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# Flood Hazard News

An annual publication of the Urban Drainage and Flood Control District

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## Commemorating the 50<sup>th</sup> Anniversary of the 1965 Flood

By

Kevin Stewart, UDFCD; Bill DeGroot, UDFCD retired;  
and Bryan Kohlenberg, UDFCD

Fifty years ago the Denver area was beginning a long recovery process from its worst disaster in modern times, brought forth by the destructive flooding of June 16-17, 1965. No one alive at that time had ever seen anything like it. The damages then were comparable in magnitude (~\$4 billion in current dollars) to Colorado's more recent experience...the "September-to-Remember" floods of 2013. This article will attempt to draw some contrasts between those two major flood events, but the main goal is to remember the earlier event and highlight the good things that have happened over the past five decades largely in response to the infamous 1965 Flood.

### Contrasts

Living with a new normal became a theme in the aftermath of the 2013 floods. This premise was equally true for Denver area residents in 1965. So much has been written about the '65 flood over the years that to recount too many specifics would be redundant. But some recap of the details from 1965 is needed to gain a clearer picture of the risks people face today, primarily as it relates to the South Platte River.



FRIDAY, JUNE 18, 1965



SATURDAY, JUNE 19, 1965

The '65 Denver flood originated in the Plum Creek watershed in Douglas County south of Castle Rock from a storm that produced upwards of 14 inches of rain over a 3 to 4 hour period. Ten-inch plus rains also fell in the Cherry Creek basin causing an estimated peak flow rate of 39,900 cfs at the old Melvin gaging station located downstream of Piney Creek in the flood pool of Cherry Creek Reservoir. This event was larger than the major flood that occurred in August of 1933 when the Castlewood Canyon Dam failed. Had Cherry Creek Dam and Reservoir not been there in 1965, the losses along Cherry Creek through Denver would have been devastating.

The large rain totals from the June 16, 1965 storm were similar to 2013 figures, but they occurred over a much shorter time period. In 2013, while 7-day totals approached 18 inches, maximum 24-hour measurements were closer to 12-inches and the peak 6-hour measurement from automated rain gauges was just slightly more than 6-inches. In other words, the '65 rainstorm was in a league by itself when compared to 2013.

Damages along Plum Creek and its two major tributaries, East and West Plum Creek, were extensive and the peak flows were much higher than the regulatory (100-year) discharges used today. The following table compares some of the estimated 1965 flood peaks with the 100-year (1% annual chance) and 500-year (0.2% annual chance) published flow rates for Plum Creek and the South Platte River:

Location	1965 Peak Flows (CFS)	Q100/Q500 (CFS)
East Plum Creek near Castle Rock	126,000 (6/16)	15,800 / 26,400
West Plum Creek at Sedalia	36,800 (6/16)	11,700 / 19,200
Plum Creek at Louviers	154,000 (6/16)	39,100 / 70,400
South Platte River at Littleton	110,000 (6/16)	12,700 / 22,000
South Platte River at 19 <sup>th</sup> Street	40,300 (6/17 @ 0145)	22,000 / 35,000

#### Fatalities

News reports occasionally leave false impressions about what really happened in June of 1965. More than one story last summer commemorating the flood made reference to 21 lives that were lost while showing shocking pictures of damages along Plum Creek and the South Platte River. Research for this article revealed that the South Platte River Basin claimed between the 8 and 13 lives. The other 10 or so

Colorado fatalities occurred in the Arkansas River Basin. At least 2 deaths were directly related to flooding in the Plum Creek drainage basin in Douglas County. Although the

numbers differ somewhat between sources, not a single source reported any direct flood-related deaths along the main stem of the South Platte River—an interesting detail considering the massive devastation that this river valley suffered. Compared with 2013, both floods claimed lives in the South Platte and Arkansas River basins, but the statewide totals from 1965 were over twice the number of flood-related deaths that occurred in September of 2013.

#### Preventing Future Catastrophes

Every flood disaster of the magnitude of the 1965 flood sparks actions to prevent that disaster from happening again, and the response to this flood was no exception. Among the actions taken were the following:

- Development of the *Urban Storm Drainage Criteria Manual* by the Denver Regional Council of Governments (DRCOG), with a grant from the US Department of Housing and Urban Development (HUD)
- Creation of the Urban Drainage and Flood Control District (UDFCD) by the State of Colorado
- Construction of Chatfield Dam and Bear Creek Dam by the federal government through the U.S. Army Corps of Engineers (USACE)
- Creation by Denver of the Platte River Development Committee (PRDC), later to become the Greenway Foundation. Later on, suburban “greenway” organizations were formed upstream and downstream of Denver.

An organization called the Five County Engineer’s Council was instrumental in pursuing the idea of a regional flood control entity. The council membership included county engineers from Adams, Arapahoe, Boulder, Denver and Jefferson Counties. Also included were engineers from Public Service Company, Mountain Bell, Denver Water Board, Littleton, Englewood, Portland Cement Association and Wheat Ridge Water and Sanitation District. State Senator Joe Shoemaker became involved in 1967.

The council became the Metropolitan Urban Drainage Advisory Committee of DRCOG in 1967. DRCOG hired Wright-McLaughlin Engineers to prepare the *Urban Storm Drainage Criteria Manual* (USDCM); and the Advisory Committee helped DRCOG with policy questions during preparation of the USDCM. The policy decisions and an article by Shoemaker entitled “An Engineering-Legal Solution to Urban Drainage Problems” which appeared in the *Denver Law Journal* became the framework for UDFCD’s formation.

The Advisory Committee decided to pursue legislation in 1969 that would create an Urban Drainage and Flood Control District. Senator Shoemaker introduced the legislation, which passed; and UDFCD’s first Board of Directors meeting was held in July of 1969. Starting with a staff of two and a small planning budget, the District has grown in a very careful and responsible way to its current size and scope. The USDCM was turned over to UDFCD to maintain.

An early study showed that 26% of Denver area drainageways had developed to the point that some new flood control facilities would be needed to achieve 100-year protection, but that the other 74% “lend themselves to non-construction measures, which will preserve them as flood plains, preventing future loss of human life and property damage.” In 1973, UDFCD’s Board of Directors adopted a two-pronged approach of remedial projects in developed areas and preventive actions for undeveloped floodplains by establishing the Design and Construction, and the Floodplain Management Programs

Chatfield Dam was built at the confluence of the South Platte River and Plum Creek (the major source of floodwaters in 1965) south of Denver to reduce flood risks in the Denver area. Construction was begun in 1967 and completed in 1975, storing runoff from a total drainage area of about 3,018 square miles. The flood pool area is now operated as a state park and has become the most popular park in Colorado.



**South Platte Park includes land acquired by the USACE and City of Littleton**

In another development; in 1974 Congress, for the first time ever, at the request of the City of Littleton, authorized the USACE to use federal funds earmarked for an outlet channel

from Chatfield Dam for floodplain acquisition instead, which became part of South Platte Park. Littleton was also a major contributor of funds for the project.

Bear Creek Dam was the last of three dams built by the USACE, with Cherry Creek Dam, completed in 1950, being the first. The dam, located at the confluence of Bear Creek and Turkey Creek on the west edge of the City of Lakewood, holds back runoff from a drainage area of 236 square miles. It was authorized in 1968 but not completed until 1982. The flood pool area is managed as a park by Lakewood. Bear Creek Lake clearly prevented flood damages in both 2013 and 2015. Collectively Cherry Creek, Chatfield, and Bear Creek Dams are known as the Tri-Lakes Project.

In 1974 Denver Mayor Bill McNichols created the nine-member PRDC, with Senator Shoemaker serving as chair; with the charge to start revitalizing the South Platte River. Two years later it became a non-profit organization called The



**The USACE Tri-Lakes Projects provide flood protection for the urban core of the Denver area**

Greenway Foundation, which made it easier to raise funds from private sources. As noted above, its success encouraged the formation of other organizations to extend the greenway upstream and downstream, as well as on any number of tributaries. According to the [Greenway Foundation’s 2015 Annual Report](#) “...over \$500 million has been invested into the river and its parks and trails...”

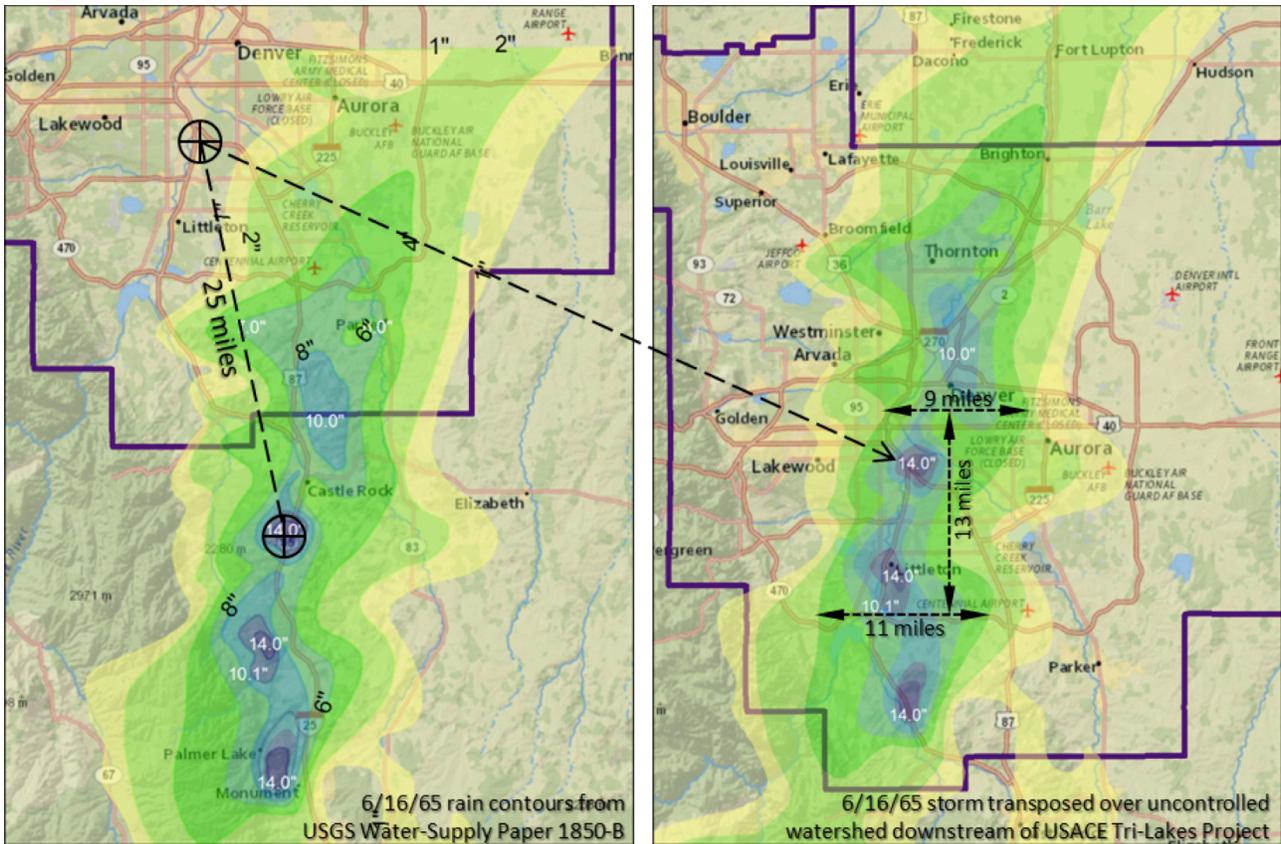
Over the last 46 years UDFCD has gone from Master Planning to adding a Floodplain Management Program and a Design and Construction Program, then a Maintenance Program and finally the South Platte River. The Flood Warning and Information Services Program spun off from the Floodplain Management Program, and stormwater quality expertise was added to the Master Planning Program.

As the UDFCD added programs and staff, it also established important policies that have endured to the present. Among those were to: 1) maintain a small staff; 2) maximize reliance on the private sector; 3) require matching funds for planning, design and construction projects; and 4) return revenues through projects to the counties they came from.

The population of the District has roughly tripled since it was formed in 1969. In spite of this large amount of urbanization, there are approximately 5,000 fewer units (e.g. single family residence = 1 unit, duplex = 2 units) in mapped 100-year floodplains. This statistic is a testament to the wisdom of the two-pronged approach envisioned over 40 years ago.

### Could it happen again?

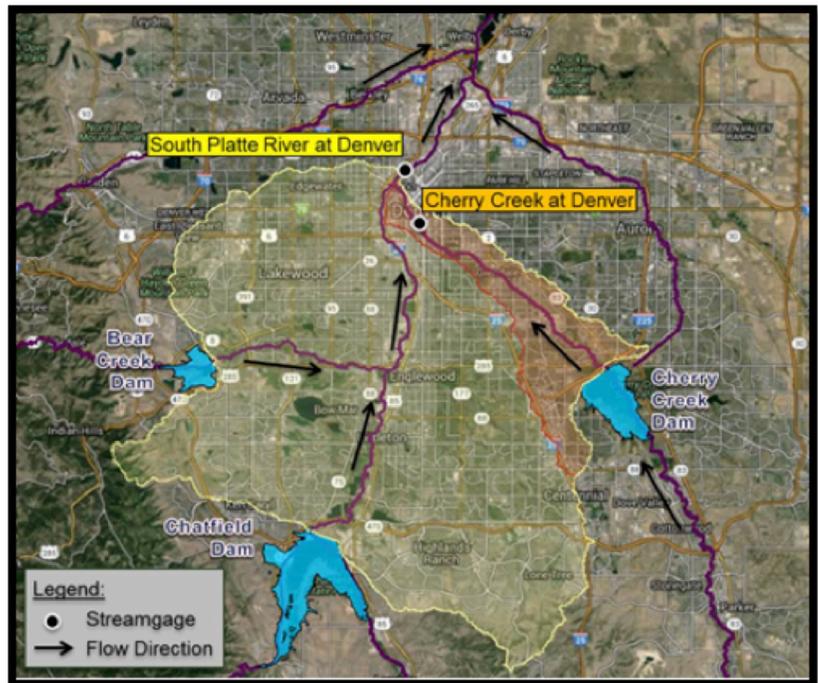
There is little doubt that if a repeat performance of the June 16, 1965 downpour occurred over the Plum Creek watershed today; many bridges, roadways, and buildings in Douglas County would again be heavily damaged by overbank flooding; but not the areas along the South Platte River through Denver. Chatfield Dam and Reservoir has effectively mitigated that risk. To put a slightly different spin on this



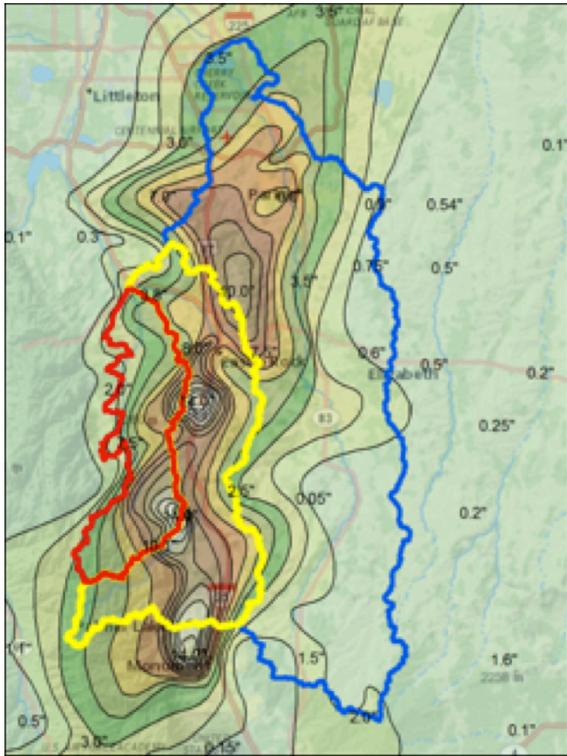
Rain contours from 1965 (left) transposed to an area downstream of the USACE Tri-Lakes dams

question, let's consider what might happen if a rainstorm of similar magnitude occurs about 25 miles further north. The two figures above show rain depths taken from a [USGS flood report](#). The figure on the right illustrates what the 1965 storm would be like with a 14-inch rain amount near the I-25/Santa Fe Drive interchange in Denver.

Note the coverage of the 4-inch plus rains (darker green). Where Cherry Creek joins the South Platte River at Confluence Park, the width of that 4"+ coverage is over 9 miles. On the south side along C-470 the width is about 11 miles with the length between being about 13 miles. This represents roughly 130 square miles over a portion of the South Platte River watershed that is not controlled by the Tri-Lakes Project (see map on right). The size of this large heavily urbanized "uncontrolled" drainage area is about 220 square miles.



