South Platte River Basin, July 25, 1998 - RAINFALL RECONSTITUTION

Prepared for:

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1.0 Introduction

On July 25, 1998 a series of significant urban flash floods occurred in the Urban Drainage & Flood Control District within the Denver metropolitan area. This report focuses on the rainfall, which affected the South Platte River basin between Chatfield Reservoir and Confluence Park where Cherry Creek merges with the South Platte River. The associated runoff event produced 13,200 cfs, which is the largest flow on the South Platte River in Denver since the May 1973 floods.

Figure 1 was taken off the District web page and is a copy of a map shown in the Rocky Mountain News on Saturday, July 26, 1998 that shows the general area of the flooding rainfall. The rainfall reconstruction was completed for an area roughly bounded by Wadsworth Boulevard on the west, the Douglas-Arapahoe County border on the south, Havana on the east and I-70 on the north.

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:

Peak 60-minute rainfall = PWI* times (Depth of updraft warm layer) times 2**
1.5km

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 4.10"	Peak 30-min 3.25"	Peak 15-min 1.95"
2	0.07"/5min	0.22"/5min	
3	0.15"/5min	0.30"/5min	
4	0.20"/5min	0.41"/5min	
5	0.35"/5min	0.54"/5min	0.90"
6	0.35"/5min	0.54"/5min	1.05"
7			

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

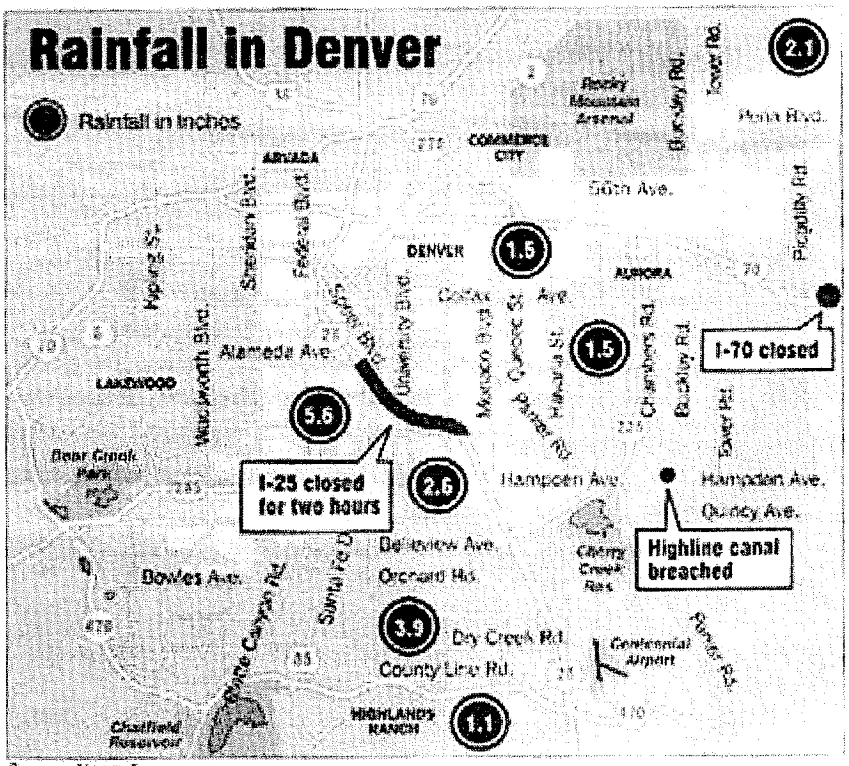
Table 1 shows the period of intense thunderstorm rainfall, which fell across south-central portion of the District, roughly just west of the South Platte River, from 432PM until 739PM. The heavy rainfall began in the south District about 515PM to 540PM as two gust fronts from a flash flooding storm over Broomfield and another storm over Aurora merged near South Santa Fe Boulevard and West Evans. As this storm formed a Denver Cyclone spinning over Englewood merged into the storm complex creating a very heavy rainfall period from 550PM until 645PM. This rainfall flooded numerous roads, including I-25. About 19 square miles of rainfall over 3.00 inches fell along the South Platte River from Littleton to near the 6th Avenue/I-25 intersection.

