

Information Services and Flood Warning Program

Kevin Stewart, PE, Program Manager

UDFCD's IS/FW program continued to leverage technology in 2015 by releasing a brand new [website](#); by going live with [OnBase](#), our long-anticipated records management/workflow software package; by helping modernize our financial/accounting procedures with solutions from [Tyler Technologies](#); and by 'tweeting in the rain' during heavy downpours.

Julia Bailey is in her sixth year of full time employment at the District where she manages the OnBase project, guides our GIS activities, makes electronic documents easily retrievable via an ever-evolving [interactive mapping](#) interface, and is our go-to person for internet and satellite communications connected with UDFCD's flood warning program. Be sure to read Julia's article in this issue of *Flood Hazard News* to learn about some of the more recent developments that she oversees.

Derrick Schauer administers our IT systems and keeps us safe from a plethora of evolving cyber threats. His support in 2015 was instrumental in developing UDFCD's new website and implementing critical software packages for budgeting, accounting and records management. Derrick just completed his eighth year of full-time employment.

2015 Flood Season Recap

This was the third consecutive record-breaking year for UDFCD's flash flood prediction program, a.k.a. F2P2, surpassing 2014's threat days by one and 2013's by four. Except for an extended period of high flows on the South Platte River punctuated by some relatively impressive storm-driven peaks, most of the flood problems in 2015 were minor in nature impacting basements, streets and some low lying areas.



This past year the ALERT System generated rainfall rate alarms on 31 days. The table on this page pinpoints the specific alarm dates for 2015 and distinguishes the days that

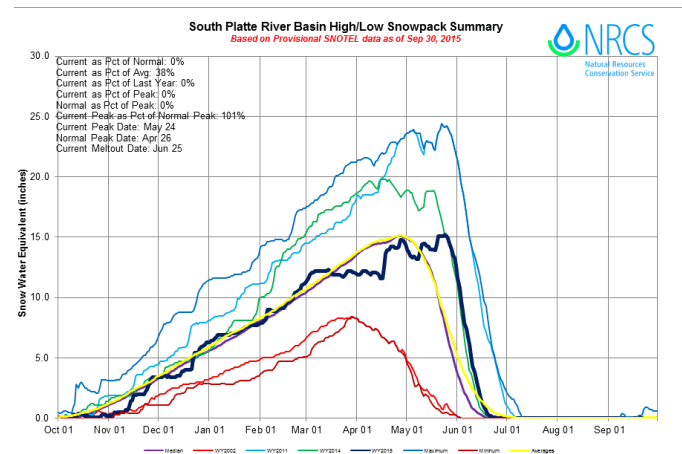
the National Weather Service issued flash flood watches and warnings.

Record 62 days with flood potential in 2015

May	4, 5, 6, 7, 8, 9, 15, 18, 19, 22, 23, 24, 25, 27, 28, 29	16
June	1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 18, 23, 24, 25	18
July	1, 2, 4, 5, 8, 9, 10, 13, 14, 15, 18, 19, 21, 26	14
August	2, 3, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 31	13
Sept	29	1

Red dates are when automated rain gauges exceeded alarm thresholds. Yellow highlighted 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. Blue boxes are when a NWS flash flood watch was the highest threat level reached and red designates a flash flood warning. Hyphenated dates indicate a late night threat period extending into early AM the next day.

ALERT and CoCoRaHS rain gauges recorded 3 days with 24-hour rainfall amounts exceeding 3 inches (May 9, June 11 & 24). Radar-rainfall estimates suggest that the region experienced two other days (May 4, June 4) where totals likely surpassed the 3-inch mark. The Colorado monsoon season that typically begins around the 4th of July was remarkably devoid of big rain producers. Seven other days deserve honorable mention (June 5, 7 & 25, July 9 & 21, and August 10 & 14) with their 24-hour rains tallying from 2 to 3 inches. A [storm summary table](#) with useful map links describes all the flood threat days predicted in 2015.



