FLOOD WARNING & INFORMATION SERVICES

KEVIN STEWART, PROGRAM MANAGER

The Flood Control District's flood warning services area (FW/IS) is preparing to make a noticeable move into the public arena in 2018 using social media and other vehicles. One good way to keep track of our progress will be to follow us on Twitter, Facebook, LinkedIn, Instagram, and YouTube. There is no breaking news on this activity yet, but keep watching. So much for the news teaser, now for the 2017 highlights…

New developments this past year include a staff change, hardened ALERT System communications, flood forecasting enhancements, and WebMap improvements. Webpages are also frequently updated and early notification processes keep evolving as Internet technologies are ever changing.

FW/IS must bid a virtual goodbye and best wishes to our project engineer, Julia Bailey, who is currently in her 8th year of District service. Fortunately, for us this farewell is only virtual because Julia's service is being broadened under UDFCD's newest program area, Operations & Development, led by Dave Bennetts. There she will continue to manage the OnBase™ project, direct GIS activities, improve WebMap capabilities, and make E-documents easy to find. She also will carry on being a key resource to FW/IS by assisting with critical Internet and satellite data communications. Be sure to read Julia's Flood Hazard News article to discover her latest contributions. Congratulations Julia!

Derrick Schauer is entering his 11th year of full-time employment as the Flood Control District's network administer. IT systems security and day-to-day operations are very high priorities for Derrick as well as website administration. Derrick will also be upgrading some critical server equipment in 2018 that will give us even better IT services well into the future.

2017 Flood Season Recap

With the number of flood threat days being somewhat above average, the flooding that did occur in 2017 failed to attract much attention. That is certainly good news for the region as recovery efforts continue from the devastating floods of 2013 and 2015.

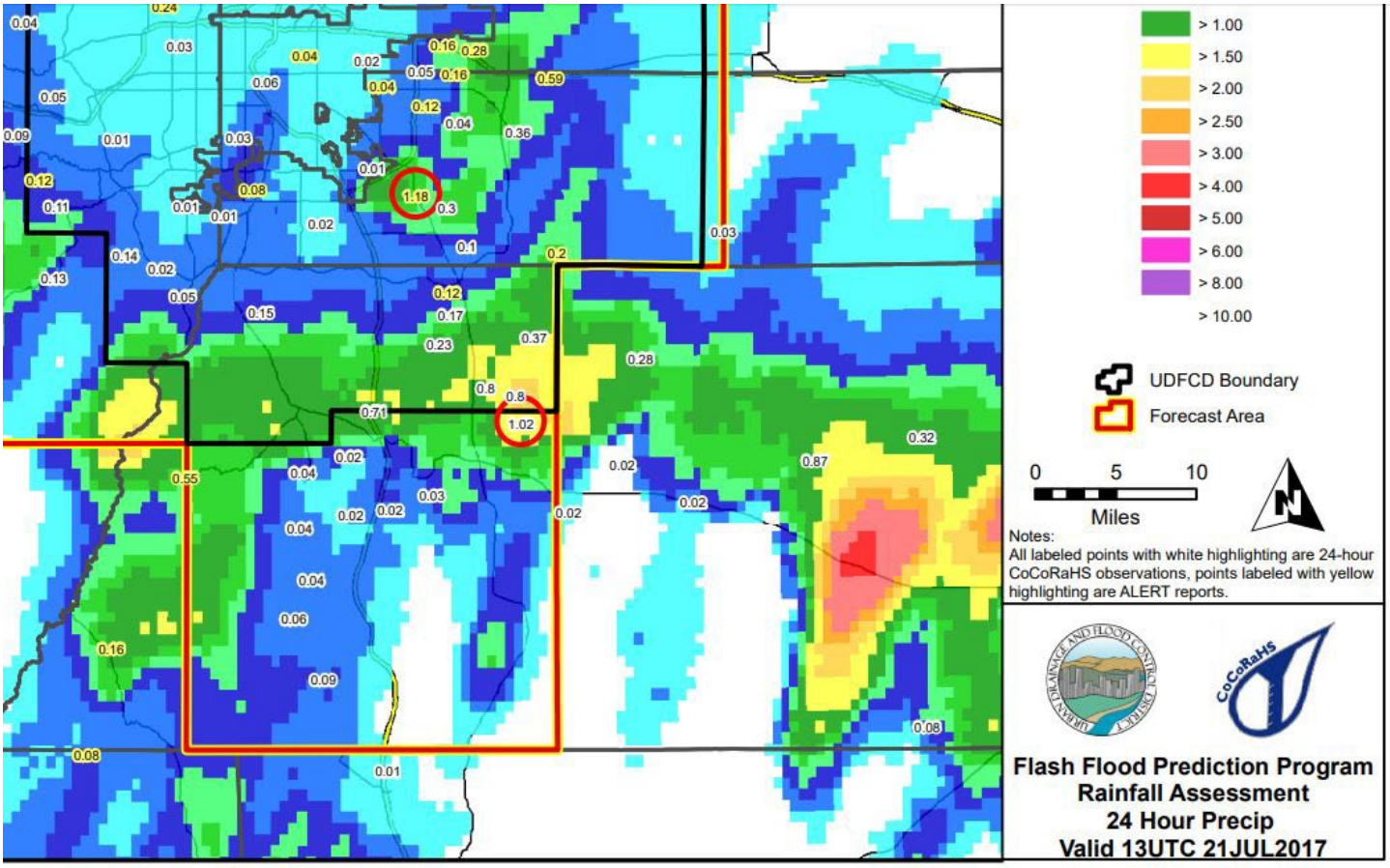
This past year the ALERT System generated rainfall rate alarms on only 15 calendar days. This compares to 21 days the previous year and 31 two years prior. And 'no', we did not change the alarm thresholds.

