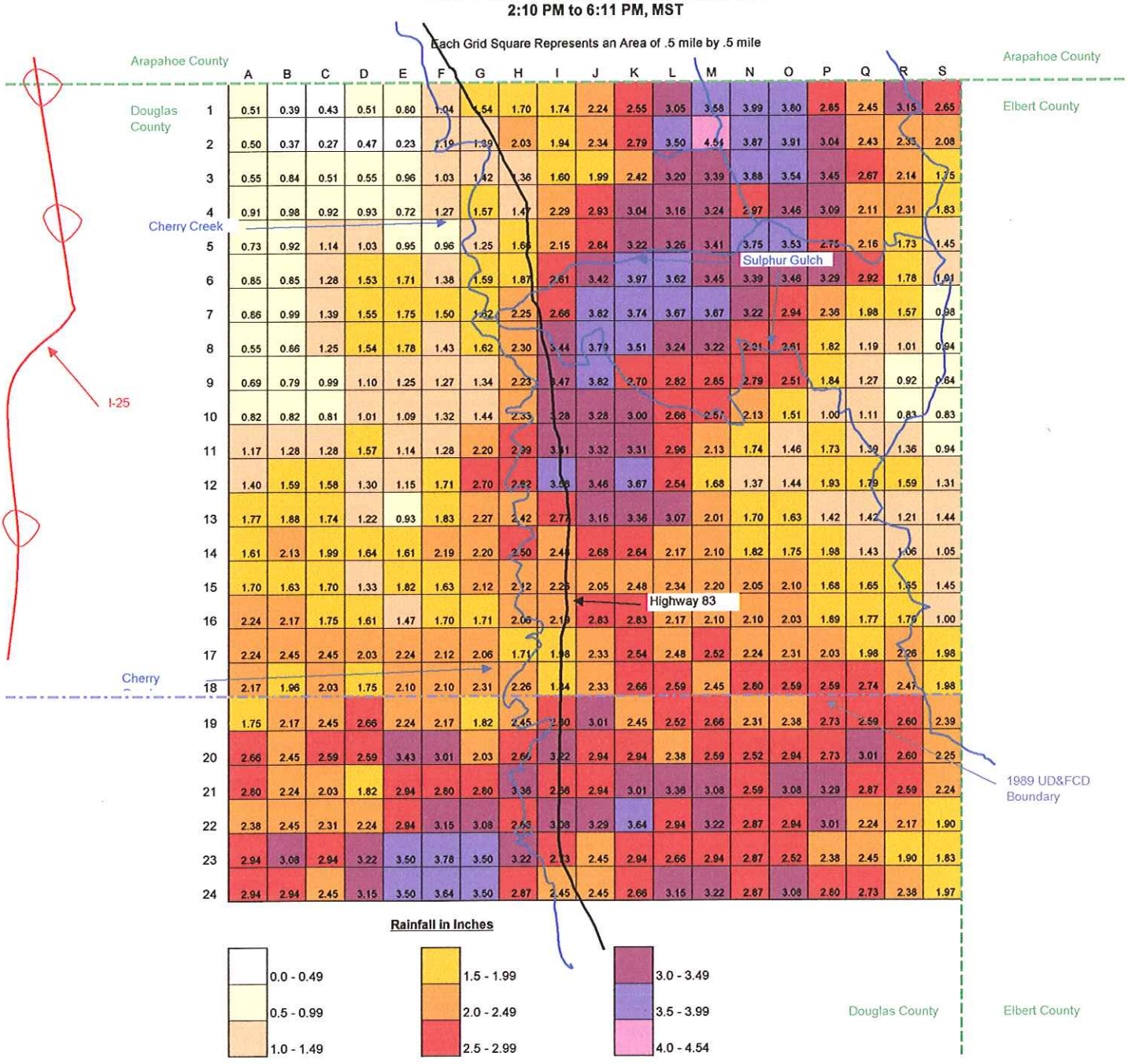


Table 3. Rainfall, Parker, CO, July 30, 1998
5:06 PM to 6:11 PM, MST



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	0.16	0.18	0.15	0.16	0.24	0.27	0.28	0.30	0.34	0.35	0.38	0.32	0.29	0.35	0.30	0.19	0.21	0.21	0.20
2	0.15	0.16	0.13	0.12	0.23	0.28	0.31	0.35	0.40	0.38	0.34	0.28	0.27	0.30	0.27	0.24	0.26	0.25	0.26
3	0.13	0.14	0.16	0.20	0.26	0.26	0.27	0.31	0.34	0.31	0.25	0.26	0.24	0.24	0.25	0.23	0.22	0.18	0.21
4	0.14	0.14	0.15	0.16	0.23	0.29	0.31	0.28	0.26	0.20	0.17	0.22	0.23	0.24	0.17	0.15	0.08	0.07	0.08
5	0.10	0.15	0.16	0.19	0.25	0.26	0.27	0.26	0.19	0.18	0.14	0.18	0.19	0.18	0.17	0.09	0.06	0.05	0.05
6	0.15	0.15	0.16	0.20	0.24	0.26	0.26	0.19	0.16	0.13	0.12	0.12	0.09	0.10	0.10	0.07	0.05	0.03	0.03
7	0.16	0.15	0.13	0.15	0.21	0.17	0.15	0.15	0.14	0.11	0.10	0.10	0.10	0.07	0.07	0.05	0.02	0.03	
8	0.13	0.16	0.13	0.14	0.17	0.17	0.15	0.13	0.08	0.08	0.08	0.09	0.07	0.04	0.02	-	-	0.03	0.03