The storm complex had three major centers: one near South Santa Fe and West Evans, one near South Santa Fe and Hampden Avenue and the other near Belleview and Hampden in north Littleton. The Evans center produced about 5.80 inches of rain and was the largest storm while the Hampden storm dropped about 4.95 inches of rain. The Littleton storm produced about 4.85 inches of rain over a smaller area than the other two storms.

The period of heavy rainfall from the three storms coincided over the same 30-45 minute window, which may have caused the excessive runoff noted in the South Platte River. All three storms rapidly diminished in intensity once the storms moved east of Colorado Boulevard into a rain-cooled air mass from the earlier Aurora storm system. By 745PM only light rain showers were noted across the District. Table 2 shows the summed radar reflectivity factors noted over each of the 0.5 by 0.5 mile grid squares. In this case a relatively close relationship between the summed precipitation and summed reflectivity values can be noted.

4.0 Conclusion

A radar-estimated rainfall study was completed south District and South Platte River basin flooding event of July 25, 1998. Basin average rainfall of almost 3.50 inches was noted with an estimated peak point rainfall of 5.81 inches. Gust fronts and a Denver Cyclone circulation feature may have contributed to the excessive rainfall production observed.



Source: News 4

Table 1. Total Rainfall, Cherry Creek, July 25, 1998
4:32 PM to 7:39 PM, MST

Each Grid Represents an Area of .5 mile by .5 mile

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	0.96	0.81	0.58	0.59	0.51	0.36	0.36	0.36	0.37	0.58	0.65	0.51	0.85	0.87	0.85	0.87	0.91	0.90	0.92
2	1.00	1.01	0.51	0.52	0.86	0.49	0.27	0.22	0.21	0.36	0.79	1.01	0.86	0.79	0.80	0.99	1.32	1.55	1.25
3	0.88	1.04	0.98	0.90	0.78	0.72	0.49	0.37	0.36	0.48	0.64	0.99	0.65	0.87	0.88	1.09	0.92	0.92	1.00
4	0.79	0.99	0.96	0.91	0.83	0.76	0.64	0.42	0.50	0.36	0.77	1.04	0.92	1.02	0.87	1.07	0.85	1.06	0.91
5	0.79	0.69	0.96	1.04	1.07	1.07	0.64	0.50	0.94	0.89	0.73	1.21	1.53	1.34	1.14	1.01	0.72	0.57	0.42
6	0.70	0.89	0.94	1.09	1.04	0.92	0.50	0.73	1.12	1.05	0.89	1.34	1.21	1.37	0.92	0.72	0.64	0.72	0.56
7	0.75	0.89	0.97	0.84	0.77	0.69	0.59	1.06	1.11	1.17	1.19	1.29	1.31	1.28	1.22	1.01	0.87	0.88	0.72
8	0.96	1.01	0.82	0.84	0.84	0.97	0.87	1.08	1.24	1.20	0.99	1.02	0.97	1.20	1.18	1.49	1.48	1.28	0.81