Intense rainfall exceeding 3 inch/hour rates occurred on May 8 & 17; June 7, July 8, 19, 20, 23, 26 & 28; and August 2, 3, 5, 12, 14 &15. All of these measurements occurred within 10 minute time-periods and they all correspond to return periods of 5-years or greater according to NOAA's precipitation frequency atlas. It may be surprising to note that this is not unusual activity for this region. In addition, these records support ongoing conversations that so called "rare events" are not rare as many news stories tend to suggest. Had a single rain gauge recorded all of these measurements, we would really have something remarkable to talk about.

Serious flooding normally requires more than just intense rainfall; the storm totals must also be high. For the Denver/Boulder metro area, this generally requires rain amounts to exceed at least an inch, and in most cases it takes over two inches before the flooding threat is elevated. In 2017, the 2-inch one-hour threshold was only exceeded one time at one ALERT gage on July 26 near Franktown in Douglas County. That same station recorded a storm total amount of 3.78" over a 7-hour period ending around 1AM on the 27th. Two other nearby

ALERT stations recorded between 2 and 3-inch storm totals. Only one other station measured over two inches of rain in a 6-hour period during the 2017 flood season. That station was also in Douglas County and the storm date was the following day, July 28. Douglas County definitely won the preferred storm track award for 2017.

Something else to keep in mind is the fact that large rainstorms in the region sometimes miss being measured by the relatively dense network of rain gauges that exists. July 20 was one of these days when radar detected what appeared to be a very large intense storm in Elbert County southeast of the District. According to radar precipitation estimates, this storm may have produced upwards of 4 inches of rain. Similar examples can be found for other days by reviewing the UDFCD storm summary maps produced for every day with flood potential.

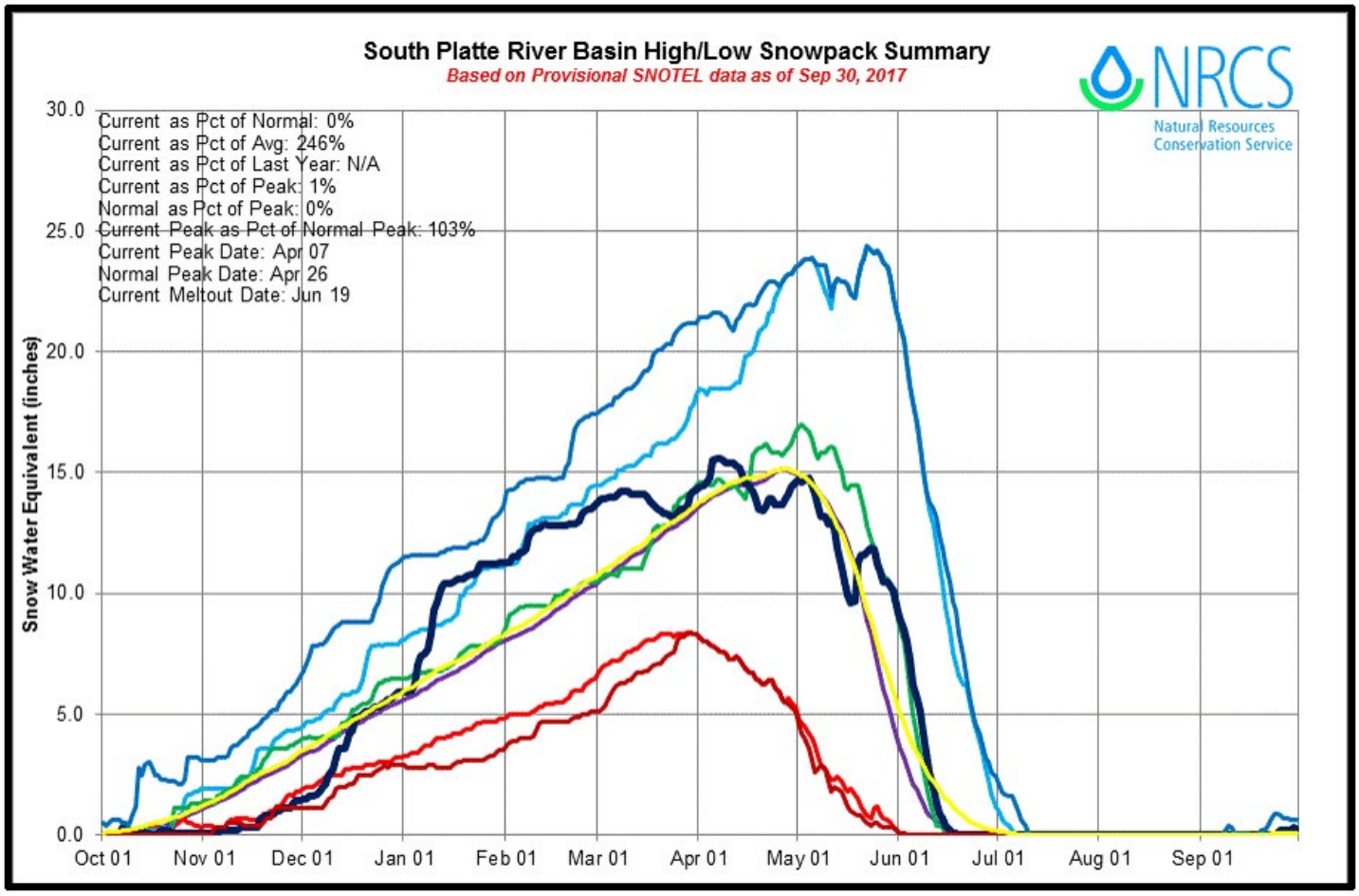


Rainfall measurements and radar precipitation estimates for July 20, 2017 storm

The following table pinpoints the specific alarm dates and shows the two days that NWS flash flood watches or warnings were issued in 2017

