Flood Hazard News

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Editor's Note: Most of the articles in this issue of *Flood Hazard News* will at least touch on the 2013 floods. The UDFCD is in the process of compiling a detailed account of what happened. A "coffee table" version of that account will be published in early spring, 2014.

Denver Metropolitan Area Fares Well During Severe Precipitation Event in September 2013

By

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Introduction

Flood damages and loss of life in the September 2013, Denver-Boulder Colorado area were significantly less than would normally be anticipated for the enormous and prolonged rainfall that fell—rainfall claimed by some as "one in 1,000 year" rainfall. One of the major reasons for this lies in key policy statements in the widely-cited *Urban Storm Drainage Criteria Manual,* maintained by the Urban Drainage and Flood Control District.

The Front Range of Colorado, including the Denver metropolitan area, has a long history of flooding. Contributing factors include:

- Intense summer thunderstorms,
- Heavy snowmelt combined with heavy spring rain on saturated soil,
- Steep, mountainous terrain causing runoff to collect rapidly and leading to flash floods,
- Large quantities of easily loosened soil, boulders and debris that are flushed down canyons into urbanized areas.
- Wildfires that ruin the soil's ability to soak in the rainfall, increasing flooding and debris flows.
- Cities that were settled on the banks of flood-prone creeks and at the mouths of canyons where flood and debris flows spread out and inundate large areas.

The effects of these factors are dramatic. The 1965 South Platte River flood devastated everything in its path for 30 miles, including a wide swath through Denver and adjoining communities.

Flood waters on Sand Creek at the confluence with the South Platte River eroded approximately 100 feet of the outside bend into the Metro Wastewater Reclamation plant property, leaving a 25 foot vertical bank.

Actions Taken After 1965 South Platte River Flood

The 1965 South Platte River flood triggered many significant actions, including (1) construction of two large flood control reservoirs (Chatfield Dam and Bear Creek Dam) immediately upstream from Denver by the U.S. Army Corps of Engineers, (2) publication of the *Urban Storm Drainage Criteria Manual* (*Criteria Manual*) in 1969 and, (3) in 1969, formation of the Urban Drainage and Flood Control District (UDFCD) by the Colorado State Legislature and Governor.

Fourmile Canyon Creek in Boulder, CO reclaimed its natural easement in what was previously a residential street and front yards during the September 2013 flooding. A major drainage system was planned for this creek but not implemented before the flood.

The UDFCD was established to respond to widespread recognition that drainage and flood control activities among the local governments in the Denver metropolitan area were fragmented and inconsistent. The primary responsibilities of the UDFCD were to map floodplains and assist with floodplain regulation, master-plan major drainageways, provide technical guidance and assistance to the planning and engineering community and construct and maintain drainage facilities, working closely with local governments.

In 1970, the UDFCD assumed responsibility for implementing and promoting use of the *Criteria Manual* within the UDFCD region, which encompasses over 1,600 square miles and 40 local governments. The *Criteria Manual* was a landmark document—never before had such broad-based information pertaining to drainage and flood control been compiled in a single reference. At the time, guidance was not available that clearly stated the problem, formulated goals and objectives, and provided detailed design criteria for wide-ranging drainage and flood control facilities. The *Criteria Manual* has been widely cited in the engineering literature and in drainage design manuals by other governments nationally and internationally.

Key Policies in the Urban Storm Drainage Criteria Manual

The foundation for the *Criteria Manual* is Chapter 1, "Policy," which lays out the guiding philosophy, policies and principles for drainage and flood control within the UDFCD. The authors and advisors (including Kenneth Wright, P.E., Jack Schaeffer, Ph.D., P.E., D. Earl Jones, Jr., P.E., and Gilbert White) recognized that it is essential to establish solid policies and principles as the foundation for detailed design criteria.

The foresight and wisdom of this was readily apparent during an extraordinary period of rain that occurred from September 9 to 15, 2013, in much of the Colorado foothills and Front Range, where rainfall return frequencies at times exceeded the 100- to 500-year event. The nature of the flooding, including, tragically, loss of life and property damage, has been extensively evaluated, and one widely shared observation is that within the UDFCD, loss of life and damages would have been far worse if the policies, principles and design criteria articulated in the *Criteria Manual* had not been implemented. Examples of this follow; more are found in the Policy chapter of the *Criteria Manual*.