Uncontrolled drainage area below the Tri-Lakes Projects



**Plum Creek watershed with 1965 rain contours**

GIS analysis of the 1965 rain contours over the Plum Creek watershed (see map above) revealed that the basin average rainfall at the confluence of East and West Plum Creeks (where the yellow and red lines meet) was 6.2 inches over an approximate 200 square mile effective drainage area. Note that the watershed representation on the map does not include the entire drainage basin of West Plum Creek since little or no runoff occurred from the western portion of that watershed. The total drainage area of East and West Plum Creek is actually 274 square miles.

From the table above we find that the peak flood flow downstream of this confluence point (Plum Creek at Louviers) was estimated at 154,000 cfs. This equates to a unit discharge of 770 cfs/sq.mi. At another point in the watershed (East Plum Creek near Castle Rock), the USGS estimated a unit peak of 1,170 cfs/sq.mi. These are both huge numbers. Another way to understand how extreme this flood was is to compare these numbers with the published 500-year discharges. At the Louviers gage that flood peak was more than twice the 500-year and at the Castle Rock location, the same comparison was almost a 5-fold difference.

Finally, let's revisit the "uncontrolled" drainage area downstream of Chatfield, Cherry Creek and Bear Creek Dams by focusing on the Denver stream gage at 19<sup>th</sup> Street. First, like the Plum Creek effective drainage basin in 1965, we have a watershed area of over 200 square miles to generate stormwater runoff. Second, the area is highly urbanized with lots of impervious features unlike the Plum Creek watershed in 1965, or today for that matter. Third, a somewhat weak

and frequently debated argument can be made that 30+ years of implementing stormwater management measures for new developments effectively controls runoff to pre-development rates. For the sake of this illustration, let's accept this premise. Then, if climate experts and meteorologists can agree that big rains like the 1965 storm can still occur that are capable of averaging 6 inches or more over large areas, say 200 square miles, then the final question becomes—could a flood peak at the South Platte River at Denver gage reach the 40,000 cfs threshold experienced in June of 1965? To be fair to our stormwater management proponents, let's assume a unit peak discharge of 500 cfs/mi<sup>2</sup> is a reasonable guess. Then a hydro-meteorologist might forecast that the expected flood peak for the South Platte River at Denver gage would be (500x200) **100,000 cfs**, which is 2.5 times larger than the 1965 flood. Now one final question--what do you believe?

**Life is good along the South Platte River.**

The 1965 Flood forever changed Denver and the surrounding metro area. The massive undertakings described in this article could not have happened without the involvement of many local governments, special districts, state and federal agencies, and non-profit organizations. The partnerships that evolved since 1965 have had a profound impact on the Denver region and the entire state. Working together, much has been achieved over the past 50 years to make the South Platte River through the city an incredible amenity. Today, people freely enjoy life on the South Platte; except when those floodwaters return to remind us all that risks still exist.



**Confluence Park looking upstream along the South Platte River**

# Hind' sight

By Paul A. Hindman

*Timely Comment from the District's Executive Director*



In last year's *Flood Hazard News*, I talked about the proposed legislation to allow dry detention basins to be constructed without obtaining a water right. Through a combined effort of many people, the legislation was passed which will allow local governments to manage their floodwaters as they have been doing for many years. I want give special thanks to Ken MacKenzie, Manager of UDFCD's Master Planning Program, who went above and beyond to make this happen. Without his technical analysis, thoughtful insight, and perseverance, I doubt this legislation would have passed (see Ken's article following this one).

Another big effort for 2015 included the District's first ever staff retreat. All employees were involved, and Mountain States Employers Council (MSEC) facilitated it.

Like any organization, it's healthy to take some time to reflect on where you have been and what direction you are headed. The last 45 years has gotten us to some great heights because of previous leaders, like Scott Tucker, who had a vision on what the District could be. In addition to reflecting on the past, present, and future of the District, we had several other reasons to take on this effort, including:

- Reflect on previous year's goals and set strategic direction for the future goals
- Explore organizational concerns or potential obstacles
- Make sure we are aligned with our Vision and Mission
- Team building; motivate and energize staff / build better relationships

We ventured into this endeavor with high hopes but also a bit of nervous apprehension. With this being a new practice for the District, we weren't sure what it would entail or what the outcome would be. Fortunately, we found the process refreshing as it allowed employees to step away from their daily environment/roles and see each other with a wider lens and a different perspective. MSEC did a terrific job coming up with clever ways to get our creative juices flowing with different formats for conversations as well as collaboration.

It all came together on April 22<sup>nd</sup>. Everyone was a little anxious but energized and ready to tackle the job of where the District could improve. After a full day's work (and a few follow-up meetings) there came a list of goals as well as an action plan for accomplishing those goals. We'd decided the best approach would be to create committees and working groups that would focus on the different topics generated from the retreat.

Working groups were developed for accomplishing specific objectives; and once the goals have been reached,

the group would then disband. Committees were developed with more of a quasi-permanent existence in mind, tackling long-term/ongoing objectives. The goal was to have the committees and working groups comprised of staff at every level and program. Below is a list of the committees and work groups that were generated.

## Committees

Name	Description
Student Intern	Provide structure for interns to increase their training and experience
Safety	Office and field safety, office emergency action plan, Identify safety trainings
GIS	Identify ways to enhance GIS capabilities across programs, georeference more data (LOMR/CLOMRs, hydrology, etc.)
Social	Increase non-work interaction; team building (holiday party, potlucks, picnics, ski trips, etc.)

## Work Groups

Name	Description
Collaborative Project Management	Identify under what set of conditions this delivery system makes the most sense, evaluate impacts on efficiency and staffing needs, develop methodology for creating project teams to accomplish local government requested projects (cross-program / multi-disciplinary). Evaluate feedback from participants; make recommendations as to the efficacy of this model.
Succession Planning	Develop methodology for cross-training, identify opportunities for growth in a flat organization, re-examine organizational structure, mentoring, development of succession plans, equal access to training & development.
Flood Documentation	Develop guidelines & specifications for deliverables focused on georeferencing and e-access (includes photos, videos, polygon extents, etc.)

Once the committees and working groups were identified, we quickly realized that in order to ensure their success, some thought should be given to which groups should be implemented first while others may benefit from developing at a later date. We knew that trying to tackle too many initiatives at the same time would be taxing on staff's schedules and might not produce the best results.

There were also a few great ideas that would be given serious consideration but wouldn't necessarily need a working group or committee to move forward. These included the development of a wellness program and exploring cross-program training opportunities. These items were taken on by key individuals with the support of management.

Then there were other suggestions that, unfortunately, won't be coming to fruition anytime soon, like having a "nap room" or a "bring your dog(s) to work day". Maybe the staff will be able to convince the next Executive Director to initiate these, but for now the answer is no.

Overall, the retreat effort was a success but it also wasn't the end of the story. Starting in 2016, the District hired Arrow Performance Group to help us develop a strategic plan and construct a succession plan that will dovetail into the retreat effort.

These kinds of efforts are not easy to accomplish and take a lot of time. However, in the end they will help us chart our path into the future of stormwater and our role in serving the Denver Metro area.

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## New State Legislation Created to Protect Stormwater Detention and Infiltration by Colorado Cities and Counties

By Ken MacKenzie, Program Manager, Master Planning Program

### Background

UDFCD has been recommending flood mitigation through detention and controlled release of flood flows since 1972, and stormwater quality management through detention, slow release, and infiltration of the water quality capture volume since 1992. These recommendations apply to onsite management as well as regional management; the latter being a more cost-effective approach since on a regional level the economy of scale comes into play with regard to construction and maintenance. With detention and slow release, we can reduce the maximum flow rates to approximate the predeveloped runoff rate for a spectrum of storm events ranging from the 2-year to the 100-year event; improving water quality while providing a high level of flood protection to downstream properties and also reducing erosive forces in our receiving streams. Local governments across Colorado require stormwater management through detention, and it has been implemented in watersheds throughout the state.

### Legal issues with Colorado water rights administration

The Colorado Department of Natural Resources' Division of Water Resources (DWR, also known as the Office of the State Engineer) performs many state water resource-related duties, including administration of water rights and monitoring of water use. With regard to stormwater management and water rights, the DWR published a memorandum on May 21, 2011 titled "Administrative Approach for Storm Water Management." This document outlined what limited approaches to stormwater detention and infiltration qualified under the State's administrative approach, indicating that administrative allowances would be made for individual sites, those being defined as discrete areas that were each developed through one development effort. It should be noted that these administrative allowances did not offer protection from a claim of material

injury by a water user. That document closed with the statement:

*These are administrative allowances that allow storm water to be managed while minimizing the impact to water rights. These allowances cannot be applied to precipitation that falls onto an area not on the individual site.*

In April 2013, a DWR water commissioner informed the City of Aspen's stormwater manager that the City might have to calculate and augment the water losses caused by evapotranspiration during storage of storm events in several regional water quality detention basins the City owns and operates, indicating that the DWR's 2011 memorandum on the state's administrative approach for stormwater management applied only to individual sites and not to regional facilities.

The City of Aspen requested support from UDFCD and in May 2013 UDFCD sent a letter to DWR requesting "concurrence regarding de minimis impacts to water rights from regional water quality detention, and for clarification of administrative allowances for regional water quality." It was our hope that the State would expand the scope of the 2011 memorandum to include the regional stormwater quality treatment that is our most effective means of treating urban runoff in regional flood control facilities and is also intrinsic to full spectrum detention. The DWR replied in a letter dated June 5, 2013, stating that:

*Due to the uncertainty on the question of whether the benefit of retiming the hydrograph for the public good supersedes a priority claim that may benefit from water that results from urbanization, we are unwilling at this time to make the same administrative allowance for regional or watershed detention.*

Following that letter UDFCD met on two occasions with DWR to discuss how we could continue to fulfill our duty to protect the health, safety, and welfare of the citizens of

Colorado with regard to stormwater pollution reduction within the Colorado water rights framework. Ultimately, DWR sought a legal opinion from the Colorado Attorney General's office.

The DWR received the legal opinion from the Attorney General's office, and, in April 2014, responded to UDFCD. In that letter DWR explained that with regard to the question of impact, Colorado has no legal recognition of a threshold amount of injury that is "de minimis," meaning that any deprivation of water to a water user with a right to the water is injurious, even if that deprivation is with regard to timing alone. Among other things, the letter stated:

*The diversion of these flows for regional water quality detention has all the components necessary to be termed an appropriation and as such constitutes a diversion of water for a beneficial use. When that diversion takes place at a time when senior water rights are not satisfied, the Division Engineer has the responsibility to curtail the diversion... if the diversion is not curtailed, holders of water rights downstream of the regional water quality detention facilities can make a claim of material injury...*

The April 2014 letter went on to state:

*...while a Federal agency may require such regional water quality detention, that requirement does not supersede state water administration and water right protections due to the fact that the provisions of the WQCA, Section 25-8-101 et seq., C.R.S., and the Clean Water Act ("CWA"), 33 U.S.C. Section 1251 et seq., were expressly subordinated to Colorado's constitutional prior appropriation system.*

The State's newly formulated position would have hindered our efforts to protect the health, safety, and welfare of the citizens of Colorado with regard to flood protection and stormwater pollution reduction, and this was patently unacceptable. We felt at this point that if the law prohibited us from doing good, then the law was bad. We had no choice other than to seek legislative protection for our activities.

### **A legislative solution**

We formed a statewide taskforce to solicit legislative relief in the form of a state bill defining these activities as non-injurious to water rights and protecting them from curtailment by the DWR and from baseless lawsuits by holders of water rights. The Colorado Stormwater Council's support was instrumental. We committed UDFCD funding and received matching funds from Colorado communities including Arapahoe and Douglas Counties, Aurora, Denver, Golden, Highlands Ranch, Lakewood, Littleton, SEMSWA, and Westminster. Many others offered additional funding assistance. We collected letters and resolutions of support from 40 communities across the State and from organizations like CASFM, the Colorado Chapter of ASCE, the Metro Mayors Caucus, the Pikes Peak Council of Governments, the Cherry Creek Basin Water Quality Authority, and many more. We hired Bennett Raley of the law firm *Trout, Raley, Montano,*

*Witwer & Freeman, P.C.*, and we hired Julie McKenna of the lobbying firm *Brandeberry McKenna Public Affairs*. Our ultimate success was as much attributable to their invaluable efforts as it was to anything else. We won the support of the Colorado Municipal League, Colorado Counties Inc., the Colorado Water Congress, and even the Colorado Farm Bureau, although support from these last two was certainly not unanimous.

Colorado Senator Jerry Sonnenberg (R-1) took up our cause in the form of Senate Bill 15-212 "*Storm Water Facilities Do Not Injure Water Rights*." A northeastern Colorado rancher and farmer, Senator Sonnenberg was also the chair of the Senate Water Resources Review Committee which made him an ideal bill sponsor. Opposition to SB 15-212 came almost entirely from the Arkansas River basin downstream of Pueblo, where many landowners attempt subsistence farming based on water rights so junior that they can only collect and store irrigation water when the Arkansas River is at or near flood stage. Animosity between this group and the upstream cities and counties, particularly in the tributary Fountain Creek watershed is well documented, and they arrived at the Statehouse committee hearings by the busload to denounce the proposed bill with emotionally charged (if not misguided) rhetoric. To our dismay, this ultimately resulted in an amendment to the bill excluding many stormwater detention and infiltration facilities within the Fountain Creek watershed from protection under the statute. A few water lawyers opposed the bill simply for the sake of posturing, or based on their intentionally disingenuous interpretation of the bill's intent, or on their belief that Colorado water law is sacrosanct and should hence forever be immune from change.

Weekly webinars informed supporters of the bill's progress through the Senate Water Resources Review Committee and then the House Local Government Committee. The bill was amended three times, in an effort to address the concerns of the opposition. Ultimately, Senate Bill 15-212 passed as amended in the House by a vote of 60 to 4 and in the Senate by a vote of 33 to 2, and was signed into law by Governor Hickenlooper, becoming effective on August 5, 2015 as Colorado Revised Statute (CRS) §37-92-602 (8).

### **What it means to Colorado cities and counties:**

This statute provides legal protection for any regional or individual site stormwater detention and infiltration facility in Colorado, provided the facility meets the following criteria:

1. It is owned or operated by a governmental entity or is subject to oversight by a governmental entity (e.g., required under an MS4 permit),
2. It continuously releases or infiltrates at least 97% of all of the runoff from a rainfall event that is less than or equal to a 5-year storm within 72 hours after the end of the event,
3. It continuously releases or infiltrates as quickly as practicable, but in all cases releases or infiltrates at least 99%

of the runoff within 120 hours after the end of events greater than a 5-year storm,

4. It operates passively and does not subject the stormwater runoff to any active treatment process (e.g., coagulation, flocculation, disinfection, etc.),

5. If it is in the Fountain Creek (tributary to the Arkansas River) watershed, it must be required by or operated in compliance with an MS4 permit.

The statute specifies that runoff treated in stormwater detention and infiltration facilities shall not be used for any other purpose by the owner/operator/overseer (or that entity's assignees), shall not be released for subsequent diversion or storage by the owner/operator/overseer (or that entity's assignees), and shall not be the basis for a water right or credit.

There are specific notification requirements that apply to all new stormwater detention and infiltration facilities, including individual site facilities built by private parties as a development requirement. For any stormwater detention and infiltration facility constructed after August 5, 2015 and seeking protection under the new statute, the "entity that owns, operates, or has oversight for" shall, prior to operation of the facility, provide notice to all parties on the substitute water supply plan notification email list maintained by the State Engineer. This notice must include the following:

1. The location,
2. The approximate surface area at design volume,
3. Data that demonstrate that the facility has been designed to comply with the release rates described in Items 2 and 3 above.

The DWR maintains seven email lists, one for each of the seven major watersheds in Colorado (these coincide with the seven DWR Divisions). UDFCD worked with DWR and the Colorado Stormwater Council to develop a simple data sheet and an online map-based compliance portal website that allows all municipalities and counties in Colorado to easily upload this required notification information. The website application automatically sends email notifications to the proper recipients, relieving public works staff of the emailing burden while also minimizing the volume of email going out to the email list recipients.

The notification requirement applies only to new stormwater facilities (constructed after August 5, 2015), which the statute provides a "rebuttable presumption" of non-injury to water rights. This rebuttable presumption is contestable but only by comparison to the runoff that would have been generated from the undeveloped land condition prior to the development necessitating the stormwater facility. Stormwater facilities in existence before August 5, 2015 are defined in the statute as materially non-injurious to water rights and do not require notification.

### **Conclusion**

The success of this legislative effort was directly attributable to the strong relationship and mutual respect between UDFCD and the cities and counties of Colorado, and was the result of a lot of hard work by the dedicated leaders and staff members of those communities who banded together through the Colorado Stormwater Council, the Colorado Water Congress, and other organizations to create this new law safeguarding our duty to protect the health, safety, and welfare of the citizens of Colorado.

# Master Planning Program

Shea Thomas, Senior Project Engineer and Ken MacKenzie, Program Manager

## Master Planning Projects

We completed 10 planning studies and two flood hazard area delineation studies in 2015, with seventeen additional projects under way; and we plan to begin seven new planning studies in 2016.