39 periods over 41 days with flood potential in 2017		
May	**8, 9, 17-18, 26, 29**	**6**
June	**1, 2, 5, 6, 7, 11-12**	**7**
July	**8, 12, 13, 14, 15, 20, 21, 23, 25, 26, 27, 28, 29, 30**	**14**
August	**3, 5, 6, 7, 10, 12, 13, 14, 15, 16, 22, 30**	**12**
Sept	**11, 17**	**2**

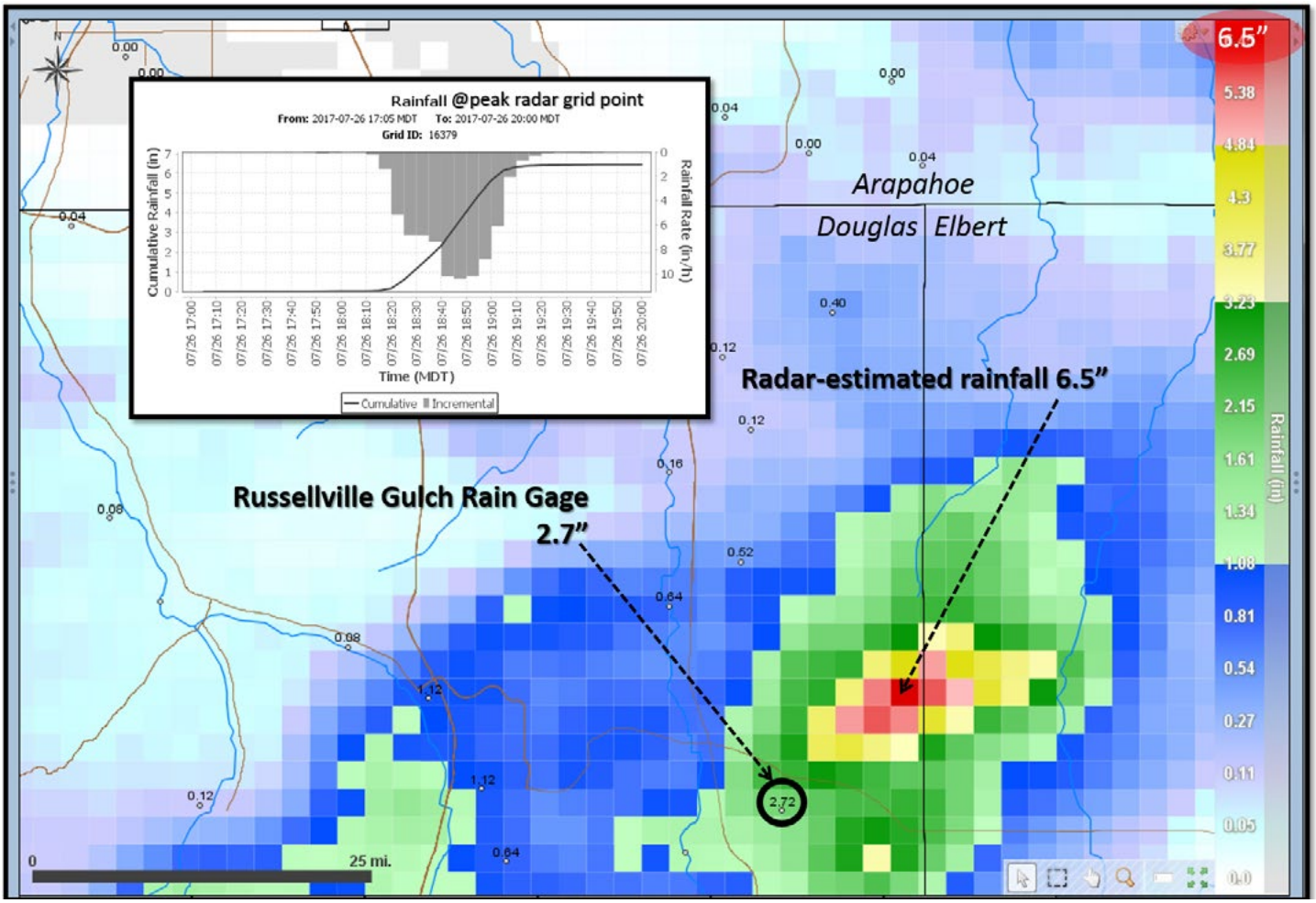
- **Red dates** are when automated rain gauges exceeded alarm thresholds.
- **Blue dates** indicate heavy rainfall only affected areas outside UDFCD's main area of concern such as the Hayman Burn Area in SW Douglas County and watersheds in northern Boulder County.
- **Green dates** are when a NWS flash flood watch was the highest threat level reached.
- **Orange** designates a flash flood warning.



The 2017 snowpack for the South Platte River basin (dark blue line above) tracked well above average (yellow line) from January to mid-March. Melting then brought the snowpack to near normal until a storm in mid-May caused a jump to above normal into June. Consequently, the water supply reports were good and the snowmelt runoff did not cause any serious flooding problems for our region, which was aided by a dry June.

Rainfall Surpasses 100-Year Threshold

In 2017, only one day (July 26) had recorded rainfall intensities that exceeded the 100-year threshold (1% AEP-annual exceedance probability) according to NOAA Atlas 14. The Russellville Gulch ALERT rain gage in Douglas County recorded a storm rainfall total of 3.78" between 5:30PM and 1AM. Rainfall maximums for 10 to 60-minute time periods had estimated return periods exceeding the 100-year threshold. The 30-minute maximum was between a 200 and 500-year event. It is interesting to note that according to a gage-adjusted radar estimate, the Russellville Gulch gage apparently did not measure the heaviest rainfall produced by this storm. Due to the relatively small footprint of the storm and its location, the impacts from the runoff attracted little attention.