Promoting General Health and Welfare

Policy Statement**:** *Adequate drainage for urban areas is necessary to preserve and promote the general health, welfare and economic well-being of the region. Drainage is a regional feature that affects all governmental jurisdictions and all parcels of property. This characteristic of drainage makes it necessary to formulate a program that balances both public and private involvement. When considered in a comprehensive manner—on a regional level with public and private involvement—drainage facilities can be provided in an urban area in a manner that will avoid uneconomic water losses and disruption, enhance the general health and welfare of the region, and assure optimum economic and social relationships.*

This policy statement links sound drainage practices to the protection of public health and welfare and economic vitality, emphasizes the regional nature of storm drainage, speaks to the need for comprehensive approaches and defines the importance of public/private partnerships, all which helped to mitigate loss of life and damages during the 2013 flood.

Initial and Major Drainage Systems

Policy Statement: *Every urban area has an "initial" and a "major" drainage system, whether or not actually planned and designed.*

The *Criteria Manual* states that urban drainage planners should recognize that two separate and distinct drainage systems exist: the "initial" and "major" drainage systems. The initial or "convenience" system collects and conveys smaller day-to-day runoff events and consists of local swales, streets, gutters and inlets and storm drains. The major system conveys large infrequent events and, when well

designed, protects the urban area from extensive property damage, injury and loss of life. The major drainage system will exist whether or not it has been properly planned and designed and whether or not development is situated wisely with respect to it.

A design frequency for the initial system of 2-10 years, 100 years is suggested for the major system, and for "critical facilities" such as hospitals, police and fire stations, and emergency communications centers, potentially 500 years. These conservative return frequency recommendations coupled with freeboard requirements for channels and detention basins and the recommendation to carefully manage floodplain development unquestionably limited damage during the 2013 floods and facilitated the ability of emergency responders to reach those in need of help (although not addressed by this paper, the emergency

Exposition Park and Regional flood Detention Facility in Aurora, CO; a city park under dry-weather conditions served its dual purpose as a flood storage detention basin during September.

response network throughout Colorado was extraordinarily effective).

Runoff Management Requires Space

Policy Statement: *Runoff routing is primarily a space allocation problem.*

If adequate provision is not made for drainage volume and space demands, stormwater runoff will conflict with other land uses, and result in damages and impair or disrupt the functioning of other infrastructure.

Drainage Facilities Should Be Multi-objective and Multipurpose

Policy Statement: *An urban storm drainage strategy should be a multi-objective and multi-means effort.*

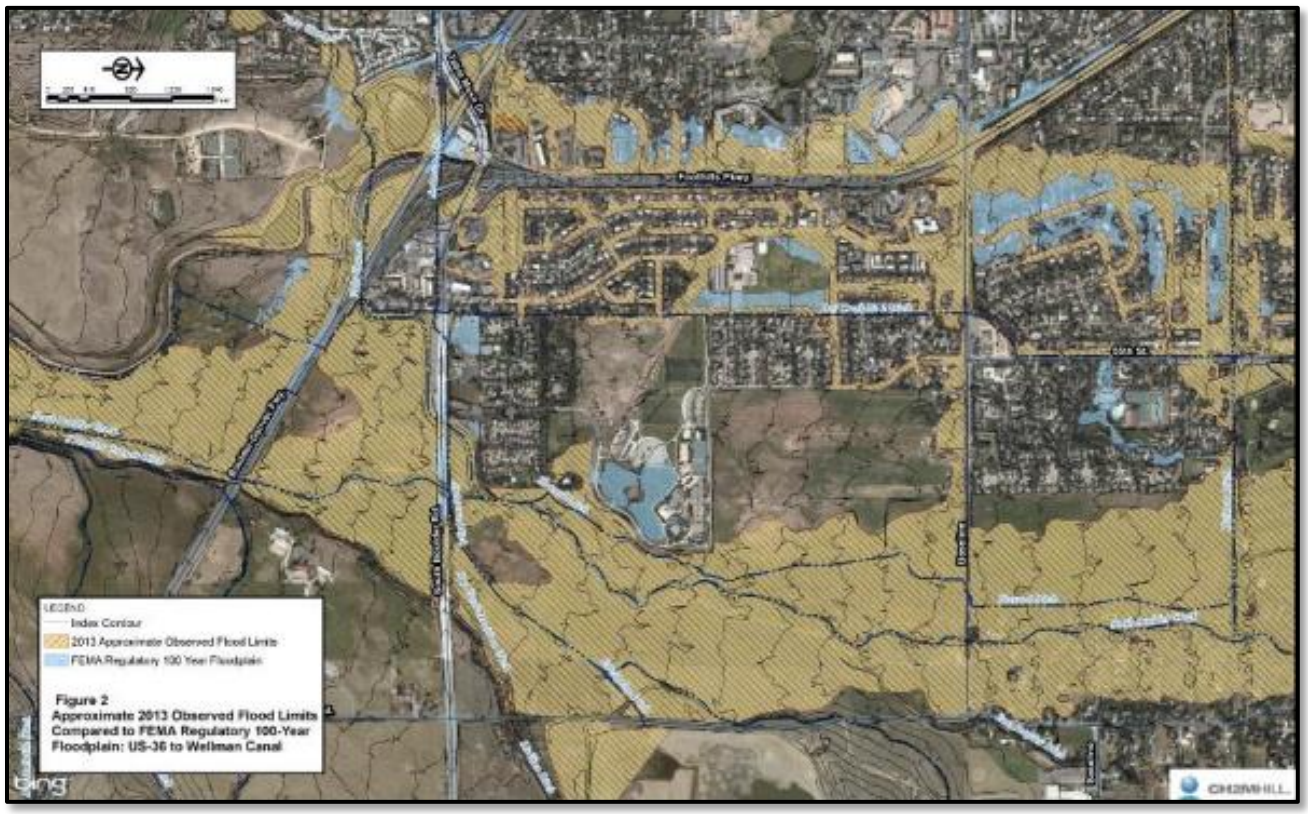
Storm drainage facilities that fulfill multiple objectives will be viewed as community assets by the public. The many competing demands placed upon space and resources within an urban region argue for a drainage management strategy that meets multiple objectives, including water quality enhancement, groundwater recharge, recreation, wildlife habitat, wetland creation, protection of landmarks and amenities, control of erosion and sediment deposition and creation of open space, among others. This policy emphasizes the paramount need to protect public health, safety and welfare, and provides design guidance for channels, ponds, water quality controls and other structures related to safety. Within the UDFCD region, the only two deaths that occurred during the September 2013 flood were the result of driving a vehicle into floodwaters.