9	0.96	1.01	0.82	0.57	0.70	0.64	0.59	1.19	1.17	1.20	1.29	0.95	1.15	1.64	1.74	1.44	1.28	1.13	0.86
10	0.92	1.01	0.84	0.90	0.91	0.78	1.06	1.34	1.36	1.31	1.27	1.40	1.56	1.63	1.57	1.73	1.82	1.79	1.07
11	1.09	1.13	0.99	0.66	0.89	1.04	1.24	1.38	1.49	1.27	1.53	1.59	1.56	1.37	1.57	1.86	1.77	1.63	0.76
12	1.01	1.26	1.20	1.01	1.11	1.15	1.12	1.74	1.59	1.51	1.64	1.39	1.65	1.64	1.57	1.54	1.83	1.46	1.24
13	1.08	1.37	1.16	1.16	1.44	1.19	1.29	1.72	1.68	1.73	1.85	1.54	1.86	1.88	1.64	1.53	1.56	1.71	1.08
14	1.43	1.34	1.16	1.64	1.79	1.51	1.86	2.16	2.68	2.34	1.61	1.67	1.57	1.68	1.86	1.57	1.41	1.07	0.85
15	1.47	1.48	1.29	1.70	2.02	2.32	2.65	2.57	2.11	2.04	1.82	2.01	2.02	1.77	1.40	1.46	1.46	1.46	1.14
16	2.30	2.01	1.48	1.92	2.85	2.43	2.98	3.83	2.58	2.03	1.81	1.81	1.96	1.77	1.46	1.39	1.34	1.26	1.12
17	2.50	2.27	2.38	2.41	3.31	4.31	4.72	4.02	2.83	1.86	1.57	1.69	1.87	1.84	1.74	1.37	1.37	1.21	1.21
18	2.04	1.99	1.88	2.77	4.01	4.95	4.59	4.55	3.60	2.21	2.24	2.14	2.06	2.05	1.74	1.67	1.57	1.44	1.38
19	1.21	1.55	2.32	3.49	4.90	5.81	5.26	4.80	3.13	2.88	2.16	2.25	2.15	2.05	1.71	1.71	1.64	1.36	1.53
20	1.10	1.47	2.41	3.84	4.86	5.02	4.77	4.99	2.93	2.81	2.45	2.16	2.10	2.10	1.63	1.59	1.63	1.56	1.49
21	1.61	1.80	2.99	4.45	4.62	5.29	5.07	5.06	3.79	2.48	1.98	1.95	1.85	1.85	1.79	1.71	1.61	1.61	1.51
22	1.79	2.15	3.58	4.06	4.31	4.81	5.42	4.59	3.42	2.12	1.83	1.64	1.59	1.56	1.65	1.63	1.49	1.35	1.40
23	1.62	1.78	3.41	4.49	4.24	4.94	4.44	3.96	3.92	2.55	2.13	2.04	1.75	1.59	1.36	1.46	1.41	1.49	1.49
24	1.67	1.91	2.84	4.09	3.71	3.66	4.09	3.74	3.44	2.78	2.25	2.16	1.67	1.34	1.41	1.41	1.51	1.60	1.53
25	1.62	1.73	2.83	3.58	3.29	3.86	4.47	4.52	3.98	3.08	2.74	2.36	1.74	1.52	1.47	1.54	1.69	1.69	1.76
26	1.54	1.81	2.48	3.09	3.64	3.72	3.63	4.28	3.62	2.76	2.47	1.86	1.79	1.57	1.49	1.62	1.62	1.62	1.62
27	1.86	1.73	2.79	3.52	3.95	3.52	3.80	4.37	3.57	2.50	2.33	2.21	1.94	1.94	1.69	1.74	1.81	1.56	1.69
28	1.53	1.60	2.09	2.82	3.64	4.13	4.86	3.98	2.89	2.30	2.12	2.06	2.06	2.02	1.98	1.97	2.03	2.24	2.05
29	1.32	1.42	1.61	2.45	3.08	3.24	4.16	4.04	2.77	2.37	2.06	1.93	1.74	1.57	1.59	1.88	2.10	2.15	2.07
30	1.14	1.16	1.20	1.92	2.80	3.06	3.40	3.80	2.73	2.17	1.90	1.65	1.58	1.44	1.64	1.70	1.85	2.04	1.97
31	1.12	1.07	1.14	1.45	2.89	3.03	3.37	3.48	2.17	1.91	1.78	1.55	1.40	1.15	1.53	1.71	1.71	1.97	1.90
32	1.19	1.17	1.24	1.16	1.72	2.20	2.37	2.59	2.19	1.84	1.42	1.40	1.27	1.41	1.38	1.60	1.78	1.83	1.79
33	1.08	1.04	0.98	0.91	1.32	1.84	1.93	1.86	1.71	1.33	1.22	1.16	1.06	0.86	0.99	1.09	1.21	1.36	1.56