Other Noteworthy Events of 2017

Before reminiscing about last year, let's revisit an earlier event that occurred on Cherry Creek through downtown Denver in 2015. That year's issue of Flood Hazard News reported a peak discharge of approximately 2,000 cfs. Subsequent reviews suggested that the actual Cherry Creek peak was considerably higher. The USGS agreed and in March of 2017, they updated their stage/discharge rating for the Cherry Creek at Denver stream gage and revised their official peak flow estimate to 3,350 cfs for the 6/24/15 event. This correction reminds us to continue questioning peak flow measurements when evidence warrants further scrutiny. In addition, we should always keep in mind that streamflow records remain provisional and subject to revision until declared official, and even then, know that the best estimates may still be flawed.

Cherry Creek flooding near Speer Blvd. and Stout St. on June 24, 2015

In 2017 the ALERT System recorded 18 days with rainfall amounts exceeding one-inch. The following events were the more prominent:

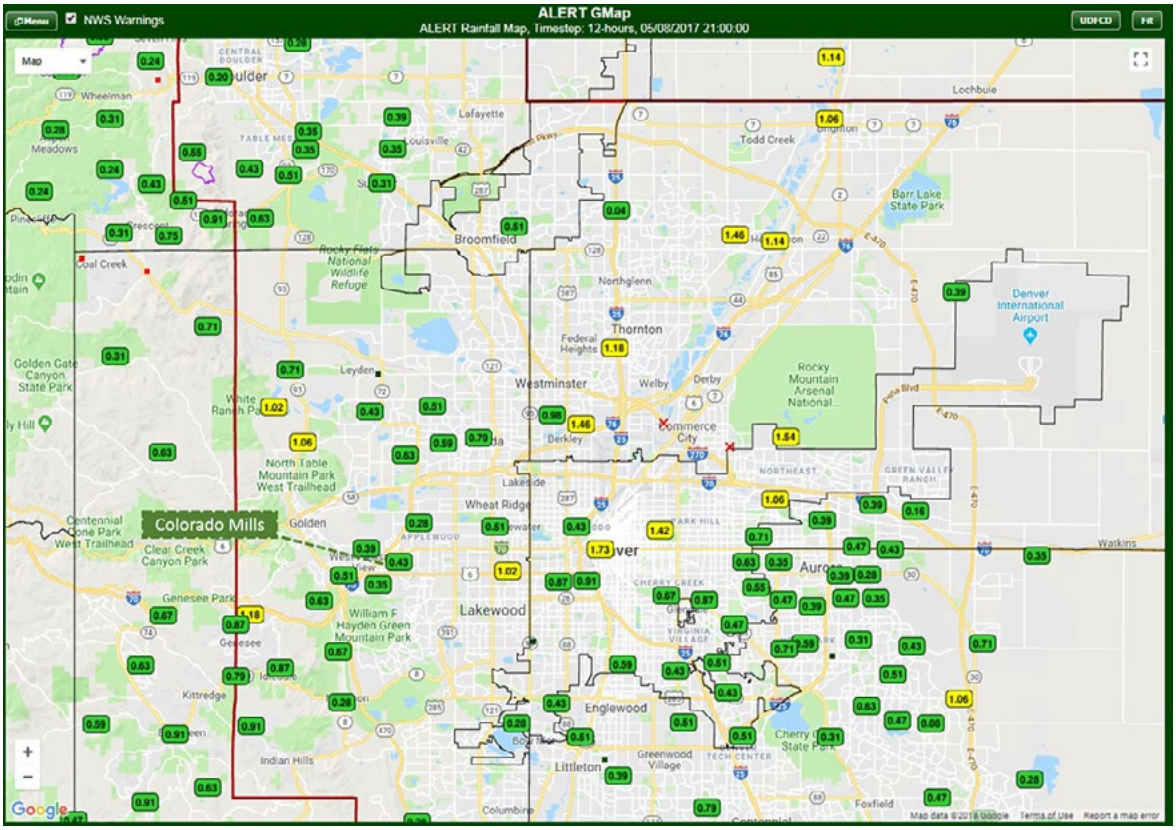
Hailstone from Olde Town Arvada, May 8, 2017
Photo credit: Nick Stewart, resident

Monday, May 8 will be long remembered by many people who live, work, shop and play in Jefferson County as the day that brought business to a screeching stop for six months at the upscale indoor Colorado Mills shopping mall. This late afternoon hailstorm is ranked among the nation's 16 billion-dollar weather and climate disasters of 2017 and is Colorado's most costly to date.

This day was also the first flood threat day of the 2017 flood season with Messages being issued at 12:38 PM for all UDFCD counties calling for strong/severe thunderstorms capable of producing up to 1.1 inches of rain in 30-minutes or less. The forecast also noted the potential for large hail exceeding 1-inch in diameter, straight-line gusty winds, frequent lightning, and possibly an isolated tornado. Although UDFCD's meteorological services are tasked to focus on heavy rainfall, the forecasters are free to provide additional weather information while encouraging local officials to monitor the National Weather Service for severe weather statements and warnings.

A forecast product issued earlier in the day suggested a worst-case rain scenario could deliver up to 2.4" in 45-75 minutes. This day illustrates well how the Flood Control District's long-running Flash Flood Prediction Program is intended to work.

This day in Colorado history is also well known for the 1969 flood that resulted from a long duration rainstorm (May 4-8) and provided the final spark for the Colorado legislature to establish the Urban Drainage and Flood Control District.

