Flood Hazard News

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Rainfall – Runoff Analysis for the September 2013 Floods in Boulder, CO

By
Bob Harberg, City of Boulder, Ken MacKenzie and Kevin Stewart, Urban Drainage and Flood Control District, and Shannon Tillack and Andrew Earles, Wright Water Engineers

Introduction

Many people in the City of Boulder (City) and across the Front Range recall the "biblical" rainfall and "1,000-year" storm characterizations of the September 8 – 16, 2013 flood. Flooding was devastating in many watersheds as steep mountain canyons emptied runoff, rocks and debris into drainageways crossing the City for days. While many stream gages were washed out during the flood, observed high water marks and hydraulic analyses conducted following the flood were used to estimate peak flows and to approximate the floodplain extents. Working with the City of Boulder and the Urban Drainage and Flood Control District (UDFCD), Wright Water Engineers, Inc. (WWE) analyzed the rainfall and runoff response from the 2013 flood within the City.

This analysis indicates that for many creeks in Boulder, the runoff response from the event was below adopted regulatory 100-year peak flow rates. Watersheds analyzed include South Boulder Creek, Bear Canyon Creek, Skunk Creek (including Kings Gulch and Bluebell Canyon Creek), Gregory Canyon Creek, Boulder Creek, Goose and Twomile Canyon Creeks, and Wonderland and Fourmile Canyon Creeks. A summary of the findings for South Boulder Creek, Boulder Creek, and Fourmile Canyon Creek are presented below. A copy of the full report with information for all of the above-mentioned watersheds can be obtained from the UDFCD Electronic Data Mapping site (http://udfcd.gisworkshop.com) by searching under any of the affected streams.

The analyses conducted by WWE included determining the 5-, 10-, 15-, and 30-minute, and 1-, 2-, 6-, 12-, and 24-hour "worst case" rainfall return periods for the 2013 flood for watersheds within and draining through Boulder. Based on analysis of "worst case" rainfall (e.g. the maximum depth of precipitation falling during a given "window of time" during the storm), the short-duration (5-, 10-, and 15-minute) rainfall depths resulted in return periods typically less than the 10-year design storm. However, for longer durations, return periods increased dramatically. For 12- and 24-hour durations, rainfall depths often exceeded the NOAA Atlas 14 1,000-year precipitation depths. Coupled with rainfall-runoff modeling by others, this information helps to explain why a "1,000-year storm" did not produce a "1,000-year flood."

In addition to the work done to characterize rainfall return periods, the team also performed comparisons with design storms (UDFCD 2-hour rainfall distributions used in the Colorado Urban Hydrograph Procedure [CUHP] for many watersheds) to compare the design storm rainfall intensities with the observed intensities. This information, along with flow estimates/measurements collected by Dr. Bob Jarrett, flow estimates from City consultants, and 2013 flood inundation mapping prepared by the City, allowed WWE to evaluate the relationship between return periods for rainfall (defined by comparison with NOAA Atlas 14) and return periods for runoff (defined by comparison with peak flow return period data from existing master plans).

South Boulder Creek

The upper portions of the South Boulder Creek watershed experienced total rainfall depths somewhat lower than those used in the 100-year 72-hour general storm used in recent master planning efforts. However, short-duration intensities were higher than those used in the general storm. The heavy rainfall in the upper watershed did not begin until the evening of September 12, by which time considerable downstream flooding had occurred from runoff from the portion of the watershed below Gross Reservoir, a Denver Water storage facility located on South Boulder Creek at the lower end of the upper watershed.

The middle and lower portions of the watershed experienced several strong surges of rainfall, the heaviest of which was on September 11, when flooding in many urban areas in Boulder was at its worst. An additional surge on the 12th and into the 13th added another 3 to 5 inches of precipitation on saturated soils, producing further flooding. Total rainfall depths for the lower watersheds were considerably larger than for the 100-year general storm; and rainfall intensity was also greater, which helps to explain the severe flooding experienced on South Boulder Creek and it's West Valley Overflow in the city, despite relatively minor runoff contributions from the upper watershed above Gross Reservoir.

South Boulder Creek bike path washed out near U.S. Highway 36. Source: CH2M HILL

Bull Gulch post-flood railed railroad embankment (looking north). Source: Michael Baker International

Runoff measurements by Dr. Jarrett and from UDFCD ALERT stream gages were used to develop runoff estimates within the South Boulder Creek watershed. Runoff estimates indicate that the watershed above Gross Reservoir was not a major contributor to the flooding experienced in the City. This is due to a variety of factors, including the fact that the heaviest rain in the upper watershed occurred late on the 12th and into the 13th of September, while the lower watershed had the most intense rain (and flooding) on September 11. In addition, storage was available in Gross Reservoir that aided in attenuating runoff, and Denver Water diverted some of the runoff from the upper watershed to Ralston Reservoir in the Ralston Creek watershed.

It is somewhat surprising that the rainfall in the upper watershed late on the 12th and early on the 13th did not produce greater peak flows, with 3- to 6-hour rainfall depths with return periods of greater than 100-year falling on the upper basin. However, the largely forested upper watershed would have substantial hydrologic losses from depression

storage (alpine lakes), interception, infiltration and storage in forest litter, as well as transient storage (i.e., temporary storage in floodplain overbank areas as the flood moves down the canyon), which would delay and lessen peak flow rates and helps to explain the runoff response observed.

To evaluate the runoff return periods, WWE compared flow estimates from the 2013 flood to hydraulic model results for the general storm (72 hours) and the thunderstorm (6 hours, higher intensity). The estimated flow rate at Eldorado Springs of between 2,000 and 2,100 cfs corresponds to a 50- to 100-year return period for the general storm and a 10- to 25-year return period for the thunderstorm, which tends to produce higher peak flows than the general storm for larger return periods. The flow estimate of roughly 5,600 cfs along South Boulder Creek near Highway 93 exceeds the 500-year frequency modeling results for the general storm and falls between a 50- and 100-year event for the thunderstorm modeling results.

Debris in Boulder Creek near Folsom Street. Source: UDFCD

It should be noted that the flow at this location was heavily influenced by a large (2,000 cfs) contribution from a tributary called Doudy Draw, which experienced very intense rainfall, well in excess of design storm parameters, in addition to a large surge of water and debris from a railroad embankment failure in a tributary called Bull Gulch. The area above the embankment failure was approximately 0.80 square miles (only a small portion of the overall watershed); however, the sudden release from the embankment failure, combined with the very intense rainfall drove the high runoff rates observed for the Doudy Draw watershed.

Boulder Creek

During the 2013 flood precipitation depths and intensities within the Boulder Creek watershed generally increased from west to east with total rainfall from September 11 – 13 of approximately 2.6 inches in the west sub-watershed increasing to approximately 9.7 inches in the east sub-watershed. Rainfall return periods for the worst-case 6-hour durations ranged from a 25-year to greater than a 300-year event.

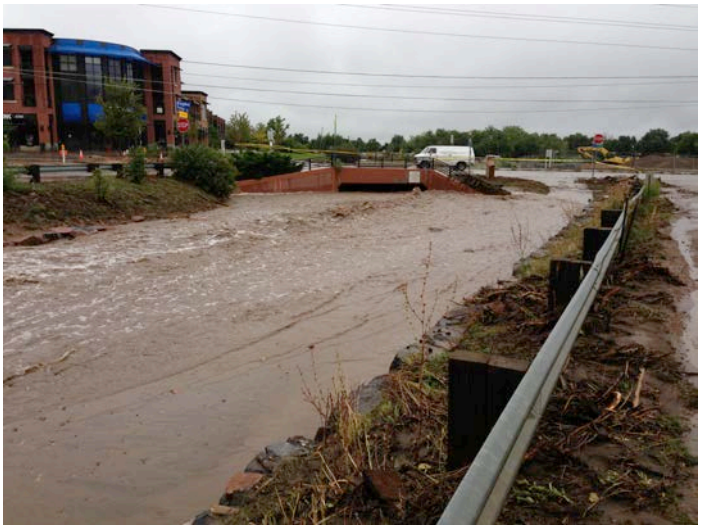
To understand the flooding that occurred along Boulder Creek in 2013, it is important to recognize that the creek characteristics change dramatically over a short distance as it passes through the City. The creek goes from a steep mountain stream, to an urban waterway/greenway within the City, to a plains stream with a broad floodplain and meandering channel downstream of the City. Runoff estimates for peak flows in the upper Boulder Creek watersheds ranged from less than a 10-year to a 15-year event. Through the City, the peak flow estimates increase to approximately a 25-year event. East of the City, near the City of Boulder Wastewater Treatment Plant, where Boulder Creek spreads out across a broad floodplain, the runoff estimates were approximately equivalent to a 25-year event. In many areas along the corridor, gravel pit embankments were overtopped or breached, connecting a broad floodplain. This study did not evaluate runoff further east than the wastewater treatment plant.

Fourmile Canyon Creek

Within the Fourmile Canyon Creek upper and middle sub-watersheds, maximum 1-hour rainfall depths were between NOAA 10- and 50-year design rainfall depths, which are consistent with the peak discharge estimates developed by Dr. Jarrett at these locations. For durations of 3 to 12 hours, the maximum rainfall depths from the 2013 flood were in the range of 100- to 200-year NOAA design rainfall depths. The maximum 24-hour rainfall depths were approximately 8.5 inches, which are greater than the NOAA 1,000-year, 24-hour design rainfall depths.

The lower Fourmile Canyon Creek sub-watersheds east of the foothills experienced more intense rainfall in the early part of the storm (evening of September 11th) than the upper sub-watersheds, but had less total rainfall over the 36-hour period. Maximum 1-hour rainfall depths for these sub-watersheds were between NOAA 10-year and 50-year design rainfall depths.

Runoff measurements from Dr. Jarrett for the upper reaches of Fourmile Canyon Creek indicate a 25-year to 50-year flood. Further downstream on Fourmile Canyon Creek in the City, the estimated peak discharge of 2,300 cfs is in the range of a 50-year to 100-year flood. Significant flooding also occurred on portions of Wonderland Creek east of Broadway



Fourmile Canyon Creek west of Broadway. Source: Muller Engineering Company

Fourmile Canyon Creek overflow path along Topaz Drive. Source: UDFCD

where flows from Fourmile Canyon Creek spilled to the south to Wonderland Creek.

Fourmile Canyon Creek is a classic alluvial fan situation in an urban area. In large floods, there will be significant debris that will clog culverts, damage or destroy bridges, reroute flows, etc., and thus spread out from the apex of the fan at the base of the foothills. In the 2013 flood, there was significant channel avulsion (formation of a new channel)/migration upstream of Broadway on Fourmile Canyon Creek.

Conclusions

Based on the detailed analysis of the rainfall and runoff response for the September 2013 flood within the City of Boulder, the following general conclusions can be drawn:

- For longer rainfall durations, watersheds in the City experienced very infrequent return periods (e.g. 100-year, 500-year, 1,000-year). Shorter durations had more frequent return periods and sub-hour durations in many cases had return periods of less than a 10-year event. Peak intensities never rose to the levels used in 100-year design storms, and the runoff response in many cases was less than a 100-year return period. When evaluating rainfall for short-duration return periods, and the resulting runoff, it is important to keep in mind that in many watersheds, there were several "waves" of intense rainfall over the duration of the storm, and the rainfall that occurred later in the storm was on saturated ground, and the runoff response would be magnified beyond what the rainfall return period would indicate.
- The comparisons with design storms demonstrate that the assumptions relative to the temporal distribution of rainfall are conservative (e.g. high intensities over short durations). In most cases, peak rainfall intensities from the actual 2013 event were no more than ⅓ to ½ of design storm values and did not produce the peak flow rates that the design storm produces for the same amount of rainfall due to the temporal and spatial distribution of rainfall.
- The runoff response was typically between a 25- and 50-year event for many watersheds; however, some watersheds including lower portions of South Boulder Creek and the lower portion of Fourmile Canyon Creek experienced flows on the order of a 100-year event or greater.

Hind' sight

By Paul A. Hindman

Timely Comment from the District's Executive Director

In last year's *Hind' sight* report, I talked about the floods of 2013, describing how the damages from that flood event would have been much worse if policies and practices introduced by UDFCD hadn't been initiated. One of the key practices to protect land and property from flooding is to construct regional detention basins. These basins are also used to protect downstream water quality by minimizing stream degradation and removing pollutants. These basins have proven themselves over and over again to be a vital part in being a steward of the streams in the metro area with the goal of protecting the public from floods and pollution. Many other communities across the state have also incorporated the policy of installing regional detention basins to protect their citizens. Since these basins did not hold water for consumptive use, they were not subject to water decrees administered by the State Engineer. Or so everyone thought.

In 2013, a state water commissioner in Pitkin County challenged the City of Aspen's use of regional stormwater detention, claiming the City should augment the evapotranspiration water losses that occur during the two to three days that the stormwater is detained. The City of Aspen then reached out to UDFCD for assistance on this issue and Ken MacKenzie, Manager of the Master Planning Program, took the lead and met with the State Engineer regarding regional stormwater detention. The focus was that these basins detain stormwater for the sole purpose of flood control and/or water quality and do not interfere with the water rights of downstream users.

After seeking counsel from the Attorney General's office, the State Engineer has provided these statements:

1. The Federal Clean Water Act requirements are subordinated to the Colorado State Constitution;
2. The State is unwilling to make any administrative allowance for regional or watershed-scale stormwater detention;
3. Providing regional stormwater detention constitutes a diversion of water for a beneficial use;
4. When that diversion takes place at a time when senior water rights are not satisfied, the State Engineer has the responsibility to curtail the diversion;
5. Because that diversion diminishes peak flows, even if the same volume of water accrues to the stream at a later time, the State Engineer's position is that the holders of senior water rights will utilize the available supply for a longer period of time and the more junior water rights will not come into priority and thus are injured;
6. If the diversion is not curtailed, holders of water rights can make a claim of material injury; and
7. The State offers no protection from a claim of material injury by a water user, regardless of whether the detention or infiltration occurs regionally or an individual site.

In essence, what these statements say is that local governments (LG's), in complying with state and federal laws requiring them to manage the quantity and quality of stormwater, are required to augment the loss of water either in quantity or time for all regional stormwater basins. If this policy stands, it will cost local governments tens, if not hundreds, of thousands of dollars just to manage their stormwater as required by law. In some basins in the State, it may not even be possible to obtain a water right.

Seeing how this will be a huge problem and cost for all LG's throughout the State, UDFCD spearheaded the formation of a task force with the sole objective of passing legislation that would amend the Colorado law to allow stormwater detention without augmenting the insignificant water loss, either in amount or time. Several LG's joined the cause and at the time of writing of this article, draft legislation is being proposed to the 2015 general assembly. If passed, LG's will be able to continue to manage their stormwater using the tool of detention basins, without the risk of violating Colorado Water Law. I'd like to mention that Ken MacKenzie has done an exceptional job of leading this effort and providing his technical expertise to the lobbyists, water organizations, lawyers, task force, and politicians. His work has been invaluable to everyone involved. My hope is that in the 2015 General Session of the Colorado Legislature, this will be resolved and LG's can get back to business as usual.

Master Planning Program

Shea Thomas, Project Manager and Ken MacKenzie, Program Manager

Master Planning Projects

We completed six planning studies and four flood hazard area delineation studies in 2014 with eighteen additional projects under way; and we plan to begin five new planning projects and two smaller alternatives analysis studies in 2015.

To date, UDFCD has completed a total of 103 major drainageway planning (MDP) studies, 92 outfall system planning (OSP) studies, and 97 flood hazard area delineation (FHAD) studies, which includes many updates to studies completed in the past.

Urban Storm Drainage Criteria Manual

Progress continues on an update of the Urban Storm Drainage Criteria Manual (USDCM), Volumes 1 and 2, with a hopeful release date of mid-2015. One of the most respected drainage criteria manuals nationally and around the world; all three volumes of the USDCM are available in pdf format on our web page (www.udfcd.org) for download. We encourage you to check the website frequently for the latest updates.

A September to Remember

Working with Wright Water Engineers, we have published a coffee table book memorializing the massive flooding of September 2013. Containing over 300 full-color images, this book evaluates the performance of the planning and floodplain management activities and the hundreds of construction projects that saved lives and property during those terrible days.

A September to Remember can be purchased on Amazon.com for $13.10.

Join UDFCD on LinkedIn

In 2012 we created a LinkedIn group and now have over four hundred members. We would love to have you join the conversation!

Share your experience, ask a question about the criteria manual, software, or spreadsheets and hear what we and other users have to say. We post messages to this group whenever a new version of the spreadsheets, software or manual is posted so this is a great way to be alerted to new releases on our website. We also use this forum to inform our community about changes to national and state policy and law.

STATUS OF PLANNING PROJECTS

Project	Sponsors	Consultant	Status
Airport Creek Alternatives	Broomfield	Olsson	0% Complete
Big Dry Creek MDP & FHAD	SEMSWA, Greenwood Village, Englewood	Ayres	60% Complete
Bear Canyon Creek Mitigation Plan	Boulder	AMEC	0% Complete
Boulder Creek Master Plan	Boulder, Boulder Co., Longmont	ICON	10% Complete
Box Elder Creek MDP & FHAD	**Adams Co., Aurora, DIA, SEMSWA, Arapahoe Co.**	**Olsson**	**Complete**
Coal Creek (Yale to County Line) FHAD	**Arapahoe Co.**	**Matrix**	**Complete**
Coal Creek & Rock Creek MDP & FHAD	**Erie, Lafayette, Louisville, Broomfield, Superior, Boulder Co.**	**RESPEC**	**Complete**
Coal Mine Road Alternatives	SEMSWA, Arapahoe Co.	Matrix	0% Complete
Dry Gulch OSP Update	Lakewood, Denver	ICON	70% Complete
East Toll Gate Creek (Lower) MDP	**Aurora, Buckley**	**J3**	**Complete**
Erie OSP	**Erie, Boulder Co., Lafayette**	**RESPEC**	**Complete**
Goose Creek & Twomile Canyon Creek Floodplain	Boulder	ICON	90% Complete
Gregory Canyon Creek Mitigation Plan	Boulder	CH2M Hill	65% Complete
Happy Canyon Creek MDP & FHAD	**SEMSWA, Doug. Co., Lone Tree, Parker**	**Muller**	**Complete**
Kalcevik Gulch MDP	Adams Co., Westminster	Enginuity	85% Complete
Leyden Creek MDP	Arvada	ICON	50% Complete
Little Dry Creek MDP & FHAD	Arvada, Westminster, Adams Co.	Olsson	25% Complete
Montclair Basin OSP	Denver	Enginuity	45% Complete
Newlin Gulch MDP & FHAD	Parker, Douglas Co.	Muller	20% Complete
Niver Creek MDP & FHAD	Thornton, Federal Heights, Adams Co.	Brown & Caldwell	15% Complete
North Dry Gulch OSP	Lakewood	Muller	35% Complete
Sand Creek Right Bank Tributaries OSP	Aurora	Merrick	35% Complete
Senac Creek MDP	**Aurora, SEMSWA**	**Matrix**	**Complete**
Weir Gulch MDP & FHAD	Denver	Michael Baker Jr.	55% Complete
Westerly Creek (Upper) MDP & FHAD	Aurora, Denver	CH2M Hill	95% Complete

MDP = Major Drainageway Plan, OSP = Outfall Systems Plan, FHAD = Flood Hazard Area Delineation

UDFCD Software

You may download the UDFCD unit hydrograph program *Colorado Urban Hydrograph Procedure (CUHP),* and other free software, including *UDSEWER* that includes a profile plotter, and many other free design aid workbooks from our website (www.udfcd.org). To download the CUHP companion EPA SWMM program, we have placed a hyperlink from our software site to the EPA website.

UDFCD Annual Seminar

At our 2014 annual seminar we had 326 registrants. The proceedings are available at: http://udfcd.org/conferences/conferences.htm

On April 7, 2015 we will have our next annual seminar. This one-day program will be at the Omni Interlocken in Broomfield, and early registration will be $95. Please mark your calendar and join us to find out what is going on regionally and nationally in drainage, stormwater quality, and floodplain management. Registration information will be available soon.

Stormwater Quality & Permitting Support Activities

Holly Piza, Project Manager and Ken MacKenzie, Manager, Master Planning Program

UDFCD continued to be active in the stormwater quality arena in 2014, with commitments to the following organizations and activities:

UDFCD BMP Monitoring Program:

UDFCD has been monitoring stormwater BMPs since the late 1990's. This year UDFCD continued monitoring on five stormwater research sites. Information for each is available on our website. Sites currently monitored by UDFCD include the following BMPs:

- Green Roof,
- Rain Garden,
- Slotted Concrete,
- Permeable Interlocking Concrete Pavement (PICP), and a
- Rainwater Harvesting system.

UDFCD is also currently in design on a new permeable interlocking concrete pavement (PICP) site that will separately monitor untreated runoff, effluent from a PICP section with a sand layer, and effluent from a PICP section without a sand layer.

New Studies and Projects:

High Line Canal for Stormwater Runoff Reduction &Treatment Feasibility Study

As Denver Water considers phasing out the canal for water delivery, all affected communities are working together to find a means to preserve the recreational experience offered by this historic landmark, and to save the trees. Working with Denver Water, the City and County of Denver, Aurora, Arapahoe County, and Douglas County, UDFCD completed a feasibility study demonstrating the viability of repurposing the canal for stormwater quality treatment and runoff reduction. A separate article detailing this important effort can be found in this issue.