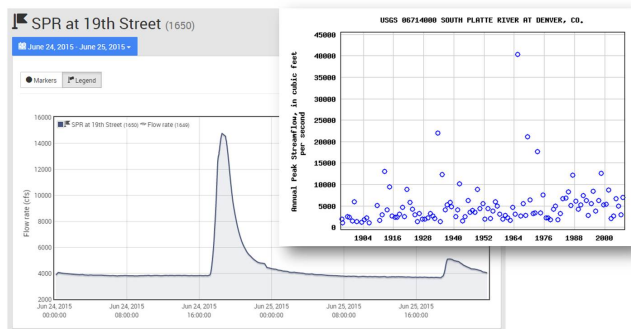
The 2015 snowpack for the South Platte River basin tracked close to average making for a good water year for northeast Colorado. However, cool temperatures and some additional mountain snow in May kept the snowpack well above normal thru mid-June resulting in a record-setting runoff season that impacted USACE reservoir operations at Chatfield, Cherry Creek and Bear Creek dams.

With this year's *Flood Hazard News* cover story commemorating the 50th anniversary of the infamous 1965 Flood, it is highly ironic that Chatfield Dam & Reservoir (completed in 1973 in direct response to the '65 Flood) broke its high water record in 2015 on the very same date as that historic flood—June 17. After reaching the previous record of 5,447.6 set in 1980 on May 25, the water level in Chatfield continued to rise, eventually reaching its new record of 5,448.48 on June 19.

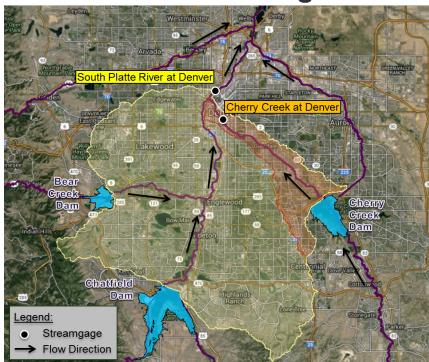
The annual peak for the South Platte River was 14,700 cfs measured at the Denver 19th Street gage at 6:30 PM on June 24. The combined flow releases from the USACE Tri-Lakes Project (Chatfield, Bear Creek and Cherry Creek Dams) was 3,600 cfs on June 24 with Chatfield releasing 3,000 cfs. Consequently, the peak flow contribution from the 220 square-mile uncontrolled watershed area below the dams was roughly 11,000 cfs, producing the fifth largest flood in 120 years.

South Platte River at Denver Streamgage Hydrograph June 24, 2015 Event (14,700 cfs)

5th largest since 1895, exceeded only by the floods of 1933, 1965, 1969 & 1973



Uncontrolled Drainage Areas



The contribution from Cherry Creek on June 24 played a significant role in the peak measured for the South Platte River at Denver gage. The highest and most intense rainfall amounts occurred in that portion of the uncontrolled

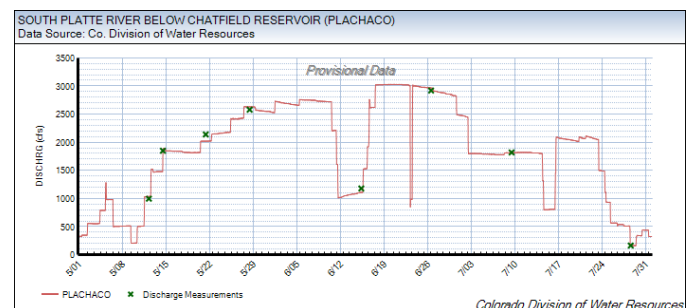
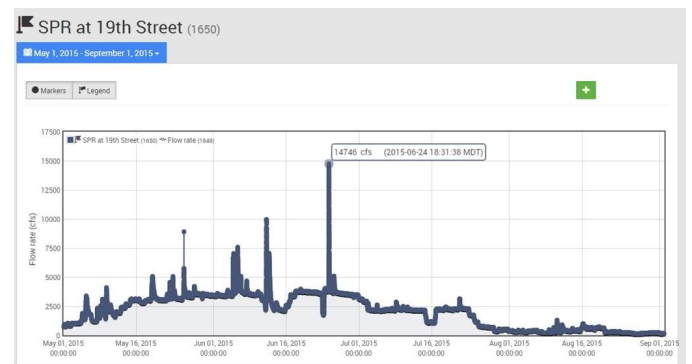
drainage area (map provided by U.S. Army Corps of Engineers, Omaha District). A peak 5-minute rain rate of 8.5 in/hr

occurred at 5 PM in Denver near the Alameda & Holly intersection with a rainfall total measuring 2.24 inches in just over one hour. With the exception of Bear Creek feeding 350 cfs from the dam, the left bank tributaries to the South Platte River contributed little to that day's peak flows.