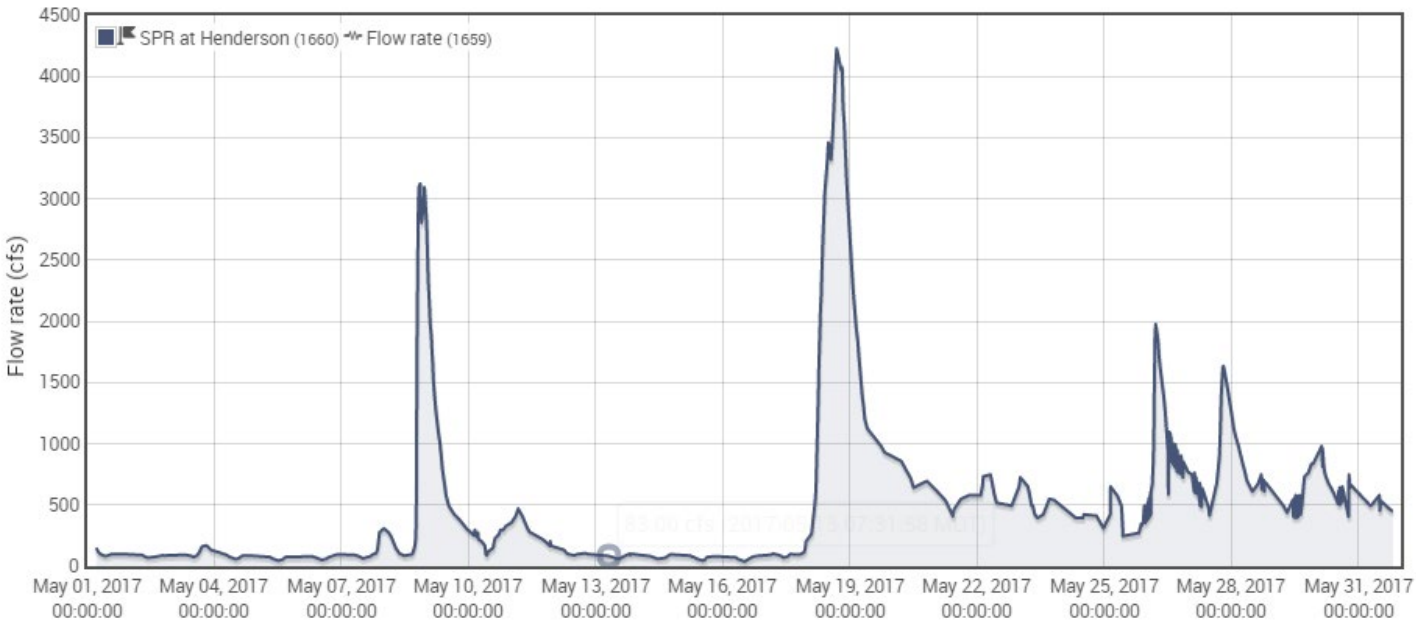


The intense rainfall on May 8 occurred between 3:10 PM and 7:20 PM. Rainfall alarms occurred at ten stations in Denver, Adams, Arapahoe (Aurora) and Jefferson counties. The map shows a rainfall amount of 0.43" at Colorado Mills, which is in the Lena Gulch watershed in Lakewood. Given the hail at this location, this ALERT rain gage very likely under-reported what actually occurred. Tipping bucket gauges are not designed to measure frozen precipitation.

Regarding the stormwater runoff from the May 8 event, no serious stream flooding was reported but due to extreme rooftop damage from the hail, the water damage inside the Colorado Mills mall was significant. A few water level gauges did measure their annual peaks from this event in Golden, Arvada, Lakewood, Wheat Ridge, Denver, Aurora and Centennial. Cherry Creek trail flooding in downtown Denver may have been one of the more interesting high water areas in the metro area that day.

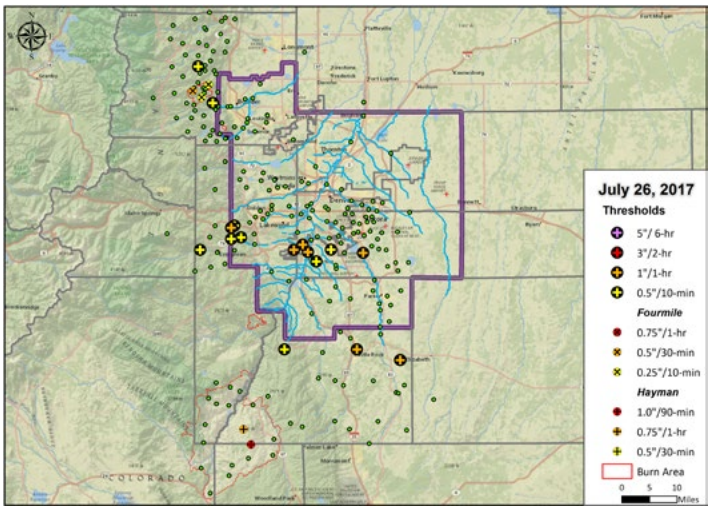
Cherry Creek trail inundation near Champa Street in downtown Denver at 3:40PM on May 8, 2017
Photo credit: Jason Stawski, UDFCD

The May 17-18 rain/snow storm produced the largest region-wide precipitation event of the year with liquid water accumulations exceeding 3-inches throughout much of southeast Boulder County. No intense rainfall was reported during this period. However, water level gauges recorded annual peaks from this winter-like storm at a number of stations in Adams County, Arvada, Lakewood, Broomfield, Thornton, Sheridan, Denver and Aurora.



June was unusually quiet with just a single valid rain alarm being recorded for the entire month. That day was Wednesday, June 7, and the location was the Murphy Creek Golf Course in Aurora where an isolated storm produced about an inch of rain with no notable stream flooding. Six flood threat periods were documented for June spanning seven calendar days. In the six days preceding June 7, a number of strong storms did produce heavy rainfall and some severe weather, but those events missed the ALERT rain gauges. For information about these events, see the storm summary table that contains short descriptions for all flood threat days. The annual streamflow peaks that occurred in June resulted primarily from mountain snowmelt runoff.