City and County of Denver Green Infrastructure Manual

UDFCD is currently working with the City and County of Denver on a new criteria manual to help promote distributed BMPs for ultra-urban sites. The manual will include street side stormwater planters, curb extensions (bump outs), green alleys, tree trenches, and green gutters. The manual should be available mid-2015. Once this effort is completed we will assist any other community within the District in adapting this manual to their own needs. It is our hope that many other communities will adopt this guidance manual.

Education and Outreach:

The Colorado Stormwater Center at Colorado State University provides stormwater-related education, training, and research with the goal of maintaining and improving the health of lakes, rivers, and streams through proper stormwater management. UDFCD applied for and received, for the third year, a Colorado State water quality improvement fund grant providing $25,000 to help the center continue through their second year. UDFCD staff also assisted with instruction of four BMP Inspection and Maintenance courses. UDFCD will continue to assist with instruction within the UDFCD boundary and serve on the steering committee to help ensure the success of the Colorado Stormwater Center throughout the State. See http://stormwatercenter.colostate.edu/ for information on upcoming classes and certifications.

Colorado MS4 Permit Assistance:

As a Phase I MS4 permit requirement, Denver, Aurora, and Lakewood must each monitor in-stream water quality s during runoff-producing events. UDFCD has assisted these communities in complying with the requirement since 1998 by co-funding and managing the data collection, analysis, and reporting activities. After losing one of our in-stream wet-weather monitoring sites during the 2013 flooding on Sand Creek, UDFCD rebuilt the site and continued to collect another year of important data. Together with our partners, UDFCD has collected 17 consecutive years of wet-weather in-stream data at five locations within the UDFCD boundary.

UDFCD also continues to host and actively participate in the general assembly and legislative committee meetings for the Colorado Stormwater Council, an MS4 permittee-only group comprising 98% of all permit holders in Colorado.

Information Services and Flood Warning Program

Kevin Stewart, PE, Program Manager

With enormous challenges facing affected Colorado communities following the 'September-to-Remember' floods of 2013, efforts in 2014 were undertaken by many to further document and better understand this epic event. The cover story by Wright Water Engineers is a great example. For those of us in the flood business, the experience opened various opportunities to talk about what happened. Many career-first moments will be long remembered. For me this included two "inside-the-beltway" encounters. The first trip was made at the request of the U.S. Geological Survey to brief both houses of Congress on the importance of streamgages and how they provide critical information to the public, emergency responders, and resource managers needed to protect, manage and sustain our Nation's surface waters. This event was hosted by New York Senator Charles E. Schumer and California Congresswoman Grace Napolitano. The second trip was in response to an invitation from the White House Office of Science and Technology Policy, National Security Council, and FEMA to attend the White House Innovation for Disaster Response and Recovery Initiative Demo Day at The White House. The goal of this initiative, launched in the wake of Hurricane Sandy, is to find the most effective ways technology can empower survivors; first responders; and local, state, tribal, territorial, and Federal governments with critical information and resources. Prior to the main event I was selected to arrive early to participate in a small group workshop focused on 'predictive analytics' and tasked with developing challenges for technologists and innovators.

On steps of U.S. Capitol
May 2, 2014

Entrance to White House

Entrance to White House West Wing
July 29, 2014

These two events were certainly seminal moments in my rewarding career at UDFCD and marking my 30th year of service. I am honored to have had these unique opportunities to represent the District in our Nation's capital.

Our Information Services Engineer Julia Bailey continues to make creative improvements to the way our electronic documents and data are made widely available. Be sure to read Julia's article in this issue of *Flood Hazard News* to learn more about the most recent enhancements. Julia is also the technical lead on implementing UDFCD's records management software, OnBase™ by Hyland.

On the IT-front, Derrick Schauer continues to keep a close eye on the District's current and future needs. Efforts in 2014 focused on new software implementations for the finance & accounting department and records management. For an update on new website developments soon to debut, see Derrick's short news clip in this issue.

2014 Flood Season Recap

Last year's 2013 recap reported a record number of threat days since UDFCD instituted its flash flood prediction program some 35 years prior. Would you believe 2014 surpassed that record? Well, it did, but with far less drama than 2013, which left the region reeling to recover from the disastrous floods brought by the record-breaking rains of September 9-15. Overall, the 2014 floods were relatively small causing mostly street flooding and minor damage.

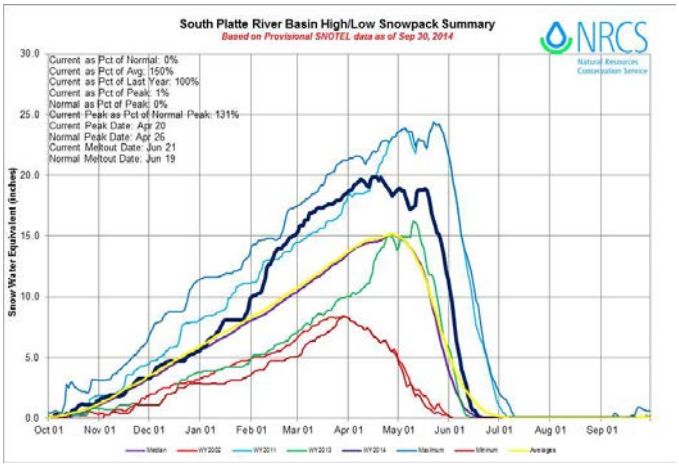
This past year the ALERT System generated rainfall rate alarms on 32 days, surpassing the 2013 statistic by one day. By comparison, the 2012 count was only 13. The table below identifies the specific alarm dates for 2014.

Record 61 days with flood potential in 2014

April	27	1
May	7-8 (single period), **20**, **21**, **22**, **23**, **24**, 25, **26**, 29, **30**, **31**	12
June	5, 6, **8**, 12, 14, 18, 21, **22**, **23**, **24**, 25, 27	12
July	**3**, 4, **7**, 8, 9, **11**, **12**, **13**, **14**, **15**, **16**, 23, 24, **25**, **27**, **28**, **29**-30	18
August	**5**, **7**, 8, **10**, 14, 15, 19, 22, **23**, **25**-**26**, 27, **28**, 29	14
Sept	20, 21, 22, **29**	4

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 only recorded 2 days in 2014 with 24-hour rainfall totals exceeding 3 inches (July 12 & July 30). This compares with the 2013 stat of 6 days, 4 of which happened during the September floods. Seven other days (May 21, June 8, July 7, 11, 12&29 and August 25) measured 24-hour rain totals between from 2 to 3 inches. A storm summary table and corresponding maps are available for every day that heavy rainfall was predicted.

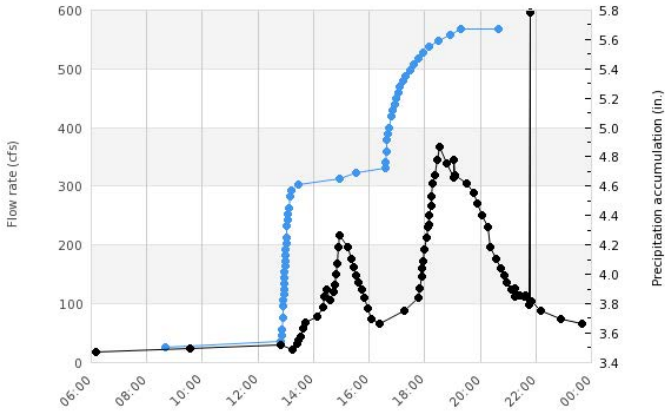


The 2014 snowpack for the South Platte River basin was well above normal and the spring runoff was well-behaved with no flood warnings needed for the Denver metro area. Boulder County runoff was the primary concern for the region due to the high water tables and the large amount of debris and loose soils left by the September floods. Stream levels were carefully monitored by the Boulder Office of Emergency Management after massive volumes of woody debris and sediment were moved away from the stream channels over the winter months. Many fingers were crossed as the meltout progressed hoping that the expected high streamflows would recede well before heavy rains threatened. All worked out as hoped.

An early season downpour that few people noticed occurred south and east of DIA early Sunday morning between 5AM and 7AM on **April 27**. One ALERT rain gage west of Watkins recorded 1.3 inches. Further east radar-estimated rainfall amounts approached 3.5 inches that nearby rain gages were unable to verify.

The May thunderstorms held off until Tuesday, May 20, when a 7-day period of severe weather brought tornadoes, hail and minor flooding to the region. The greatest 24-hour rainfall measurement of 2.0 inches occurred in Aurora on May 21 and the most intense 5-minute rainfall for the month occurred on May 22 at 4:37PM at the Lakewood County Club (8.0 in/hr). ALERT rainfall statistics for 2014 are summarized in a convenient MS-Excel workbook online. A number of local news reports and YouTube videos were also captured to document this interesting week of weather.

NWS flash flood warnings were issued on the last two Fridays in May (5/23 and 5/30) for the Fourmile Burn Area (FMBA) in Boulder County, but fortunately no serious flooding occurred. This is the area that experienced a tragic wildland fire in 2010, following by a damaging flash flood in 2011, and was then devastated again by the September floods of 2013. Consequently, all concerned parties including residents have been very sensitive about the potential for flooding when heavy rainfall threatens this area. Some good news here is that the watershed is recovering nicely and the flash flood potential appears to be fading. However, the NWS will likely continue issuing conservative warnings until they are assured that the elevated flood threat cause by the fire has ended.

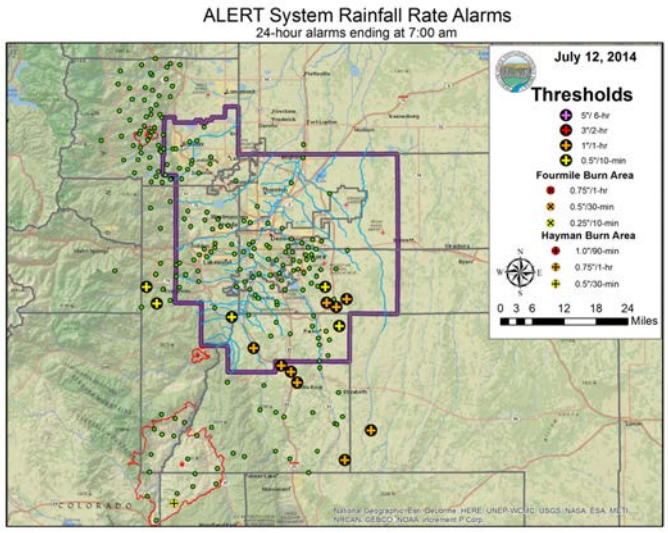


Piney Creek hydrograph June 8, 2014

June delivered a number of bouts of severe weather with tornado warnings being issued for 5 days. Sunday, **June 8** was the biggest rain day of the month with Aurora being the primary target. The Piney Creek at Liverpool streamgage, first installed in May of 2008, measured a rather unimpressive record peak flow of 360 cfs at 6:30 PM. The rains that produced this runoff came in two waves and yielded between 2 and 2.5 inches with maximum 5-min intensities of 5.2 in/hr occurring around 1PM.

July is Colorado's summer monsoon month with Independence Day announcing its arrival with heavy rains over the foothills of Jefferson County and near Broomfield. This was followed by a weekend of nice weather, and then Monday, **July 7** produced one of the more notable big rain days of 2014. The Jefferson County Mountains south of Evergreen and north of Buffalo Creek (*location of the 1996 wildfire and deadly flash flood*) received some of the most intense rainfall with totals approaching 3 inches near the 2012 Lower North Fork burn area. A 9News report of flooding along Cub Creek near the Brook Forest Inn contains an interesting interview with a resident *(@ 5-minute point in video*) contrasting this flood and the 2013 event. Arvada and Aurora also measured some of the higher rainfall amounts of the day. NWS issued a flash flood warning for northeast Elbert County and a portion of central Arapahoe County east

of the UDFCD boundary effective from 8PM to just past midnight.



Saturday, **July 12** was the 2014 record-holder for the number of rainfall rate alarms generated by the ALERT System with 14 stations triggering 32 alarms between 4:30 and 8:15PM. The activity prompted the NWS to issue a flash flood warning for northwestern Douglas County effective until 10PM. Rainfall totals exceeded 3 inches. No significant damages were reported.

Wednesday, **July 30** did not record any intense rainfall but amounts totaled over 1.5 inches over much of Lakewood causing Lakewood Gulch in Denver to record its annual peak of 700 cfs at 12:35PM. A second high water measurement of 400 cfs occurred later that same day.

While August delivered a number of heavy rain threats, storm totals were low and no noteworthy floods happened. Monday, **August 25** recorded the highest daily rainfall of the month with storms lasting into the early AM hours Tuesday. Denver and Aurora experienced some minor street flooding.

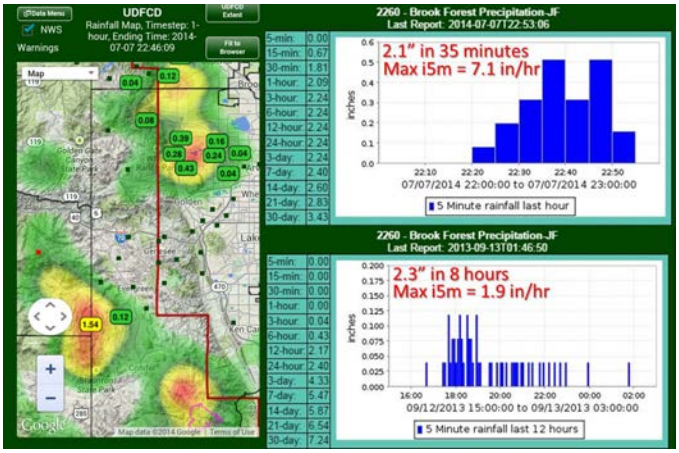
Monday, **September 29** brought the last hurrah of the 2014 flood season and the fourth post-season flood threat day, which normally ends on September 15 when UDFCD stops providing its daily flood prediction and notification services. Intense rainfall in Adams County, Denver and Aurora between 2:30 and 3:30PM caused 11 rate alarms with a few rain totals exceeding 2 inches. Quite a remarkable event for this time of year! September 29 was also the latest "Message Day" in the 36-year history of the F2P2. It might also be noted that no flood threat days occurred during the first two weeks of this month. What a contrast to 2013!

Understanding Extremes—Part IV

Seven years ago I wrote a short opinion piece about the frequency of so-called extreme rainstorms, and what it takes to cause an equally rare flood. Two years later I expanded on those ideas by suggesting some ways that subject matter experts could more effectively talk with people about flood risk. Then, after the 2010 Labor Day Fourmile Canyon Wildfire in Boulder County, I took a third shot at this subject with a slightly different twist inspired by an elevated flood risk caused by the fire, and the very high likelihood that a dangerous flash flood would severely impact this area in the next few years. As it turned out, the floods did come and the property damage was extreme, but thankfully, no lives were lost.

The Colorado STR (September-To-Remember) floods of 2013 created many opportunities to continue this conversation in Colorado and across the nation. This year's STR-13 cover story by Wright Water Engineers explains well how an extreme 1/1000 annual chance rainfall can cause flood magnitudes far less extreme. A small localized flood this past July in the Jefferson County foothills spurred this writer to share one "final" real-world example.

The STR-13 rains brought nearly 7.5 inches to the mountain community of Brook Forest over a 7-day period. Brook Forest is located along Cub Creek south of Evergreen. Cub Creek flows into Bear Creek just downstream of Evergreen Lake. An intense thunderstorm occurred on July 7 (*see previous discussion & video*) that dropped a mere 2.1 inches of rain. Yet, as one resident reported, the flooding that occurred was more severe than the STR-13 event. How can this be?



The figure above compares the 2013 and 2014 events. Both events generated about the same amount of rain, but the 2014 storm did so in just over 30 minutes while the STR-13 storm took much longer. Rainfall intensity once again was the primary factor affecting the flood's impact, not the amount or the storm's return period. Rainfall frequency never equals flood frequency in real events.

Meteorological Support

The 2014 flood prediction and notification services were provided by Genesis Weather Solutions in partnership with Skyview Weather for the 8th consecutive year. This program has served UDFCD local governments for the past 36 years with early predictions of potential and imminent flood threats. A variety of forecast products including daily heavy

precipitation outlooks, quantitative precipitation forecasts (QPF), and storm track maps are routinely disseminated. GWS President Bryan Rappolt has participated actively as an F2P2 forecaster for the past 21 years through various business enterprises. Bryan's Skyview partners included lead forecaster and 8-year veteran Brad Simmons supported by Alan Smith, Andrew Muniz, Alex Trellinger, Zach Paiz and Skyview's president Tim Tonge. The Flash Flood Prediction Program, a.k.a. F2P2, was established after the deadly 1976 Big Thompson Canyon flash flood. The program operates in close partnership with the National Weather Service from mid-April through mid-September focusing primarily on heavy rain threats.

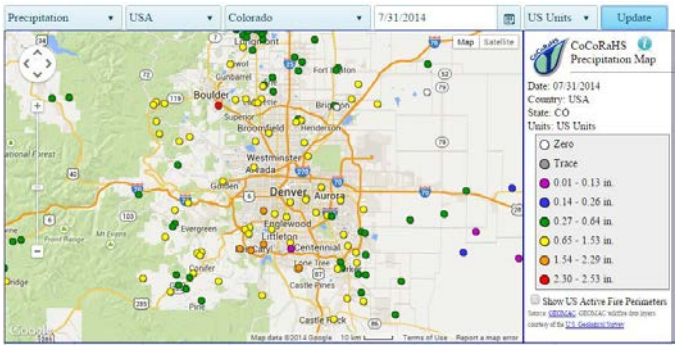
The trends of the past two flood seasons suggest that it may be time to make some adjustments to the F2P2 calendar. The September 2013 floods occurred during the last week of the program, followed by 2 weeks that yielded 4 additional threat days. The 2014 season ended much softer with no threats during the first half of September, but the last 2 weeks again produced 4 threat days with 9-29 (*news video*) delivering a very interesting last hurrah. UDFCD reactivated the F2P2 for all of these late season threats. Rather than reactivating the services for post-season events, Jefferson County Emergency Management recommended changing the program to begin on May 1 and end on September 30. UDFCD likes this suggestion and is taking steps to prepare for this change in 2015, including making sure the system stands ready for early operations in late April should the need arise. Acceptance by affected local governments will be sought.

Another change being considered for 2015 is to stop making phone calls to 911 communication centers that concern the potential for heavy rainfall that may cause nuisance flooding later in the day. These messages are non-emergency in nature and are only intended to inform local officials of the possibility. We have also learned that it is not common practice for comm centers to disseminate non-emergency information. Given the success of UDFCD's Internet subscription service, the need to bother busy dispatchers with non-emergency information no longer exists. By dropping these calls we estimate that approximately 60 calls per year for each 911 communication center can be avoided. Over the last two flood seasons that number represents over 1,000 calls. Email and text messages will continue to reach all key players. Phone calls concerning imminent flood threats and high threat potentials will continue to be made.

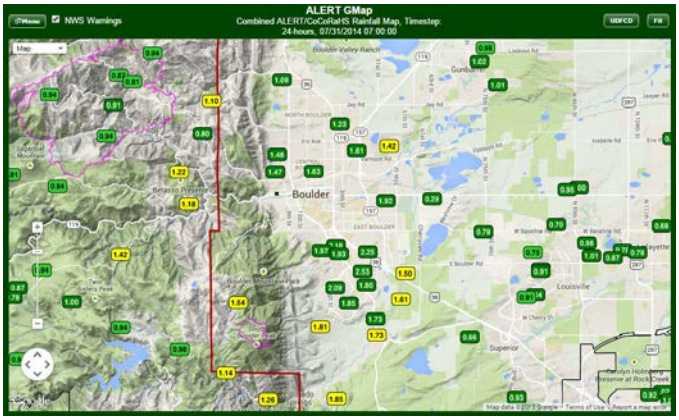
In 2014 Boulder County expanded the F2P2 service area to include the Left Hand Creek and Saint Vrain Creek watersheds in the northern Boulder County. The F2P2 protocols were the same for this region. Boulder County provided the funds for this expanded service area. This was largely in response to the 2013 flood disaster that severely affected this portion of the county where Longmont and Lyons are located.

An annual report and a complete archive of F2P2 messages and related products are available.

CoCoRaHS Update



Google Map display of 24-hr CoCoRaHS measurements at ending time of 7AM, July 31, 2014.



Combined ALERT-CoCoRaHS Google Map display for same time period. Note 2.53" maximum value matches the red dot scale maximum in previous map. CoCoRaHS measurements are displayed as white on green.

Since 2001 UDFCD has been a proud sponsor of CoCoRaHS, now a large nationwide network of over 10,000 volunteer observers of rain, hail and snowfall events. A new Google Map display being developed by CoCoRaHS staff in Fort Collins will make viewing CoCoRaHS observations easy from a large national scale perspective down to state and local levels. This web map application is certain to evolve. If you are not yet a CoCoRaHS observer, please consider becoming one soon by visiting www.cocorahs.org.

EMWIN-Denver Regional Update

Under the leadership of Jefferson County's deputy director of emergency management Rick Newman, EMWIN-DR has become a stable and dependable warning notification tool used by 22 Colorado counties serviced by the NWS Denver/Boulder warning and forecast office. EMWIN is supported nationally by the NWS and stands for the Emergency Managers Weather Information Network. The software and satellite downlink equipment is hosted by UDFCD. Rick's steering committee, which now meets semi-annually, guides how the customized delivery of NWS

weather warnings will occur. UDFCD also maintains the EMWIN-DR email subscription lists available to all 22 counties. NWS conference calls concerning high threat weather systems approaching the region are routinely announced using this system. EMWIN-DR also supports a secure web-based application for formatting non-weather emergency messages for public broadcast via the Emergency Alert System.