Cherry Creek flooding near Speer Blvd. and Stout Street, June 24 at 5:55PM, estimated peak flow **3,550 CFS**. Photo by UDFCD's Shea Thomas

From a broader perspective, the discharge hydrograph below shows the flashy nature of the June 24 event compared to the much longer period of high reservoir releases that lasted from early May thru late July. A few other rainstorms over the uncontrolled watershed resulted in doubling the flow rates at the 19th Street gage during that same period, with June 11 (10,000 cfs) being the second most notable followed by May 25 (8,900 cfs) then June 5 (7,600 cfs) and finally June 12 (7,100 cfs).



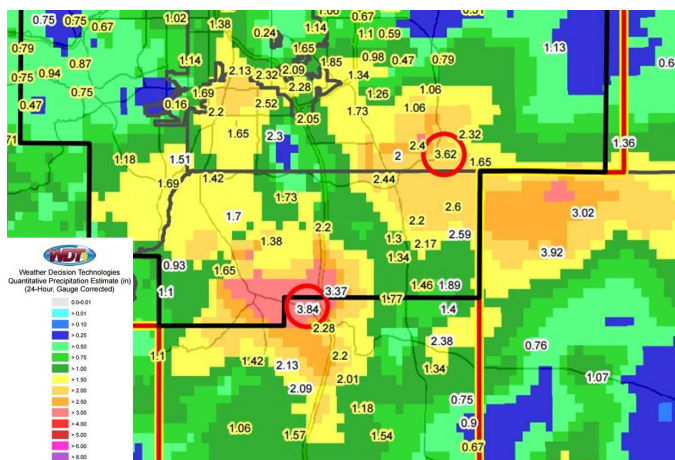
30-year historic average peak releases from Chatfield are less than 500 cfs

Resulting damages from this extended wet and stormy period ultimately lead to a [federal disaster declaration](#) on July 16 that included local governments in three UDFCD counties: Adams, Boulder and Denver. Repairs to public infrastructure, bank erosion and associated costs of responding to the problems are eligible for federal reimbursement. Vehicles and massive trees were pulled from the South Platte River. The City of Thornton in Adams County was hit particularly hard. Arapahoe County communities also had considerable losses that are not eligible for federal disaster assistance. UDFCD provided assistance within limits of available funds, heavily taxing the District's 2015 maintenance budget.

Rain Measurements Exceeding 1% IDF Thresholds

This writer has, on more than one occasion, alleged that the Denver/Boulder area experiences at least one rain event every year that exceeds the 1% chance (100-year) threshold defined by point precipitation frequency estimates for the region, commonly referred to in hydrologic engineering design practice as intensity-duration-frequency (IDF) curves. In 2015, three days recorded rainfall intensities reaching this "rare" status according to [NOAA Atlas 14](#).

On Thursday, **June 11** between 5 PM and 6 PM, a rain gage in Douglas County near the intersection of U.S. 85 and Happy Canyon Road measured rainfall that exceeded 100-yr intensities for time periods of 5, 10, 15 and 30 minutes. The first rainfall rate alarm tripped at 5:27 PM and the maximum measured 5-minute intensity was 9.9 in/hr. The comparable NOAA 100-yr value at this location is 8.8 in/hr. This was the most intense rainfall recorded by the ALERT system in 2015. It may also be worth noting that this particular rain gage (2.28" storm total) was not located in the area where the largest 24-



hour rain amounts occurred according to the following map:

On Wednesday, **June 24** the second most intense rainfall of the 2015 flood season was recorded at the gage near the Holly/Alameda intersection in Denver with almost 1.2 inches in 10 minutes (7.1 in/hr) at 5:05 PM and a total of 2.2 inches from the 1-hour duration storm. Another rain gage near the I-

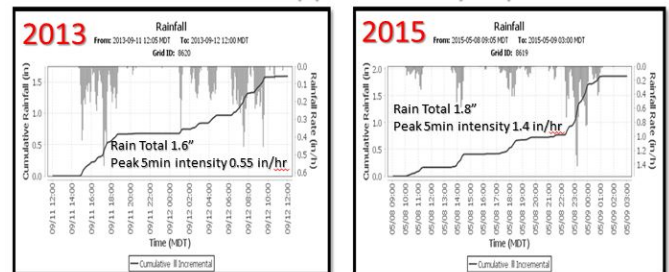
70/Havana Street interchange also topped the 1% intensity threshold at 5:15 PM.