9	0.13	0.16	0.15	0.12	0.13	0.15	0.15	0.13	0.11	0.11	0.11	0.09	0.12	0.13	0.06	0.09	0.08	0.08	0.08
10	0.12	0.12	0.11	0.10	0.11	0.13	0.11	0.09	0.06	0.06	0.06	0.07	0.12	0.10	0.11	0.09	0.06	0.06	0.06
11	0.05	0.02	0.02	0.10	0.09	0.09	0.10	0.05	0.05	0.03	0.02	0.02	0.03	0.06	0.06	0.05	0.09	0.03	0.03
12	0.07	0.05	0.04	0.11	0.10	0.10	0.11	0.10	0.08	0.03	0.03	0.02	-	0.04	0.04	0.04	0.04	0.04	0.04
13	0.09	0.06	0.06	0.03	0.02	0.08	0.10	0.11	0.11	0.07	0.07	0.06	0.05	0.02	0.02	0.02	0.02	0.02	0.03
14	-	0.03	0.03	0.03	-	0.02	0.03	0.12	0.10	0.09	0.05	-	-	-	-	0.02	0.03	-	-
15	0.02	0.02	0.02	-	-	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	-	-	0.02	0.02	0.03
16	-	-	-	-	-	0.02	0.03	0.03	0.02	0.03	0.03	-	-	-	-	-	-	-	-
17	-	-	-	-	-	0.02	0.03	0.03	0.02	0.02	0.02	0.03	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4. Total Rainfall, Parker, CO, July 30, 1998
2:10 PM to 6:11 PM, MST