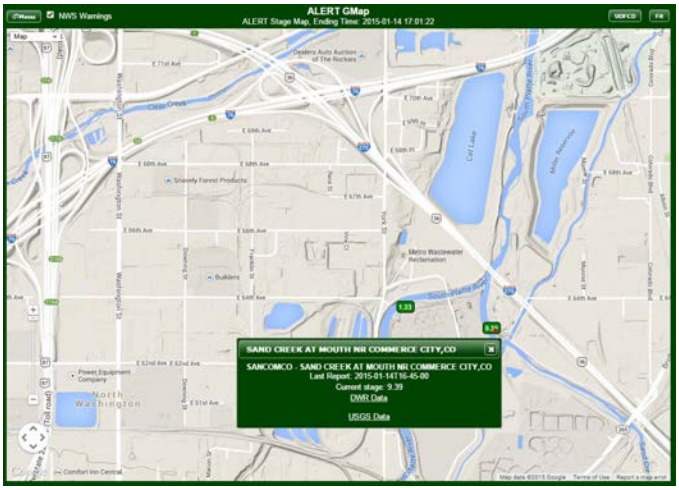
ALERT System News

The ALERT system operated by UDFCD currently consists of 9 repeaters that receive transmissions in real-time from 222 gaging stations hosting 199 rain gages, 107 stream gages and 26 full weather stations. In Douglas County three new stations were installed in 2014—two on Sellers Gulch and a backup legacy repeater at Castle Rock. The Sellers Gulch stations were installed by the County as part of their East Plum Creek flood detection network. One of these stations hosts a streamgage and both stations are equipped with 1mm tipping bucket rain gauges. The Castle Rock repeater provides a low cost redundant radio path to safeguard against data loss should the newer ALERT2™ repeater backbone become disabled.

Havana Pond at RMA Wildlife Preserve Rain/Stage Gage

In response to the STR-13 floods causing so many dam spillways to spill, many for the first time, three new stage gages were installed for the Arvada/Blunn Reservoir in Arvada, Westerly Creek Dam in Aurora and Havana Pond at the Rocky Mountain Arsenal National Wildlife Refuge. Havana Pond was one of the larger impoundments that failed during the 2013 event, posing a serious threat to Commerce City residents and prompting a partial evacuation of the city. Fortunately a railroad embankment downstream of this dam held back the surge of water, preventing damages that would have occurred otherwise. The new ALERT station was added as part of the dam repairs. The Havana Pond and Westerly Creek Dam station are also equipped with rain gages.

A number of stations were damaged during the STR-13 floods. Many stations maintained by Boulder County on James Creek, Left Hand Creek and North & South Saint Vrain Creeks were completely destroyed. District-maintained stations were damaged or destroyed in 2013 on the following streams: Boulder Creek, Fourmile Creek and South Boulder Creek in Boulder County; Bear Creek and Van Bibber Creek in Jefferson County; Cherry Creek in Denver; and Sand Creek in Commerce City near its confluence with the South Platte River. The Sand Creek station was severely damaged and abandoned because a relocated USGS streamgage effectively eliminated the need to continue supporting both stations. Also, near real-time data from USGS satellite-linked sites are now routinely displayed by the ALERT System websites.

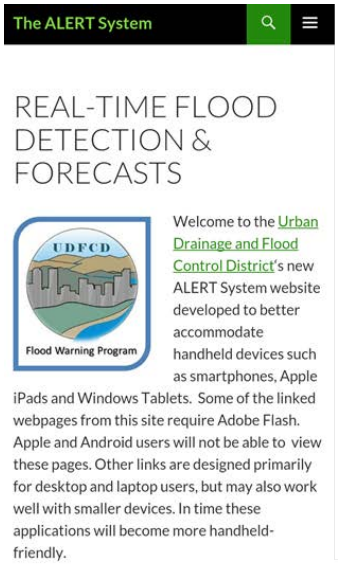


OneRain and Water & Earth Technologies (WET) provided preventative maintenance and repair services for 2014, enabling successful data collection of over 11 million ALERT data reports. The 'Resources' box at end of this article contains links to annual reports and other pertinent documents.

Record high water measurements were set for only three stations in 2014: Piney Creek in Aurora (360 cfs on June 8), Lakewood Gulch in Denver (700 cfs on July 30) and East Plum Creek in Douglas County (a mere 44 cfs on May 26). These relatively small "record" flow rates reflect how uneventful the 2014 flood season really was, with 7/30 being the most impressive event of this group. All three stations have been in operation for short term periods of 9 years or less, with the East Plum Creek station having the shortest record of only 5 years. The Lakewood Gulch record peak is somewhat miss-leading given that an indirect flow measurement of 970 cfs was made for an event the prior year (7/13/2013). It was later determined that the station was not reporting due to a radio failure. It happens!

A MS-Excel™ workbook of annual and record peak water level measurements for the ALERT System is available.

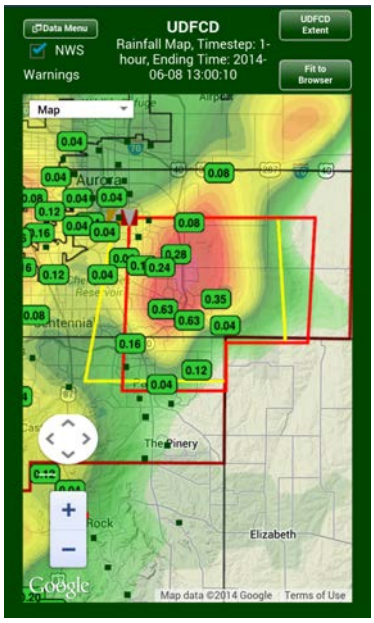
			RECORD HIGH WATER				2014			
STATION NAME	INSTALL	TYP	PEAK STAGE	PEAK FLOW	PEAK DATE	PEAK TIME	PEAK STAGE	PEAK FLOW	PEAK DATE	PEAK TIME
Carr Street	30-May-1988	PS	27.20	3,010	7/22/1991	15:11	22.49	250	7/8/2014	0:07
Ralston Reservoir	23-Sep-1988	PS	49.87	865	9/12/2013	21:08	44.35	0	7/18/2014	18:27
West Woods	2-Aug-1989	PS	3.92	264	9/13/2013	3:33	2.97	160	7/8/2014	0:00
Simms Street	25-Oct-1990	S	3.68	1,227	9/13/2013	4:47	2.68	742	7/8/2014	1:47
Leyden Reservoir	30-May-1988	PS	5.00	0	5/18/1995	3:28				
Leyden Reservoir	16-Dec-2002	PS	108.92	1,351	9/12/2013	19:12	97.18	130	5/13/2014	11:33
Leyden Confluence	2-Aug-1989	PS	4.20	3,520	8/6/1995	20:36	2.49	86	7/30/2014	20:14
Sports Complex	3-Jul-1989	PS	3.70	440	7/22/1991	14:22	3.08	354	5/30/2014	17:14
Van Bibber @ Hwy 93	14-Aug-1990	PS	4.30	665	7/29/2003	14:51	1.86	575	7/7/2014	23:39
Montview Park	9-Jun-1988	PS	10.45	1,211	9/12/2013	12:53	6.22	430	5/22/2014	17:17
Kelly Dam	22-Sep-1988	PS	62.81	820	9/12/2013	12:08	50.25	72	7/30/2014	21:21
Expo Park	21-May-1988	PS	65.88	133	9/12/2013	9:22	57.34	32	9/29/2014	20:00



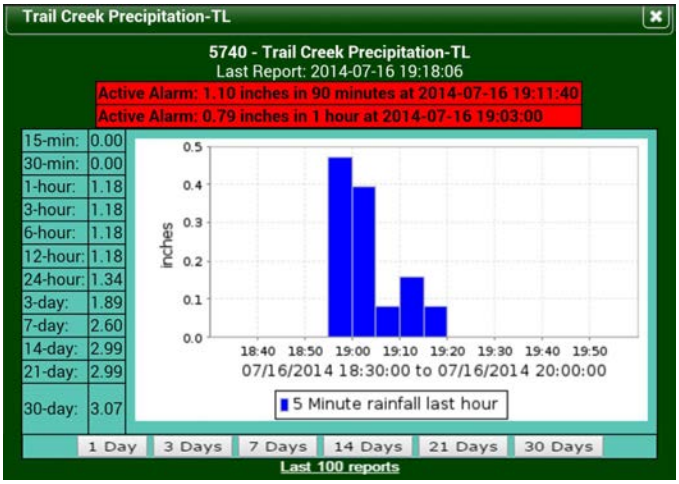
Website Innovations

Two primary websites were supported during 2014. The public website uses a software package developed and maintained by OneRain called Contrail Web. The second website used primarily by UDFCD Flood Warning Program partner agencies displays ALERT data collected by two NovaStar-5 base stations, one located at UDFCD and a backup remote site supported by Green House Data in Cheyenne, Wyoming. The NS-5 platforms and the popular ALERT GMap display feature are maintained by WET. Data from satellite-monitored stream gages operated by the USGS and Colorado's Division of Water Resources can also be viewed from both ALERT websites.

Improvements made in 2014 were largely driven with handheld users in mind. WordPress was selected for NS-5 users featuring a cascading style sheet (CSS) look and feel along with blogging capabilities to keep users apprised of new developments and other items of interest.



The GMap display was enhanced to capture as much critical information as practicable for a first-look assessment. The cell phone screen capture image shows a NWS Severe Thunderstorm warning area as a yellow box, a Tornado warning as a red box, a current looping radar image, and one hour rainfall totals. All of these features are activated by default. The settings can be easily changed using the Data Menu. Touching the NWS warning box icons will display the text associated with the warning. Touching the rainfall values will produce a corresponding data plot along with other useful information and related links (*see example below*).



Another useful GMap feature enhancement for 2014 is the blinking active alarms that occur whenever a 3 inch/hour rainfall rate is exceeded within a 10-minute time period or when rainfall amounts exceed 1-inch with a 60-minute time period. Rain gauges in burn areas like the example above have alarms thresholds set somewhat lower and adjusted as watershed conditions improve.

The ALERT streamgage map display supported by Leonard Rice Engineers (LRE) was updated in 2014 to make it more handheld device friendly. The color codes represent potential impacts related to current stream levels, emulating the highly acclaimed NWS Advanced Hydrologic Prediction Service (AHPS)

Beyond ALERT

For the second consecutive year the City and County of Denver made good use of radar-derived precipitation estimates to be notified when an approaching storm is expected to exceed critical rainfall thresholds. ALERT rain gauge measurements are used to improve the accuracy of the rainfall estimates for each 1km radar grid. A storm-tracking algorithm is used to forecast rainfall expected 30 minutes in the future. The notification criteria is set equal to the ALERT rainfall rate alarm thresholds so, in theory, officials can receive warnings of imminent low impact flooding for a very specific area up to 30 minutes before heavy rainfall occurs.

Another practical and cost-saving use of this technology is for post-storm evaluation. When local governments are threatened with litigation following a localized flood, the web-based application can be used to quickly quantify the nature of the event that caused the alleged damages. Early discovery of storm facts can, on occasions, bring a rather quick halt to superfluous claims. This application was developed by Vieux, Inc. of Norman, Oklahoma.

Various real-time hydrologic models have been implemented and continue to evolve. Usage of these models to date has been sparse and the opportunities to interact with these models are limited. This should change in the future as more push products are developed to engage decision-makers sooner. A separate article in this issue of *Flood Hazard News* is devoted to a new model developed for East Plum Creek in Douglas County. The Lena Gulch model in Jefferson County supported by LRE was updated late last year to improve its performance, to better accommodate post-event evaluations, and to make possible rainfall inputs from radar or other sources. The Vflo hydromodel by Vieux continues to provide threat assessment and automatic notifications for the Boulder Creek watershed including Fourmile Creek and Fourmile Canyon Creek, which sustained heavy losses in the September 2013 floods.

Wednesday Webinars were introduced in 2014 to provide training and to demonstrate firsthand how to best make use of the wide variety of UDFCD-supported web-based applications developed to anticipate, recognize and evaluate flood threats. These useful tools consist of multiple radar applications, real-time hydrologic models, data-rich mapping utilities, etc. Each 'GoToWebinar' session is recorded and available for later viewing. UDFCD plans to continue this service in 2015.

The City of Aurora prompted District staff to help develop a graphically jam-packed instruction manual in 2014 for UDFCD's Flood Warning Program using Microsoft PowerPoint™. Sections of the manual covered many of the more popular features of UDFCD-supported websites, F2P2 information, the ALERT System, radar display options, email subscriptions, and flood preparation and monitoring expectations. The slide show was designed for hard copy reproduction and can easily be modified and adapted for use by other local governments.

UDFCD's Flood Hazard Information Tool or FHIT has grown substantially since the STR-13 floods. This easy to use web-driven tool provides a convenient way to document floods; identify damage thresholds; show conveyance capacities of stream channels and crossing structures; view photos and videos; and read pertinent documents. In 2014, local governments began assuming more direct responsibility to keep their records up-to-date and administer the online SQL database. Individualized training is available for all UDFCD's partner agencies that would like to get involved.

As always, UDFCD welcomes your ideas on how we can continue providing 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 available. Open directories are provided for downloading detailed annual reports concerning the maintenance of the ALERT System and F2P2 operations.

New Website Available Soon

By Derrick Schauer, Information Systems Technician

In 2014 we began an effort to redesign the UDFCD's main website. This project involved changes to site content, navigation and device accessibility. As tablets and smart phones continue to become popular choices for business professionals, selecting a website platform that is compatible with mobile devices was a must-have feature. WordPress is a platform that has the ability to automatically recognize if a user is viewing the site with a PC or mobile device and will scale the content appropriately.

Changes to the site structure and content were other factors addressed through the redesign. Based on recommendations from a web consultant and statistics gained from analysis tools, the site structure was modified to improve content access and overall user experience. We are pretty excited about the new changes and hope you will be too. Keep your eye out for a new UDFCD website in 2015.

Electronic Data Management (EDM) Application Update

Julia Bailey, Information Services Engineer, Information Services and Flood Warning Program

Several updates were made to the District's web mapping application in 2014. The mapping interface is used to view mapped layers such as streams, project and study areas, floodplains, etc. The interface is also used to search for and retrieve report documents including as-builts, design reports, master plans, and flood hazard area delineation reports.

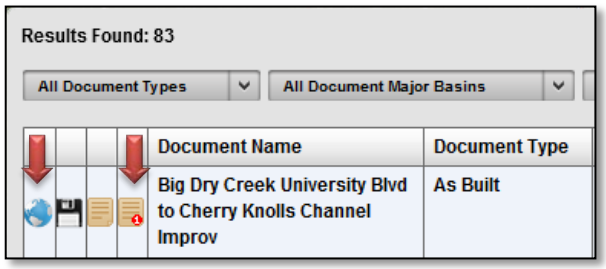


Figure 1: New map and preview features added to the document search results table.

There are two new features available in the document search results window (Figure 1). The first is a map feature that gives the ability to direct the map to and highlight the corresponding project limit or study area. This feature is accessed in a new column of the results table. Each document result in the table has either a blue or a grey globe icon. When the user clicks on the globe next to a master plan, for example, the map will show the corresponding study area.

The second feature that was added to the document search results table is a first page preview button. Since many of the reports have a large file size and it takes several minutes to download them, this feature is helpful to preview the report cover and decide if you've found the correct document. Like the map feature, the preview option is added as a new column in the search results table. The icon is a document with the number 1.

Before last year, report documents were associated with points on the map. Last year project lines and study areas replaced those point features. New in 2014, current project reaches and study areas have been added. In the Legend under clickable features, users can turn on projects and isolate either current or completed projects. When a user clicks on a current study, they are redirected to a website with more information on the master planning study.

Additionally, the floodplain data has been broken up into two layers. The first layer represents a downloaded version of the National Flood Hazard Layer (NFHL). The second layer is comprised of mapped floodplains based on flood hazard area delineation reports. The floodplains in this layer are not on the NFHL because either they are too small or they may be in the process of being added. A disclaimer when entering the interface will give the last updated date for the specific floodplain layers.

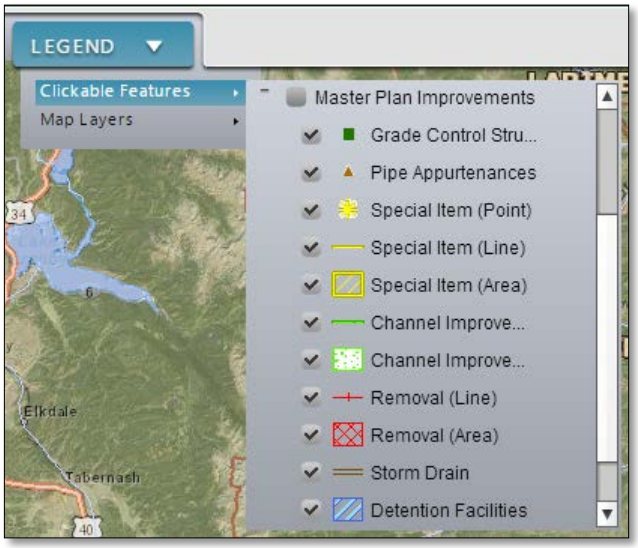


Figure 2: Master plan improvement data layers listed in the legend.

One of the most exciting enhancements in 2014 was the addition of the Master Plan Improvement layers (Figure 2). Shea Thomas was the mastermind behind a tool called SWIFT for organizing planned improvements in GIS form. Eleven layers from the SWIFT dataset including grade control structures, channel improvements, and detention facilities, etc. have been added to the mapping interface.

Each layer is clickable. When a user selects a master planning improvement feature on the map they will see a pop-up box with information specific to the feature. Information shown in the popups varies with each layer. Some of the information available is shown in Figure 3.

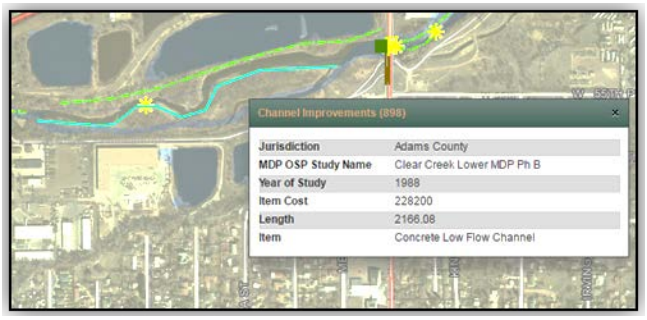


Figure 3: Information popup for channel improvements layer.

Thanks to GIS Workshop Inc. for providing hosting, development, and support services. As always, comments are appreciated. (Email: Jbailey@udfcd.org)

Design, Construction & Maintenance Program

David Bennetts, PE, CFM, Program Manager and Laura Kroeger, PE, Assistant Program Manager

CIP and Work Plan

The DCM program is funded by three different legislative authorizations; the Construction Fund, the Maintenance Fund, and the South Platte River Fund. Each year the District prepares a work plan for each of the funds. The 5-year Capital Improvement Plan (CIP) lists capital construction projects by county for the Construction and South Platte River funds. The CIP shows the District's financial participation, which will be matched by the participating local governments, for a 5 year window of time. This allows both the District and local government partners to plan funding levels into the future.

The Maintenance Work Plan lists projects for the Maintenance and South Platte River funds. Work is listed by county, category of work, the local government where the work is located, project location, description of work, and the estimated cost. Maintenance work is funded entirely by the District. Both the 5-year CIP and Maintenance Work Plan are developed based on prioritized project requests from local governments. Copies of both of these plans are available on the District's website: http://www.udfcd.org/design_const_maint/dcm_home.html.

Routine Maintenance

Routine work provides basic flood control maintenance along the major drainageways within the District. Services typically performed include mowing, trash and debris removal, weed control, and tree thinning. The District is currently maintaining over 350 drainageways and spent $862,500 in 2014 for Routine Maintenance. Private contractors are hired each year to perform the maintenance on a unit price basis. The District's website has maps of the routine work broken down by county, major drainageway and reach.

Restoration Maintenance

Restoration work is site specific construction work to address isolated drainageway problems that are included in the Maintenance Eligibility Program. This work often mitigates the need for more costly improvements in the future. Types of restoration activities include: sediment removal, local erosion repair and bank protection, drop structure repair, and channel grading, stabilization, and revegetation. All of this work is accomplished using private contractors either through a public bidding process or a pre-qualified contractor selection process. In 2014, the District completed $ 8,597,400 of restoration work.

Design and Construction Projects

Design and construction projects implement master planned improvements. Generally, the District manages final designs prepared by consulting engineers. The local governments are involved in all aspects of the design process, and usually acquire any necessary ROW. Projects are publically bid for construction. In 2014 the District authorized approximately $ 8,755,000 for construction projects. Below is a brief outline of a few capital and maintenance projects that have been recently completed:

Adams County

Grange Hall Creek Pedestrian Bridge

A regional trail crossing washed out along Grange Hall Creek between 108th Avenue and Riverdale Road during the floods of September 2013. The City of Thornton and the District partnered to rebuild the pedestrian crossing. The crossing had been previously designed as part of a 2012 capital improvement project, but was not constructed with that project due to funding constraints. The crossing was irreparably damaged by the flood, and was in need of complete replacement, so the design was employed to reconstruct the crossing in early 2014.

Post Flood Trail Damage

Reconstructed Trail Crossing

Little Dry Creek at Federal Tunneling

Major improvements are planned for the Little Dry Creek corridor from Federal Boulevard to Lowell Boulevard, including a formalized regional stormwater detention basin, creek reconstruction, a formal park, and the new Westminster Station on the forthcoming RTD Fastracks Northwest Rail Line. Many utilities must be moved to make way for these future projects, several of which were relocated during a significant project at Federal Boulevard in 2014, where the District partnered with the City of Westminster (City) and Adams County (County). This project also involved installation of an additional culvert under Federal Boulevard to increase conveyance for Little Dry Creek and lower the floodplain.