An isolated storm along the I-76 corridor in Jefferson and Adams counties around 6:30 PM on Thursday, **July 9** produced rain amounts approaching 3 inches. A rain gage near the Pecos Street interchange caught 2.91 inches over a 90-minute period and exceeded 2.5 inches in 60 minutes, making this measurement the maximum 1-hour total for 2015. The 100-year 1-hour NOAA value for this location is 2.4 inches.

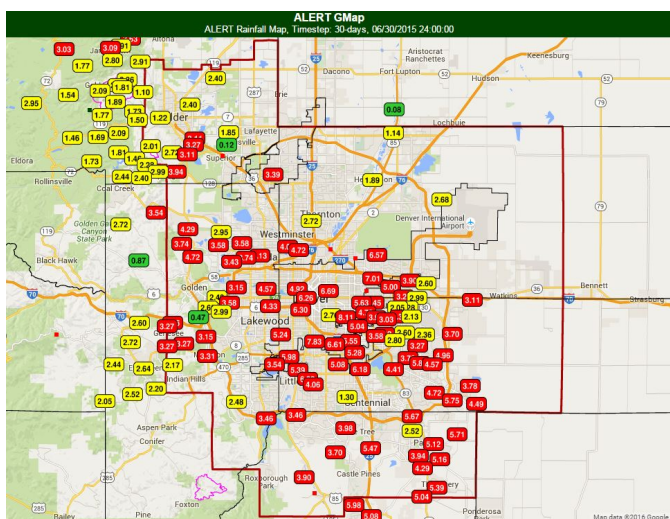
Other Notable Events

Monday, **May 4** was the first of six consecutive threat days with one CoCoRaHS observer in southern Elbert County 30 miles southeast of the District measuring 3.14 inches. By the following weekend, rainfall totals for the region exceeded 4 inches at multiple locations with basement flooding being reported by many Denver area residents. Some homeowners in Westminster said that the heavy rains were worse than what happened in September of 2013, which resulted in the infamous \$4 billion flood/landslide disaster. Radar-rainfall estimates were used to compare peak 5-minute rainfall intensities nearly triple that which occurred in the same area the week of September 11, 2013.

2015-May more intense than 2013-September Rain totals approximately equal



During the month of May a high percentage of ALERT stations measured precipitation totals between 5 and 8 inches. Climate records suggest that the average precipitation for May in Denver is about 2.6 inches. June rain totals were of similar magnitude compared to climate norms where the Denver average is 2.0 inches. Note the number of gages on the following map (highlighted in red) that reported over 3 inches in May.



Regarding streamflow measurements, new records were set for Van Bibber Creek in Arvada on May 8; for Goldsmith Gulch at Iliff Avenue in Denver on June 11 where the side-channel detention basin filled to a record 11.2 foot depth; and for Murphy Creek in Aurora, also on June 11. South Platte River gages also measured impressive peaks from the June 24 event described previously. A summary of annual and record peaks is continually being updated (see [Resources](#) box at end of this article).

The last NWS flash flood warning of 2015 affecting the District occurred on Monday, **August 10** at 2:33 PM for NE Douglas and SW Arapahoe counties. The following text taken from the NWS warning illustrates how ALERT gages continue to be a highly trusted source for making warning decisions:

* AT 232 PM MDT...DOPPLER RADAR AND AUTOMATED RAIN GAUGES INDICATED A THUNDERSTORM PRODUCING HEAVY RAIN OVER CENTENNIAL. UP TO 1.64 INCHES OF RAIN HAS FALLEN IN CENTENNIAL IN THE LAST 30 MINUTES. FLASH FLOODING IS EXPECTED TO BEGIN SHORTLY.