Rainfall in Inches

0.0 - .49	1.5 - 1.99	3.0 - 3.49	4.5 - 4.99
0.5 - .99	2.0 - 2.49	3.5 - 3.99	5.0 - 5.49
1.0 - 1.49	2.5 - 2.99	4.0 - 4.49	5.5 - 5.99

Table 2. Summed Incremental Radar Reflectivity Levels
Cherry Creek , July 25, 1998
4:32 PM to 7:39 PM

Each Grid Represents an Area of .5 mile by .5 mile

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	29	24	20	18	16	13	13	13	10	19	23	17	27	29	27	29	32	29	31
2	32	30	17	14	26	15	8	6	9	13	28	35	31	28	27	34	42	46	38
3	28	29	30	29	25	20	15	10	12	17	25	33	22	29	27	37	31	31	32
4	23	28	28	28	26	24	19	18	20	14	27	36	32	22	30	41	35	38	33
5	23	20	26	27	28	29	19	19	27	25	24	35	44	42	38	36	26	21	18
6	18	23	24	28	27	25	19	24	27	27	25	37	35	42	30	26	25	26	24
7	19	23	24	24	21	20	18	31	32	31	33	36	37	37	38	35	29	27	25
8	28	29	22	21	23	25	23	28	32	31	28	27	24	37	35	47	47	42	32
9	28	29	22	16	17	18	17	31	29	31	33	24	30	44	49	46	42	38	31
10	25	29	24	23	26	24	27	37	38	35	34	36	39	40	44	49	50	50	35
11	31	34	27	21	25	29	34	40	41	34	40	39	39	34	39	49	49	45	23
12	30	41	37	29	32	30	32	43	43	40	42	38	42	42	39	42	50	39	32
13	33	43	34	31	39	38	39	43	47	47	47	42	45	44	40	42	40	44	33
14	40	43	32	45	46	42	41	54	58	52	45	44	43	44	47	42	40	33	26
15	46	49	42	44	50	51	56	54	55	54	42	47	50	46	40	40	39	39	32
16	67	62	47	39	60	56	59	67	60	56	51	48	47	44	39	36	35	34	28
17	69	66	58	49	61	73	76	67	60	51	42	44	47	45	43	37	37	33	33
18	58	56	48	57	63	71	74	70	68	56	51	51	50	50	43	44	42	40	40
19	38	44	49	65	75	83	79	72	64	64	53	53	53	51	46	46	45	39	42
20	34	43	56	66	73	74	68	71	59	64	56	51	52	52	43	44	45	44	41
21	45	51	71	71	73	74	74	73	66	62	51	50	50	50	47	48	46	46	43
22	52	60	74	77	71	74	79	67	61	53	52	45	44	44	43	47	41	39	40
23	47	49	69	80	77	70	67	63	62	60	57	53	45	43	38	40	37	38	38
24	46	51	60	73	66	64	64	61	62	63	59	57	45	37	39	39	41	42	41
25	45	49	58	68	61	60	65	66	67	66	64	56	48	40	39	41	43	43	44
26	44	50	53	62	59	60	55	65	65	62	62	51	48	42	41	42	42	42	42
27	49	48	60	62	65	61	58	62	64	63	62	58	52	52	46	45	46	42	44
28	44	46	49	55	63	70	71	64	58	55	56	57	57	53	51	49	50	53	50
29	41	43	39	47	54	55	69	65	60	58	57	55	48	42	43	48	51	52	50
30	32	34	28	42	53	57	62	66	60	57	55	49	46	40	44	45	47	50	49
31	30	29	28	34	49	56	58	60	51	53	51	47	42	36	42	45	45	49	48
32	33	31	30	33	41	52	53	58	52	50	44	43	40	40	40	43	46	47	46
33	32	29	26	27	35	49	48	49	43	39	33	34	31	26	28	30	32	35	38

Incremental Radar Reflectivity Values

1 - 9	30 - 39	60 - 69
10 - 19	40 - 49	70 - 79
20 - 29	50 - 59	80 - 89