The last week in July is notorious for large flash floods and heavy downpours. This time of year is generally considered the peak of Colorado's Summer Monsoon. The most memorable event that week occurred during Colorado's centennial celebration in 1976, when the Big Thompson Canyon between Estes Park and Loveland received more than a foot of rain in a very short time period, sending a wall of water down the canyon claiming 143 precious lives.



ALERT System Rainfall Rate Alarms

The 2017 flood season added to this statistic with the one-week period from July 23 to July 30 having six of seven days having flood threat with Wednesday, July 26 being the only flash flood warning day of the year for the Flood Control District. Details about the most intense rainstorm activity are described above for an area in Douglas County near Franktown. Elsewhere, rainfall amounts exceeded 1-inch in less than 1-hour time periods at 7 ALERT stations, and 3 inch/hour rain rates were exceeded at 10 locations between 4:57 PM and 10:43 PM. Annual peaks for the following streams occurred on this day, however, no serious impacts were reported by the evening news coverage, which focused on street flooding problems in the metro area. The next day coverage by the Denver Post provides a good synopsis of the flooding that did get noticed. It is fascinating to note that nobody appears to have been affected by the ~500-year rainstorm that occurred near Franktown.

Plum Creek in Douglas County
Slaughterhouse Gulch in Littleton
Willow Creek and Little Dry Creek in Centennial
Marston Lake North in Denver
Cherry Creek in Parker
Happy Canyon Creek in Douglas County
Piney Creek in Aurora
Goldsmith Gulch in Denver
South Platte River in Denver
Lena Gulch in Golden
Van Bibber Creek in Arvada
Ralston Creek in Arvada

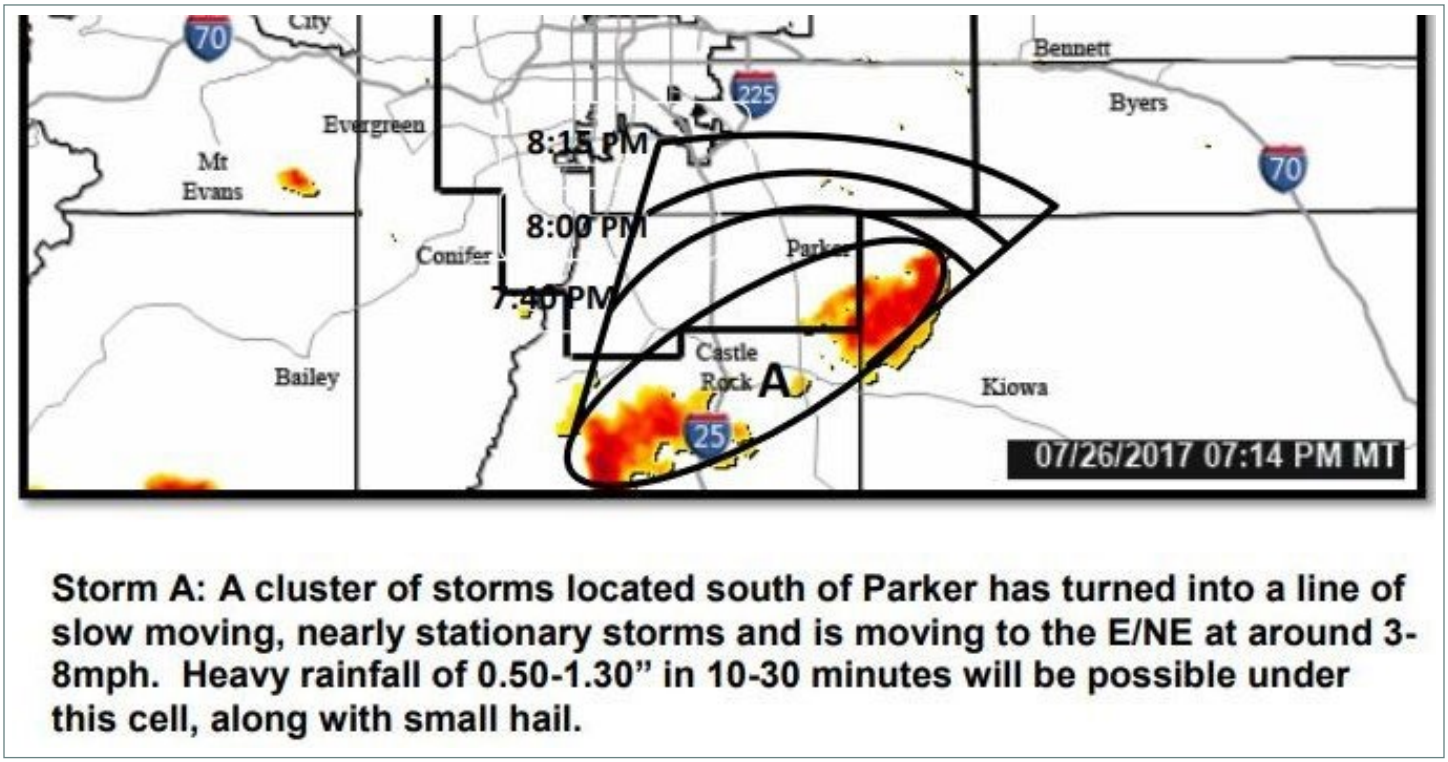
The remainder of the 2017 flood season (August & September) was relatively benign with only a few days presenting some concerns for low impact flooding. One storm on Tuesday, August 15 in the Castle Rock area may have dumped in excess of 2.5 inches in a short period according to radar, but that storm too was of little consequence to areas within the Flood Control District.

Meteorological Support

UDFCD's flash flood prediction and notification services, a.k.a. F2P2 – short for Flash Flood Prediction Program, operates from April 15 through September 30 in close partnership with NOAA's National Weather Service, focusing primarily on intense rainstorms that threaten the Flood Control District. This long-running program was conceived shortly after the July 31, 1976 Big Thompson Canyon flash flood. It has been serving UDFCD local governments since 1979.