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	0.51	0.39	0.43	0.51	0.80	1.04	1.54	1.70	1.74	2.24	2.55	3.05	3.58	3.99	3.60	2.85	2.45	3.15	2.65
2	0.50	0.37	0.27	0.47	0.23	1.19	1.39	2.03	1.94	2.34	2.79	3.50	4.54	3.87	3.91	3.04	2.43	2.35	2.08
3	0.55	0.84	0.51	0.55	0.96	1.03	1.42	1.36	1.60	1.99	2.42	3.20	3.39	3.88	3.54	3.45	2.67	2.14	1.75
4	0.91	0.98	0.92	0.93	0.72	1.27	1.57	1.47	2.29	2.93	3.04	3.16	3.24	2.97	3.46	3.09	2.11	2.31	1.83
5	0.73	0.92	1.14	1.03	0.95	0.96	1.25	1.66	2.15	2.84	3.22	3.26	3.41	3.75	3.53	2.75	2.16	1.73	1.45
6	0.85	0.85	1.28	1.53	1.71	1.38	1.59	1.87	2.61	3.42	3.97	3.62	3.45	3.39	3.48	3.29	2.92	1.78	1.91
7	0.86	0.99	1.39	1.55	1.75	1.50	1.82	2.25	2.66	3.82	3.74	3.67	3.67	3.22	2.94	2.36	1.98	1.57	0.98
8	0.55	0.86	1.25	1.54	1.78	1.43	1.62	2.30	3.44	3.79	3.51	3.24	3.22	2.91	2.61	1.82	1.19	1.01	0.94
9	0.69	0.79	0.99	1.10	1.25	1.27	1.34	2.23	3.47	3.82	2.70	2.82	2.85	2.79	2.51	1.84	1.27	0.92	0.64
10	0.82	0.82	0.81	1.01	1.09	1.32	1.44	2.33	3.28	3.28	3.00	2.66	2.57	2.13	1.51	1.00	1.11	0.83	0.83
11	1.17	1.28	1.28	1.57	1.14	1.28	2.20	2.39	3.31	3.32	3.31	2.96	2.13	1.74	1.46	1.73	1.39	1.36	0.94
12	1.40	1.59	1.58	1.30	1.15	1.71	2.70	2.82	3.56	3.46	3.67	2.54	1.68	1.37	1.44	1.93	1.79	1.59	1.31
13	1.77	1.88	1.74	1.22	0.93	1.83	2.27	2.42	2.77	3.15	3.36	3.07	2.01	1.70	1.63	1.42	1.42	1.21	1.44
14	1.61	2.13	1.99	1.64	1.61	2.19	2.20	2.50	2.49	2.68	2.64	2.17	2.10	1.82	1.75	1.98	1.43	1.06	1.05
15	1.70	1.63	1.70	1.33	1.82	1.63	2.12	2.12	2.25	2.05	2.48	2.34	2.20	2.05	2.10	1.68	1.65	1.55	1.45
16	2.24	2.17	1.75	1.61	1.47	1.70	1.71	2.06	2.19	2.83	2.83	2.17	2.10	2.10	2.03	1.89	1.77	1.79	1.00
17	2.24	2.45	2.45	2.03	2.24	2.12	2.06	1.71	1.98	2.33	2.54	2.48	2.52	2.24	2.31	2.03	1.98	2.26	1.98
18	2.17	1.96	2.03	1.75	2.10	2.10	2.31	2.26	1.84	2.33	2.66	2.59	2.45	2.60	2.59	2.59	2.74	2.47	1.98
19	1.75	2.17	2.45	2.66	2.24	2.17	1.82	2.45	2.90	3.01	2.45	2.52	2.66	2.31	2.38	2.73	2.59	2.60	2.39
20	2.66	2.45	2.59	2.59	3.43	3.01	2.03	2.66	3.22	2.94	2.94	2.38	2.59	2.52	2.94	2.73	3.01	2.60	2.25
21	2.80	2.24	2.03	1.82	2.94	2.80	2.80	3.36	2.56	2.94	3.01	3.36	3.08	2.59	3.08	3.29	2.87	2.59	2.24
22	2.38	2.45	2.31	2.24	2.94	3.15	3.08	2.63	3.08	3.29	3.64	2.94	3.22	2.87	2.94	3.01	2.24	2.17	1.90
23	2.94	3.08	2.94	3.22	3.50	3.78	3.50	3.22	2.73	2.45	2.94	2.66	2.94	2.87	2.52	2.38	2.45	1.90	1.83
24	2.94	2.94	2.45	3.15	3.50	3.64	3.50	2.87	2.45	2.45	2.66	3.15	3.22	2.87	3.08	2.60	2.73	2.38	1.97

From Table 4. Total Rainfall from 2:10 PM to 6:11 PM
Cherry and Piney Creeks, July 30, 1999
Single Grid Square with Highest, Total Amount of Rainfall, 4.27 inches

X-Axis Ref No.	Green-wich Time	Mtn Std Time	Inches of Rain	X-Axis Ref No.	Green-wich Time	Mtn Std Time	Inches of Rain	X-Axis Ref No.	Green-wich Time	Mtn Std Time	Inches of Rain
1	2010	210 PM	0.28	16	2139	339 PM	-	30	2306	506 PM	-
2	2016	216 PM	0.28	17	2145	345 PM	-	31	2312	512 PM	-
3	2022	222 PM	0.42	18	2151	351 PM	-	32	2318	518 PM	0.03
4	2028	228 PM	0.70	19	2157	357 PM	-	33	2323	523 PM	0.05
5	2034	234 PM	0.42	20	2203	403 PM	-	34	2329	529 PM	0.04
6	2040	240 PM	0.42	21	2209	409 PM	-	35	2335	535 PM	0.03
7	2046	246 PM	0.28	22	2215	415 PM	-	36	2341	541 PM	0.04
8	2052	252 PM	0.07	23	2220	420 PM	-	37	2347	547 PM	0.05
9	2058	258 PM	0.28	24	2226	426 PM	-	38	2353	553 PM	0.03
10	2103	303 PM	0.70	25	2232	432 PM	-	39	2359	559 PM	-
11	2109	309 PM	0.28	26	2242	442 PM	-	40	5	605 PM	-
12	2115	315 PM	0.07	27	2248	448 PM	-	41	11	611 PM	-
13	2121	321 PM	0.07	28	2254	454 PM	-				
14	2127	327 PM	-	29	2300	500 PM	-				
15	2133	333 PM	-