To date, UDFCD has completed a total of 110 major drainageway planning (MDP) studies, 93 outfall system planning (OSP) studies, and 99 flood hazard area delineation (FHAD) studies, which includes many updates to studies completed in the past.

## Urban Storm Drainage Criteria Manual

In December 2015 we completed a major update of the Urban Storm Drainage Criteria Manual (USDCM), Volumes 1 and 2. Please see Holly Piza's article on the major changes in this new version. All three volumes of the USDCM are now available in pdf format on our web page (<http://udfcd.org/criteria-manual>) for download. We encourage you to check the website frequently for the latest updates.

## Join UDFCD on LinkedIn

We've created a LinkedIn group and already have over five 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.

## 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](http://www.udfcd.org)). To download the CUHP companion EPA SWMM program, we have placed a hyperlink from our software site to the EPA website. Several of the design aid workbooks have undergone major revisions to match the changes in drainage and stormwater quality criteria.

## STATUS OF PLANNING PROJECTS

Project	Sponsors	Consultant	Status
Airport Creek US36 to UPRR Alternatives	Broomfield	Olsson	90% Complete
Bear Canyon Creek Mitigation Plan	Boulder	AMEC	25% Complete
Bear Creek at Sheridan Alternatives	Denver	Michael Baker Jr.	75% Complete
<b>Big Dry Creek MDP</b>	<b>SEMSWA, Greenwood Village, Englewood</b>	<b>Ayres</b>	<b>100% Complete</b>
Big Dry Creek FHAD	SEMSWA, Greenwood Village, Englewood	RESPEC	0% Complete
<b>Boulder Creek Master Plan</b>	<b>Boulder, Boulder Co, Longmont</b>	<b>ICON</b>	<b>100% Complete</b>
Clear Creek FHAD	Adams Co, Denver, Arvada, Wheat Ridge, Jefferson Co, Golden	ICON	0% Complete
<b>Coal Mine Road Alternatives</b>	<b>SEMSWA, Arapahoe Co</b>	<b>Matrix</b>	<b>100% Complete</b>
Dry Gulch OSP Update	Lakewood, Denver	ICON	70% Complete
<b>Goose Creek &amp; Twomile Canyon Creek Floodplain</b>	<b>Boulder</b>	<b>ICON</b>	<b>100% Complete</b>
Grange Hall Creek MDP & FHAD	Thornton, Northglenn, Adams Co	RESPEC	25% Complete
<b>Gregory Canyon Creek Mitigation Plan</b>	<b>Boulder</b>	<b>CH2M Hill</b>	<b>100% Complete</b>
Harvard Gulch MDP & FHAD	Denver, Englewood	Matrix	70% Complete
<b>Kalcevik Gulch MDP</b>	<b>Adams Co, Westminster</b>	<b>Enginuity</b>	<b>100% Complete</b>
Lee Gulch in Centennial Alternatives	SEMSWA	ICON	10% Complete
<b>Leyden Creek MDP</b>	<b>Arvada</b>	<b>ICON</b>	<b>100% Complete</b>
Little Dry Creek MDP & FHAD	Arvada, Westminster, Adams Co	Olsson	25% Complete
Montclair Basin OSP	Denver	Enginuity	50% Complete
<b>Newlin Gulch MDP &amp; FHAD</b>	<b>Parker, Douglas Co</b>	<b>Muller</b>	<b>100% Complete</b>
Niver Creek MDP & FHAD	Thornton, Federal Heights, Adams Co	CH2M Hill	75% Complete
North Dry Gulch OSP	Lakewood	Muller	70% Complete
<b>Oak Gulch OSP Update</b>	<b>Parker</b>	<b>Enginuity</b>	<b>100% Complete</b>
Plum Creek MDP & FHAD	Douglas Co	Enginuity	70% Complete
Sand Creek Right Bank Tributaries OSP	Aurora	Merrick	90% Complete
<b>South Boulder Creek MDP</b>	<b>Boulder</b>	<b>CH2M Hill</b>	<b>100% Complete</b>
Third Creek MDP & FHAD	Brighton, Commerce City, Adams Co, Aurora	Matrix	25% Complete
Weir Gulch MDP & FHAD	Denver	Michael Baker Jr.	75% Complete
<b>Westerly Creek (Upper) MDP &amp; FHAD</b>	<b>Aurora, Denver</b>	<b>CH2M Hill</b>	<b>100% Complete</b>

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

## UDFCD Annual Seminar

At our 2015 annual seminar we had over 330 registrants. The proceedings are available at: <http://udfcd.org/presentations>

On April 5, 2016 we will have our next annual seminar. This one-day program will be at the Omni Interlocken in Broomfield. Early registration will be \$99. 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.

# Urban Storm Drainage Criteria Manual Volumes 1 and 2 Update – What has Changed?

Holly Piza, PE, Master Planning Program

Over the last several years UDFCD has been working on a major update of the *Urban Storm Drainage Criteria Manual, Volumes 1 and 2*. UDFCD developed a group of stakeholders consisting of communities within the region, consultants, and other interested parties. Many provided input and review for the update. Below is a summary of the biggest changes.



**Drainage Law:** This chapter was updated with new and more recent case law. New law related to detention of stormwater as it related to water rights was also added.

**Planning:** The Planning chapter was rewritten as guidance for communities and consultants who seek information on developing a stormwater master plan.

**Flood Risk Management:** This is a new chapter that takes the place of the Floodproofing chapter. It includes guidance on floodproofing but also covers the fundamentals of floodplain management, mapping changes, flood insurance; and UDFCD, local, and State programs. The chapter also includes information for property owners regarding potential sources of financial assistance and selection of a floodproofing method.

**Rainfall:** UDFCD developed new Depth Reduction Factors (DRFs) based on data from a study completed in 2010 by the City of Colorado Springs. Data from the *Fountain Creek Rainfall Characterization Study* were used to develop new

DRFs for minor (2- through 10-year) events. Since areal-average rainfall over a large watershed is generally lower than the point rainfall, a DRF is applied to reduce point precipitation values to areal-average precipitation values.

Although the new *NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 8-Midwestern States* was published with new precipitation values in 2013, UDFCD determined that the difference between the new values and those from the previous *NOAA Atlas 2* was not statistically significant, and therefore did not adopt the new values. For more information on this decision see the UDFCD position paper regarding this issue dated September 11, 2013 and available at [www.UDFCD.org](http://www.UDFCD.org).

**Runoff:** The Runoff chapter contains new runoff coefficients and a new time of concentration equation for urban catchments. The basis for these changes is documented in a paper titled *Derivation and Calibration of Volume-based Runoff Coefficients for Denver Area, Colorado* (Guo, 2013). This is available at [www.UDFCD.org](http://www.UDFCD.org). These changes also resulted in a need to modify a number of Excel-based workbooks. Changes to UD-Inlet were made to update peak runoff calculations as well as allow for design of multiple inlets within one workbook. The change will also impact the UD-Rational workbook. However, further updates are

**The Manuals use photographs to illustrate both concepts and real events as shown here and on the next page.**



**Photograph 7-6.** Weir performance decay can be observed in this picture as flow appears to enter only the first two inlets while exceeding the height of the upstream curb.

planned for this workbook and it will be re-released in the summer of 2016.

**Streets, Inlets, and Storm Drains:** From 2006 to 2011, hundreds of street and area Inlet physical model tests were conducted at the CSU Hydraulics Laboratory. This facilitated refinement of the HEC-22 methodology for inlets common to Colorado. This study informed revisions to the Streets, Inlets, and Storm Drains chapter as well as the UD-Inlet workbook.

**Open Channels:** This chapter is a rewrite of the Major Drainage chapter. It includes discussion of the functions and benefits of natural streams and lists principles of stream restoration. It includes guidance for design of naturalized channels as well as vegetated and rock-lined swales. It also provides guidance relevant to both preparing and reviewing a hydraulic model using HEC-RAS.

**Hydraulic Structures:** The Hydraulic Structures chapter now includes guidance for sculpted concrete drop structures and allows use of the simplified method for design only with grouted (stepped or sloping) boulder and sculpted concrete drop structures. Additionally, all details were updated and several details were added. Discussion on bridges was removed from this chapter and is now located in the Culverts and Bridges chapter.

**Stream Access and Recreational Channels:** This is a new chapter that includes design of shared use paths adjacent to streams and guidance for design of recreational channels. This chapter is largely related to safety issues and also contains a summary list of all USDCM criteria pertaining to public safety as well as considerations for reviewing safety of a proposed project.

**Culverts and Bridges:** Guidance on bridges, including hydraulic modeling recommendations using HEC-RAS, was added to this chapter. Also, information regarding safety grates was expanded including straightforward guidance as to when a safety grate is recommended.

**Storage:** Previously, the Storage chapter included a number of different approaches for designing detention basins. This was simplified with the single recommendation of full spectrum detention in the new chapter. The concept of full spectrum detention has been expanded with detailed guidance on how to implement full spectrum detention while incorporating many of the stormwater quality treatment measures described in Volume 3 of the USDCM. This resulted in significant changes to the UD-Detention workbook, which was released at the same time as the update.

**Revegetation:** The Revegetation chapter was completely rewritten and includes guidance for upland, riparian, and wetland vegetation. The chapter includes site preparation, material selection and installation, mulching, maintenance, and post-construction monitoring.

## Photos from the Hydraulic Structures chapter



**Photograph 9-4.** View of the sheet pile cutoff wall and steel reinforcement for a sculpted concrete drop structure prior to the concrete placement. Note the steel reinforcement has been spot welded to the sheet pile.



**Photograph 9-5.** Example of stepped downstream face for a grouted boulder drop structure. Note dissipation of energy at each step for low flows.



**Photograph 9-9.** A sculpted concrete drop structure along Marcy Gulch in Highlands Ranch, CO represents a basic structure design.

# Stormwater Quality & Permitting Support Activities

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

UDFCD continued to be active in the stormwater quality arena in 2015, with commitments to the following activities and organizations:

## **UDFCD BMP Monitoring Program:**

UDFCD has been monitoring stormwater BMPs since the late 1990's. This year UDFCD continued monitoring influent and effluent water quality for 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,
- Permeable Interlocking Concrete Pavement (PICP), and a
- Rainwater Harvesting system.

In addition to the above-mentioned sites, two new research sites are currently in construction. UDFCD is partnering with CDOT to monitor a Media Filter Drain (MFD), a type of infiltration trench with engineered media drained by underdrain. The second site, located in the RINO district of Denver is a new permeable interlocking concrete pavement (PICP) project 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. Both projects are on schedule to be ready to monitor in 2016.

## **Special Studies and Projects:**

### Pathogens Toolbox

The 2016 303(d) list includes 35 E. Coli impaired stream segments with 38 more segments listed for monitoring and evaluation for potential impairment. These numbers have almost doubled in the past eight years. UDFCD is currently working on a pathogens toolbox document that will outline an approach to help communities begin to look closer at specific watersheds and address this issue.

### City and County of Denver Green Infrastructure Manual

UDFCD helped the City and County of Denver finalize a new criteria manual to help promote distributed BMPs for ultra-urban sites. The manual includes streetside stormwater planters, curb extensions (bumpouts), green alleys, tree trenches, and green gutters. Future plans include assistance to other communities within the District in adapting this manual to their own needs.

### Nationwide Stormwater Treatment Costs and Maintenance Needs

UDFCD is leading a team of communities across the nation to further evaluate the whole life cycle costs and long-term maintenance and operation of distributed stormwater quality

treatment infrastructure. This work is being coordinated through the Environmental and Water Resource Institute's Municipal Water Infrastructure Council, and is expected to be completed in 3-4 years.

### Quantifying Stream Degradation as a Source of Nutrient Loading

UDFCD is partnering with the Big Dry Creek Watershed Association and Colorado State University in a study on Big Dry Creek in Adams County. This creek has a history of channel instability and incision, likely increasing nutrient loading in the South Platte River by contributing sediment bound phosphorus and decreasing riparian denitrification. Given that the South Platte River has significant nutrient issues, and the rollout of statewide in-stream nutrient criteria, examining this previously neglected source is an essential part of an overall nutrient reduction strategy. The study will result in a tool to estimate loading rates and predict how these will change over time; and recommendations for ecological engineering approaches, including bank bioengineering and floodplain reconnection. Finally, a methodology for assessing the effectiveness of this strategy in reducing nutrient loading from channel degradation will be developed. This study should be completed in 2017.

## **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 staff assisted with instruction of two 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.

## **Colorado MS4 Permit Assistance:**

As a Phase I MS4 permit requirement, Denver, Aurora, and Lakewood must each monitor in-stream water quality 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. Together with our partners, UDFCD has collected 18 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.

# Floodplain Management Program

David Mallory, PE, CFM, Program Manager

## What Changed? What's New?

Change is inevitable, right? Change can sometimes be dicey because it may signal challenges ahead. However, change may also afford unexpected opportunities. Many of our communities, state agencies and federal partners have experienced staff turnovers/expansion and/or reorganization. That means many well nurtured relationships will need renewal. For example, the Tri-lakes Regulatory Office, US Army Corps of Engineers has new folks. While this may present some challenges with environmental permitting, we were able to open a dialog around our shared vision of viable stream systems that interface with a rapidly growing major metropolitan area. The discussion has been productive, helpful and I believe advances our shared goals.

Another federal example is the Federal Insurance and Mitigation Administration (FIMA) which is a part of FEMA. Reorganization will occur in early 2016 that will bring flood insurance, flood risk management, floodplain management and building science groups, among others, together. Again there will be challenges and opportunities with the new organization and personalities. A stated focus for FIMA is customer service. This is a terrific opportunity because we have sought to improve the customer experience through the FEMA programs we are involved in. The Cooperating Technical Partners (CTP) grant program is operating under revised federal grant guidelines (as are all federal grant programs). This means a few more hurdles, paperwork and reports, but it also means meeting new performance metrics. We are confident our LOMC Delegation Program is top notch and will measure up well to a national standard.

Here at the UDFCD, the walls moved! We went through an office overhaul that effectively better utilized our current space allocation. Now that the dust has settled and noise has subsided we have an improved space. Every time we remodel, the physical Library gets smaller as more documents are moved to the digital platform. Speaking of the digital platform, our document management software went live in late 2015. The Floodplain Management Program deals with a large number of documents due to development referrals, LOMC case files and floodplain mapping reviews. We also need to retrieve documents on a regular basis, particularly true for the Maintenance Eligibility Program (MEP). Teresa Patterson and Mike Sarmiento worked long and hard with Julia Baily and Kecia Doke to customize the OnBase software to meet the needs of the FPM program. We continue to work on workflows, document templates and shortcuts that will eventually make us more efficient.

## Changes in the Floodplain Management Program

Our colleague and friend Joanna Czarnecka (Senior Construction Manager) left in April to pursue her engineering career in the private sector. I understand she was a hot commodity as she sought alternate opportunities, eventually joining Engenuity as a design engineer. Joanna made exactly the right decision in my view, but we do miss her! So who could possibly replace Joanna? Meet Mike Sarmiento! Mike has been with the UDFCD for 30 years with the Design Construction and Maintenance Program. Mike expressed an interest in joining FPM and in March he did. Teresa's article on the MEP goes into detail on Mike's responsibilities and impact on the program. I continue to be impressed with Mike's transition to the FPM Program.

Our construction oversight is very different from any other construction observation activity due to unique contractual relationships, control over the case load, choice of contractors and so forth. Mike has exceeded my expectations (and they were high!), resulting in a smooth transition in our field operations. He has also taken the initiative to actively participate in the document management transition. Mike and Teresa have also conducted a number of MEP workshops with individual communities and otherwise done an incredible job building depth and strength in the MEP. We have struggled to keep up with the large increase in development referrals; however Teresa, Mike and John are working through the backlog.

## Floodplain Mapping Program Update

The Floodplain Mapping Program is directed by Terri Fead. Terri is one of the hardest working, dedicated and skilled colleagues I have ever had the privilege to work with. She has charge and direction over Flood Hazard Area Delineation Studies (FHADs), Letters of Map Change (LOMRs and LOMRs) and Physical Map Revisions (PMRs). Two years ago we formed a partnership with FEMA Region VIII to convert our FHADs into official federal floodplain maps through the PMR process. The process is somewhat lengthy, but much shorter than a standard mapping project due to the preliminary work in preparing the FHADs and Master Plans. We currently have seven PMR projects in process. The first to reach the finish line will be Big Dry Creek (AdCo). It will become effective in January of 2016. One PMR project includes nine FHADs for a combined total of 60 panels, 100 stream miles and 16 communities. We currently send individual letters to every property owner who is newly mapped into the official floodplain (Special Flood Hazard Area).