Skyview Weather provided the meteorological support once again with daily outlooks, quantitative rainfall forecasts, storm track predictions, and location-specific flood threat notifications when warranted. Skyview President Tim Tonge has been with the program for the past 12 years. Skyview's project manager Brad Simmons is an 11-year F2P2 veteran. Other support staff consisted of 5-year veteran Alan Smith along with Justin Brooks and Nick Barlow, both returning for their second consecutive flood season.

An annual report and a complete F2P2 product archive is available.



Clip from Skyview Storm Track Prediction

CoCoRaHS Update

UDFCD has been a proud sponsor of the Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) since 2001. This large network of over 20,000 volunteer observers covers all 50 states, Canada, Puerto Rico, the U.S. Virgin Islands and the Bahamas. Funding of CoCoRaHS relies on sponsorships and individual contributions. Consequently, this unique non-profit organization continues to seek new financial partners. Visit the CoCoRaHS website to donate or become a volunteer observer.

ALERT System News

The ALERT system operated by UDFCD covers an extensive regional area with over 230 gaging stations that monitor rainfall, water levels and weather conditions in real-time. Stations on Big Dry Creek and Brantner Gulch in Thornton came on line in 2017 as reported in last year's issue of Flood Hazard News. No other stations were added in 2017, but by the 2018 flood season, we anticipate that one new rain gage and a stream gage will be operating in the Coal Creek Canyon watershed located near the Boulder/Jefferson county line. A new rain gauge near Jamestown in Boulder County is also expected soon.

OneRain and Water & Earth Technologies (WET) again provided routine preventative maintenance and unscheduled repair services for 2017, enabling successfully data collection of over 14-million ALERT reports. The Resources box at end of this article contains links to annual reports and other pertinent documents.

A MS-Excel™ workbook summarizes annual water level/flow peaks and historic maximums for the period of record. The spreadsheet documents the date, time, gage height/stage and corresponding flow rate. Appropriate notes are also included as cell-specific comments where data is missing, questionable, or supplemented by other

10 Minute Peak Intensities						15 Minute Peak Intensities						30 Minute Peak Intensities					
Station	Date	Tips	Inches	in/hr	Frequency	Station	Date	Tips	Inches	in/hr	Frequency	Station	Date	Tips	Inches	in/hr	Frequency
2900	7/26/17 18:20:55	30	1.181	7.087	<200yr	2900	7/26/17 18:23:49	40	1.575	6.299	<200yr	2900	7/26/17 18:30:21	60	2.362	4.724	<500yr
2320	7/26/17 21:29:18	22	0.866	5.197	<50yr	2320	7/26/17 21:32:55	24	0.945	3.780	<50yr	1520	7/26/17 22:25:09	39	1.535	3.071	<100yr
2250	7/26/17 17:00:22	17	0.669	4.016	<25yr	1520	7/26/17 22:12:38	23	0.906	3.622	<50yr	1640	7/26/17 22:22:29	34	1.339	2.677	<50yr
1520	7/26/17 22:07:51	16	0.630	3.780	<10yr	2250	7/26/17 17:00:52	22	0.866	3.465	<25yr	2940	7/28/17 15:53:14	33	1.299	2.598	<25yr
1710	7/20/17 16:19:00	16	0.630	3.780	<10yr	2310	7/26/17 21:32:51	22	0.866	3.465	<25yr	1710	7/20/17 16:34:09	29	1.142	2.283	<25yr
2310	7/26/17 21:32:51	16	0.630	3.780	<25yr	1640	7/26/17 22:18:55	21	0.827	3.307	<25yr	2320	7/26/17 21:42:33	28	1.102	2.205	<25yr
2940	7/28/17 15:45:50	16	0.630	3.780	<25yr	2940	7/28/17 15:52:14	21	0.827	3.307	<25yr	5740	7/19/17 16:59:14	27	1.063	2.126	<25yr
5740	7/19/17 16:42:45	16	0.630	3.780	<10yr	1710	7/20/17 16:22:12	20	0.787	3.150	<10yr	1710	7/26/17 20:56:52	26	1.024	2.047	<10yr
1620	7/26/17 20:34:27	15	0.591	3.543	<10yr	5740	7/19/17 16:44:08	19	0.748	2.992	<10yr	2920	7/23/17 12:48:33	26	1.024	2.047	<10yr
1640	7/26/17 22:18:55	15	0.591	3.543	<25yr	2920	7/23/17 12:40:01	18	0.709	2.835	<25yr	2310	7/26/17 21:34:55	24	0.945	1.890	<10yr
2350	7/26/17 21:28:06	14	0.551	3.307	<10yr	1620	7/26/17 20:38:23	17	0.669	2.677	<10yr	2250	7/26/17 17:02:06	23	0.906	1.811	<10yr
600	7/8/17 15:44:08	13	0.512	3.071	<5yr	2240	7/26/17 21:27:51	17	0.669	2.677	<10yr	100410	7/30/17 17:03:33	23	0.906	1.811	<10yr
620	7/26/17 22:21:32	13	0.512	3.071	<10yr	2350	7/26/17 21:32:59	17	0.669	2.677	<10yr	1530	7/26/17 22:24:44	22	0.866	1.732	<10yr
2240	7/26/17 21:22:32	13	0.512	3.071	<10yr	3040	7/15/17 14:15:57	16	0.630	2.520	<10yr	2350	7/26/17 21:38:50	21	0.827	1.654	<10yr
2920	7/23/17 12:37:51	13	0.512	3.071	<5yr	5720	7/26/17 19:18:59	16	0.630	2.520	<5yr	2750	7/26/17 22:20:28	21	0.827	1.654	<5yr
5720	7/26/17 19:17:57	13	0.512	3.071	<5yr	100410	7/30/17 16:59:58	16	0.630	2.520	<5yr	5720	7/26/17 19:32:34	21	0.827	1.654	<5yr
2800	7/26/17 19:34:27	12	0.472	2.835	<5yr	600	7/8/17 15:48:13	15	0.591	2.362	<5yr	620	7/26/17 20:57:04	20	0.787	1.575	<5yr

Similarly, monthly rainfall data is analyzed and tabulated for various peak rainfall periods ranging from 5-minutes to 24-hours. Highlighted cells indicate that a pre-defined alarm threshold was exceeded for the respective time period. The table now includes a column that shows NOAA-14 frequencies for each measurement.