Tuesday, **September 29** was the last “official” heavy rain threat day of the 2015 flood season with UDFCD’s routine flood prediction services now extending through the entire month of September for the first time in the program’s 37-year history. Previously the program ended on the 15th. Proving itself worthy, intense street-flooding rainfall was observed at the Lakewood County Club at 5PM on this day. It is interesting to note that this was the only day of the month that forecasters recognized as having flood potential. By coincidence, it was a September 29 the previous year that delivered the “last hurrah” of that flood season, acknowledged then as the latest “Message Day” in the program’s history.

At the end of each flood season, UDFCD notifies local governments that its prediction services have ended for the year and recommends continued vigilance, noting that as the flood potential will decrease from now on, it still exists. Subsequent to the end-of-service notice, heavy alarm-producing rainfall did occur in the region on October 3 in Arvada, on October 5 in the Hayman Burn Area of Douglas

County, and again in the upper Cherry Creek drainage basin of Douglas County on October 6. Never let your guard down!

Meteorological Support

The 2015 flood prediction and notification services were provided for the 9th consecutive year by Genesis Weather Solutions, in partnership with Skyview Weather. This program has served UDFCD local governments since 1979 with early predictions of potential and imminent flood threats. Forecast products include daily heavy precipitation outlooks, quantitative precipitation forecasts (QPF), and storm track maps. GWS President Bryan Rappolt has participated actively as an F2P2 forecaster for the past 22 years through various business enterprises. Bryan’s Skyview partners include lead forecaster and 9-year veteran Brad Simmons supported by Alan Smith, Andrew Muniz, and Skyview’s president Tim Tonge.

The Flash Flood Prediction Program, a.k.a. F2P2, operates in close partnership with the National Weather Service from May through September focusing primarily on heavy rain threats. This year for the first time the normal operational period was shifted by 2 weeks, beginning on May 1 and ending on September 30. Previously services ran from mid-April to mid-September. F2P2 forecasters are prepared to issue threat notifications during the last 2 weeks of April, but the normal daily services now start on May 1.

Another change made for 2015 was to discontinue voice notifications concerning the potential for heavy rainfall because of the non-emergency nature of these messages. In an average year this change would reduce the number of 911 calls by roughly 60 per communication center served by the F2P2. Eight primary contact points are affected by this modification. It was also recognized that email and text messages regarding possible threats effectively reached local government decision makers and first responders. Phone calls to 911 dispatchers continue to be made concerning imminent flood threats. This procedural change was very well received by all parties. Currently over 3700 email/text message subscriptions for forecast products, threat notifications, NWS warnings and ALERT system alarms are supported by UDFCD with some of those subscriptions being distribution lists that reach a much larger audience. The [annual report](#) and a complete [archive](#) of F2P2 messages and related forecast products are available.

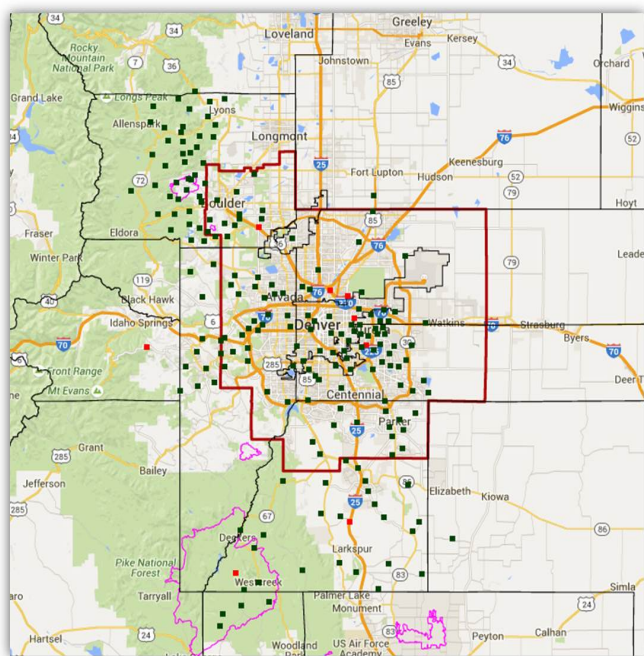
CoCoRaHS Update

Since 2001 UDFCD has been a proud sponsor of the Community Collaborative Rain, Hail & Snow Network known as CoCoRaHS. This large network of over 10,000 volunteers covers all 50 states, Canada, Puerto Rico and U.S. Virgin Islands. The Bahamas is slated for addition in 2016. Funding of CoCoRaHS has relied on sponsorships, contributions by individuals and grants. One of those federal grants came to its end in 2015. Consequently, this unique non-profit is reaching out to find new financial partners. If you are a frequent user