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 2015. We were able to increase the funding levels for FY 2016 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. In March, FEMA switched to their new technical services contractor, Compass JV (mainly AECOM and CDM Smith). Another change, right? The transition required some adjustment, but moved us closer to all digital submittals. Terri issued new [submittal guidelines](#). FEMA also provided an [online submittal tool](#) that allows direct submittal, including the review fee to FEMA. The applicant will receive a small discount and case number at the end of the process.

Terri collaborates with Shea Thomas in the Master Planning Program on the preparation and review of master plans and FHAD studies. Currently we have eight FHAD'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, Grange Hall Creek in Northglenn, Thornton and Adams County and Third Creek in Commerce City, Brighton and Adams County.

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. All of the projects were completed by early 2014 with the exception of Douglas County. For a variety of reasons the project schedule was extended several times. We are delighted that all the review comments have been attended to, all appeals have been processed and the maps will become effective March 16, 2016. Thank you very much Terri Fead!

### **Technical Mapping Advisory Council (TMAC)**

The Technical Mapping Advisory Council (TMAC) was codified as part of BW-12 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 representative is from New York City. In all, the council has 20 members from federal, state, local and private sector organizations. It is a unique group of professionally diverse individuals. The council has completed the first year, issuing [two reports](#). The first is the annual report with a series of recommendations. The Council will continue to issue annual reports as long as TMAC is active.

The second report addresses future conditions including sea level rise, changes in climate and population growth. The future conditions report also included recommendations to FEMA. Some recommendations are rudimentary but many are truly transformative. FEMA has evaluated and concurred with the TMAC recommendations. FEMA will report to congress in mid-2016 on the implementation strategy. Some recommendations will require rule making and possibly legislation while others will require additional funding.

Someone recently asked if I was satisfied and pleased with the first year's effort. I am very proud of the Council's accomplishments in 2015. The Council took on a lot of topics and produced a large body of work. There's more to come, so stay tuned.

### **In Summary**

It's been a busy year, full of changes, challenges and opportunities in every sector of the FPM Program. Everyone I talk to is very busy, much better than the alternative for sure. In some respects the FPM Program is in renewal. Teresa, Mike and I have less than two-year's experience in our current positions. I hope you find us accessible as we all work on strengthening old relationships and building new ones. In the end it's those important relationships that help us navigate the changes.

# Maintenance Eligibility Program

Teresa L. Patterson, P.E., CFM, Project Manager, Floodplain Management Program

For a second year in a row the Maintenance Eligibility Program (MEP) has experienced several exciting new adventures.

## Staffing Updates

In March, Mike Sarmento, a long-time UDFCD veteran Senior Construction Manager, celebrated his 30-year anniversary with the District and chose to migrate from the Design, Construction & Maintenance Program to the Floodplain Management Program. We are very happy for Mike's addition to our Program to assist with both the field and office operations of the MEP and other Floodplain Management Program duties. Mike made great strides learning about Floodplain Management, a completely foreign topic, and understanding the intimate workings of the MEP. Within six months of joining the Floodplain Management Program, Mike tested and passed the exam for the ASFPM Certified Floodplain Managers program, which demonstrates his continued commitment to the District, the Floodplain Management Program, and overall public safety.

After seven years of service with the Floodplain Management Program, largely as the Senior Construction Manager for the MEP field operations, Joanna Czarnecka left the District in April to pursue advanced engineering applications in the consulting industry. We are so grateful for her contributions to the Floodplain Management Program over the years. I am particularly blessed for her assistance during my first year at the District and our partnership in running the MEP, the Community Rating System (CRS) Assistance, and jump-starting the Program for Public

Information (PPI) efforts that were so greatly successful in 2015. Thank you!

## MEP Case Numbers Are Up

I'm happy to report that in 2015 we witnessed a significant upturn in the number of development projects occurring throughout the Denver Metro area signifying that the Great Recession is coming to a close. In 2015 we logged around 580 submittal applications for our review for flood safety considerations and compliance with current stream design standards. At any given time, we are tracking the construction progress of roughly 40 projects in varying stages of construction across the Denver Metro Area.

## MEP Workshops a Great Success

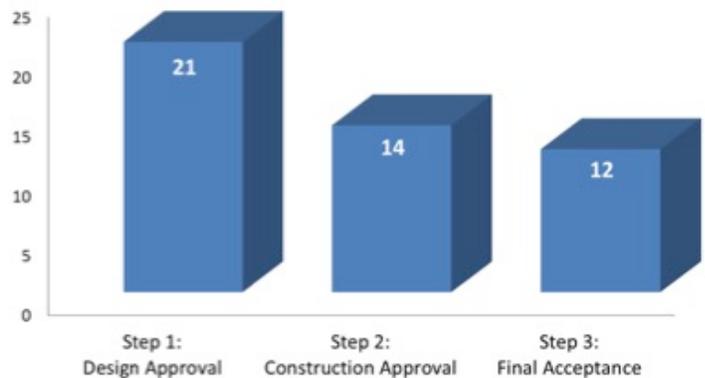
While working with our local government contacts, Joanna and I identified an opportunity to strengthen the relationship with our community counterparts through outreach and education. We developed a half-day MEP Workshop that covers the services provided by UDFCD, focusing mainly on maintenance needs and how the MEP process bridges the District programs. The content of each workshop was tailored to the specific community needs and their familiarity with the MEP. Workshops were hosted at the community's facilities to maximize attendance and permit more flexibility with attendee's schedules.

We presented six workshops (at Douglas County, Parker, Denver, Brighton, SEMSWA/Arapahoe County, and Adams County) with more than 100 total attendees. Each workshop was co-presented by either Joanna or Mike and myself with additional participation from David Mallory and the Design,

MEP SUBMITTAL REVIEWS COMPLETED IN 2015



MEP APPROVALS IN 2015





**Realigned Westerly Creek channel with a naturalized stream design for shallower flow more connected to the channel overbanks and softer bank armoring techniques**

project was a great success and we will continue to monitor the vegetation restoration efforts for final acceptance to the MEP.

### **Pipe Outfall 79**

The Highlands Ranch Metro District addressed a steep, incised channel suffering from significant channel degradation in a Highlands Ranch residential neighborhood. The Pipe Outfall 79 channel improvement project tackled excess street runoff and pipe outfall instabilities with a combination of grouted and ungrouted boulders. The design team deemed that the channel was too steep for traditional flattening through drop structures and that the corridor would be better suited with a rock-lined channel instead. The resulting project eliminated the channel incision, raising the profile for the majority of the channel section, while saving most of the mature trees and providing better maintenance access through the narrow corridor.

Construction & Maintenance Program Project Manager for the specific community. The workshops have been well received and we can't be more grateful to the attendees for taking time out of their busy schedules to help us understand how we can assist them better.

### **MEP Projects**

Project sizes varied widely again this year, from large-scale developments to single pipe outfall projects along existing streams. There were a couple notable projects to highlight from 2015 that are challenging traditional channel design practices and migrating to more incorporation of natural channel design.

### **Westerly Creek North**

The Westerly Creek North project is the most northern section of the Westerly Creek Greenway in the Stapleton Redevelopment Area. The design of this project was nearly completed in the mid-2000s but the economy caused the project to be shelved. In 2014 the project was resurrected and the channel design was revisited relying heavily on experiences from the upstream section of Westerly Creek. Barb Chongtoua from the Design, Construction & Maintenance Program and I worked with the design team and Denver Parks to shape the project into a more naturalized stream design, incorporating void-filled riprap and riffle drop structures into the design.

Construction of the channel was completed within six months of breaking ground and was challenged by uncharacteristic rainfall early this summer. Overall the



**Void-filled riprap channel armoring and shallow flow depths allow for a more stable, steep channel section**

# Information Services and Flood Warning Program

Kevin Stewart, PE, Program Manager

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

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

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

## 2015 Flood Season Recap

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



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

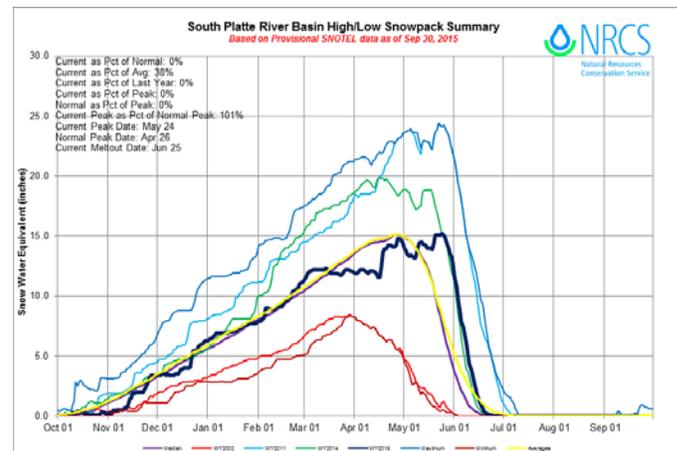
the National Weather Service issued flash flood watches and warnings.

## Record 62 days with flood potential in 2015

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

Red dates are when automated rain gauges exceeded alarm thresholds. Yellow highlighted dates indicate heavy rainfall only affected areas outside UDFCD's main area of concern such as the Hayman Burn Area in SW Douglas County and watersheds in northern Boulder County. Blue boxes are when a NWS flash flood watch was the highest threat level reached and red designates a flash flood warning. Hyphenated dates indicate a late night threat period extending into early AM the next day.

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



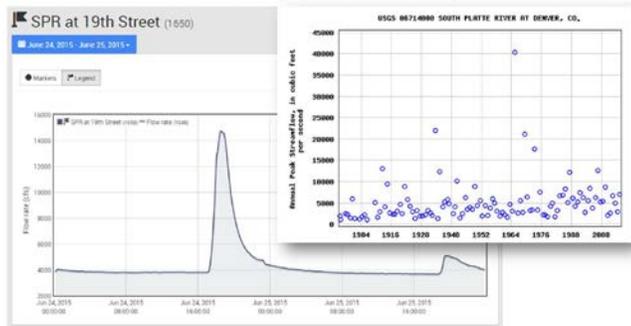
The 2015 snowpack for the South Platte River basin tracked close to average making for a good water year for northeast Colorado. However, cool temperatures and some additional mountain snow in May kept the snowpack well above normal thru mid-June resulting in a record-setting runoff season that impacted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

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

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

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

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

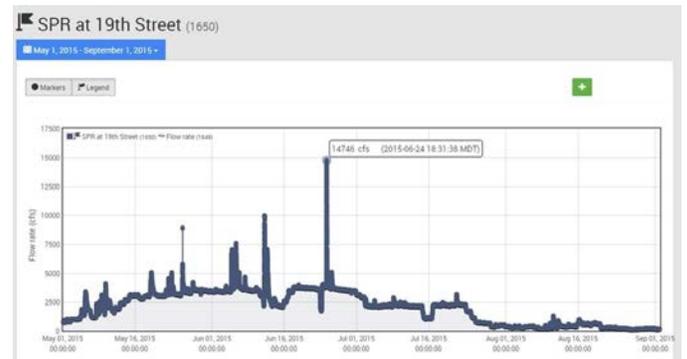


occurred at 5 PM in Denver near the Alameda & Holly intersection with a rainfall total measuring 2.24 inches in just over one hour. With the exception of Bear Creek feeding 350 cfs from the dam, the left bank tributaries to the South Platte River contributed little to that day's peak flows.



Cherry Creek flooding near Speer Blvd. and Stout Street, June 24 at 5:55PM, estimated peak flow ~2,000 CFS.

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

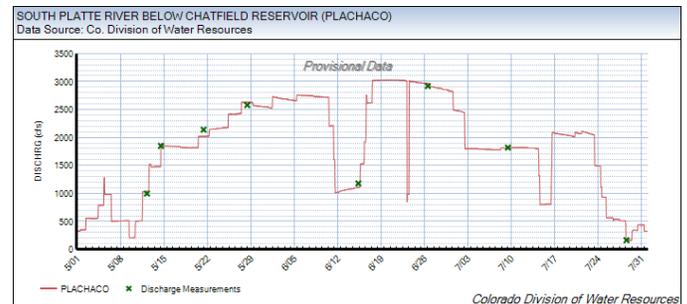


### Uncontrolled Drainage Areas



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

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



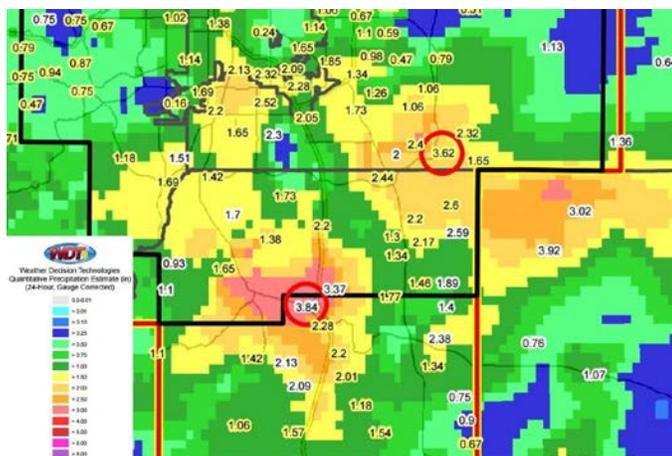
30-year historic average peak releases from Chatfield are less than 500 cfs

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

### Rain Measurements Exceeding 1% IDF Thresholds

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

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



hour rain amounts occurred according to the following map:

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

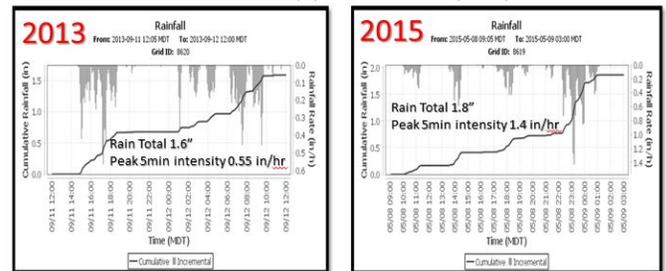
70/Havana Street interchange also topped the 1% intensity threshold at 5:15 PM.

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

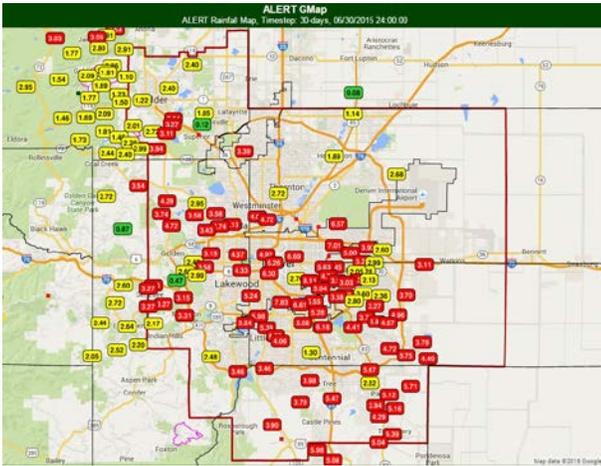
### Other Notable Events

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

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



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



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

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

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

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

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

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

### Meteorological Support

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

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

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

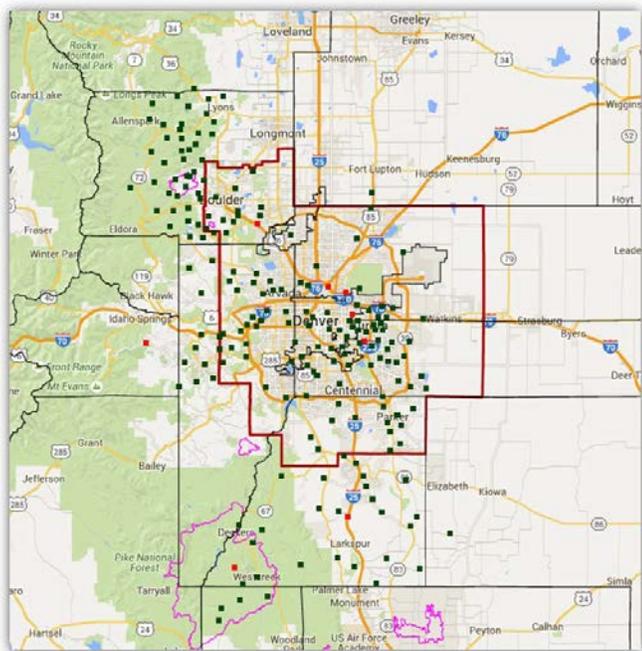
### CoCoRaHS Update

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

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

### ALERT System News

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



2015 ALERT rain gage locations

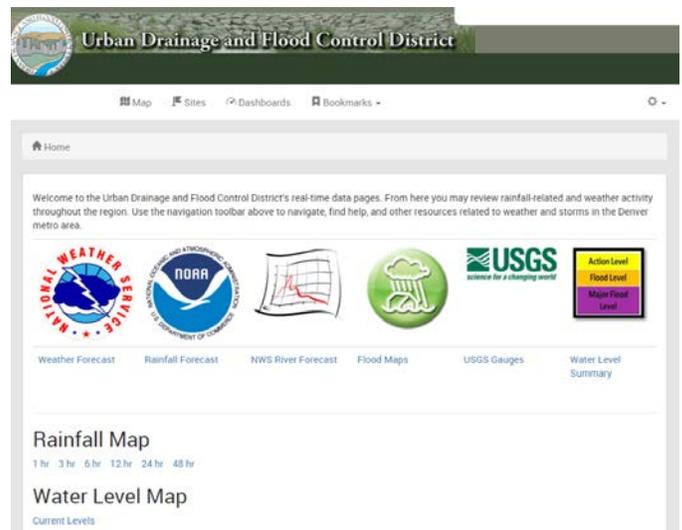


Coal Creek rain/stage gage at McCaslin Blvd in Superior

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

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

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

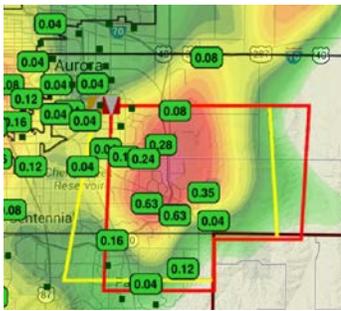


Two primary websites were supported during 2015. The public website above uses a software package called [Contrail](#). The second website was designed primarily for UDFCD flood warning program partners and hosts a number of data mapping applications not authorized for public use.