The Federal Boulevard embankment is over fifty feet tall, which necessitated the use of trenchless technology to relocate a 10-inch Crestview sanitary sewer and a 24-inch City sanitary sewer. These sewer lines were located within the existing box culvert carrying Little Dry Creek under Federal Boulevard. Relocating these sewer lines allowed them to be removed from the box culvert, increasing conveyance under Federal Boulevard.

The 10-inch sewer line was replaced by a 14-inch fusible PVC pipe. The initial plan was to install a 12-inch sewer line within a 30-inch steel casing, constructed with a 4-inch guided boring machine rod to establish line and grade and a 30-inch pipe auger to install the casing. The guided boring machine rod was installed to line and grade, but the 30-inch steel casing construction halted when subterranean cobbles knocked the casing off grade. A horizontal directional drill was used to push the 4-inch rods out of the hole, and then was pulled back with a 14-inch auger to install a 14-inch fusible PVC pipe. The extra diameter will allow for future sliplining.

Fourteen-inch fusible PVC and ream

Thirty-inch casing and auger

The 24-inch sewer line was replaced with a 36-inch sewer line that was placed within a new 54-inch steel casing, constructed using a microtunnel machine. A guided boring machine and pipe hammer were considered as an alternative to the microtunnel, but cobbles along the casing centerline prevented installation of a guide rod.

One hundred and eight inch tunnel-boring machine.

An important goal for this corridor is to formalize stormwater detention that already occurs upstream of the Federal Boulevard embankment, and to lower the floodplain to reduce risk to the Northwest Rail Line and to nearby residences. To achieve this goal, additional conveyance was needed under Federal Boulevard. An additional 108-inch diameter culvert was tunneled under Federal Boulevard to increase conveyance capacity to supplement the capacity of the existing box culvert. This culvert was installed using a tunnel-boring machine (TBM).

Tanglewood Creek

Tanglewood Creek from 121st Avenue to 123rd Avenue drained through Timberlake Pond (a regional detention basin) and through a reach of channel with a failing concrete trickle channel and grouted riprap drop structures that were falling apart. The outlet works for Timberlake Pond consisted of a clogged 18-inch pipe and a failing grouted riprap spillway that drained over and across an apartment complex driveway.

Silver Hills Middle School and Mountain Range High School are only a quarter mile north of the project area, leading to heavy pedestrian traffic along the creek corridor, even though no formal trail existed. The District partnered with the City of Westminster (City) to reconstruct and naturalize the channel, to rebuild the pond outlet works, and to formalize the trail through the project corridor, connecting with another trail project being constructed to the north by the City.

Tanglewood Creek

Pre- and post-construction channel

Pre- and post-construction spillway

Arapahoe County

Capital Highlight

The UDFCD and the City of Aurora completed construction of a capital project on **Bolling Drive Tributary from 38th Avenue to Tower Road,** located northeast of 38th Avenue and Tower Road. The project constructed a missing section of channel; which allows for retention ponds on south side of 38th Avenue and east of the High Line Canal to be converted to detention ponds and be connected to Bolling Drive Tributary. The project provided a grade separated trail crossing at Tower Road for a future trail system along Bolling Drive Tributary and the High Line Canal.

This separated grade crossing functions as maintenance access and in the future will provide an important part of the regional trail system planned for the community, including a key connection to the Light Rail that is currently being built by RTD. The project received grants from Adams County Open Space and Great Outdoors Colorado for the trail components and the separated grade crossing at Tower Road.

Maintenance Highlight

The UDFCD and City of Cherry Hills Village completed a maintenance project on **Little Dry Creek at Woodie Hollow Park** located northwest of Belleview Avenue and Broadway. Little Dry Creek was suffering from degradation and bank erosion that threatened the adjacent trail and loss of park property. The project received an Open Space Grant from Arapahoe County for trail improvements and protection and to enhance park safety around Little Dry Creek. One check structure was installed to mitigate further channel degradation, and a combination of grouted boulder wall and bio-engineered soil wraps was used to protect the trail and park property. The trail was relocated further away from steep channel sections and vertical banks were sloped back where possible to improve safety.

Pre- and post-construction of Bolling Drive Tributary

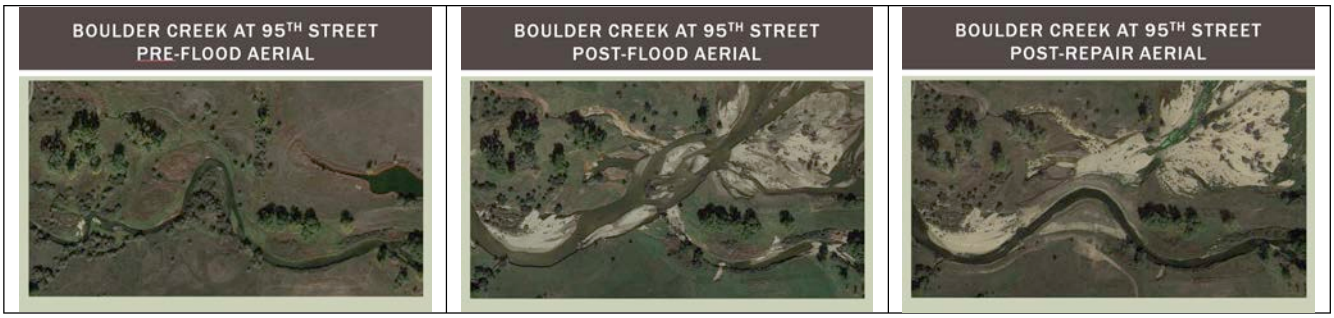
Pre- and post-construction at Woodie Hollow Park

Boulder County

Boulder Creek at 95th Street

The reach of Boulder Creek adjacent to 95th Street in Boulder County has a history of being modified to support gravel mining operations. During the flood of September 2013, the creek re-aligned itself at an oxbow upstream of 95th Street such that the creek flowed uncontrollably across an 800-foot width of 95th Street. Flow along the creek no longer reached the actual 95th Street bridge for Boulder Creek, nor the large water supply headworks just east of 95th Street. In the immediate aftermath of the flood, the District assisted Boulder County by constructing a temporary diversion channel to route the creek back into the pre-flood main channel and back to the 95th Street bridge.

In early 2014 the District assisted Boulder County by constructing a more permanent bank repair. The repair involved re-establishing some of the pre-flood channel meander, and introduced a secondary channel to the south to mitigate for some of the stream length lost in the flood. The permanent repair withstood high spring runoff, but will overtop for flow exceeding around 1,000 cfs (similar to the pre-flood configuration). Pre-flood, post-flood, and post-repair aerial photos are shown below.



City and County of Broomfield

Nissen Reservoir Drainageway at Lowell

The reconstruction of Lowell Blvd from 120th Ave to Midway Blvd is now underway. The District is contributing $1M towards design and construction of the crossing that will provide 100-year capacity and an improved maintenance access/pedestrian underpass. Hamilton Construction expects to have the Nissen Reservoir Drainageway CON/SPAN structure completed in early 2015.

Rendering of Nissen Reservoir Drainageway Crossing at Lowell Blvd

City Park Drainageway-Phase 2

In 2015 Broomfield, Westminster and the UDFCD desire to initiate the design and construction of the City Park Drainageway-Phase 2 from just upstream of Lowell Blvd along the south side of 120th Avenue to Big Dry Creek. Phase 1 of this project was previously constructed in 2009. This phase will separate the City Park/Nissen Reservoir Drainageway confluence upstream of Lowell Blvd and provide 100-year conveyance from the Phase 1 channel to Big Dry Creek.

Jefferson County

McIntyre Gulch

The construction of McIntyre Gulch just upstream of 6th Avenue and Wadsworth Boulevard was completed this year. This junked out drainageway within an older residential neighborhood in Lakewood was experiencing severe loss of capacity due to heavy tree growth and alien fill material placed by others in hopes of keeping the gulch out of their properties. Improvements consisted of two grouted boulder drops, grouted boulder walls, a new access bridge, and bank stabilization. Several private structures were either demolished or moved to make room for the project. It was imperative that all property owners along this 600-feet reach were supportive of this project since they were all asked to dedicate drainage easements to Lakewood.

As typically happens with projects of this nature the adjoining property owners, and in this case farm animals, participated almost full-time with construction inspection. Many landscaping changes were requested along the way as the new channel improvements unfolded. Continuous communication during construction was necessary to ensure all were relatively happy with the final outcome. The biggest challenge was to make sure each owner was getting a fair deal and not more or less than others. Good luck with that, especially since stream alignments never follow property lines.

WHPacific provided the engineering design and Left Hand Excavating was selected to construct the project. Arrowhead Landscaping completed the final re-vegetation and landscaping. The District handled daily construction observation. All performed admirably, evidenced by the relationships and trust developed with the property owners during construction. Total construction cost was approximately $750,000.

Ralston Creek

Over the past several years the banks of Ralston Creek upstream of Indiana Street have been experiencing minor erosion. As a result of the September 2013 flood, a 14-foot high stream bank adjacent to an old landfill collapsed. The UDFCD, at the request of the City of Arvada and with the help of Walsh Environmental and Valles Construction, ventured into the world of extreme bioengineered stream bank restoration with vegetated soil lifts to stabilize the bank.

Starting with a toe of firmly placed rock riprap, fifteen fabric (coconut fiber) wrapped soil lifts with native wetland and upland seeds were installed up the slope. Each wrapped lift is securely anchored to each successive lift and into the existing bank without disturbing or releasing any landfill

McIntyre Gulch before (after tree removal) and after construction

material. Additional willows and shrubs were added at the appropriate lift elevations to help with establishing critical root mass throughout the bank. Several onsite dead tree trunks were used as deflectors within the low-flow channel to encourage fish and wildlife habitat.

Ralston Creek before and after construction

This unique pilot project will be monitored over the next few years and evaluated as a potential stream bank restoration option in other locations within the UDFCD. Total construction cost was approximately $70,00.

City and County of Denver

Stream systems, like Cherry Creek, are an important asset to our community for open space and floodplain management. The riparian areas are the transitional areas between dry lands and streams. They are commonly associated with floodplains. Plant communities you are likely to see in riparian areas include grasses, shrubs, trees, and wetlands. In Denver, these areas can be found in parks, greenbelts, and along trails such as Goldsmith Gulch.

1. **What makes streams like Cherry Creek a healthy riparian and stream system?**
   - Native grasses, shrubs, and trees
   - Dense ground cover with limited exposed soil
   - Minimal invasive weeds
   - Variety of grasses, shrubs, and trees
   - Absence of trash
2. **Why are healthy Riparian and Stream Systems important to our Community?**
   - Improves water quality by filtering out pollutants like road oils and fertilizers.
   - Reduces soil erosion and damage to our bridges, properties, and parks during rainstorms.
   - Attenuates flow during rainstorms.
   - Enhances our recreation and outdoor experiences along multifunction trail corridors.
   - Provides us with educational opportunities.
3. **How does the UDFCD currently manage the riparian and stream systems?**
   - We mow grasses for weed control.
   - We conduct trash and debris removal for better flood conveyance.
4. **Why is a more Adaptive Vegetation Management Plan needed?**
   - A healthy riparian and stream system relies not exclusively on the absence of trash and weeds, but also requires diversity in native grasses, shrubs, and trees.
   - We have come to realize that mowing is NOT effective in eliminating weeds. Implementation of a Vegetation Management Plan that excludes mowing is necessary. A more integrated weed management approach that includes a combination of mechanical, chemical, and cultural measures increases management efficiency as compared to relying on a single method.
5. **What does the Vegetation Management Plan look like?**
   - Continue trash and debris pick-up
   - Exclude mowing.
   - Catalog the types of weeds that have invaded our open spaces.
   - Implement with the Integrated Weed Management Approach.
   - Thin overgrown areas of shrubs and trees.
   - Plant grasses, shrubs, and trees in sparse areas.

In summary, streams are valuable assets to our community, and improving their health with an enhanced management approach will help them to become self-sustaining, ultimately reducing costs over time. Moving forward, you will see visible changes, such as tall and healthier grasses, shrubs, and trees

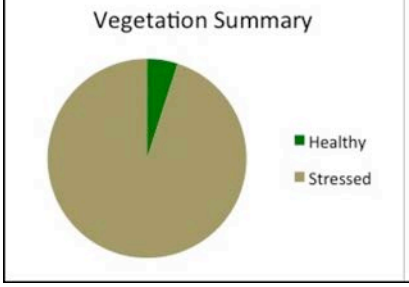
Cherry Creek

With Mowing **June 2013**

Average Daily High Temperature:	88 °F
Previous 3-Month Precipitation:	
April:	0.96 in
May:	0.72 in
June:	1.12 in
Total:	2.80 in

Without Mowing **June 2014**

Average Daily High Temperature:	88 °F
Previous 3-Month Precipitation:	
April:	0.96 in
May:	0.80 in
June:	3.12 in
Total:	4.88 in



These figures show the results of efforts to study the effects of the Vegetation Management Plan on Cherry Creek and Goldsmith Gulch in Denver.

Goldsmith Gulch

With Mowing **July 2012**

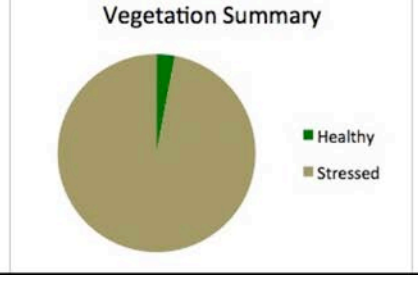
Average Daily High Temperature:	91 °F
Previous 3-Month Precipitation:	
May:	1.20 in
June:	0.76 in
July:	1.48 in
Total:	3.44 in

With Mowing **July 2013**

Average Daily High Temperature:	88 °F
Previous 3-Month Precipitation:	
May:	1.88 in
June:	0.60 in
July:	2.44 in
Total:	4.92 in

Without Mowing **July 2014**

Average Daily High Temperature:	88 °F
Previous 3-Month Precipitation:	
May:	2.44 in
June:	1.00 in
July:	3.20 in
Total:	6.64 in



South Platte River

Denver County Update. In the Denver reach of the South Platte River, a number of projects were on going in the 2014 construction season. The goals of these projects include maintaining and improving the channel's flood carrying capacity, enhancing water quality, improving the aquatic and wildlife habitat, improving maintenance and emergency access to the river, and implementing long needed park and trail improvements. The projects, part of the Greenway Foundation's River Vision Implementation Plan (RVIP), include Johnson-Habitat Park Improvements, Grant Frontier/Overland Park Improvements, and Weir Gulch at Sun Valley Improvements. These three projects have an estimated value of over $16 million.

The Weir Gulch Improvements were completed in the early summer of 2014 after about 10 months of construction. These improvements were constructed by Naranjo Civil Constructors, and were the first completed project of the RVIP. The improvements won an American Society of Landscape Architects Colorado Design Award for projects over $500,000. The award was presented at their National meeting held in Denver in November of 2014. Congratulations for the award go to the design team of DHM Design and ICON Engineering.

The Johnson-Habitat Park Improvements project is still underway, with anticipated completion in the summer of 2015. The Grant Frontier/Overland Park Improvements project was broken down into three phases to help more effectively construct the project. The first phase of improvements started late in 2014 and should be complete in the summer of 2015. These improvements removed the 8 foot high sloping grouted rubble/rock drop structure upstream of Florida Avenue which required portage for boaters. The river was lowered and re-graded, and 4 smaller structures were installed as well as several jetties and rock vanes. Trail and access improvements are also being built. The remaining two phases of work are due to start in the spring of 2015, and all construction in the area should be complete by 2016.

In addition to these three projects, the UDFCD and Denver have been working on a forth project that was identified in the RVIP as the Confluence Park Improvements. A Confluence Park Master Plan had identified a number of needed improvements including enlarged channel conveyance, water quality and habitat enhancements, ramp and pedestrian bridge replacement, plaza and amphitheater revisions, additional outdoor seating areas, a revamped whitewater course, and better tie in to the surrounding businesses and park areas. The first phase of these improvements will include replacement of the ramps on the west side of the river and replacement of the Shoemaker Plaza area. This work is estimated to be about $4 million dollars and, with funding in place, construction is slated to start in the spring of 2015.

Weir Gulch Confluence with the South Platte River

Completed Playground at Weir Gulch

Drop Structure on Weir Gulch

In addition to these construction efforts, several planning efforts are underway for the South Platte River in Denver. The Greenway Foundation was successful in receiving a $450,000 Water Supply Reserve Account Grant from the Colorado Water Conservation Board. These funds will be combined with funds from the UDFCD and Denver to complete a comprehensive planning study of the river from

Johnson – Habitat Park under construction

6th Avenue to 58th Avenue. This effort will start in the spring of 2015 and should take about a year to complete.

Concurrent with this study, the U.S. Army Corps of Engineers has started a feasibility study of three drainageways in Denver; Harvard Gulch, Weir Gulch, and the South Platte River. Their efforts on Harvard Gulch and Weir Gulch will be coordinated with on-going master plans on each of the drainageways. The Corps efforts on the South Platte River will be coordinated with the CWCB/Denver project.

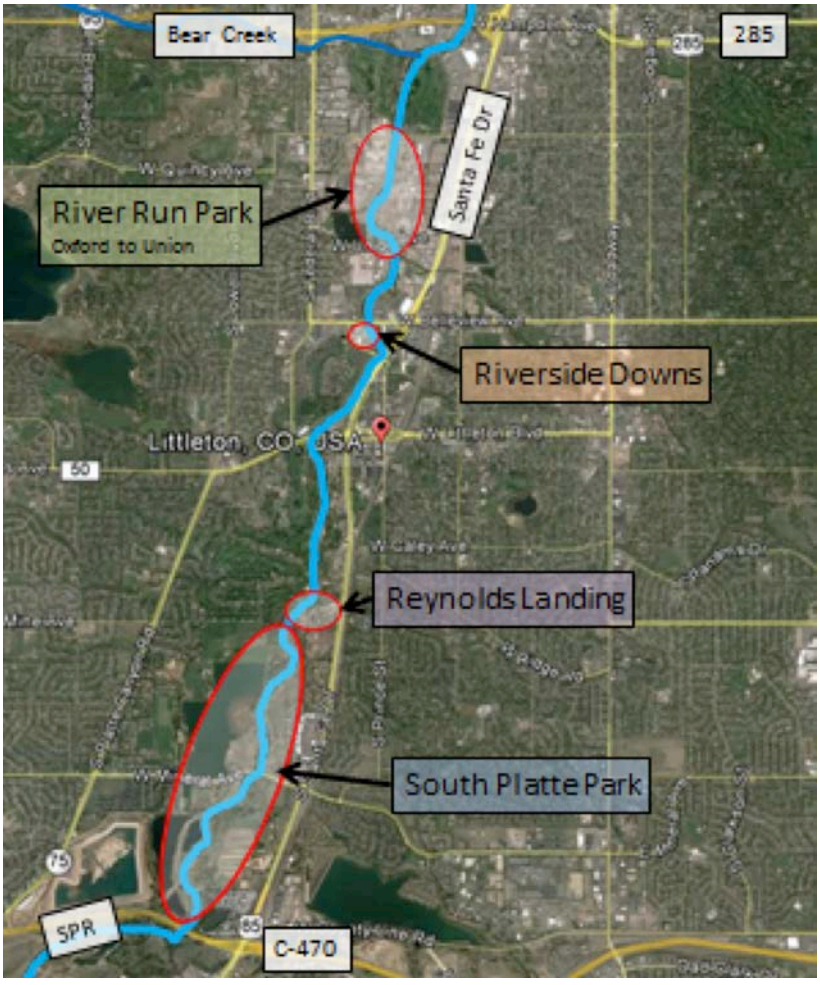
Arapahoe County Update. The South Platte Working Group 2 continues to lead the charge in redefining the South Platte River through Arapahoe County. The purpose of the working group is to preserve and protect the river corridor as a community asset, and to enhance the quality of life in western Arapahoe County through an ongoing collaborative process to improve the natural environment, economic benefit, and recreational features of the South Platte River. Currently there are four active projects that are leveraging Arapahoe County Open Space working group funds and the UDFCD is involved in three of them, River Run Park, Reynolds Landing and South Platte Park River Enhancements.

River Run Park is in the final design phase with an anticipated construction start date of September 2015 for Schedule I. Schedule I includes in-stream improvements north of Oxford Ave. as well as better river access and vegetation enhancements. The design team for the project is McLaughlin White Water Engineers and DHM.

Reynolds Landing is just starting to be imagined. The short-term objective is to make a trail connection from the Mary Carter Greenway Trail to the Breckenridge Brewery that is at the entrance to the park, by spring of 2015. The design team of DHM and McLaughlin White Water Engineers will work with the stakeholders to develop a master plan for the park and then move to final design.

South Platte Park River Enhancements has work completed from the northern park boundary to Mineral Ave. The third and final phase of the project, which stretches from Mineral to the southern park boundary, began in January and will be completed by summer 2015. The designer for the South Platte Park Enhancements is Ecological Restoration Consultants (ERC), the contractor doing the river work is Naranjo Civil Constructors and the revegetation contractor is Arrowhead Landscaping.

The following DCM staff members contributed to this column: Bryan Kohlenberg, P.E., CFM, Project Manager; David Skuodas, P.E., CFM, LEED AP, Project Manager; Richard Borchardt, P.E., CFM, Project Manager; Barbara Chongtoua, P.E., CFM, Project Manager; Steve Materkowski, E.I., Senior Construction Manager.