of this valuable data source and would like to help, you can find the necessary details in their [2015 Fundraiser letter](#). If you are not yet a CoCoRaHS observer, please consider becoming one soon by visiting www.cocorahs.org.

ALERT System News

The ALERT system operated by UDFCD has nine FCC-licensed radio repeaters that receive data transmissions from 230 locations in ten counties. This real-time flood detection network hosts 197 rain gages, 110 stream gages and 25 full weather stations. In 2015, two new stations were installed: a rain/stage gage on Coal Creek at McCaslin Boulevard in the Boulder County Town of Superior; and a similar station in Douglas County on Plum Creek at Sedalia.



2015 ALERT rain gage locations

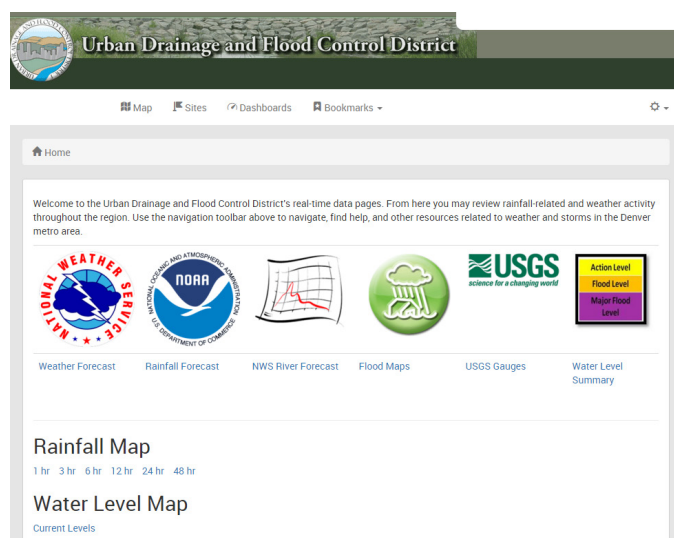


Coal Creek rain/stage gage at McCaslin Blvd in Superior

OneRain and Water & Earth Technologies (WET) provided routine preventative maintenance and unscheduled repair services for 2015, enabling successful data collection of nearly 12 million ALERT data reports. The [Resources](#) box at

end of this article contains links to annual reports and other pertinent documents.

A [MS-Excel™ workbook](#) is available that summarizes the annual peaks and maximums for the period of record for every ALERT streamgage in the network including discontinued stations and those temporarily out of service. The corresponding data includes the date, time, gage height/stage and flow rate. Appropriate notes are also included as cell-specific comments where data is missing, questionable, or supplemented by other measurements.

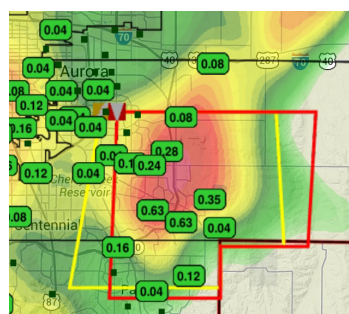


Two primary websites were supported during 2015. The public website above uses a software package called [Contrail](#). The second website was designed primarily for UDFCD flood warning program partners and hosts a number of data mapping applications not authorized for public use.



Twitter may possibly be the most popular way for millions to keep informed about current weather and flood conditions; and to openly share what they are witnessing in real-time using short text messages, photos and videos. This social media phenomenon has become a valuable information source for many emergency managers, public information specialists and other officials. Following the September 2013 floods, a Twitter employee (Jim Moffitt, formerly with OneRain) began presenting information at flood conferences about how effective Twitter was during the worst of the flooding in Boulder. Jim's talk had a catchy title

of “Tweeting in the Rain” and it generated lots of ideas about some other possible real-time applications.