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

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



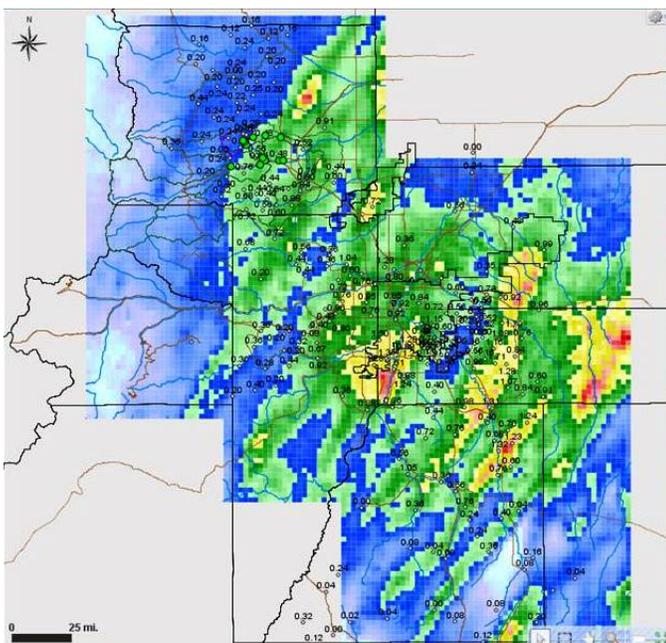
UDFCD stepped into this modern social media world in 2015 by developing its own version of Tweeting in the Rain that automatically generates Tweets whenever ALERT rain alarms occur. A “light” version of the popular [GMap](#) website is linked to the Tweets.

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

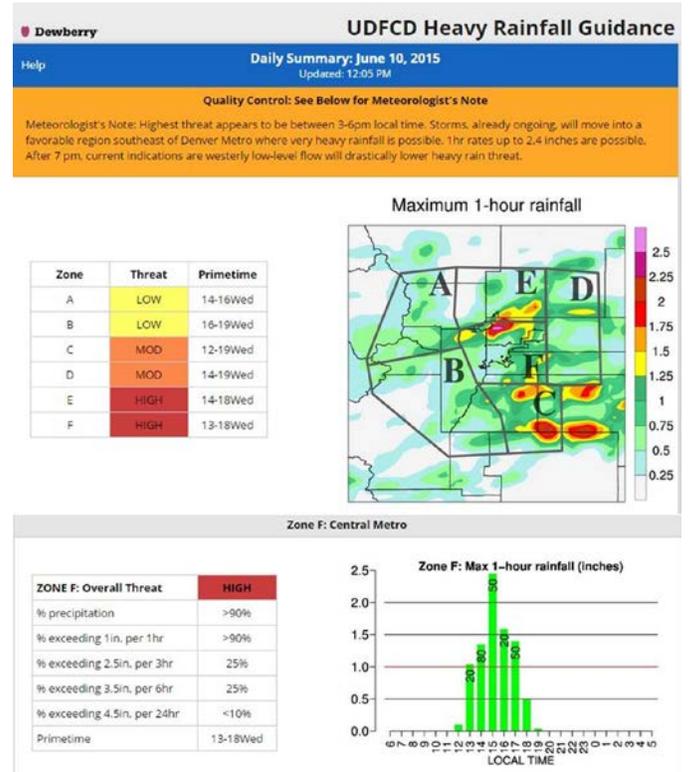
### Beyond ALERT

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

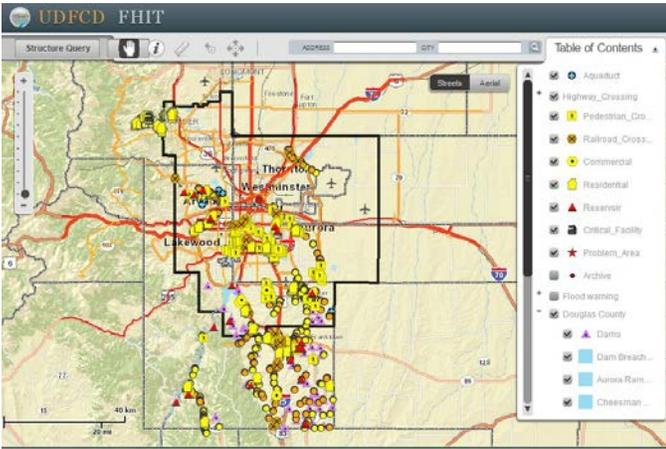
### UDFCD’s RainVieux GARR coverage for 2015



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



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



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

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

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

### Resources

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

## New Website Released

by Derrick Schauer



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

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

# Document Management Update

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

## Brief History

In 2009, the District engaged in an effort to reduce paper and made a move towards electronic filing. The first step was to scan printed reports and information from our library and make them available on our website. Then, in December of 2009, we implemented our first electronic records management (RM) system. This system was designed specifically to manage the retention periods of records. Meanwhile, working documents were being stored on a file share until they became final. At this point we identified two key faults. First, storing files in a project folder on the file share, then filing them in a RM system is twice the work. Select library documents are later posted on the website as well. Filing a document in 2-3 places is time consuming and requires discipline. Second, to effectively manage projects, staff must be able to find files in one place. Files need to be organized by project as they are on the file share instead of by retention like in the RM system; it is cumbersome to manage projects with files scattered in two locations.

## Vision

The objective evolved beyond a paperless office to a full integration. The District's vision for electronic and document content management was to streamline activities related to the creation, storage, retention, and retrieval of documents while standardizing terminology in addition to file structures and integrating a GIS component for internal and external document and information retrieval. The District selected an enterprise content management solution, OnBase by Hyland Software, and rolled out the first phase of implementation on November 2<sup>nd</sup>, 2015.

## Considerations

Migrating the current organizational scheme or filing structure is the most common starting place when implementing a new system like OnBase. The vision required that we rethink everything from calling something a letter vs. correspondence to regrouping the entire organization of documents. Starting from the ground floor meant looking at all types of documents in a discovery period and identifying commonalities across projects and activities. A new system both modifies previous constraints and also guides certain design considerations such that the new design is geared to take full advantage of additional functionality offered by the software. The existing filing scheme at the District was functioning but there was a strong desire for standardization.

The next consideration was to accommodate a standardized file structure without compromising the design of a robust database structure. A database offers the best capabilities for search-ability and quick retrieval of information and documents. A file structure is typically slower to navigate than retrieval by database query. Since, the system is intended to be accessed by everyone in addition

to those responsible for records management, the most familiar storage and retrieval methods are through a file structure.

Part of the file structure and indexing design strategy was to anticipate who the audience might be in the future. One particular audience to consider includes users of our web map a.k.a. the EDM. In order to use a web map like the EDM to pull documents from OnBase, documents must contain index values that correspond to geographical features.

An additional challenge to consider was how quickly to fully implement the software. Every day for years, people have been creating documents and saving them to a directory location. It is a routine that is so fundamental—most people don't think about it at all. Full implementation would mean that people are retrained on how they create documents, where they save, and how they edit. This software sits on top of the windows environment. Creating, viewing, editing, and storing documents happens directly through OnBase and requires users to have a familiarity with the software. A comfort level that won't negatively impact efficiency comes with training and practice over time. Afterwards, the hope is that with a streamlined process, overall efficiency is improved and old storage methods can be retired.

Finally, the District had to revise business processes that had not yet become electronic. Much of the communication with accounting was through paper forms that have been recreated in OnBase and are now routed electronically. Additionally, in 2016 the District is implementing electronic signatures eliminating steps in the process. A document will not need to be printed for signature, scanned, and stored again into the OnBase system. Instead, we will be able to capture e-signatures on documents that have already been filed, while still maintaining a paper process for organizations that have policies in place preventing them from using electronic signatures.

## What's Next?

The first phase of implementation includes scan, store, and retrieve capabilities with basic workflow processes. Implementing document management software provides the groundwork for many big ideas planned in the future. OnBase is a platform with opportunities to automate even more processes down the road. Excitingly, a desktop and mobile friendly web map with document management integration is planned for future development.

# 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 Stream Management Plan lists projects for the Maintenance and South Platte River funds. County, category of work, the local government where the work is located, project location, description of work, and the estimated cost list work are all listed in this plan. Stream management work is entirely funded by the District. Development of both the 5-year CIP and Stream Management Plans are based on prioritized project requests from local governments. Copies of both of these plans are available on the District's website: <http://udfcd.org/design-construction-maintenance/>.

## 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. District projects are constructed utilizing our Project Partner process, or in some cases, are publically bid. In 2015, the District authorized approximately \$10,460,000 for construction projects.

## Stream Management

Stream management provides basic flood control maintenance along the major drainageways within the District. Services typically performed include mowing, trash and debris removal, weed management, and tree thinning. The District is currently managing over 350 drainageways and spent \$680,000 in 2015 for Stream Management. Private contractors are hired each year to perform the work 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 eligible for maintenance. 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 through a pre-qualified contractor selection process. In 2015, the District completed \$ 10,460,000 of restoration work.

Below is a brief outline of a few capital and maintenance projects that have been recently completed.

## Adams County

Major improvements are underway in 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



### Box culvert extension east of Federal Blvd

Westminster Station on the forthcoming RTD Fastracks Northwest Rail Line. This is a joint project between the District, the City of Westminster (City), and Adams County (County).

A previous phase of the project included re-alignment of utilities under the 40-foot tall Federal Boulevard



**New drop structure at lake outlet**

embankment, which involved 30-inch, 54-inch, and 108-inch tunnels and two water line relocations. Another previous phase included lowering the channel downstream of Federal Boulevard, extension of the existing 10-foot by 14-foot box culvert on both sides, and removal of two sanitary sewer lines that were running within the bottom of the box culvert.

In 2015 work has commenced on constructing a new lake, creek reconstruction, rebuilding the regional trail, and construction of a new road called Creekside Drive along the south side of the project area. To date, approximately 200,000 cubic yards of material has been excavated and hauled off, with an additional 85,000 cubic yards of excavation left to go. The Westminster Station is planned to open in July of 2016, and the goal is to have all creek work, trail work, and Creekside Drive work complete by the station's opening day.

**Brantner Gulch** crosses Riverdale Road just north of 128<sup>th</sup> Avenue in the City of Thornton and unincorporated Adams



**Box culvert construction on Brantner Gulch**

County. The existing culvert under 128<sup>th</sup> Avenue was a 48-inch corrugated metal pipe that was significantly undersized; as such the road has been overtopped by flooding once or twice per year for the past several years. A new box culvert is under construction to pass the 100-year flood under Riverdale Road; this new structure is a triple 16-foot by 12-foot box culvert. The box culvert was designed such that one cell could be retrofitted and used as a trail underpass should one be desired in the future. Construction is anticipated to be complete in early spring 2016.

Several dozen insurable structures lie within the 100-year floodplain of **Westerly Creek** south of Montview Boulevard. The existing box culvert to carry Westerly Creek under Montview Boulevard was significantly undersized, causing the 100-year flood to overtop the road and back water into many of these structures. In addition, the regional trail along



**Bridge construction on Westerly Creek**

Westerly Creek had no safe crossing of Montview Boulevard for trail users. A 2,500-foot length of Westerly Creek was lowered and re-aligned, a new 60-foot bridge for Montview Boulevard was installed, and the trail re-built to pass under Montview Boulevard at the new bridge. The floodplain is being re-mapped, which will result in most of the insurable structures no longer being within the 100-year floodplain. Construction of this project was completed in early 2016.

In the City of Thornton near the boundary with the City of Northglenn, **Grange Hall Creek** was eroding and creating vertical banks in excess of 10 feet tall in a formal park area. An ecological restoration of the creek was undertaken to improve the health of the stream and to eliminate the falling



**Existing bank erosion on Grange Hall Creek**

hazard posed by such tall vertical banks adjacent to active trail and park users. Vertical banks were laid back and revegetated, and grade control was installed using logs held in place with soil anchors. This project was completed in November of 2015.

## Arapahoe County

The District, the City of Aurora, and the Cherry Creek Basin Water Quality Authority completed construction of a capital project on **Cherry Creek near the Storm Soccer Facility**, located southwest of Arapahoe Road and Chambers



**After construction – Cherry Creek near the Storm Soccer Facility**

Way. The project consisted of a sculpted concrete drop structure that provides stream stability, improves water quality, and provides access to the stream from the neighboring regional trail. The drop structure protects a water line that was exposed by Cherry Creek.

In addition, the stepping-stones along the top of the drop provide another way to cross the creek just downstream of an existing wood bridge. The pools within the drop structure enhance the appearance of the drop and help with fish passage. This drop structure serves multiple purposes of stream stability, improving water quality, and providing access to the stream while being sensitive to the environment.

The District and the Cities of Englewood and Littleton completed an emergency maintenance project on **Big Dry Creek upstream of Lehow Avenue** located southwest of Lehow Avenue and Broadway. Big Dry Creek was one of the streams that had high flows during the extended rainfall that occurred during the early summer of 2015. The stream sustained severe bank erosion that closed the adjacent trail and threatened a sanitary sewer that runs parallel to the



**Before – Big Dry Creek upstream of Lehow Avenue**

stream. Soil riprap bank protection, native grass seed, and erosion control blanket were installed. A District student

intern designed the repair under the supervision of the Project Manager, which shortened the response time and reduced project costs. The trail was replaced and sanitary sewer was protected.

## Boulder County

In 2013, Original Town Superior experienced significant flooding, with estimated peak flows in **Coal Creek** exceeding the 100-year flood. The Town of Superior and the District partnered to construct improvements to Coal Creek to reduce flood risk such that all insurable structures in Original Town Superior would be outside the 100-year floodplain. The floodplain through Original Town narrows in a few distinct places, and the design team was able to identify a solution that minimized the construction footprint by focusing only on the narrow sections. A second bridge span was added at 2<sup>nd</sup> Avenue, old bridge abutments were removed at 3<sup>rd</sup> Avenue to widen the creek corridor, and overbank conveyance was increased upstream of 3<sup>rd</sup> Avenue to contain the 100-year flood and keep it safely away from insurable structures in the



**Reconstructed Channel at 2<sup>nd</sup> Avenue**

town. This project was completed in December of 2015.

Topography in the City of Louisville generally slopes from west to east, towards Coal Creek. The BNSF Railroad tracks along the east side of downtown Louisville sit on top of a 5-foot embankment, which impounds runoff trying to reach Coal Creek. This has resulted in a mapped 100-year floodplain over much of the downtown area. A project is underway to install a 100-year outfall system to capture the 100-year flood and route it underneath the railroad tracks. East of the BNSF Railroad tracks these new outfalls will drain to the Harney Lastoka Open Space. New outfall channels will be constructed to drain flows through the open space and to Coal Creek. This project is underway, with construction anticipated to be complete in the summer of 2016.

Hundreds of multi-family homes currently lie within the **Wonderland Creek** 100-year floodplain along a one-mile reach from Winding Trail Road downstream to Foothills Parkway. The District partnered with the City of Boulder to



**Rendering of improvements upstream of 28<sup>th</sup> Street**

design improvements to the creek to reduce the 100-year flood risk such that all of these multi-family homes will no longer be in the 100-year floodplain. The project includes a new bridge and underpass at the crossing of the BNSF Railroad, relocation of the Boulder and White Rock Ditch, six separate road crossing improvements, and a new trail corridor with underpasses at Kalmia Avenue and at 28<sup>th</sup> Street. The project was bid in the fall of 2015, with

construction expected to be complete in late 2017.



**Vegetation choking Bear Canyon Creek**

Flood recovery work from the 2013 flood is still underway, particularly to remove sediment. Significant sediment removal efforts

were undertaken on Boulder Creek at Arapahoe Road and on South Boulder Creek at McSorley Lane and at Arapahoe Road. In addition, Bear Canyon Creek south of Arapahoe Road had become choked with vegetation and downed trees. This increased roughness along the creek was increasing the flood risk to an adjacent levee, so the District engaged in a tree thinning and debris removal effort to alleviate the problem.