South Platte Working Group 2 Projects Map

Floodplain Management Program

David Mallory, PE, CFM, Program Manager

Bill retired!

My long-time mentor and friend, Bill DeGroot retired after 40 years of service to this District and the field of floodplain management. My article in the 2013 edition of Flood Hazard News was devoted to his legacy. Bill has retired, but has not entirely disappeared. But wait, there's more. He graciously accepted the assignment as editor of this edition of *Flood Hazard News*. He has also done a little consulting, accepted speaking assignments, is active in ASFPM and CASFM, and in floodplain management curriculum development.

New additions to the Floodplain Management Program

Bill's departure in February left the Floodplain Management Program with a vacancy. In the middle of March, we welcomed Teresa Patterson to the program. Sometimes referred to as David 2.0, she brings enormous depth to the program. Teresa comes to us and the public sector with fifteen years of solid private sector experience. Teresa's recent experience with RESPEC Water & Natural Resources included work on Flood Hazard Area Delineation Studies and construction projects, all of which are very relevant to the services we provide in this program. She also has recent experience with H&H modeling (including two-dimensional), GIS and AutoCAD. Teresa got up to speed very quickly and has proved a great addition to the Floodplain Management Program which puts a smile on my face. Her current assignment is managing the Maintenance Eligibility Program.

John Pflaum has been assisting us for several years in a contract capacity. For a variety of reasons we converted his service to part-time temporary. John provides technical support to both Terri, for FHAD reviews, and Teresa for construction plan reviews.

National Flood Insurance Program

We have used this space over the last two years to share information regarding the Biggert-Waters Flood Insurance reform Act of 2012 or BW12 for short (Fact Sheet) The most reported aspect of BW12 has been the large increases in flood insurance premiums. Bill's article last year went into specifics on the loss of subsidized rates and the expected loss of grandfathered rates in late 2014. Congress received a lot of constituent love over rate increases which they pasted onto FEMA. Congress insisted that FEMA delay implementation of BW12 and FEMA insisted they lacked the authority to do so. On March 21, 2014, President Obama signed into law the Homeowner Flood Insurance Affordability Act of 2014 (HFIAA) (Fact Sheet). The law repeals and modifies certain provisions of BW12. However, many of the provisions of BW12 remain in force. FEMA is working through the mountain of details, including the insurance premium refunds mandated by HFIAA. Although a detailed discussion of the impacts of BW12 and HFIAA is beyond the scope of this article, I believe a couple of observations are germane:

- All policies are on track to reach actuarial rating, whether the transition is 5 years or 20 years,
- Hazard identification and risk communication will become more important,
- Communities' reliance on the Community Rating System (CRS) will increase,
- Hazard mitigation, including adaptation to ever increasing extreme weather patterns is imperative,
- We need to step up our game in encouraging safe and proper development.

For nearly four hundred years, we have developed along the coast and rivers in a way to use the resource to support trade and communities. We need to work hard and fast to reduce the risk and losses due to floods and storms. These federal laws are intended to incentivize better behavior, but in my view, communities and citizens are facing some very real challenges at the end of a very sharp sword. A gradual, affordable and equable approach is needed in order to keep good intentions from becoming a financial disaster.

In response to these new challenges, we are actively working with our community partners to standup a regional Program for Public Information (PPI). The PPI initiative is a program within CRS and will enhance individual communities' CRS classification. We also want to provide more CRS support to local governments. Everything UDFCD does, from master planning to maintenance is eligible for CRS credit. Finally, we are overhauling our annual flood risk brochure. We are moving to a community based brochure, rather than the drainage basin approach that we have used for years. The main reason for this move is to maximize the CRS credits for this activity. We'll report again next year how these initiatives faired so stay tuned.

Technical Mapping Advisory Council (TMAC)

The Technical Mapping Advisory Council (TMAC) was mandated as part of BW12 and modified by HFIAA. Congress mandated a specific list of activities for TMAC to work on and a specific makeup of the council (TMAC page). I was honored to receive a 2-year appointment as one of two representatives of local CTPs. The other local CTP representative is from New York City. In all, the council has 20 members from federal, state, local and private sector organizations.

The council will develop recommendations in the following general areas:

- Future conditions to include the effects of sea level rise and future development in risk identification,
- Accuracy and ease of use of Flood Insurance Rate Maps, including mapping standards and data quality,
- Maintenance of maps on an ongoing basis and leveraging federal action with state and local participation.

The council had two meetings in the fall of 2014, so work is just now getting underway. The future conditions report is due in the fall of 2015, so stay tuned.

LOMC delegation

We have been reviewing requests for Letters of Map Change (LOMC) for FEMA since July 1, 2001. We have had a pretty busy year again; with 40 cases received in 2014. Thanks to a grant increase for FY 2014 we had a fund surplus at the end of the year. We were able to maintain the funding levels for FY 2015 which we are pretty excited about. Terri Fead is fully in charge of the LOMC Delegation Program and it shows in the performance, quality and communication. I also want to emphasize the significant contributions made by ICON Engineering, our review consultant and Baker, FEMA's consultant in making the past 13 years so successful.

We decided to recompete the engineering services contract this year. I'm glad we did, because the process identified areas where we could improve service. I'm pleased to announce that ICON Engineering won the contract, but it was a close call. Our focus for the upcoming years will be increased customer service:

- We will meet with any applicant requesting a meeting and/or assistance in preparing submittals,
- Greater access to ICON on technical issues via phone, email and meetings,
- Streamlined additional data requests and processing.

We intend to conduct an annual telephone interview with selected applicants in order to solicit feedback on the LOMC experience and adjust as necessary.

Floodplain delineation

We collaborated with the Master Planning Program to complete five digital flood hazard area delineation (DFHAD) studies this year; Coal Creek and Rock Creek in Boulder County, Erie, Lafayette, Louisville, Broomfield and Superior; Happy Canyon Creek and Badger Gulch in Arapahoe County, Douglas County, Lone Tree and Parker; Coal Creek in Aurora and Arapahoe County; Box Elder Creek in Adams County, Denver, Aurora and Arapahoe County; and Rangeview Gulch Update in Littleton

We have eight DFHAD's underway; Weir Gulch in Denver and Lakewood; Upper Westerly Creek in Denver and Aurora; Big Dry Creek in Englewood, Cherry Hills Village, Greenwood Village, Centennial and Arapahoe County, Little Dry Creek in Arvada, Westminster, and Adams County; Niver Creek in Federal Heights, Thornton and Adams County; Plum Creek in Douglas County; Harvard Gulch in Denver and Grange Hall Creek in Northglenn, Thornton and Adams County.

All of these studies are compatible with FEMA's DFIRM specifications, and will be provided to FEMA for incorporation into the appropriate DFIRMs. Terri Fead is our program lead and continues to do an excellent job of assuring that the DFHADs are done to our standards and FEMA's.

We negotiated an agreement with FEMA Region 8 to put together a timeframe of when DFHADs will be completed so that they can be scheduled by the region for Physical Map Revision (PMR) funding as they are completed. This will help get the DFHADs into the DFIRM database and onto the National Flood Hazard Layer quicker. The first two PMRs, consisting of seven DFHADs, are in the post-preliminary phase. We are starting to see a lot of community interest in outreach workshops. We participated in the planning, preparation and presenting at several workshops hosted by SEMSWA.

DFIRM projects

In 2009 we received four grants from FEMA to update existing DFIRM's for the City and County of Broomfield, City and County of Denver, Jefferson County and Douglas County. At the end of 2014 Broomfield is complete with an effective date of October 2, 2013. Denver is complete with an effective date of November 20, 2013; and Jefferson County is also complete with an effective date of February 5, 2014. The only remaining project is Douglas County, which is in the post-preliminary phase. We expect the effective date to be fall of 2015.

FasTracks Coordination

Last year we reported that all was quiet on the FasTracks front. Not so in 2014! The North Metro Rail Line (NMRL) is in full swing. The NMRL crosses the South Platte River three times before heading into Thornton and Northglenn along the old UPRR line. Challenging crossings include Hoffman Drainageway and Grange Hall Creek. We have met frequently with the NMRL team to figure out how the rail improvements can be made while protecting adjacent properties and maintaining the integrity of published master plans.

Maintenance Eligibility Program

Teresa Paterson takes over the Maintenance Eligibility Program! I did not task her with writing a separate article this year since she has been with us for less than a year. And what a year it has been. Anecdotally, we believe development has come back stronger than before the Great Recession. There are large projects like Sterling Ranch in Douglas County, RTD spinoff projects like Aviation Station TOD in Denver and challenging projects like Lowry Vista in Denver and Sonic Automotive in Golden. Fieldwork continues to be excellently managed by Joanna Czarnecka. She has been very busy covering the entire metropolitan area for the

Maintenance Eligibility Program. Again, lots of projects, some more challenging than others such as Verona Estates in Centennial (SEMSWA). Teresa has begun a number of new initiatives, which she will report on in the 2015 edition. Flood Rebuilding Workshop

Joanna saw a news article concerning the $4 million grant that Colorado Housing Assistance Corporation bestowed on Habitat for Humanity to rebuild flood-damaged homes in Boulder County. She wondered if the home builders had any idea how to build in the hazardous areas that would be safe and not saddle the homeowner with colossal flood insurance premiums. Joanna reasoned they did not. She and Teresa teamed up with Michael Gease and Matt Buddie from FEMA Region 8 and Jamie Prochno with CWCB to develop a really excellent workshop on rebuilding. They met for the first time on July 31st and held the workshop in Longmont on September 9th. A really great effort in a short amount of time. I couldn't be prouder of their energy, talent and initiative. They have plans to present this workshop again to other audiences in 2015.

Bill DeGroot receives a standing ovation at his final Board of Directors meeting on February 3, 2014.

CRS is important! UDFCD support for District CRS Communities

by Joanna Czarnecka, E.I., CFM, Floodplain Management Program

Try Googling the word "CRS" some time. The list of results is endless and many have nothing to do with stormwater. To the floodplain management community it is most commonly known as the acronym for the Community Rating System (CRS).

The CRS is a voluntary incentive program created by FEMA for communities in the National Flood Insurance Program (NFIP) that offers discounts to flood insurance premiums for policyholders within the CRS community. The program is designed to credit communities that go above and beyond the minimum NFIP requirements as part of their own floodplain regulations and policies. The CRS program is a great example of "doing the right thing" when it comes to public safety, reducing flood damages, stream health, flood risk awareness, and sustainable floodplain management. Although implementation of the CRS program can be a very lengthy process requiring a significant time and resource commitment, many communities in Colorado have chosen to join the program to get credit for practicing sound floodplain management and to reward their citizens with reduced floodplain insurance premiums.

Although the Urban Drainage and Flood Control District (UDFCD) is not a local government and cannot have its own CRS program, for years we have been advocates and supporters of the CRS programs for our local government entities. With the updated 2013 CRS accreditation system, we saw a need to improve our support to UDFCD CRS communities.

In 2010 French Wetmore, Insurance Services Office (ISO) Specialist and CRS guru prepared a report, *State Support for the Community Rating System,* to summarize UDFCD's efforts as they pertain to the CRS program. The document can be found at our website www.udfcd.org in the *Recent News* section. The report provides a great summary of CRS credits that a community can claim based on efforts that UDFCD and the Colorado Water Conservation Board already implement in their programs. Since the new CRS update in 2013, we recognize a need to update the report. UDFCD is currently working with Mr. Wetmore to update this report based on the 2013 CRS Coordinator Manual and we will share it once it becomes available in the spring of 2015. This update will also include considerations for "uniform" CRS credits for UDFCD communities.

The City of Boulder represented by Heidi Hansen receives an award for improving its CRS Classification and CRS Activities from Michael Gease from FEMA Region 8, at the CASFM CRS Committee Meeting in April.

UDFCD recognizes that there is a need to improve the process that documentation is provided to CRS communities for UDFCD activities. CRS communities can receive CRS credits for activities performed by UDFCD like the flood warning system, floodplain mapping, master planning studies, floodplain rules and regulations, public outreach, and stream maintenance activities. The year 2015 begins a more concerted effort to outline the potential credits that CRS communities may be able to claim for work that UDFCD performs on behalf of local governments.

Our goal is to make the information more readily available in a format that is consistent with the needs of the CRS program, more transparent and easily available, as well as to offer a more unified service to our customers. With the upcoming UDFCD website update, most of this information will be available in one place and downloadable from the CRS Resources tab. We hope that this will eliminate the daunting task of contacting multiple individuals at UDFCD to get what you need for backup information. The website interface will be more user-friendly and lessen some of the struggle of getting all the paperwork ready for your next cycle visit.

Another effort that was triggered by the 2013 CRS manual update is formation of a multi-jurisdictional Program for Public Information (PPI) Committee. A number of interest meetings were held in 2014 to discuss participation in this PPI for communities served by UDFCD. Starting in early 2015, the committee will be formalized and begin work on a plan for public outreach information efforts and additional CRS credit. The committee will be comprised of both members of the participating local governments and non-government stakeholders. UDFCD has hired Susan Hayes to facilitate the committee efforts in hope of expediting this monumental effort. Within the Denver metro area the major drainageways cross-jurisdictional boundaries, and it is our hope that this joint effort will reach more people and produce consistent results throughout the region. This will be the first multi-jurisdictional PPI Committee of its kind in the nation.

UDFCD also helped facilitate this year's CASFM CRS Committee meetings and we wish to continue this support in the future. This helped us also to be more involved and keep updated on all the great things the committee does "behind the scenes". The use of *GoToMeeting*, a remote meeting platform, has enabled us to broaden member involvement throughout Colorado even though the meeting is hosted in Denver.

UDFCD will continue to increase our involvement with the CRS program in the future as a service to the all of these hard working communities within our area who choose to be a part of something bigger and joined the CRS. Kudos to you!

New to the UDFCD in 2014

John Pflaum and Teresa Patterson with the Floodplain Management Program and Terri Schafer, Controller.

Repurposing the High Line Canal for Stormwater Quality and Runoff Reduction

Ken A. MacKenzie, PE, UDFCD: Jessie Nolle, PE, and Alan Leak, PE, RESPEC Consulting and Services

Introduction

The High Line Canal (HLC) winds its way across the southeast quadrant of the Denver metro area (Figure 1). Originally constructed in the late 1880's to convey irrigation water to the plains south and east of Denver, it took on a recreation component in the 1970's as hikers, bikers and equestrians began to use the canal's maintenance road. Now, in the 21st century, another use is being proposed: stormwater quality and runoff reduction.

The HLC is owned and operated by Denver Water. With its current use for irrigation water deliveries, it loses between 60% and 90% of the water taken at the canal's head gate to infiltration, seepage, and evapotranspiration prior to delivery to its customers. Also, over the last century the canal has become lined with Plains cottonwoods and other trees, creating a bucolic, shaded recreation experience for thousands of walkers, joggers, equestrians, and bicyclists that travel the canal daily.

Denver Water wishes to cease use of the canal for water delivery and is working with the Urban Drainage and Flood Control District (UDFCD) and 20 other stakeholders including cities, counties, parks districts, and state agencies to investigate ways to use the canal to provide stormwater quality, runoff reduction, and a means to maintain the trees, and thus the recreation amenity. Reasonably, the same losses that are bad for water delivery should be good for stormwater pollutant reduction, runoff reduction, and tree irrigation.

Construction of two pilot projects is proposed to begin in 2015 and 2016.

History of the High Line Canal

The Northern Colorado Irrigation Company built the HLC between 1879 and 1883 as a gravity-flow, transbasin water diversion to supply South Platte River water from Waterton Canyon to numerous agricultural and institutional users located on the plains south and east of Denver. However, the High Line Canal did not provide a reliable source of water to users along its length of 66 miles until it was sold to the Antero and Lost Park Reservoir Company in 1909. The Denver Water Board (now Denver Water) acquired the HLC in 1924. The canal is currently owned and operated by Denver Water.

As land use gradually transitioned from agricultural use to commercial and residential uses, the number of consumers of HLC water was reduced. The canal still delivers water to about 80 customers in the upstream reaches. The current capacity of the HLC is approximately 600 cubic feet per second (cfs) at the head gate at a depth of about 6 feet, but in recent years it has been running at an average depth of only about 3 feet.

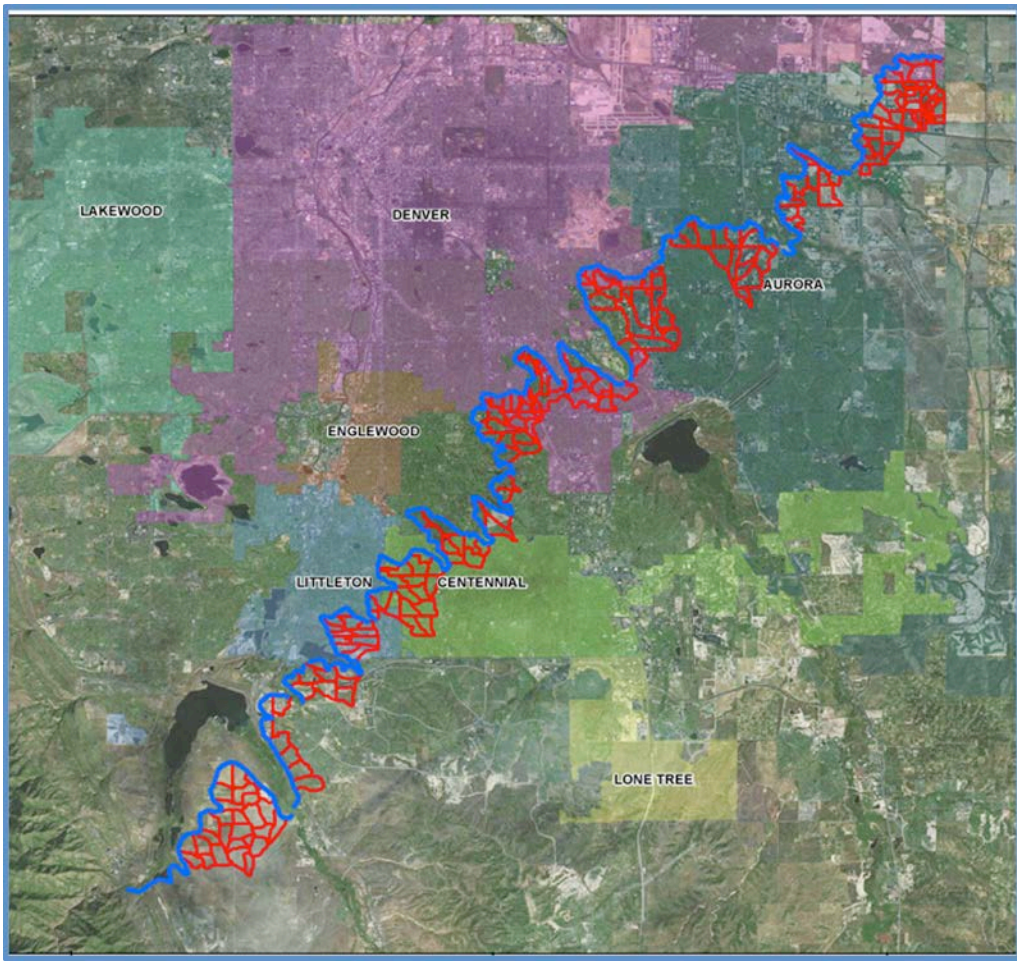


Figure 1: The 66 mile long High Line Canal flows from the mouth of Waterton Canyon at the lower left side of this map, in a northeasterly direction. The red areas are local watersheds tributary to the canal where stormwater treatment is currently absent or limited.

In the 1970s, recreational use agreements were established between Denver Water and the various municipalities the HLC passes through. The High Line Canal is one of the premier recreational corridors in the Denver metro area, with a multiuse trail running adjacent to the canal for its entire length. In an effort to protect this recreation experience for the entire Denver metro area, the High Line Canal Working Group was formed in 2010. This group is a collaborative organization that works to secure funding for and implement projects that will help enhance and protect the unique recreation experience along the HLC. Their vision statement is that the "High Line Corridor be protected forever as an intimate treasure and continuous recreation experience along a historic, naturally scenic canal."

Feasibility Study And Conceptual Design

In 2014 the UDFCD, Denver Water, and four local governments completed a feasibility study and conceptual design process that determined that it is indeed feasible to use the HLC as a stormwater runoff water quality facility both from a physical hydraulic perspective and from a cost-savings perspective, especially if future water quality regulations require not only new and redevelopment but also existing development not currently treating stormwater runoff to retrofit their sites to provide treatment.

An additional benefit not initially seen as a major component of a retrofit of the High Line Canal is that the proposed improvements would allow stormwater runoff to provide water to the extensive stand of existing trees along the canal that would otherwise be deprived of their historic source of water as Denver Water continues to reduce the use of the canal to transport water to its customers.

The following general considerations were accounted for during the development of the feasibility study and conceptual design:

- Allow the existing canal to be used to the fullest extent possible to store stormwater runoff for the amount of time the runoff can be stored in order to provide the most benefit for water quality and vegetation maintenance.
- Provide trash and debris control at the inflow points into the canal.
- Provide or maintain access and facilities design that considers maintenance preferences of the local jurisdictions.
- Design facilities with the understanding that while the intent may be to treat the water quality capture volume, larger storms will have to be accommodated without undermining the integrity of the proposed facilities or causing a new flood risk to adjacent properties.
- Consider the aesthetics and potential health and safety concerns of the corridor from the perspective of the trail users and nearby residents.