UDFCD supports two websites for accessing ALERT data. OneRain maintains the public website linked from UDFCD's flood safety webpage. This page also contains links to the F2P2 and Twitter websites. The 'alert5' website is a good starting point for our flood warning partner agencies.

Westminster Public Safety Center

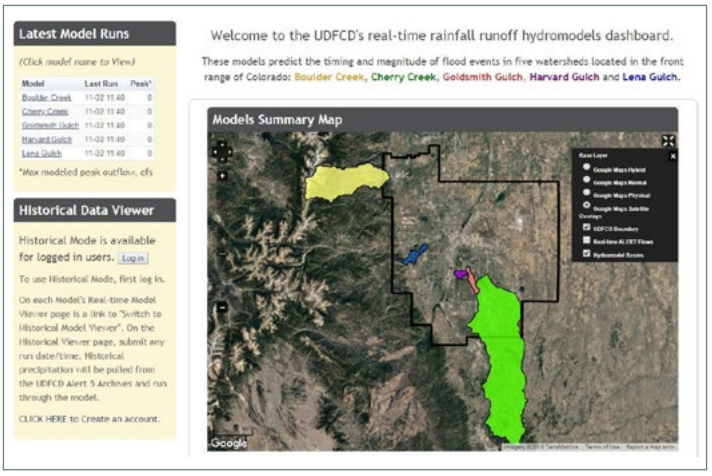
ALERT antenna at the Westminster Public Safety Center

Last year the City of Westminster allowed UDFCD to install a new ALERT antenna and data receiver at their Public Safety Center. This building is home to the Westminster Police Department and Emergency Communications, and is adjacent to Westminster City Hall. The location is a strategic high point between Denver and Boulder that is capable of receiving radio transmissions from all ALERT data repeaters. After real-time data reports are received by this facility, they are sent via IP connections to multiple data collections platforms. Consequently, this unique site now serves as a critical backup data relay station for UDFCD's ALERT System operations.

The Flood Control District is grateful for its long-standing partnership with the City of Westminster and would like to extend a huge THANK YOU to the following Westminster staff: Emergency Management Coordinator Greg Moser, Emergency Communications and Technical Services Administrator Russ Bowers, Nelson Martinez with the Public Safety Communications Center, IT Network Engineer Jeff Butler, and Telecommunications Administrator Dan Hord. Thanks also to Glenn Hetchler and Scott Bores with OneRain; and Markus Ritch and his staff at WET for their roles in guiding this project to a successful completion.

Real-Time Hydromodels

The 2017 flood season provided few opportunities to evaluate RT-Hydromodels performance, but improvements continue to be made nevertheless. Leonard Rice Engineers made viewing past events much easier. Future plans also include training for technical partners. Webinars and in-person trainings are being considered for 2018.



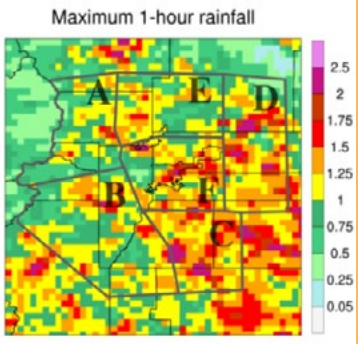
QPF-MAX Improvements

Dewberry continued to improve a new web-based precipitation forecast tool that was first introduced in 2015. UDFCD's Heavy Rainfall Guidance Tool—a.k.a. QPFMAX—uses an ensemble of high-resolution rainfall prediction models that is updated four times daily. An operational report is available that documents its 2017 performance and makes recommendations for future revisions. The forecast worked out exceptionally well for the July 26 event.

	QPFMAX*	POP1**	Threat
All Zones	2.34 inches	85%	HIGH

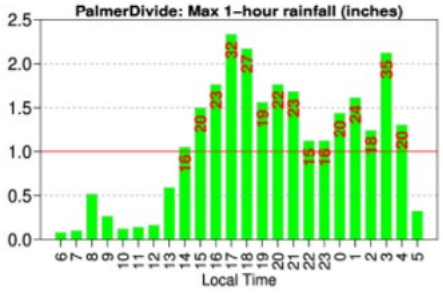
Zone	POP1**	Primetime	Threat
A	27%	---	MOD
B	27%	---	MOD
C	22%	---	VERY HIGH
D	18%	---	HIGH
E	26%	---	MOD
F	19%	---	HIGH

QPFMAX*: Maximum 1-hour rainfall.
POP1**: Chance of exceeding 1 inch in 1-hour.



Zone C: Palmer Divide

ZONE C: Overall Threat	VERY HIGH
% precipitation	>90%
% exceeding 1in. in 1hr	22%
% exceeding 2.25in. in 3hr	52%
% exceeding 3.5in. in 6hr	17%
% exceeding 4.5in. in 24hr	13%
Primetime	---



QPFMAX from July 26, 2017

RESOURCES

Visit the F2P2 website for a complete archive of daily forecasts, flood threat notifications, storm track predictions, storm summary maps, and other products.

Download a workbook that contains the annual peaks and record high water levels measured by the ALERT System.

Read annual reports concerning ALERT System maintenance and flood forecasting operations.