**City and County of Broomfield**

The new **Nissen Reservoir Drainageway crossing of Lowell Blvd**, part of a larger roadway project from 120<sup>th</sup> Avenue to Midway Boulevard, is nearing completion. The project, funded by the District and Broomfield, provides a 100-year capacity, double Con/Span arch structure to fix the frequent flooding of Lowell Boulevard; and also a grade separated trail underpass. This trail crossing will function as maintenance access and provide trail access to the Metzger Farm Open space just downstream, consistent with Broomfield’s Transportation, Drainage and Trails Master Plan.

The entire roadway project should be complete within six months.



**Nissen Reservoir Drainageway arches under construction**

Broomfield, Westminster and the District are partnering to design and construct the remaining reach of **City Park Drainageway to Big Dry Creek**. The primary goal is to separate the City Park and Nissen Reservoir Drainageways upstream of Lowell Blvd in order to reduce risk of flood damage to the downstream Metzger Farm Open Space ponds on Nissen Reservoir Drainageway. Project coordination and alternative alignment development is underway. Construction is anticipated to begin in 2017.

**City and County of Denver**

**Havana Street Dam** is located on Irondale Gulch in the Rocky Mountain Arsenal National Wildlife Refuge (Refuge) in Denver near 51<sup>st</sup> Avenue and Havana Street. The facility is operated by the US Fish and Wildlife Service, as a flood control dam regulated by the State of Colorado. In September 2013, as a result of the intense storms that hit the Denver Metropolitan area, the dam breached, conveying flood waters downstream toward Adams County. Inadvertent flood detention provided by an old railroad embankment on the Refuge was able to capture and



**Failed spillway on Havana Street Dam in 2013**

attenuate the flows from the breached dam minimizing the flooding downstream.

Denver, as the lead agency working in partnership with Adams County, applied for FEMA Disaster assistance. Havana Street Dam was approved as a FEMA project. The UDFCD was requested to lead a design and construction effort to repair the dam to pre-disaster condition. The design to restore the dam was completed by Muller Engineering Company in 2014, with construction completed in the spring of 2015 by Tezak Heavy Equipment Constructors. The dam was completed just in time as the storms of June and July 2015 came through bringing storm waves near the emergency spillway.

An ALERT gage measuring rainfall depths and flow rates was also installed at the dam. The ALERT gage will help the operation team and emergency managers make informed and timely decisions during the flood season. A flood preparedness plan complete with an emergency phone call tree and emergency response triggers will be developed in



**Havana Street Dam spillway construction nearing completion during June 18, 2015 storm**

2016 to ensure a coordinated response between the operation team and emergency managers.

**Westerly Creek Dam**, located at Alameda Avenue and South Havana Street (southeast Denver), and within the Westerly Creek watershed was also activated during the September 2013 storms. This State of Colorado Class I High Hazard Dam protects portions of Denver and Aurora.

On September 13, 2013 Westerly Creek Dam impounded approximately 2000 acre-feet of water as a result of the storm. The resulting impoundment increased the surface area of the flood pool to approximately 125 acres, which inundated a significant portion of the adjacent Common Grounds Golf Course. The drawdown of the flood pool took approximately 30 days and was back to a normal operation on October 14, 2013.

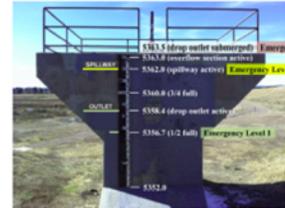
One mile downstream of Westerly Creek Dam is **Kelly Road Dam**. This facility, like Westerly Creek Dam, serves as

regional detention, is a Class I Dam, and captures stormwater runoff from the downstream portion of the Westerly Creek watershed in addition to the flows released by Westerly Creek Dam. On September 12, 2013, the storm resulted in the activation of Kelly Road Dam's emergency spillway resulting in the flooding and closure of 11<sup>th</sup> Avenue.

**FLOOD ALERT LEVELS**

Pool Elevation (FTSD Elevation)	Situation	Actions	Emergency Level
5372.0	Overlapping of the top of dam		Level 3 Urgent situation
5364.0	Pool elevation 1.0 feet above green-lined, overflow section	OEM evacuates public at 5364.0	Level 3 Urgent situation
5363.5	Pool elevation 0.5 feet above green-lined, overflow section, water level rising	OEM alerts public of emergency	Level 2 Ready-developing situation
5363.0	Green-lined overflow section activated	Dam Sponsor maintains spillway and overflow section	Level 2 Ready-developing situation
5362.5	Reservoir full, concrete spillway activated, water level rising	OEM considers evacuation	Level 2 Ready-developing situation
5360.0	Reservoir 3/4 full	OEM activation	Level 1 Non-emergency or unusual situation
5358.4	Drop outlet structure activated	Dam Sponsor consults Westerly Creek Dam Sponsor about closing 48" valve. Valve operation performed by Westerly Creek Dam Sponsor at approved times.	Level 1 Non-emergency or unusual situation
5356.7	Reservoir 1/2 full (100-yr event), water level rising	Dam Sponsor increases monitoring	Level 1 Non-emergency or unusual situation
5342.0	Base flow through 30-inch low-level conduit, reservoir < 1% full	Normal Operating Condition	None

\* Conduct notifications for corresponding Emergency Level



Note: this table is a guide for determining the Emergency Level for an unusual or emergency event, judgment must be exercised when making the determination.

**Decision aid for Kelly Road Dam**

Westerly Creek Dam and Kelly Road Dam met performance expectations during this event and, overall, experienced no structural damage. To enhance emergency preparedness and response, Westerly Creek Dam has been equipped with an ALERT gage to measure rainfall depths and flow rates. Kelly Road Dam was already equipped with an ALERT gage. Emergency Action Plans have been developed for both dams to help the Denver, Aurora, and UDFCD Operation team and emergency managers make timely and coordinated decisions regarding dam safety and to assist emergency managers with communications and responses. The remapping of the flood inundation area associated with the two dams will begin in 2016.

**Douglas County**

**Fonder Draw** is located in the Pinery subdivision near the intersection of Lightning View Drive and Thunderbird Road in Douglas County. The District partnered with Douglas County and completed stream improvements approximately 800 feet long in October 2015. Project limits extended from upstream of Lightning View Drive to an existing utility berm at the downstream project limit. Included in the scope was to address inadequate capacity of the existing roadway crossing while removing properties from the floodplain, upgrade infrastructure, define a bank full channel through the reach, and improve ecological function.

The existing 42" corrugated metal pipe at Lightning View Drive was replaced with a 6' x 4' reinforced concrete box culvert and a 10' x 10' concrete drop box inlet structure to reduce flooding across and along Lightning View Drive. Downstream of the road crossing, bank slopes were stabilized with soil wrapped lifts, and retaining walls constructed using timber from downed trees within the project limits. The downstream utility berm had a 30" elliptical corrugated metal



**Fonder Draw post-construction looking downstream**

pipe, which was replaced with a 6' x 6' reinforced concrete box culvert to convey the 100-year flow.

**Big Dry Creek at Cheese Ranch** is located in the Highlands Ranch Metro District west of Ashburn Lane paralleling the Big Dry Creek Trail. The District partnered with Highlands Ranch and completed channel improvements approximately 850



**Big Dry Creek post-construction**

feet long in December 2015. Project limits extend from upstream of the Big Dry Creek Trail pedestrian crossing near Ashburn Lane halfway to the pedestrian crossing off Cornell Circle.

Included in the scope was addressing stream stability by flattening bank slopes, widening the channel bottom, and constructing two sculpted concrete drop structures with cutoff walls. The sculpted concrete drop structures were each about a four-foot change in elevation from crest to invert. Slopes were stabilized with buried riprap and erosion control blanket.

**Stream Management** in Douglas County has evolved away from mowing streams as a form of weed management similar

to Denver County. In 2015, the District implemented buffer mowing at a couple of sites where requested. One site has been mowed completely at the end of the season to determine what benefits can come of a complete mow at the end of the season. This site will be monitored during the 2016 season and compared to the other sites within Douglas County to establish a framework for a better method of managing vegetation.

**Jefferson County**

The UDFCD and the City of Golden have partnered to fund the construction on a troublesome reach of **West Fork of Kenney's Run** from upstream of 24th Street, adjacent to Golden High School, to just downstream of 23<sup>rd</sup> Street. Large trees, undersized culverts, alleyways, homes, and other channel obstructions severely limit the capacity of the existing channel, causing debris blockage and frequent overtopping. Flows exceeding the existing culvert capacities and surrounding street capacities threaten many residential properties in the area. This capital project construction involves culvert replacements, channel/bank grading and stabilization, boulder walls, four drop structures, wet utility relocations, street/alley repairs and site restoration.

Several challenges are being encountered during construction of this project. Given the proximity to the high school, effectively managing road closures, school and bus traffic, and students/pedestrians is critical. Right-of-way is also very tight with minimal space for equipment, material storage and channel access. Interferences with existing alleys, streets and garage entrances are being coordinated with the nearby property owners. Finally, at the downstream end of the project, new boulder wall construction is in close proximity to an existing residential structure. Extra care was needed to protect this property during construction.

After the project is complete the West Fork of Kenney's



**Boulder wall construction downstream of 23<sup>rd</sup> Street**

Run channel and culverts will have increased capacity for stormwater flows from Golden High School to downstream of 23rd Street. The 100-year discharges will be contained within the channel and risk for roadway overtopping will be greatly reduced. Once construction is complete several properties and structures will be mapped out of the regulated flood hazard area.

The UDFCD and Jefferson County completed two maintenance projects on **Dutch Creek** within 700 feet of each other just upstream of Field Street. The banks of Dutch Creek were experiencing erosion adjacent to a residential subdivision, threatening backyards and potentially houses. Since both eroding banks were experiencing similar hydrology, sheer stresses, and orientation to the sun, the design team decided to construct two different methods of bank repair. The reach 1 bank was constructed with soil wrap lifts while reach 2 used the more traditional soil riprap, both laid back at a 3:1 slope. The intent is to monitor and compare the performance of both banks over the next few years. Sort of a cage match: VEGETATION versus ROCK!!

**South Platte River**

The South Platte River saw very high and sustained flows in 2015 due to high snow melt runoff late into the season. The river averaged 3,000 to 4,000 cfs well into the summer, and received several large storms on top of the high run-off. One storm in downtown Denver sent flows down Cherry Creek and into the South Platte River at Confluence Park on the evening of June 24<sup>th</sup>. Just downstream of Confluence

Park at the South Platte River 19<sup>th</sup> Street gage, the recorded flows reached 14,700 cfs. This is the 5<sup>th</sup> highest recorded flow since 1895 when the 19<sup>th</sup> Street gage was put into operation.

The high flows had a real impact on the 2015 construction season on the river. Several newly constructed projects sustained damage, and needed repairs and revegetation as soon as the flows receded. Other areas of the river sustained damage that qualified for FEMA assistance, and we are working with our local government partners to implement the repairs as soon as the funds become available.

**Adams County Update.** In 2015, the South Platte River in Adams County saw a series of smaller restoration projects and flood debris and tree removal after the flows receded in the fall. One large new project was started with the selection of a consultant team for the 88<sup>th</sup> Avenue Open Space Park project. Adams County acquired the site, a former sand and gravel mine in 2003 from Aggregate Industries, Inc. This multi-faceted project will focus on environmental restoration, developing public access to amenities, river and trail improvements, and revegetation with native species.

**Denver County Update.** The Denver reach of the South Platte River saw continued implementation of the Greenway Foundation's River Vision Implementation Plan (RVIP). This plan calls for the implementation of key projects in five different reaches of the river with an estimated value of \$30 million; and rehabilitation of 1.25 miles of the river. The five

projects include Confluence Park, Johnson Habitat Park, Grant Frontier/Overland Park Improvements, Weir Gulch at Sun Valley, and River North Park in the RINO area.

Weir Gulch was completed in 2014. Johnson-Habitat Park was completed in 2015, and won awards from several organizations including the Colorado Association of Stormwater and Floodplain Managers, the American Public Works Association, and the American Society of Landscape Architects. The Grant Frontier/Overland Park

**Dutch Creek Project Photos**



**Pre-construction Reach 1**



**Post-construction Reach 1 - Soil Wrap Lifts**



**Pre-construction Reach 2**



**Post-construction Reach 2 - Soil Riprap**

## Completed Projects on the South Platte River in Denver



**Johnson-Habitat Park**



**Overland Park Reach – upstream of Florida Avenue**

**Pasquinel's Landing Park**



reach was broken into three projects, and two were

completed in 2015. The first included the removal of the drop structure upstream of Florida Avenue and regrading over 2000 feet of channel, and the second was channel work and the reworking of Pasquinel's Park. The third project, Grant Frontier Park, involves a major regrading of the overbank area in an effort to naturalize the area and create riparian and wetland areas along a new secondary channel.

The two remaining projects to be implemented include the Confluence Park Plaza improvements and the River North Park in the RINO area. Confluence Park construction was delayed due to site conditions and high water in 2015, and is slated to start again in the early fall of 2016. Denver Parks will build the River North Park, and construction should start later this year.

In addition to the construction projects in Denver, several large planning efforts, working with the U.S. Army Corps of Engineers, are underway. One is a Feasibility Study on three drainageways in Denver; the South Platte River, Harvard Gulch, and Weir Gulch. The Corps interest in the South Platte River is in ecological restoration and habitat improvements. The study covers the river from 6<sup>th</sup> Avenue north to 58<sup>th</sup> Avenue, and will result in a Chief's Report recommending a list of improvements to receive federal support matched by local dollars. The second effort is a Reconnaissance Study for the southern part of the river in Denver, again focused on identifying projects to receive possible federal support.

**Arapahoe County Update.** It is just the beginning of the transformation of the South Platte River through Arapahoe County. The South Platte Working Group, made up of local governments and special districts that touch the South Platte River, has made a commitment to the vision and the corridor as a whole, to work collaboratively and to the long-term effort that ensures a legacy for future generations. Their goals are:

- To increase and enhance the recreational value of the corridor;
- To preserve and enhance the natural areas, wildlife habitat and protect water quality;
- To encourage and improve opportunities for education and interpretive activities; and
- To encourage land uses that are compatible with recreational goals and contribute to the economic well being of Arapahoe County.

In 2015, two of four short term projects were completed, the third started and the fourth scheduled to begin in early 2016. The exhibits below show the location of the four projects, and a brief description of each project.

UDFCD is a proud partner to Arapahoe County, the Cities of Englewood, Littleton and Sheridan, the Colorado Water Conservation Board (CWCB) and South Suburban Park and Recreation District to help bring about these projects that reengage the river with the people and the environment as well as to continue to provide flood protection.

### Challenges

**Permitting** - Each project requires a USACE 408 Modification since this reach of river was part of the original USACE project in sponsorship with CWCB, Downstream of Chatfield Channelization Project. This process is time intensive and had a steep learning curve for the first project, but the USACE is on board as a partner and we are optimistic about future time frames.

**Funding** – Projects are expensive!

2015 Sustained High Flows in the River – South Platte Park River Enhancement Project was just on the heels of completion when the water started to rise. With no relief until mid-July, much of the imported topsoil for the vegetated riparian banks was lost along with any plantings that were put in earlier in the season. Structurally the project held up well, but the ecological restoration side needs to be redone. The project team is strategizing on when to do the rework to minimize the risk of high water.

### Wins

**Project Partners** – All the projects managed by UDFCD have used the project partner approach and have seen great benefits from solid designs, value engineering and great construction product.

**Community Support** – Public outreach has been met with overwhelming support for these projects. The underserved communities that surround River Run are excited to host a unique regional trailhead, which includes recreational amenities like no other in the metro area. The River Run project features a standing wave for a large range of flows to play in, designed by McLaughlin White Water – Merrick and Company.

**Funding** - Arapahoe County Open Space challenged all the partners to leverage the 8 million dollars they were willing to jump start projects with. To date \$6.4 million of Arapahoe County Open Space Funding has been matched with another \$10 million from over 7 other agencies to fund the four projects. The remaining \$1.6 will be leveraged over the next year for the second phases of the above listed projects.

**Working with the low water conditions** – Reshaping the channel to optimize the flows in the river. The South Platte River Enhancement project brought down the channel width from about 100 feet to about 40 feet, creating more depth and variety of flow.