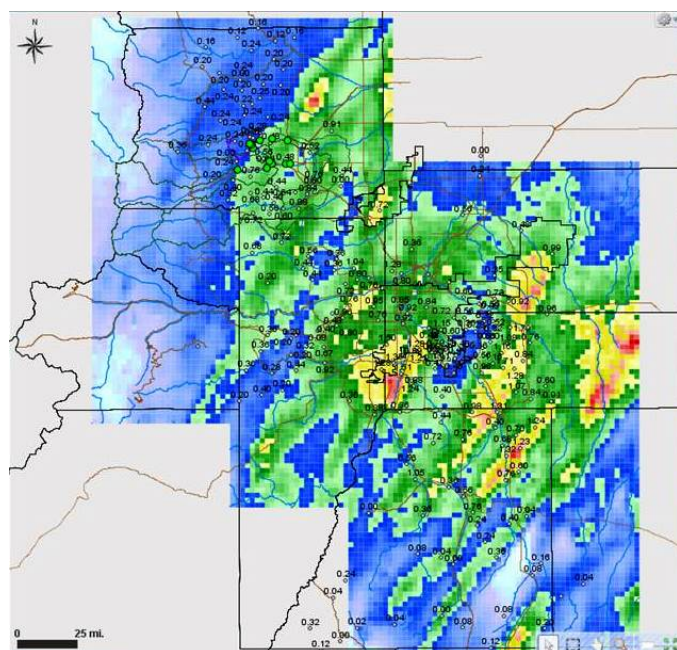
UDFCD stepped into this modern social media world in 2015 by developing its own version of Tweeting in the Rain that automatically generates Tweets whenever ALERT rain alarms occur. A “light” version of the popular [GMap](#) website is linked to the Tweets.

Hashtags like #udfcdrain, #denverrain and #douglascountyrain make it easy for Twitter buffs to follow flooding rainfall events for specific areas of interest. Visitors will see 3-hour rainfall amounts on a map with a looping radar image, flashing rain alarm locations and NWS warning areas. Users can read the NWS warnings by touching the icon associated with the respective polygons. The map will update automatically every minute. Familiar navigable features offered by Google Maps make this real-time website very easy to use.

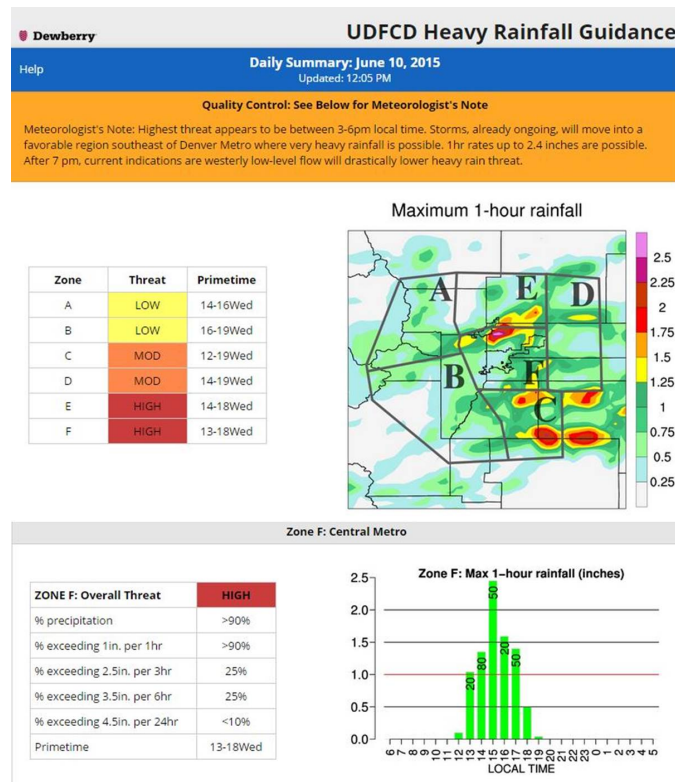
Beyond ALERT

For the third consecutive year Denver’s flood operations staff used radar-derived precipitation estimates to better visualize storm coverage and receive automated notifications when approaching storms are expected to exceed critical rainfall thresholds. Post event use of this product has proven most helpful in responding to damage claims by contractors and residents, and in evaluating the performance of hydrologic models. This capability was first introduced after the 2010 Fourmile Canyon Fire in Boulder County. In 2015