Hydrologic Analysis Of Tributary Area

A feasibility-level hydrologic analysis was performed for the areas draining to the High Line Canal to determine peak flow rates and volumes for existing and future development conditions. Peak flow rates were developed for the 2-year precipitation event and for a water quality precipitation event. The water quality event modeled is the 80th percentile runoff event, a 2-hour design storm based on a 0.53-inch, 1-hour point rainfall distributed temporally as a 0.61-inch, 2-hour rainfall. The Colorado Urban Hydrograph Procedure (CUHP) version 1.4.3 was used with EPA SWMM version 5.0.022 to develop the peak flow rates and volumes for each event. The canal, with all of its tributary watershed subcatchments, is shown in Figure 1.

Canal Physical Characteristics

The High Line Canal drops approximately 132 ft. over 66 miles, yielding an average channel slope of two feet per mile, or 0.04 percent. The bottom width of the canal varies from approximately 20 feet at the upstream end to 9 feet at the downstream end. Side slopes are generally steep and were assumed 2H:1V for modeling purposes.

A significant amount of land drains toward the HLC. Most of this land area drains to one of the several major drainageways that cross the canal. For the purpose of this project, these lands were not considered to drain to the canal itself because they will be required under Colorado water rights administration to bypass the canal as they have historically.

Water Quality Hydrology

Early in the development of the feasibility study, there were discussions about which best management practices (BMP) model would be best suited for use in retrofitting the canal. The mechanisms by which stormwater runoff can be treated in various BMP facilities include sedimentation, filtration, straining, adsorption/absorption, biological uptake, and hydrologic processes such as infiltration and evapotranspiration. The physical characteristics of the canal lend themselves most ideally to an extended detention basin, bioretention basin, or sand filter model. Filtration, sedimentation, straining, and adsorption/absorption are all likely to occur naturally once the canal is retrofitted. A hybrid of an extended detention basin and a bioretention basin was chosen as the treatment model.

The water quality capture volume (WQCV, equivalent to the 80th percentile runoff event) is based on the area and imperviousness of each subcatchment and on the desired drain time of the WQCV. For the Denver region, this volume can be estimated as:

$WQCV = 0.22IT^{0.19}$, where:

WQCV = Water Quality Capture Volume (watershed inches)
I = Imperviousness expressed as a decimal
T = Drain time (hours)

A drain time of 24 hours was used to calculate the WQCV although the basins themselves will be designed to drain in 72 hours, disregarding the unknown infiltration/ET losses for any particular segment. The 24-hour drain time was chosen for calculation purposes for two reasons. The first is that the goal of the project is to be able to capture and treat all the runoff from 80 percent of all runoff events (90 percent of all precipitation events). This is estimated to result in removal of between 80 percent and 90 percent of the annual total suspended solids (TSS) load.

The second is that a 24-hour drain time is midway between the regionally-recommended drain time of a bioretention basin (12 hours) and an extended detention basin (40 hours), and the proposed facilities have characteristics of both types of BMPs. The actual 72-hour drain time is the maximum time allowed under Colorado water law without needing a water right to use the water. This extended detention will allow more water infiltration and uptake by the trees.

Water Quality Capacity Requirements

The High Line Canal model was divided into 52 individual design reaches. Initially the reaches were established to each be almost exactly1 mile long. Although the canal typically has the capacity to hold up to about 6 ft. of water depth before overtopping, a treatment storage depth of 3 feet was assumed at the downstream end of each reach as this is generally the recent historic depth of water in the canal. This assumption yields a depth of about 1 foot at the upstream end of the reach assuming water is allowed to pond over the entire length of the reach. Reach boundaries were then adjusted to better distribute stormwater inflows and to coincide with the locations of existing storm sewers that could serve to pass water out of the canal.

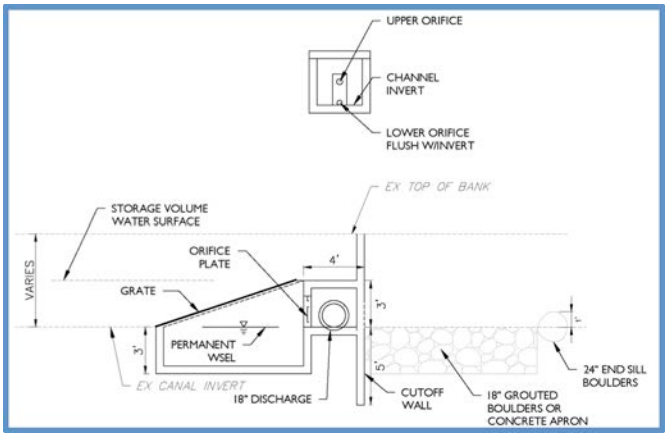


Figure 2: Structures like this will be at the ends and the midpoint of each canal reach. The end structures will drain the portion of the WQCV that is not lost to infiltration and ET into a receiving drainageway or existing storm drain. The midpoint structures will simply meter the volume from the upper segment into the lower segment for each reach.

It was quickly realized that separating each reach into two basins by constructing a berm at the midpoint of the reach, with the upstream segment draining to the downstream segment prior to discharging from the canal, would result in 30 to 40 percent more stormwater storage and treatment than would a single 1-mile basin. The structures at the midpoint and ends of each segment are envisioned as depicted in Figure 2.

The results of the CUHP/SWMM modeling show that many reaches of the canal have more capacity than what is required to treat the WQCV calculated for their tributary watershed; however, several reaches of the canal draining the larger tributary watersheds are only able to provide partial treatment of the WQCV. These watersheds will require additional upstream treatment facilities to fully treat the WQCV. These modeling results are summarized in Figures 3 and 4.

Large Storm Capacity Requirements

During the September 2013 flood events in the Denver metro area and in previous years, the High Line Canal was inundated with stormwater runoff and flow within the canal overtopped the canal banks at several locations. Immediately prior to previous intense rainfall events that caused the flooding, the HLC was carrying a base flow with a depth of approximately 3 feet. This is the approximate depth of flow that the canal has historically conveyed as an irrigation water delivery system in the last 20 or so years. Thus, when a storm event occurred while the canal was running, the capacity of the canal to carry stormwater runoff was limited to the surcharge area above the canal base flow. Similarly, one goal of this project is to allow the canal to carry stormwater runoff at levels that have been experienced in the recent past. Thus, the heights of the control structures have been limited to 3 feet in order to meet this constraint.

As an additional protection against canal bank overtopping, an emergency overflow facility should be considered during final design to minimize the potential negative effects of adding stormwater to the canal. Overflow facilities should be sized to remove the same flow rate from the canal that has been diverted into the canal for water quality treatment. The overflow facility could be located opposite either the inflow point into the canal segment or near the proposed outlet facility (if capacity exists) and at an elevation near the top of canal bank to avoid inadvertently discharging flows in excess of the water quality volume to allow the canal to continue conveying stormwater flows as it has historically.

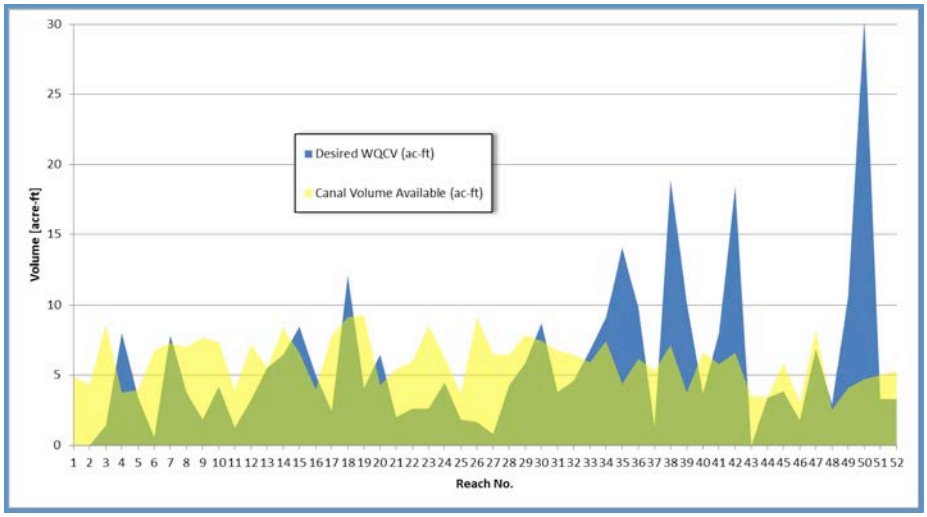


Figure 3: comparison of the volume available in each reach of the canal vs. the minimum volume necessary to fully treat the WQCV for the tributary watershed.

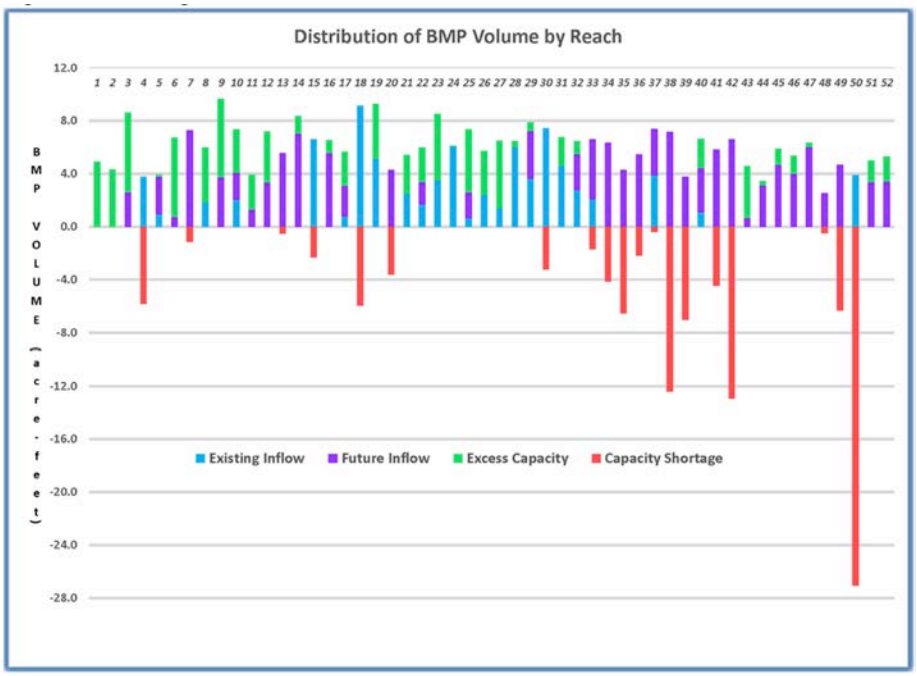


Figure 4: Reaches with existing inflows represent the most cost effective retrofit opportunities. Future inflows represent opportunities to reconstruct existing storm drains that currently cross under the canal. These reaches will cost much more to retrofit.

Costs

Two separate cost estimates were prepared. The first estimate was prepared for the proposed retrofit of the High Line Canal for water quality purposes. This estimate included the costs of the in-canal control and outlet structures as well as the outfall storm sewers and forebays needed to direct stormwater runoff into the canal, and did not include a value for land, as the canal already exists with no other value to that land besides carrying water. A summary of those costs by jurisdiction is shown in Table 1.

A second cost estimate was prepared assuming the canal could not be used for water quality treatment and thus an alternative method of obtaining water quality treatment for the subject watersheds would needed at some future time. Those costs, excluding annual operations and maintenance (O&M), amounted to $75.4 million, over twice the cost of providing stormwater treatment in the canal. It is important to note that this comparison may not be fair given that new development and redevelopment activities in the Denver region are required to provide flood control detention, and that stormwater treatment is typically placed in the same space as flood control.

Conclusions

It appears that repurposing the High Line Canal to provide water quality treatment is a feasible option. The concept is not without its detractors however and there are many concerns related to surface flooding from overtopping, basement flooding from seepage, aesthetics, odors, mosquitos, and possible injury to existing water rights. Additionally, until Denver Water finds alternate means of servicing its remaining water customers, stormwater infrastructure will have to accommodate water delivery flows with freeboard for flood events. Having said this, the majority of the project sponsors believe retrofitting the canal will provide many benefits for much less cost than any alternative means of providing those same benefits.

If the HLC is not repurposed to provide water quality treatment for stormwater runoff and to provide a water supply for existing vegetation, alternative infrastructure will ultimately be required to meet these needs. Acquisition of land and construction of infrastructure required for alternative water quality facilities will

Table 1: Cost Summary by Jurisdiction

Jurisdiction	Total Capital Cost - Control and Outfall Structures	Total Capital Cost - WQ Outfall Systems	Grand Total Capital Cost	Total Annual O&M Cost
Douglas County	$2,035,500	$5,105,022	$7,140,522	$211,158
Littleton	$796,500	$3,227,906	$4,024,406	$103,163
SEMSWA	$1,239,000	$3,146,876	$4,385,876	$138,611
Greenwood Village	$619,500	$575,511	$1,195,011	$55,591
Cherry Hills Village	$442,500	$596,292	$1,038,792	$41,791
Denver	$1,593,000	$6,288,625	$7,881,625	$185,371
Aurora	$2,124,000	$7,943,506	$10,067,506	$213,396
Totals	**$8,850,000**	**$26,883,737**	**$35,733,737**	**$949,081**

eventually be needed, but the more immediate and crucial need will be to prevent the loss of the existing stand of cottonwood trees along the length of the canal. Irrigation infrastructure and the cost of water will present a substantial cost to local entities.

Every design reach of the High Line Canal that has the capacity to treat the full WQCV of the tributary area is expected to remove 80 to 90 percent of the annual TSS load coming from that tributary area, along with proportionate percentages of nutrients and metals. The WQCV of all the tributary basins to the canal is approximately 297 acre-ft.

Thirty-one reaches can treat the full WQCV for their tributary watersheds; while another 18 reaches can treat some portion of WQCV of their tributary watersheds. The total storage deficit for those 18 reaches is 95 acre-ft, and even with that deficit, the canal is able to treat 202 acre-ft. of stormwater runoff for every precipitation event equal to or greater than the WQCV-sized event. If this volume of runoff were to be treated in a separate facility, an extraordinary amount of land would be required, some of it in already densely developed areas.

The Arapahoe County Open Space and Trails Advisory Board presented its annual *Our Progress Takes Flight* award to UDFCD. Holding the award is Executive Director Paul Hindman flanked by Arapahoe County Commissioner Nancy Sharpe and Board Chairman Paul Lopez.

The Colorado Association of Stormwater and Floodplain Managers received the 2014 Outstanding Chapter Award from the Association of State Floodplain Managers. Several UDFCD employees have been instrumental in building the organization. Two of them are Shea Thomas (holding the award) and Dave Bennetts (R) with Board Chairman Paul Lopez.

Using rainwater harvesting for stormwater control

Holly Piza, P.E., M.ASCE

Introduction

Conventional rainwater harvesting systems provide stormwater runoff volume reduction while also enabling use of stormwater for other water demands on site. However, they cannot be relied on for consistent stormwater treatment. The practice does not typically provide the volume required to capture the water quality capture volume (WQCV) when it rains because the cistern may already be full. This practice is further complicated in Colorado where western water law dictates that diverting and using rainwater for beneficial use is illegal without a water right.

In 2012, Urban Drainage and Flood Control District (UDFCD) received a temporary permit from the State allowing for the construction and evaluation of an above ground rainwater harvesting system on a new school building owned by Denver Public Schools (DPS). Per water law in Colorado, this system requires detailed accounting and augmentation.

The project is part of a Water Environment Research Foundation (WERF) study on high-performance stormwater control measures (SCM) that utilize cloud-based infrastructure. At this site, an 11.3 cubic meter (3,000-gallon) cistern collects rainwater from the roof of a school building and uses it for irrigation of the adjacent landscape areas. When available, the cistern will capture a rainfall depth of approximately 18 mm (0.7 inches), slightly larger than the water quality rainfall event in the Denver area. What makes this design unique, and specifically designed for treatment of stormwater, is that the system has a real-time connection to NOAA weather forecasting and will drain prior to an event, commensurate with the forecast, so that the volume is available for stormwater capture. The controls for this system are fully automated and can also be controlled remotely. Geosyntec Consultants developed the equipment assembly used to release and measure water evacuated from the system, as well as the software utilized for this purpose.

The primary goals for this study were to evaluate how using automated controls at the outlet of a SCM could improve efficiency; and to evaluate how effective rainwater harvesting in a semi-arid climate could be for stormwater management and irrigation water supply. This project is a partnership consisting of UDFCD, WERF, and DPS. The project is also made possible by an Urban Watershed Research Institute research grant, Denver Water's augmentation of rainwater used for irrigation, and the Denver Green School, where the system is located.

OptiRTC software, developed by Geosyntec Consultants, was used to provide data monitoring and automated control for the rainwater harvesting system. OptiRTC aggregates data from a number of components at the site and provides a cloud-based platform and real-time data for analysis and visualization on a web dashboard. At this site it also provides an adaptable system based on algorithms programed by Geosyntec Consultants. The system monitors NOAA weather forecasting and will purge the cistern in advance of a rain event of a user-specified probability.

For this site, determining the appropriate probability required close monitoring of storm events. If the probability is set too high the system may not purge, resulting in an overflow. If the probability is set too low, the system may purge unnecessarily. The Probability of Precipitation (PoP) was initially set at 70% for this project. Following initial monitoring of the system, Geosyntec recommended and set the PoP at 60 percent. When the chance of a rainfall event is 60% or greater, the system will evaluate the volume available in the cistern, and if necessary will purge the cistern to ensure that that volume is available. For example, if NOAA forecasts 13 mm of rain with a 60 percent probability and the cistern is full, a valve will automatically open and drain the cistern commensurate with the rooftop tributary area multiplied by 13 mm multiplied by a user-defined runoff coefficient. Water drained from the cistern is slowly released to the storm drain system. Figure 1 shows the configuration of the rainwater harvesting system.

Rainfall and Sizing of the Cistern

This area of Colorado receives approximately 380 mm (15 inches) of precipitation per year. The system was designed to provide irrigation water for surrounding landscape areas from

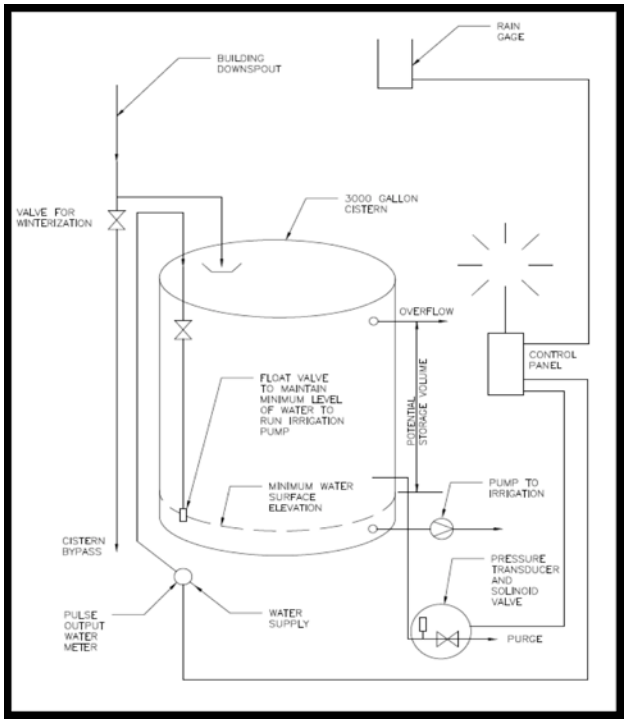


Figure 1. Denver Green School rainwater harvesting schematic.

mid-April through September. Approximately two-thirds of the total annual precipitation is anticipated during this timeframe. Historically, May is the wettest month, receiving over 51 mm (2 inches) on average and September is the driest month receiving less than 25 mm (1 inch).

WQ-COSM, a continuous simulation model was used to assist in sizing the cistern. This is a statistical model used for optimizing water quality capture volume. Thirty years of rainfall data for the Denver area were used to run the model. It was assumed for the purpose of this evaluation that all stored runoff would be used over a period of 72 hours. Based on the output of the model an 11.3 cubic-meter (3,000-gallon) cistern was selected. Based on the assumptions used in running the model, this size cistern should capture approximately 85 percent of the total precipitation during the period from April through September. Considering dead storage and the elevation of overflow for the constructed cistern, less than 85% should be anticipated.

The area of the roof draining to the cistern is approximately 678 square-meters (7,300 square-feet). For this watershed, an 11.3 cubic meter (3,000-gallon) cistern corresponds to a capture volume associated with approximately 18 mm (0.7 inches) of rainfall. The water quality capture volume in this area is the runoff volume associated with 15 mm (0.6 inches) of rainfall, which corresponds to the 80th percentile event.

The size of the landscaped area to be irrigated with this water was not a consideration in designing the cistern. However, water use is relevant to the study and irrigation data are included in this article. The area of irrigation can be described as follows: in 2012, when the project began, three irrigation zones were established and planted with drought tolerant species. Two areas contain perennials and one area was seeded with grasses. The total area to be irrigated was approximately 186 square-meters (2,000 square-feet). In 2013, additional perennials were planted and the irrigation schedule for establishment of new plants continued in all three zones. At the end of 2013, several plants in zone one and two were lost due to school kids trampling the area. Zone one also had clay soils and very high sun exposure that did not support the perennials. In May 2014, the school decided to stop irrigation in zone one and created different use for this area. The school received a donation at the same time for new perennials in zone two and three. For these reasons, irrigation demand has been relatively consistent because every year it has been scheduled to help establish new plantings. However, it should be noted that the area of irrigation was reduced from approximately 186 square-meters (2,000 square-feet) to approximately 111 square-meters (1,200 square-feet) beginning in 2014.