*The following DCM staff members contributed to this column: Bryan Kohlenberg, P.E., CFM, Senior Project Engineer; David Skuodas, P.E., CFM, LEED AP, Senior Project Engineer; Richard Borchardt, P.E., CFM, Senior Project Engineer; Barbara Chongtoua, P.E., CFM, Senior Project Engineer; Steve Materkowski, E.I., Senior Construction Manager, Mike Sarmiento, SET, Senior Construction Manager; Will Comerer, Engineering Intern*

# South Platte River Working Group 2 Projects Map

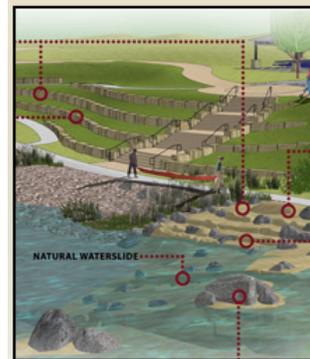


## River Run Park

**River Run Park**  
Create a Unique Regional Park Experience that Celebrates the River

- Maintain 100-yr Flood Protection
- Increase Regional Trail Connectivity and Capacity along Mary Carter Greenway
- Optimize river aquatics and riparian health
- Create new recreation features on land and in water with better accessibility and comfort facilities

## River Run at Oxford



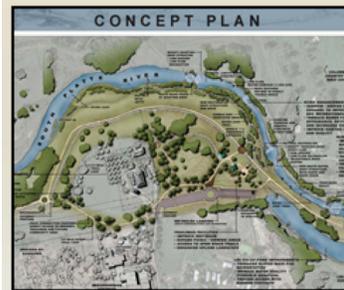
- Schedule I Construction - North of Oxford Avenue, November 2015 – Summer 2016
- Budget \$6,000,000 (design and construction)
- Includes:
  - In-River Improvements - two boat chutes and standing wave, river access, cobble beach, and riparian plantings
  - Trailhead – parking lot expansion, large pavilion, flush restrooms, natural play area, trails, plaza with tables and benches, trees and revegetation
- Project Team – Merrick (McLaughlin White Water), DHM, ERO and Naranjo Civil Constructors

## Reynolds Landing

**Reynolds Landing**  
Full-Service Trailhead and Recreational Area

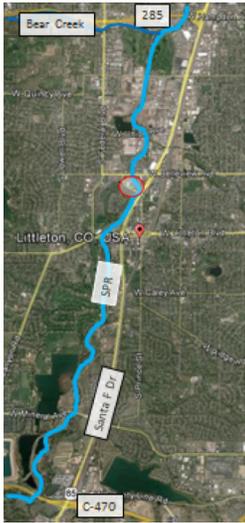
- Maintain 100-yr Flood Protection
- Fluid connection of brewery into the park and park into the brewery
- Active play area that engages both the open space and the river
- Trailhead

## Reynolds Landing



- Schedule I Construction – Upland Park and Trail Connection, February 2016 – Summer 2016
- Budget \$1,500,000 (design and construction)
- Includes:
  - Trailhead Improvements – parking lot expansion, pavilion upgrades, additional smaller shelter, playground, flush restrooms, trees and revegetation
  - Trail Connection – regional trail connection to Breckenridge Brewery and park
- Project Team – DHM, Merrick and Edge Contracting

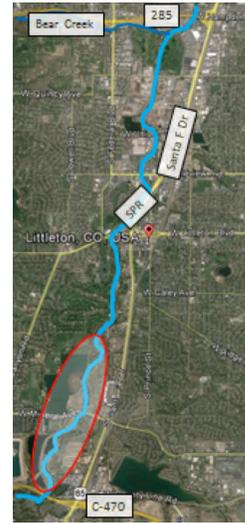
## Riverside Downs



**Riverside Downs**  
Connecting People, Business and Recreation

- Maintain 100-yr Flood Protection
- Create Stronger Connection To Local Businesses
- Create Better River Access
- A New Place For Shopper, Diners and Recreationists to Enjoy

## South Platte Park



**South Platte Park River Enhancements**  
Restore the natural beneficial functions of the floodplain

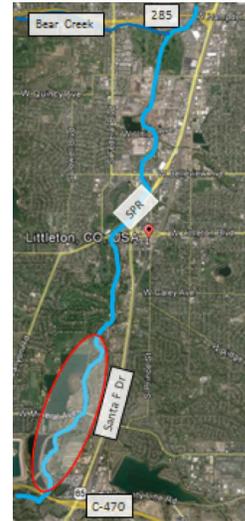
- Maintain 100-yr Flood Protection
- Improve aquatic habitat through channel reshaping and riffle, pool, glide sequences
- Develop and restore riparian habitat through riparian terraces and plantings
- Preserve existing quality habitat and ecosystems

## Riverside Downs



- Completed by Littleton
- Budget \$1,100,000 (design and construction)
- Includes:
  - Improved Trail Connection to businesses and river
- Project Team—DHM and Merrick

## South Platte Park River Enhancements



**Team**  
ERC  
ERO  
Naranjo Civil Constructors

**Schedule**  
High flow recovery effort, Summer 2016

**Budget**

- Design \$480,000
- Construction \$3,900,000

# Lower Boulder Creek Ecological Restoration Project

By Mike Sarmiento, Senior Construction Manager, Floodplain Management Program

Boulder County Parks and Open Space and the U.S. Army Corps of Engineers Omaha District (USACE) held a groundbreaking ceremony for the Lower Boulder Creek Ecological Restoration project on October 8<sup>th</sup>, 2015. The ceremony was well attended by a wide variety of stakeholders including citizens, local government elected officials, UDFCD, and other local government agencies. This project is the culmination of a ten-year process of collaboration between Boulder County Parks & Open Space and the USACE. The \$2.6 million project was awarded to American West Construction, a local contractor with extensive experience with stream restoration projects in the front-range region. Funding levels are 65% federal funds and 35% county funds including the land value.

The restoration site is located within a 430-acre parcel of open-space owned and maintained by Boulder County. This site is nearby existing ponds and other wildlife habitat. In this section Boulder Creek flows in a linear northeasterly direction between 109th Street and approximately 115th Street (Kenosha Road). Pre-1970 mining created a highly modified, linear channel and earthen levees with little riparian value. Since that time typical runoff and flood events such as the September 2013 flood have accelerated the channel headcutting and bank erosion resulting in vertically eroded banks with very little ecological value.

The Boulder County Parks and Open Space vision for this corridor began in 1998 with master planning. In 2002, they began partnering with the USACE to create a restoration design, however, due to budgetary and other higher priority projects the project was delayed until 2015. The selected design alternative will return Boulder Creek to a meandering stream that is reconnected to its floodplain, thus greatly enhancing the overall ecological diversity. The old channel alignment will be backfilled while the new alignment will relocate and extend the nearly 5000 lineal feet of channel to about 6000 lineal feet with much wider floodplain benches (See Figure 1). The design incorporates extensive channel sinuosity by creating approximately ten compound bends. The intent is to allow for the stream to self-design in order to reach relative geomorphic stability.

This project includes maximizing the salvage and re-use of existing onsite materials such as river cobbles (See Figure 2) and woody materials. Tree trunks and root wads will be used to create energy deflectors and enhance natural sediment accumulation along most of the channel bends, thereby increasing fish and aquatic habitat while simultaneously providing bank stabilization. In addition, the project will salvage and replant a large number of native trees.

American West has made significant progress on the new alignment since the October ceremony. The new alignment is now complete and crews are now constructing the cobble-riffle structures and pools. The design includes a bankfull

width that averages about 58 feet and incorporates much wider (150 feet) floodplain benches. The intent is to create a series of eight cobble-riffle rundowns and point bars throughout the new alignment. Pre-formed scour holes will be excavated downstream of each of the riffle-drop sections.

The revegetation component will take advantage of the upcoming spring growing season and will include installing native trees and shrubs, upland grasses and forbs, as well as riparian and wetlands plantings. Boulder County and American West anticipate that all construction and revegetation will be completed by next fall.

Boulder County Parks and Open Space is very excited about this partnership with the USACE. If you would like more information, please contact Ernst Strenge with BCPOS at 303-678-6269 or by email at: [Estrenge@bouldercounty.org](mailto:Estrenge@bouldercounty.org). UDFCD is providing construction observation of this project for our Maintenance Eligibility Program.



**Figure 1: New Channel Alignment with increased sinuosity. View is looking west (upstream).**



**Figure 2: Reuse of the existing channel cobbles and riffle materials.**

# Rating Extensions for Water Resources Streamgages

Kate Malers, P.E., Water & Earth Technologies

Kevin Stewart, P.E., UDFCD

UDFCD operates a network of real-time flood monitoring streamgages for early flood detection and warning. Other agencies including the Colorado Division of Water Resources (DWR) and the United States Geological Survey (USGS) also collect data from Front Range streams, which is used primarily for water resources management. Whether they are operated for flood detection or water availability use, gages located in natural streams typically measure the water depth or stage, and report their respective gage height readings. Stream stage can be continuously monitored economically and accurately, but knowing flow rates associated with the stage data is also critically important. The corresponding discharge data is analyzed to characterize streamflow and estimate impacts.

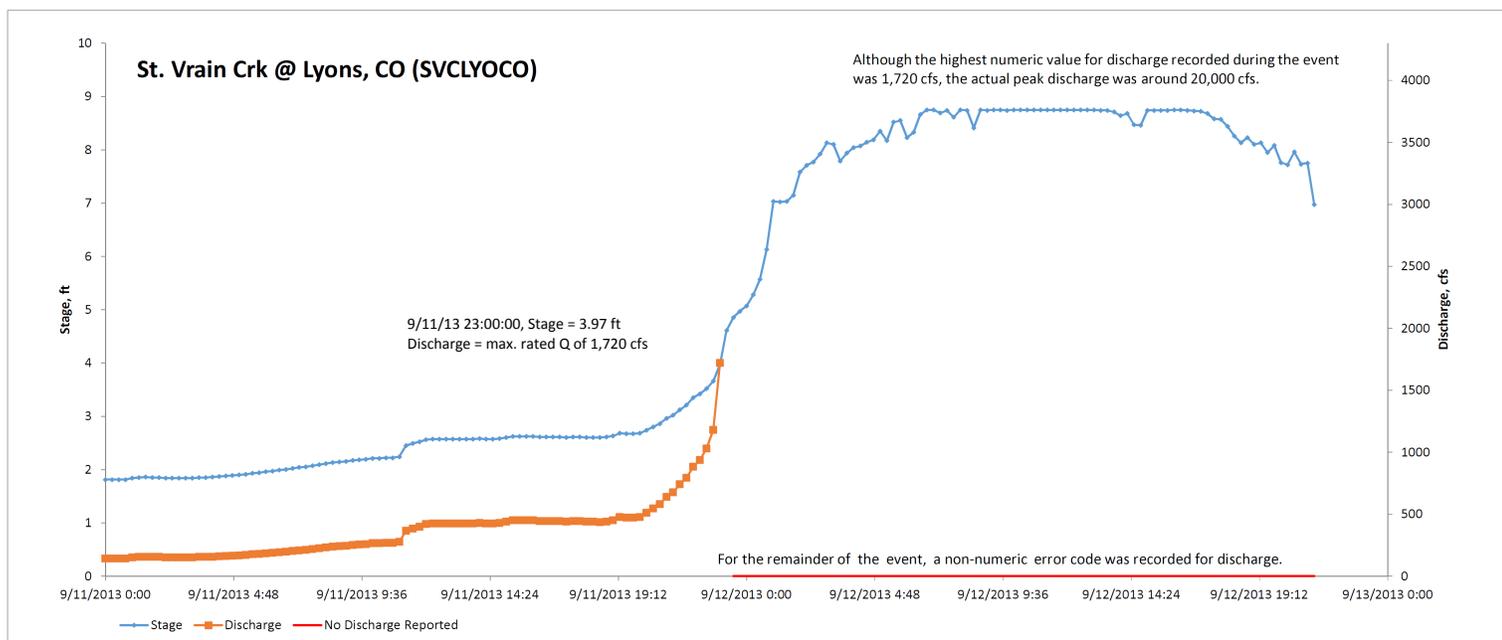
The software that receives and stores stage data from remote streamgages uses a stage/discharge rating to assign a discharge for each stage measurement in the record. There are some challenges inherent in developing reliable stage/discharge ratings for gages in natural stream channels. The relationship between stage and discharge is unique for each gage site and can change over time, either gradually through incremental aggradation or degradation, or suddenly in response to a flood or other event that impacts the channel's hydraulic characteristics.

Water resources agencies like DWR and USGS are tasked with providing very accurate estimates of discharge, especially during low flow periods. They are continually

challenged by the gradual geometric changes that occur naturally in stream channels. Streamgage flow ratings are typically developed empirically from an on-going program of relatively frequent direct flow measurements. To compensate for changing channel capacities, ratings are frequently "shifted" and occasionally revised to match field measurements, which involve surveying the stream cross-sectional area, measuring the flow velocity and calculating the discharge. Discharge monitoring is not continuous, like stage monitoring, but it is relatively frequent, with each gage site visited multiple times a year to provide a comparison between the rated discharge and the flow rate measured in the field. Discharge measurements are made during summer low flows and during spring runoff, and if possible, during flood events. It is important to understand, however, that stage/discharge ratings for many DWR and USGS gages extend only as far as the highest discharge measured in the field. During a flood, gages with ratings that fall "short" of the peak do not provide any useful high flow information even though they continue to report accurate stage values.

Saint Vrain Creek was one of many Front Range streams that experienced very large flows during the September 2013 floods. The DWR streamgage at Lyons (SVCLYOCO) provides an example of when a water resources gage with a "short" rating fails to deliver critical flow data. Figure 1 below shows that SVCLYOCO appears to have done an excellent job of reporting stages (plotted in blue) until it was destroyed by the

**Figure 1. Stage and discharge measured at SVCLYOCO (St. Vrain Creek @ Lyons), September 11-12, 2013**



flooding at some time after 9 PM on September 12. The gage reported a maximum stage of 8.75 feet during the event. However, all of the stage measurements after 11 PM the previous evening exceeded the maximum rated stage for the gage (3.97 feet/1,720 cfs). No discharge values were associated with higher stage values; consequently the flow rate plot is truncated (orange line). The operational assumption made during the flood was that the gage had failed. Post-flood analysis revealed that the peak discharge that occurred at Lyons was more in the range of 20,000 cfs, not 1,720 cfs.

There are frequently discrepancies in the discharges reported by DWR/USGS gages and UDFCD gages, and sometimes even between the data from UDFCD gages that are co-located with a DWR or USGS gage. Small discrepancies are typically caused by the frequent application of “shifts” to DWR/USGS ratings to maintain desired accuracy for low flow measurements. Sometimes a difference in the temporal resolution between the two data streams produces varying results. Large discrepancies in high flow reports have general been due to the “short” ratings. This can be confusing when emergency managers and their technical support personnel are viewing both data sources concurrently with tools like UDFCD’s [ALERT GMap](#).

UDFCD has relied on theoretical hydraulic models like HEC-RAS to develop stage/discharge ratings for streamgages that provide *reasonable* estimates of discharge by extending the DWR and USGS ratings. Hydraulic models commonly used

for floodplain management purposes can also be used to estimate flows for water depths that have never been experienced, much less measured. Ratings developed from theoretical models are not as accurate as making direct flow measurements, especially for low flows. Larger flood flows are far more difficult to quantify with the high degree of accuracy required for effective water resources management, but theoretical ratings certainly do provide enough accuracy to inform emergency response. Theoretical ratings can also be improved by comparing the theoretical discharge estimates with direct flow measurements when available. This is one advantage of having a UDFCD streamgage located at DWR/USGS gaging station.

Last winter DWR developed rating extensions for several streamgages (Bear Creek at Morrison, Boulder Creek at Orodell, and Clear Creek at Derby) to avoid confusion created by the truncated discharge hydrographs resulting from “short” ratings. The results of that pilot project are currently being reviewed. DWR is particularly interested in considering the relative uncertainty inherent in empirical extrapolation versus using theoretical hydraulic models for extended ratings. Developing hybrid-rating curves that incorporate both empirical data and hydraulic models presents some interesting challenges and opportunities. UDFCD is collaborating with DWR as they continue their investigation into how to best address the desires of constituencies interested in real-time flood flow measurements.