Preservation of Floodplains

Policy Statement: *Floodplains should be preserved whenever feasible and practicable.*

The need to preserve floodplains is a dominant theme. This policy has been adopted by the local governments within both the Denver metropolitan area and along the Colorado Front Range. This is unquestionably a major reason why flood damages were not much worse during the September 2013 flooding. Nature has claimed a prescriptive easement for floods, via its floodplains, that cannot be denied without public and private cost. Floodplains often provide a natural order to the land surface, with drainageways that serve as outfalls for urban drainage, bottomland for wildlife habitat, riparian corridors and specialized vegetation. The UDFCD and local governments have mandated that floodplain encroachment can occur only after competent engineering and planning have been conducted to assure that the flow

Multipurpose detention facilities have significant social benefits. For example, this park in Aurora features baseball, tennis, soccer, passive recreation and on September 11th, 135 acre-feet of flood storage.



South Boulder Creek FEMA-mapped floodplain in blue, vs. September 2013 observed floodplain in tan. This shows the extent of the 2013 flooding in a large preserved floodplain and in older residential areas that are located in the floodplain and which experienced damage in 2013. Source: City of Boulder and CH2M Hill.

capacity is maintained, risks of flooding are defined, and risks to life and property are strictly minimized.

Reserve Sufficient Right-of-Way to Permit Lateral Channel Movement

Policy Statement: *Reserve sufficient right-of-way for lateral movement of incised floodplains.*

The September 2013 flooding in the UDFCD provided convincing evidence of the need to reserve sufficient right-of-way to permit stream channels to mitigate laterally, and to convey massive quantities of sediment and debris from high-gradient, mountainous watersheds. The amount of lateral movement (migration) in stream channels in September 2013 was remarkable. Outside the UDFCD, flood flows tore through the channel banks into adjoining reclaimed gravel pit lakes, which led to uncontrolled cascading overflows and extensive damage to public and private facilities. UDFCD has developed specific criteria for gravel mining in the alluviums of rivers and streams which specify a combination of wide separation distance between, and armoring of, the stream and the adjacent gravel pit embankments to minimize this risk.

In closing, the *Urban Storm Drainage Criteria Manual* has steadily evolved over time, with regular updates in response to field experience; technical developments (such as new computer models); legal, regulatory and policy precedents; increased emphasis on environmental protection and low impact development practices; and many other factors. The UDFCD early flood warning system, with over 200 real-time flood detection rain and stream flow gages throughout the region, all of which are telemetered into sophisticated computers that issue warnings to first responders, was not even a concept in 1969, when the *Criteria Manual* was originally published. In September 2013, this system was critically important in saving lives and mitigating property damage. The *Urban Storm Drainage Criteria Manual* and UDFCD will continue to evolve in response to many factors, but with the protection of public health, safety and welfare always as the paramount goal.