Data and Analysis

Volume reduction and irrigation supply. This article includes all data collected from September 25, 2012 through September 11, 2014. On average for all data collected, the system reduced stormwater runoff on a per event basis by 88 percent and provided 76 percent of the irrigation demand.

In 2012 the PoP was changed to 70 percent, because at the original 60% the system was being purged too frequently. A balance is required between having the volume available when it does rain, but otherwise retaining the water for irrigation. In September the cistern overtopped twice. At no time during the two months of monitoring in 2012 was the solenoid valve enabled. A total of six rain events totaling 23 mm (0.9 inches) occurred during September and October and the system reduced stormwater runoff by 77 percent on a per event basis. It should be noted that stormwater purged from the cistern was considered reduced in calculating volume reduction. One hundred percent of the irrigation used in the surrounding landscape areas came from rainwater in 2012.

In 2013 the cistern overtopped twice in July. The solenoid valve enabled on August 5th and again on August 6th allowing for 59 percent capture of rain events totaling 18 mm (0.7 inches) on August 7th and 8th. In September the Denver area experienced widespread flooding. The rain gage at this site recorded 132 mm (5.2 inches) over three days, a value in excess of the one percent probability rainfall event. Eleven percent of this storm was captured. The solenoid valve was enabled twice in late September, allowing for additional capture of subsequent storms although more precipitation occurred then was forecasted. In mid-September, the PoP was reduced to 60 percent. A total of 23 rain events totaling 274 mm (10.8 inches) occurred in June through September. On average, the system reduced stormwater runoff by 83 percent on a per event basis. Fifty-four percent of the irrigation used in the surrounding landscape areas came from rainwater in 2013.

In 2014 Denver experienced a particularly wet year with 43 rain events spaced relatively evenly throughout the season. The longest period of no precipitation was 19 days. The cistern overtopped twice in 2014. On July 14 the cistern overtopped during a rain event totaling 6 mm (0.25 inches), capturing 90 percent of this storm. On July 29th it overtopped again after capturing 26 percent of a 51 mm (2.0-inch) rain event. The solenoid valve was enabled 16 times. This allowed for 100 percent capture of nine storms that followed purging of the cistern. It should be noted that on four occasions the solenoid valve was enabled twice prior to a single storm event. A total of 43 rain events totaling 196 mm (7.7 inches) occurred May through September 11th. On average, the system reduced stormwater runoff by 92 percent on a per event basis in 2014. Ninety-one percent of the irrigation used in the surrounding landscape areas came from rainwater in 2014.

Cistern overtopping for a rain event that exceeds the capacity of the empty cistern is normal and expected. Cistern overtopping after it was purged but did not create enough

volume is an indication that either different programming would help, or that errors in forecasting contribute to inefficiencies of the system. Determining why the cistern overtopped is a way of evaluating the system performance without getting too far into the data.

Water quality. In 2013 three samples were collected from the discharge pipe of the cistern or an irrigation head. Samples were tested for E. coli and other constituents. E. coli in all samples was below detection limits. Other constituents including nutrients and metals were below concentrations found in typical stormwater runoff in the Denver area. Detection of E. coli was not anticipated at this site as the roof of the structure has no tree cover and therefore, no apparent source for pathogens (i.e., birds).

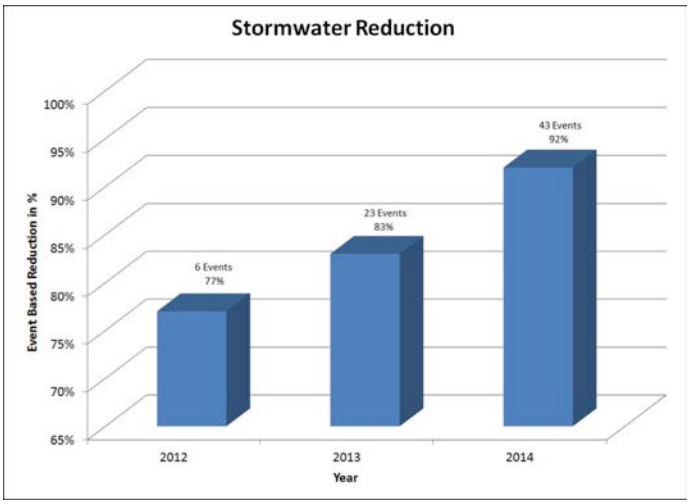
Project Costs

The cost of the cistern, pump, and downspout totaled $4702. The cost of the OptiRTC was $15,000 for a total cost of $19,702. This project also received partial funding of the OptiRTC from WERF. Funding provided by WERF has not been included in the above costs. All costs are based on actual cost paid in 2012. Denver Water provided augmentation of diverted rainwater at the cost of $100 per year.

Conclusions

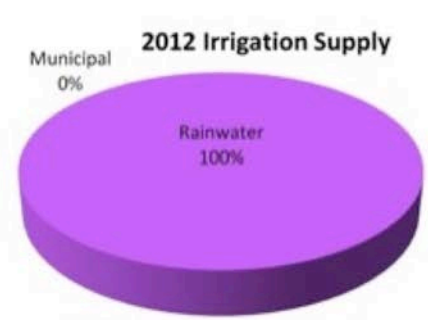
Effectiveness of cloud-based infrastructure for stormwater management. Substantial volume reduction can be achieved by pairing cloud-based infrastructure with on-site SCMs. Data from all years combined show an 88 percent volume reduction in the average storm event. This exceeds volume reduction reported by the International BMP Database for normally dry vegetated BMPs (SCMs), which were found to be more effective than other BMPs in the database. Bioretention with underdrains was found to be most effective for volume reduction with over 50 percent reduction. (International BMP Database, 2011) This value of reduction can only be realized if the evacuated water from the cistern is discharged to a location where it can be used, infiltrated, or otherwise reduced.

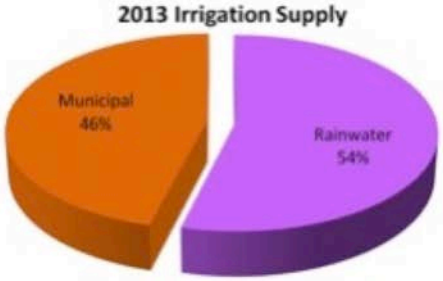
At this site, a second SCM could not be constructed for this purpose. However, given the slow rate of release from the cistern when the solenoid valve is enabled, it may be possible to achieve a second SCM on site with a minimal footprint. This type of system would also be effective in a

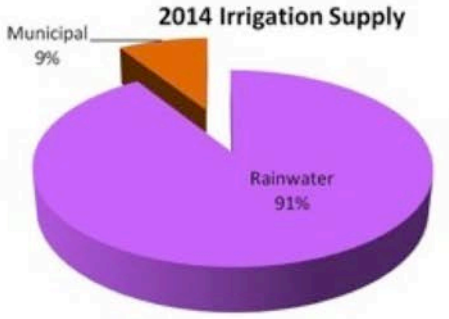


community with a combined sewer overflow (CSO), where enabling the valve and releasing water from the cistern in advance of the storm event would allow a greater volume of water to be treated before the storm and a reduction in untreated wastewater entering the receiving water.

Effectiveness of rainwater harvesting for supplemental irrigation water in the Denver area. Rainwater harvesting can provide significant reduction in irrigation demand for sites with a large rooftop to irrigated landscape area ratio (e.g., 3:1). Other water saving techniques such as the use of rain sensors and native plants and grasses will improve the effectiveness of rainwater harvesting for supplemental irrigation water. Although the current cost of water is relatively inexpensive, (approximately three dollars per thousand gallons for residential use), the cost of a water tap can be a significant consideration [e.g., A 19 mm (three-quarter inch) water tap in the Denver area costs over $8000 and a 25 mm (1-inch) tap is in excess of $19,000]. When a planned rainwater harvesting system is used to reduce the size of the required water tap, the cost savings could be in excess of the harvesting system infrastructure cost.







Implementation of the Sacramento Soil Moisture Accounting Model for Douglas County, CO

Markus Ritsch, P.E., Water & Earth Technologies, Inc.; Kevin Stewart, P.E., UDFCD, and Garth Englund, P.E., Douglas County, CO

Through a cooperative program between the Urban Drainage and Flood Control District and Douglas County in 2014, Water & Earth Technologies, Inc. (WET) implemented the Sacramento Soil Moisture Accounting (SSMA) rainfall-runoff model to provide operational forecasts of stream flow on East Plum Creek. The SSMA was implemented for East Plum Creek with the lower forecast point being co-located at the USGS stream gage upstream of the Haskins Gulch confluence near Castle Rock. The ALERT gaging station #2820 is coincident with a USGS stream gage.

The SSMA model is a native component within the NovaStar5 base station software application used by UDFCD. The ALERT monitoring network provides real-time rainfall input to the model. NovaStar5 can run the SSMA at different time steps ranging from 15 minutes to 6 hours.

The SMA is a conceptual, lumped parameter model that provides a simplified representation of the physical runoff process. The fundamental concept in the SSMA is that the soil column has two soil zones; an upper zone and a lower zone. The first represents the upper soil layer and interception storage while the lower zone represents the bulk of the soil column and ground water storage. Within both zones there is tension water capacity and free water capacity. Tension water is held tightly to soil particles and can only be depleted as evapotranspiration. Free water can move both horizontally and vertically through the soil profile. Free water can be depleted by evapotranspiration or drained as surface runoff, interflow, percolation and ground water base flow.

The SSMA employs a unit hydrograph that converts runoff generated from the model into instantaneous discharges. Together the SSMA and unit hydrograph models are used to simulate and forecast hydrologic stream conditions.

The SSMA was selected for three reasons: 1) it is implemented at very low cost because it is native to the currently running NovaStar5 base station software, 2) it is a continuous simulation model that tracks soil moisture conditions through time and 3) a regional parameter set was obtained from the National Weather Service (NWS). The NWS also uses the SSMA to prepare river basin forecasts across the U.S.

In Colorado, the NWS runs the SSMA for the South Platte River basin out of its Missouri Basin River Forecast Center (MBRFC). The NWS forecast point nearest our basins of interest is Plum Creek at Sedalia (Figure 1). The SSMA parameter set utilized by the MBRFC for Plum Creek at Sedalia was applied directly to our implementation of the SSMA for East Plum Creek above Haskins Gulch without alteration. The Plum Creek at Sedalia MBRFC forecast point has a tributary area of 275 square miles. East Plum Creek at Haskins Gulch drains 116 square miles.

The primary input to the SSMA is basin rainfall. Basin rainfall, in this case, is derived from the real-time ALERT monitoring network using a predetermined set of Thiessen station weights to generate a mean areal precipitation time series representative of each sub-basin. The modeled basins

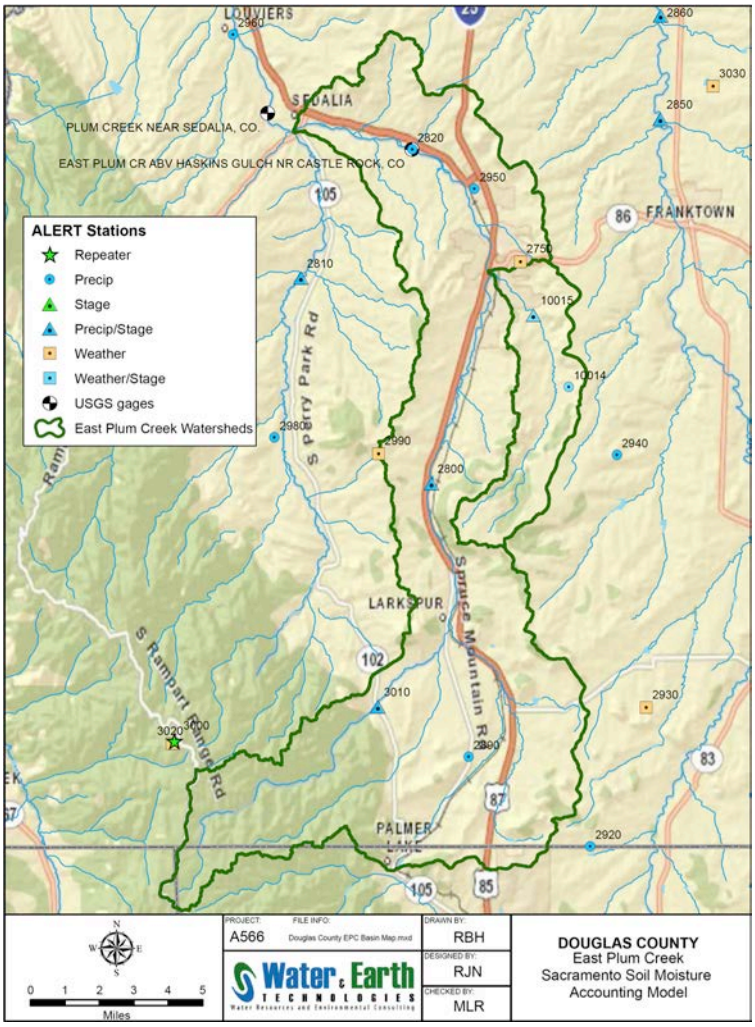


Figure 1. Plum Creek Watershed Map

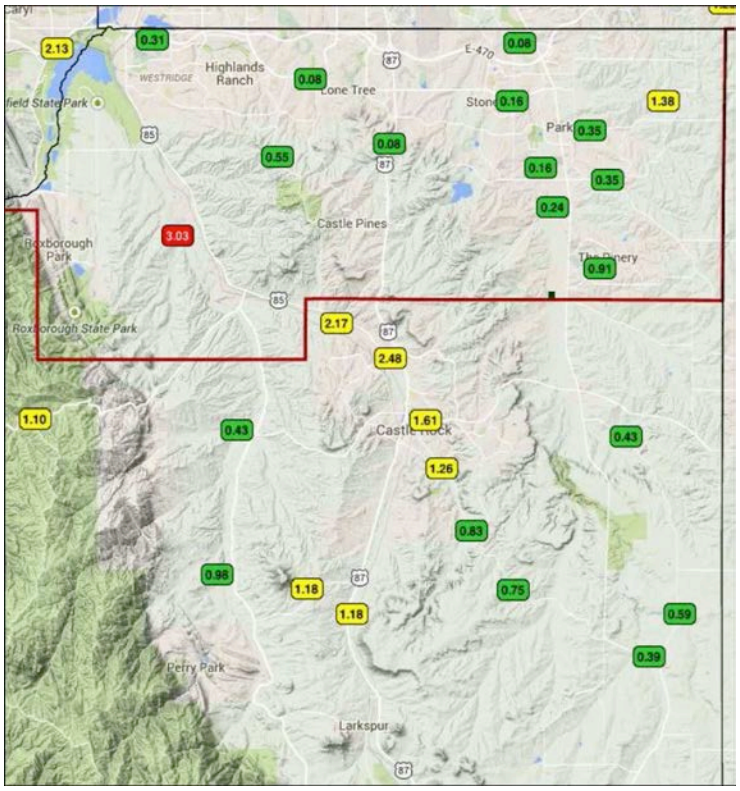


Figure 2. Six-Hour Rain Totals for July 12, 2014

and the ALERT gage locations are shown on the Figure 1. Station weights are assigned within NovaStar5, which then generates the basin average rainfall time series and supplies this time series to the SSMA.

The first real test of the SSMA occurred on July 12, 2014. Heavy rainfall began in the late afternoon and persisted into the evening during a 3-hour storm with rain totals exceeding two inches in the East Plum Creek watershed (Figure 2).

From a meteorological perspective, deep low-level moisture was in place due to thunderstorm outflow boundaries that pushed through during the previous night. Training thunderstorm cells moved over Douglas County prompting NWS to issue Flash Flood Warnings.

The USGS gage at East Plum Creek above Haskins Gulch recorded a peak discharge of 1,180 cfs at approximately 9:00 PM on July 12, 2014 (Figure 3). The USGS station stopped recording data just before midnight on July 12.

NovaStar5 runs the SSMA on a 15-minute time step, producing forecasts that extend 90 minutes into the future. The model runs continuously every 15 minutes. The simulated flow forecast (blue line) relative to the measured USGS discharge (green line) for the period July 11 through July 14, 2014 is shown on Figure 4. The basin rainfall (red line) is plotted vertically from the top of the plot. The observed data from the USGS includes an interpolation for the period of missing measured data. Overall, the NovaStar5 SSMA flow forecast matches the discharge measured by the USGS very well. UDFCD and Douglas County are encouraged by this early success and hope to add alarm and notification functionality to the simulated flow forecast to obtain additional lead-time for emergency responders. UDFCD may also consider further implementations of the SSMA incorporating radar-rainfall estimates as inputs to the model.

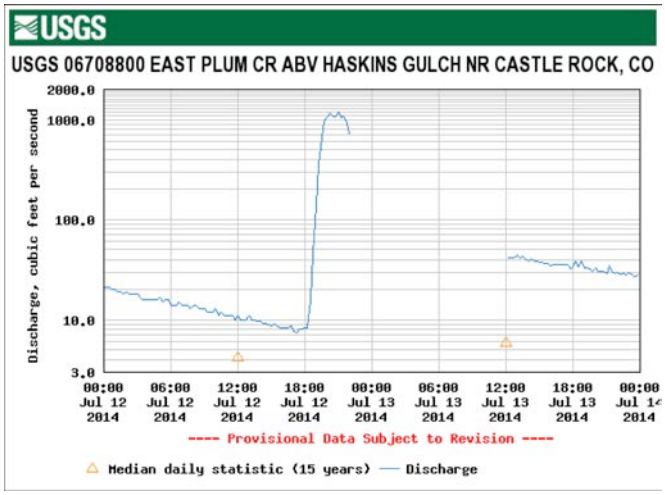


Figure 3. USGS Instantaneous Discharge for July 12, 2014

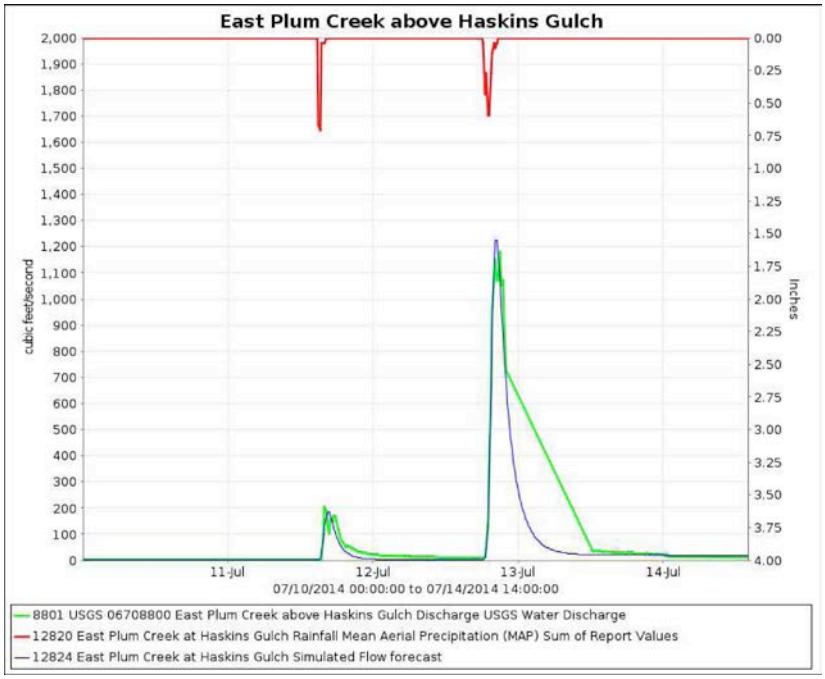


Figure 4. NovaStar5 Simulated Flow Forecast for July 12 Storm

2014 Professional Activities of District Staff

Paul Hindman, Executive Director

*Co-Chair of Cherry Creek Stewardship Partners annual "Run for the Watershed"
*Moderator, 2014 Cherry Creek Stewardship annual conference
*Committee member, APWA National House of Delegates transition to Council of Chapters
*Member, APWA National President nominating committee
*Member, APWA National Water Resource Committee
*Moderator, Public Works Stormwater Summit, American Public Works Association (APWA) International Congress & Exposition, Toronto, Canada
*Co-presenter, "Tired of the Dog Fight? Effectively Creating Change", APWA International Congress & Exposition, Toronto, Canada
*Board Member, National Association of Flood and Stormwater Management Agencies
*Board Chair, Colorado County Officials and Employees Retirement Association
*Ambassador, Backpacks to Briefcases, Adams County School District
*Sponsor, 9 to 5 Adams County Commissioner's' Career Expo
*Board Member, One Water One World (OWOW)