St. Vrain Creek at Lyons gage after the flood

Approx. Loc. Of  
SVCLYOCO gage



St. Vrain Creek at Lyons gage before the  
2013 flood

# 2015 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.
- \* 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)
- \* Presented *Water rights versus Detention*, Special Districts Association Annual Conference, Keystone, CO
- \* Presented *Flood Control-Creating a Safe Community*, American Water Works Association Annual Conference, Denver, CO
- \* Presented *Stormwater Versus Water Rights*, UDFCD Annual Conference, Broomfield, CO

## **Kevin Stewart, Manager, Information Services and Flood Warning Program**

- \* Board Member & Past President, National Hydrologic Warning Council (NHWC)
- \* Alternate NHWC Representative, Department of Interior Advisory Committee on Water Information, Subcommittee on Hydrology
- \* Member of ASCE, APWA, ASFP, CASFM, American Meteorological Society and Colorado Emergency Management Association
- \* Invited speaker, National Weather Service Hydrology Workshop in Boulder in April
- \* Attended WERA 1012 “*Managing and Utilizing Precipitation Observations from Volunteer Networks*” in Estes Park in May
- \* Co-presented “*A Case Study in Radar-Based Hydrology – The September Floods of 2013*” and awards program MC at the 11<sup>th</sup> NHWC Training Conference & Exposition in Indianapolis, IN in June
- \* Attended Natural Hazards Workshop and Natural Hazards Mitigation Association Conference in Broomfield in July
- \* Co-presented “*Hydrologic Modeling of a Recovering Burn Area*” at CASFM Conference in Vail in September
- \* Presented “*2013 Colorado Flood Recovery – preparing for the next “Big One” thru enhanced decision support*” at NHWC Flood Warning Workshop in Austin, TX in October

## **Ken MacKenzie, Manager, Master Planning Program**

- \* Moderator and speaker at EWRI LID Conference (Houston, TX, January 19-21).
- \* Moderator and speaker at UDFCD annual seminar (Broomfield CO, April 15).
- \* Speaker at WEFTEC 2015 Stream Restoration Workshop (Chicago IL, September 27).
- \* Speaker at the 2015 Sustaining Colorado Watersheds Conference (Avon CO, October 27).
- \* Stormwater Committee Chair for the National Association of Flood and Stormwater Management Agencies (NAFSMA).
- \* Vice-chair of Municipal Water Infrastructure Council of the Environmental and Water Research Institute (EWRI MWIC) of ASCE.
- \* Task Committee Chair for EWRI MWIC.
- \* Treasurer of the Board of Directors of the Urban Watershed Research Institute (UWRI).
- \* 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, WERF, & CASFM.

### **David Bennetts, Manager, Design, Construction & Maintenance Program**

- \* Co-presented *Planning for Variability and Uncertainty: Climate Change and the UDFCD Urban Drainage System* at the District's annual seminar in April in Denver, CO
- \* Co-presented *Remembering the 1965 South Platte River Flood* in June at the History Colorado Center in Denver, CO
- \* Presented *'A History of Denver, the UDFCD, and the 1965 Flood* at the Biennial of the Americas Implant event in July in Denver, CO
- \* Attended NAFSMA's Annual Meeting in August in Jackson, WY
- \* Attended APWA's Annual Congress in August in Phoenix, AZ
- \* Co-presented *Remembering the 1965 South Platte River Flood* in September at CASFM's annual conference in Vail, CO
- \* Co-presented *'Johnson Habitat Park Project'* as part of the project awards presentations in September at CASFM's annual conference in Vail, CO
- \* Moderator of the 'Stream Restoration' Track at CASFM's annual conference in September in Vail, CO
- \* Co-presented *Planning for Variability and Uncertainty: Climate Change and the UDFCD Urban Drainage System* at APWA's Colorado Chapter Conference in October in Breckenridge, CO
- \* Council Member, CU Denver Engineering Leadership Council and Construction Engineering and Management Advisory Board
- \* Board Member, Colorado Chapter, American Public Works Association
- \* Member of ASCE, APWA, ASFPM, NAFSMA, 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 Society of Civil Engineers (ASCE).
- \* Appointed to FEMA's Technical Mapping Advisory Committee (TMAC) as the CTP local government representative. Attended TMAC meetings in Washington DC, throughout the year.
- \* Participated in Colorado Flood Technical Assistance Partnership meeting throughout the year.
- \* Participated in several Maintenance Eligibility Workshops with Teresa Paterson and Mike Sarmiento throughout the year.
- \* Attended the FEMA Region 8 CTP/RAD meeting in February.
- \* Presented *UDFCD, Case Study in Successful Floodplain Management* as a Subject Matter Expert to TMAC in March.
- \* Presented *A September to Remember, Was it Foreseeable?* at the RMLUI in March.
- \* Presented *New Initiatives in Flood Risk Communication* with Teresa Paterson and Joanna Czarnecka at the UDFCD Annual Seminar held in Broomfield in April.
- \* Attended the Natural Hazards Workshop and NHMA Practitioners Symposium in Broomfield in July.
- \* Attended the NAFSMA Annual Meeting held in Jackson Hole, August.
- \* Attended the CASFM Annual Conference in Vail and presented *What is Your Definition of Floodplain Management?* with Bill DeGroot, September.
- \* Participated in the FEMA/ASFPM/NAFSMA partnership meetings held in Washington DC, September and December.

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

- \* Rocky Mountain Public Works Institute Steering Committee Chair, second class graduated in October
- \* Presented on "Creating a Learning Organization" at Colorado APWA Annual Conference in Breckenridge, CO
- \* Presented on "What is Sprouting up along the South Platte River" at the South Platte River Forum in Loveland, CO
- \* Panel Speaker on APWA Public Work Institutes at APWA Congress in Phoenix, Az
- \* Wrote article in the APWA Reporter, December addition titled, "Succession Planning: Developing your "farm team""
- \* Lead Rocky Mountain Public Works Institute class on Creating an Effective Team, Denver, CO

**Bryan Kohlenberg, Senior 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 2015 IECA Environmental Connection Conference in Portland, February
- \* Attended UWRI Water Rights Analysis and Engineering Course, March
- \* Attended UDFCD annual Stormwater & Floodplain Management Seminar, April
- \* Co-presented *Revisiting the '65 South Platte River flood - 50 years later*, at History Colorado in June, and at the CASFM Annual Conference in Vail, September
- \* Attended 2015 IECA Mountain States Chapter Winter Conference, November

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

- \* Served as Technical Advisory Committee Member for the Cherry Creek Basin Water Quality Authority
- \* Presented *Piney Creek Projects Update* at Cherry Creek Basin Water Quality Authority and Liverpool Metro District in April, 2015
- \* Attended American Public Works Association National Conference in August, 2015
- \* Presented "Cherry Creek at Eco Park Project" at Colorado Association of Stormwater and Floodplain Managers Annual Conference in September, 2015
- \* Attended Cherry Creek Basin Stewardship Conference in November, 2015
- \* Attended Stream Restoration Class in November, 2015

**Shea Thomas, Senior Project Manager, Master Planning Program**

- \* Presented "*Challenging Uncertainty in Hydrologic Paradigms*" at the UDFCD Annual Seminar in Broomfield, Colorado in April.
- \* Presented "*A September to Remember*" to the Washington County Flood Control Authority in St. George, Utah in May.
- \* Presented "*Planning for Variability & Uncertainty: Climate Change and the UDFCD Urban Drainage System*" at the CASFM Conference in Vail, Colorado in September.
- \* Presented "*Establishing Calibrated Guidelines for 2-D Rainfall Modeling within the UDFCD*" at the CASFM Conference in Vail, Colorado in September.
- \* Attended the NAFSMA annual meeting in Jackson Hole, Wyoming in August.
- \* Served as Vice Chair of CASFM.
- \* Elected Chair of CASFM.
- \* Served on the Stormwater Management and Floodplain Management Committees for NAFSMA.

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

- \* Speaker on the *Evolving Routine Maintenance to Stream Management* at the UDFCD Annual 2015 Conference, Broomfield, CO
- \* Facilitated a Workshop on *Vegetation Challenges for Urban Streams—Adaptive Vegetation Management Solutions* the Colorado Stream Restoration Network, June 2015, Longmont, Colorado
- \* Participated in *Rosgen Fluvial Geomorphology Level 2 Training*, July 2015, Bend, Oregon
- \* Attended Cherry Creek Stewardship Partners 2015 Annual Congress in Englewood, Colorado
- \* Attended Rocky Mountain River Restoration 2015 Conference, Breckenridge, Colorado
- \* Secretary for the ASCE EWRI Stormwater Infrastructure Committee
- \* Chairperson for the ASCE EWRI Adaptive Stormwater Management Task Committee
- \* Member of Education Committee for the Colorado Riparian Association
- \* Workshop Coordinator for the Colorado Stream Restoration Network
- \* Active Member of ASCE, APWA, Chi Epsilon, ASFPM, CRA, and CASFM Professional Societies
- \* Working Member of ASCE EWRI Urban Water Resources Research Council, Water, Wastewater, and Stormwater Council, Stormwater Infrastructure Committee, Urban Stream Restoration Committee

### **Holly Piza, Senior Project Manager, Master Planning Program**

- \* Co-instructor for training course on BMP Maintenance and Inspection for the Colorado Stormwater Center on May 14-15 and August 19-20 (various locations in the UDFCD region).
- \* Authored a paper and presented Rainwater Harvesting with Cloud-based Infrastructure at the Low Impact Development Conference held by the Environmental and Water Research Institute (EWRI) of ASCE in Houston, TX on January 19<sup>th</sup> and at the UDFCD Annual Seminar in Broomfield, CO on April 7<sup>th</sup>.
- \* Presented Sustainable Stormwater Management to a group of developers in the RINO district on January 22 at the Industry site in Denver, CO.
- \* Co-presented Better BMPs in Colorado – Linking Design, Construction, and Maintenance at the EWRI Congress in Austin, TX on May 21<sup>st</sup>.
- \* Presented What Makes a great Consultant? – the Client’s Perspective for a group of consultants on June 12<sup>th</sup> in Denver, CO.
- \* Co-presented Maintaining Permeable Pavements for a Washington Stormwater Center webinar on June 17<sup>th</sup>.
- \* Organized and lead annual field trip for the Colorado Association of Stormwater and Floodplain Managers (CASFM) on June 23<sup>rd</sup>.
- \* Co-instructed a workshop on bioretention and presented Permeable Pavement Maintenance at the CASFM conference on September 24 in Vail, CO.
- \* Presented Sustainable Stormwater Management as a guest lecturer to a Planning and Urban Design class at the University of Colorado in Denver.
- \* Presented Permeable Pavements for Stormwater Management at the Local Technical Assistance Program (LTAP) Training on December 15<sup>th</sup> in Castle Rock, CO.
- \* Task Committee Chair for the Municipal Water Infrastructure Committee (part of the 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, Senior Project Manager, Design, Construction & Maintenance Program**

- \* Member of CASFM, ASFPM, APWA, Toastmasters
- \* Attended Sustaining Colorado Watersheds Conference
- \* Completed the Water Leaders Program organized by the Colorado Foundation for Water Education
- \* Guest Lecturer for UC-Denver Construction Management Graduate Class
- \* Guest Lecturer for Denver University Colorado’s Rivers Class
- \* Instructor for APWA Public Works Institute
- \* Co-Presenter for *When Tunneling isn’t Boring Something Has Gone Wrong* at CASFM Annual Conference, September
- \* Co-Presenter for *An Exciting Boring Project* at APWA Inspectors Conference
- \* Achieved *Competent Communicator* credential through Toastmasters

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

- \* Member of ASCE, NSPE, CASFM and ASFPM
- \* Attended Annual Region 8 CTP Meeting, FEMA, February
- \* Presented, *Getting Local Floodplain Studies on the MAP!* at the E0241 CTP Special Topics Training, EMI, February
- \* Attended FEMA Region 8 Annual Meeting, February
- \* Attended ASFPM Annual Conference in Atlanta in June
- \* Attended HEC-RAS 5.0 2D Model Training Workshop, ASFPM, May
- \* Attended Flood Insurance for the Floodplain Manager Workshop, ASFPM, June
- \* Attended USGS Fluvial Erosion Hazard (FEH) Mitigation Program and High Water Mark Workshop, ASFPM, June
- \* Attended “How to Talk About Map Changes and Flood Insurance,” ASFPM, June
- \* Attended Floodplain Modeling Using GIS Technology Workshop, ASFPM, June
- \* Attended HEC-RAS 2D Training, CASFM, June
- \* Attended Hydrology Using HEC-HMS, UWRI
- \* Participated in Region 8 CTP Mentoring Session and Attended MT DNRC Floodplain Resource Seminar, MT DNRC, July
- \* Attended 2015 CASFM Annual Conference, September
- \* Attended Flo-2D Predicting Urban Flooding and Culvert Workshop, CASFM, September
- \* Attended “Continuing Opportunities for Coordination between Flood Plain Managers and Dam Safety Engineers – Recent Lessons Learned” Workshop (CASFM, October 2015)
- \* Attended Stream Restoration Planning and Design Short Course, DTW and Associates, LLC, November
- \* Participated in Hazard Mitigation Implementation Webinar, ASFPM/APA, December

**Teresa L. Patterson, Project Manager, Floodplain Management Program**

- \* Member of CASFM and ASFPM
- \* Presented MEP Workshop-Douglas County (January 2015)
- \* Attended FFRMS Briefing Webinar (February 2015)
- \* Attended Nonstructural Flood Proofing Techniques for At-Risk Development Webinar (February 2015)
- \* Attended CRS Webinar Series: Developing Outreach Projects (Activity 330) Webinar (February 2015)
- \* Attended CRS Webinar Series: Developing a PPI and CIP Webinar (March 2015)
- \* Presented MEP Workshop-Parker (March 2015)
- \* Presented MEP Workshop-Denver (April 2015)
- \* Attended ASFPM Annual Conference (May/June 2015)
- \* Attended HEC-RAS 5.0 2D Model Training Workshop (ASFPM, May 2015)
- \* Attended Using Map Mashups & Story Maps to Tell Your Story Workshop (ASFPM, June 2015)
- \* Attended CRS Outreach Projects & FloodSmart: How Communities Can Expand Outreach Workshop (ASFPM, June 2015)
- \* Attended Presenter Training for the Ward's 3D Flood Model Workshop (ASFPM, June 2015)
- \* Presented MEP Workshop-Brighton (June 2015)
- \* Attended HEC-RAS 2D Training (CASFM, June 2015)
- \* Presented MEP Workshop-Adams County (July 2015)
- \* Presented MEP Workshop-SEMSWA/Arapahoe County (August 2015)
- \* Attended 2015 CASFM Annual Conference (September 2015)
- \* Attended EMI L0278 National Flood Insurance Program/Community Rating System Workshop (November 2015)

**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
- \* Steering Committee member for EMWIN- Denver (Emergency Managers Weather Information Network)

**Mike Sarmiento, Senior Construction Manager, Floodplain Management Program**

- \* Presented to Colorado Stream Restoration Network on "Case Studies - Westerly Creek at MLK Blvd and Big Dry Creek at Cheese Ranch" and served on discussion panel, January
- \* Attended Colorado Weed Network Meeting in Golden (NREL), February
- \* Attended the High Altitude Restoration Conference at CSU in Ft. Collins, CO, March
- \* Attended UDFCD Annual Seminar, April
- \* Attended Society of Wetland Scientists (Rocky Mountain Chapter) annual Meeting, April
- \* Conducted Maintenance Eligibility Program Workshop for City of Denver, April
- \* UDFCD Technical Roundtable and Field Trip: Riffle and Cascade Drop Structures, June
- \* Conducted Maintenance Eligibility Program Workshop for City of Brighton, July
- \* Conducted Maintenance Eligibility Program Workshop for SEMSWA and Arapahoe County, August
- \* CASFM Annual Conference in Vail, CO, and received Certified Floodplain Manager (CFM) certification, September
- \* CASFM Quarterly Lunch and Learn "Continuing Opportunities for Coordination Between Floodplain Managers and Dam Safety Engineers - Recent Lessons Learned", October
- \* Attended CRS Committee Meeting at UDFCD, October
- \* Attended annual Cherry Creek Conference; "The Influence of the Cherry Creek Basin", November
- \* Attended "Stream Restoration Basics and Techniques" Workshop by Dr. David Williams, November
- \* Member of American Public Works Association, American Institute of Hydrology, Association of State Floodplain Managers, Colorado Riparian Association, Colorado Association of Stormwater and Floodplain Managers, Society of Wetlands Scientists, Society of Ecological Restoration, National Institute for Certification of Engineering Technicians

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

- \* APWA Congress
- \* CO APWA Management Conference
- \* CO APWA Inspectors Conference
- \* CO Emergency Management Conference
- \* CO APWA Representative: State All Hazards Advisory Committee
- \* UDFCD Representative: SPCURE
- \* Attended Emergency Management "Safe Community Forum"
- \* Member: APWA
- \* Member: CO Emergency Management Association

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

- \* Attended the 2015 UDFCD Annual Stormwater and Floodplain Management Seminar
- \* Attended the 2015 APWA Colorado Awards Program
- \* Attended the 2015 APWA Colorado Inspector Conference
- \* Attended the 2015 Mountain States Chapter o 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**

- \* Current member of APWA
- \* Current member of IECA
- \* Participated in IECA annual CO conference
- \* Participated in APWA Inspectors Conference

**Darren Bradshaw, Construction Manager, Jefferson and Broomfield County – Design, Construction & Maintenance Program**

- \* Continued membership in Association of State Floodplain Managers (ASFPM), International Erosion Control Association (IECA) and 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 Portland, February
- \* Attended Water Rights Engineering Course in March
- \* Attended the UDFCD annual Stormwater & Floodplain Management Seminar in April
- \* Attended the Mountain States Chapter of IECA Winter Conference in November

**Urban Drainage and Flood Control District**  
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