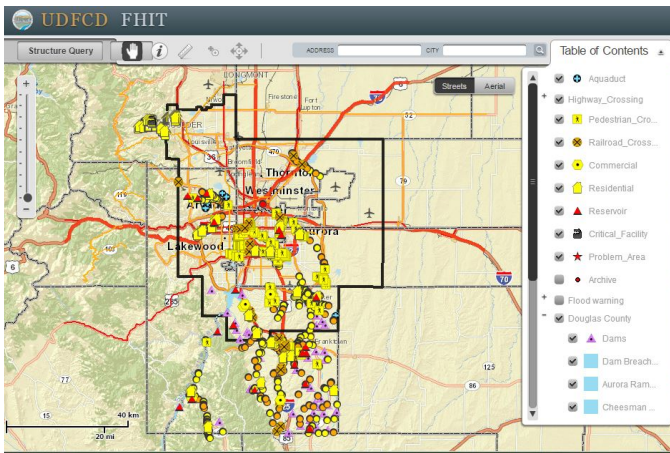
UDFCD’s RainVieux GARR coverage for 2015



UDFCD had service provider, [Vieux and Associates](#), add additional area to their RainVieux GARR product. GARR has become a commonly recognized acronym in the field of hydrometeorology that stands for [Gage Adjusted Radar Rainfall](#). Archived data back to 2011 was made accessible for this expanded coverage opening new avenues for innovative hydrologic investigations.



High resolution gridded weather forecast models compete to answer the question...which one is best? Weather news reports frequently call attention to differences between European models and those built in the USA. Canada offers some nice options too and meteorologists all seem to have their personal preferences. With so much invested in this research, UDFCD chose to take a closer look in 2015 by having meteorologists from Dewberry ([read report](#)) develop a website that leverages model outputs to advance the art of flash flood prediction. The website presents the collective results from 13 different quantitative precipitation forecast (QPF) models without favoring any particular model. Time series graphics are used to reveal agreement between the models. One-hour rainfall maximums are extracted from the models and presented geographically. Agreement between the models was used as the criteria to estimate the likelihood of a flash flood. The combined information presents a picture of where and when heavy rainfall is expected hours ahead of storm development and the impact-based threat levels corresponding to pre-defined forecast zones. Further analysis and refinement of this tool is planned for 2016.



UDFCD's flood hazard information tool known as [FHIT](#) has become increasingly useful thanks to local governments that have taken responsibility for maintaining this valuable resource. Douglas County, Aurora and Denver now fully control the content within their respective jurisdictions. The City of Lakewood is currently taking steps to join these

dedicated professionals in 2016. Emergency managers and other decision makers now have a convenient way to anticipate impacts from developing storms and respond more effectively. Real-time decision aids may soon be available to make this information even more helpful and easier to use. Local partners that would like training on how to use and support this tool should contact [Kevin Stewart](#) at the District.

As always, UDFCD welcomes your thoughts on how we can better serve all of our partner agencies and the public with high quality information services.

Resources

A complete archive of daily forecasts, flood threat notifications, storm track predictions, storm summary maps, and other products can be found at the [F2P2 website](#). A MS-Excel workbook containing [annual and record stream levels and peak flows](#) measured by the ALERT System is also available. Open directories are provided for downloading detailed annual reports concerning the maintenance of the [ALERT System](#) and [F2P2 operations](#).

New Website Released

by Derrick Schauer



In October of 2015, UDFCD launched its new website. As reported in last year's *Flood Hazard News*, content organization and mobile device compatibility were the two primary focuses of the redesign. To address the content piece, scattered links were cleaned-up and the site navigation structure was simplified. A search component was added to make it easier to find information quickly. To enhance mobile device compatibility, WordPress™ was selected as the design tool and it works great! Its intuitive interface made for an easier build-out with an ability to automatically detect the type of device being used to display the webpages and then size the content appropriately.

The feedback received so far has been positive as we continue to make tweaks moving forward. If you haven't had a chance to visit the site yet, we encourage you to do so and take a quick tour. As always, UDFCD welcomes your comments and suggestions.