Kevin Stewart, Manager, Information Services and Flood Warning Program

*National Hydrologic Warning Council (NHWC) Board Member and Past President
*U.S. Department of the Interior Advisory Committee on Water Information, Subcommittee on Hydrology
*Member: ASCE, APWA, ASFPM, CASFM, NHWC, American Meteorological Society (AMS), and Colorado Emergency Management Association
*Opening speaker at APWA Colorado Chapter's 2014 Construction Inspection Conference in Greenwood Village, CO in February
*Presented *Operating a Flood Alert System from Data to Decisions* at NHWC Colorado Advanced Flood Warning System Workshop in February
*Panel participant on *Risk & Response* at CASFM/CSU-sponsored 2013 Colorado Flood Forum in Broomfield in February
*Invited presenter on *UDFCD Flood Warning & Threat Assessments for 2014* at FEMA Flood Recovery Coordination Cell Meeting in Centennial in March
*Wrote article entitled "2013 Flood Season Recap" for *Colorado Water*, a publication of the Water Center of Colorado State University, March/April 2014 edition
*Presented *Comprehending the Consequences of the September Floods of 2013* at UDFCD Annual Seminar in Denver in April
*Invited presenter on *The Importance of Streamgages in the aftermath of the Colorado Floods of September 2013* at separate USGS Congressional Briefings for the US Senate and House of Representatives staff at the U.S. Capitol in Washington, DC in May
*Presented *Never Let Your Guard Down – Lessons for ALERT System Managers and Operators from the Colorado Floods of September 2013* at the ALERT Users Group 25th Flood Warning Systems Training Symposium in Reno, NV in May
*Panelist on *Colorado Flooding* at AMS 21st Conference on Applied Climatology and 17th Symposium on Meteorological Observation and Instrumentation in Westminster in June
*Invited attendee at The White House Innovation for Disaster Response and Recovery Initiative Demo Day and selected participant in small group workshop on *Predictive Analytics* at The White House in Washington, DC in July
*Program speaker on *Categorizing the September 2013 Colorado Floods* at CASFM Social in Arvada in August
*Invited speaker at National Weather Service Central Region Hydrology Program Managers Meeting, NWS/NOAA Training Center in Kansas City, MO in September
*Invited speaker on *2013 Floods* at the South Platte Coalition for Urban River Evaluation (SPCURE) in Denver in September.
*Attended CASFM 25th Annual Conference in Vail in October
*Program speaker on *How a 1000-year Rainfall Causes a 25-Year Flood* at Boulder Torch Club Meeting in October
*Invited speaker on *Epic Colorado 2013 Floods – Lessons Learned* at NHWC Pacific Northwest Advanced Flood Warning Systems Workshop in Grand Mound, WA in October

Ken MacKenzie, Manager, Master Planning Program

* Invited speaker at the Flood Risk Management Conference in Edinburgh, Scotland on February 4 & 5
*Participated in NACWA's 2014 Region 8 Integrated Planning Workshop in Denver, CO on March 31
*Presented "*Green Infrastructure Criteria and Policies*" at the American Water Works Sustainable Management Conference in Denver, CO on April 1
*Presented "*UD-FSD—a New Tool to Size and Design Full Spectrum Detention Basins"* at a CASFM Lunch & Learn training event in Denver, CO on April 16
*Presented "*Green Infrastructure & LID Criteria, Policies, and Plans"* at the 2014 Stormwater Equipment Manufacturers Association Annual Meeting in Denver, CO on May 14
*Guest Lecturer at the University of Colorado on October 7
*Presented "*Quantifying the Flood Reduction Benefits of Green Infrastructure and Low Impact Development*" with Dr. Andrew Earles at the National Association of Flood and Stormwater Management Agencies in Boston MA on October 16
*Guest Lecturer at Colorado State University on October 20
*Stormwater Committee Chair for the National Association of Flood and Stormwater Management Agencies (NAFSMA)
*Treasurer of the Board of Directors of the Urban Watershed Research Institute (UWRI)
*Steering Committee Member for the 2015 Municipal Water Infrastructure Council Symposium in Austin, TX
*Task Committee Chair for the Municipal Water Infrastructure Council of the Environmental and Water Research Institute (EWRI) of ASCE
*LID Committee member for the Urban Water Resources Research Council of EWRI
*Served on ASCE Transportation & Development Institute's Permeable Pavement Committee in development of a national standard on design of permeable pavements
*Served on the Water & Environment Research Foundation (WERF) committee creating a model to link stormwater BMP systems performance to receiving stream protection
*Steering Committee Member for the Colorado Stormwater Center
*Member of EWRI, NAFSMA, ASFPM, WERF, & CASFM

David Bennetts, Manager, Design, Construction & Maintenance Program

*Moderator of the *Risk and Response* track at the CASFM Flood Forum in February in Broomfield, CO
*Co-presented *New Approaches to Project Management* at the District's annual Seminar in April in Denver, CO
*Co-presented *A Flood Control District's Perspective of the 2013 Colorado Floods* at the River Management Society's Annual Conference in April in Denver, CO
*Instructor for APWA's Public Works Institute in June in Denver, CO; and November in Montrose, CO
*Co-presented *A Flood Control District's Perspective of the 2013 Colorado Floods* at ASFPM's Annual Conference in June in Seattle, WA
*Co-presented *A Flood Control District's Perspective of the 2013 Colorado Floods* at APWA's Annual Conference in August in Toronto, Canada
*Moderator of the *Stream Restoration* track at CASFM's annual conference in October in Vail, CO
*Attended APWA's Colorado Chapter Conference in October in Denver, CO
*Panelist on *5th Annual Stream Restoration Panel Discussion* at the Sustaining Colorado Watersheds Conference in October in Vail
*Moderator of *Restoration Case Studies: Urban Systems* at the Sustaining Colorado Watersheds Conference in October in Vail
*Guest Lecturer for CU Denver's "Masters of Engineering in Construction Engineering Management – Construction Engineering" class in October in Denver, CO
*Council Member, CU Denver Engineering Leadership Council and Construction Engineering and Management Advisory Board
*Board Member Colorado Riparian Association
*Member of ASCE, APWA, ASFPM, CASFM

David Mallory, Manager, Floodplain Management Program

*Co-chair of the Floodplain Management Committee of the National Association of Flood and Stormwater Management Agencies (NAFSMA)
*Board Member & Treasurer of the Natural Hazard Mitigation Association (NHMA)
*Additional Memberships in the Association of State Floodplain Managers (ASFPM), the Natural Floodplain Function Alliance (NFFA) and the American Public Works Association (APWA)
*Appointed to FEMA's Technical Mapping Advisory Committee (TMAC) as the CTP local government representative
*Attended the NHMA Annual Board Retreat held in Washington DC, January
*Presented *Cooperating Technical Partners (CTP) Lessons Learned* at the NAFSMA Mentoring Session held in Sugar Land, Texas, February
*Attended the CASFM Colorado Flood Forum, February
*Presented *Working Together to Reduce the Misery Caused by Foreseeable Natural Events* at the Critical Infrastructure Symposium held in Colorado Springs, April
*Presented *Floodplain Management Program, Under New Management* with Terri Fead at the UDFCD Annual Seminar held in Denver, April
*Participated in the FEMA/ASFPM/NAFSMA partnership meeting held in Washington DC, April
*Presented *A Whole Community Approach To Resilience* at the CHART Workshop held in Alexandria, Louisiana, May
*Attended the ASFPM Annual Conference held in Seattle, June
*Attended the first TMAC meeting held in Washington DC, September
*Presented *A September to Remember, Was it Foreseeable?* at the ABA Local and State Government Law Section meeting in Denver, October
*Attended the NAFSMA Annual Meeting held in Boston, October
*Organized a field trip and presented *Stormwater Management Systems as Mitigation* at the ASFPM National Flood Mitigation and Flood Proofing Workshop held in Broomfield, October
*Attended the second TMAC Meeting held in Washington DC, December

Laura A. Kroeger, Assistant Manager, Design, Construction & Maintenance Program

*Rocky Mountain Public Works Institute Steering Committee Chair, first class graduated in October
*ACEC Scholarship Committee
*Presented on "Importance of Stream Health" with David Bennetts and Mary Powell, ERO at UDFCD Seminar
*Wrote article in the *APWA Reporter*, October addition titled, "Branding your Department"
*Participated as a speaker for a Click, Listen and Learn program through APWA on "Executive Soft Skills"
*Presented "Tired of the Dog Fight, Effectively Creating Change" at APWA Congress in Toronto, Canada
*Lead Rocky Mountain Public Works Institute class on Leading Change and Creating an Effective Team, Montrose, CO

Bryan Kohlenberg, Project Manager, Design, Construction & Maintenance Program

* Continued as National Society of Professional Engineers' (NSPE) scoring coordinator for the Jefferson County, North Metro and Colorado State MATHCOUNTS competitions for 6th, 7th and 8th graders
*Member of ASCE, APWA, ASFPM, IECA, Chi Epsilon Alumni, and CASFM
*Attended 2014 IECA Environmental Connection Conference in Nashville, February
*Attended IECA Denver Transit Eagle P-3 Site Tour, May
*Attended APWA Colorado Chapter Conference, October
*Attended 2014 IECA Mountain States Chapter Winter Conference, November

Rich Borchardt, Project Manager, Design, Construction & Maintenance Program

*Attended APWA – Colorado Chapter's Awards Banquet in January
*Attended CASFM's Flood Forum in February
*Attended UDFCD's Annual Seminar in April
*Presented "Floods and Safety" at Denver Water Fest in May
*Attended CASFM's Annual Conference in October
*Attended APWA – Colorado Chapter's Annual Conference in October
*Attended "Ennegram, Leveraging the Power of Personality" training in November

Shea Thomas, Project Manager, Master Planning Program

*Presented "*You Plan for It…Then It Happens – A Flood Control District's Reflection on the 2013 Colorado Floods*" at the River Management Society conference in Denver, Colorado in April
*Presented "*You Plan for It…Then It Happens – A Flood Control District's Reflection on the 2013 Colorado Floods*" at the ASFPM conference in Seattle, Washington in June
*Presented "*SWIFT – StormWater InFormation Tool*" at the ESRI User Conference in San Diego, California in July
*Presented "*You Plan for It…Then It Happens – A Flood Control District's Reflection on the 2013 Colorado Floods*" at the APWA Congress in Toronto, Canada in August
*Presented "*A September to Remember*" at the UFSMA annual conference in Bryce Canyon, Utah in September
*Attended the CASFM annual conference in Steamboat Springs, Colorado in October
*Served as Vice Chair of CASFM
*Served on the Conference and Scholarship Committees for CASFM
*Served on the Stormwater Management and Floodplain Management Committees for NAFSMA

Barbara Chongtoua, Project Manager, Design, Construction and Maintenance Program

*Speaker on the Evolving Floodplain Management Presentation at the Cherry Creek Stewardship Partners 2014 Conference, Parker, Colorado
*Secretary for the ASCE EWRI Stormwater Infrastructure Committee
*Committee Member for the Colorado Riparian Association
* Moderator for the ASCE EWRI 2014 National Congress
*Attended ASCE EWRI Congress 2014 in Portland, Oregon
*Attended Cherry Creek Stewardship Partners Annual Congress in Englewood, Colorado
*Active Member of ASCE, APWA, Chi Epsilon, ASFPM, CRA, and CASFM
*Member of ASCE EWRI Urban Water Resources Research Council, Water, Wastewater, and Stormwater Council, Stormwater Infrastructure Committee and National Safety Standards for Storm Water Facilities Sub-committee, Urban Stream Restoration Committee

Holly Piza, Project Manager, Master Planning Program

*Served as a panelist for School of Mines Career Fair on February 6th in Golden, CO
*Co-instructor for training course on *BMP Maintenance and Inspection* for the Colorado Stormwater Center on March 10-11, March 20-21, May 15-16, and October 29-30 (various locations throughout the UDFCD boundary)
*Co-presented *Hazardous Sediments in Stormwater* at the UDFCD Annual Seminar on April 5th in Denver, CO
*Presented *Our Role With Water* at the Denver Metro Water Festival, on May 21 in Denver, CO
*Presented *Maintaining Filtering BMPs* at the Front Range Environmental Managers Meeting on June 17th in Colorado Springs, CO
*Organized and lead the annual field trip for the Colorado Association of Stormwater and Floodplain Managers (CASFM) on July 9th
*Co-instructor for training course *Stormwater BMP and LID Selection, Design and Economics* on September 25-26h in Denver, CO
*Presented the Denver Green School (DGS) rainwater harvesting site to Denver Water and Colorado Springs Utilities on October 21st
*Participated in the Adams County Commissioners' Career Expo, speaking to some of the approximately 6,000 8th grade attendees (November 18th)
*Co-presented *Bioretention in the Desert* at the ASLA Annual Meeting and Expo on November 21 in Denver, CO
*Task Committee Chair for the Municipal Water Infrastructure Committee (part of the Environmental and Water Research Institute (EWRI) of ASCE
*Steering Committee Member for the Colorado Stormwater Center
*Served as the CASFM Stormwater Quality Committee Chair
*Member of ASCE/EWRI, WERF, & CASFM

Dave Skoudas, Project Manager, Design, Construction & Maintenance Program

*Member of ASCE, CASFM, ASFPM, APWA
*Attended APWA Congress in Toronto, Canada
*Instructor for Presentation Workshop for the APWA Public Works Institute
*Instructor for Presentation Workshop for CASFM Lunch and Learn
*Instructor for Presentation Workshop for APWA Younger Members Group
*Guest Lecturer for UC-Denver Construction Management Graduate Class
*Panelist for 2013 Flood Panel Discussion at CASFM Flood Symposium
*Panelist for 2013 Flood Panel Discussion at APWA Colorado Chapter Conference
*Panelist for 2013 Flood Panel Discussion at ASCE Colorado Chapter March Meeting
*Presented *Boulder County and Adams County Flood Recovery* at CASFM Metro Social
*Presented *How to Define Success, Then How to Achieve It* at CASFM Annual Conference
*Co-Presenter for *Engineering Forensics: Recreating Fourmile Canyon* at CASFM Annual Conference
*Presented *Partnerships and Multi-Objective Planning* at the Colorado Watershed Symposium

Terri L. Fead, P.E., CFM, Project Manager, Floodplain Management Program

*Member of ASCE, NSPE, CASFM and ASFPM
*Attended 2013 Colorado Flood Forum sponsored by CASFM and CSU, February
*Attended Managing Floodplain Development through the NFIP, CASFM, March
*Attended E0241 CTP Special Topics Training at EMI, March
*Co-Presented '*Floodplain Management Program "Under New Management"* at UDFCD Annual Stormwater and Floodplain Management Seminar, April
*Participated in ND Grants Online Grantee Training by FEMA, May
*Participated in Flood Resistant Design CodeMaster webinar by FEMA, May
*Attended Nonstructural Flood Risk Mitigation in Conjunction with BW-12 and HFFIA, USACD, June
*Attended ASFPM Annual Conference, June
*Attended Annual Natural Hazards Research and Applications Workshop, Natural Hazards Center, June
*Attended 2014 NHMA International Practitioners Symposium, NHMA, June
*Attended Colorado Flood Proofing and Flood Recovery Workshop by CWCB/USACE, September
*Attended 2014 CASFM Annual Conference, October
*Attended 6th National Mitigation and Floodproofing Workshop by ASFPM, October
*Member of Cherry Creek High School Engineering Physics Advisory Committee

Teresa L. Patterson, Project Engineer, Floodplain Management Program

*Member of CASFM and ASFPM
*Co-Presented "Double Duty or Double Trouble: Design Considerations for Pedestrian Underpass through Drainage Structures" at Montana Storm Water Conference, April
*Co-Presented "Urban Storm Water Planning-A Case Study" at Montana Storm Water Conference, April
*Attended UD-FSD CASFM Lunch & Learn, April
*Attended UDFCD Annual Stormwater and Floodplain Management Seminar, April
*Participated in Grimm-Waters Meets Biggert-Waters: Impacts and Implications webinar, April
*Attended Managing Floodplain Development through the NFIP, April
*Attended 2014 NHMA International Practitioners Symposium, June
*Attended The Secrets of Giving an Effective Presentation CASFM Lunch & Learn, July
*Attended Dam Safety Practices & Hydrology by UWRI, August
*Co-Presented Flood Recovery and Rebuilding Workshop (FEMA/CWCB/UDFCD), September
*Attended 2014 CASFM Annual Conference, September
*Attended 6th ASFPM National Mitigation and Floodproofing Workshop, October
*Participated in Denver Regional Dam Safety Emergency Preparedness Workshop (CO-DNR), November
*Participated in NAI, the CRS, and the new NAI How-To Guides webinar, December
*Participated in Understanding Flood Zone Determination: Essentials for Floodplain Managers webinar by ASFPM, December
*Participated in Cooperating Technical Partner Information Exchange: Digitizing Unmodernized FIRMS webinar (ASFPM), December

Julia Bailey, Information Services Engineer, Information Services and Flood Warning Program

*Member American Public Works Association (APWA)
*Attended the ESRI Annual International Users Conference in San Diego, CA in July
*Attended the APWA International Public Works Congress in Toronto, Canada in August
*Steering Committee member for EMWIN-Denver (Emergency Managers Weather Information Network)
*Completed APWA Emerging Leaders Academy as a member of Class 7

Mike Sarmento, Senior Construction Manager, Design, Construction & Maintenance Program

*Received a Bachelor of Science Degree (Cum Laude) in Land Use –Environment and Resources from Metropolitan State University of Denver
*Accepted as Master of Science Degree Candidate in Ecological Restoration at University of Florida
*Co-Presented "Simplifying Stormwater Permitting for Maintenance Activities and Small Projects in Waterways" with Jennifer Keyes of Wright Water Engineers at the IECA National Congress in February
*Co-Presented "Riparian Floodplain Stewardship Initiative at Urban Drainage and Flood Control District" with Jenelle Kreutzer of ERO Resources at the Society of Wetlands Scientists (Rocky Mountain Chapter) Annual Meeting in April
*Co-Presented "Weir Gulch at S. Platte River" project to The City Park Alliance Tour with Michael Bouchard of Denver Parks and Recreation in July
*Coordinated and co-managed the Cherry Creek at Fourmile House Bank Stabilization project for students with the Volunteers for Outdoors Colorado with Barbara Chongtoua and Will Comerer
*Co-Presented the Kelly Road Dam tour with Barbara Chongtoua and Will Comerer of UDFCD, Kevin Lewis of Denver Public Works, and Mike Earnest with City of Aurora for the Logan School elementary students in April
*Attended the Fish Passage Workshop in Berthoud, CO in January
*Attended APWA Colorado Chapter Construction Inspector Conference in February
*Attended UDFCD Annual Conference in April
*Attended the Cherry Creek Watershed Conference in October 2014
*Member of American Public Works Association, Society for Wetlands Scientists, Colorado Riparian Association and Society for Ecological Restoration
*NICET – Certified Senior Engineering Technician Highway Construction (Level IV)
*Engineering Technician and Land Management & Water Control: Erosion and Sediment Control (Level III)
*American Institute of Hydrology – Certified Level III Water Quality Technician

Steve Materkowski, Senior Construction Manager, Design, Construction & Maintenance Program

*APWA Congress
*CO APWA Inspectors Conference
*CO Emergency Management Conference
*CO APWA Rep: State All Hazards Advisory Committee
*District Rep: SPCURE
*Attended UWRI Dam Safety Course
*Presented "Confluence at the Confluence" at SPCURE
*Presented "Wassup with Stormwater" at Metropolitan State University of Denver
*Presented at River Management Conference - Denver
*Presented at APWA Public Works Institute – Emergency Management Module

Joe Williams, Senior Construction Manager, Design, Construction & Maintenance Program

*Attended the 2014 UDFCD annual Stormwater and Floodplain Management Seminar
*Attended the 2014 APWA Colorado Awards Program
*Attended the 2014 APWA Construction Inspection Conference
*Attended the 2014 Mountain States Chapter of IECA Winter Conference
*Continued membership into the American Public Works Association (APWA)
* Continued membership into the International Erosion Control Association (IECA)

Jeff Fisher Senior Construction Manager, Design, Construction & Maintenance Program
*Continued membership in the International Erosion Control Association (IECA)
*Continued membership in American Public Works Association (APWA)
*Attended the APWA Construction Inspection Conference in February
*Attended the UDFCD annual Stormwater & Floodplain Management Seminar in April
*Attended the APWA Colorado Chapter Conference in October
*Attended the Mountain States Chapter of IECA Winter Conference in December

Darren Bradshaw, Construction Manager, Jefferson and Broomfield County – Design, Construction & Maintenance Program
*Continued membership in Association of State Floodplain Managers (ASFPM)
*Continued membership in the International Erosion Control Association (IECA)
*Continued membership in American Public Works Association (APWA)
*Continued certification for the ASFPM Certified Floodplain Manager (CFM)
*Attended the APWA Construction Inspection Conference in February
*Attended the IECA Environmental Connection Conference in Nashville, February
*Attended the UDFCD annual Stormwater & Floodplain Management Seminar in April
*Attended the APWA Colorado Chapter Conference in October
*Attended the Mountain States Chapter of IECA Winter Conference in December

Joanna Czarnecka, Construction Manager, Floodplain Management Program
* Member of the Colorado Association of Stormwater and Floodplain Managers (CASFM), Association of State Floodplain Managers (ASFPM) and the American Public Works Association (APWA)
*Attended Water Rights Engineering by UWRI, February
*Attended Managing Floodplain Development through the NFIP by CASFM, March
*Attended UD-FSD CASFM Lunch & Learn, April
*Attended UDFCD Annual Stormwater and Floodplain Management Seminar, April
*Participated in Grimm-Waters Meets Biggert-Waters: Impacts and Implications webinar, April
*Attended 2014 NHMA International Practitioners Symposium, June
*Attended The Secrets of Giving an Effective Presentation CASFM Lunch & Learn, July
*Attended Dam Safety Practices & Hydrology by UWRI, August
*Co-Presented Flood Recovery and Rebuilding Workshop (FEMA/CWCB/UDFCD), September
*Attended 2014 CASFM Annual Conference, September
*Attended 6th ASFPM National Mitigation and Floodproofing Workshop, October
*Participated in Denver Regional Dam Safety Emergency Preparedness Workshop (CO-DNR), November
*Participated in NAI, the CRS, and the new NAI How-To Guides webinar, December
*Participated in Understanding Flood Zone Determination: Essentials for Floodplain Managers webinar (ASFPM), December
* Member of CASFM CRS Committee

Urban Drainage and Flood Control District
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